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Geology of the Greywell area, Basingstoke, Hampshire.

Geology and Landscape Programme
Commissioned Report CR/12/104.

BRITISH GEOLOGICAL SURVEY

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COMMISSIONED REPORT CR/12/104.

Geology of the Greywell area, Basingstoke, Hampshire.

A R Farrant

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Contents

Contents ..... **i**

1 Introduction **1**

2 Bedrock Geology **3**

2.1 Seaford Chalk Formation 4

2.2 Newhaven Chalk Formation 4

2.3 Lambeth Group 5

2.4 Thames Group 5

3 Superficial Geology **6**

3.1 Alluvial deposits 6

3.2 Clay-with-flints 6

3.3 Head 6

4 Geological Structure **7**

5 Conclusions **8**

References **8**

FIGURES

Figure 1. Existing 1:50 000 scale bedrock geological map for the Greywell area based on the 1897 six-inch survey. Base map ©Ordnance Survey; Licence No. 100021290. 2

Figure 2. Existing 1:50 000 scale bedrock and superficial geological map for the Greywell area. Base map ©Ordnance Survey; Licence No. 100021290. 2

Figure 3. Revised geological line-work for the Greywell area superimposed on the OS 1:25 000 map. Base map ©Ordnance Survey; Licence No. 100021290. 3

Figure 4. Summary of evolving stratigraphic nomenclature of the Chalk Group in England (Hopson, 2005). 4

Figure 5. Revised geological map of the Greywell-Odiham area. Base map ©Ordnance Survey; Licence No. 100021290. 9

Figure 6. Revised geological map of the Greywell-Odiham area (as per Figure 5) superimposed on the published geological map. Base map ©Ordnance Survey; Licence No. 100021290. . 10

1 Introduction

This report gives a brief account of the geology of the Greywell area near Basingstoke, Hampshire. The Greywell area lies approximately 8 km east-south-east of Basingstoke, and is located on the 1:50 000 scale geological map sheet 284 (Basingstoke). The area was last completely mapped during the six-inch survey of the Basingstoke district, which was published in 1897 (Figures 1 and 2). A partial revision of the Chalk outcrop was undertaken in 2007 by K A Booth, but did not include the Palaeogene outcrop. The published geological map is based on the 1897 six-inch survey of the Basingstoke district (Figures 1 and 2). Consequently the map does not show the new Chalk lithostratigraphy, nor is the bedrock related to modern topographical contours. Thus there is considerable uncertainty in the location of the Chalk-Palaeogene contact in the Greywell area.

As part of a groundwater modelling investigation in the Whitewater River catchment, focussed on the Greywell pumping station, BGS was asked by the client (Jacobs Engineering) to undertake a partial revision of the Basingstoke geological map sheet around the Whitewater valley. The present survey was commissioned to obtain additional field data and combine that with borehole records and topographic data to provide a more accurate indication of the Chalk–Palaeogene boundary. The area between Up Nately, Greywell, North Warnborough and Odiham was resurveyed in mid September 2012 by A R Farrant, in particular focussing on the Chalk–Palaeogene boundary, including a zone up to 0.5 km either side of the contact. Superficial deposits were also mapped, but no additional boreholes or sections were excavated or logged. Existing BGS records including old field-slips, borehole records and historic maps, along with information on the Greywell Canal Tunnel from the Surrey & Hampshire Canal Society (see http://www.basingstoke-canal.org.uk/engineering/tunnels.htm) were also used in the compilation of the new line work. Fieldwork was undertaken by a standard walkover survey with a soil auger. The new line-work is shown in Figures 3, and also in Figures 5 and 6 at the end of the report.

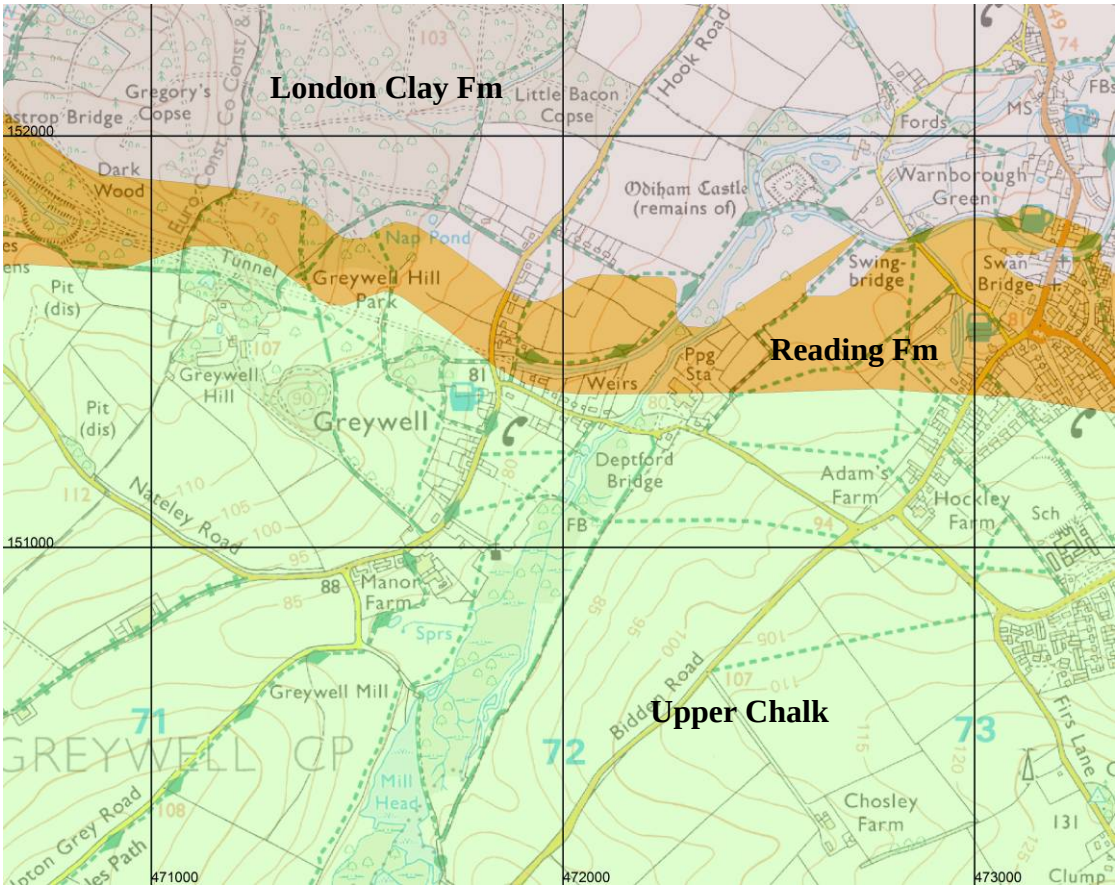

Figure 1. Existing 1:50 000 scale bedrock geological map for the Greywell area based on the 1897 six-inch survey. Base map ©Ordnance Survey; Licence No. 100021290.

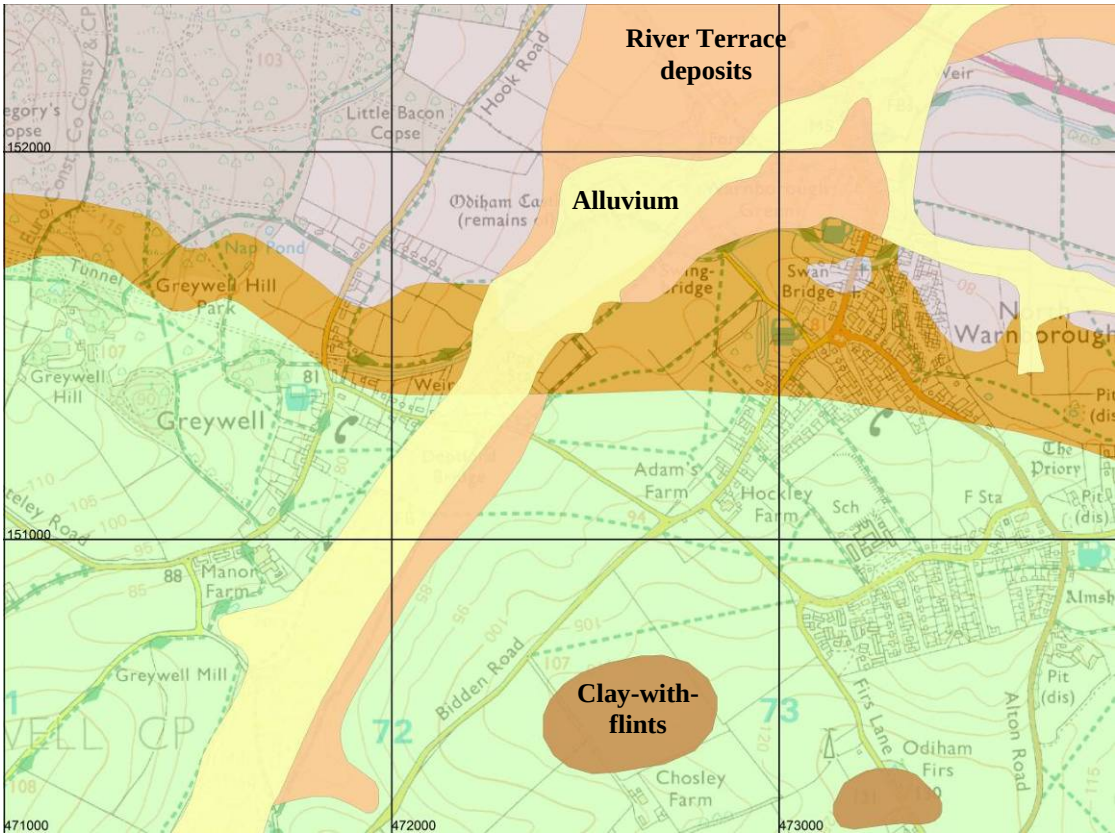

Figure 2. Existing 1:50 000 scale bedrock and superficial geological map for the Greywell area. Base map ©Ordnance Survey; Licence No. 100021290.

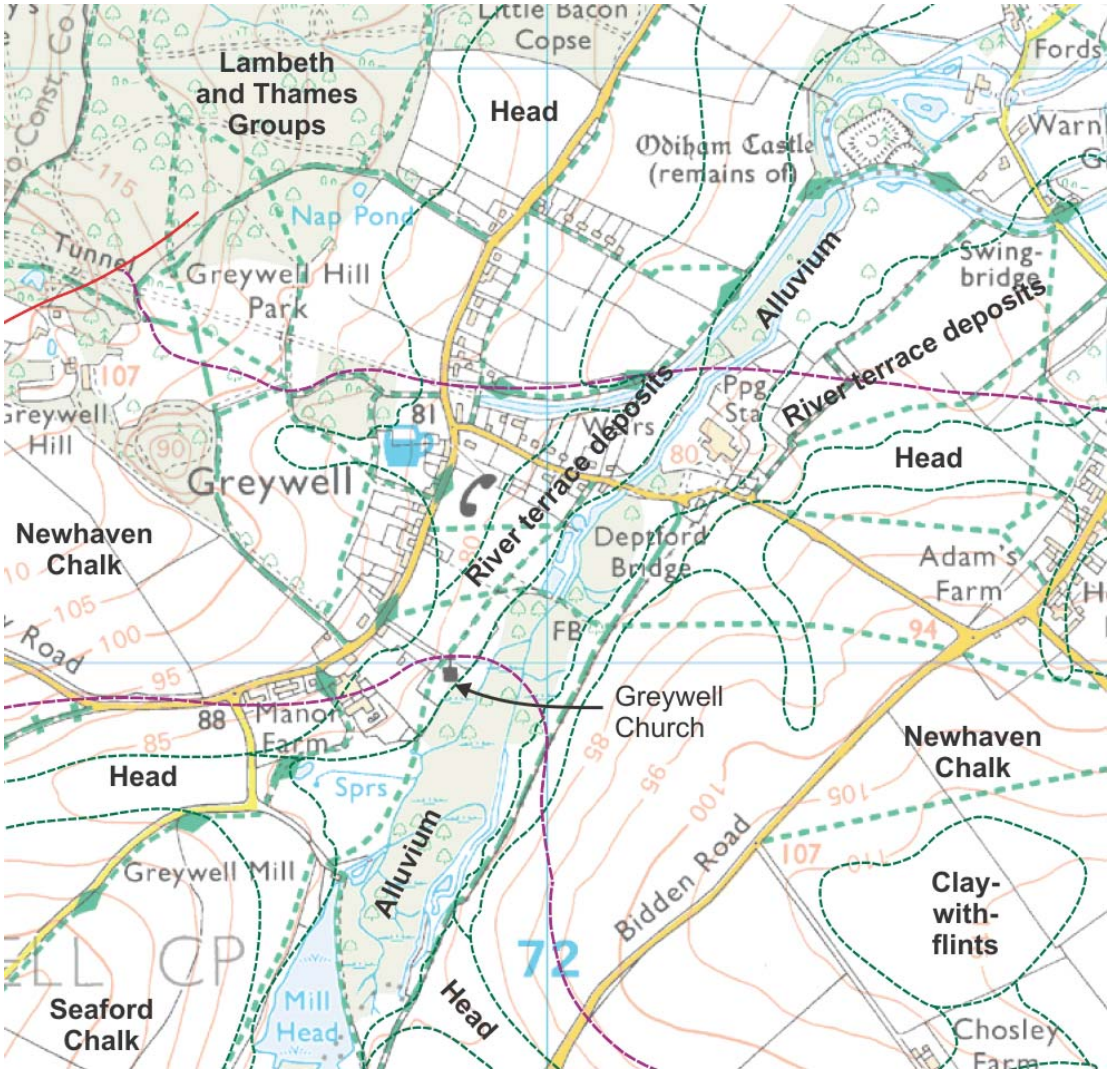

Figure 3. Revised geological line-work for the Greywell area superimposed on the OS 1:25 000 map. Base map ©Ordnance Survey; Licence No. 100021290.

2 Bedrock Geology

The bedrock geology of the Greywell area can be conveniently subdivided into three main units; the Late Cretaceous Chalk Group and the overlying Palaeogene Lambeth and Thames groups. The Chalk in the Basingstoke area can be subdivided into nine formations (Hopson, 2005; Aldiss et al., 2012), of which the Seaford and Newhaven Chalk formations occur around Greywell (Figure 4). The Lambeth Group is divided, in this area, into the Upnor and Reading formations. Locally, the basal Upnor Formation does not exceed a metre or so in thickness and has not been separated from the Reading Formation on the map. The Thames Group is represented by the London Clay Formation, with a thin basal Harwich Formation. Across much of the area, the bedrock geology is concealed by superficial deposits (mostly alluvial or solifluction deposits), particularly within the valley bottoms, but also across significant areas of the Chalk outcrop. In areas where there are thick or extensive superficial deposits, the bedrock geology is inferred from borehole data and the regional geological structure.

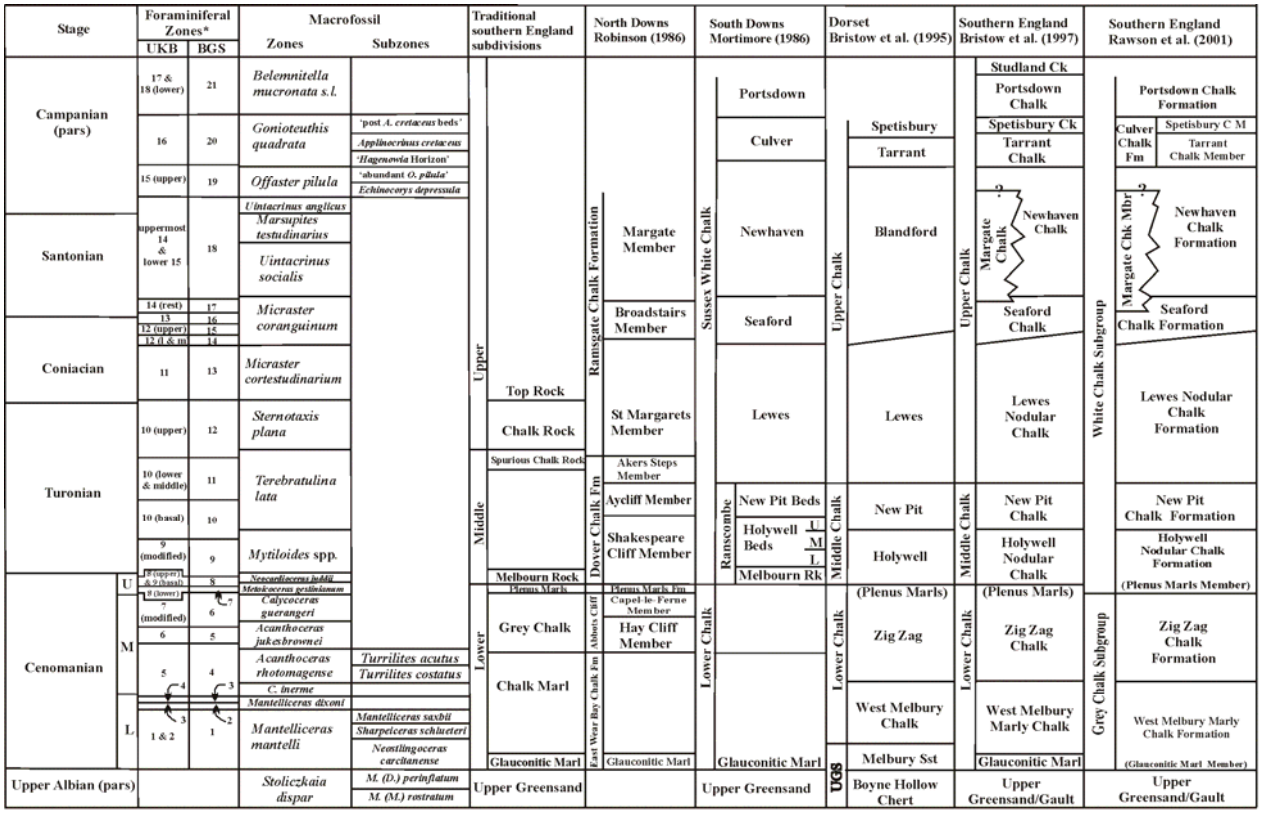

Figure 4. Summary of evolving stratigraphic nomenclature of the Chalk Group in England (Hopson, 2005).

2.1 SEAFORD CHALK FORMATION

The oldest bedrock unit in the Greywell area is the Seaford Chalk Formation. This is between 60 and 70 m thick, and crops out in the valley south of Greywell church. It underlies much of the Chalk dip slope between Greywell and Herriard. Topographically, the Seaford Chalk Formation forms the characteristic smooth convex downland slopes across much of the south-eastern corner of the Basingstoke sheet. It is composed primarily of soft, smooth, blocky, white chalk with abundant seams of large nodular and semitabular flint, and thin harder nodular chalk beds near the base (Aldiss et al., 2012). The flints in the lower part of the unit are often highly carious, whereas higher in the succession the flints are black and bluish black, mottled grey, with a thin white cortex. These flints commonly enclose shell fragments, particularly in the lower third of the unit. Some of the large flint bands, notably the Seven Sisters Flint (Mortimore, 1986) (15–20 m above the base of the formation), form almost continuous seams and in places create local topographical features. The Seven Sisters Flint is distinguished from other large flints by its significant inoceramid bivalve content of *Platyceramus* and *Volviceramus*, an association that is typical of the lower part of the Seaford Chalk. *Platyceramus* also occurs in the upper part of the Seaford Chalk, associated with *Cladoceramus* (Mortimore, 2011). Thin, planar, sheet flints, are also common in parts of the succession. It dips beneath the valley floor close to the church, but will occur at depth beneath the Greywell pumping station. Pits containing *Micraster coranguinum*, a fossil echinoid indicative of the Seaford Chalk, have been recorded at Manor Farm, Greywell [SU 7145 5094] and on the Bidden Road at [SU 7180 5005] (Brydone, 1912).

2.2 NEWHAVEN CHALK FORMATION

The Newhaven Chalk is up to 20 m thick in the Greywell district and crops out extensively over the eastern part of the Chalk outcrop, especially east of Odiham. It is well exposed in several old

pits in the Greywell area, especially in the old quarry just south of Odiham. It is composed of soft to medium–hard, blocky, smooth, white chalks with regular marl seams and flint bands (Aldiss et al., 2012). Typically, the marls vary between 1 and 10 mm thick. The flints are generally much smaller and less continuous than those in the underlying Seaford Chalk. Tabular and sheet flints are not so well developed, but small finger, horn and *Zoophycos* flint forms are more common (Mortimore, 2012). Channels with hardgrounds and phosphatic chalks occur locally in the succession elsewhere but none have been identified during the survey of this district.

Only the lower part of the Newhaven Chalk Formation is preserved beneath the basal Palaeogene unconformity, predominantly the *Uintacrinus socialis* and *Marsupites testudinarius* biozones. Faunas associated with these biozones have been recorded from several old pits in the Greywell area (Brydone, 1912; Woods, 2007), and these have been used to interpret the chalk lithostratigraphy of the area. *Uintacrinus socialis* occurs in an old pit near Adams Farm, 400 m south-east of the Greywell pumping station [SU 7261 5121], and is also recorded from a pit on the Nately road [SU 7083 5119] and the large quarry just south of Odiham.

2.3 LAMBETH GROUP

The Palaeogene succession preserved in the Greywell district is composed of the Lambeth Group, which rests unconformably on the eroded surface of the Chalk (Newhaven Chalk Formation), together with the succeeding Thames Group. The Lambeth Group corresponds to the strata formerly described as the Woolwich and Reading Beds. In this area, the Lambeth Group consists of two units, the Upnor and Reading formations (Ellison et al., 1994). Within the Basingstoke district, these two formations are not divisible in the field as only a very thin Upnor Formation is present. The basal part of the 'Woolwich and Reading Beds' (now known as the Upnor Formation) comprises green or reddish brown sand, or interbedded sand and clay with abundant rounded to well-rounded, stained flint pebbles with locally glauconitic, shelly, sandy clays and sands. This basal bed is usually less than 1 m thick in this area, at maximum up to 2 m in places, and marks an early Palaeogene marine transgression.

The Reading Formation consists predominantly of mottled, bright red and grey clay and silty clay and is 20 to 25 m thick. The complex mottling has been ascribed to pedogenic processes with multiple overprinting of palaeosols (Buurman, 1980). Lenticular bodies of well sorted, fine- to medium-grained sand occur locally at various levels, particularly at the top and base. The Reading Formation is not presently well exposed, but former brickyard sections are described in the Basingstoke memoir (Osborne White, 1909). Mottled clay was identified at several localities within the Greywell Hill Park and in North Warnborough. Fine to medium-grained brown sand is present in an old pit north of Odiham [SU 7376 5132], and was also observed in the canal cutting west of the Greywell tunnel.

2.4 THAMES GROUP

The Reading Formation is overlain by the London Clay, which consists mainly of a cyclic series of grey, pyritic, bioturbated clay and silty clay, with some fine-grained sandy silty clay with and clayey silty sand. A glauconitic sandy bed, representing the Harwich Formation, occurs at the base. The formation represents a return to fully marine deposition with each cycle commencing with a transgressive flint pebble bed passing up into silty clays and clays representing the high sea level and later channel sand representing a regressive phase. The formation is up to 100 m thick in adjacent parts of Berkshire. This unit, although noted in places, was not comprehensively mapped for this work.

3 Superficial Geology

The Greywell area is largely covered by superficial deposits, especially in and along the margins of the Whitewater valley, but also capping some of the interfluves. Soliflucted material derived from the Clay-with-flints also mantles many of the slopes, particularly around Odiham. Superficial deposits can be subdivided into several mapping units, which are described below. These are alluvial deposits (Alluvium and River Terraces), the Clay-with-flints, which caps some of the interfluves, and two units of Head (valley bottom and slope deposits).

3.1 ALLUVIAL DEPOSITS

The alluvium in the district comprises a complex interdigitation of four distinct lithologies; flinty sandy gravel (in places chalky), dark brown or black peat or peaty clay, pale grey silty fine- to medium-grained quartz sand, and fine-grained sandy clay. Much of the wet fenland either side of the Deptford Bridge consists of peat. Just north of the Greywell pumping station, hand augering indicates that the upper part of the alluvium consists of c. 0.5–1 m of peaty soil overlying grey fine- to medium-grained quartz sand. This is probably underlain by flint gravels. Boreholes at the pumping station suggest the alluvium is up to 10 m thick, with up to 3 m of peat overlying sand, clay and gravel, with many worn and rolled flints. Boreholes at Deptford Bridge indicate c. 1 m of chalky brown clay over 4 m of pebbly sandy clay. In general, the finer grained peaty lithologies overlie coarser flinty sandy gravels at depth, over highly weathered bedrock.

Along the valley sides, especially between Greywell and North Warnborough, the alluvium is bordered by a low river terrace c. 1 m above the floodplain. This river terrace deposit comprises fluvial sandy, chalky and flinty gravel. Along the inner margins of the terrace, the gravels are probably intermixed with solifluction material derived from the steeper valley sides, which consist of silty clay with some flint and minor amounts of chalk. The terrace feature merges upstream into valley bottom Head around 800 m south-west of Deptford Bridge.

3.2 CLAY-WITH-FLINTS

The Clay-with-flints is primarily a remanié deposit created by the dual actions of the weathering and erosion of the original Palaeogene cover and dissolution of the underlying Chalk. It is typically composed of orange-brown or reddish brown clays and sandy clays containing abundant flint nodules and pebbles. At the base of the deposit the matrix becomes stiff, waxy and fissured, and of a dark brown colour with relatively fresh nodular flints stained black and/or dark green by manganese compounds and glauconite. It is most widespread on the high ground and interfluves underlain by the Newhaven Chalk Formation south of Odiham. This deposit was mainly mapped on the basis of its characteristic reddish brown sticky clayey soil with nodular, often stained (orange), flints.

3.3 HEAD

Head (Ch) is a heterogeneous assemblage of superficial deposits that have accumulated by solifluction, hillwash and hillcreep and which is generally confined to valley bottoms and the lower slopes of valley sides. In general, head comprises an assemblage of pale yellow-brown, silty, sandy flinty gravel. The gravel/clay content varies depending on the local bedrock source and is noticeably more sandy or contains an abundance of well rounded flint pebbles where material is derived from areas with a Palaeogene cover. Similarly, head derived from Seaford Chalk is more gravelly with many fresh large nodular or broken angular flint shards, sometimes in a chalky matrix.

Most of the dry valleys on the Chalk have a head deposit covering the valley floor. This is usually thickest and most prevalent in the lower reaches of the dry valley network, where the gradient lessens markedly, and can be absent where the valley is narrow or steep. In many cases, the lower limit of the head deposits occur at the highest springhead, below which the deposits are usually mapped as alluvium. Head deposits also mantle the lower slopes either side of the Greywater valley upstream of Deptford Bridge. Here, several metres of flinty, pebbly sandy loam, sometimes with some chalk fragments, have accumulated on the lower valley slopes.

Head is very rarely exposed, and due to the considerable flint content cannot be penetrated with a hand auger. The thickness of most head deposits in the area is therefore unknown. Borehole records suggest that the head is mostly less than 2 m in thickness, but could locally attain 4 m or more in the downstream ends of the larger dry valleys. Large parts of the area shown as chalk bedrock with no overlying superficial deposit may carry a thin, extensive, but discontinuous blanket of head or flinty clay soil less than metre thick.

A distinct, separate unit of solifluction deposits, mapped as Head 1(Ch1), occurs on some slopes and is associated with the solifluction and down-slope movement of the Clay-with-flints. These slope deposits range from flinty gravels to reddish brown, sandy clays containing abundant flint nodules and pebbles that are generally much more shattered than those in the Clay-with-flints from which the unit is directly derived. The lithology is strongly dependant on the lithology of the parent deposit. Several large sheets occur in this district, generally no more than a few metres thick. The deposits are most widespread on north- and east-facing slopes on the Chalk dip-slope south of Odiham, and commonly grade laterally into areas with only a thin flinty veneer or spread down to the valley bottom where they merge into valley bottom head, fluvial river terrace deposits or alluvium. Between Odiham and North Warnborough these slope deposits consists of a fine-grained silty, sandy, sometimes flinty, clay which extends out onto the Palaeogene outcrop. Consequently between the Whitewater valley and Odiham, the Chalk-Palaeogene contact is largely obscured.

4 Geological Structure

The geological structure of the Greywell area is relatively simple, although the mapping has indicated some local structural complexity. The Chalk is observed to dip at between 4 and 6° to the north-north-east. A northward dip of 6° is recorded from an old pit on the Nately road [SU 7083 5119], whilst 700 m to the south-east, chalk exposed in an old pit at Manor Farm [SU 7145 5094] has a dip of 4° to the north-north-east. The large quarry south of Odiham has a dip of 4° to the north. However, evidence from boreholes suggests the dip increases to the north, reaching a maximum approximately along the Chalk–Palaeogene boundary or a short distance to the north, before levelling out within the London Clay Formation. A dip of approximately 18° is inferred from the depth of the Chalk in a borehole at Hatchwood House [SU75SW 96 at SU 7478 5117], and 16° from the outcrop pattern of the London Clay Formation around Dogmersfield Park [SU 7651]. However, considerations of the outcrop patterns around North Warnborough and Greywell Hill Park suggests the severity of the flexure decreases westwards, and around Greywell Hill Park the dip is less, around 10° to the north-north-east. No observations of the dip were obtained from the Palaeogene strata, but the outcrop patterns suggest dips drop to less than 5° towards Hook.

There are no mapped faults on the existing Basingstoke 1:50 000 scale geological map sheet (284). However, the existence of an old chalk pit at [SU 7128 5166] and the observation that the collapsed western end of the Greywell Canal Tunnel is in clay suggests that a north-east–south-west orientated fault downthrows the chalk to the west a short distance to the north-west of Greywell Hill House. It is possible that similar, smaller minor faults may influence the orientation of the Greywater valley, but with the available evidence, it is not possible to prove

this. A minor fault with a down-throw of a few metres to the south is visible in the old quarry south of Odiham, but not is traceable outside the quarry.

5 Conclusions

Revised geological mapping of the Greywell area suggests the Chalk–Palaeogene contact lies approximately 100-150 m north of the Greywell pumping station, which itself is located on the lowest of a series of chalk springs. The old geological map is shown to be inaccurate by borehole records that indicate that Chalk is at rock-head beneath the pumping station. As the bedrock in the valley is buried by up to 10 m of superficial deposits, the actual location of the contact cannot be determined with any greater precision and its position shown in Figures 3, 5 and 6 must be viewed as conjectural. Moreover, the thickness of the valley fill, which is not known exactly, will partially determine the location of the contact at rock-head. Similarly the position of the Chalk–Palaeogene contact east towards Odiham, although reasonably well defined, must also be viewed as conjectural given the thickness and extent of the superficial deposits.

The dip of the bedrock beneath the Greywater valley is thought to steepen from c. 4° (to the north or north-north-east) south of Deptford Bridge, to more than 10° within the Palaeogene north of the bridge, before levelling out to less than 5° within the London Clay. The paucity of good boreholes or borehole records in this area means that the geological structure cannot be determined any more accurately by mapping alone. To constrain the location of the Chalk-Palaeogene contact further, or to improve the understanding of the geological structure, then it will be necessary to drill a series of shallow boreholes through the superficial deposits.

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British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: http://geolib.bgs.ac.uk.

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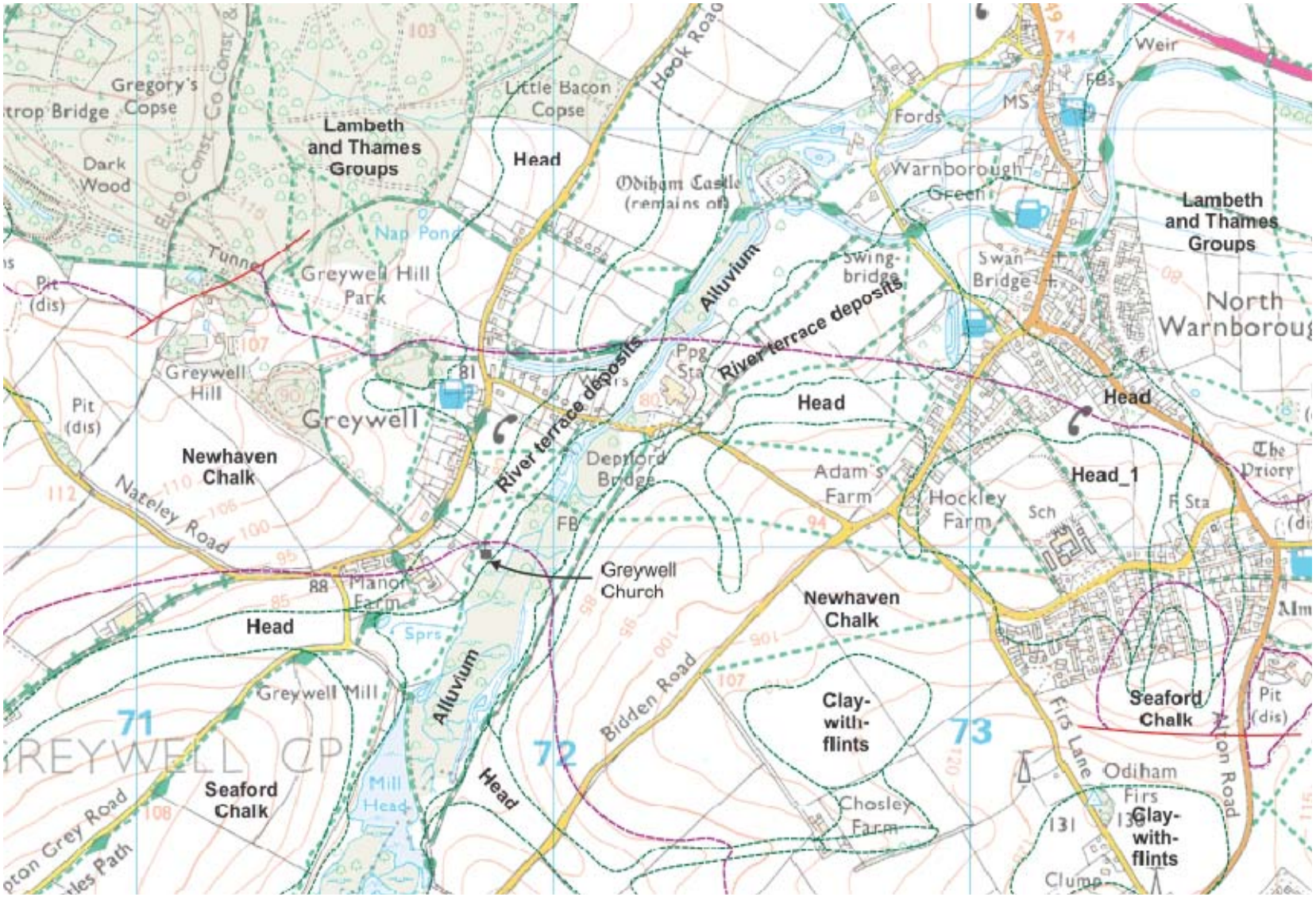

Figure 5. Revised geological map of the Greywell-Odiham area. Base map ©Ordnance Survey; Licence No. 100021290.

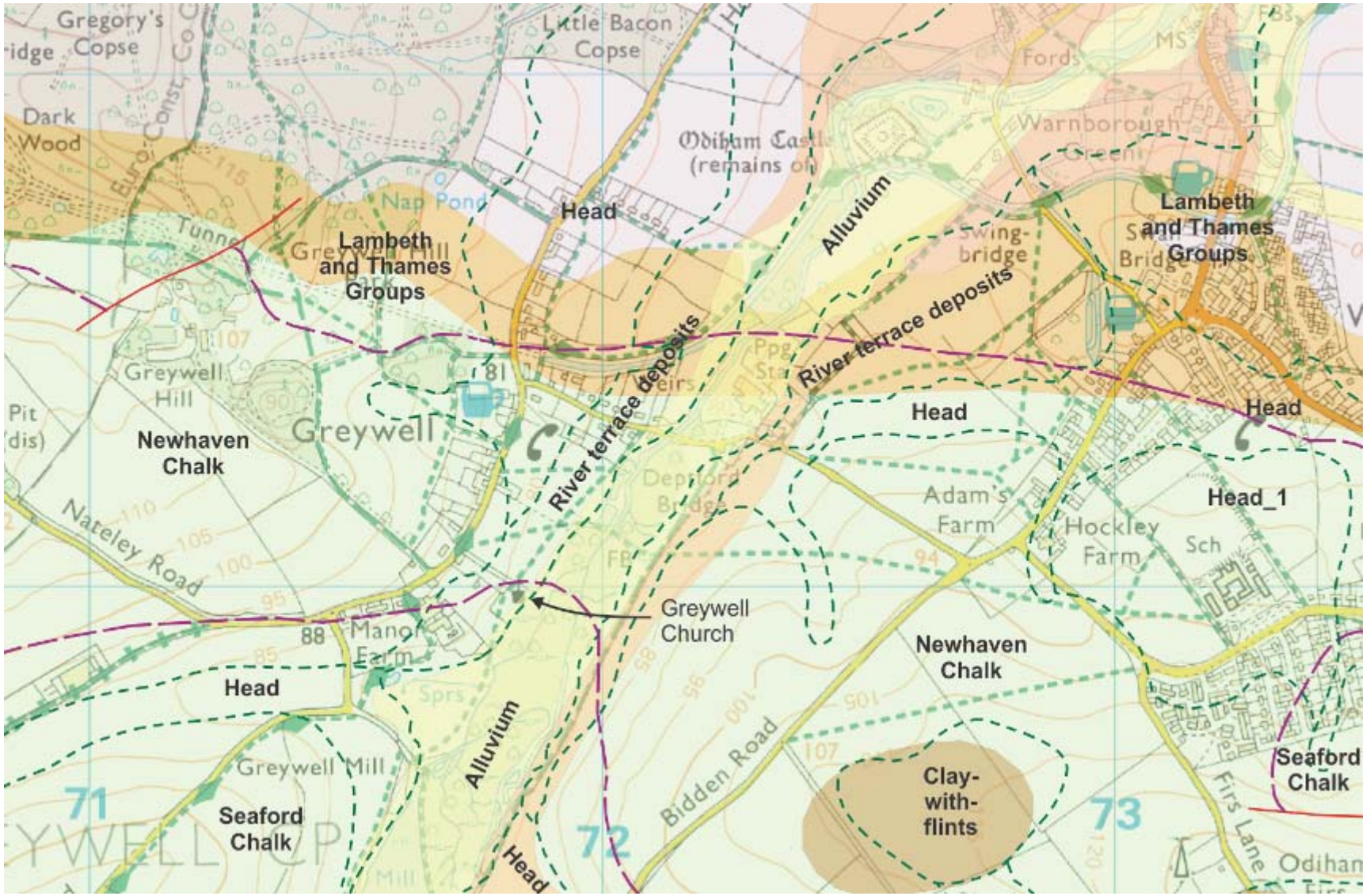

Figure 6. Revised geological map of the Greywell-Odiham area (as per Figure 5) superimposed on the published geological map. Base map ©Ordnance Survey; Licence No. 100021290.