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Geology of the Brackley and Charlton area (SP 53 NE and part of SP 53 NW)

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Geology of the Brackley and Charlton area (SP 53 NE and part of SP 53 NW)

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Foreword

This report describes the geology of the 1:10 000-scale sheets SP 53 NE and part of SP 53 NW (the Brackley and Charlton area) and is read to best advantage in conjunction with those maps. The area of sheet SP 53 NW east of grid line 53, and sheet SP 53 NE were surveyed on the 1:10 560 or 1:10 000-scale by A Horton in 1963, P M Hopson in 1991 and A J M Barron in 1998-99. Mr Horton and Dr Michael J Oates (formerly Peko Petroleum, now of BG Group) also logged a number of sections exposed during the construction of the Brackley bypass in 1986. Dr Oates and Mr H P Powell also provided a number of other section descriptions.

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Contents

1 Introduction

This report describes the geology of the 1:10 000-scale sheets SP 53 NE and part of SP 53 NW (the Brackley and Charlton area) and is read to best advantage in conjunction with those maps. This 35-km² area includes parts of four 1:63 360 or 1:50 000-scale geological sheets: 201 (Banbury), 202 (Towcester), 218 (Chipping Norton) and 219 (Buckingham). The area was first geologically surveyed by T R Polwhele and A H Green at the 1:63 360-scale in about 1863 as part of the Old Series 1-inch sheet 45NE, published in 1873.

Sheet SP 53 NW was part surveyed by T H Whitehead in 1941 and fully resurveyed by V Wilson and E A Edmonds on the 1:10 560-scale in 1956-58. This formed part of the survey of 1:63 360-scale sheets 201 (Banbury), published in 1963, and partially revised and republished at 1:50 000-scale in 1982, and 218 (Chipping Norton), published in 1968. Both sheets were accompanied by explanatory memoirs (Edmonds et al., 1965; Horton et al., 1987). The area of sheet SP 53 NW north of grid line 38 and east of grid line 53 was resurveyed, and the area of sheet SP 53 NE north of grid line 38 was surveyed on the 1:10 560-scale by A Horton in 1963 as part of the survey of 1:63 360-scale sheet 202 (Towcester), published in 1969. The area of sheet SP 53 NE east of the River Great Ouse (i.e. in Buckinghamshire) was surveyed by P M Hopson on the 1:10 000-scale in 1991 as part of a study of sand and gravel resources for Buckinghamshire County Council (Sumbler, 1991). The remainder of sheet SP 53 NE was surveyed and the area of sheet SP 53 NW east of grid line 53 and south of grid line 38 was resurveyed by A J M Barron in 1998-99 as part of a resurvey of the 1:50 000-scale geological sheet 219 (Buckingham), a new edition of which is in preparation. This will be accompanied by a brief account of the geology (Sumbler, in preparation).

The geology of the concealed rocks of the area is known principally from a series of boreholes drilled by the Gas Council in the 1960s, as part of a scheme to store imported natural gas in structural reservoirs in the Triassic sandstones. The plan was scrapped on the discovery of gas beneath the North Sea (see Horton and Poole, 1977). The data from these boreholes is based mainly on an interpretation of downhole gamma ray logs, supplemented by logs of the borehole chippings.

In addition to geological data acquired through fieldwork, use was made of earlier geological maps, records of quarries, localities, boreholes and wells, and interpretation of commercially available aerial photography. The resulting map includes some important revisions to the earlier maps, mainly in the pattern of faulting and the additional detail in the stratal sequence. This report is based mainly on this latest work, but also incorporates data from other sources where appropriate, as indicated herein (see References and Information Sources). Measured sections from the lettered localities indicated on the maps and referred to in the text are given in Appendix 1. In addition, details are given of a number of sections which lie close outside the area but which are relevant to the account, and might otherwise remain unpublished. Abbreviated logs of selected boreholes are given in Appendix 2.

The Brackley – Charlton area lies in southern Northamptonshire, although it includes a small part of Buckinghamshire in the extreme east. It is an area of low ridges and hills, surrounding the shallow valleys of the headwaters of the River Great Ouse, which flows east to the Wash. In the extreme west a ridge forms the watershed between the catchments of the Great Ouse and the River Cherwell – a tributary of the Thames.

It is a predominantly rural area, with scattered farms, and little woodland, but the picturesque market town of Brackley lies in the east. The word Brackley is Germanic in origin and is probably named after the Saxon founder of the village, Bracca, and 'ley' meaning clearing. The town stands on the intersection of the Northampton-Oxford (A43) and Banbury-Buckingham (A422) roads. These both now bypass the town, to the east and south respectively. The railways

arrived in the middle of the 19th Century, and Brackley got its first station at the south end of the town on the line that ran through from Banbury to Bletchley. Fifty years later, in 1899, a second station was built at the top of the hill for the Great Central Railway as part of its extension line from Leicester to London. Both of these lines were closed in 1966 as part of the Beeching cuts, and today Brackley does not have a railway station. Recently the town has expanded considerably, with large residential developments to the north-west and east, and light industry to the south-east. Industrial activities include soap-making and motor-racing. Further information about the town can be found at www.brackley-index.co.uk/.

The area also includes the villages of Charlton and Farthinghoe in the extreme west, Hinton-in-the-Hedges, and Evenley in the south. The former WWII Hinton Aerodrome is now a private airfield.

1.1 NOTES

Both this report and the corresponding maps (Geological Sheets SP 53 NW and NE) give an interpretation of the data available at the date of compilation. The maps should be regarded as interim documents prepared prior to the compilation of the 1:50 000-scale map and account of the geology of Sheet 219 (Sumbler, in prep.); in particular, certain geological concepts and lithostratigraphical names may be subject to future revision.

This map depicts the disposition of the surface outcrops of the various bedrock and superficial deposits that are for the most part concealed beneath soil and vegetation. The geological boundary lines between these outcrops are mostly inferred from indirect evidence such as landforms and the characteristics of rock fragments (brash) and other material ploughed up in the soil, and from exposures of strata in quarries, or are extrapolated from adjoining ground. The map is thus the subjective interpretation of the surveyor, and all geological boundaries carry an element of uncertainty. Boundaries of solid formations and faults which can be located (in the opinion of the surveyor) within approximately 20 metres on the ground (“observed” lines) are depicted with unbroken lines on the map, all others are shown broken.

Copies of the 1:10 000-scale map can be purchased from BGS, Keyworth, where records of boreholes and other data may also be consulted by prior arrangement. Copyright restrictions apply to the use of both the map and this report, and to the copying of the material thereof. The map and report are internal publications of the BGS and any information extracted from them should be acknowledged by the appropriate bibliographical reference.

National Grid References are given in square brackets throughout. All lie within 100-km square SP (or 42) unless otherwise stated.

SYSTEM	GEOLOGICAL UNIT	ESTIMATED THICKNESS (m)
QUATERNARY	Landslip	
	Head	up to c. 2
	Calcareous tufa	up to c. 2
	Alluvium	up to c. 4
	River terrace deposits, undifferentiated	c. 1
	Till	up to c. 7
	Glaciofluvial deposits	up to c. 3
MIDDLE JURASSIC	GREAT OOLITE GROUP:	
	Forest Marble Formation	up to 2
	White Limestone Formation	c. 11
	Rutland Formation	1 to 6
	Taynton Limestone Formation	0 to 6
	Sharp's Hill Formation	0 to 4
	Horsehay Sand Formation	1 to 6
	INFERIOR OOLITE GROUP:	
	Northampton Sand Formation	0 to 6
LOWER JURASSIC	LIAS GROUP:	
	Whitby Mudstone Formation	27 to 44
	Marlstone Rock Formation	1.8 to 4
	Dyrham Formation	8 to c. 20
	Charmouth Mudstone Formation	c. 100 to 135
TRIASSIC	PENARTH GROUP	3 to 10
	MERCIA MUDSTONE GROUP (including Blue Anchor Formation)	7 seen

Table 1 Geological sequence proved within sheets SP 53 NE and NW (Brackley and Charlton area)

(NB Thicknesses of concealed formations (from the Whitby Mudstone Formation downward) are mainly based on interpretations of geophysical logs, and allowances should be made for their inherent inaccuracies)

2 Mercia Mudstone Group

The oldest strata proved in the Brackley and Charlton area are the 6.7 m of reddish-brown micaceous silty mudstone beds proved at the bottom of the Gas Council GCN-98 borehole (Appendix 2; SP 53 NE/1). These represent the topmost part of the Mercia Mudstone Group. Horton et al. (1987, fig. 8) infer the group to thicken northwards from about 50 to 65 m across the area. In addition, Horton et al. (1987, pp. 11-12, fig. 7) infer the presence of at least 20 m and possibly 35 m of Sherwood Sandstone Group strata, represented by pebbly, gritty sandstones with silty mudstone beds, of the Bromsgrove Sandstone Formation underlying the Mercia Mudstone Group.

3 Penarth Group

From borehole data in part derived from the interpretation of geophysical logs (Appendix 2), the Penarth Group is thought to thicken northwards from about 3 to about 10 m across the Brackley and Charlton area. However, the area straddles the zone in which Horton et al. (1987, fig. 11, pp. 19-20) regard the typical Worcester Basin Penarth Group sequence (mudstone-limestone) as passing south-east into an arenaceous facies ('Twyford Beds') developed on the margin of the London Platform. However, Sumbler (2001) considers that this correlation is uncertain and that the Twyford Beds may represent the basal portion of the Lias Group.

Chippings logs for this interval are available for only three boreholes. In SP 53 NE/1, pale grey fine-grained sandstone material was recovered with mudstone, and this is interpreted by Horton et al. (1987) as indicating the zone of passage between the facies. In borehole SP 53 NE/5, only dark grey mudstone (Westbury Formation), pale grey mudstone and off-white limestone (Lilstock Formation) was retrieved at the level of the Penarth Group as interpreted from the geophysical logs. However, fine-grained calcareous sandstone recovered during drilling below may be Twyford Beds material. The off-white fine-grained limestone chippings recovered from the base of borehole SP 53 NE/4 are typical of the upper part of the Penarth Group (Langport Member of the Lilstock Formation), but the beds below were not penetrated.

4 Lias Group

4.1 CHARMOUTH MUDSTONE FORMATION

The Charmouth Mudstone Formation comprises a thick sequence of predominantly grey mudstone, variably calcareous, with thin shell-detrital argillaceous limestone beds and nodule layers. In boreholes in the Brackley and Charlton area, it ranges in thickness from about 110 to 127 m (Appendix 2), although Horton et al. (1987, fig. 15) infer the formation (as the 'Lower Lias') to thicken from as little as 100 m in the south-east to perhaps 135 m in the extreme north-west.

A number of the calcareous beds or groups of beds have been found to be laterally persistent and readily recognisable on borehole geophysical logs, especially natural gamma response logs, and have been termed 'markers', the most important of which are the so-called 70 Marker, 85 Marker and 100 Marker (Horton and Poole, 1977). These markers have been identified in the logs of many of the Gas Council boreholes in the area (Appendix 2), and their levels within the formation indicate that the majority of the south-eastward thinning of the sequence takes place in the lower part (below the 70 Marker), with the effect progressively decreasing upward (Horton et al., 1987, figs 17 and 18).

4.2 DYRHAM FORMATION

Borehole data in the Brackley and Charlton area (Appendix 2) show the Dyrham Formation to range from 8.8 to over 14 m in thickness. However, Horton et al. (1987, fig. 19) infer the formation (as the 'Middle Lias Silts and Clays') to thicken to perhaps 20 m in the extreme north-west. The formation comprises predominantly silty micaceous mudstone and siltstone beds, becoming finely sandy upwards and including thin sandy limestone beds near the top.

4.3 MARLSTONE ROCK FORMATION

From borehole data (Appendix 2) the Marlstone Rock Formation in the Brackley and Charlton area ranges from 1.8 to 3.7 m in thickness without any apparent systematic pattern to the variation. It comprises ferruginous moderately shell-detrital sandy limestones and calcareous sandstones, similar to that in the area to the west (Horton et al., 1987).

4.4 WHITBY MUDSTONE FORMATION

The Whitby Mudstone Formation is the oldest formation at outcrop and is also present at depth throughout the Brackley and Charlton area. It comprises grey, silty, micaceous mudstone, generally poorly fossiliferous, with scattered ferruginous and phosphatic nodules in parts. Cambering of the overlying Inferior Oolite and Great Oolite groups' strata precludes meaningful thickness estimates from the formation's outcrop, and its range of 27 to 44 m is derived from borehole data (see Appendix 2). However, the 21 m of strata proved in SP 53 NE/2 (and the 18 m proved in SP 63 NW/2 to the east) is excessively thin, probably due to cambering (and possibly valley bulging). These figures have led to the misleading isopachytes in this area of Horton et al. (1987, fig. 21). The thin (8.5-m) sequence proved in borehole SP 53 NE/4, which is sited close to the outcrop of the top of the formation, is a result of the borehole passing through a fault plane.

The formation includes at the base a sequence of fossiliferous shale and fine-grained limestone beds (the Fish Beds and Cephalopod Limestones; see Horton et al., 1987, p 42). The gamma log of borehole SP 53 NE/3 suggests they form the basal 3 m of the Whitby Mudstone Formation here, which seems excessive and may be a logging artefact, and they may not exceed 1.5 m. They are proved to a depth of 1 m in two cored boreholes (Appendix 2, SP 53 NE/52 and 58). Limestone chippings recovered from the Whitby Mudstone Formation in several of the Gas Council boreholes are probably from the Cephalopod Limestones.

The formation gives rise to a heavy, grey-brown clay soil, and grey clay was seen dug on the outcrop in many places. The formation is no longer exposed but about 2.4 m of grey fossiliferous clay (mudstone) were formerly seen at Brackley (Turweston) brick-pit (Appendix 1, Locality H; Woodward, 1894), and a similar thickness, with septarian nodules, in a temporary section on the Buckingham Road (Locality S) and in deep bridge foundations [SP 595 380].

5 Inferior Oolite Group

5.1 NORTHAMPTON SAND FORMATION

The Northampton Sand Formation is present in the west and central parts of the Brackley and Charlton area, thinning eastwards from a maximum of about 6 m, to zero just to the west of Brackley. It is locally present east of this limit (see below), and is thought to be locally absent to the west at Hinton-in-the-Hedges [558 367]. It comprises a sequence of sandy ironstones, ferruginous limestones and ferruginous sandstones, which weather to red-brown, and yellow-brown shell-detrital sandy ooidal limestones. Horton et al. (1987, p. 51) claim that a basal phosphatic pebble conglomerate is ubiquitous in the district to the west. Little evidence of this was observed during the survey (but see below) and it is not reported in borehole logs in this area. However, its possible presence has human implications because of its suspected link with the production of naturally occurring radon (see 9.6).

The formation crops out along the middle slopes of the valleys, commonly forming a slight shelf. Its outcrops are extensively affected by cambering (7.2) around Hinton-in-the-Hedges and in Steane Park [55 38], where they are up to 400 m wide. However, west towards Farthinghoe,

although the formation is still some metres thick, the outcrops narrow considerably, possibly as a result of valley bulging. The formation is evidently very thin around Brackley Gorse [565 381], and Bradshaw (1978) surmised its absence.

The formation is currently exposed in one location in the Brackley and Charlton area: 0.4 m of thinly-bedded orange-grey medium- to coarse-grained peloid and ooid limestone is visible in a bank 400 m south-east of Charlton [5324 3587] (BA 108). Large shell fragments are common, and the matrix is highly ferruginous in parts. A few possible pebbles were recorded. A 0.1-m bed of pebbly shelly limestone was formerly exposed at Brackley brick-pit (Appendix 1; Locality H), and considered by Arkell (1933) to represent an attenuated 'Hook Norton Beds' – the lower part of the Chipping Norton Limestone Formation, by comparison with the section in the Fritwell railway cutting [514 286], 12 km to the south-west. However, Horton et al. (1987) and Sumbler (in prep.) regard the 'Hook Norton Beds' of the Fritwell section to be Northampton Sand Formation, non-sequentially overlain (Sumbler, in prep.) by the white sands of the Horsehay Sand Formation, the lateral equivalent of the entire Chipping Norton Limestone Formation. Thus it is more likely that the bed at Turweston represents an attenuated Northampton Sand locally preserved east of its general limit, and it is possible that this bed is more widely present than the formation's extent shown on the maps. It has a fauna here including bivalves and rhynchonellids that is regarded by Bradshaw (1978) as typical of the formation in this area.

On the outcrop the soil is an orange-brown loam with angular fragments of ironstone and shell-detrital limestone; the latter distinguishing it from the soils of the Horsehay Sand Formation. A strong spring line (see 9.3) marks the base and tufa (see 8.5) is commonly deposited below this.

6 Great Oolite Group

6.1 HORSEHAY SAND FORMATION

The strata overlying the Whitby Mudstone Formation, or Northampton Sand Formation where that is present, comprise a sequence of pale-coloured largely uncemented sand, which is present throughout the Brackley and Charlton area. Formerly known as the 'Swerford Beds' (Richardson, 1911) in this area, and correlated both with the 'White Sands' of Northampton, and the Bathonian Chipping Norton Limestone Formation (Arkell, 1933; Arkell et al., 1933), it was later ascribed by Horton (1977) to the Aalenian 'Lower Estuarine Series' (now Grantham Formation). However, Bradshaw (1978) argues that these beds form a transitional semi-marine facies between the fully marine Chipping Norton Limestone Formation and the fluviatile/lacustrine sandy lower part (Stamford Member) of the Rutland Formation (formerly 'Upper Estuarine Series'), both of Bathonian age. This conclusion is supported by Fenton et al. (1994). As the sand beds in this area are of deltaic facies, and what Bradshaw terms the Wellingborough Limestone Member (now Wellingborough Member) of the Rutland Formation is ascribed to the Taynton Limestone Formation in this area, the underlying mudstone-dominated beds and sand beds are differentiated as separate formations: the Sharp's Hill Formation (see 6.2) and Horsehay Sand Formation (new name) respectively.

The Horsehay Sand Formation is thought to range in thickness from 1 to 6 m in the Brackley and Charlton area. However, some measurements are estimates derived from outcrops, which may be affected by cambering and valley bulging (see 7.2). The variation appears to be largely non-systematic. The formation is at its thinnest near Charlton [533 360], and south and east of Brackley where it comprises 0.8 and 0.9 m of sand and sandstone in two sections (Appendix 1; localities H and F, respectively). In a nearby borehole (Appendix 2; SP 53 NE/2), it is 2.7 m thick, and is 1.45 m thick just to the east of the area at the sewage farm (Appendix 1; Locality Y). It attains its maximum thickness north-east of the town (borehole SP 53 NE/3) and in the Hinton-in-the-Hedges area (borehole SP 53 NE/5).

The formation comprises medium- to fine-grained quartzose sand, silty in parts, and locally cemented into calcareous or weakly ferruginous sandstone. Generally pale grey and brown to off-white, it may also be stronger in colour, including purplish and black. Where better exposed outside the area (e.g. as the 'Lower Estuarine Series' of Horton et al., 1987), ferruginous layers and nodules, and dark grey mudstone and silt/siltstone beds are reported in places, rootlets and lignitic debris are common, and shells and shell debris very rare. It is unbedded to weakly bedded and cross-bedded.

The Horsehay Sand forms broad outcrops, particularly around Hinton-in-the-Hedges and Steane. A greyish brown loamy soil is developed, with sandstone fragments and common ironstone chips. Where the Northampton Sand is absent, a strong spring line may emerge at the base (see 9.3).

6.2 SHARP'S HILL FORMATION

The Sharp's Hill Formation comprises up to 4 m of shelly mudstone, siltstone, marl and limestone strata. It is thickest in the south-west around Charlton, and is 3.6 m thick in the borehole at Hinton-in-the-Hedges Aerodrome (Appendix 2; SP 53 NW/4).

The formation is generally present in the western half of the area and apparently absent in the east. However, it is also locally absent around Steane and Farthinghoe, and was mapped locally to the west and east of Brackley town, and around Evenley Hall in the south-east. All five of the former exposures that show the formation (Appendix 1; localities E, F, G, H and Y) lie away from the mapped outcrops. However, at all but one, the beds seen total less than 1 m, and it is likely that here, and elsewhere, the formation's narrow outcrop may be obscured or difficult to detect, and it is generally present more widely than shown.

Greenish grey mudstone and marl beds dominate the formation, and the rest of the sequence is highly variable, including siltstones and limestones (Horton et al., 1987, pp. 74-77). The fauna is abundant, locally dominated by oysters, including *Praeexogyra*.

The argillaceous nature of the formation is reflected in its clayey soil, with abundant fragments and whole shells of small oysters.

6.3 TAYNTON LIMESTONE FORMATION

Throughout the Brackley and Charlton area, a sequence of pale coloured, coarse-grained shell-detrital and ooidal limestone lies within the predominantly argillaceous sequence beneath the White Limestone Formation. This is sufficiently similar to the Taynton Limestone of the Cotswolds (Sumbler et al., 2000) to be assigned to this formation. This area lies close to the north-east limit of the formation (on BGS 1:63 360-scale sheet 202; unpublished BGS data), where it passes by lithological passage (increasingly micritic matrix, loss of ooids) into the Wellingborough Member (Rutland Formation). At Croughton eastern quarry (Appendix 1; Locality V) to the south of the area, the formation was partially exposed at the base of the section, and is described in its unweathered state as grey shelly ooidal micrite with marl beds. Unweathered ooids are very dark to black, but when weathered they assume a distinct pinkish orange colour in a pale buff matrix. Locally within the Brackley and Charlton area, the sequence includes beds of fine-grained limestone and marl (Appendix 1; Locality E), similar to those of the latter unit, and also seen at the Brackley Sewage Farm section to the east (Appendix 1; Locality X). These lithologies presage this transition.

The formation is up to about 6 m thick in this area, as proved in two boreholes (Appendix 2; SP 53 NE/5 and 7). However, through most of the area it is less, and it is very locally absent between the Sharp's Hill and Rutland formations west of Hinton-in-the-Hedges [5547 3670]. Currently (1998) it is exposed in only one place; about 0.3 m of thin-bedded, pale grey, coarse-grained shell-detrital ooidal grainstone is visible in a disused quarry [5352 3627] near Charlton.

The outcrop is pock-marked with similar shallow pits (see 9.1), and Bradshaw (1978) reported numerous small exposures of up to 0.7 m of similar stone (terming them Wellingborough Limestone Member) between Charlton and Farthinghoe, and a 2 m temporary section in Farthinghoe [5380 3982]. The formation was temporarily exposed along the Brackley bypass (Appendix 1; localities E, F and J), where at the first it is almost 2 m thick. It was formerly partially exposed in the bottom of Turweston railway cutting (Appendix 1; Locality P)

The Taynton Limestone Formation of this area is highly fossiliferous, with numerous bivalves, and in some beds common large rhynchonellid brachiopods and *Clypeus muelleri*.

Many of the outcrops form broad shelves or flat-topped spurs with generally very stony soil, containing slabs of limestone and common fossils.

6.4 RUTLAND FORMATION

The Rutland Formation (formerly Upper Estuarine Series) of the Brackley and Charlton area is equivalent to the upper part (above the Wellingborough Member) of the formation of the type area (Northamptonshire–Rutland–Lincolnshire); the beds below being differentiated as separate formations. Here, the formation comprises grey, brown, orange and greenish beds of mudstone with subordinate marl, marly limestone, fine-grained limestone and sand, all shelly to some degree. In the Milton Keynes area 25 km to the east, Horton, Shephard-Thorn and Thurrell (1974 pp. 16-17) record seatearth lithologies (mudstone with listric surfaces and rootlets) and semi-marine, brackish and freshwater bivalves, reflecting its near-shore, shallow water aspect there. Although rootlets were observed in some beds at Croughton eastern quarry (Appendix 1; Locality V), and further west (Horton et al., 1987, p. 82), rhynchonellid and terebratulid brachiopods and limestone beds with marine bivalves were observed in the Brackley and Charlton area (localities B, N and P), and at Croughton, reflecting the westward facies passage into its fully marine correlative, the Hampen Formation of the Cotswolds. A bed rich in *Modiolus* sp shells was excavated from the base of the Turweston cutting, near Locality P.

In this area, the Rutland Formation ranges between 1 and 6 m thick, averaging 2 to 5 m, with no systematic variation. It is thickest around Brackley town (Appendix 2; SP 53 NE/7) and between Charlton and Hinton-in-the-Hedges, and thinnest around Steane [55 39 area]. It is not currently exposed, but was well seen in temporary exposures for the Brackley bypass and A43 (Appendix 1; localities A, B, C, J, K, N and W). In addition, it was formerly fully exposed, albeit too weathered to determine original lithology, in Turweston railway cutting (Locality P), where it is 3.15 m thick, and to the south of the area, in Croughton eastern quarry (Appendix 1; Locality V), where it is 3.64 m.

The formation's outcrop forms a slight slack below the lip of the White Limestone Formation plateau. It develops a heavy grey-brown clay soil with fresher greenish clay and marl commonly ploughed up, as well as numerous bivalve shells, particularly at the top and base. In this respect, the formation resembles the Sharp's Hill Formation.

6.5 WHITE LIMESTONE FORMATION

The White Limestone Formation is present throughout the Brackley and Charlton area. It has been deemed to pass northwards by gradual lithological change into the Blisworth Limestone and part of the Blisworth Clay [formations] (Horton et al., 1974) (Sumbler, 1996 p. 40), in a zone lying hereabouts. For cartographic convenience, this change is taken at the ^{2}40-grid line for 1:10 000-scale maps, and at the northern edge of the Buckingham sheet (about ^{2}387) on the 1:50 000-scale series.

The formation forms broad, near flat, plateau-like outcrops on the higher ground, which are covered by extensive till deposits to the north of Brackley. Where complete, it is 11 to over 12 m thick. Elsewhere, underlying the plateaux, it is generally 6 to 10 m thick, as proved in boreholes

(Appendix 2; SP 53 NE/5 and 7). There are no longer any sections in the Brackley and Charlton area, but it was formerly well exposed in Turweston railway cutting and during the construction of the Brackley bypasses (Appendix 1). The higher part of the formation is currently (2001) moderately exposed to the south at Croughton Quarry and lower parts in excavations for the A43 improvements south of Barley Mow roundabout (Appendix 1; localities T, Z and A1).

The White Limestone comprises a sequence of off-white to pale grey and brown, fine- to coarse-grained peloidal limestones, predominantly with fine-grained (micritic) matrices (packstones–wackestones), and with varying amounts of ooids, shells and shell debris. Higher energy grainstone types are rare. Interbedded with the medium- to thick-bedded limestones, and into which they grade in places, are thinner beds of darker-coloured, shelly, shell-detrital, peloidal, silty marl. The fauna is diverse, and dominated by bivalves, gastropods and brachiopods, with echinoids and corals.

The formation is subdivided in the Oxfordshire area into three members; in ascending order the Shipton, Ardley and Bladon members (Sumbler, 1984). These were recorded in sections at Croughton Quarry (Appendix 1; localities T, U and V), which have been broadly correlated with a number of temporary or lost sections (localities L, M, N and P) in the Brackley and Charlton area. This has been achieved by the tentative identification of individual beds, either of a distinct lithology (e.g. a marl, or porcellanous limestone) or fossil bearing, or both. Such include the Fimbriata-Waltoni Bed (a greenish mudstone bed with bivalves and lignite) at the base of the Bladon Member, or the 'Roach Bed' (a brown sandy shelly limestone with lignite; Sumbler, 1984) near the base of the Ardley Member. The presence of aphanoptyxid gastropods, some identified to species level, has enabled recognition of the Excavata and Bladonensis beds (Sumbler, 1984), and tentative subdivision into members at the above localities, and some others by inference (localities A, C, D, J and K). Bed-by-bed correlation has proved unviable over the wider area, though possible very locally between localities L and M (less than 300 m), where an orange-coloured very shelly marly limestone bed is seen at both, and may persist over a wider area.

[MJO writes:] In general terms, the Ardley Member is characterised by abundant peloidal/ooidal packstones, wackestones or grainstones, with well-developed aphanoptyxid-carrying beds and recrystallised coral moulds. Peloids become absent within a metre of the top of the Shipton Member, which is dominated by silty micrite. A useful marker across the area is a bed of glauconitic calcareous clay in which echinoid radioles abound, and fish and crocodile teeth and large lignite fragments are common. The bed overlies the horizon with numerous dinosaur tracks, seen at Ardley Fields Quarry [SP 545 260], 12 km south-south-west of Brackley.

From the above, full thicknesses of 4.5 and 2.3 m can be inferred for the Shipton and Bladon members respectively, and a thickness range of 5.7 to perhaps 6.8 m for the Ardley Member. In addition, the Shipton and Ardley members are tentatively distinguished in a borehole (Appendix 2; SP 53 NE/5), making the former 4.9 m thick. However, although argillaceous beds are more common in the Shipton than the Ardley Member, their limestones are too similar in lithology and material from the marker beds is too rare to enable them to be distinguished on the maps. The Bladon Member is distinguished in places on maps to the south, in part by observation of the clayey soil on the Fimbriata-Waltoni Bed, but not in the Brackley and Charlton area, due to lack of such field evidence.

In the extreme east, the formation's lower beds contain rhynchonellid brachiopods, probably *Kallirhynchia*, in two locations (Appendix 1; localities N and P), which characterise the Roade Member (new name; formerly [Kallirhynchia] Sharpi Beds) of the area to the north. This presages the passage of the Shipton Member into the Roade Member, whose presence is the criterion defining the Blisworth Limestone Formation in the district to the north.

Rubbly limestone brash, commonly with bivalve and brachiopod shells, is abundant in the soil on the outcrops. There are a number of shallow disused pits across the outcrop (see 9.1). The formation gives rise to a strong spring line at its base (see 9.3).

6.6 FOREST MARBLE FORMATION

The Forest Marble Formation is the youngest solid unit present in the Brackley and Charlton area. It is represented by a small faulted outcrop in the extreme east, south of Turweston [599 370]. Here it comprises up to 2 m of greenish grey mudstone, weathering to grey-brown, with calcareous nodules (‘race’). The formation is better seen in the areas to the south and east (see Sumbler, in preparation). It was formerly fully exposed in Croughton southern quarry (Appendix 1; Locality U), where it comprises between 5.6 and 6.6 m of greenish-grey marl and mudstone and shelly, fine-grained limestone in lenticular beds. Here it is overlain by 1.0 m of shell-detrital limestone of the Cornbrash Formation, which forms several outcrops within the zone of down-faulted strata in the Croughton area.

7 Structure

Regionally, the Jurassic strata in the south-east Midlands dip very gently (0.3º) to the south-east (Horton et al., 1987, fig. 6) and this is the case in the Brackley and Charlton area, indeed the dip is even less through much of it. Locally, dips steeper and in other directions than this may be deduced from outcrop patterns. Some of these relate to non-diastrophic, superficial structures (cambering, see 7.2), but some dips in fault-bounded blocks may relate to fault movements. For instance a dip of about 20º to NNW was observed in a temporary section on the Brackley bypass (Appendix 1; Locality M).

7.1 FAULTING

A number of faults were identified in temporary sections, deduced from levels in boreholes, or were detected during the survey. No faults are currently exposed, although they can be pinpointed in many places by sharp changes in the brash in fields, and are depicted in places by unbroken lines (“observed” lines) on the maps.

The majority follow a consistent east-west trend (with minor cross faults) continuing from that seen in the Chipping Norton district (sheet 218) to the west. All are thought to be normal faults, and most have a displacement of less than 10 m. However, a throw of perhaps 23 m locally can be deduced from borehole data (Appendix 2; SP 53 NE/4), although the Whitby Mudstone hereabouts may be affected by valley bulging. The pattern of box-faulting on the south side of Brackley [58 36] is strikingly similar to that deduced during the 1863 1” scale survey.

There appears to be little or no relation between faulting and topography.

7.2 SUPERFICIAL STRUCTURES

The strata at outcrop in the Brackley and Charlton area are locally affected by superficial structures. These include valley bulging and cambering, which affect the strata along valley bottoms and sides respectively. Notes on the maps highlight some of the locations of cambered strata, but the affected areas are likely to be more extensive than shown.

Most of the outcrops of the Whitby Mudstone Formation along the valleys of the Great Ouse and its tributaries may be valley bulged. This is indicated by the relatively elevated levels of the base, or basal strata, of the formation in boreholes (Appendix 2; SP 53 NE/4, 52, 58). West of Steane, bulging in minor valleys [544 390 to 550 393; 551 390 area] has resulted in narrowing of the outcrops (and apparent thinning) of the overlying strata.

Elsewhere, many of the adjoining slopes of Northampton Sand Formation and Great Oolite Group strata (‘cap-rock’) are cambered, and lowered below their original level. As a result, these strata may be disrupted and comprise blocks separated by minor faults (‘dip and fault

structures'). These are generally parallel to the valley axis and penetrate to the base of the cap-rock sequence but not normally far beyond (Horswill and Horton, 1976, p. 434, fig. 6). However, the displacements on the faults are usually quite small (1 to 3 m) (Horswill and Horton, 1976, fig. 6), such that they may be undetectable solely from outcrop patterns (boundary offsets). Also, the faults may be closely spaced (up to 15 metres; i.e. too close to portray at 1:10 000-scale). No clear evidence of the presence of dip-and-fault structure was observed during the survey.

Around Brackley Gorse, later erosion has left detached cambers in three places [565 381; 560 382; 568 376].

8 Quaternary

8.1 GLACIOFLUVIAL DEPOSITS

Lenses of sand and gravel up to 3 m thick underlie the till north of Brackley [591 391 area]. These are interpreted as glacial outwash, and boulders are noted in one place [5928 3906]. They do not appear to have been worked for mineral. Away from these outcrops, pebbles of quartz and quartzite ('Bunters') are commonly seen scattered on the outcrops of the solid formations. These may indicate that these (or other) sand and gravel deposits were formerly more extensive.

8.2 TILL

A broad, gently rounded plateau of till (boulder clay) overlies the White Limestone Formation north of Brackley. In addition, there are two smaller till deposits: south of Turweston [600 370] and near Evenley Hall [591 357]. They comprise grey-brown stony sandy clay (diamicton) with clasts of local limestone, flints, Bunter pebbles and pellets of chalk. The latter degrade near the surface, but the other stones are numerous in the heavy brown clayey soil.

No boreholes penetrate the till deposits, and its maximum thickness of 7 m is an estimate based on contours for the areas around The Worlidge [578 395] and Fox Covert [595 396].

8.3 RIVER TERRACE DEPOSITS, UNDIFFERENTIATED

A deposit of orange-brown clayey gravelly medium sand borders the Great Ouse floodplain in the extreme south-east [598 357]. Its surface lies 1-2 m above the alluvium, and it is estimated to be around 1 m thick. The gravel fraction comprises flints and Bunter pebbles.

8.4 ALLUVIUM

Alluvial deposits comprising brown silty clay and silt, passing down into sand, and commonly underlain by sandy gravel, underlie the floodplains of the Great Ouse, its tributaries and the stream through Charlton (a tributary of the Cherwell). Boreholes west, south and east of Brackley (Appendix 2; SP 53 NE/1, 52, 58 and 157) and a temporary section (Appendix 1; Locality S) show these to average 1.5 to 3 m in total thickness, in places attaining almost 4 m, with the gravel beds reaching 1m. Organic-rich layers are noted in some boreholes, which may be compressible. Large wood pieces and a bone, identified by A Currant (Natural History Museum) as pig of Iron Age aspect, were collected from the gravel in the excavation. The deposits in the minor tributaries are unlikely to exceed 2 m in thickness.

8.5 CALCAREOUS TUFA

Deposits of very pale brown calcareous silt or silty clay were recorded in two places near springs: at Ash Spinney [564 388] and south-east of Hinton-in-the-Hedges [564 364]. These are interpreted as tufa deposits, chemically precipitated from calcium carbonate-saturated water issuing from the limestone formations. The deposits are probably less than 2 m thick and are typically very soft and unstable if loaded. Tufa was seen in soil elsewhere close to the base of the Northampton Sand Formation.

8.6 HEAD

Deposits of stony silty clay and gravel lying in hollows west of Brackley Grange [570 388 area], near Turweston [597 372] and near Turweston Field Farm [600 360] are thought to be colluvium or hillwash (head).

8.7 LANDSLIP

A small landslip was identified affecting a slope of Whitby Mudstone Formation at Black Jack Spinney [5735 3625]. It encroaches onto the alluvium, and the sharp break along its upper side also suggests that it may be recent. However, it may have been modified by man. No other slips were delineated during the survey, but possible degraded landslips were observed north-west of Hinton-in-the-Hedges [554 378]. Other slopes underlain by clay formations, especially the Whitby Mudstone Formation, may include older slipped material, which has become unidentifiable through natural processes or man's actions.

9 Economic geology

9.1 CONSTRUCTION STONE

Degraded small quarries on the outcrops of the Taynton Limestone, White Limestone and Northampton Sand formations testify to their former usage for local construction and road-making purposes. The Taynton Limestone was used for building as well as walling stone. However, it is of insufficient thickness and quality to be of any current economic interest.

9.2 CLAY

A backfilled pit at Burwell Farm [5935 3795] is the site of Brackley (Turweston) brickpit (Appendix 1; Locality H), formerly working the Whitby Mudstone for brick clay.

9.3 WATER SUPPLY

The Brackley and Charlton area forms part of the recharge area for the White Limestone Formation, which is an important regional aquifer. Groundwater in this area, although naturally of high quality, is highly vulnerable to contamination from both diffuse and point source pollutants from discharges into or onto the ground. The Environment Agency has responsibility for, amongst other matters, the protection of groundwater and has produced a series of 1:100 000-scale Groundwater Vulnerability maps, which form a component of the Agency's Policy and Practice for the Protection of Groundwater. The Brackley and Charlton area is covered by sheet 31 of the series (National Rivers Authority, 1995).

In the past, the settlements and farms of the Brackley and Charlton area would have been supplied by springs and wells as detailed for each parish by Tiddeman (1910) and Woodward

(1909). The wells would have drawn from the various permeable Great Oolite formations and, where present, the Northampton Sand Formation. Most properties may now be on mains water, although some local sources may be maintained for emergencies or non-domestic purposes.

During the survey (1998-99), a number of springs were observed in the area, feeding small covered reservoirs, catch wells, ponds, and streams and eventually the rivers. Those not depicted by Ordnance Survey on the 1982 (SP 53 NW) and 1997 (SP 53 NE) 1:10 000-scale topographic maps have been added to the geological map (symbolised Spr). A number of these, some of them strong, emerge at or near the bases of the Northampton Sand, Horsehay Sand, Taynton Limestone and White Limestone formations, where they overlie impermeable strata. The water from the limestone formations is likely to be highly calcareous, reflecting their moderate solubility, and resulting in the deposition of tufa (see 8.5).

9.4 MADE GROUND AND WORKED GROUND

As stated above (9.1; 9.2), there are many small disused pits in the outcrops of the limestone formations, and a few in the Northampton Sand and Whitby Mudstone formations. Some are shown as part of the Ordnance Survey topography, but many were identified during the survey. Most are depicted by the Infilled Ground ornament, indicating that they are regarded as partially or wholly backfilled, the smallest are shown with the small pit symbol. A borrow pit [578 365] was opened to the south-west of Brackley for fill for the western bypass embankments in 1991. Its exact extent is unknown, and the area shown as Infilled Ground is that of disturbed ground evident from aerial photographs.

Cuttings and embankments associated with the Brackley bypasses, road improvements and railways are shown as Worked Ground and Made Ground respectively, except where cuttings have been backfilled, as at Turweston [599 366] and north of Brackley [590 383]. As a former military airfield, Hinton-in-the-Hedges aerodrome has many associated earthworks, including much buried masonry (e.g. air-raid shelters), in its vicinity. Most are too small to depict at 1:10 000-scale, although a gun emplacement is shown as Made Ground [5505 3705].

Three areas of landscaped ground are shown: an area of sports grounds in Brackley [587 369], a park around St James' Lake [580 367] and an industrial estate at Reynard Park [586 363].

9.5 ENGINEERING HAZARDS

The principal engineering hazards which might occur in this area are unstable natural or artificial slopes, swelling and shrinkage of clays, voids in limestone strata, compressible layers in alluvial deposits and problems with backfilled pits or cuttings.

Slopes in clay formations (e.g. Whitby Mudstone, Sharp's Hill, Rutland and Forest Marble formations) are potentially unstable and, where an identifiable landslip has occurred in the past, it is depicted on the map. However, older landslips obscured by later processes (including man's activities) may not have been recognised (see 8.7). Changes to the conditions, such as excavations, loading, steepening and altering drainage, may increase the propensity of a slope to fail.

Clay or clay-rich formations or deposits (Whitby Mudstone, Sharp's Hill, Rutland and Forest Marble formations, till) are also subject to swelling and shrinkage, depending on moisture content, which can be affected not only by drainage but also by vegetation, notably trees. This can pose foundation stability problems.

River alluvium commonly includes organic (peat) layers, which may compress under additional loading (e.g. artificial structures).

Limestone formations are prone to potential engineering problems where they have undergone cambering (see 7.2) or dissolution (see 9.3). Here, voids may have formed which are partially or

wholly filled with rubble or loose rock, and subsequently covered by soil. They may become obscured over time and later reappear e.g. because of loading or extreme weather (drought or rain).

9.6 OTHER CONSIDERATIONS

The radioactive decay of uranium in the phosphatic pebble layer at the base of the Northampton Sand Formation may be largely responsible for the raised levels of naturally occurring radon that has been detected in soils and houses in large parts of Northamptonshire (Sharman, 1991) (Sutherland, 1992). However, Appleton and Ball (1995) suggested that radium present in a disseminated form through the mass of the Northampton Sand may emit more radon than the thin, uranium-enriched phosphatic pebble layer at the base of the Northampton Sand. Sharman (1991), Sutherland (1992) and Appleton and Ball (1995) claimed that the overlying predominantly sand unit (which they term the Lower Estuarine Series or Grantham Formation) is also a major source of radon, which in their study areas is universally underlain by the Northampton Sand. As it is highly permeable and not known to be phosphatic (and hence significantly radioactive) (Horton, Shephard-Thorn and Thurrell, 1974; Horton, Poole et al., 1987), it may be that here it is simply allowing easy passage of radon from the strata below.

In the Brackley and Charlton area, the Northampton Sand is probably generally absent in the eastern part (but see 5.1). The subsequent sand-dominated unit (the Horsehay Sand Formation, see 6.1) is present throughout. Following from the above, it is likely that elevated radon levels may be present on the outcrops of the Northampton Sand, and those of the Horsehay Sand only where it overlies the former formation. Elsewhere, lower levels are likely to pertain.

The radon potential of the strata at this level varies from relatively low to moderate in the region between Banbury and Kettering (BGS, unpublished data). The reasons for this lateral variation are being evaluated as part of the BGS Environmental Radioactivity and Radon Geohazards projects.

10 Information sources

Listed below are the principal items of unpublished data that were utilised during the survey and preparation of Sheet SP 53 NE and part of SP 53 NW and this report. Almost all this data is held in BGS archives and is available for consultation. In addition, published large-scale maps (1:10 560 and 1:10 000 scale) and commercially available air photographs are listed. Other published data is referred to in the text and listed in References.

10.1 BOREHOLES

At the time of publication, BGS held records of 170 boreholes sited within Sheet SP 53 NE and the part of SP 53 NW reported on, the full logs are held in the National Geological Records Centre at BGS Keyworth. Summary logs of those referred to in the text appear in Appendix 2. Each borehole record held by BGS is given a unique registration number, in which the borehole logs for each 1:10 000 sheet are numbered consecutively in order of acquisition; thus the full designation is in the form SP 53 NE/1.

10.2 MAPS

The following large-scale geological maps cover all of Sheet SP 53 NE and the revised part of SP 53 NW; these unpublished maps are held in the National Geological Records Centre at BGS Keyworth; they form the basis of the small-scale published 1:63 360 and 1:50 000-scale editions

of sheets 201 (Banbury), 202 (Towcester) and 218 (Chipping Norton). Both the manuscript (MS) field maps (with surveyor and date of survey) and the derivative fair-drawn 'standards' (with date of official release) are listed. Some of these maps carry brief notes giving details of exposures etc. Those of the most recent survey effectively supersede the earlier maps and form the basis of the 1:50 000-scale sheet 219 (Buckingham) that is in preparation.

County Series maps (all 1:10 560 scale)

County	Number	Surveyor	Date	Notes
Northants	58SE/E	T H Whitehead	1941	MS field map (partial survey)
Northants	58SE/E	V Wilson	1959	MS field map (full survey)
Northants	59SW	H B Woodward	1896	MS field map (partial survey)
Northants	62NE/E	T H Whitehead, revised V Wilson	1941, rev. 1959	MS field map (partial/full survey)
Northants	63NW/E	H B Woodward	1896	MS field map (partial survey)
Oxon.	11NE/W	H B Woodward	1896	MS field map (partial survey)

National Grid maps

Number	Surveyor	Scale	Date	Notes
SP 53 NW	V Wilson	1:10 560	1959	MS standard (full).
SP 53 NW	A Horton	1:10 560	1963	MS field map (partial survey). Reg. No. 19186-19187
SP 53 NW	A Horton	1:10 560	1965	MS standard (partial).
SP 53 NW	A J M Barron	1:10 000	1997	MS field map (partial survey). Reg. No. 39441-39444
SP 53 NW	A J M Barron	1:10 000	2000	MS standard (partial).
SP 53 NE	A Horton	1:10 560	1963	MS field map (partial survey). Reg. No. 19190-19191
SP 53 NE	A Horton	1:10 560	1965	MS standard (partial).
SP 53 NE	A J M Barron/ P M Hopson	1:10 000	1991/ 1998	MS field map (partial survey). Reg. No. 22609-22612
SP 53 NE	A J M Barron	1:10 000	1999	MS standard (full).

10.3 AIR PHOTOGRAPHS

	Source	Scale	Date
Film 01 93. Frames 153-158	NRSC	1:25 000	1993

10.4 OTHER DOCUMENTS

BGS Field Notebook record sheets are indexed using a unique two-letter Geologist Code followed by a sequential number:

A J M Barron (Geologist Code BA) (1998-2001): Locations BA 108, 111, 124-127.

A Horton's field notes for Croughton southern quarry (1976) and temporary excavations on the Brackley eastern bypass (1986) (NGRC files).

M J Oates's graphic sections of temporary excavations (1986, 1989, 1992, 2001).

H P Powell's graphic section of a temporary excavation (1991).

Appendix 1 Localities

Paraphrased and classified by A J M Barron. All lie within sheet SP 53 NE (Brackley) unless otherwise stated.

A [5811 3547] Temporary section, Brackley bypass (A Horton, October 1986)

Dip up to 4º to south

White Limestone Formation, Shipton Member (0.8)	Thickness m
LIMESTONE, pale cream, micritic, shelly, rubbly	0.8
Rutland Formation (1.6-1.9)	
MARL, with sandy limestone bed at base	0.6
MUDSTONE, brown, mottled grey with oysters	0.2
SILT, ochreous brown, squeezed	0.3-0.6
MUDSTONE, greenish-grey, with black layer, squeezed, paler below 0.34	0.5

B [5811 3550-5814 3555] Temporary section, Brackley bypass (A Horton, October 1986)

Rutland Formation (5.0-5.25)	Thickness m
MARL, pale greenish-grey, very silty	1.5 seen
MARL, pale grey, silty, packed with oysters	0.4
MUDSTONE, brownish grey, mottled greenish, interbedded with thin limestone lenticles, many oysters	0.6
MUDSTONE, very dark greenish-grey, waxy, with a few shells	up to 0.25
MUDSTONE, pale greenish-grey, calcareous, oysters near base	0.2
MARL, pale fawn, interbedded more and less calcareous, scattered ooids, bivalves, rhynchonellids and shell debris	0.75
LIMESTONE, fawn, shelly, shell debris	0.45
MARL, dark brown, silty, rubbly	0.2
MUDSTONE, greenish-grey, silty, weathering brown	0.25
MUDSTONE, greenish, silty, with much shell debris, weathering brown	0.35
MARL, ochreous, silty, weathering greenish to pale brown and soft	0.3 seen

C [5823 3576] Temporary section, Brackley bypass (A Horton, October 1986)

White Limestone Formation, Shipton Member (0.15)	Thickness m
LIMESTONE, micritic, massive	0.15 seen
Rutland Formation (0.7+)	
CLAY, greenish-grey	0.7
MUDSTONE, bluish-grey, silty, on dark grey carbonaceous mudstone	seen

D [5841 3617] Temporary section, Brackley bypass (A Horton, October 1986)

White Limestone Formation, ?Shipton Member (1.95)	Thickness m
LIMESTONE, off white, porcellanous, with gastropods	0.45
LIMESTONE, pale grey brown, peloidal micrite, shelly, hard, rubbly	0.55
MARL, olive-green, with shell debris/pellets	0.25
LIMESTONE, pale olive-grey, peloidal micrite	0.7 seen

E [5845 3632] Temporary section, Brackley bypass (A Horton, October 1986)

?Rutland Formation (0.3)	Thickness m
CLAY, grey	0.3
Taynton Limestone Formation (1.95)	
MARL, with thin limestone beds	0.6
LIMESTONE, off white to pale brown, micritic, with shell debris	c. 0.3
MARL, clayey in parts, oyster-rich	0.3
LIMESTONE, shelly, shell debris grainstone, flaggy	c. 0.2
Sharp's Hill Formation? (0.6)	
MARL, oyster-rich	0.6
Horsehay Sand Formation (0.3)	
SAND, grey, silty, clayey	0.3 seen

F [5896 3622] Temporary section in pit, Brackley bypass (A Horton, October 1986)

Taynton Limestone Formation (0.65)	Thickness m
LIMESTONE, pale grey-brown, ooidal grainstone, with shell debris, hard	0.5
MARL to marly limestone, brown, weathered to marly silt	0.15
Sharp's Hill Formation? (c. 0.1)	
MUDSTONE, grey, greenish and ochreous mottled	c. 0.1
Horsehay Sand Formation (0.9)	
SAND, purplish grey, silty with rootlets; passing into:	0.25
SAND, ochreous brown, fine-grained with harder pockets	0.65
Whitby Mudstone Formation (0.3)	
MUDSTONE, grey	0.3 seen

G [5896 3622] Temporary section, Brackley bypass (A Horton, October 1986)

Sharp's Hill Formation? (0.3)	Thickness m
CLAY, purplish, silty	0.3
Horsehay Sand Formation (0.8)	
SAND, grey	0.8

H [5935 3795] Brackley (Turweston) brick-pit

Paraphrased and metricated from Woodward (1894) and Richardson (1923, pp. 110-111).

Sharp's Hill Formation? (0.6)	Thickness m
MARL, brown, abundant *Praeexogyra hebridica* and rhynchonellids	0.6
Horsehay Sand Formation (0.8)	
SAND, black, argillaceous	2.4
SANDSTONE, brown, ferruginous	0.6
SAND, white and black	0.35
Northampton Sand Formation (0.1)	
LIMESTONE, ooidal, with numerous bored Lias limestone pebbles and common bivalves and rhynchonellids	0.1
Whitby Mudstone Formation (2.4)	
CLAY, grey, with ammonites	2.4

J [5932 3852] Temporary section, Brackley bypass (A Horton, October 1986)

White Limestone Formation, Shipton Member (2.5)	Thickness m
LIMESTONE, pale grey-brown, silty, shell-debris-rich, micritic, hard with softer marly beds	2 seen
MARL, brown, ooidal, with clay partings	0.5
Rutland Formation (2.5)	
CLAY, brown to greenish-grey, paler, siltier and more calcareous down	0.7
OBSCURED	c. 0.6
MARL, pale green, silty, scattered bivalves	1.0
MUDSTONE, dark grey	0.2
Taynton Limestone Formation (1.3)	
LIMESTONE	1.3 seen

K [5961 3882-5965 3892] Composite temporary section, Brackley bypass (A Horton, October 1986)

White Limestone Formation, ?Shipton Member (4.0)	Thickness m
MARL	seen
LIMESTONE, pale grey-brown, silty, shell-detrital, micritic, hard, massive	0.79
MARL, very pale greenish grey, silty, shell debris, with two clayey seams	1.12
LIMESTONE, pale olive shell debris micrite with many burrowing bivalves, brown weathering	0.35
MARL, pale greenish grey-brown, silty	0.3
LIMESTONE, off white, fine-grained micritic/microspar	0.07-0.1
MARL/LIMESTONE, olive grey-brown, fine-grained peloidal shell debris micrite, scattered bivalves	0.8
LIMESTONE, pale grey-brown, peloidal, micritic, scattered shell debris including gastropods	0.45
MARL/LIMESTONE, pale grey-brown, shell debris micrite, rubbly	0.1
Rutland Formation (1.95+)	
MARL, ochreous brown, silty, laminated, decalcified, muddy wisps and pockets; more clayey down, passes into greenish grey mudstone, waxy with pale silt laminae and rare shells; darker grey downwards, much shell debris at base; non-sequence?	0.4
MUDSTONE, greenish grey to dark grey, silty or waxy in parts, black rootlet traces	0.31
SILTSTONE, pale greenish grey; clayey at top, calcareous below	0.9
MARL, pale grey, very silty, shelly with bivalves including oysters	seen
SILT, pale brown, decalcified, clayey	0.35

L [583 358] Temporary section along road cutting, Brackley bypass (M J Oates, 20/7/86)

White Limestone Formation, Ardley Member (1.75)	*Thickness m*
LIMESTONE, pale grey-brown, micritic, some shell-debris; passes up into soil	1.0
LIMESTONE, marly, yellow-grey, soft	0.15
LIMESTONE, pale grey-brown, micritic	0.2
LIMESTONE, marly, yellow-grey, slightly silty, a few bivalves; passing into green-grey plastic shell-detrital CLAY at base	0.4

White Limestone Formation, Shipton Member (3.2)	Thickness m
LIMESTONE, pale grey-brown, micritic, possible intraclasts (Excavata Bed?)	0.5
LIMESTONE, marly, orange, limonitic, rubbly, abundant bivalves, rhynchonellids; passes down into MARL	0.4
LIMESTONE, pale grey-brown, very fine-grained, micritic, abundant burrowing bivalves; softer towards base	0.5
LIMESTONE, cream to pale grey-brown, hard, micritic	0.2
MARL, grey	0.2
LIMESTONE, pale grey-brown, micritic, intraclasts, massive, stylolites	0.3
LIMESTONE, pale grey-brown to mid grey, micritic, limonitic; passing marly down	0.2
MARL, orange-grey, silty, with lignitic debris and bivalves	0.2
LIMESTONE, dark yellow-grey, micritic, silty, with lignite and bivalves including *Modiolus*; passing into soft dark grey and orange marl/silty clay	0.7
Section terminated by fault at north end.	

M [5835 3607] Temporary section, Brackley bypass (M J Oates, 20 July 1986)

White Limestone Formation, Bladon Member (1.72)	Thickness m
LIMESTONE, orange-dark grey brown, very silty, scattered small shell fragments, otherwise unfossiliferous; crumbly to rubbly	0.43
OBSCURED	0.43
LIMESTONE, grey brown, micritic, unfossiliferous; darker and marly towards top	0.43
SILTSTONE, orange-brown-greenish, soft (Fimbriata-Waltoni Bed?)	0.43
White Limestone Formation, Ardley Member (6.12)	
LIMESTONE, pale grey-brown to grey, biomicritic, abundant sparry shells including small gastropods, very hard, moderately massive (Bladonensis Bed?)	0.1
MARL, orange-brown, streaky, a few layers of *Liostrea*	0.5
LIMESTONE, cream, micritic, silty, hard, bivalve infauna	0.17
LIMESTONE, orange, micritic, very silty, crumbly, rubbly	0.17
LIMESTONE, cream, micritic, slightly silty, sparry shells, large gastropod	0.3
SILTSTONE, orange-brown-greenish, soft	0.05
LIMESTONE, grey-brown, limonitic, abundant infaunal bivalves, *Aphanoptyxis*, *Clypeus* fragment	0.1
MARL, orange-brown, argillaceous, scattered *Liostrea* and terebratulids; more calcareous upwards	0.3
LIMESTONE, mid green-grey, micritic, marly, crumbly, bivalves, scattered ooids	0.2
MARL, orange-brown, firm, streaky, bivalve infauna and *Liostrea* fragments; more calcareous and shelly towards top	0.25
LIMESTONE, pale green-grey, micritic, marly, crumbly, bivalves	0.17
MARL, greenish-grey-brown, firm, pale streaks, *Liostrea* fragments	0.13
LIMESTONE, pale grey to grey-brown, ooidal, micritic, shelly, rubbly, bivalve infauna, echinoid debris, *Kallirhynchia*	0.4
MARL, orange-brown, firm, streaky, *Liostrea* debris in layers; more calcareous and shelly towards top, with bivalve infauna	0.43
LIMESTONE, white to cream, fine micrite matrix, small ooids (pale orange, disseminated), hard, massive; top very shelly and coarsely ooidal, otherwise less fossiliferous	0.64
LIMESTONE, white to cream, fine micrite matrix, small ooids as above,	

rubbly	0.2
LIMESTONE, white to cream, fine micrite matrix, pale orange ooids, shell debris and whole moulds, corals, gastropods abundant locally; hard, massive	0.43
LIMESTONE, pale grey-brown to orange, silty ('Roach Bed'?)	0.85
LIMESTONE, white to cream, micritic, slightly silty, hard	0.43
MARL, orange, silty, limonitic, soft, rare limestone intraclasts	0.3
White Limestone Formation, Shipton Member (2.99)	
LIMESTONE, cream to pale grey, micritic, silty, hard, shell debris and brachiopods, gastropods, *Liostrea*, decapod (Excavata Bed?)	0.55
MARL, grey-orange, silty, small oyster fragments	0.43
LIMESTONE, pale grey-brown to grey, micritic, slightly limonitic, abundant bivalves	0.21
LIMESTONE, pale grey-brown, micritic, silty, hard, shelly	0.85
MARL, orange-brown with greenish grey streaks, slightly silty, with *Liostrea*; lens of cream to grey-brown rubbly limestone	0.27
LIMESTONE, pale grey-brown, micritic, moderately hard, rubbly	0.25
LIMESTONE, mid grey-brown, micritic, moderately hard, rubbly, with a few *Liostrea*	0.43

Dip about 20º to NNW.

N [5985 3917] Temporary section along road cutting, A43 (M J Oates, 12 July 1986)

White Limestone Formation, Shipton Member (1.4)	Thickness m
LIMESTONE, pale grey-brown to cream, micritic, marly, gastropods, *Liostrea*; rubbly towards base	0.6
LIMESTONE, cream, micritic, shell-detrital, rubbly	0.5
LIMESTONE, cream, micritic, shell detrital, pectiniid bivalves, rhynchonellids (?*Kallirhynchia*)	0.3
Rutland Formation (3.4)	
MARL, pale grey-brown, very calcareous, silty, with "race", gastropods and bivalves	1.0
LIMESTONE, yellow-grey, micritic, limonitic, hard, abundant burrowing bivalves, rhynchonellids	0.1
LIMESTONE, orange, rubbly, silty, marly, abundant rhynchonellids, terebratulids and bivalves, including *Pholadomya*, *Modiolus*, *Liostrea*	0.65
LIMESTONE, white to cream, very fine-grained micritic, porcellanous, bivalves	0.15
MARL, pale grey-brown to orange, silty	0.2
LIMESTONE, cream, micritic, silty, rubbly	0.4
LIMESTONE, cream, micritic, silty, massive, bivalves	0.15
SILTSTONE, yellow-grey, calcareous	0.15
CLAY, orange-yellow, calcareous seams; less calcareous down	0.15
CLAY, orange to pale grey-brown, silty, laminated, with rootlets, lignite and oyster debris, soft; less silty down	0.15
CLAY, grey to green-grey, rootlets, a little shell debris, poorly bedded	0.3 seen

P [599 366] Turweston cutting (M J Oates, June 1986) (now backfilled)

	Thickness m
Topsoil, with limestone brash	0.4
White Limestone Formation (8.3)	
LIMESTONE, cream, ooidal, shell detrital, micritic, hard, flaggy in top 0.3 m; rubbly below	0.8

LIMESTONE, cream, ooidal, poorly-consolidated, crumbly texture, abundant and diverse fauna, *Liostrea, Acrosalenia, Bathrotomaria*	0.3
LIMESTONE, cream, micritic, micro-ooidal patches, especially towards top, hard, rubbly; branching corals in situ (spar-filled moulds) commoner towards base	0.3
LIMESTONE, cream, micritic, silty, moderately hard	0.4
LIMESTONE, cream, shell-detrital, micritic, massive, hard	0.4
LIMESTONE, pale grey, brownish weathering, marly, moderately hard, rubbly	0.1
MARL, brownish grey	0.3
GAP	2.7
MARL, brown-weathering, silty	c. 0.2
LIMESTONE, pale cream, fine-grained micrite (porcellanous), hard; flat top, dense vertical joints, *Steneosaur* tooth	0.3
MARL	0.1
LIMESTONE, pale cream, micritic, becoming hard, bivalves, abundant *Kallirhynchia*	0.3
SILT, orange-grey, firm, unfossiliferous	0.4
LIMESTONE, cream to brownish grey, micritic, hard, abundant infaunal bivalves, *Modiolus*, gastropods, sparse *Kallirhynchia*; becoming yellow-grey, firm	0.4
MARL, yellow-grey, firm to soft, streaky, unfossiliferous	0.4
LIMESTONE, cream to brownish grey, shell-detrital, micritic, hard; porcellanous in part	0.9
Rutland Formation (3.15)	
SILT, brown-weathering, soft	0.9
MARL, yellow-grey to medium grey; firm at top, becoming crumbly or blocky down	0.7
MARL, off-white at top, khaki-brown weathering, blocky, slightly silty, firm, abundant *Liostrea*, sparse *Pholadomya;* two thin (1 cm) silt beds 0.05 and 0.1 m above base	0.7
CLAY, dark brownish grey, firm, blocky, sparse small aragonitic bivalves	0.15
MARL, pale brown, silty, soft, abundant *Liostrea*	0.1
MARL, pale brownish grey, soft to firm, matrix-supported orange-weathering peloids/ooids, abundant *Liostrea*	0.3
LIMESTONE, pale brownish grey, micritic, moderately hard, peloidal, rubbly, *Burmirhynchia concinna*	0.1
MARL, pale brownish grey, soft to firm, abundant peloids/ooids, abundant *Burmirhynchia*	0.2
Taynton Limestone Formation (c. 0.4 seen)	
LIMESTONE, pale grey to brownish grey, peloidal, micritic with orange-weathering ?ooids, firm to moderately hard, rubbly, *Liostrea*, *Burmirhynchia*, and abundant infaunal bivalves	c. 0.1
LIMESTONE, as above, with shell debris, moderately hard, flaggy, echinoid fragments, infaunal bivalves, small calcite spar-filled shell moulds	0.1
LIMESTONE, pale grey, micritic, slightly rubbly, abundant spar-filled shells, fewer peloids/ooids, *Liostrea*	0.2 seen

Q [5967 3672] Temporary section, Buckingham Road (M J Oates, June 1986)

White Limestone Formation (2.45 seen)	Thickness m
LIMESTONE, cream to grey, ooidal, shell detrital, micritic, abundant bivalves	1.0
CLAY, brown-weathering, slightly silty, common *Liostrea*	0.15
LIMESTONE, cream, micritic, massive, abundant bivalves	0.7
MARL, orange brown, sparse *Liostrea*	0.1
LIMESTONE, cream, micritic, massive, abundant bivalves	0.5

R [5967 3672] Temporary section in borrow pit, Hinton Road (H P Powell, 12/12/91)

Dip to ENE

	Thickness m
LIMESTONE rubble, mixed with clay	
White Limestone Formation (and Rutland Formation?)	
CLAY, brown	c. 0.2
LIMESTONE, peloidal, shell detrital, micritic (wackestone)	0.5-0.7
MARL, brown, with *Liostrea* and echinoid spines; passing down into:	c. 0.5
LIMESTONE, pale grey, wackestone texture, with *Clypeus*, *Pholadomya* and corals	0.5-0.6
CLAY, brown, with abundant *Liostrea* and terebratulids	0.05-0.10
LIMESTONE, micritic, with epithyrids, rhynchonellids and corals	0.4-0.5
CLAY	0.05-0.10
LIMESTONE, micritic, with *Modiolus*, and *Pholadomya* in life position at base	c. 0.3
MARL, brown, with bivalves including *Modiolus*; passing down into a mixture of marl and nodular limestone; passing laterally into MARL, brown to greenish grey, with *Liostrea*	0.25
LIMESTONE, pale grey, marly, with bivalves and rhynchonellids	c. 0.25
MARL, brown, with *Globularia*	c. 0.25
LIMESTONE, pale grey, micritic, nodular, impersistent	0.1-0.2
MARL, greenish grey	0.60
LIMESTONE, upper part shell-detrital; lower part white and pinkish bioturbated micrite; very hard	0.80
CLAY, green	seen

S [5947 3682] Temporary section, Buckingham Road roundabout (M J Oates, 1/6/86)

	Thickness m
Topsoil	0.3
Alluvium (c. 3-3.7)	
CLAY, yellow grey, silty, soft; passing down into: SAND, dark yellow brown, coarse-grained, unconsolidated	3
GRAVEL, dark brown to grey, peaty, silty, unconsolidated, subangular flint and quartz grains, abundant wood fragments and land and freshwater molluscs, rare bones (?pig)	0.2-0.5
GRAVEL, dark grey, unconsolidated, mainly well rounded quartz cobbles; fills channel in bedrock	0-0.2
Whitby Mudstone Formation (up to 2.5 seen)	
CLAY, blue-grey, soft, fossils including ammonites (*Dactylioceras*); layer of septarian concretions 1.5 above base, and reported at base	2.5 seen

NB The following sections lie outside the area of sheets SP 53 NW and NE but are mostly unlikely to be otherwise published, and/or are relevant to this account.

T, U and V. Croughton Quarry (SP 53 SE)

This is the location of regionally important sections in the Rutland, White Limestone and Forest Marble formations. However, no detailed account has been published, although Sumbler (1984, fig. 3) gives a partial graphic section.

There are three distinct excavations at this site, all disused (1998) and separated by unworked strips up to 50 m wide (for layout see 1:10 000-scale sheet SP 53 SE). However, faulting and a southward dip of about 2º results in each quarry exposing a slightly different interval of strata. The western quarry [563 337] currently exposes up to about 3 m of the White Limestone Formation (Locality T). The southern quarry was in operation in the 1970's, exposing from the Shipton Member continuously up to the Cornbrash (Locality U), but is now landscaped and flooded, and no section is available. The western and eastern quarries were briefly open in the late 1980's, during construction of the M40 motorway, together exposing a continuous section from the Taynton Limestone up to the top of the White Limestone Formation, but the eastern excavation (Locality V) has been entirely backfilled and landscaped.

T [5623 3357] Croughton western quarry (BA 111) 7/5/99

Formerly probably showed the full thickness of the Ardley Member.

White Limestone Formation, Bladon Member (c. 1.2)	Thickness m
LIMESTONE, very pale grey to pale brown, blocky and rubbly weathering	0.85 seen
MARL, pale yellow-grey (Fimbriata-Waltoni Bed with bed below)	0.1
MUDSTONE, mid grey-green to dark grey, slightly silty, slightly shell-detrital, blocky; more yellow, silty and marly down	0.2-0.3
White Limestone Formation, Ardley Member (1.62 seen)	
LIMESTONE, very pale pinkish grey, medium- to coarse-grained peloidal and ooidal grainstone to packstone (Bladonensis Bed)	0.07
LIMESTONE, off-white to very pale grey, fine- to coarse-grained peloidal and ooidal packstone to wackestone; massive at top and base, marly and friable in middle 0.5	1.55 seen

U [5664 3349] Croughton southern quarry (A Horton, 20/10/76; reproduced as graphic section in Sumbler, 1984, fig. 3)

Cornbrash Formation (1.0)	Thickness m
LIMESTONE, dark brownish grey and rubbly weathering, shell detrital; with clay flakes and clay-filled burrows	1.0 seen
Forest Marble Formation (5.6-6.6)	
MARL, pale greenish grey, micritic, scattered shell debris, weathering to silty clay	up to 0.15
MUDSTONE, greenish grey, with brown silty limestone wisps and lenticles; darker downwards	0.33
LIMESTONE, pale grey-green, micritic with thin darker layers; ?porcellanous, weathered to marl; clay drapes on top; sharp base	0.15-0.2
MUDSTONE, greenish grey, with brown silty shell detrital limestone lenticles, small oysters and plant fragments; darker softer 0.13-m mudstone layer in middle; brown calcareous shelly clay at base	0.79-0.84
LIMESTONE, pale grey-green, fine-grained, micritic, porcellanous with thin indefinite shell debris layers; scattered bivalves, also in clusters;	

lenses of soft limestone with shelly bioturbated pockets; bed of up to 0.3 m of greenish thin-bedded shell debris limestone with oysters and plant fragments, passing laterally into marl; sharp, channelled base	0.74
MUDSTONE, mid grey, laminated, soft, a few rootlets and silty wisps; thickening and passing laterally into paler grey mudstone with brown mottling (possible seatearth)	0.81-1.38
LIMESTONE, pale greenish grey, fine-grained, ?recrystallised, possible hardground; with shell debris-filled burrows, some fine-grained shell debris layers, crystalline ?coral masses, some plant debris; increasingly shell-detrital down; basal bed of greenish grey sandy marly shell-detrital clay 0-0.3 m thick; sharp base	up to 1.37
MARL, greyish brown, shell-debris-rich, uncemented, bedded, with mudstone beds and plant fragments; non-sequential base	0-0.30
MUDSTONE, greenish grey, with brown mottles at top, lignitic rootlets, a few shells including oysters; passing paler and yellow mottled down; sheared seatearth	1.30
White Limestone Formation, Bladon Member (c. 2.3)	
LIMESTONE, pale greenish grey at top, passing down into pale purplish grey with dark mottles, rootlets, sparse shells, hardground (with bed below forms 'Upper Epithyris Bed')	0.76-0.91
LIMESTONE, grey, blue-hearted, shell detrital, micritic	up to 0.66
MARL, dark grey, shell debris bands (with 2 beds below forms Fimbriata-Waltoni Bed)	0.05-0.08
MUDSTONE, dark grey with greenish and ochreous tints, many shells and plant fragments; thickens laterally into ooidal shell debris limestone resting on 0.03-0.13 m dark grey clay	0.25-0.50
MARL, greenish grey, silty, clay-filled rootlets and stained burrows; passes laterally into hard porcellanous limestone with bivalves	0.33 seen
JUNCTION OBSCURED	?0
White Limestone Formation, Ardley Member (6.5-6.8)	
LIMESTONE, pale greenish grey hardground at top, passing down into brownish grey, micritic, with *Aphanoptyxis* gastropods, bivalves and burrows (Bladonensis Bed)	0.76
LIMESTONE, off-white, peloidal, soft at top, more massive down	c. 0.58
LIMESTONE, pale brownish grey, fine-grained with greenish laminae at top; coarser and more peloidal down	0.84
LIMESTONE, pale brownish grey, micritic with scattered peloids and shell debris increasing down	0.15
LIMESTONE, pale brown, soft, marly, with shell debris and ooids; grading to grainstone; wispy bedding traces	0.15-0.46
LIMESTONE, pale greenish grey, micritic, scattered brownish pellets, bioturbated with numerous shells; very soft and marly in basal 0.23	(not recorded)
LIMESTONE, pale grey-brown, soft, marly, with ooids and shell debris; almost a grainstone	1.09
LIMESTONE, pale grey-brown, blue-hearted, micritic, shelly, shell detrital and ooidal, bioturbated; passing below 0.6 into: ooidal, shelly, shell detrital grainstone with much plant debris and sand at base ('Roach Bed')	1.85
MUDSTONE, dark grey, with layers of shell debris and scattered oysters	0.15
LIMESTONE, mid grey, sandy, with shell debris and ooids, oyster-rich layers	0-0.15
MUDSTONE, dark grey, sandy, with layers of shell debris; non-sequence?	0-0.15

MUDSTONE, greenish grey, with shell debris and shells, faint bedding traces, rare rootlets; non-sequence at base	0.30
White Limestone Formation, Shipton Member (1.37 seen)	
LIMESTONE, marly in top 0.05, very hard, blue-hearted micrite below with pellets, shell debris and abundant bivalves, intensely burrowed at top (Excavata Bed)	0.76
LIMESTONE, pale brown, micritic, with scattered grains	0.61 seen
MARL, bioturbated	seen
LIMESTONE	seen

V [563 336 and 567 336] Croughton western and eastern quarries, composite log (M J Oates, 7/1/89)

White Limestone Formation, Bladon Member (2.25)	Thickness m
LIMESTONE, greenish yellowish grey to grey, porcellanous, unfossiliferous, narrow calcite veins ('Cream Cheese Bed')	1.0
LIMESTONE, yellowish grey, peloidal, shell-detrital, micritic; massive towards base, *Aphanoptyxis*	0.3
MARL, yellowish grey, friable (weathered); with nodular peloidal shell-detrital micrite	0.15
LIMESTONE, yellowish grey, peloidal, shell-detrital, micritic, cross-bedded	0.4
CLAY, grey, soft, blocky, unfossiliferous; weathered (Fimbriata-Waltoni Bed)	0.4
White Limestone Formation, Ardley Member (5.69)	
LIMESTONE, yellowish grey, peloidal, shell-detrital, micritic, *Aphanoptyxis bladonensis* preserved as green marl-filled moulds; massive towards base (Bladonensis Bed)	0.72
LIMESTONE, cream, micritic, rubbly, sparse shell fragments	0.57
LIMESTONE, yellowish grey, micrite, peloid streaks, thin, planar, hard, low angle cross beds; porcellanous towards top; basal 0.2 m marly and rubbly	0.87
LIMESTONE, pinkish orange, peloidal, shell-detrital, micritic, hard	0.4
OBSCURED	c. 1.0
LIMESTONE, pale orange, gritty, fine-grained shell fragments, low angle cross bedding, *Aphanoptyxis*, *Clypeus*, serpulids, abundant *Liostrea*	0.1
LIMESTONE, yellowish grey, pale grey hearted, peloidal, shell-detrital, micritic	0.43
LIMESTONE, yellowish grey, pale grey hearted, peloidal, shell-detrital, micritic, hard, massive	0.7
LIMESTONE, yellowish grey, pale grey hearted, peloidal, shell-detrital, micritic, hard, massive, rare bivalve fragments, echinoid, lignite ('Roach Bed'?); limit of weathering at base	0.5
MARL, mid grey, silty, firm, *Liostrea*, shell fragments, echinoid radioles	0.4
White Limestone Formation, Shipton Member (c. 4.5)	
LIMESTONE, mid grey, peloidal, shell-detrital, micritic, hard, massive; top interburrowed with pale grey micrite, abundant bivalve infauna; thins to north	0.3-0.6
CLAY, mid-dark grey, firm, well bedded, bivalve infauna, *Clypeus* and *Pleuromya* abundant, terebratulid fragments	0.06
LIMESTONE, mid grey, peloidal, shell-detrital, micritic, hard, massive, *Clypeus*; interburrowed hardground at top	0.54

MARL, dark grey, well bedded, shell fragments	0.05
LIMESTONE, pale grey, micritic - almost porcellanous, abundant *Liostrea* fragments; very hard at top; firm, grading to marl at base	0.4
LIMESTONE, mid grey, micritic, hard, bivalves, *Pholadomya* in life position abundant, black composite bivalve moulds	0.17
LIMESTONE, mid grey, micritic, hard, bivalves, large *Pholadomya* in life position	0.25
MARL, grey, peloidal, shell-detrital, soft	0.05
LIMESTONE, mid grey, micritic, slightly gritty, slightly peloidal; soft in middle	0.5
MARL, olive green, ?glauconitic, well-bedded, soft-firm; becoming greyer to base	0.1
LIMESTONE, mid grey, streaked greenish grey, firm, marly, micritic; rootlets from top; passing to dark grey and softer at base	0.35
LIMESTONE, mid grey, micritic, gritty, black-coated joints	0.7-0.9
LIMESTONE, mid grey, greenish at top, micritic, silty, argillaceous; harder calcareous bed in middle; low angle cross bedding below, with *Procerites*; thin dark grey lenticular clay at base	0.8
Rutland Formation (3.64)	
CLAY, olive green; rootlets at top; passing down green-grey, moderately hard, calcareous, silty, almost a limestone; *Modiolus*	1.25
CLAY, olive green, soft, rootlets	0.3
LIMESTONE, pale grey, micritic, silty, medium hard, rootlets; dark grey burrows in top, porcellanous in basal 0.3m	0.45
LIMESTONE, mid grey, silty, marly, firm-moderately hard, abundant marine bivalves, including *Pinna* in life position	0.61
SAND, mid grey, soft to firm, fine-grained, well bedded, a few small bivalves	0.15
CLAY, dark grey to black, abundant small thin bivalves; thin seams of soft yellowish grey clay	0.23
SILTSTONE/MUDSTONE, mid grey, firm, blocky, well-bedded	0.1
MARL, pale green, with black argillaceous burrow fills; passing down into brownish yellowish grey; mid grey at base, with black peloids	0.55
Taynton Limestone Formation (1.35 seen)	
LIMESTONE, mid grey, ooidal, micritic, medium hard, black peloids; sand streak at base	0.25
LIMESTONE, mid grey, ooidal, micritic, very hard, silty, black peloids, abundant *Burmirhynchia* and *Modiolus*	0.4
LIMESTONE, mid grey, ooidal, micritic, very hard, silty; passing sparry down, *Burmirhynchia*	0.6
MARL, mid grey, black peloids, *Clypeus*	0.1 seen

W [6015 3940] (SP 63 NW) Temporary section in road cutting, A43, near Whitfield

(M J Oates, 12 July 1986)

White Limestone Formation (0.6)	Thickness m
LIMESTONE, pale grey to grey-brown, micritic, sparse infaunal bivalves; 0.15 m-long *Diplocraterion* burrow at top	0.3
LIMESTONE, pale grey to grey-brown, micritic	0.3
Rutland Formation (0.93-1.2)	
SILTSTONE, grading to sandstone, yellow, argillaceous, laminated at top and base, soft, unconsolidated; sparse *Ostrea* shells and debris	0.3
CLAY, brown, silty, argillaceous silt streaks, *Ostrea*, abundant rootlets	0.03-0.3

CLAY, dark grey, blocky, soft-firm, sparse rootlets; silty and shelly at base with comminuted and some whole thin bivalve shells and *Ostrea*	0.3
CLAY, dark olive green-grey, irregular top, a few rootlets	0.3

X [601 361] (SP 63 NW) Temporary section, Brackley Sewage Farm (M J Oates, June 1992)

Taynton Limestone Formation	Thickness m
SILT, green-orange, soft, weathered	0.3
MARL, orange, shelly, with 'race'	0.15
LIMESTONE, buff, silty, rootlets, bivalves, *Liostrea*, moderately hard	0.15
OBSCURED	?
LIMESTONE, pinkish-cream, peloidal	0.15
LIMESTONE, pale grey to cream, hard, splintery, unfossiliferous	0.15
OBSCURED	?
LIMESTONE, cream, silty, hard, abundant *Liostrea, Burmirhynchia concinna, Modiolus, Camptonectes*	0.55
MARL, orange, limonitic, shelly, *Liostrea*	0.1
LIMESTONE, pinkish-cream, micritic, hard, a few *Liostrea*	0.25
MARL, orange, silty, moderately hard; shelly at top	0.2

Y [601 360] (SP 63 NW) Temporary section, Brackley Sewage Farm lagoon (M J Oates, June 1992)

Sharp's Hill Formation (2.15)	Thickness m
MARL, buff, brown and yellow, silty, very abundant *Liostrea*; limonitic parting at base	0.8
MUDSTONE, dark grey to brownish grey, silty, marly, unfossiliferous, weathered; becoming darker down; layer of limonitic nodules at 1.0	1.35
Horsehay Sand Formation (1.45)	
SAND, yellow to white, very fine-grained, unfossiliferous	0.3
SILT, black, very carbonaceous, lignitic; uppermost 0.2 seen, reported thickness:	1.15
Whitby Mudstone Formation (seen)	
CLAY, blue-grey, plastic, unfossiliferous	seen

Z [5760 3320] (SP 53 SE) New road cutting, A43, south of Barley Mow
(M J Oates, 12 August 2001)

White Limestone Formation, Ardley Member (2.6)	Thickness m
LIMESTONE, grey-brown, peloidal, shell-detrital, micritic, fine texture, abraded shell fragments, some sparry, hard, flaggy-weathering, rubbly, marine infauna, sparse gastropods; porcellanous down	1.0
LIMESTONE, pale grey-brown, fine grained, peloidal, shell-detrital, packstone-grainstone, very hard	0.7
LIMESTONE, pale grey-brown, peloidal, shell-detrital grainstone; hard, prominent top surface	0.5
MARL orange-grey, weathered, firm, becoming harder towards base, streaky with comminuted carbonate grains, abundant *Liostrea*, sparse marine infaunal bivalves, *Modiolus*, fish debris	0.4
White Limestone Formation, Shipton Member (2.6)	
LIMESTONE, v pale or, fine grade micrite, matrix-supported peloids, firm, decalcified, abundant marine infauna especially towards top	0.45
LIMESTONE, pale cream to grey, peloidal, shell-detrital, micritic, with fine-grained peloids and shell debris, echinoid fragments (*Clypeus*	

muelleri), hard	0.2
LIMESTONE, pale pinkish cream to grey, micritic, abundant comminuted fine-grained shell debris, silty, hard	0.45
LIMESTONE, pale cream to grey, micritic, large fragile shell fragments with abundant finer debris, hard, abundant *Pholadomya*	0.4
MARL, orange-brown, weathered, soft, marly	0.35
MARL, orange-grey, well-bedded, very fine carbonate grains, soft to firm, argillaceous, shell fragments, abundant *Stiphrothyris* towards top	0.35
LIMESTONE, pale cream to grey, micritic, moderately hard, abundant marine infauna (large unbroken shall fragments)	0.4
LIMESTONE, pale buff, biomicrite, abundant sparry or fibrous calcite shell debris, hard, silty, echinoid fragments; base not seen	0.2 seen

A1 [567 320] (SP 53 SE) Pond excavation, A43, west of Heath Farm

(M J Oates, 12 August 2001)

White Limestone Formation (2.7)	Thickness m
MARL, pale brown, peloids in soft/unconsolidated micritic matrix	0.15
LIMESTONE, buff, peloidal grainstone, fine-grained peloids, very hard	0.1
LIMESTONE, buff, peloidal grainstone, fine-grained peloids, very hard	0.35
LIMESTONE, brown/grey, peloidal packstone/wackestone, locally sparry, very hard; becoming yellow-grey, peloidal grainstone, shell fragments, very hard	0.35
LIMESTONE, pale grey-brown to grey, peloidal shell-detrital grainstone, locally micritic, very hard	0.25
LIMESTONE, pale grey-brown to grey, peloidal grainstone, very hard, shall fragments, sub-spherical to elongate peloids	0.15
LIMESTONE, pale grey-brown, packstone-grainstone, very hard, abundant *Aphanoptyxis*, abundant bivalve infauna at top, sandy (“roach”)	0.2
LIMESTONE, pale grey-brown, peloidal shell-detrital grainstone, very hard, thin shell fragments, *Aphanoptyxis*, very abundant bivalve epifauna	0.2
MARL, green-grey, soft to firm, well-bedded, abundant glauconite-rich horizontal burrows; some peloidal streaks, some echinoid radioles, *Liostrea*, lignite, crocodile tooth, fish scales; becoming grey (base of weathered zone), with peloidal streaks, scattered glauconite grains, with abundant echinoid radioles, *Liostrea* and shell fragments	0.4
LIMESTONE, grey, peloidal packstone/wackestone, intense bioturbation, pyritic composite bivalve moulds, abundant bivalve infauna, hard	0.25
LIMESTONE, grey, peloidal packstone/wackestone, with pale grey micrite burrow-fills with pyritic linings, hard	0.3 seen

Appendix 2 Boreholes

Only logs of boreholes within the Brackley and Charlton area (SP 53 NE and SP 53 NW east of grid line 53) are shown.

SP 53 NW/2 GCN-91 [5472 3924]

Surface level c. +134 m above OD

	Thickness (m)	Depth (m)
Northampton Sand Formation	2.1	2.1
Whitby Mudstone Formation	37.5	39.6
Marlstone Rock Formation	3.7	43.3
Dyrham Formation	14.3	57.6
Charmouth Mudstone Formation *(100 Marker at 73.8; 85 Marker at 95.1; 70 Marker at 123.4)*	126.5	184.1
Penarth Group	8.5	192.6 (terminal depth)

SP 53 NW/4 Hinton-in-the-Hedges Aerodrome (Walltree Farm) [5418 3715]

Surface level c. +153 m above OD (from contours)

	Thickness (m)	Depth (m)
Rutland and White Limestone formations	5.2	5.2
Taynton Limestone Formation	4.6	9.8
Sharp's Hill Formation	3.6	13.4
Northampton Sand and Horsehay Sand formations	3.4	16.8
Whitby Mudstone Formation	34.1	50.9
Marlstone Rock Formation	1.8	52.7
Charmouth Mudstone and Dyrham formations	32.0	84.7 (terminal depth)

SP 53 NW/9 Farthinghoe Lodge Farm [5343 3947]

Surface level c. +158 m above OD (from spot heights)

	Thickness (m)	Depth (m)
Northampton Sand Formation	4.0	4.0
Whitby Mudstone Formation	44.2	48.2
Dyrham and Marlstone Rock formations	9.4	57.6 (terminal depth)

SP 53 NW/14 Farthinghoe Bypass H6 [5398 3998]

Surface level +153.34 m above OD

	Thickness (m)	Depth (m)
Whitby Mudstone Formation	31.5	31.5 (terminal depth)

SP 53 NE/1 GCN-98 [5681 3805]

Surface level +110.6 m above OD

	Thickness (m)	Depth (m)
Alluvium	2.4	2.4
Whitby Mudstone Formation	15.2	17.7
Marlstone Rock Formation	1.8	19.5
Dyrham Formation	13.1	32.6
Charmouth Mudstone Formation *(100 Marker at 49.4; 85 Marker at 72.8; 70 Marker at 98.5)*	118.3	150.9
Penarth Group	9.8	160.6
Mercia Mudstone Group	6.7	167.3 (terminal depth)

SP 53 NE/2 GBK-1 [5959 3682]

Surface level +110.0 m above OD

	Thickness (m)	Depth (m)
Taynton Limestone Formation	2.7	2.7
Sharp's Hill Formation	0.6	3.4
Horsehay Sand Formation	2.7	6.1
Whitby Mudstone Formation	21.0	27.1
Marlstone Rock Formation	2.7	29.9
Dyrham Formation	12.2	42.1
Charmouth Mudstone Formation *(100 Marker at 56.4; 85 Marker at 78.3; 70 Marker at 104.9)*	? c. 110	? c. 152
Penarth Group	?	?
(terminal depth)		167.6

SP 53 NE/3 GBK-2 [5917 3847]

Surface level +120.4 m above OD

	Thickness (m)	Depth (m)
Taynton Limestone Formation	0.9	0.9
Sharp's Hill Formation	0.6	1.5
Horsehay Sand Formation	6.1	7.6
Whitby Mudstone Formation *(Cephalopod Limestones and Fish Beds from 37.8 to base)*	33.2	40.8
Marlstone Rock Formation	3.4	44.2
Dyrham Formation	11.6	55.8
Charmouth Mudstone Formation *(100 Marker at 71.9; 85 Marker at 92.0; 70 Marker at 116.4)*	115.2	171.0
Mercia Mudstone Group and Penarth Group	27.1	198.1 (terminal depth)

SP 53 NE/4 GBK-11 [5800 3659]

Surface level +107.3 m above OD

	Thickness (m)	Depth (m)
Whitby Mudstone Formation (faulted)	8.5	8.5
Marlstone Rock Formation	3.4	11.9
Dyrham Formation	14.3	26.2

	Thickness (m)	Depth (m)
Charmouth Mudstone Formation *(100 Marker at 42.1; 85 Marker at 67.1; 70 Marker at 97.2)*	116.1	142.3
Penarth Group	0.9	143.3 (terminal depth)

SP 53 NE/5 GBK-16 [5614 3555]

Surface level +142.6 m above OD

	Thickness (m)	Depth (m)
White Limestone Formation *(Ardley Member to 1.5; Shipton Member to 6.4)*	6.4	6.4
Rutland Formation	3.0	9.4
Taynton Limestone Formation	5.5	14.9
Sharp's Hill Formation	0.9	15.8
Horsehay Sand Formation	5.8	21.6
Northampton Sand Formation	2.1	23.8
Whitby Mudstone Formation	31.1	54.9
Marlstone Rock Formation	2.1	57.0
Dyrham Formation	8.8	65.8
Charmouth Mudstone Formation *(100 Marker at 71.9; 85 Marker at 92.0; 70 Marker at 116.4)*	117.0	182.9
Penarth Group	3.4	186.2
Mercia Mudstone Group	5.8	192.0 (terminal depth)

SP 53 NE/6 GBK-18 [5623 3639]

Surface level +124.1 m above OD

	Thickness (m)	Depth (m)
Horsehay Sand Formation (?+Northampton Sand Formation)	3.4	3.4
Whitby Mudstone Formation	35.7	39.0
Marlstone Rock Formation	1.8	40.8
Dyrham Formation	11.3	52.1
Charmouth Mudstone Formation *(100 Marker at 68.9; 85 Marker at 89.9; 70 Marker at 118.0)*	112.8	164.9
Penarth Group	4.3	169.2
Mercia Mudstone Group	3.7	172.8 (terminal depth)

SP 53 NE/7 Brackley Corporation Well [5837 3740]

There are several wells on this site to varying depths up to 69 m. Below is an interpretation of one of the deeper and more informative logs.

Surface level +143.41 m above OD

	Thickness (m)	Depth (m)
White Limestone Formation	7.0	7.0
Rutland Formation	6.1	13.1
Taynton Limestone Formation	6.1	19.2
Horsehay Sand Formation	4.0	23.2

	Thickness (m)	Depth (m)
Whitby Mudstone Formation	31.6	54.8
Dyrham and Marlstone Rock formations	12.3	67.1 (terminal depth)

SP 53 NE/52 Brackley Bypass Borehole AQ [59428 36801]

Surface level +101.62 m above OD

	Thickness (m)	Depth (m)
Alluvium		
CLAY, silty, yellow brown	1.1	1.1
SILT, grey brown, clayey and organic	1.35	2.45
Whitby Mudstone Formation		
MUDSTONE, grey, silty; weathered to grey and brown silty clay in top 2 m	16.55	19.0
LIMESTONE, grey, sandy, shelly (Cephalopod Limestone?)	0.3	19.3
MUDSTONE, dark grey, silty, shelly	0.7	20.0 (terminal depth)

SP 53 NE/58 Brackley Bypass Borehole AV [59401 36544]

Surface level +100.35 m above OD

	Thickness (m)	Depth (m)
Alluvium		
CLAY, silty, brown, with gravel	1.1	1.1
SILT, brown, clayey and organic	1.15	2.25
GRAVEL, brown, silty, sandy	0.95	3.2
Whitby Mudstone Formation		
MUDSTONE, grey, silty; weathered to grey and brown silty clay in top 3 m	15.85	19.05
LIMESTONE, dark grey, sandy, shelly (Cephalopod Limestone?)	0.95	20.00 (terminal depth)

SP 53 NE/157 [5861 3636]

Surface level +102.10 m above OD

	Thickness (m)	Depth (m)
Topsoil	0.4	0.4
Alluvium		
CLAY, mottled orange-brown and grey, silty	1.20	1.60
CLAY, grey and green-grey mottled, silty, slightly sandy, with peaty inclusions and traces of sandy gravel	2.20	3.80
Whitby Mudstone Formation		
CLAY, dark grey, silty, fissured	6.20	10.00 (terminal depth)

References

Most of the references listed below are held in the Library of the British Geological Survey at Keyworth, Nottingham. Copies of the references may be purchased from the Library subject to the current copyright legislation.

APPLETON, J D, and BALL, T K. 1995. *Radon and background radioactivity from natural sources: characteristics, extent and relevance to planning and development in Great Britain***.** British Geological Survey Technical Report No. WP/95/2.

ARKELL, W J. 1933. *The Jurassic System in Great Britain***.** (Oxford: Clarendon Press.)

ARKELL, W J, RICHARDSON, L, and PRINGLE, J. 1933. The Lower Oolites exposed in the Ardley and Fritwell railway cuttings, between Bicester and Banbury, Oxford. *Proceedings of the Geologists' Association*, Vol. 44, 340-355.

BRADSHAW, M J. 1978. A facies analysis of the Bathonian of eastern England. Unpublished PhD thesis, Oxford.

EDMONDS, E A, POOLE, E G, and WILSON, V. 1965. *Geology of the country around Banbury and Edge Hill***.** Memoir of the British Geological Survey No. Sheet 201 (England and Wales).

FENTON, J P G, RIDING, J B, and WYATT, R J. 1994. Palynostratigraphy of the Middle Jurassic 'White Sands' of central England. *Proceedings of the Geologists' Association*, Vol. 105, 225-230.

HORSWILL, P, and HORTON, A. 1976. Cambering and valley bulging in the Gwash valley at Empingham, Rutland. *Philosophical Transactions of the Royal Society of London*, Vol. A283, 427-462.

HORTON, A. 1977. The age of the Middle Jurassic 'white sands' of north Oxfordshire. *Proceedings of the Geologists' Association*, Vol. 88, 147-162.

HORTON, A, and POOLE, E G. 1977. The lithostratigraphy of three geophysical marker horizons in the Lower Lias of Oxfordshire. *Bulletin of the Geological Survey of Great Britain*, Vol. 62, 13-33.

HORTON, A, POOLE, E G, WILLIAMS, B J, ILLING, V C, and HOBSON, G D. 1987. *Geology of the country around Chipping Norton***.** Memoir of the British Geological Survey No. Sheet 218 (England and Wales).

HORTON, A, SHEPHARD-THORN, E R, and THURRELL, R G. 1974. The geology of the new town of Milton Keynes. *Report of the Institute of Geological Sciences, No 74/16*.

NATIONAL RIVERS AUTHORITY. 1995. Groundwater vulnerability of Bedfordshire. Groundwater vulnerability map sheet 31. 1:100 000. (Solihull: National Rivers Authority.)

RICHARDSON, L. 1911. The Inferior Oolite and contiguous deposits of the Chipping Norton district, Oxfordshire. *Proceedings of the Cotteswold Naturalists' Field Club*, Vol. 17, 195-231.

RICHARDSON, L. 1923. Certain Jurassic (Aalenian-Vesulian) strata of southern Northamptonshire. *Proceedings of the Geologists' Association*, Vol. 34, 97-113.

SHARMAN, G. 1991. Radiometric investigation of radon in soil gas over Jurassic rocks of Northamptonshire, England. *Environmental Geochemistry and Health*, Vol. 13, 146-147.

SUMBLER, M G. 1984. The stratigraphy of the Bathonian White Limestone and Forest Marble formations of Oxfordshire. *Proceedings of the Geologists' Association*, Vol. 95, 51-64.

SUMBLER, M G. 1991. *Sand and gravel deposits west of Buckingham***.** British Geological Survey Technical Report No. WA/91/21C.

SUMBLER, M G. 1996. *London and the Thames Valley***.** British Regional Geology (London: HMSO for British Geological Survey.)

SUMBLER, M G. 2001. *Geology of the Bicester area (SP 52 SE)***.** British Geological Survey Technical Report No. WA/01/10.

SUMBLER, M G. in preparation. *Geology of the Buckingham district***.** Sheet Explanation of the British Geological Survey. Sheet 219 (England and Wales)

SUMBLER, M G, BARRON, A J M, and MORIGI, A N. 2000. *Geology of the Cirencester district***.** Memoir of the British Geological Survey, Sheet 235 (England and Wales)

SUTHERLAND, D S. 1992. Radon in some East Midlands sedimentary rocks. *Transactions of the Leicester Literary and Philosophical Society*, Vol. 86, 15-19.

TIDDEMAN, R H. 1910. *The water supply of Oxfordshire***.** Memoir of the Geological Survey of Great Britain

WOODWARD, H B. 1894. *The Jurassic rocks of Britain. Vol. 4. The Lower Oolitic rocks of England (Yorkshire excepted)***.** Memoir of the Geological Survey of the United Kingdom

WOODWARD, H B. 1909. *The water supply of Bedfordshire and Northamptonshire***.** Memoir of the Geological Survey of Great Britain