THE GEOLOGY UNDERLYING THE LOWER CHESS VALLEY
& WHY THE LOSING REACH LOSES WATER.

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River Chess
Smarter Water
Catchment

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1. INTRODUCTION

The River Chess flows between two urban environments, to the northwest it starts just above the town of Chesham, then flows through a rural environment of small arable and livestock farms until it reaches Rickmansworth where the Chess joins the River Colne.

The lower Chess valley carries a generally west to east flowing river with a pronounced dog leg right around village of Sarratt. The river has been used historically to power a sequence of mills, starting in Chesham, and spaced intermittently all the way down to Rickmansworth. None of these mills are working today, but most of the structures are still in place. In addition to harnessing the power of the river for milling activity, historically there was always a thriving watercress business along the whole length of the river. The use of the river for these purposes has meant that it has been highly altered over the centuries with only a few isolated areas where the river still flows along its natural channel. With the exceptions of Chesham, Loudwater and Rickmansworth, there is little in the way of domestic housing close to the river.

The valley is typical of the Chilterns and is asymmetric (Catt & Cheshire, 2010) and conforms to this with a steep sided north facing slope and a more gentle south facing slope. Most of the valley bottom is farmed, mainly for grazing livestock. There is one farm at Sarratt that occasionally produces watercress, but sewage discharges have made production problematic. The sides and tops of the valley are mainly used for our arable farming and woodland. In recent years arable farmland has converted to grassland for grazing and hay production.

The woodland is historically connected to furniture production, which once was a mainstay of the Chiltern area. There are ancient woodlands featuring the iconic tree of the Chilterns, the Beech; this shallow rooted tree thrives on chalk. The ancient woodlands also include ash and oak. There are a number of woodlands that have been relatively recently planted with conifers and a variety of hardwood trees. These woods are regularly harvested, with timber being transported to be processed away from this area. The woodland is home to the nationally scarce coralroot bittercress.

The valley bottom has evidence of several water meadows, especially between the villages of Latimer and Sarratt. These meadows would be regularly flooded in springtime to encourage early grass growth and allowing the graziers to get their livestock to market earlier than the competition, thereby securing the higher prices. None of these water meadows function today, but many of the structures are still in place and the outline of the field channel patterns can be seen clearly, especially in high groundwater years. These meadows support a wide variety of wild plants that thrive in damp conditions, including meadow sweet, lady's smock and various sedges. Along the valley bottom we see water loving trees such as willow, alder and poplar. In certain locations bat willow is farmed to supply the cricket bat industry. There are areas of the valley bottom where deep layers of peat occur.

Little has changed in the valley over the past century, just a passive decline in traditional farming and milling activity, giving over to the equestrian industry and public recreation. One of the area's best walks runs the length of valley. Its popularity being enhanced by good public transport links via the Metropolitan and Chiltern railway lines.

Early indications that the lower reaches of the Chess River might be prone to low water flow and potential water loss were initially reported by the Environment Agency in 2006, although at that stage the low flows were indicated to be result of abstraction at the Chorleywood Pumping Station (Kidney, 2006).

Increased monitoring of the lower Chess following the introduction of additional flow meters has confirmed this reduced flow south of Valley Farm Ford (Water cress beds). The present study was established by the River Chess Smarter Water Catchment team in order to:

i develop & improve an understanding of the losing reach of the Chess, where water levels change through surface and groundwater interactions.

ii review the influence of the underlying geology and abstraction on flows in this reach, to evaluate the causes of flow loss through this stretch of the river.

In order to fulfil the aims outlined above, a desk-based study has been carried out on the subsurface geology of the lower Chess valley, which has been enhanced by a series of investigatory walks along the river side between Latimer Bridge and the Scotsbridge Mill, Rickmansworth. These walks were carried out between October 26th, 2023, and December 2nd, 2023.

2. ABSTRACTION IN THE LOWER CHESS

The key abstraction point on the lower Chess is the Affinity Water Chorleywood Pumping Station (Public water Supply/PWS) immediately to the west of the river, south of Sarratt bridge (TQ935076). Key borehole data examined from this location indicates that abstraction boreholes reached total depth still within the New Pit Chalk Formation (Veolia, 2003).

The Environment Agency report on the Chess (Kidney, 2006) regarded the loss of flow in the lower Chess as probably being the result of the abstraction at Chorleywood as they state in their conclusions:

> "6. Accretion profiles also suggest that there is a loss in flow beyond Sarratt, this may be linked to the impact of pumping from Chorleywood PWS."

They have little data to confirm this, and they go on to say that:

> "However, increased monitoring and investigations would be required to confirm a relationship.".

Given the need to assess the impact of this PWS it is worth noting at this stage that the licence controlling abstraction at this location limits daily withdrawal of water at just above nine megalitres per day and it is clear from Affinity Water data and Environment Agency monitoring that this rate is never exceeded (see Figure 1).

Given this abstraction evidence for the Chorleywood PWS we have to compare this with the estimates we have for the fall in flow rate over the losing reach between Latimer and the Rickmansworth gauging station. It is extremely unlikely that the abstraction at Chorleywood is the key element in surface river flow as the open borehole section is within the lower part of the New Pit Chalk Formation, which is likely to hinder vertical water movement within the chalk because of the number of laterally extensive marl seams there are present within this formation.

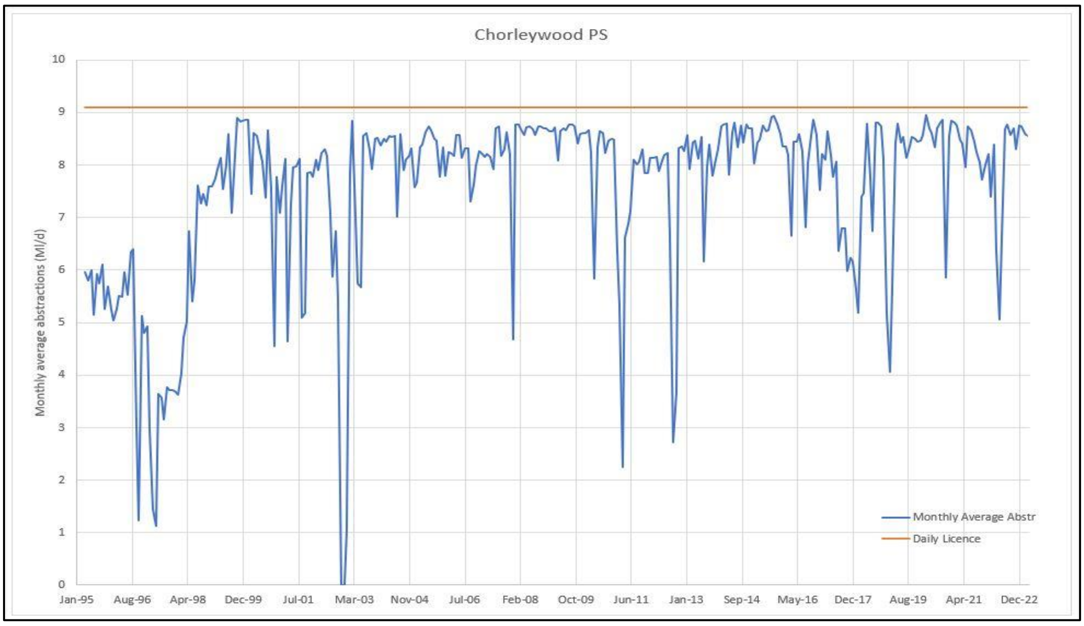

Fig. 1: Monthly average abstraction at Chorleywood Pumping Station, plotted with the daily licenced abstraction for comparison (Courtesy Affinity Water).

We have data for the flow rates through the lower Chess River initially on the basis of gauging stations at Latimer, Valley Ford (Watercress Farm), Solesbridge Mill and Rickmansworth. These were used by Affinity Water when they plotted flow rate between June and November 2023 (see Figure 2).

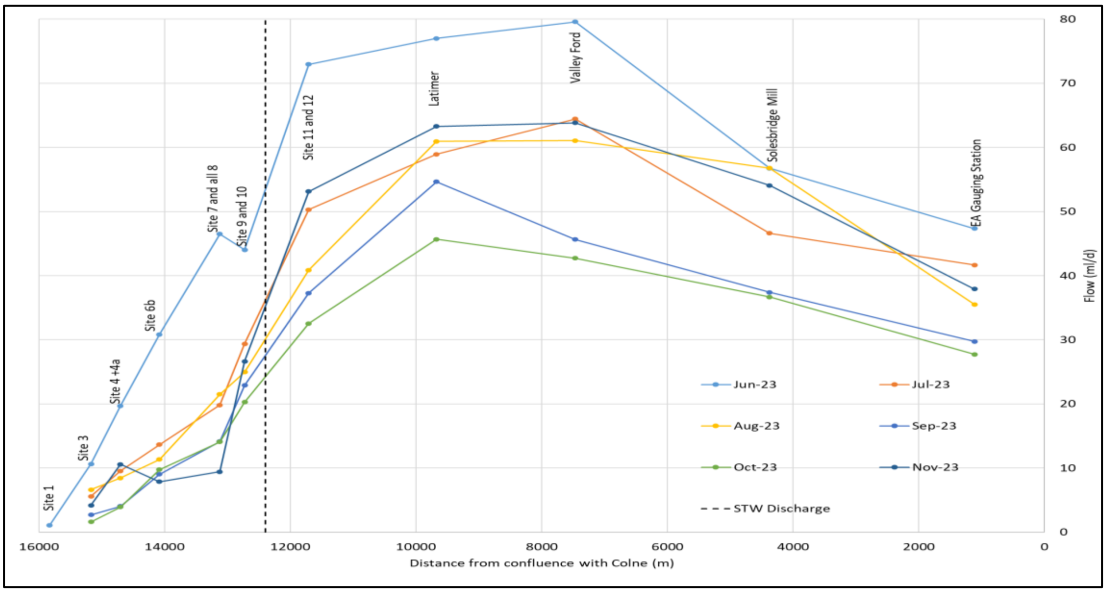

Fig. 2: Flow rates for the Chess River (focussing on the lower Chess) during the second half of 2023 (Courtesy Affinity Water).

It is clear in Figure 2 that flow rates are still rising downstream as far as Latimer regardless of which month's data is used. There is some evidence (June flow measurements) to indicate that rates are still rising as far downstream as Valley Ford. Simply subtracting the Rickmansworth rate from the Valley Farm rate gives some indication of the flow loss in the lower reach of the Chess.

June 2023	10.4 ml/d
July 2023	18.2 ml/d
August 2023	25.8 ml/d
September 2023	22.7 ml/d
October 2023	15.5 ml/d
November 2023	24.0 ml/d
Average	19.3 ml/d

On the basis of these figures, there is no way that the flow rate loss within the lower Chess can be wholly attributed to abstraction at the Chorleywood PWS. The average daily loss is too great to be accounted for by abstraction which is always less than 9 Ml/d.

Natural water loss into the subsurface geology is the obvious alternative and it is most likely that there is subsurface flow downdip towards the Colne valley and into the chalk aquifer of the London Basin.

3. REGIONAL GEOLOGICAL HISTORY

The geological history of the Chess valley goes back much further than many people realise (at least 1.5Ma) and consequently the subsurface geology has undergone the impact of a series of major climatic changes through time. These Pleistocene, ice age, events have impacted on the Chess valley and how the river connected, first to the Proto-Thames River and subsequently with the River Colne.

All these events have been summarised on Figure 3 of this report and an attempt is made here to provide a narrative behind these events.

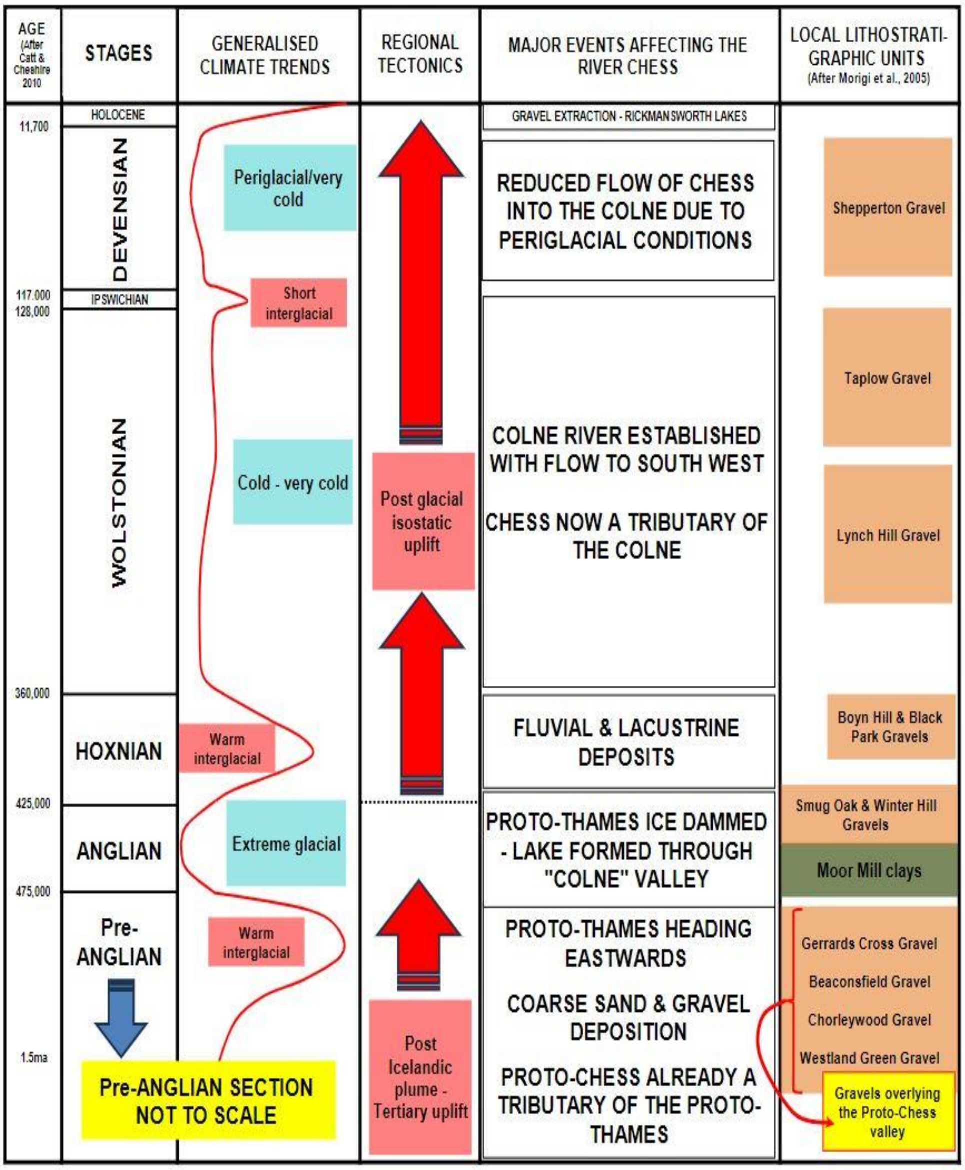

Figure 3: Summary diagram of Pleistocene geohistorical events affecting the region of the Chess valley

3.1 Proto-Thames

Prior to the Anglian Glaciation (475,000 - 425,000 years ago) a major river flowed through south-east England referred to generally as the Proto-Thames. From approximately the location of modern-day Marlow, this river flowed north eastwards, passing over the location of modern-day Beaconsfield, then on between the locations of Amersham and Rickmansworth and onwards through the Vale of St. Albans. This route took the Proto-Thames over what would eventually become the lower reach of the Chess valley.

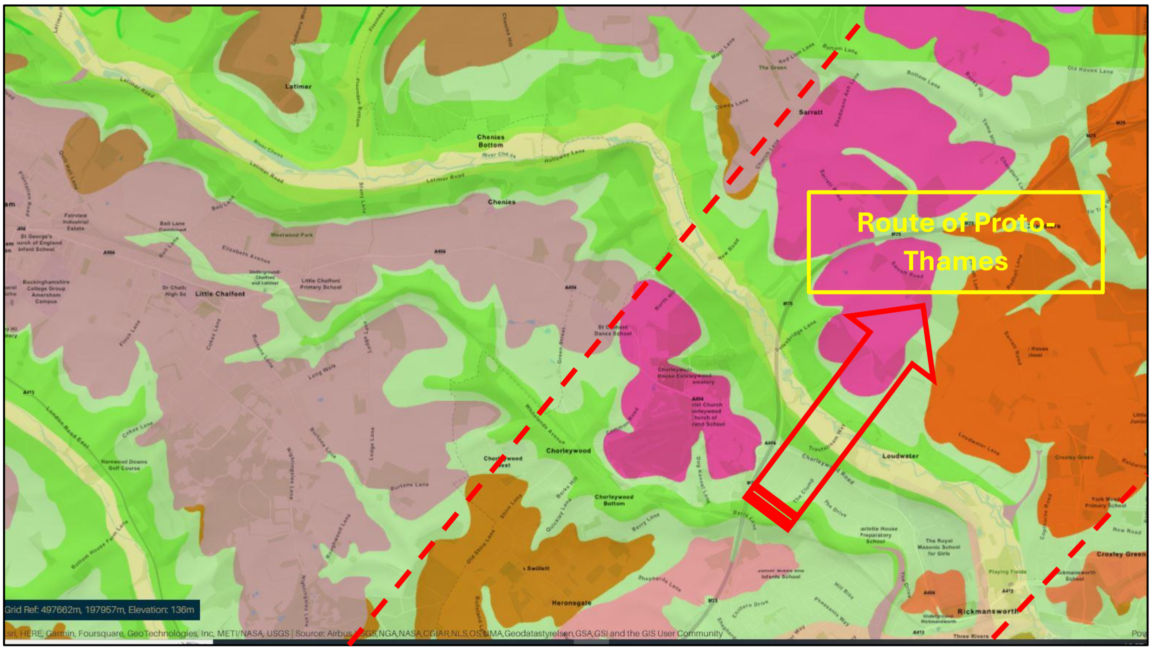

Figure 4: Current distribution of Quaternary deposits resulting from Proto-Thames terrace gravel deposition. Proto-Thames passed directly over the line of the lower River Chess. Base map from BGS digimap. Key: Beaconsfield Gravels Chorleywood Gravels Gerrards Cross Gravels.

Being a major river, the Proto-Thames carried with it huge loads of coarse sands and gravels which were deposited as a series of terrace gravels, the oldest of these affecting the area through which the Chess will eventually pass is the Chorleywood Gravel. Other gravels deposited over the route of the future lower Chess include the Beaconsfield Gravel and the Gerrards Cross Gravel (Morigi *et al.,* 2005). The locations of these deposits as they are currently recognised are shown in Figure 4.

The route of the Proto-Thames takes it through the Vale of St. Albans and on north eastwards, across the southern part of East Anglia and finally into the southern North Sea (see Fig.5, taken from Belshaw *et al.,* 2014).

Figure 5: Major river drainage pattern, pre-Anglian Glaciation. Note the presence of northern tributaries flowing into the Proto-Thames from the Chilterns (Belshaw et al., 2014).

It is impossible to say what the full impact the presence of a major river such as the Proto-Thames had on the underlying chalk substrate as it flowed over it, particularly during a period of extreme climate changes. This would have included innumerable freeze-thaw cycles both during the Anglian glaciation and the subsequent peri-glacial cold period of the Devensian Stage.

Any precipitation draining through the pre-Anglian sands and gravels would inevitably become mildly acidic and as such would have caused long-term erosion of the underlying chalk. Karstification of the chalk in the area of the Chess valley is regarded as being inevitable during this period. It is worth noting that the creation of the present-day Chess valley has caused the erosion of a considerable amount of sands and gravels in the immediate vicinity of the valley as well as the erosion of the chalk which created the valley itself. Karstification structures, such as swallow holes, which may have been created during this initial period of erosion have subsequently been lost, however the continued existence of the subsurface structures that they were associated with cannot be ruled out.

3.2 Anglian Glaciation

The Anglian glaciation was the period during which glacial ice sheets penetrated the furthest south into southern England. Thick ice sheets were present as far south as Hornchurch in Essex and Finchley. In the Vale of St. Albans, the Proto-Thames river was blocked by thick glacial ice sheets and water backfilled the Proto-Thames valley south westwards towards Marlow and Slough forming a major glacial lake (Moor Mill Lake). If there was any flow through the Chess valley during this freeze/thaw dominated period, then it would have contributed to this lake.

3.3 Post Anglian Climate Impact

In the immediate aftermath of the Anglian glaciation the water flow through the Proto-Thames valley was reversed and the Thames River now followed a new route from Slough eastwards following the Thames valley route we recognise in the present day. Consequently, water flow through the existing valley had also been reversed and the newly established Colne River flowed from the south of St. Albans south westwards until it reached a confluence with the Thames at Staines.

The northern Chiltern tributaries, which had previously flowed into the Proto-Thames now contributed to the river Colne, these including the Ver, Gade, Bulbourne, Chess, Misbourne and Wye. Regional uplift of the Chiltern region continued, largely as a result of post-glacial isostatic rebound, and the Chess now flowed across ground previously occupied by the Proto-Thames, passing across and eroding through the "Thames" gravel terraces which were spread over the top of the chalk in the region. This interpretation would imply that the postglacial uplift created, in essence, perched valleys with consequent high erosion flow systems induced by the change in base level, with consequent accelerated karst erosion and river capture.

From post-Hoxnian times (360,000 years ago) until the start of the "modern day" Holocene period we have effectively 350,000 years of cold peri-glacial climatic conditions, punctuated by relatively short warmer inter-glacial times (Ipswichian 117,00 – 126,000 years bp). During this considerable time span the lower reach of the river Chess eroded through and removed sediments belonging to the Chorleywood Gravels, the Beaconsfield Gravels and the Gerrards Cross Gravels. Each of these sand and gravel rich lithological units would have potentially caused any precipitation to acidify and subsequently cause dissolution in, and of, the underlying chalk.

The Devensian period (117,000 – 11,700 bp) is known widely as the "Last Glacial Maximum", although in England glacial conditions reached no further south than north Norfolk, the south Midlands and South Wales (Catt & Cheshire, 2010). In the Colne valley and the Chiltern northern tributary valleys, any deposition would have been entirely periglacial in origin. There is very strong evidence indicating that cold and warm periods alternated during the Devensian (Mitchell *et al.,* 1973), so again there would have been cyclic freeze/thaw conditions throughout the region, frequently at a diurnal level.

3.4 Conclusions

The formation of what has been referred to herein as the Proto-Chess river valley during the pre-Anglian period is one of the key elements of the present report. The origin of the river Chess and the erosion of the current valley system is a result of the conditions that existed through this critical time span.

Given the geological history that the area, now referred to as the lower Chess losing reach, has undergone during the last million years, it must be expected that the underlying chalk sediments have been structurally damaged consequently.

There was ample time for the creation of a subsurface karstic system within the underlying chalk and for elements of this to be eroded away during uplift and the associated formation of the lower Chess valley.

4. CHALK FORMATION STRATIGRAPHY

4.1. Chalk formations

The Chess valley is underlain by Upper Cretaceous Chalk, originally deposited between 89 and 92 million years ago. Whilst the Chalk of southern England can be divided into nine different lithostratigraphic formations only two of these occur beneath the losing reach of the lower Chess valley; these units are the lower part of the Lewes Nodular Chalk Formation and the upper half of the New Pit Chalk Formation. The uppermost valley sides of the Chess comprise younger chalk of the topmost Lewes Nodular Chalk Formation and the basal Seaford Chalk Formation. However, these units no longer have any impact on the losing reach of the Chess and descriptions of them have therefore been omitted herein.

4.2. Lewes Nodular Chalk Formation

The Lewes Nodular Chalk has very different characteristics to those of the underlying New Pit Chalk. The Lewes Nodular Chalk Formation comprises “a hard nodular chalk, with conspicuous regularly developed flints, thin marls and hardgrounds” (Morigi et al., 2005). The hard nodular chalks occur as a series of condensed hardgrounds, principally the Chalk Rock hardground and the slightly higher Top Rock hardground (both part of the Kensworth Member (Hopson et al., 1996), both of which occur on the valley flanks of the Chess losing reach. These beds are extremely hard and were often used as quarry floors in old quarry workings locally. The typical succession seen throughout the Chiltern region, with minor variations in thickness, is that recorded at Kensworth Quarry (See Figure 7). The distinctive Chalk Rock unit (see Fig. 6), where it occurs along the flanks of the Chess valley, creates an obvious break in slope which is easily recognised and mappable along the valley sides (see Figure 6).

Figure 6: Example of Chalk Rock hardground unit, Kensworth Quarry, Dunstable, showing complex of open *Thalassinoides* burrows.

The Lewes Nodular Chalk Formation has been described as “characteristically hard, nodular, locally iron stained and flinty. Marl seams, up to 0.1m thick, occur throughout. Hardgrounds occur locally, and at least some of the thickness variation in the Lewes Nodular Chalk may be caused by condensed sequences or depositional breaks at these horizons. Layers of flints are regularly spaced throughout the succession, ... at some horizons these flints almost interlock to produce laterally continuous bands” (Bailey, 2023).

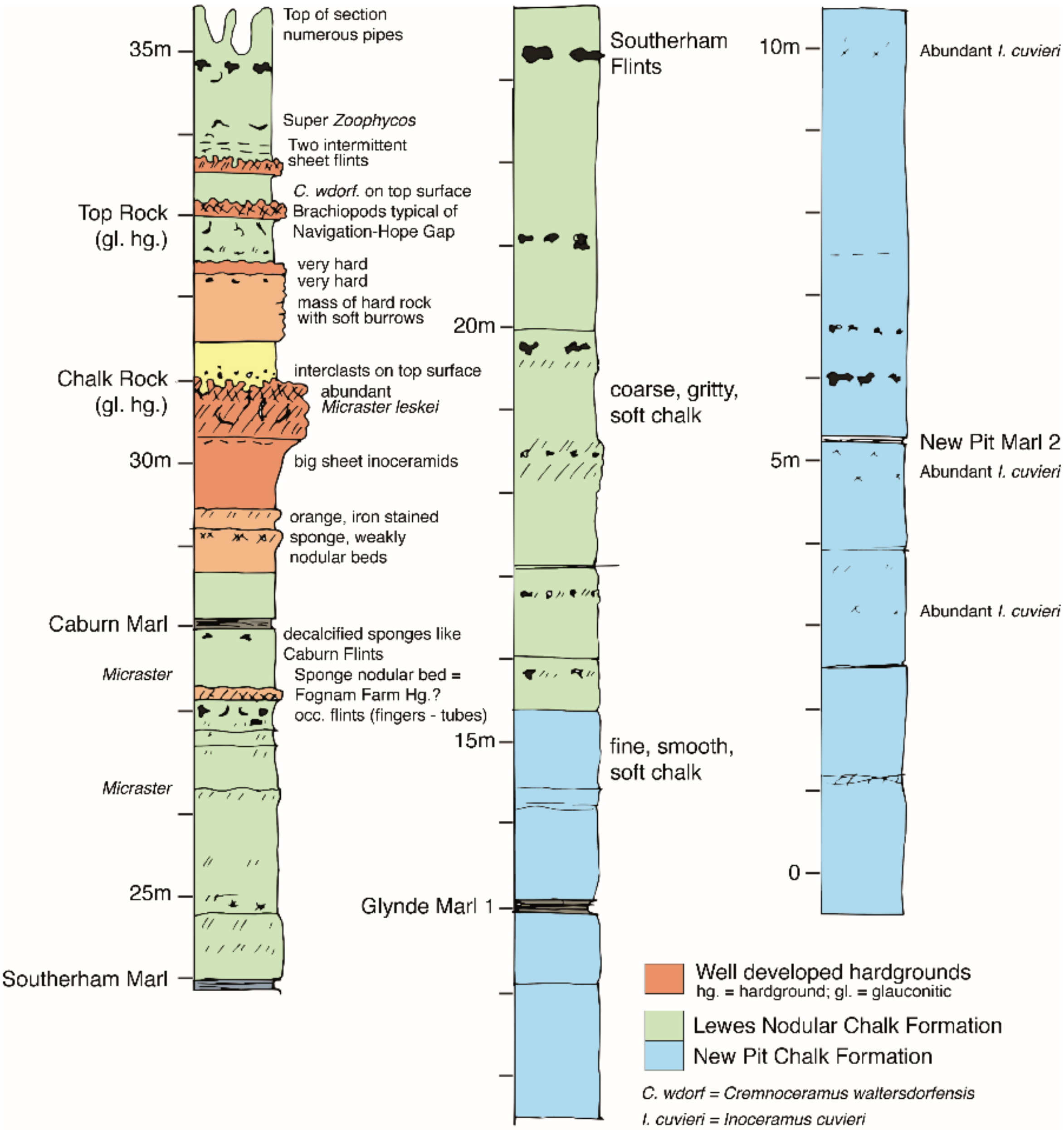

Figure 7: Kensworth Quarry section, Dunstable (Bailey & Wood, 2010), illustrating the marl rich, flint poor, New Pit Chalk Formation and the overlying Lewes Nodular Chalk Formation, with increased flint content and capped by thick indurated chalk beds (Chalk Rock unit).

Joint systems are not as common in the Lewes Formation as the distinctive sets recognised in the underlying New Pit Chalk Formation and the "well developed nodular chalk seams are interbedded with extremely soft to very soft chalks. Because of this variation in competency between layers the more brittle hardgrounds tend to be more densely fractured, presumably as the result of differential compaction" (Mortimore, 2021, Bailey, 2023). This variation may well account for the lack of overt fracture systems in the Lewes Nodular Chalk Formation, although widely spaced conjugate joints are noted in this formation.

The hardgrounds represent a series of fossilised sea floors, approximately 90 million years old, which combine in some locations to create an important mapping feature within the Chalk forming a break in the local topography.

4.3. New Pit Chalk Formation

The New Pit Chalk Formation is described as a "massively bedded, non-nodular chalk, with fairly regularly developed marl seams and sporadic flints" (Morigi et al., 2005). It is the presence of the marl seams which characterises this unit, as these calcareous clay seams, frequently between 1cm and 10cm thick, are extremely widespread, being recognised across the whole of southern England and in a number of cases even across into northern Europe (Wray & Wood, 1998).

The New Pit Chalk has been described as "smooth textured and more massively bedded" with "Marl seams and marly chalk horizons, up to 0.1m thick, which are common throughout" (Mortimore, 2021, Bailey, 2023).

The most complete New Pit Chalk Formation section in the Chiltern area is that exposed in Kensworth Quarry near Dunstable (NGR TL015197). In the original description of this quarry 15 metres of New Pit Chalk Formation were described (see Figure 7); subsequent additional excavation by the quarry owners plus measurements at the Baldock bypass excavation have proven that double the amount of this formation is present along the line of the Chilterns. Forty-two metres of New Pit Chalk Formation are recorded in boreholes in the London Basin.

Figure 8: New Pit marly chalk exposed in the temporary cutting for the Weston tunnel, Baldock bypass (TL259339). Note lack of flints common marl seams and common minor joints.

In addition to the characteristic marl seams and relatively low flint content, it is also important to recognise the distinctive fracture system frequently logged in the New Pit Chalk Formation. These are frequently recorded as “inclined conjugate fracture systems” (Mortimore 2021) and have been recorded at Kensworth Quarry, at an angle of approximately 60^o (Bailey, 2023). These fractures are key to the permeability of the New Pit Chalk, as water flow at depth will be concentrated along these structural lines.

The New Pit Chalk Formation is a major part of the Chalk aquifer because of the concentration of fractures present; it also forms the bedrock beneath the River Chess from above Amersham downstream to the Loudwater estate, i.e. throughout the majority of the losing reach.

5. STRUCTURE

5.1 Structure in the Chalk

Close examination of the relatively recently published geological map covering the Chess losing reach i.e. Sheet 255 Beaconsfield map, together with the associated explanation (Morigi *et al*., 2005) shows almost zero structure, with no faults or folds indicated within the chalk. There are few faults marked on this map and little evidence to indicate any underlying structure. It is generally recognised that the Chalk dips regionally by a few degrees to the southeast into the London Basin. More recently, work by the British Geological Survey (BGS) has established the existence of very low angle southwest – northeast trending folds in the Chiltern Chalk (Farrant *et al.,* 2019).

Geological mapping of the Chiltern river catchments by the BGS over the last 12 years, together with work resulting from the HS2 Ground Investigations, has updated our understanding of structures present in the underlying Chalk. It has become much more apparent that many of the river valleys and dry valleys in the Chilterns have underlying structure (faulting and associated jointing) which has enhanced their erosional history (Bailey, 2020).

Farrant *et al*. (2018) established NNW-SSE trending faults underlying the Misbourne valley, truncated to the south by the NE-SW trending Old Amersham fault. This fault also has a second subparallel fault present just to the south, the Quarrendon fault, which also trends NE-SW. These were illustrated in the recent description of the geology around Chalfont St. Giles by Marsh (2023).

BGS mapping between the Misbourne and Chess valleys has not established any major lines of faulting in the latter (Farrant*, pers. comm*.), although it is extremely tempting to suggest that a north easterly continuation of the Quarrendon Fault could well account for the unusual dogleg in the Chess valley. Marsh (*op.cit*.) notes the orientation of the high number of dry valleys in the Chiltern area and suggests that these could be following structural lines.

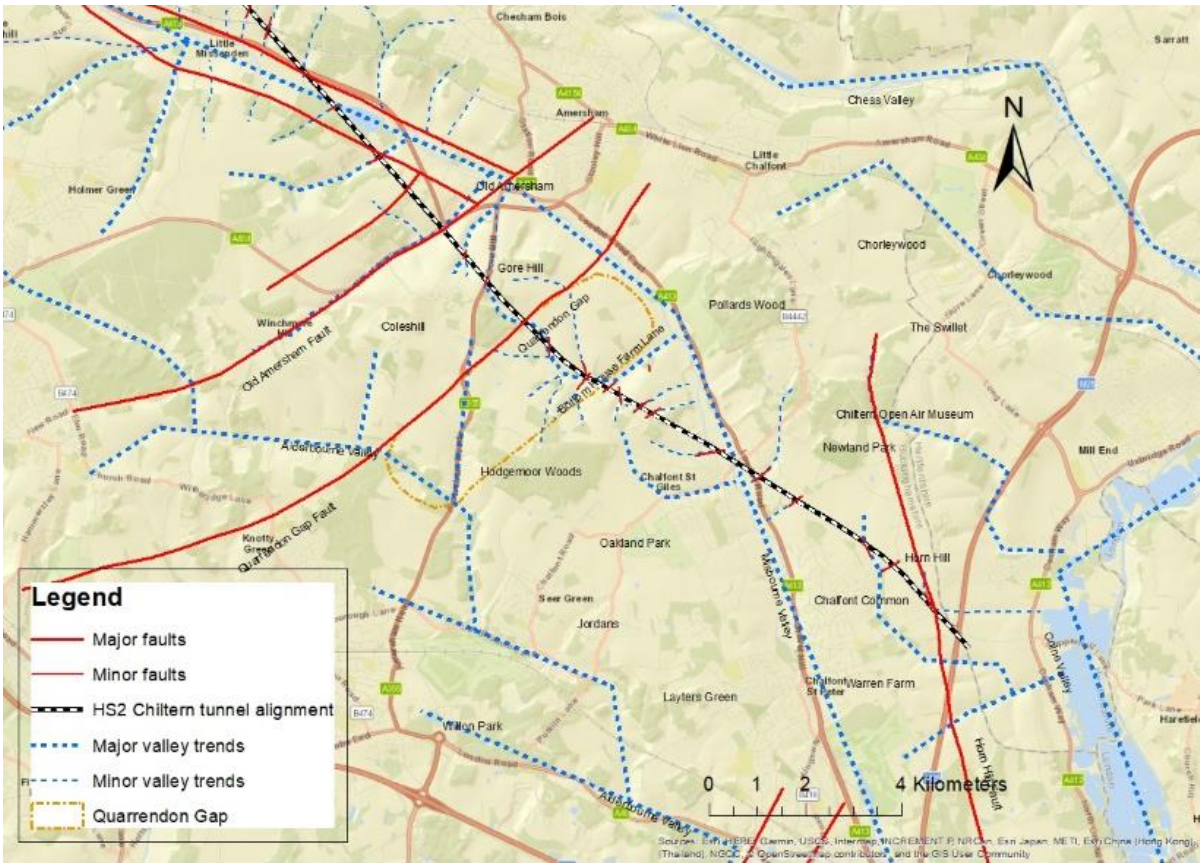

Figure 9: Faulting in the Misbourne valley and adjacent area (Marsh, 2023).

There are number of dry valleys which feed into the River Chess, including a number which generated springs. Figure 10 is a LiDAR image of the Chess valley between Latimer and Rickmansworth, illustrating dry valleys which might occur due to the presence of underlying structural lines. Note that the Chorleywood dry valley is subparallel just to the west of the Chess valley.

The NNW-SSE alignment of the main river valleys in this part of the Chilterns is very striking, even to the extent that the Wye, Misbourne and the losing reach of the Chess parallel the alignment of the Colne valley between Rickmansworth and Denham. The implication is that these valleys occur along lines of underlying structure in the Chalk. The suggestion that there are underlying faults which generated valley development is purely speculative at this time and requires further investigation.

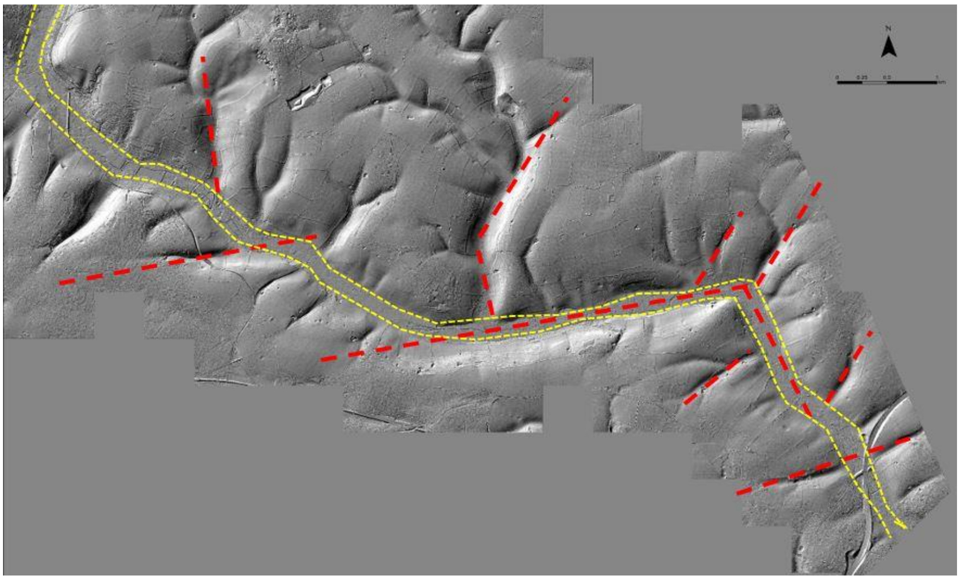

Figure 10: Speculative faulting in the Chess valley. NNW-SSE lines are parallel with the Horn Hill Fault (Marsh, 2023), which itself parallels the line of the Colne valley.

Should any number of these fault lines actually exist then they would have been sufficient to cause the generation of hydrogeological pathways, particularly during the extended history being proposed here for the Chess River. Similarly, the presence of numerous springs along the Chess (e.g. Valley Farm) is also significant as "large springs are indicative of connected networks of karstic voids to sustain their discharges" (Maurice *et al.*, 2020). This is dealt with in greater detail in a later chapter.

Geological mapping in the Chiltern region has always suffered from a lack of rock exposure. The region is either vegetated by farmland and/or woodland or urbanised, removing any opportunity for the field mapping geologist to identify any subsurface structure. Only following the ground investigations for the HS2 Chiltern Tunnel did Align recognise up to 50 lines of faulting along the 16 kilometre length of the tunnel (Align, 2020). In addition, whenever civil engineering works are carried out in the area, e.g. the A41 Aston Clinton bypass and the A505 Weston tunnel on the Baldock bypass, additional faulting is recognised. In time it will be acknowledged that the Chalk of the Chiltern region has undergone a complex structural history.

5.2 Regional uplift of the Chilterns

It is widely recognised that southeast England has undergone and is possibly still undergoing progressive structural uplift, "mechanisms of uplift in the Thames valley may be considered in two broad categories. One is loading and unloading of the surface, by erosion and deposition, by advance and retreat of ice sheets, and by transgressions and regressions of the sea. The other is control of surface elevation from below, by hot blobs within the asthenospheric mantle, and by magmatic underplating" (Lovell, 2023).

Essentially, Lovell suggests that much of the uplift recognised in the Chilterns, exemplified by the presence of Pliocene red sand and gravel deposits at 167 metres above OD at Little Heath, Berkhamsted, is the result of the proximity of the region to "a postulated 'warm finger' of the distal Icelandic plume". The impact of this 'hot spot' may well have existed from early in the Cenozoic era, as suggested by the potential loss of c500 metres of Chalk in the region prior to Lambeth Group deposition, but this is yet unproven as evidence is sketchy.

In addition to this, there has been isostatic re-adjustment of the region due to the removal of Pleistocene ice sheets. Maddy *et al.* (2000) and Bridgland & Schreve (2009) account for considerable uplift (c.20 metres) recognised in the displacement of the Thames gravels as being due to glacial rebound following the removal of Anglian glacial ice.

In all probability, we're looking at a combination of both these mechanisms in the creation of, and persistence of the Chiltern cuesta. Where early faulting is present, then valleys breach the escarpment, such as the Misbourne and the Bulbourne. In the case of the Chess there is no faulting evident in the source area and a dendritic drainage pattern is obvious in the subsurface geology.

There has been a complex geological history controlling the development of the region, which continues to the present day. The more we accept the impact of structural faulting on the development of the geomorphology and topography the easier it becomes to understand the subtle development of dry valleys, springs and swallow holes in the vicinity of the Chess losing reach.

6. CHESS VALLEY FORMATION

As has already been inferred in Section 2 of this report, it is believed that the Chess has had a lengthy existence, pre-dating the Anglian glaciation, acting as a northern tributary of the Proto-Thames during the Early Pleistocene, and potentially even further back than this, into the Cenozoic Era.

The Chess rises from a series of springs surrounding the town of Chesham. It is clear from the old geological map of this area (Sheet 238 – published in 1923) that the majority of these springs originate from percolation through the Chalk Rock into the top of the New Pit Chalk Formation which causes spring water to flow out at the surface (see Figure 11). The river follows a northwest – southeast route, as do virtually all the Chiltern Chalk streams, at least two of which are now known to follow lines of faulting. The suggestion is that the Chess river could also be following a common structural trend until it swings eastwards at Latimer.

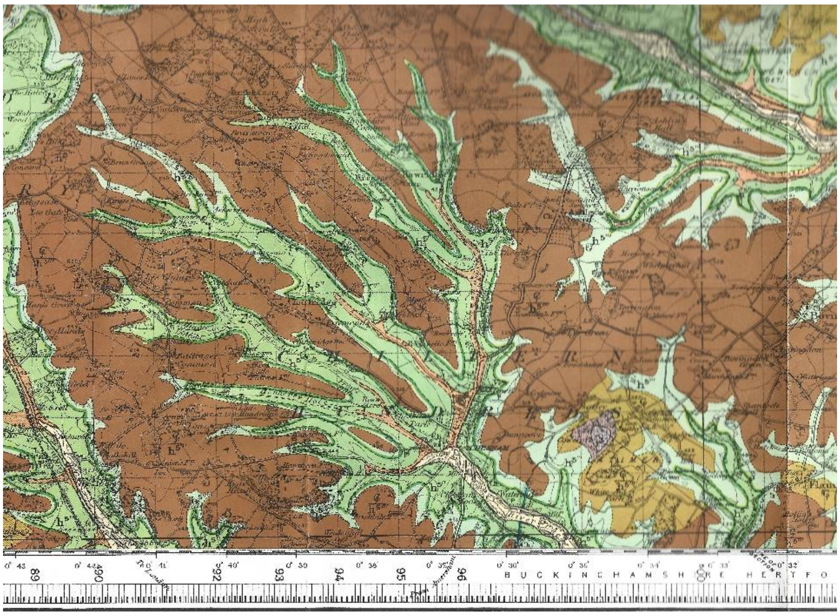

Figure 11: Geological map of the headwaters of the Chess River, illustrating the dendritic pattern arising from springs generating flow into the confluence in Chesham itself. Note the NW-SE trend in the stream pathways and also in the Bulbourne river to the northeast.

This is pure speculation, however, if the Quarrendon fault, which is already recognised cutting across the Misbourne valley, was to be extended to the east northeast then it would intersect the line of the Chess just around the river bend at Latimer (See Figure 9).

The implication is that the Chess could possibly be following existing lines of structural weakness in the underlying Chalk. There has to be some initial cause for the erosion of the valley to follow the route that it does. The fact that the route also includes a very distinctive dogleg to the east at Latimer implies that there is an underlying cause. The suggestion here is that there is a probable line of faulting which caused the Latimer dogleg.

Proto-Thames gravel deposits, particularly the Chorleywood Gravels occur on both flanks of the Chess losing reach. The base of these gravels occurs at approximately 80 metres above OD, and they are approximately 35 metres thick to the west of Micklefield Green. The river itself is recorded between 69 metres and 63 metres above OD through the losing reach (68 metres at Sarratt Mill). The post Anglian uplift of the area has already been accounted for by the glacial isostatic re-adjustment over the last 425,000 year (Maddy *et al.,* 2000) and Bridgland & Schreve (2009). Effectively the river has eroded through approximately 35 metres of gravels plus, approximately 15 metres of chalk, to be at its current height above OD.

It is inevitable that any existing karstic structures in the uppermost 15 metres of chalk across the Chess valley have been eroded away during the post Anglian period, although deeper voids and cavities may still exist.

7. SWALLOW HOLES

There is a curious lack of swallow holes in the lower Chess valley when compared with the situation described for other comparable Chiltern chalk streams such as the Misbourne and the Ver. Maurice *et al.* (2020) have carried out the most comprehensive review of karstic topography and subsurface structures in the Chiltern area to date. One of the primary conclusions they arrive at is that the development of swallow holes, voids and karst structures appear to be associated with the presence of Paleogene Lambeth Group deposits resting directly on the top of the Chalk in the vicinity.

It is clear from the BGS Beaconsfield Sheet 255 geological map, as well as the recent mapping completed by the BGS (Farrant *et al.*, 2018), that there are no Lambeth Group deposits remaining in the area around the flanks of the Chess losing reach, and that this may account for the paucity of swallow holes around the lower Chess.

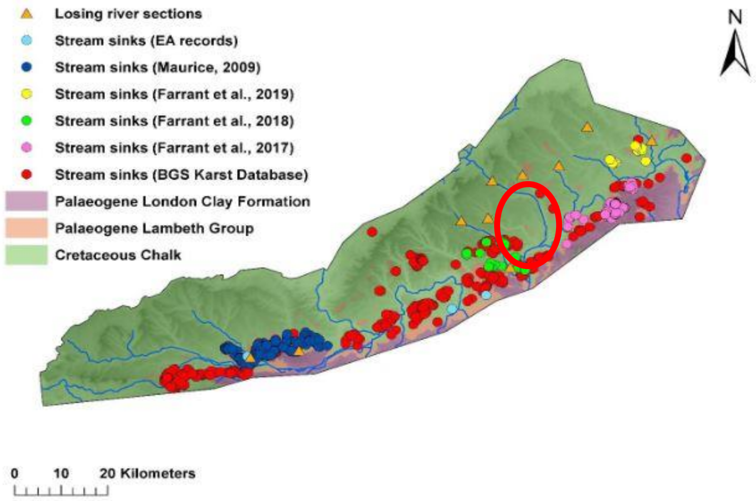

Figure 12: Sinkholes in the Chiltern area recognised by Maurice *et al.*, 2020. The lower Chess area is marked by O showing the absence of sinkholes around the lower Chess.

The absence of obvious sink holes along the lower Chess valley has been confirmed by walking the whole route of the river below Latimer.

Only in the field Just to the west of Mill Farm, at Chenies Bottom, is there a definite depression which potentially could be related to a sink hole (see Figure 13). This is recorded as a depression by Maurice et al. (2020).

Figure 13: Possible sinkhole depression in field due west of Mill Farm, Chenies Bottom (TQ013988).

This lack of overt evidence for subsurface flow does not automatically indicate that the subsurface chalk below the lower Chess valley does not act as an active hydrological conduit. Farrant *et al.* (2023) observe that “Uplift and valley incision change the hydrological boundary conditions on glacial-interglacial timescales, rendering many conduits redundant before they can achieve breakthrough and rapidly enlarge.” This is exactly the situation we see today in the lower Chess valley, where there has been rapid uplift in post Anglian times to the extent that we record valley incision of at least 43 metres during the last 425,000 years.

A complex karstic structure is likely to be absent in this area because Lambeth Group sediments are absent, probably due to erosion during the pre-Anglian Proto-Thames phase, and subsequent down cutting of the valley has occurred at such a rate that a karstic complex has never had chance to develop. Nevertheless, the presence of at least one possible sink hole in the valley supports the possibility that there could be others below the riverbed itself and in the urbanised areas down river below Solesbridge Lane.

It is considered likely that subsurface permeability via joint systems within the underlying New Pit Chalk Formation chalk, together with the development of hydrological conduits along clay seams, provide ample routes for water movement. Any groundwater flow is likely to be downdip to the south and southeast into the Colne valley and potentially further into the London Basin.

8. SPRINGS

The distribution of springs in the lower Chess valley is relatively normal from a geological perspective. In the majority of the springs identified from Latimer and downstream spring water is fed from below the level of the Chalk Rock close to the boundary between the Lewes Nodular Chalk and the underlying New Pit Chalk Formation. Groundwater is effectively percolating down through any Seaford Chalk Fomation chalk present and downwards through the permeable Lewes Nodular Chalk Formation until it hits the impermeable clay bands present at the base of the Lewes Nodular Chalk (Caburn Marl Bed and Southerham Marl Bed).

Each of these marly claystone units is likely to be in the order of 10 centimetres thick and water flow will be along them rather than through them. Where these clay bands intersect the surface, a spring is likely to flow.

Fig. 14: Spring and borehole map Latimer to Sarratt Mill. ◆ - BGS recorded boreholes ◆ – Springs

The majority of the springs identified during this and other recent studies occur below the slope breaks created by the underlying Chalk Rock unit within the Lewes Nodular Chalk Formation. The only exceptions to these are those wells deemed as artesian springs which occur close to the Water Cress Farm at Crestyl Cottage (TQ027989). These are most likely generated by a pressure head existing within the New Pit Chalk Formation joint permeability, as the boreholes do not appear to have been drilled deep enough to penetrate the underlying Holywell Nodular Chalk Formation aquifer.

Typical examples of normal spring flow during October and November 2023 are illustrated below.

Fig. 15: Spring in Sarratt Bottom below Chalk Rock slope break

Fig 16: Spring close to footbridge east of the Royal Masonic School (TQ062957). Downstream of Chalk Rock crossing the valley floor.

In both the examples shown spring flow is being generated at a level close to the Lewes Nodular Chalk – New Pit Chalk formation boundary, which marks the down section break from higher permeability chalks to low permeability chalk with significant marl seams. It is worth noting here that given the pressurisation within the New Pit Formation, there is probably a degree of vertical hydraulic disconnection between the Chalk aquifer and the river bed itself; this confirms that any abstraction effect at the Chorleywood PWS is, at the very least, attenuated

There are no obvious springs recognised between Sarratt Bottom downstream to below Solesbridge Mill. However, there are several small ponds in the river valley within this section which are most likely being sourced by subsurface springs (See Figure 17).

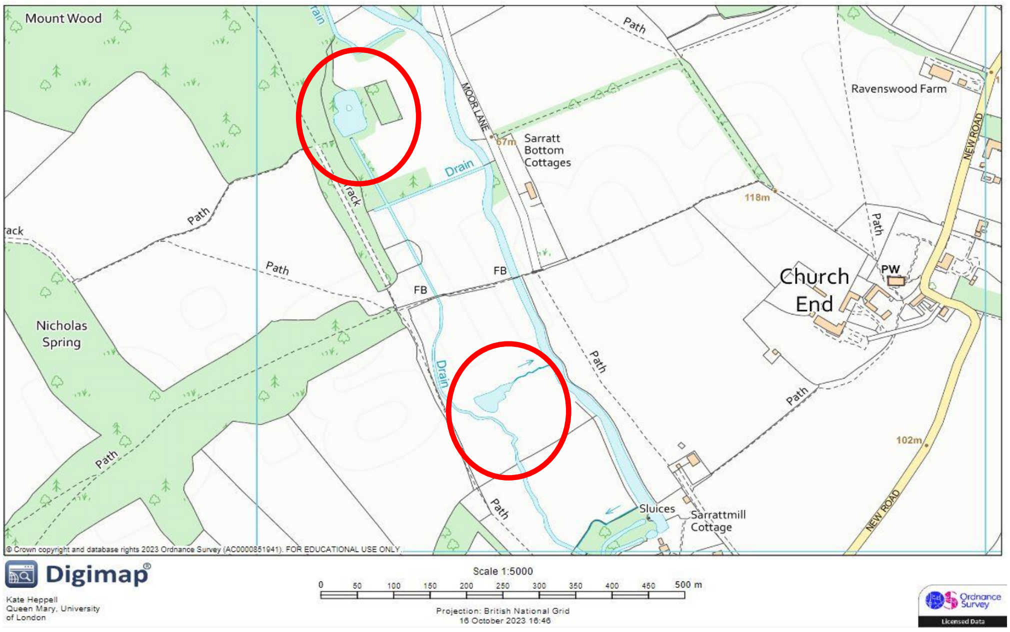

Fig. 17: Spring fed ponds between Sarratt Bottom and Church End

A total of eleven springs have been logged between Latimer and Scotsbridge Mill during the course of this study, with a potential additional three being recorded as spring fed lakes. No springs occur south of Scotsbridge Mill. All these springs generate high quality flow into the Chess and therefore contribute to the losing reach.

9. CONCLUSIONS

There is clear evidence of water flow loss over the course of the lower Chess between Sarratt Bottom and Rickmansworth.

The level of water loss is sufficiently high that it cannot be solely accounted for by abstraction from the Chorleywood pumping station.

The geological history of the lower Chess valley is recognised as complex, with the river commencing as a tributary of the Proto-Thames River over half a million years ago.

Proto-Thames river gravels occur on the valley tops on either side of the lower Chess; these include the Chorleywood Gravels, the Beaconsfield Gravels and the Gerrards Cross Gravels. The first of these (Chorleywood) is currently recorded at 111 metres above OD.

The current river Chess valley is recorded at 68 metres above OD at Sarratt Mill. This implies that there has been in the order of c.43 metres of uplift and incision over the last half million years.

This rapid incision and consequent valley erosion, in the absence of Lambeth Group sediments, probably accounts for the lack of obvious swallow holes and karstic topography in the valley. However, this does preclude the occurrence of subsurface karstic structures, given the history that the river Chess has within the valley.

Currently no geological structures/faults have been mapped in the lower Chess valley, however, faulting is now clearly established in the nearby Misbourne valley and, although speculative, it is easy to see that potential easterly extension of the Quarrendon Gap Fault and a northerly extension of the Horn Hill fault could explain the unusual “dogleg” route of the Chess valley.

The presence of such geological lines of movement would enhance the potential development of karstic structures in the subsurface chalk. This would enhance subsurface water loss at this direction change.

Given that the line of the lower Chess valley lies immediately beneath the original Proto-Thames valley, then it becomes easy to envisage that the subsurface chalk has undergone considerable fracturing and potential dissolution.

Natural water loss along the lower Chess valley seems inevitable and is likely to be widespread throughout the valley floor. As such, it is impossible to stop and unlikely that any human intervention might reduce it. On a positive note, the natural water loss reduces the possibility of flooding in the lowermost reaches of the river, particularly through urbanised areas such as the Loudwater Estate and below the Scotsbridge Mill.

It should be acknowledged that the relatively high numbers of mills previously active in the lower reach of the Chess Valley means that human activity has led to extensive stretches of the river being artificially perched. Such perched stretches could enhance water loss.

Finally, as with virtually all the Chiltern region, the lower Chess valley is covered by vegetation and/or urban development and, as such, it is impossible to see any actual geological outcrops. We're fortunate that the presence of the Chalk Rock within the Chalk succession creates obvious breaks in slope down both sides of much of the valley and allows the underlying geology to be interpreted. Nevertheless, the lack of exposure means that the interpretation of hydrogeological pathways within the subsurface chalk is largely speculative currently.

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References

Align JV., 2020. Chiltern Tunnel – Chalfont St Giles ventilation shaft information event Exhibition panels and questionnaire. HS2 public consultation event held in Chalfont St Giles, Buckinghamshire, March 2020.

Bailey, H. W. 2020. Why are Chalk Stream valleys where they are? *The Chiltern Magazine*, Chiltern Society.

Bailey, H. W. 2023. Geology of the Chiltern Chalk aquifer. *Geology Today*, 39 (1) pp 18-26.

Bailey, H.W. & Wood, C.J. 2010. The Upper Cretaceous Chalk. In: Catt, J.A. (Ed.) *Hertfordshire Geology and Landscape*. Hertfordshire Natural History Society, pp. 36-60.

Belshaw, R.K., Gibbard P.L., Murton, J.B. & Murton, D.K. 2014. Early Middle Pleistocene drainage in southern central England. *Netherlands Journal of Geosciences*, 25, 1-11.

Bridgland, D.R. & Schreve, D.C., 2009. Implications of new Quaternary uplift models for correlation between the Middle and Upper Thames terrace sequences, UK. *Global and Planetary Change*, 68, 346–356.

Catt, J.A. & Cheshire, A. 2010. Quaternary deposits and later landscape development. In: Catt, J.A. (Ed.) *Hertfordshire Geology and Landscape*. Hertfordshire Natural History Society, pp. 118-184.

Farrant, A.R., Cripps, C., Woods, M.A. & Horabin, C. 2016. Scientific and technical report to accompany the Chess catchment GSI3D geological model. *British Geological Survey Commercial Report*, CR/16/165. 31pp.

Farrant, A.R, Thompson, J., Cripps, C., Vernon, R., Woods, M. & Thorpe, S. 2018. Scientific and technical report to accompany the Misbourne catchment GSI3D geological model. *British Geological Survey Commercial Report*, CR/18/043. 31pp.

Farrant, A.R., Maurice, L., Ballesteros, D. & Nehme, C. 2023. The genesis and evolution of karstic conduit systems in the Chalk. In: *The Chalk Aquifers of northern Europe.* Geological Society, London, Special publications, 517, 15-37.

Hopson, P. M., Aldiss, D. T. and Smith, A. 1996. Geology of the country around Hitchin. *Memoir of the British Geological Survey*, Sheet 221 (England and Wales), HMSO, London, 153 pp.

Kidney. V. 2006. Investigation of low flows and abstraction in the Lower Chess catchment Desk Study. Environment Agency, Thames region, North East Area.

Lovell, B. 2023. Is the tilt of the Thames valley towards the east caused by a distal lobe of the Icelandic mantle plume? *Proceedings of the Geologists Association*, 134, 68-76.

Maddy, D., Bridgland, D.R. & Green, C.P. 2000. Crustal uplift in southern England: evidence from the river terrace records. *Geomorphology,* 33, 167-181.

Marsh, A. H. 2023. Observations on the geology of the country around Chalfont St Giles, Buckinghamshire, *Proceedings of the Geologists Association*, 134(1).

Maurice, L., Bunting, S., Farrant, A. & Mathewson, E. 2020. BGS Karst Report Series: C4 Karst in the Chalk of the Chilterns and the Berkshire and Marlborough Downs. *British Geological Survey Open Report*, OR/20/044. 48pp

Mitchell, G.F., Penney, L.F., Shotton, F.W., & West, R. 1973. *A correlation of Quaternary deposits in the British Isles*. Geological Society, London, Special Report, 4.

Morigi, A.N., Woods, M.A., Reeves, H.J., Smith, N.J.P. & Marks, R.J. 2005. *Geology of the Beaconsfield District – a brief explanation of the geological map.* 1:50,000 Sheet 255, British Geological Survey, Nottingham.

Mortimore, R. N. 2021. Chalk. All we need is a fracture log! *Quarterly Journal of Engineering Geology and Hydrogeology.* https://doi.org/10.1144/qjegh2021-031

Veolia Water Partnership. 2003. Downhole inspection report, Chorleywood Pumping Station Borehole Nos. 1 & 3. Unpublished in-house report.

Wray, D.S. & Wood, C.J. 1998. Distinction between detrital and volcanogenic clay-rich beds in Turonian-Coniacian chalks of eastern England. *Proceedings of the Yorkshire Geological Society*, 52, pp95-105.