STANSTEAD ABBOTTS

THE IMPORTANCE OF THE CHALK AQUIFER AND THE LEA

BY
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The local area has a thick layer of chalk rock beneath it which historically provided chalk to feed the lime kilns and used untreated to enrich the soil. Less obviously the chalk strata act as an aquifer [*a rock able to store water and allows water to move through it*] and conveys additional water from the Colne Valley catchment area eastwards into the middle Lea Valley. This additional water enters the groundwater and comes out onto the surface through various springs in the Lea Valley. This article attempts to describe and explain how this occurs and what local problems and benefits this gives rise to. Historical challenges have included the permanent marshy areas on the valley floor and regular flooding. On occasions the floods have caused considerable damage to both Ware and Stanstead Abbotts. On the other hand, the two settlements were able to benefit from an all-year-round navigation. The additional millions of gallons a day from the aquifer has tended to even out the flow in the river Lea, lessening the effect of intermittent rainfall. This allowed the Lea to be navigable for shallow draught boats all year round, long before any navigation improvements were made. This unusual situation allowed trade from both Ware and Stanstead to be carried by water reliably from very early times. This led to both settlements becoming significant market places in Hertfordshire by the time of the Domesday Book.

The extra water from outside the normal catchment area of the river Lea, is made possible by the underlying geology to the south west of the middle Lea valley. Water enters the chalk via a significant number of swallow holes in the valleys of the Catherine Bourne and the Mimms Hall Brook at Water End. These streams are located near South Mimms & North Mimms respectively some 12 to 13 miles south west of Stanstead Abbotts. These streams drain a 35 square mile area located between Shenley, Barnet and North Mimms. All the rainfall in this area would normally flow westwards into the headwaters of the river Colne and thence into the Thames, instead a large proportion of it disappears down swallow holes. Only after heavy rain does excess water pass over the swallow holes to flow along an ancient course of the river to reach the river Colne.

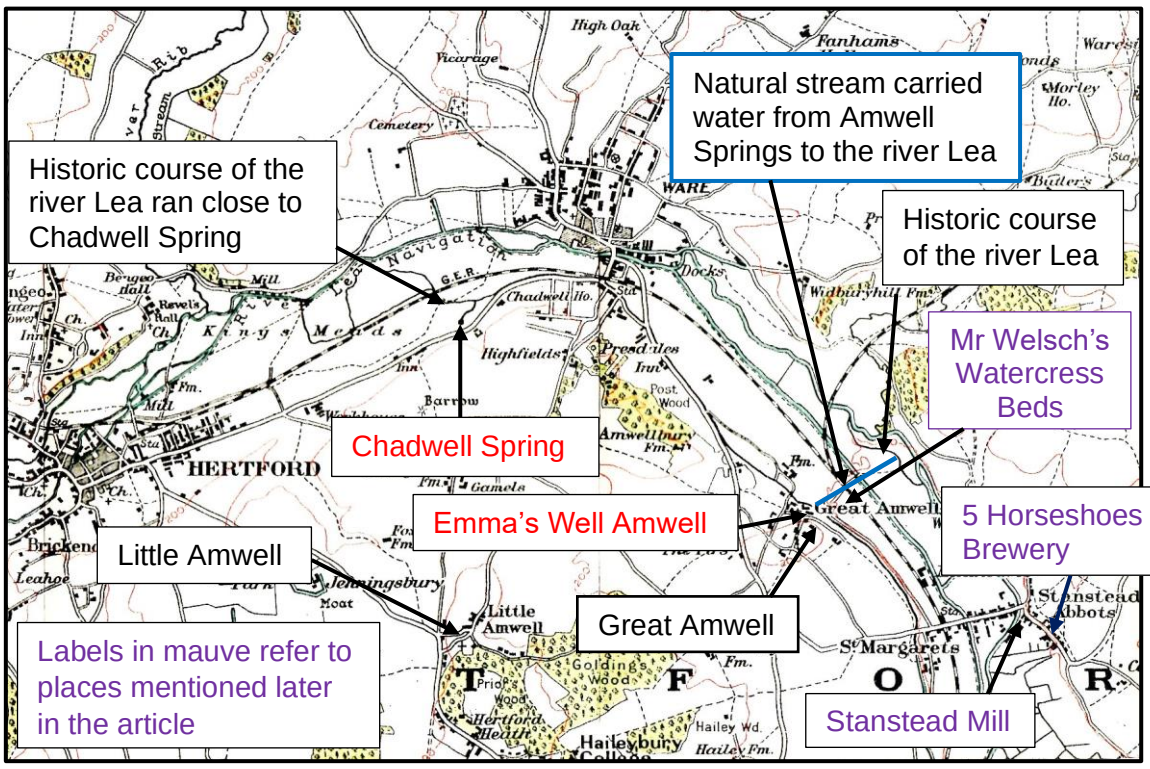
The concentration of swallow holes in the area is due to past geological events. The chalk was firstly subject to folding by crustal movements and then suffered considerable erosion. Later deposits were then laid down on top of the eroded surface of the chalk. There was further erosion when the area was covered by glacial ice during the Anglian glaciation between 478,000 and 424,000 years ago. This in places left just a thin layer of impermeable deposits covering the chalk. Later several lengthy periods of cold tundra conditions saw severe freeze thaw activity, which fractured the upper layers of the chalk. This made the surface of the chalk very vulnerable to water erosion allowing water to widen the cracks and fissures in the top layers of the chalk. This led to swallow holes developing and much of the surface water going underground into a maze of fissures and small pipes dissolved out of the chalk rock.

The site at Water End covers an area of some 28 acres within which there are in excess of 15 active swallow holes. It is an unusual feature and designated as a site of special scientific interest [SSSI]. After heavy rainfall a large lake forms as the volume of water exceeds the capacity of the swallow holes. Sometimes the lake overflows with water entering the headwaters of the river Colne. For most of the time the surface water simply disappears down the swallow holes. The top surface of the chalk is irregular with many large pipes and widened fissures that lead deep into the chalk. This allowed water going down the sinkholes to enlarge fissures at depth which extend miles underground. This led to the chalk having many interconnecting passageways through which water can travel considerable distances from Water End before perhaps reappearing at springs in the Lea Valley.

Much work in the last 100 years has explored what happens to the water once it goes down the swallow holes. In 1927,28 and 32 a sequence of tests were carried out to find out where the water went after going down the swallow holes at Water End. Fluorescent dyes were used to see if the water did in fact make its way to the springs in the Lea valley. The tests showed that four Lea Valley springs were connected underground with the Water End swallow holes. The springs with the timings, of the first arrival of the dyed marker, were recorded as Woolmer's Park [60 hours], Chadwell Spring [90 hours], Great Amwell [Emma's Well] 92 hours and the Lynch Mill Spring at Hoddesdon [79 hours]. A similar study in 1935 using the swallow holes in the Catherine Bourne valley showed comparable speeds of flow. Average speeds between swallow holes and the springs were between 2.5 and 2.8 miles a day.

Further research in 2010 showed that the springs in the Lea Valley were also connected to swallow holes well to the west and north of Water End. It also proved that all the swallow holes were connected underground by what must be a complex three-dimensional maze of pipes and fissures. Calculated underground water speeds varied from 1.1 to 2.42 miles per day and reflected the rainfall pattern. An interesting discovery was that pulses of dye arrived at the springs over a three-week period following rainfall, with only about 15% of the dye ever re-emerging at the springs and wells in the Lea Valley.

LOCATION MAP OF LOCAL SPRINGS AND PLACES MENTIONED IN THE TEXT



When the underground water arrives at the Lea Valley part of it remains in the Chalk Aquifer, some enters the groundwater in the sands and gravels beneath the valley floor and the remainder issues out onto the surface via the springs. This ensures a greater store of water at depth in the chalk, a higher water table level in the valley floor and additional water in the river Lea. This extra water increases the risk of flooding by both the Lea topping its banks and groundwater flooding caused by the level of the water table rising above ground level in the flood plain of the Lea Valley. It is perhaps not surprising that the local area has particularly hard water given the amount of time the water spends passing through the chalk before eventually becoming available as drinking water. The two major springs that are most relevant locally are what were historically referred to as the Great Springs at Chadwell and Amwell.

A view from the valley side above Chadwell Spring looking north taken on the 6th October 2010. The round pool closest to the camera is the site of the main Chadwell Spring used since the early 1600s as the start of the New River. This has supplied London with fresh water ever since. As can be seen from the standing water on the valley floor the water table is quite high despite the considerable extraction of water from underground.

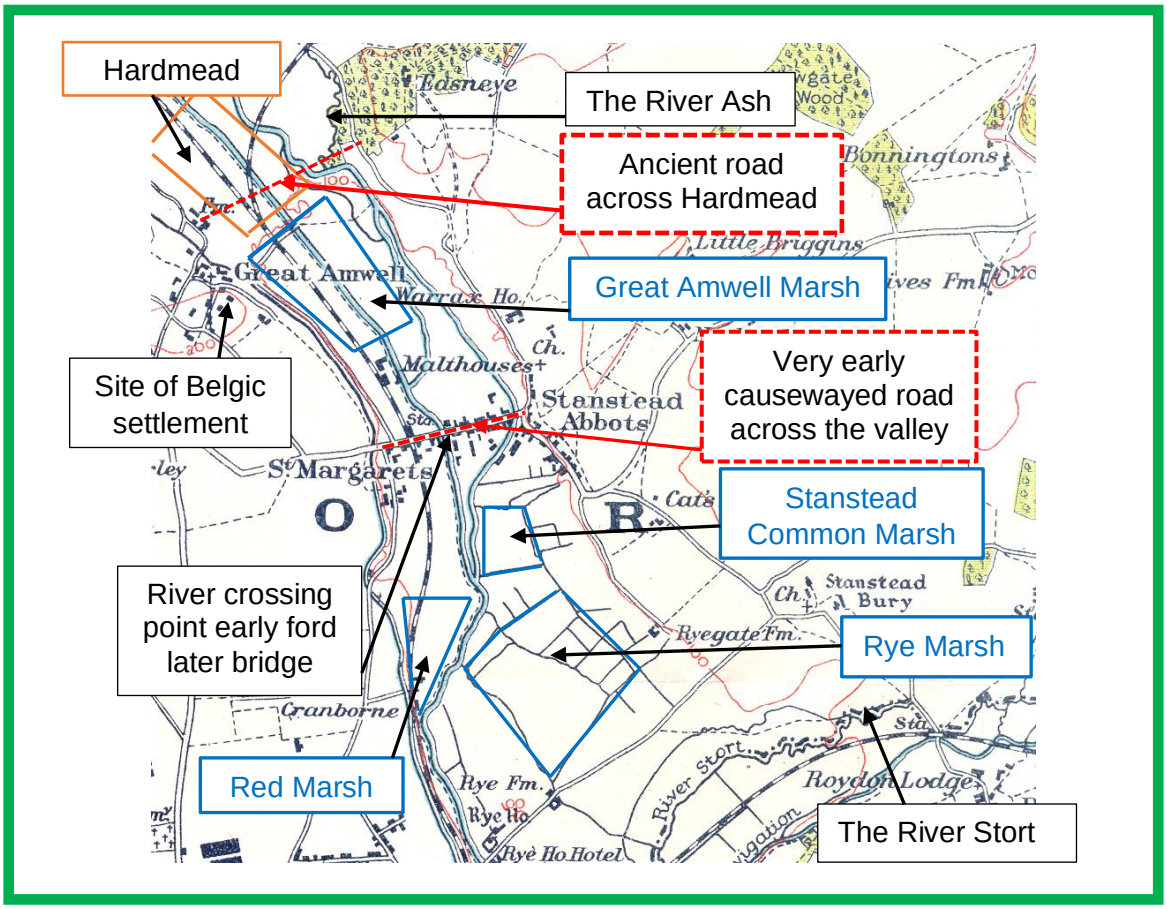
A picture taken looking down into Emma's Well at Great Amwell from the adjacent road. This image was taken on the 7th February 2013 and is unusual as it shows significant water within the artificial brick lined pond that exists there. Emma's Well is one of the four original main springs at Amwell, two were used to supply water to the New River and the fourth still exists in a private garden not far away from Emma's Well.

In pre-Roman times the Lea Valley saw small settlements develop above the regular flood level along the valley sides. Locally archaeological evidence has been found for such settlements at Ware, Great Amwell and Stanstead Abbotts, in some cases stretching back thousands of years. The places people chose to settle were often associated with locations where it was possible to cross the valley floor and ford the river. The then shallow river afforded many fordable locations so it was the limited places where the valley floor could be easily crossed that dictated the positions of valley crossing points. The high-water table on the valley floor meant much of the flood plain was marshy and flooding was a very common event. This led to crossing points developing at significantly drier places in early times at Ware, Great Amwell and Stanstead. At Ware the original ford was by the current pharmaceutical factory and was moved downstream to the present bridge around 1100 as the town was being developed into a sizeable riverside market town. A gravel spread close to the north side of the river providing an area free from all but the worst flooding events.

At Great Amwell the valley was crossed just to the north west of Amwell Springs giving access to the valley of the river Ash and the north side of the Lea Valley. The valley floor being crossed on slightly raised ground known as Hardmead which was sufficiently above the water table to provide a normally dry crossing route. A Pre-Roman [Belgic] settlement with once impressive earthworks was located on the hill above the site of Great Amwell church and a road from the similarly dated settlement at Little Amwell led down through the woods passed the church and then across the valley. The road crossing Hardmead existed in regular use in the early 1600s but went out of use when the Lea Navigation was built and cut the road in half during the mid-1760s. [*Later replaced by Amwell Marsh Lane further downstream in 1841/2.*]

At Stanstead Abbotts the road crossing the valley floor was from early times an important east to west route. It was located at about the only suitable point to cross the Lea Valley between where the valleys of the rivers Ash and Stort joined that of the Lea. The road across the valley was located between permanently marshy ground on either side [*see map below*] and required a raised causeway to avoid the annual shallow flooding risk. Initially Stanstead developed as a valley side settlement on the limited land between the flood plain and the sometimes steeply rising valley side. An attempt was made by the De Burun family around 1100 to create a matching settlement on the limited flood free flat land on the opposite side of the valley. They even applied for permission to hold a weekly market and an annual fair. However, their attempts were not very successful with significant growth of the settlement at St. Margarets not occurring until the Victorian period.

LOCATIONS MENTIONED IN THE TEXT

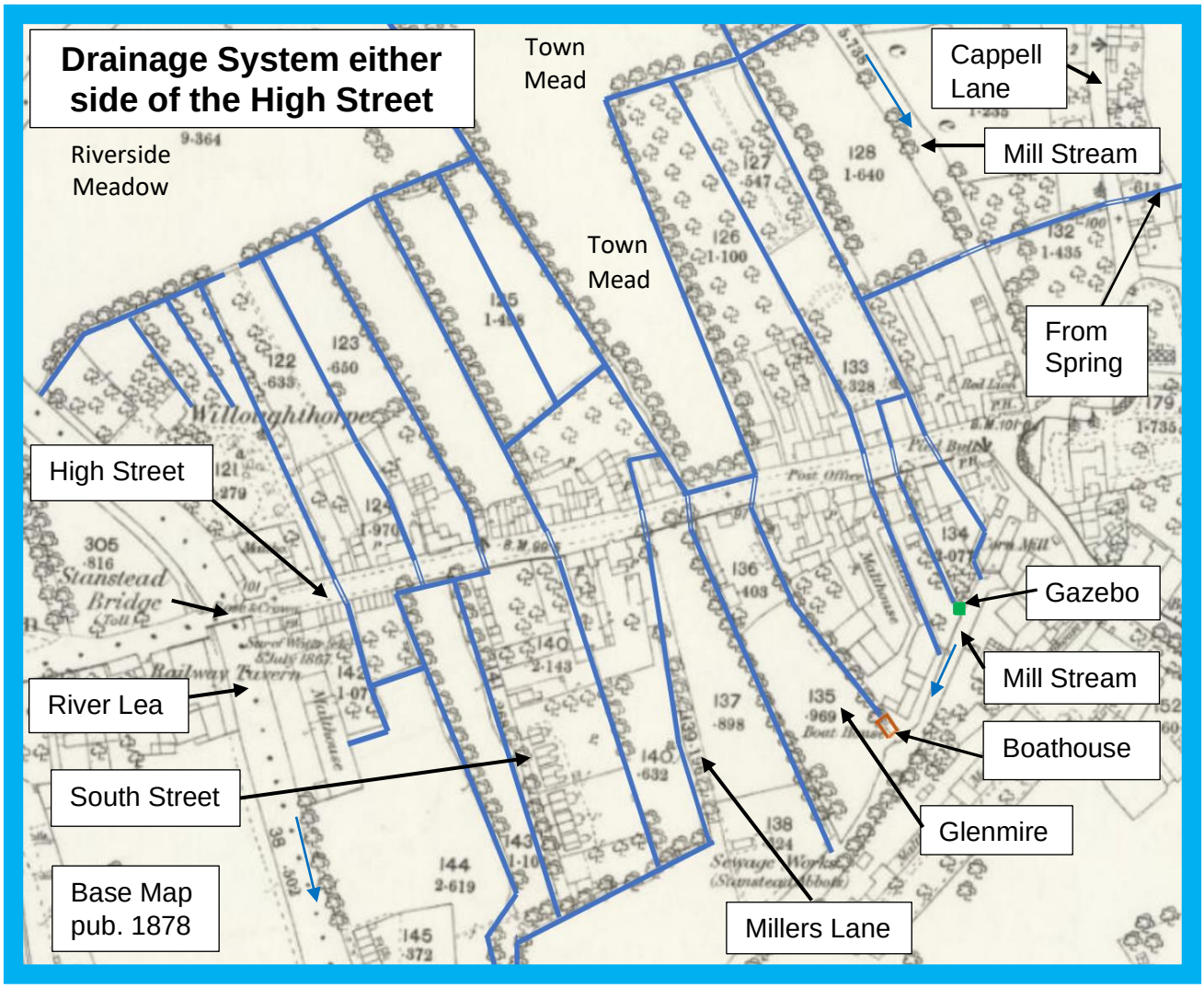


The abundance of water in the Middle Lea Valley strongly influenced where people chose to build their homes as well as to develop the main settlements at Ware and Stanstead Abbotts. Both these significant settlements were sited with good access to the navigable river which provided a cheaper form of transport than the early roads, for sending goods to London. At Stanstead Abbotts developments included the building of a larger watermill in 1278/9 and a steady growth in agricultural production. This was matched with the necessary population increase to facilitate the economic growth. St Margarets became the site of a Warehouse / Granary owned by London Merchants in the 1240s but saw only limited commercial and population growth over the following centuries. At Great Amwell the river was on the other side of the valley from the village which limited the development of river transport there.

The importance of the river traffic on the “Ware River” as it was called, is underlined in the 1400s by two Acts of Parliament designed to make improvements to the natural river. Firstly, the river was deepened in places and obstacles to navigation removed and the second Act ensured arrangements were put in place for regular maintenance of the Lea. In the latter part of the 1500s a further attempt was made to improve the navigation strongly supported by the City of London. Up to this point in time the natural flow of water along the river Lea and the extra supply of water from the chalk aquifer remained unaltered by human activity. The focus tended to be associated with flood prevention and deepening the river to introduce larger boats and barges to transport goods more easily and cheaply to London.

The Lea improvement scheme of the 1570's was an attempt to create a navigation unimpeded by any locks or weirs and deepen it throughout to allow significantly larger boats & barges to be used. With the removal of most locks and weirs there was no way the flow of water could be properly controlled. In dry weather water ran away downstream leaving too little for navigation and in wet weather it was not possible to fully manage the excess flow. This worryingly led to a greater risk of flooding than before the scheme was implemented. In addition, the river required increased costly maintenance and so it is not surprising that the money was spent instead on reversing many of the changes made by the scheme. With plenty of workers around for navigation work they were also employed for land drainage works. To both bring land into more productive agricultural use and reduce the impact of minor floods. A scheme to drain riverside pastures next to the river between Rye House and Dobbs Weir is recorded as occurring about 1570. The Rye Manor at the time was in the possession of William Frankland a London merchant and Stanstead Abbotts had been granted to Sir Edward Baeshe in 1559 by Queen Elizabeth I.

When Sir Edward came to Stanstead, he was the first owner and resident Lord of the Manor since the Norman invasion of 1066, with the money and intentions to spend on improving the Manor. He took an important role in the management of the 1570s navigation improvements including making financial contributions to the scheme as well as the changes needed after the scheme proved defective and locally, he improved land drainage. At the time Stanstead was under pressure to expand its agricultural output and hence its population to meet the rising demand for goods in London. The most obvious way to expand the village was to develop out along the road between the valley side and the river bridge. This required a more effective drainage system than that originally in place, which simply ensured that the causeway carrying the road did not act as a dam and hold back flood water. Sometime in the late 1500s a more extensive system of ditches was added to drain the flood plain on either side of the road more effectively. This was a more complex drainage system than would be provided or required for draining grazing land on the flood plain. No such scheme was put in place on the St. Margarets side of the river, which had to wait until the C19th before any significant building on the flood plain occurred.



The map above shows the extent of the drainage ditch system either side of the High Street as it was in about 1840. It should be noted that the water is culverted under the High Street in several places. In the years up to 1840 some lengths of the channels would have been culverted under new buildings lining the road. The tithe map shows that 77% of the High Street was built up by 1840 and 11% remained flanked by drainage ditches. Side streets were not added until South Street in the 1860s and Glenmire Terrace in the 1890s. It is difficult to imagine that in the last 30 years of the C19th the children of South Street caught minnows and sticklebacks and other aquatic delights in a tree lined stream, [*down the western side of the road*], opposite the houses in which they lived. Today, only some sections of this system of ditches can be easily seen. The most obvious flows alongside the High Street car park then passed the village café. It can be viewed by looking over the brick wall behind the old telephone box. Another obvious example is at the bottom of South Street with a ditch heading off towards the boatyard and the Millstream. Over time many of the ditches either side of the High Street have been culverted or just simply abandoned. It is notable than many older High Street properties date from the 1600s and early 1700s, after the drainage improvements of the late 1500s. The surviving buildings that pre date 1570 are located close to the river bridge or at the other end of the High Street. *[See Appendix].*

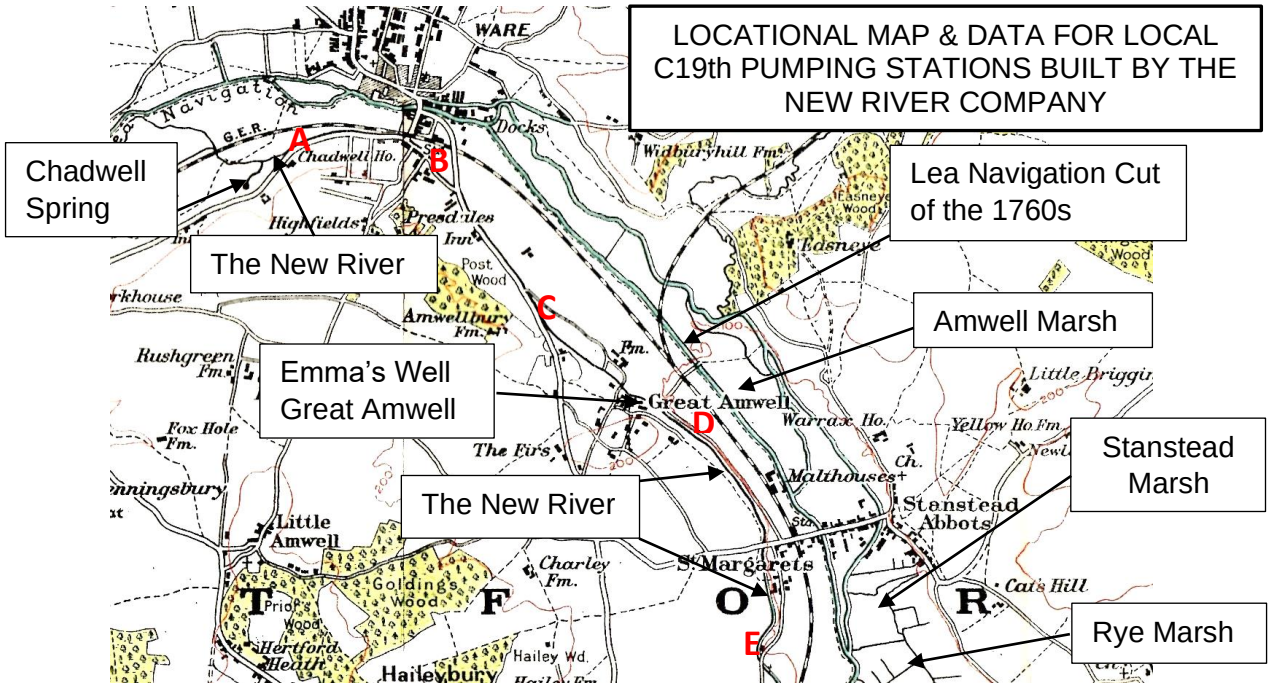
This picture taken on 5th March 2013 gives us a little peep from the pavement over the wall by the café and old telephone box. The land to the left was once the Town Mead [see map above]. Its ground level is marked GL on the photograph, which was considerably lower than the raised land surface upon which the houses were built, indicated by NL. The new land surface gradually declines from pavement height to the natural level of the flood plain by the time the car park is reached behind the houses their gardens and garages. In this view the water level in the stream gives a good idea of the level of the water table under the houses fronting the High Street. The stream flows into a culvert under the High Street before making its way underground along Glenmire Terrace. It is culverted under the left-hand side of the road down towards the millstream

This view is of the same stream at the back of the houses. It was taken on the 15th March 2014 not long after flood waters had receded. The water remained a little higher than normal and not that far below the surface level of the car park, just visible to the right of the picture. During the flood of 2014 water came up to the top of the steps and for a while was threatening to enter the ground floor of the adjacent High Street properties. The flooding was caused by a blockage in the drainage channel further downstream somewhere underground in Glenmire Terrace.

The original surface of Town Mead was some 2 feet 6 inches below the height of the centre of the High Street. However, the Town Mead near the road was lower than the main field requiring a steep earth ramp to enter the field from the High Street. Cows heading for a milking parlour close by managed the ramp with few problems but the vehicles of the visiting annual Funfair found it a bit of challenge. The causeway across the valley, built a long while ago, was originally likely to have been some two feet in height above the flood plain level, sufficient to be dry during the many shallower flood events.

By 1613 the New River was in use, initially only taking water from the springs at Chadwell and Great Amwell. It has been estimated that the usual output of water at Chadwell was between 6 and 8 million gallons a day and at Amwell 4 to 5 million gallons. Not all the water from either spring entered the New River to provide unpolluted drinking water for London. It is recorded that even before water was taken direct from the river, the loss of a major portion of the water from the springs made a noticeable lowering of the water level in the Lea. There was from the start a suspicion locally that the New River Company would want to take water from the river Lea and thus more significantly reduce the water available for navigation and to power the watermills. These fears were well founded as in 1620 permission was granted to abstract water from the river where the Lea came close to the large spring at Chadwell. Much local anger arose as it was thought this would impact negatively on the amount of water in the river. Hertford was to suffer most as water was being removed from the historically difficult stretch of the navigation between Hertford and Ware. It was not until an Act of Parliament in the 1730s that a workable system for all was implemented. The New River Company became responsible for ensuring adequate water for the navigation and the mills at Ware. To avoid the continuance of conflict the New River Company purchased the Ware water mill and turned the millstream into the navigation channel. In the 1830s the Company was to purchase Stanstead Abbotts Watermill to avoid similar difficulties. The much-improved navigation of the 1760's when the Navigation Cut was opened between Ware and Stanstead along with many other improvements, all helped to improve the navigation and boost the local economy.

The 1850s saw more changes including the lowering of the river level by 3 to 4 feet as it flowed past Stanstead and St. Margarets. All these changes progressively allowed more effective management of the water available for Stanstead Mill, the navigation on the Lea as well as reducing the flood risk. Up until 1800 there was no significant extraction of water from the chalk aquifer but this was to change dramatically in the C19th. The ever-growing need for fresh water in London led to the New River Company building coal fired steam powered beam engines to pump water up from the underlying chalk.



	Location	Max Pumping Capacity in Millions of gallons a day	Year Built	Depth of Well in feet
A	Broadmeads in Ware	1.5	1880	500
B	Amwell End in Ware	1.2	1868	419
C	Amwell Hill	3.3	1847	160
D	Amwell Marsh	5.6	1884	392
E	Rye Common St Margarets	4.6	1883	204

C Amwell Hill pumping station

D Amwell Marsh pumping station

E Rye Common [St Margarets] Pumping Station

The pumping stations were located beside the New River spaced out along the watercourse. They were powered by coal fired boilers the steam from which drove borehole pumps. The boreholes themselves were typically a twelve-to-fifteen-foot diameter circular shaft. The depth of the shafts varied from station to station depending on the local geology and the capacity of the pumps fitted. The top of the shafts where they passed through the non-chalk deposits were lined with brick or cast iron. Lower down within the chalk, galleries were dug out sideways. They were four feet wide and six feet tall and reached out some distance into the chalk. This large exposure of the chalk underground allowed water to pass from the fissures in the chalk into the galleries and borehole quickly enough to keep up with the rate of pumping. The steam boilers and engines were replaced with electric pumps in the mid-C20th.

The introduction of steam powered pumps in the C19th to extract water from the chalk aquifer started to lower the level of water in the chalk rock. It also reduced the amount of water entering the surface water table and the amount coming out of the springs and into the River Lea. This had the effect of causing some previously existing wells to dry up, reduced the height of the water table and lowered river levels.

As the C19th progressed dry summers caused the Chadwell and Amwell springs to temporarily cease to flow. In addition, the watermill at Stanstead Abbotts started to experience increasing periods of time when there was insufficient water to fully operate. In the 1860s a steam boiler was added to the mill in order to supplement water power. This was of course more expensive than water power alone. The growing of Water Cress was particularly reliant on continuous supplies of pure fresh water in the summer months. All these issues began to raise concerns about the amount of water being removed from the chalk. The local area was seen to be paying a high price for the water being sent to London along the New River.

By the 1890s there was even more demand for water to be sent to London, but the impact of the local extraction of water from the chalk aquifer was already having a negative economic impact in the Lea Valley. In addition, it had become clear that extracting water from the chalk deep below London was also drawing water sideways through the chalk from under Hertfordshire. At this time a Royal Commission was set up charged with investigating the supply of water to the capital city. The Commission's report was published in 1893 and includes an insight into the situation in and around Stanstead Abbotts. Of particular interest is the fact that local people were interviewed and their evidence is recorded in the report.

Extracts from The Royal Commission on Metropolitan Water Supplies 1893

Mr Welch's Watercress Beds [1892]

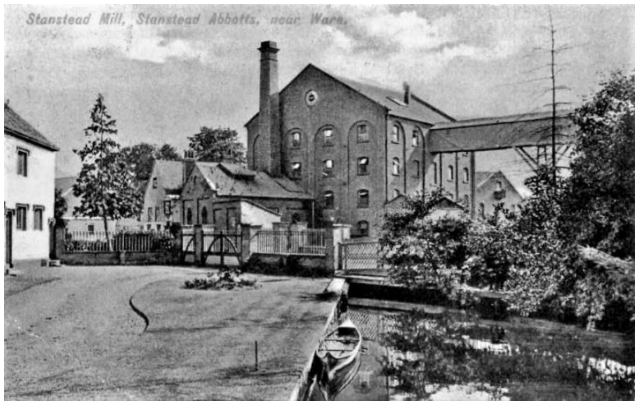
The watercress beds belonging to Mr Welch are located close to Amwell Springs, adjacent to the railway and on the south east side of Amwell Marsh Lane. [*Today that is the lane used to access the wild life sanctuary on the other side of the railway & river Lea*]. **Messrs Henry and Robert Ginger, watercress men** stated that when pumping is carried out at Amwell Hill and Amwell Marsh pumping stations simultaneously the water in the watercress beds fed from Amwell Springs will become dry within 24 hours of the pumps commencing. **Mr Welch** claimed that when both pumping houses were fully working Amwell Spring would cease to flow. Within 13 minutes of the pumps stopping the spring would start to flow again but it would take a further 10 minutes for its full flow to be restored.
[*This watercress bed and another very close to Emma's Well and alongside Amwell Lane were to go out of use early in the C20th due to a lack of the essential pure water from Amwell Springs*.]

Mr Pearce at Stanstead Mill [March 3rd 1893]

The flow of water has been in steady decline here for the last nine years, during which time Mr Pearce has occupied the mill, and is most especially noticeable during the summer months. This is when the river is dependent on the springs for its supply. The present mill has one water wheel, which should furnish the motive power for the six pairs of stones with some accompanying dressing machinery, but only four pairs of stones and dressing machinery can now be worked. In the summers the supply of water is very short and last year for quite two months only one pair of stones could be driven [*by water*], and that not continuously. The old mill which has been replaced by the present mill *[1866*], had thirty years ago ten pairs of stones driven entirely by water power furnished by two water wheels.
A **Mr Turner a miller** working for Mr Pearce has been at the mill ten years, there were six pairs of stones in the mill but rollers were introduced a year ago. In the latter end of the summer in an ordinary summer and autumn they can drive two pairs of stones with other machinery. They were shorter of water the summer before than any summer he has ever known. The wheel is a breast wheel, the fall of water from the top of the head water to the tail water is seven feet and four inches with a gate opening of eight feet nine inches with a depth of opening of nineteen and one quarter inches.

Mr Perkins Brewer at The Five Horseshoes Brewery Stanstead Abbotts [August 1892]

Mr Perkins has a well on his premises upon which his brewing business depends. His business also includes the Five Horseshoes public house located on Vicarage Road [*Roydon Road*]. This well is fourteen feet deep, used to always contain about five feet of water, but is now much affected by the pumping operations of the New River Company. When the pumps of the Stanstead [*Rye Common*] pumping station, situated one quarter of a mile away, are working, the supply of water at once begins to decline and it has been known for the well to be drained quite dry. At the present time the water is very low and continues to decrease and sometimes none can be drawn from the well. The water in the well is now normally four to five feet deep before the pumping station begins its work. The level of water is never very high now, not so high as it used to be. Any summer time they can pump it dry and we have to wait for it to rise again, perhaps fifteen minutes after the pumps stop. If both pumps at the pumping station are in use, they can pump it dry in two hours perhaps less.



Stanstead Mill in about 1905

The Five Horseshoes Pub and Brewery C 1900

This 1968 picture shows the last of the big floods before the flood relief scheme was constructed in the mid-1970s. The village High Street historically experienced such floods every decade with minor floods an annual risk in earlier centuries. The water in 1968 had briefly reached a maximum depth of about three foot in the middle of the road, the picture being taken a day later.

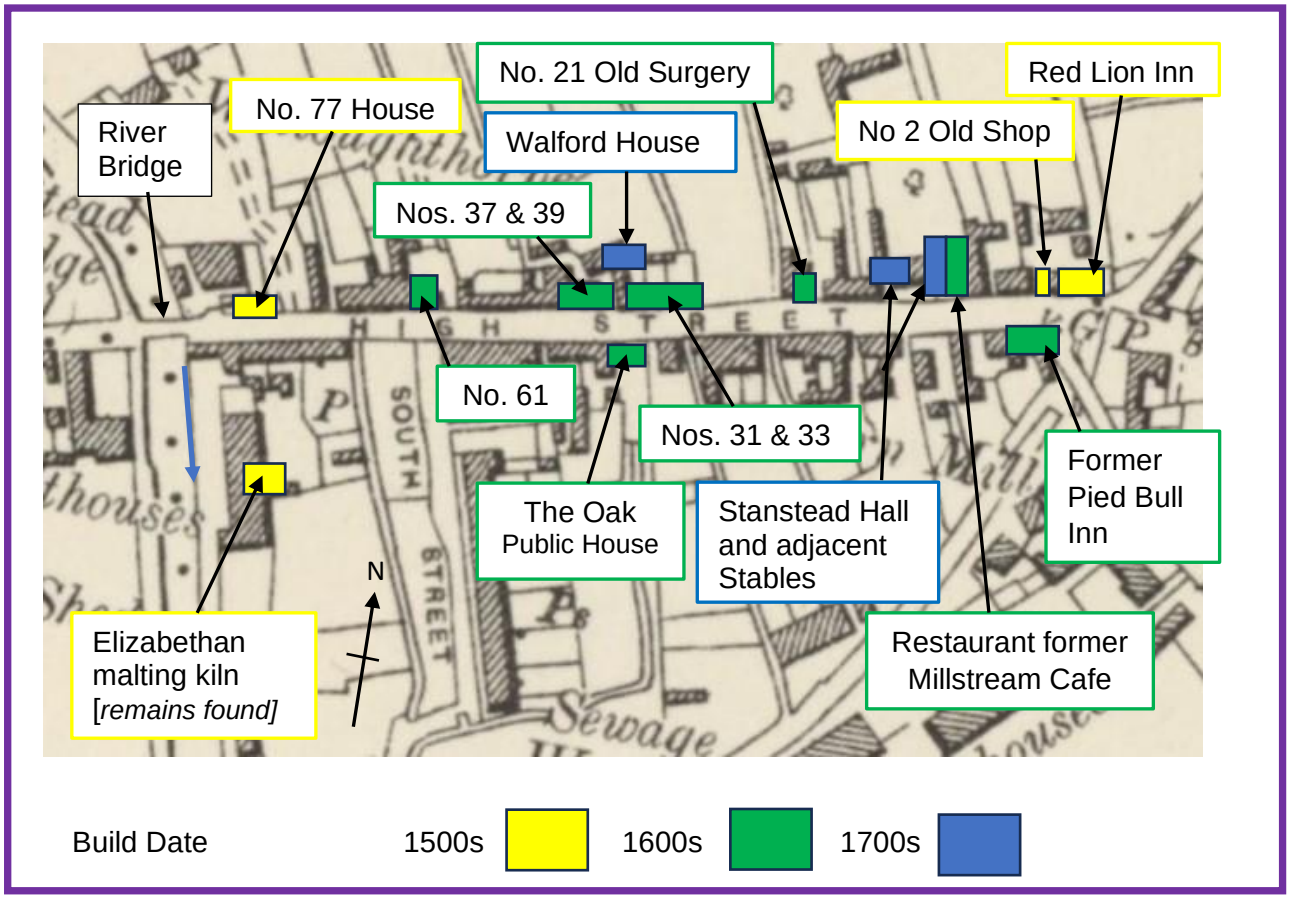
It was also noted in the Royal Commissions Report in 1893 that the fields on the valley floor were drier than they used be and there was less water in the drainage channels. These drainage channels had existed for centuries and now could be seen to be carrying much less water especially when the pumping stations were working. A Mr Harmer indicated that this did not alter the way the pastures were farmed. In the report it mentions that the amount of water taken from the river Lea in 1891 at Hertford, averaged 22.5 million gallons per day, [*destined for the New River*].

Chadwell Spring was frequently monitored and results show how much the water extracted from the ground had affected the flow of water from the spring. It should be remembered that before the pumping of water from the chalk the output of water at Chadwell had been estimated at 6-8 million gallons per day. Some examples of average flow are 1883-3.6 ,1884-2.1 [a dry year], 1893-3.5 m, 1897 a low of 2.5 [*followed by a temporary failure of flow*, *attributed to over pumping locally and from under London*]. Information about Amwell Spring is less detailed but it produced about half the discharge of Chadwell over the same time span and was notable for its great variability of flow reflecting the pattern of rainfall. It is hardly surprising that the proprietors of the watercress beds at Amwell, along with the mill and brewery in Stanstead Abbotts were increasingly concerned. Action based on the findings of the Royal Commission led to greater care being taken concerning the amount of water removed from the chalk and the river Lea. Artificial recharging of the aquifer under London *[pumping water from surface reservoirs down into the chalk*] has been taking place in the wetter months of the year since the early 1990s, which highlights how work of the Royal Commission in the early 1890s is still very relevant today.

Appendix Follows ⇩

Appendix

DISTRIBUTION OF OLDER BUILDINGS ALONG THE HIGH STREET



The above map is based on the listed building information for the High Street plus the 1500s dated malting kiln relics. The oldest buildings date from the 1400s & 1500s are located exclusively at either end of the High Street. By the river bridge both surviving structures date from the 1500s and were associated with commercial activities benefitting from a riverside location. The malting and wharfage downstream of the river bridge is the historic site of commercial activity associated with river transport. This was supplemented at the end of the C13th by wharfage at the Roydon Road Mill close to the Pied Bull Inn.

At the other end of the High Street is a very old building which for centuries has been the Red Lion Inn thought to have first opened its doors to the public in 1538. The building next to it is an old building known locally for many years as Springham's Shop also dated to the 1500s. However, both these buildings may well be older and date from the fourteenth hundreds. Both these buildings are at the margins of the historic flood area and close to where the High Street rises to meet the higher flat land at the base of the valley side. The central section of the High Street is notable for the fact that many of its existing older buildings date from the 1600s or early 1700s. Examples include the Oak Public House which displays a wonderful array of old timbers dating from the 1600s, inside the bar area. While Stanstead Hall and its adjacent stable block are a fine example of 1700s grandeur built by Michael Pepper the Stanstead water miller in 1752.

Although not a comprehensive survey of the buildings that once existed it does give an indication of a flurry of building work across the valley floor from the 1600s onwards. This was to continue into the 1800s with the building of rows of terraced houses *[some later turned into shops]* and further into the century Victorian villas all mostly still surviving today. Some replaced earlier buildings but others like those between Millers Lane and Glenmire Terrace were built on open fields. It was not until the mid-1900s that the High Street was fully built up on both sides.

Stuart Moye July 2023