GEOLOGICAL SURVEY OF ENGLAND AND WALES

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MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE

GEOLOGY OF THE FENLAND.

BY

SYDNEY B. J. SKERTCHLY, F.G.S.

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NOTICE.

In this Memoir on the Fenland, the author has written a complete and detailed account of all the strata from the most recent surface depositions down to and including those of the Glacial Epoch, and in connexion with this large subject he gives a masterly account of all its historical and archæological bearings, in a manner that has not previously been attempted. It cannot, therefore, fail to be of value both to those interested in practical matters relating to the Fenland, and to others who look upon the subject chiefly in an archæological and a geological point of view. It is perhaps possible that some geologists may raise a question respecting the purely terrestrial character of the Chalky Boulder Clay, in connexion with the phenomena presented by the same deposit further south, in Norfolk and Suffolk, where it overlies thick strata of soft, incoherent, and apparently undisturbed sand. Till these regions and other large contiguous areas have been systematically surveyed, it seems to me, in the meantime, premature to question the well-considered conclusions of Mr. Skertchly, who has so carefully collected all the available information afforded by the Fenland, and used it so judiciously.

Andrew C. Ramsay,
Director-General.

Geological Survey Office,
28, Jermyn Street, S.W.
5th November 1877.

NOTICE.

THE large tract of country, commonly known as the Fenland, which is treated of in this Memoir, was almost wholly surveyed by Mr. S. B. J. Skertchly; the exception being a part of the Cambridge boundary comprised in Sheets 51 N.W. and 51 S.W., which was mapped by his colleagues Messrs. Penning and Jukes-Browne. The Memoir descriptive of this area has also been written entirely by Mr. Skertchly, with the exception of a few notes on pit-sections contributed by Mr. J. W. Judd, who made a preliminary examination of a part of the Fenland comprised in Sheet 64, when on the staff of the Geological Survey.

Although the flat and low-lying district treated of in the present Memoir consists of quaternary deposits of newer date than the glacial deposits of the vicinity, and might not be considered by some persons to offer a very interesting field for geological research, Mr. Skertchly entered upon his task as a labour of love, and brought to bear upon it an amount of care, patience, and enthusiasm that has enabled him to impart a great amount of interest to the subject, and to produce the present work.

Mr. Skertchly has not confined himself merely to an account of the distribution and stratigraphical relation of the deposits which occur within the Fenland, but, in addition to a general description of the area in question, he has given an epitome of its history from the earliest historical times, and has treated of its Physical Geography, Drainage, Meteorology, and other kindred matters more or less related to Geology, which cannot fail to interest the general reader as well as those persons who may be personally and specially interested in the district.

But although Mr. Skertchly's work treats of the Fenland more especially, its utility may extend to all similar regions where humid soils covering low-lying areas necessitate artificial drainage on a large scale, where estuarine deposits are being thrown down, and where littoral accumulations are being formed.

Besides giving an account of observed phenomena, the author has stated the theoretical conclusions at which he has been led to arrive with regard to the age of the Boulder Clay, and the special conditions under which he considers it as most likely to have been formed. For the author's views on merely theoretical subjects, as well as upon his theories of glaciation, he alone must be held responsible; but since his acquaintance with the district is a very intimate one, and he has availed himself of every opportunity of patiently and carefully working out all the special branches of his subject which seemed important, his opinions must necessarily carry considerable weight. Still, in this instance, as in all other geological work, the absolute correctness of special theoretical deductions based upon more or less obscure and imperfect data, and upon observations collected within a limited area, will have to be tested by the aid of subsequent knowledge and more extended experience, which can only be made available when the survey of the whole country has been completely and continuously carried to a close,—or, as the author expresses himself, "much more work must be done before it can be deemed "permanently established," p. 214.

It is hoped that the information contained in the Appendices, of which the list of works relating to the geology and physical geography of the Fenland forms an important feature, will be considered valuable contributions bearing on our knowledge of the subject.

The lists of fossils from the Fenland Strata have been revised by Mr. Etheridge, Palæontologist to the Geological Survey.

H. W. Bristow,
Senior-Director.

Geological Survey Office,
28, Jermyn Street,
London, S.W.
18th October 1877.

PREFACE.

THE Fenland is a great expanse of country hitherto but scantily explored by geologists, for although much has been written upon special points no comprehensive treatise has before appeared. As the main points of this volume are described in the first chapter, it only remains for me to thank the numerous friends who have assisted me with local and other information. Foremost among these are Messrs. T. H. Miller, F.R.A.S., of Wisbech, W. H. Wheeler, C.E., of Boston, and J. Peckover, of Wisbech. Sir John Coode, C.E, has kindly allowed me to make use of his report on the Nene and supplied me with several sections. Mr. W. Wells, has given me notes on the neighbourhood of Whittlesey. Mr. S. Smith of Wisbech has assisted me in many ways, especially with the use of his valuable collection, and Mr. A. Grugeon, of Leyton, has kindly looked over my botanical notes, and examined specimens of peat. Many others have assisted me in various ways; indeed I have met with unvaried kindness everywhere among fen-men. The Director and Director General of the Geological Survey have spared no pains to enrich the work with the value of their criticisms, and to them I owe more than it would be becoming to express more definitely.

Two years have elapsed since I left the Fens, and several points doubtfully spoken of in the volume have been cleared up, and a few require slight modification; but so much of interest lies in this weird land, that if the book awaits the completion of our knowledge thereof, there would be no hope of its ever seeing the light.

SYDNEY B. J. SKERTCHLY.

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GEOLOGY OF THE FENLAND.

CHAPTER I.

GENERAL DESCRIPTION OF THE FENLAND AND SCOPE OF THE WORK.

I.—General Description of the Fenland.

Boundaries.—The district treated of in this memoir lies within the counties of Lincoln, Northampton, Huntingdon, Cambridge, Suffolk, and Norfolk. It occupies parts of the Ordnance One-inch Sheets, Nos. 51, 52, 64, 65, 69, 70, 83, and 84, and embraces an area of about 1,300 square miles. On the north its boundary extends from Lincoln, by Stixwould, Mareham-le-Fen, and Firsby, to Burgh-le-Marsh, where it joins the Marshland of the Lincolnshire coast, which is indeed only a continuation of the Fenland. On the west its margin runs from Lincoln parallel with the River Witham to Billinghay, on the western side of which village an arm extends northward as far as Metheringham; the boundary thence continues S. by W. by Billingborough and Bourn to Tallington, west of Market Deeping. From this point the line becomes sinuous and runs by Peterborough, Yaxley, Woodwalton, and Ramsey, to Somersham. The southern boundary extends with a wavy course from Somersham to Earith, Swaffham Priory, Kennet, and Mildenhall. On the east the fens extend from Mildenhall to Lakenheath and Stoke Ferry, thence bending to the west as far as Fordham, from which village the boundary again runs north by Downham Market to King's Lynn and the sea, with an inflexion along the Nar Valley.

The total area as measured on the Ordnance maps is as follows:—

Quarter-Sheet	51 S.W.	9	square miles.
„	51 N.W.	50	„ „
„	51 N.E.	42	„ „
„	64	196	„ „
„	65	425	„ „
„	69	321	„ „
„	70	196	„ „
„	83	30	„ „
„	84	37	„ „
Total	-	1,306	square miles.

Rivers.—The important rivers flowing through the Fenland are four in number, viz.:—The *Witham*, entering at Lincoln and emboguing into the Wash below Boston; the *Welland*, entering at Market Deeping and discharging into the Wash north of Spalding; the *Nene*, entering at Peterborough and flowing into the Wash north of Wisbech; and the *Ouse*, entering at Earith and passing into the Wash at King's Lynn. Of minor rivers there may be mentioned the *Steeping*, flowing by Firsby and Wainfleet to the sea; the *Bain*, a tributary of the Witham, which it enters at Dogdyke from Horncastle; the *Glen*, which flows through Deeping Fen to the Welland north of Spalding; the *Cam*, whose junction with the Ouse is below Ely, the *Lark*, *Little Ouse*, (or *Brandon River*), and *Wissey* (or *Stoke River*), which join the Ouse north of Ely, and the *Nar*, which joins the Ouse below Lynn. These rivers collectively drain the country east of the watershed of the Trent, north of that of Thames, and west of the watershed of Norfolk formed by the East Anglian Heights. The total area thus included is nearly 6,000 square miles, or over four and a half times that of the Fenland itself. When, therefore, we consider the large expanse of country whose waters are poured through the fens, and bear in mind that throughout their lower courses the channels are maintained by artificial means; and moreover, that the fens themselves possessed no adequate natural drainage-system, we are forcibly reminded that the welfare, not only of the Fenland but of the district draining into it also, is dependent upon the efforts of man.

It is a noticeable feature that a large town stands at the entrance of each river into the fens, and another at each mouth. Thus we have Lincoln and Boston on the Witham, Stamford, and Spalding on the Welland, Peterborough and Wisbech on the Nene, and St. Ives and Lynn on the Ouse. On the smaller rivers Cambridge stands on the fen-border of the Cam, Brandon of the Little Ouse, Stoke Ferry of the Wissey, and Steeping of the R. Steeping.

Scenery.—The above state of the fen rivers is the consequence of the peculiar physical condition of the Fenland, which consists of a low plain varying from five to twenty feet above the Ordnance datum, or mean tide-level. Much of this land is below the highwater level of ordinary tides, and would be overflowed almost daily, but for the erection of great banks along the seaboard, which are known as the "Sea walls." Slight elevations, of 20 to 80 feet, stand out from the dead level of the fens like islands from the midst of the sea. Islands, indeed, they once were and the name of the places built upon them, Thorney,* Whittlesey, Eastrea, Stoney, Maney, Hilgay, Southery, Ely, Coveney, Stuntney, &c., still bear testimony to their former insular condition. These "islands" lie south of a line drawn from Market Deeping to Ford-

* The word *ea* in Anglo-Saxon means *water, running water, a stream*, or *river*. *Ey* in Anglo-Saxon signifies *island*, and in Norman, or the old French language, *a watery place*. In modern English these words are used as terminations indifferently one for the other, as Anglesey and Selsey, for Anglesea and Selsea.

ham, the only exceptions being Sibsey and Stickney to the north of Boston. The largest is Ely, which with the neighbouring islands constitutes the important division known as the Isle of Ely. With these trifling exceptions, there is nothing to break the monotony of the plain; and when the isles and bounding hills lie beyond the field of vision, the landscape is as even, and the horizon as circular, as is the sea view when no land appears. Through this dreary land the Witham, the Welland, the Nene, and the Ouse once found their sluggish way, interlacing at numerous points, almost losing themselves in meres and morasses, flooding the land in winter, drying into strings of stagnant pools in summer, and on meeting the salt water of the sea pushing it back, till the tide gathering strength, overcame the river waters and rushed up the estuaries as bores. Now, the rivers are banked and travel direct to the sea, the winding estuaries are straightened and bores are of very rare occurrence; every mere and morass is drained, the whole country is intersected with artificial dykes, and powerful engines pump the surplus water into the arterial cuts. The land, which up to the time of Elizabeth, furnished only coarse fodder to cattle and geese, and afforded a home to countless wild fowl and fish, upon which a half-savage, scanty population subsisted, is entirely under cultivation, possesses but few acres of waste, and forms one of the richest agricultural districts of the kingdom.

In describing the present aspect of the Fenland it is convenient to divide it into three sections, dependent upon their geological characters, and each possessing peculiarities of its own. These divisions are as follows:—

1. *The Gravel-land.*
2. *The Peat-land.*
3. *The Silt-land.*

These, with the Wash, embrace the whole area treated of in this memoir.

1. *The Gravel-land.*—This division may be divided into three geographical areas; one on the north running along the whole border of the fens; a second bordering the west coast of the fens from Heckington to Peterborough; a third forming irregular stretches round the south and east in the vicinity of the Rivers Nene and Ouse. Of these areas the northern one merges into the hill drift of Lincolnshire, the western is a true beach gravel, the southern and eastern seems to be the remains of the old valley gravels of the adjacent rivers.

The gravel is elevated a few feet above the general surface of the peat, which lies to the east, and to which it gently slopes. It is distinguished by its gravelly soil, covered by a thin layer of peat on the east. Numerous villages stand upon it, finding a good solid foundation, and a fair water supply. It was early enclosed, bordering as it does upon the high land, and tokens of its early culture are seen in the hedge-rows, found almost exclusively upon ancient enclosed lands. On the east, where the peat encroaches upon it, and where it was, in consequence, swampy, the hedge-rows cease, and show by their termination the limit of cultivation in former times.

2. *The Peat-land.*—The peat land occupies nearly the entire west of the Fenland, to the east of the gravel where that deposit exists, and the whole of the southern area, as may be seen by reference to Plate I. There are, in addition, small outlying patches, as for example, one to the north-west of Wisbech, and another to the north of Boston. The peat is marked by certain peculiar features which at once stamp it with an individuality.

In the first place, although it occupies nearly one-half of the entire Fenland, *no village occurs upon it*, with the exception of Benwick, at which place the peat is thin, and the underlying gravel serves as a support for the buildings. The reason for this distribution is that no solid foundation is afforded by the spongy peat. Even at the present day but few houses stand upon it, and these are supported upon piles driven deep into the clay beneath.*

Other peculiarities are the perfect evenness of the surface, the absence of hedge-rows, and the undeviating character of the long roads or "droves." The even surface is a consequence of the mode of formation of the peat. The absence of hedge-rows results from the comparatively modern date of enclosure, and the long straight roads follow the course of the "dykes" or drains, by which the land is retained in a fit state for culture. These lands might almost be mapped by enclosing the areas in which the roads are long and perfectly straight.

It must be remembered, however, that there is no direct geological relation between the absence or presence of hedge-rows and the character of the roads. These features are, nevertheless, directly dependent upon the drainage; and, inasmuch as drainage is more or less dependent upon geological character, they may be said to be determined by the latter, and to afford useful empirical evidence for the field geologist. The early enclosed lands were such as from their superior elevation produced "winter land," or land not liable to be drowned in the winter. The divisions of property were marked by hedges, and as the gravel and silt lands lie on the whole higher than the peat district, we find the hedges roughly marking out the comparatively high gravel land on the west from the comparatively high silt land on the east.

3. *The Silt-land.*—This division occupies the north and central portions of the Fenland, bordering upon the Wash, and is in extent equal to one-half of the entire fen district. The soil is clayey and silty, and the surface of the land somewhat uneven, thereby affording a marked contrast to the level surface of the peat. The general elevation is somewhat higher than that of the peat land, averaging about 15 feet above Ordnance Datum. Villages and towns are plentifully distributed upon it, as the

* Mr. Wells, M.P., of Holme, informs me that the piles are very perishable, and he is going to try concrete foundations near Whittlesey Mere, which will have to be laid 18 feet below the surface.

silty beds afford good foundations. No water can be obtained by wells, except in small quantities, and of inferior quality. The supply is derived from the dykes and rivers, or in the case of large towns (Boston, Spalding, and Wisbech) is conveyed in pipes from the high lands several miles distant. Hedge-rows are plentiful, the roads often remarkably crooked, as may be seen to perfection between Donington and Bicker. Altogether this division is unmistakeable in its physical aspect, though in some parts, as in West and Wildmore Fens, the silt land lies as low and is as level as the peat. For similar reasons to those before given these low-lying silt lands were among the last to be enclosed and cultivated, and upon them we find the absence of hedge-rows, and the undeviating roads so characteristic of newly reclaimed fen.

Direction of the Trees.—A very noticeable feature throughout the Fenland is the bending of the trees towards the north-east. Many of the dykes and droves are bordered by aspens, and when a long line of these slender trees is seen bowed in one direction the appearance is very striking. This north-easterly direction is towards the sea, but near the coast the sea-breezes exercise their influence, and the trees all grow with a bend away from the sea, as may be observed at Hunstanton. Fig. 11 shows a group of trees bending in the usual direction. It was sketched in the neighbourhood of Holbech.

Among the highlands of the Isle of Ely the uniform direction of the growth of the trees is not so prominently seen, the reason for which will be presently given.

This subject has an especial interest to the geologist in connexion with the direction in which the trees of the buried forests beneath the peat are found to lie. Throughout the main expanse of peat, whenever the trees are seen *in situ*, the direction in which they lie is almost invariably north-east and south-west, varying but a few degrees on either side of those points. In other words, the buried trees lie in just the same position as the living trees would take if free to fall. This analogy is perfect, even for the exceptional cases in the Isle of Ely, wherein the living trees do not grow in any determinate direction.

The cause of the uniform direction of the trees is to be sought in the direction of the prevalent winds, and in the Appendix tables showing the direction of the wind are given for Wisbech and Boston.

Embankments and Drainage.—The maintenance of the Fenland in a fit condition for agriculture is a perpetual struggle with the salt waters of the sea on the one hand, and the fresh waters of the highlands and fens on the other. To protect the country from inundation by the sea great banks were erected in early, probably Roman, times, along the entire coast of Lincoln, Cambridge,* and West Norfolk, and are maintained with interested solicitude to the present day.

To prevent the highland waters from overflowing the fens, the

* Cambridge was then a maritime county. See Plate II.

Romans caused a long cut, called the Car Dyke, to be made along the whole western edge of the low land, its object being to serve as a catchwater. This dyke is now but little used, owing to a different system of drainage having been introduced by the Dutch engineers, who planned the drainage of the Bedford Level, in the reign of James the First. Catchwaters have, however, been adopted in draining the more recently reclaimed fens, such as the East, West, and Wildmore fens. It is now generally admitted by engineers that the Roman plan of surrounding the highland with a catchwater, deepening and improving the outfalls of the natural drainage into which the fen waters were conducted by artificial cuts, is the most advantageous method of maintaining the fens in a condition fit for occupation. The fens unprotected by catchwaters permit the highland waters to ramify through them instead of being confined to a few channels, and necessitate large and costly drains to convey the combined high and low land waters away.

The interior drainage as commenced by the Romans has already been mentioned. By far the greater portion of the Fenland is, however, drained in a similar manner to the lowlands of Holland. Indeed, as has been hinted, it was the Dutch engineers who were first consulted when the reclamation of the fens was seriously undertaken, and the impress of their nationality is still observable in the lines of trees bordering the long drains and droves, and the pumping windmills (now, however, nearly replaced by steam-pumps), which make the landscapes of Dutch and English Holland so strikingly similar. The principal of Dutch draining is the construction of large arterial drains through the centre of the fens, into which successively smaller drains, ramifying through the entire district, pour their waters. The main drains unite with the rivers near their mouths, and are protected at their junctions by self-acting sluices, which prevent any reflux of river or tidal waters. Smaller sluices protect the minor drains at their union with the larger cuts. In this system the natural is made subservient to the artificial drainage, and the river courses are interfered with to a great extent.

There can be little doubt that the adoption of this Dutch plan was a serious error, and even at the time of its projection was opposed by engineers of eminence, one of them (Westerdyke) a Dutchman, being among the first to show that the conditions of the English and Dutch fens were totally different. Mr. Wheeler, C.E., writing on this subject, remarks that Holland and Flanders are "utterly dissimilar to the fens of the counties of Lincoln and "Cambridge. The former were contiguous to the sea, and "recovered directly from it, and were unprovided with any "natural rivers, rendering the use of sluices absolutely necessary. "The fens of this part of the country are several miles from "the ocean, and through their midst run natural rivers which at "one time had regular and continued currents."*

The most recently reclaimed fens, the East, West, and Wild-

* The Fens of South Lincolnshire, W. H. Wheeler, C.E. London, 1868, p. 32.

more Fens, were drained at the commencement of this century by Rennie upon the old system of catchwaters, and with marked success.

II.—The Scope of this Work.

It is perhaps necessary to explain what is the scope of the present volume, and wherein and why it differs from other memoirs of the Geological Survey.

It has never before happened that a whole volume has been devoted to quaternary geology for the very sufficient reason that in no other part of the United Kingdom can such an area as the Fenland be found. Every portion of the fen deposits is of post-glacial date,* thereby reducing the time-limits of our subject, and, moreover, some of the beds are still in process of formation; hence this volume, unlike most others, is a tribute to geological archæology or archæological geology, and does not deal with those strata whose ages remove them from the grasp of the antiquarian. The history of fen geology dates no further back than the shadowy days of palæolithic man and the mammoth, yet great changes have taken place in the physical features of the land, some from cosmical, others from artificial causes. It is one of the objects of this volume to treat of those changes.

Before attempting to solve the cosmical problems, the artificial changes must be studied, and these are within the pale of written history. Hence we open with a sketch of the history of the Fenland, from which we learn how man has altered the face of the country, and what were the natural difficulties with which he had to contend. Because it is my earnest desire to render this a useful practical guide to the Fens, I have gone over all the records of the district and epitomised them in the three following chapters. The labour of this work was very great, and the result is not captivating, though it will prove of great service as obviating the necessity of spending months of labour upon legal documents. All the chief drainage works, descriptions of the physical features of the country, accounts of floods and storms, and other information necessary to the understanding of the geology of the fens are therein given, with as much completeness as possible. From these records we obtain vivid pictures of the country from the earliest historical times. Another advantage of this epitome is that care has been taken only to give such facts as have resulted in work, for quite a quarter of the whole literature is occupied with descriptions of schemes which came to nothing, and of acts of parliament never enforced. In this historical section, much room is devoted to drainage questions, which are of paramount importance to fenmen. This subject is intimately connected with geology and meteorology, hence its introduction.

Upon the correct relation between evaporation and drainage, both of which are largely influenced by geological characters, the welfare of the Fenland depends, so that I have deemed it necessary to discuss these questions somewhat elaborately.

* That is to say, newer than the glacial deposits of the vicinity. See remarks on pp. 204, 214.

All this portion of the volume is only indirectly related to geology, but as the Survey Memoirs aim at being practically, as well as theoretically useful, no apology is needed for their introduction. The meteorological section is almost entirely original, the records being chiefly the work of Mr. W. H. Wheeler, C.E., of Boston, and Mr. S. H. Miller, F.R.A.S., of Wisbech, while I am responsible for the deductions.

Very little, indeed, was accurately known of the geology of the fens before the work was placed in my hands in 1870, and that little was chiefly confined to the Cambridgeshire district.

The prevailing opinion seemed to be that theFenland was covered over most of its area with peat of variable thickness, which reposed upon a bed of "Buttery Clay" of doubtful origin, beneath which occurred a second bed of peat, containing the remains of an ancient oak forest. In some places three beds of peat were known to exist. Seawards, the peat was supposed to dip beneath marine silts of a character perfectly distinct from the Buttery Clay. These fen beds were believed to rest upon the Oxford and Kimeridge clays. The gravel beds were supposed to be of preglacial age, and to have little connexion with the true fen beds. Such, I believe, to be a fair statement of what was known of the general lie of the fen beds as gathered from the writings of Prof. Sedgwick, the Rev. O. Fisher, the Rev. T. G. Bonney, Prof. H. G. Seeley, and others.*

Upon a more extensive examination of the country every one of these suppositions was found to be incorrect, though most of them were legitimate deductions from the facts then known. The true relation of the beds is as follows:—There is no bed of peat constantly underlaid by Buttery Clay, and eastwards overlaid by marine silts, but the peat sometimes forms one bed twenty feet thick, and is sometimes largely intercalated with marine silts. There may be one, two, three, or four peat beds within a few yards of each other, for the whole country was a debateable ground between land and sea, and when the one prevailed peat grew, and when the other had the mastery, silts were deposited. Roughly speaking the peat is thickest in the south, and sends out tongues, as it were, into the marine clays and warps which I include under the title *silt*. In some places the peat thins away at the surface, in others it has become covered with silt before dying out. The Buttery Clay proves to be only one facies of the silt, is undoubtedly marine, and is no more constant than other fen beds, and the name must fall as applied to a distinct stratum. Gravels form the most ancient of the fen beds, underlying all the others, and they are indisputably post-glacial.* Mr. Judd, my former colleague, first recognised the gravel as forming a beach to the fens in Lincolnshire, and I have since traced it as forming an almost continuous floor to the fen basin. Much, however, remains to be worked out respecting these gravels; for instance, those to the

* See Bonney, Geology of Cambridgeshire, 1875; and Judd, Geology of Rutland &c.; Mem. Geol. Surv. 1875.

north and south-east are certainly not altogether marine, for the marine gravels and sands run up the hills into the highlands and down into the valleys also, overlying solid rocks and glacial beds, and I think at present the higher parts are the detritus of great land floods which happened contemporaneously with the formation of the marine beds below. Again the gravels to the south seem not to be true beach gravels, but the remains of the valley gravels of adjacent rivers which were deposited at a time anterior to any of the fen beds.

It is in these last-named re-arranged valley gravels alone that palæolithic implements are found. The beach and flooring gravel never contains an implement of any kind; the newer fen strata, however, yield very many neolithic implements. Hence in the Fenland the break between the older and newer stone ages occurred entirely in *post*-glacial times.*

The study of the formation of the marine silts leads us to the question of the silting up of the Wash. It is shown that a breadth of three miles of land has accreted in some places since the Roman occupation, and that the process is still going on. The silt is brought in from the sea, and is not a delta-deposit from the fen rivers. It is deposited only at the slack of high water on the coast, and in the rivers for the most part at the same time, though a little settles in sheltered places during the ebb. As soon as the silted material is up to the level of high-water spring tides, the glass-wort, locally called Samphire (*Salicornia herbacea*), springs up and forms the best indication of newly-formed land.

The whole of the marine beds of the Fenland have been brought up by the sea, and are not estuarine deposits of the rivers; hence the Wash is not an estuary but a bay, and the Fen beds are not estuarine but marine. The Wash is no more the estuary of the Fen rivers than the Straits of Dover is the estuary of the Thames.

The buried forest is found not to be a single deposit in a "second bed of peat," distibuted co-extensively with the peat, but there are at least five distinct horizons of trees each characterised by its own species, of which the Scotch Fir (*Pinus sylvestris*) alone is not indigenous, and the forests are confined to the peat in the vicinity of the highlands.

The changes of the river channels are traced in detail, and it is shown that only the Wellland has remained true to its original outfall. The geological history of the Witham is selected as a sample of the fen rivers, and worked out with some approach to completion.

The Appendices contain a table of the heights of important places in and round the fens, meteorological tables, a bibliographical list, a list of sections, glossary of local and obsolete terms, &c. These have been collected together at the end of the volume for convenience of reference, and are cited in the body of the work and in the index.

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* Post-glacial, that is to say, with the reservation given in p. 7.

I may perhaps be permitted briefly to state what I claim for this work. I do not consider the geology of the Fens to be by any means exhausted, indeed no one can be more sensible of the numerous points of interest barely hinted at or unnoticed, but an area of thirteen hundred square miles involves the work of a lifetime, instead of the four pleasant years I spent in the Fenland. I do, however, claim to have finally settled the relations of the peat and silt beds to each other, the post-glacial age and marine nature of most of the gravels, the origin of the boulder-clay, and the inter-glacial age of the palæolithic deposits. The local peculiarities must be worked out independently by local geologists, who will, I trust, find in this volume a conscientious and trustworthy guide.

CHAPTER II.

HISTORY OF THE FENLAND.

It is scarcely possible to interpret the geological evidence of the Fenland without some knowledge of the history of the district. We shall, therefore, give a brief epitome of the state of the country from the earliest records down to the present time, dwelling almost entirely upon the changes which have been produced by drainage, cultivation, &c. This is the more necessary, inasmuch as geology and history link themselves in the Fenland. The oldest of the true fen beds are newer than the glacial period, the most recent are still in process of formation, so that archæology and geology here merge into one another.

We shall divide our remarks under the following heads:—

1. *The Roman Period.*
2. *The Early English Period;* embracing the time between the departure of the Romans to the time of Henry II.
3. *The Mediæval Period;* extending from the time of Henry II. to Elizabeth.
4. *The Recent Period;* reaching from the reign of Elizabeth to the present time.

I.—The Roman Period.

The written records of the Roman occupation of the Fenland are practically *nil.* If we except such obscure phrases by Tacitus as *paludibus emuniensis*, and *silvas ac paludes emunire,* which may allude to the draining and banking of marshes, there is literally no written evidence of the Roman occupation of the district.*

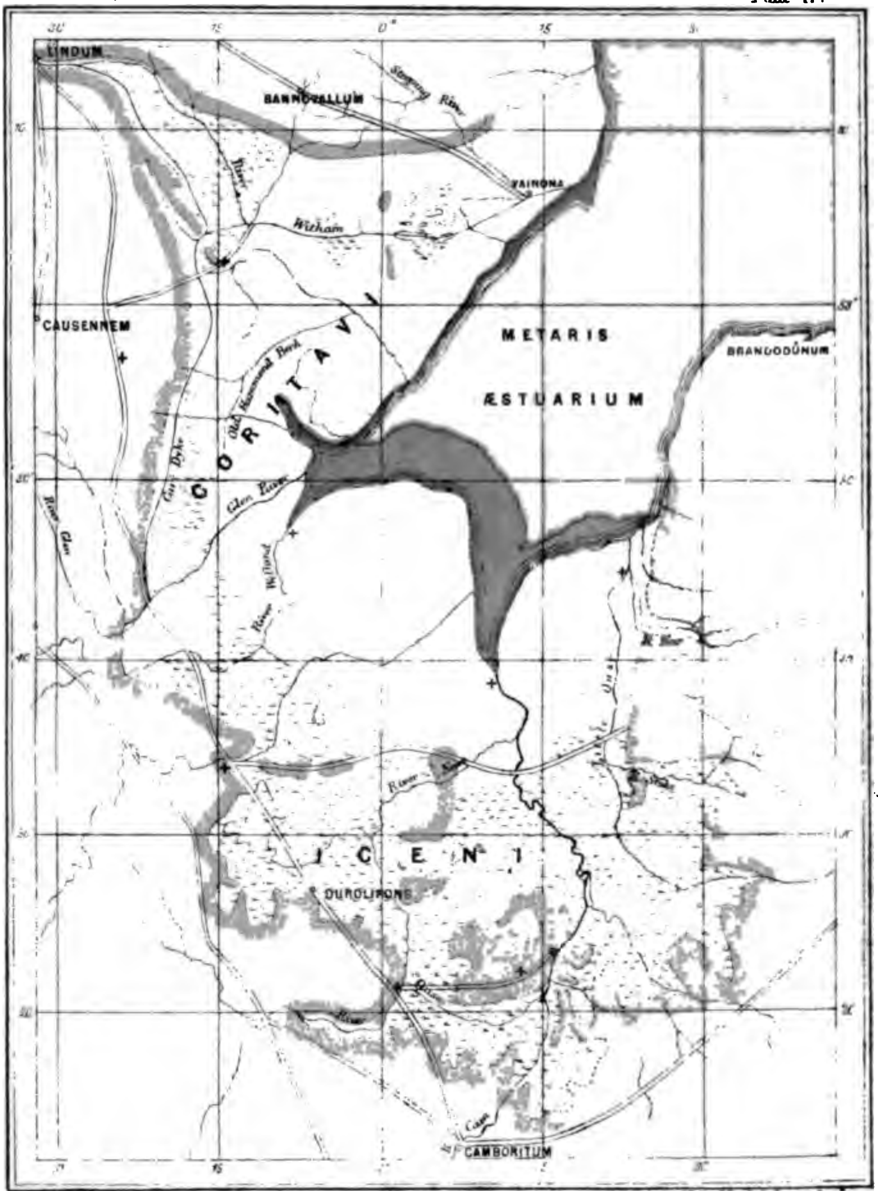
Not so, however, with respect to Roman antiquities. The fens abound with Roman relics; among the most prominent of which

* The Fenland is part of the province of *Flavia Cæsariensis*, and was inhabited by the Coritani (or *Koritavi*) in the north, and the *Iceni* in the south. See Plate II.

GEOLOGICAL SURVEY
OF ENGLAND AND WALES.

To face page 11

Plate II.



Dangerfield lith. 22, Bedford St. Covent Garden

THE FENLAND DURING THE
ROMAN OCCUPATION.

are the sea-walls, roads, drains, and stations, showing that this indefatiguable people strove to render habitable a district which, even then, must have possessed tracts of surpassing fertility. This is not the place to enter upon a description of the antiquities attributable to the Romans, and I shall not attempt to do so, but confine my remarks to points which throw light upon the physical state of the country.

The principal Roman stations in the Fenland were Lindum (*Lincoln*), Vainona (*Wainfleet*), Camboritum (*Cambridge*), Durolipons (*Ramsey?*), Durobrivis (may be Old Lynn), and Causennis (may be Boston). Some of the names are doubtfully attached to the modern towns above given, since in the absence of written evidence it is very difficult to fix upon the proper sites. The following table gives the Itinerary of Antoninus of the road from Cambridge to Lincoln, with the different readings of Horsley and Reynolds, as quoted in Thompson's History of Boston: —

Roman Towns.	Miles.	Modern Towns.		Miles.
		Horsley.	Reynolds.	
Iciano ad Camboritum	18	*Chesterford to Icklingham.*	*Thetford to Cambridge.*	17
Durolipontem -	25	*Cambridge* - -	*Ramsey* - -	25
Durobrivem - -	35	*Castor-on-Nen* -	*West or Old Lynn*	35
Causennem -	30	*Ancaster* - -	*Boston* - -	30
Lindum - - -	26	*Lincoln* - -	*Lincoln* - -	36

According to Horsley, this important road did not pass through the fens at all, whereas Reynolds makes it run in a devious line through the heart of the fens. It is important that we arrive at as clear an idea as possible respecting the relative merits of these two opinions. It is not our place to discuss the antiquarian data which have led to such different determinations, and we merely call attention to the fact that both routes agree pretty well with the Roman distances between the respective stations, so far as the author's own measurements go. But there is a striking discrepancy between Reynolds' measurements and my own, which has a decided bearing upon the correct determination of the route and upon the geological conclusions to be deduced from it. Reynolds makes Durobrivis West Lynn, and Causennis Boston, and gives 30 miles as the distance between the stations. He, therefore, ran his line direct from Lynn by Suttonbridge to Fossdyke, and thence to Boston, which gives 30 miles as the approximate distance. But a glance at Plate II. (which shows the coast-line during the Roman occupation) shows that nearly 9 miles of this route were covered with water by every tide, namely, 5 miles between Walpole St. Andrew and Long Sutton, and 4 miles between Holbech Clough and Fossdyke. The nearest way to Boston from Lynn at that time was by Wisbech and Spalding to Bicker, and thence to Boston, for it was necessary to deviate widely from the direct course in order to avoid the great estuaries of the Nene and Welland, and Bicker Haven. The distance is, therefore, not 30 miles, but 48. The internal evidence upon which Boston has been identified as a Roman station is very slight indeed; a few earthenware vessels of doubtful age, and some few other relics are all that can be advanced in support of its being the ancient Causennis.*

It appears, then, judging from what we know of the configuration of the ancient coast line, that the road in question passed through Castor and Ancaster, both of which names are evidently of Roman date. It is, of course, open for anyone to suggest that, as in modern times, the two estuaries were crossed by causeways, the same means might have been adopted by the Romans, who were so justly proud of their highway engineering, and to this we can only reply that it is an assumption that rests upon but very slender evidence. Our object in thus attempting to decide this vexed problem will now be seen. There is no doubt that Lynn, Wisbech, Spalding, and Wainfleet were Roman stations. These towns are situated at the mouths of the Rivers Ouse, Nene, Welland, and Steeping, and if Boston were not a Roman station it would afford a solitary example of a river whose mouth was left unprotected. Moreover, the Witham is a large river, far exceeding in magnitude the Little Ouse, upon which Lynn was placed,† and the Steeping, upon which the important town of Vainona was situated. Yet again, Lindum was not merely a military centre, but a port. Hence it would seem that if there were no Roman station at Boston, the most important river in the district was strangely neglected. Nevertheless, it may be affirmed that Boston never was comparable with Vainona (*Wainfleet*), and the reason is to be sought in the geographical changes which have taken place since the Roman occupation.

Stukeley shrewdly inferred that the river had a different course in ancient times, as in Richard of Cirencester's map. "This chan-" nel," he remarked, might pass out of the present river of Witham " below Coningsby, where the river Bane falls into it, at Dock-" dike and Youldale by the water of Hobridge, north of Hundle-" house; so running below Middleholm to Blacksike, it took the " present division between the two Wapontakes, all along the " southsides of the deeps of the East-fen: and so by Blackgote " to Wainfleet, the VAINONA of the Romans."‡ He thought this was the course, especially at high floods.

This view of the matter, merely modified so as to make the northern course the principal instead of the subsidiary one, would

* See Thomson's History of Boston. Mr. Bristow, F.R.S., has called my attention to an existing road from Great Wakering to East Wick (Sheet 2) which crosses the Maplin and Foulness sands, at the distance of half a mile from the Essex coast. This road is only dry for about four hours in each tide; when it is passable.

† It will afterwards be shown that the Great Ouse flowed out at Wisbech (Ousebech) at this time. See Plate II.

‡ "An account of Richard of Cirencester," by William Stukeley, M.D., p. 27. London, 1757.

account for the neglect of the Boston site, because Vainona would be the main outfall of the Witham. It also explains the importance of Vainona.

It was therefore with great interest that I examined the country around Dogdyke for traces of the old channel, for it ought to have been traceable across the gravel by the remains of its silted-up bed. This was at once discovered, and is laid down on the Geological Survey map, and also in the index map at the commencement of this memoir. On Plates II. and IX. the probable course is indicated from Dogdyke to Wainfleet, but in consequence of the identity of the silt in the old channel with that overspreading the country, it cannot be followed throughout any part of that distance.

That the Romans fully appreciated the fertility of the Fenland, and established themselves in it, are shown by the numerous remains of ancient settlements. Of these it is not our province to write, but we may cite North Kyme, Spalding, Deeping, Gedney, Wisbech, March, &c. to prove how the Roman population spread over the whole area. Catus Decianus* and Lollius Urbicus† were the most important persons engaged in the fens, and their names may be preserved in Kate's Bridge, on the Roman road south of Thurlby, near Bourn; Kate's Cove Corner, between Whaplode and Sutton St. James, and Lolham Bridges on the Roman road south of Kate's Bridge.

To the Romans are attributed the great sea-banks which protected the ancient coast-line. There is no reason to doubt the justness of this tradition, for it is certain that the sea-banks were esteemed old in the earliest written records of the district in the 12th century. The works are of such magnitude as to be worthy of that great engineering nation, and it is in the highest degree improbable that the British or the Saxons for once threw off their native indifference, suddenly fructified with engineering skill, and afterwards relapsing into their pristine carelessness, watched the sea wear into the greatest triumph of their powers. The earliest mention of the sea-banks is in 24 Hen. II. (1178), at which time the sea-bank broke, and Holland was deluged and destroyed, owing most probably to neglect, as was certainly the case in the year 1248, or 1250, when much of Kesteven and Holland were drowned. If at this comparatively late date the native population was indifferent to the state of the banks, notwithstanding the stimulus of the Norman invasion, there are but slight grounds for supposing that their less enterprising ancestors excelled in the difficult art of sea-walling.‡

We may therefore accept the tradition which attributes this

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* Catus Decianus was made superintendent of the district after it had been subdued by Suetonius Paulinus, in A.D. 61.

† Lollius Urbicus (whose name is preserved in Lolham Bridges) was governor in the reign of Antoninus. See Stukeley, Hist. Ant.

‡ Another argument may be founded upon the distribution of the tumuli, which are with one exception near the sea-wall. From this we may infer that those who made the walls erected the tumuli, and the exception mentioned is on the line of the Roman road across the fens.

great work to the Romans, as being most likely genuine, and it is on this supposition I have gone in constructing the map of Roman Fenland. The sea-walls can scarcely be older than the Roman occupation, and we may be quite certain that the coast in Roman times was not nearer the present beach than is shown in the map, which takes the banks in question as the boundary of the land.

The banks at present stand about 9 or 10 feet above the level of the ground, and their length is about 150 miles. In many places they are almost destroyed, as near Holbech, but generally they can be traced pretty continuously. When first erected they were probably not less than 15 feet high, with a base of about 25 feet. The top was certainly flat, and formed a good road along the whole extent of coast-line. On these data about ten millions and a half tons of materials were used in the construction of the banks.*

It will be noticed that the accretion of land since the erection of the banks has been greater upon the north-west than the south-west coast, but very much greater still upon the south, where the old banks are over four miles distant from the modern ones. The question of accretion will be dealt with in a future chapter, and we would here simply remark that the maximum rate of deposition where it has been greatest, is about 59 feet per annum.

Other banks, in the interior, have been attributed to the Romans. Such is the Raven's Bank, which in some old maps was written Roman's Bank. It extended from the Welland near Cowbit, in an easterly direction to the Delph Bank, which ran north-east to the sea-wall. Another bank, which may be of Roman construction, is the Cross Bank, which may still be seen crossing Mildenhall Fen.

The object of the Raven's Bank was obviously to serve as an additional protection to the interior land from the ravages of the salt water. It is, however, possible that it is the original sea-bank, and that the Roman bank proper was erected at a subsequent date. If this bank were erected soon after the subjection of the district in the year 61, the outer bank might be between two and three hundred years younger. Some colour of truth for this hypothesis may be derived from the fact that, while at three points within the Raven Bank, namely Whaplode Drove, Gedney Hill, and Sutton St. Edmunds, fortified castella existed, no trace of a Roman station has, to my knowledge, been discovered on the seaward side of the bank, where now the important towns of Holbech and Long Sutton are situated. Should this be the case, the rate of accretion on the Marshland coast must be at least double our former estimate, or about 118 feet per annum. It may be that the district between the two banks was only occasionally drowned; in which case the Raven's Bank which may have been erected to protect the solid ground, and the outer bank have been the first attempt to reclaim the debateable ground.

The object of the Cross Bank is not so easily determined; but

* Taking the sectional area at 262 square feet, and 20 cubic feet of silt to the ton. These data are only approximate.

it was probably made to protect what is now Mildenhall Fen from the overflowing of the Rivers Little Ouse and Lark.

The drainage-works of the Romans were on a scale commensurate with their embanking labours. Their plan was to protect the lowland from the flood waters of the uplands by a cut, and to carry the interior drainage by smaller cuts into the rivers, which were themselves embanked. Most of this drainage system has been destroyed in more modern times, but certain drains may still be traced which are unquestionably Roman handiwork. Of these the Car Dyke is the principal. It is a catch-water drain which was also used for navigable purposes, and can still be traced from Lincoln along the fen border to Peterborough, and perhaps as far as Ramsey. Stukeley thinks it extended to Cambridge. That antiquary with his native facility sees in the name a record of Carausius who was one of the Roman generals employed in this part; but as *car* is a well-known British word for *fen*, and as the term is still used with that signification in the Isle of Ankholm, it does not seem necessary to adopt his interpretation. Neither is it evident how Dr. Moreton's reading *Caer Dyke*, the city ditch, can apply to a dyke which might with much more accuracy have been termed a *country* ditch.

The Roman origin is indisputable, as many remains have been, and still are, discovered along its course, and its importance may be seen from the fact that seven forts were erected upon it between Peterborough and Lincoln. They were situated at Northborough, Braceborough, Billingborough, Garrick, Walcot, Lin wood, and Washingborough.

The primary object of the car-dyke was to serve as a catchwater for the highland waters in the vicinity of the fens, and there can be but little doubt that it served its purpose admirably, though it has been suffered to fall into decay. We have before stated that Rennie adopted the catch-water system in the drainage of East, West, and Wildmore Fens with marked success.

Of interior drainage works attributable to the Romans little is traceable at this time. One of them is most probably found in the West-lode which drained the fens around Croyland and Deeping, and emptied itself into the Welland. It is now unused, the drainage being effected by Vernatt's drain.

The old Hammond Beck may be another drain of Roman origin. It drained parts of Holland. No other drains of importance can now be made out, but sufficient evidence has been adduced to show that during the Roman occupation the Fenland was cared for with exemplary solicitude; and it is equally certain that had it been mere morass this would never have been the case. There is, moreover, no record of a time when the fens have been desolate, though as we shall presently see, the nearest approach to that condition was reached in the Elizabethan era, and not, as might have been imagined, in the earlier ages.

We must now glance at some other features of the country with which, however, the Romans had nothing to do. We have seen that the main embouchure of the R. Witham was at Wainfleet, and we must trace the alterations which the remaining fen rivers have undergone. The Roman banks mark for us the estuaries of the rivers in their time, and a glance at Plate II. shows us that the R. Welland discharges much at the same spot as in Roman times, and the proximity of the banks to the modern river shows that it was not the bearer of more water then than it is at present.

The estuary of the R. Nene, on the other hand, as shown by the banks, is utterly disproportionate to the present river. The map shows that it possessed by far the largest estuary, although at present the river is of puny size compared with that which flows into the Wash at Lynn. The reason is that during and before the Roman occupation the waters of the Nene, Cam, and *Great Ouse* flowed out by Wisbech; indeed that town derives its name Wis—or Ouse—bech from this very circumstance. It is only in comparatively recent times that the channel of the Great Ouse between Littleport and Brandon Creek Bridge was cut. The old Ouse pursued a sinuous course north- and westwards, from Littleport to Upwell, where the Nene joined it as a tributary. This ancient channel is still plainly traceable, and is called the Old Croft River to the south of the Bedford River, and the Old Welney River to the north of that cut. Nor does this change of direction of the Ouse rest upon historical evidence only, for the geological data are as clear as possible. The index map, serving as frontispiece to this memoir, shows that a great deposit of warp encroaches upon the peat on either side of this old channel, and a comparison of this map with Map II. shows that the marine deposit in question is neither more nor less than a magnified inland copy of the Nene estuary as mapped out by the Roman banks. A detailed account of the beds in this old estuary will be found in a subsequent chapter. Wisbech is, therefore, geographically and geologically designed as the metropolis of Fendom, but the glory that should be hers has gone from her with the waters of her river namesake.

The Nene itself, entering the fens at Peterborough, divided into two branches, one of which flowed northwards to Noman's Land Hirn, and then again divided into two sections, of which the one passed westwards into the R. Welland at Croyland, and the other straggled through the fens and discharged into the estuary north of Wisbech. The other, and larger branch, first travelled southwards and formed the meres of Whittlesea (the largest lake south of Windermere), Ugg, and Brick, and thence north-eastwards through the highland of March to Upwell, where it joined the Ouse. The latter portion of its course affords another instance of rivers taking apparently abnormal directions, for the highland in question is the only obstacle for many miles and could have been avoided by passing two miles to the north. This speaks volumes for the antiquity of the river with regard to the fenland deposits, for it is certain that no sane river could take that direction under present aspects. The course must have been decided before the fen area was denuded, and by a strange, but happy accident the Kimeridge and Oxford Clays have withstood the degrading influence of ages of excessive waste. Had this not been the case geologists must have sought the age of the Nene in the uplands and could only have inferred that it was more ancient than the fens.

A branch also passed from Earith to Benwick joining the Rivers Ouse and Nene, in which the water probably flowed sometimes in one sometimes in the other direction.

It is clear that when the Great Ouse flowed by Wisbech, Lynn Haven only received the waters of the Little Ouse and its tributaries. There was, in fact, little or no estuary, and within historic times the river was only a hundred feet wide at the haven and a man could jump across with a pikestaff at St. Germans. It is scarcely necessary to state that at present the united waters of the two Ouse rivers form a stream unmatched on the Fenland, and at St. Germans it is a quarter of a mile wide. These changes are fully discussed in the sequel.

Such are the changes which have taken place in the rivers. But the then aspect of the country was very different from the present. Great meres existed (of which we may mention Whittlesea, Ugg, Brick, Ramsey, and Soham as the largest) which received the surplus waters; and, surrounded with reed brakes, such as even now the country produces with surpassing beauty, afforded shelter to myriads of wild birds which found abundant food in the waters. Dank morasses covered with sedge and rush and flag abounded on the peat land, and the cushion-like clumps of *Carex paniculata* afforded a hazardous foot-hold to the nimble wayfarer. On these morasses and on the firmer, or rather drier, soil grass attained a rank luxuriance, and here the cattle grazed and throve wondrously. But in winter nearly all the peat-land was drowned, or as the old fen-men say "surrounded," and then the hardy inhabitants went from island to island in small boats, or travelled quickly over the smooth ice. The border-land was clothed with forest-growth; and, sea-wards of the timber trees, clumps of willow and sallow gave shelter to the wild-boar and the wolf. On the silt lands the lower portions were surrounded in winter and often far into the summer, and East and West Fens, and especially the former, almost always presented a lake-like appearance. The soil was fertile; the waters, the woods, and the air were tenanted with game. Famine could never be known for the land literally overflowed with food, and as a consequence the people degenerated into a thriftless race, whose only strong passion was a love of freedom.

CHAPTER III.

HISTORY OF THE FENLAND (*continued*).

II.—The Early English Period.

Under this heading I include the periods between the departure of the Romans and the close of the reign of Henry the Second that is from A.D. 409 to 1189.

The written history of this period is still scanty, and may be thus epitomised.

A.D. 664.—In this year the monastery of Peterborough (Medeshamsted) was founded by Wulpher, King of Mercia, and his brother Saxulph, as stated by Ingulph.*

The Harleian MSS., Brit. Mus. No. 4127, p. 10, contains an account of Wildmore Fen, which is described as a marsh, but the record is confined to an enumeration of the different land-owners.

During the Saxon Heptarchy numerous monasteries existed in and near the Fenland. Bardeney is especially mentioned by Ingulph as the place in which Ethelred, King of Mercia, became a monk after reigning thirty years. The monastery of Croyland was founded by King Ethelbald in 716, the year of his coronation.

Felix, a monk of Croyland, who wrote about 730 or 749, and compiled the life of St. Guthlac, thus describes the fens in that neighbourhood:—"There is a prodigious fen beginning from the "banks of the Roman Gronta (R. Cam), extending a great way, "intersected sometimes by sedge, sometimes with streames of black "water, with woody islands, and crooked banks from the south "to the north as far as the sea."

Felix also remarks that, "there are immense marshes, now a "black pool of water, now foul running streames, and also many "islands, and reeds and hillocks, and with manifold windings "wide and long, it continues up to the North Sea."†

William of Croyland, in his life of St. Guthlac, describes poetically the fens, and Camden renders his lines as follows:—

> "In England from the Roman Gronta's banks
> Spreads a long fen in winding cuts and cranks;
> Stretcht to the limits of the Eastern sea,
> From South to North it makes its lengthen'd way.
> Infectious fish, thick reeds and rustling winds,
> That whispers feign, are all that here one finds."

Henry of Huntingdon, in the time of Stephen, gives the following description:—"This fenny country is very pleasant and "agreeable to the eye, watered by many rivers which run through "it, diversified with many large and small lakes, and adorned "with many woods and islands."

1130. William of Malmesbury tells us that "Here is such "plenty of fish as to cause astonishment in strangers, while the "natives laugh at their surprise. Waterfowl are as plentiful; "so that five persons may not only assuage their hunger with both "sorts of food, but eat to satiety for a penny."

Ely, whose nunnery was founded in 674 by St. Etheldreda, wife of Tombert, prince of the South Gervii, was celebrated for its vineyard, for an old saw quoted by Camden says:—

> "Hæc sunt Eliæ, lanterna, capella Mariæ
> Atque molendinum, necnon dans vinea vinum."

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* Bohn's Ed., p. 2.

† Life of St. Guthlac, by Felix, a monk of Croyland, p. 21.

William of Malmesbury also speaks admiringly of the size of the trees, and the luxuriance of the vines, and states that the land is full of monasteries, and large bodies of monks are settled on the islands in the water.

In the Saxon charters belonging to the Abbey of Croyland, given in full by Ingulph, we obtain some information concerning the state of the county. Very grave doubts are entertained respecting the authenticity of these charters, and both Hickes in his Thesaurus and Sir F. Palgrave in the Quarterly Review point out the feudal tone which pervades them, and consider it conclusively established that they are forgeries of Norman, or still more recent times. There can be but little doubt that the charters were compiled by Richard Upton, Prior of Croyland, to support the claims of his monastery in 1415. Henry T. Riley, the translator of Bohn's admirable edition of Ingulph, remarks that although in the Cole MSS., Brit. Mus., vol. 44, "there are nearly 200 folio "pages of abstracts from the abbey registers," yet a careful examination fails to show the slightest evidence that the charters were in existence between 1091 and 1415. Indeed in vol. 44, p. 53, Cole MSS., there are several mandates from Edward the Third wherein the ecclesiastics state that their "abbey had been "founded by Ethelbald five hundred years before the Conquest. "This they would have hardly dared to assert, if they had at "that moment among their archives a deed which proved that "Ethelbald founded the abbey in 716, only 350 years before "that event."* The same authority also states that "between the "years 1091 and 1415 no mention is made of the existence of *any* "*one* of these Saxon Charters."† This, however, is not quite true, since in 1085 the charter of Edred, in the year 948, is quoted to show that Alderlound is in the county of Lincoln. Several anachronisms point to the spurious nature of these documents, and to those given by the authorities quoted I would add two which bear upon our present subject. In the charter of King Wichtlaf, in 833, there occur the words *unum molendinum ventricium*, which clearly means *wind*mill as Mr. Riley translates it (p. 20). Now windmills are believed to have been unknown in England before the Conquest, and this solitary mention of one is not sufficient to establish their greater antiquity. The second is apropos of Ethelbald's charter in 716, and though not occurring in that document itself, showed that the history was not compiled from authentic records. On page 8 it is stated that "Croyland "consisting of fenny lands . . . . . . it was not able to "support a foundation of stone; wherefore, the king ordered huge "piles of oak and beech in countless numbers to be driven into "the ground, and solid earth to be brought by water in boats a "distance of nine miles, from a place called Upland, and to be "thrown into the marsh." The whole of this account is without doubt fictitious. In the first place the abbey is *not* built upon

* Ingulph's Chronicle, Editor's Introduction, p. xi.
† Ibid., p. x.

marsh (that is, peat) land, but upon solid gravel, as is shown in the index map to this volume; and there was consequently no necessity for a pile foundation. In the second place the foundations of the old abbey have been, within the last twenty years, entirely dug out, and no trace of piles found; indeed the old nave and south aisle are now the churchyard, and it is clearly impossible for the graves to be dug amidst piles. The mistake arose, doubtless, from the fact that the elevation of the hard land is so slight that at that time it would be inappreciable. Even now that the fen has sunk through drainage the rise is so slight that only an experienced eye can detect it. Moreover, in the town near the River Welland piles are found driven close together, and penetrating some five feet into the peat. They consist entirely of willow and sallow, and formed part of an ancient causeway, for they were overlaid with gravel. These piles are of great antiquity, and were probably known to, and perhaps used by the inhabitants at the date of the history.

Having thus been instrumental in assisting to demolish one portion of this doubtful legend, it is but fair to establish another part of their tradition on a firmer basis than mythical piles. St. Pega, the sister of St. Guthlac, about a year after his death, "returned by boat to her cell, which lay to the west, at a distance "of four leagues from the oratory of her said brother."* This spot is still called Peakirk, that is, Pega's Church. Brother and sister were devoted to each other, and while the sanctity of the virgin compelled her to isolate herself from her holy brother anchorites, she chose the only spot from which there was a firm road to Croyland, and established herself there. This spot is Peakirk, and the index map shows that a narrow band of gravel juts from the main mass, and, crossing the fens, terminates at Croyland, forming a natural road between the two places. It is singular that geology thus comes to the aid of history, and, while demolishing the "history" of the dark ages, confirms the truth, and shows that the position of the cell from which the University of Cambridge sprang was not chosen arbitrarily.

Had these charters been genuine, the hints they convey respecting the natural condition of the country would have been very valuable; but their evidence is happily not entirely nugatory, for the monkish chronicler, knowing the face of the country perfectly, would never have made statements of physical features which could be refuted without any difficulty. Hence, when we read of woods, marshes, pastures, and turbaries, we may rest assured that they had an actual existence, and are not to be classed with the statements whose truth was staked on piles. Woods are mentioned in the charters of Offa (793), "A wood "and marsh two leagues in length and two leagues in breadth ". . . . in the fields of Depyng." Ancarig wood (Thorney) is mentioned in the account of the defeat of the Christians by the Danes in 870. Ancarygwod and Medeshamstedwod (Peter-

* Ingulph's Chronicle, p. 9.

borough) are described in the charter of King Edgar in 966 as belonging to the royal manors of Estrey (Eastrea) and Castre (Castor). Plantations of alders are mentioned as existing on the west side of the island of Croyland in the same charter, whence, perhaps, the name Alderlound is derived, and so we might go on citing passage after passage to show that woods did exist in the vicinity of Croyland at an early date. But it is to be remarked that all these woods are situated on high land, and not in fen— Thorney, Eastrea, Castor, &c., all on islands, or outside the true fen, as may be seen by the index map.

But in other records mention is made of the forest of Kesteven, and it is stated that the low lands of South Lincolnshire (Kesteven and Holland) were afforested by Henry I. about the year 1110, and continued to be the King's hunting grounds, excepting a portion which Richard I. disafforested about 1194, until the 14th of Henry III. (1230).

Gough, in his additions to Camden's Britannia, mentions that a Mr. Neale "had by him a copy of the exemplification of the "letters patents of James I., dated Westminster, Feb. 1, ann. "5 Ang. and Scot. 41, reciting, by way of Inspeximus, the letters "patents of Henry III., dated Portsmouth, April 23 r. 14, "disafforesting the forest of Kesteven for ever, which was also "confirmed by the letters patents of 20 Edward III. wherein the "said forest is described as extending from Swafton to East "Deping as Caresdike extends itself."

Dugdale, writing of this forest, remarks that Henry the First "did afforest these fens between Kesteven and Holand, viz.: from "the bridge of East Deping (now Market Deping) to the church "of Swaiston, on the one side; and from the bridge of Bicker, "and Wragmere stake, on the other side; which metes divided "the north parts, and the river of Weland the south, excepting "the fen of Goggisland" (p. 194). It was deafforested in the 14th of Henry III. (1230) "in length on the one side, from Swastone "to East Deping, as Kares dike extends itself . . . . And, "in length, on the other side towards Holand, from the bridge "at Bikere to the great bridge at Spalding. And, in breadth, "on the one part, from that great bridge at Spalding, to East "Deping. And, on the other side, from the land of Swastune, "unto the bridge at Bikere." So that all the lands, marshes, "and turbaries, within those precints, were thenceforth to be "quit of waste and regard." (p. 195.)

The second continuation of Ingulph's History of Croyland alludes to the deafforesting in the following terms:—"This same "King Richard, in the first year of his reign, deafforested all the "marsh lands of Hoyland and Kesteven, between the River "Welland and the River Witham, which had been previously "deafforested in the time of Kings Henry the First, Stephen, "and Henry the Second; and he granted to the men on both "sides thereof, to whom, before, it had of right belonged, leave to "build upon the said marshes, and to till the same, and to enjoy "all their easements upon the same, according to the metes and "boundaries in their charter contained." (p. 282.)

It is noticeable that the terms of deafforesting do not mention woods, but only "lands, marshes, and turbaries," from which we may infer that the forest of Kesteven was not a wooded country, but only open land which afforded shelter to the "harts and hinds" in the reed and sedge and thickets of willow and alder. Indeed Dugdale in another place, to be cited presently, speaks of the reeds, &c. as affording such shelter, and he is then quoting contemporary history. The word forest does not necessarily imply woodland: it comes to us from the French *forêt*, originally *forest* from the low Latin *forestum*, and means *the out-lying country* as opposed to the cultivated, and is probably originally derived from the Latin *foris*, out of doors.

We have no right then to consider any portion of the fens to have been forest in the modern acceptation of the term during the historical period. This is important since it has been thought that the Kesteven forest was the modern successor of the buried forests of the peat.

Huntingdonshire was originally covered with a wooded forest, and its name, variously written Huntersdunescyre, Huntedunescyre, and Huntandunescyre, attest of what celebrity it was as a hunting ground. The following valuable notes from Dugdale show that the *woodland* did not reach the border of the fens, though the *forest* did.

"This county of Huntendon being then a forest, the regardors did, in 34 E. I. [1306], by virtue of the King's precept, make this following new presentment at the new Temple in London, *viz.*, that the tenants of the Abbot of Ramsey, in the town of Ramsey; the tenants of the Abbot of Thorney, in Wytlesheye; and the tenants of the Prior of Ely, in Wytlesheye, had wasted all the fen of Kyngesdelfe, of the alders, hassacks,* and rushes, estimated at a thousand acres, so that the King's deer could not have harbour there, as they had before that perambulation.

"Likewise, that the towns of Stangrund and Farsheved had wasted the Fen of Farsheved of the alders and rushes, estimated at an hundred acres.

"Also that the Abbot of Thorney had made a purpresture† in the said King's forest, within Farsheved Fen, and enclosed the same with a double ditch on the side towards Farsheved; which contained in length two miles by estimation, and two furlongs in breadth: And likewise, that the said Abbot had raised a new bank without the town of Jakele [Yaxley], containing one mile in length, against the assize of the forest.

"And, that John le Wode, of Jakele, came with the men of Wytlysheye, into the Fen of Kynggesdelfe, and set fire therein, which burnt in length and breadth about four miles, by estimation, which caused great loss to the King, in his harts, hinds, and goats. And likewise, that the men of Benewyk had destroyed a

* Clumps of *Carex paniculata*. See list of terms in Appendix.

† O. Fr. *purpresture;* the enclosure, or whole compass of a manor.

certain place in Kyngesdelfe, of the alders and rushes, called Hertyngges, containing a mile in length and breadth.

"And they likewise then presented, that the banleu* of Ramsey began at Humberdale, and so went on to Wystowe lowe, by the middle of the town of Wystowe, and so to Ranlestone; and thence to Ranelesnoge; thence to Obmere-bote; thence to Scaldemere; thence to Ayxschebeche; thence to the Newe lode, which leadeth between Middilmore and Kynggesdelfe; thence to Beaurepeyre; thence to Tyrmerekote; thence to Pollyngsecote; thence to Caldemowehache; thence to Goldepyttellade; and thence to Homberdale.

"The division betwixt this forest and the Bishop of Ely, his free chase of Somersham, began at the great river, *scil* at the three Willowes, and thence extended to Fentone lode; thence to the new bank; thence to Fentone crosse; thence to the mill at Wardeboys; thence to Pydelemare; thence to Pydele dam; thence to Ivymede; thence to Kollangeleye; thence to the Hanger of Bluntesham; and thence to the great river," (p. 366.)†

Leland says of this county, that it was "much more woody than "it is at present, and the dere resorted to the fennes. It is ful "long sins it was deforestid."‡

We can pretty confidently assert, then, that the fens have never borne forest growth within the historic period; that the woodlands did not even encroach upon the fens; that they were so early as the thirteenth century being destroyed; and that the forest of Kesteven, with its Holland and Huntingdon extensions, were "forests" in the true sense of the word, but not at all forests according to the modern limited acceptation of the term. They were, indeed, no more than unenclosed, unstocked, and unfrequented tracts of country, covered with rushes, reeds, and clumps of sedge; dotted with sallows, willows, and alders, which here and there formed low thickets. In these resorts deer and other game were secure,§ finding abundance of food, and at hand at any time to gratify the desires of the royal huntsmen.

This dearth of woodland is important as bearing upon the ages of the Buried Forests, discussed in a future chapter. It has been confidently asserted that these were the preserved relics of the forest which in early historic times covered our islands. We have now shown that there is no historical evidence of forests in the fens, but direct evidence to the contrary, and we shall hereafter give the geological proofs of the antiquity of the buried trees.

Throughout the old charters, a distinction is always made between meadow land and marsh; showing that, even at this time, considerable tracts of country formed solid ground, at least in the

* O. Fr. *banlieue*, precinct or outskirt.

† On tracing these metes on the map a considerable quantity of highland is included.

‡ Written about the year 1560. Collectanea, vol. iv. p. 48.

§ And not beast only, for Ingulph relates how "upon the mere apprehension of the "approach of war [the people fled] to the slimy retreats of the marshes, and the "alder-beds, and the mud of the lakes, as though some very strong castle of refuge." (A.D. 1032.—Bohn's Ingulph, p. 123.)

summer time. But the defective drainage often drowned, or "surrounded," the land. Thus when in 1013 people flocked to the island of Ely to escape the Danes, "it happened, fortu-" nately, that this year the inundations had increased to an " unusual degree in consequence of the frequent showers, and " consequently rendered the neighbouring fens, as also the marsh-" lands adjoining thereto, impassable." We learn that the stoutest " among them, as well as the young men, kept watch among the " sedge and the alder-beds upon the mouths of the rivers."* These alder-beds time after time afforded safe places of concealment to the inhabitants during the continuance of war.

Turbaries are mentioned in the year 1091† as occurring in the neighbourhood of Croyland, where now there is not sufficient turf to dig a single "cess."

Bicker Haven was still in existence and the salt-pans in the neighbourhood of Sutterton are especially enumerated in the charters from the time of Wichtlaf in 833 downwards, though in the account of Abbey lands which Ingulph says he himself culled with great care from Domesday, they are omitted. This Haven will be more particularly described in the sequel.

It may be interesting to quote here Ingulph's own account of the Abbey lands at the time of the Conquest, so far as they describe the condition thereof, omitting unnecessary particulars. Only the Lincolnshire estates will be enumerated:—

"At this period I myself went to London, and, having with much labour and at no small expense, extracted and culled the following tenements of ours from the two rolls before mentioned, commonly known to the English as Domesday, I have determined to state the same, briefly at least, for the information of posterity; in most cases I shall abbreviate, while in some I shall be more discursive, for the full information of my successors. If any one of posterity shall wish to read in preference word for word the amount of our property, as the same is stated more diffusely in the said original rolls, then let him betake himself to those rolls, and diligently examine the same; and I only trust that he will appreciate this short performance of mine, and will, from his heart, commend these my labours, seeing that I have so carefully and succinctly collected and thrown together into this form particulars so little known, so much dispersed, and gathered out of such a mass of confusion.‡

"In the first place, in Lincolnshire, at Croyland, in Ellowarp,§ St. Guthlac had, and still has, woods and marshes four leagues in length and three leagues in breadth. . . . . In Holeben‖ and Capelade¶ [amongst other lands] twelve acres of meadow land. . .

* Bohn's Ingulph, p. 114.

† Ib. p. 208.

‡ Another instance of monkish veracity. The account is not a faithful epitome of the Winchester Roll and Domesday.

§ The wapentake of Elloe.

‖ Holbech (?).

¶ Capella-ad-ladam, now Whaplode.

. . . In Kerton Warp,* in the berewick† of Algar twelve bovates‡ of land . . . . . ten bovates being now waste through overflow of the sea. In Donne dyk§ [amongst others] twenty acres of meadow land. In like manner [in Drayton] Saint Guthlac had and now has one carucate|| of land, assessed to payment of geld; the land consists of one carucate; the villeins here do not plough; the four salt pits here are worth five shillings and fourpence; there are five acres of meadow land.¶ In Bukenhale [amongst others] twenty-six acres of meadow land, and fifty acres of forest; the seventy acres of forest, in the time of King Edward, were valued at thirty shillings in money. In Haylington [amongst others] twenty-two acres of meadow-land. In Langtoft [amongst others] the land here is six carucates in demesne, that is to say, one carucate, and eight villeins, with four bordars,** and twenty socmen†† holding five carucates of [arable] land, and one hundred acres of meadow land; also two woods, with the property in a marsh, two leagues in length, and two leagues in breadth: the arable land being fifteen quarantenes‡‡ in length and nine in breadth. In Boston [amongst others] forty-five acres of meadow, and marshes fifteen quarantenes in length, and eight in breadth. In Repyngale [amongst others] sixty acres of meadow land. In Opton-a-green hundred in Northamptonshire§§ woods and marshes, two leagues in length and two leagues in breadth.

"In Wridthorp [amongst others] the (arable) land consists of two carucates: the meadow land of three acres. In Pokebrok hundred, in Elwyngton, the (arable) land is one carucate in demesne, and six acres of meadow land. In Soudnaveslound hundred, in Adyngton, out of two hides the (arable) land consists of four carucates; there are also six acres of meadow land. In Ausefordshew hundred, in Wendlingborough, out of five hides and a half of land, the arable land consists of twelve carucates, the meadow land thirty acres.

"Also, at Gravelcrand, in Baddeby, in Ailwordesie hundred out of four hides, the arable land consists of eleven acres, the meadow land twenty-eight acres, with woods four quarentenes in length and two quarantenes in breadth. In Widibroke hundred. at Glapthorn [amongst others] twenty acres of wood land."

From this account we may conclude that the land at this time was very far from being a vast marsh. The meadow land consisted without doubt both of those higher grounds which were not liable to flooding, and of those which from being overflowed every

* Kirton Wapentake.

† A manor, generally only a portion of a manor, as a vill or hamlet.

‡ The quantity an ox could plough in a day.

§ Donington (?).

|| By calculation from data given in the charter of Wichtlaf (A.D. 833), Ingulph, p. 20, a carucate is 4,500·5 square yards.

¶ These are in Bicker Haven, and still traceable.

** Bondmen, less servile than the villeins.

†† Socmen held land under a particular tenure.

‡‡ Forty perches.

§§ This included Alderlound, and extended to the borders of Lincolnshire, by Namanslandhyrne.

winter, formed summer land only. This latter, doubtless, formed the greater portion of the level, at any rate in the vicinity of the towns. The term marsh was confined to such lands as were throughout the year saturated or covered with water, being in fact bogs. The standing pools which abounded received the names of *lakes*, and the much larger ones of *meres*. The sites of the latter remain, having, in fact, only been drained of late years. But of the former no trace remains, yet we can form very accurate ideas of their appearance from the pools which mark the sites of the silt pits. They were shallow pools, seldom six feet in depth, and bordered with a deep fringe of reeds, which, whether in summer or winter, are very beautiful. In summer the straight vivid green stems and leaves relieve the darker colour of the rushes and flags. The gorgeous *Lithrum* shoots its flowering axis above the surrounding plants, glowing with purple flowers, and outshining the beautiful Willow Herb, with its crimson flowers and dull green leaves. The Water Iris glints in the sun like a golden flame, and the *Myosotis* lurks between the reeds upon the land side, carpeting the ground with cobalt blue. In the water itself the Water Plantain rears its panicled flower-stalk, and extends its pale rose-coloured blossoms at the tips of bright green branchlets. The Arrowhead shoots its barbed leaves above the surface, and rests its pallid flowers among the gleaming Nuphar and the glorious White Water-Lily. Along the margin gaunt willows stand, with hollowed trunks crumbling under the attacks of ligniperdous larvæ, and the breezes upturn the pointed leaves till they shimmer in the sunbeams like silver spangles. Myriads of insects hover around, conspicuous among which are the many-hued dragon-flies; and the majestic swallow-tail sails about, the king of British butterfles, but almost eclipsed by the now extinct, Large Copper, one of the most gorgeous insects in creation.

All this is changed. And even the open country with its beds of yellow *Jacobea* has gone, and the tufted sedges have vanished with it. The naturalist has to creep along the borders of the dykes to find isolated specimens of plants and insects that once abounded. The sedges then formed matted growths breast-high, amongst which the Marsh Fennel and other bog plants luxuriated. No wonder that Peter of Blois writes to the Abbot of Croyland in glowing terms:—"Before I reached firm ground," he says, "I "pulled bridle in the middle of the marshes seven times or "more, looking back in the body upon your most holy monastery, "and in my inmost heart heaping blessings upon the same; while "at the same time I grieved that, like another Adàm, I was "expelled from Paradise."*

Very little, indeed, was done in the way of draining the fens in the period we are now describing, and the waters found their way to the sea or stagnated on the land as the case might be. We read of the Asendyke, Powdike, and some few other drains,

* Introduction to Peter of Blois' Continuation of Ingulph's Hist. Croyland.

and an attempt was made by Richard de Rulos in the time of Henry I. to reclaim Deeping fen.

Besides the Roman roads several others were constructed, among which, one formed by Egelrick, a monk of Burgh, on his accession to the See of Durham, about 1048, may be placed in the front rank. "He caused a solid highway for travellers to be "made through the middle of the most dense forests and the "extremely deep marshes of Depyng as far as Spalding, con-"structed of timber and sand,—a most costly work, and one of "the greatest utility." This was one of the first of those highways which, raised above the surface of the land, traverse the country and are called *rampars*.

We learn that the sea-wall broke in the year 1178 and deluged a great portion of the fens of South Holland; but the question of such drownings will be presently discussed.*

This section may be appropriately closed with an extract from William of Malmesbury. The Isle of Ely near Thorney he describes as "a paradise, the very marshes abounding in trees, "whose length without knots, emulated the stars. The plain "there is as level as the sea, which, with the flourishing of the "grass, allureth the eye, and so smooth that there is nothing to "hinder him that runs through it; neither is there any waste "place in it, for in some parts there are apple trees, in others "vines, which either spread upon poles, or run along the ground."

CHAPTER IV.

HISTORY OF THE FENLAND (*continued*).

III.—The Mediæval Period.

Under this title we shall include the period between the times of Henry II. and the death of Elizabeth; that is, from 1189 to 1603.

Tradition ascribes to John of Gaunt, the fourth son of Edward III., one of the earliest attempts to reclaim the fens. It is more than probable that this energetic prince, owning as he did large estates in the fens, upon whose borders he resided, at Bolingbroke, Lincolnshire, would turn his attention to so seductive a project. But as he was exiled, and only returned to this country in 1390, a few years before his death, his scheme could have borne little fruit. At this time also his estates were confiscated, and annexed to the crown, in whose possession they still remain.

Thompson, in his magnificent work on The History of Boston, quotes Chapman to the effect that in 1248 or 1250 much of Kesteven and Holland were drowned owing to the neglect of the

* Stukeley, Pal. Soc. p. 2.; and Chapman's Facts, &c.

sea-banks. The following notices of drainage works and floods are given by Dugdale : —

1257. 42 Hen. III.—Henry de Bathe appointed to repair banks and distrain on adjoining lands for funds.

1280. 6 Ed. I.—Fens between Swanston and Donington drowned.

1281. 7 Ed. I.—Haute Huntre (Holland) Fen inundated.

1287. 15 Ed. I.—W. de Carleton and Will. de Caudlesby constituted commissioners to inquire through whose default the sea-banks were decayed and broken.

1288. 16 Ed. I.—Great inundation—most of Boston drowned.

1316. 9 Ed. II.—Boston and vicinity in a bad state. The commissioners of sewers made 21 presentments against persons in the neighbourhood.

1318. 11 Ed. II.—Roger de Cubbledyke, Walter de Friskeney, and Robert de Mablethorp constituted commissioners for the view and repair of banks and sewers in "those parts of Holland."

1322. 15 Ed. II.—40,000 acres of land in Holland drowned.

1326. 19 Ed. II.—Commissioners appointed for the wapentake of Skirbeck.

1330. 3 Ed. III.—Commissioners appointed for the sewers betwixt the cross at Wolmerstye and Tyd-bridge.

1331. 4 Ed. III.—Ditto, ditto for between Wrangle Haven and Boston.

1340. 13 Ed. III.—Ditto, ditto for wapentake of Kirketon.

1342. 15 Ed. III.—Kyme Eau so obstructed that ships* could not pass. Fossdyke in a bad state after being navigable for 200 years. (Chapman.)

1343. 16 Ed. III.—Commissioners appointed for wapentake of Skyrbek, to take order for repair.

1352. 27 Ed. III.—Ditto, ditto for Skerbek and Kirketon.

1352. 27 Ed. III.—Ditto, ditto for south side of Wytham, from Skerbek to Shuft.

1362. 35 Ed. III.—Ditto, ditto for the whole province of Holland.

1364. 37 Ed. III.—Ditto, ditto for the wapentake of Skerbek and Kirketon.

1367. Witham banks defective from Morton Dyke to Boston.

1370. 40 Ed. III.—Commissioners appointed for Holland.

1378. 51 Ed. III.—Ditto, ditto, ditto.

1418. 6 Hen. V.—Ditto, ditto, ditto.

1424. 2 Hen. VI.—Ditto, ditto, ditto.

1428. 6 Hen. VI.—Ditto, ditto, ditto.

1452. 30 Hen. VI.—Ditto, ditto, from Fosdyke to the road near Boston.

1570. 12 Eliz.—Aldermen appointed to survey sea-banks within the haven.

The above records show that the drainage of the Lincolnshire Fens was considered of great importance, and extreme measures

* The earliest notice I know of this Eau.

were adopted to secure the proper attention to the sea-banks: for tradition asserts that, when a breach occurred owing to the neglect of any land occupier, the offender was taught a lesson he was not likely to forget, for to stamp the crime upon his memory, he was inserted into the breach and built in. History affords no instance of a man needing a second punishment.

Great Level.—Let us now see what records remain of the legislative acts concerning the drainage of the southern portion of the Fenland, formerly known as the Great Level, now called the Bedford Level.

1292. 21 Ed. I.—A Commission ordains that the waters of Well be sent by Wisbech *their former outfall.* In this reign the Ouse was known as the Well or Utwell River, and three dams were ordered to be made in it, one at Utwell Bridge, another at Little-lode Bridge, the third at Fen Dyke Lane, their object being to stop the waters of the Nene and Welland from entering the Ouse, and force them to their old outfall at Wisbech.

The effect of this dam was disastrous in the extreme. The waters could not get away fast enough by Wisbech, "and, there-" fore, they rose high on the Level, and drowned, as appears by" the presentments of juror's sworn, 40,000 acres of marsh" ground in *Holland-fenn*, 2,000 acres of land belonging to the" Abbey of *Croyland*, 7,000 acres of meadow, marsh, and pasture" of *Deeping-fenn*, *Burgh-fenn*, and *Spalding-fenn;* as also the" marshes of Kesteven were therefore overflow'd and drown'd. And" a great portion of arable, belonging to all the towns between Fenn" draiton and Benwick, unto Utwell, 30 miles long and broad; all" the land from St. Neot to Benwick, 30 miles by 10; the land of" all the towns between Aylington and Fustcote-in-the-Fenn, 16" miles, were drowned in flood-time by the same means, as were" also the marshes of Burgh-fenn, North-fenn, and Frokenholt-" fenn." *

1301. 29 Ed. I.—Utwell dam, erected by Walter de Langtone.

1332. 5 Ed. III.—Dam at Utwell ordered to be removed because the navigation from Holme, Yaxley, and Peterborough could not pass as before they did, but had to go 50 miles (to and fro) by Old Wellen Hee and Littleport.

The dam was removed in 1331 "to the relief of the aforesaid country."

1342. 15 Ed. III.—Marshland banks having been broken, a petition was presented to the King (Ed. III.) showing that "whereas the River going to Lenne had used to run between" Banks twelve Perches asunder, but was now a full Mile in" Breadth," &c., &c.*

Nothing was done on this application, but it is important as showing, in connexion with those above quoted, that Lynn was until about the beginning of the 13th century the outfall for the Little Ouse and its tributaries only. Nevertheless, it is clear that the waters at this time could not find passage by Wisbech.

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* Armstrong. Hist. Port of King's-Lyn, and of Cambridge.

Into the causes of this decay of the Wisbech outfall we shall inquire at a future period.

1378. 2 Rich. II.—Another petition with the same object, in which it is stated that the banks between Lenne and Tilney were in a miserable condition; and the "River at Lenne was 40 "Perches wide, at 16 Feet to the Perch."

The Isle of Ely was now drowned, and in a worse condition than at any previous historic period.

1438. 16 Hen. VI.—Gilbert Haltoft procured a commission to remove "all Stamps, Dams, Weeres, or other engines between "Guyhirne and the Sea." All sewers, &c. in Wisbech-hundred to be "digged and cleansed," and also the River of Wisbech, from Guyhirne to the Sea. Nothing came of this presentment, and matters grew worse and worse.

1490. 5 Hen. VII.—John Morton, Bishop of Ely, made the new cut, called "Morton's Leam," from Standground, by Peterborough, to Guyhirn, 14 miles long. A sluice was erected at the former place to direct the waters of the Nene into the new cut.

About this time the Earl of Exeter conveyed the waters of Westlode and Deeping Fen under the bottom of the Welland by new drains into South Holland, thence to the sea-banks and under them to the sea. This proved very detrimental to the Welland, for so large a quantity of water being withdrawn, the river was no longer able to keep its outfall clear of silt, and it decayed in consequence.

1618. The Welland Commissioners and the Commissioners of Sewers in this year declared the Welland from Croyland to Spalding to be very defective, and from Spalding to the sea almost silted up. But this verges upon our next section.

Marshland.—Having described the condition of the fens of South Lincolnshire and the Great Level it remains for us to say a few words about Marshland, which lies entirely in Norfolk, being bounded on the south by the New Podike, on the west by Lincoln and Cambridgeshire, on the north by the Wash, and on the east by the Ouse River.

1181. In this year "by an antient pleading it appeareth " . . . . . . there was neither any habitation, nor ground "that yielded profit, within that part of Wegenhale, from "Busterdesdole, unto the south side of the same town, except "the monastery of Crabhous, with some lands belonging thereto; "all being then waste, and in the nature of fen."

Most of this district was a marsh.

1217. 38 Hen. III.—Sea banks out of repair.

1257. 42 Hen. III.—"The inhabitants of this country had exceeding great loss, by the breach both of the sea banks, and those which should have kept off the fresh waters."

1258. 43 Hen. III.—Much damage done "by a new inundation "of the sea, through the breach of those banks towards Wisbeche."

16 Ed. I. Breaches of the banks in the Hawe and Islington.

1290. 17 Ed. I.—Banks in Tilney and Islington "then broken "by the raging of the sea."

1291. 18 Ed. I.—Banks called Pokediche, Suvellediche, Fendiche, Gildangordiche, "then broken by floods in divers places."

1294. 21 Ed. I.—Pokediche bank broken by "certain male-" factors, having a purpose to do them mischief; . . . . by reason " whereof, as well the tides from the sea, as the fresh waters over-" flowed the pastures."

1295. 22 Ed. I.—Banks ordered to be repaired, and drains scoured, but the banks were wilfully broken.

Several other records occur, conspicuous among which are the following:—

1227. 2 Ed. III.—Banks and sewers to be repaired.

1334. 9 Ed. III.—Banks which protect Tilney and Islington were "daily torn up by the boisterous sea tides and floods of " fresh waters; insomuch as the said banks could not be preserved " . . . to defend the said town from drowning." Ordered to be repaired and banks raised.

1335. 9 Ed. III.—"In the winter season of this year, so great " were the tempests, that the towns of Walsokne, Westwalton, and " Enemuthe, received extraordinary loss by the sea."

1336. 10 Ed. III.—"The sea was so outrageous [in the winter] " that it brake the banks in sundry places, drowned many cattle, " and spoiled a great quantity of corn;" in the neighbourhood of Tilney, Walpole, Walsokne, Westwalton, and Emenuthe.

1337. 11 Ed. III.—"Upon Monday next after the feast of " St. Hillary preceding, the same bank was so broken, by the " raging of the sea, in no less than five places, that the town of " Tilney was overflowed with the sea-water, and the lands, " meadows, and pastures belonging thereto, continually drowned " for the space of seven days, by which means their winter-corn, " then sowed upon the ground, was destroyed, as also much of the " corn and hay in their barns; with an hundred muttons and sixty " ewes to the damage of cccl unto the said town [Tilney]." Other grievous damage is likewise recorded "and they said, that " these dangers did every year increase upon them."

Moreover " the stream of the water called Wellenhee, which had " wont to run towards the sea, under the sea-bank of Walsokne, " when it had made so great a depth and hollowness, that the " lands in that town had a sufficient evacuation of their waters to " the sea thereby; being, at the sute of the counties of North-" ampton, Cambridge, Huntendon, and Lincolne, made to the " King, and judgment of his Court, diverted towards Wigenhale " by Welldam; the sands were grown to that height in those " chanels wherein it had formerly passed, that the waters of the " said town of Walsokne could not drain any longer that way." The consequence was that much land was drowned.

Westwalton also suffered much loss by the breaking of the banks at this time, and the inhabitants of "Wigenhale" made the following doleful report: "That on the morrow after the Epiphany, " in the third year of the then King, a certain bank on the west " part of the said river, by means of the raging of the sea, broke; " so that the tide entered and overflowed a thousand acres of land, "sowed with corn, to the great damage of the said town. And "that on the west part of the said river, by reason of the like "tempests, happening upon the eve of S. Hillarie next before, the "before-specified bank was broken and torn, so that the tides "entered, bore down a house, and overflowed cc. acres of land "sowed with corn. And that, on the eve of S. Andrew, in the "eighth year of the said King, the said bank was by the like "mishap, broken again, for the space of three furlongs in a certain "place called Burty's hithe, insomuch as the tides flowing in "thereat overwhelmed a thousand acres of land sowed with corn; "and that on the morrow after the feast of S. Hillarie then last "past, there was by the like means a breach made on the east "part of the same river, whereby eight score acres of land, sowed "with corn, were overflowed."

"Tirington" and "South Lenne" also suffered and the inhabitants put to great expense.

In consequence of this disaster the Tenth and Fifteenth granted to the King were to a large extent remitted in the following year.

1346. 21 Ed. III.—It does not appear that any effectual repair of banks, &c. was undertaken after the above catastrophe; for in this year we find by the report of a commission that the parishes of Wigenhale, Walpole, Walsokne, Tilney, Tirington, Westwalton, and Enemeth were in a similar plight.

1361. 36 Ed. III.—In this year the inhabitants of Marshland "exhibit a doleful petition to the King, showing that whereas "the said country of Marshland had been much overflowed and "surrounded by great and violent floods of salt water, to the "extraordinary damage of the said King and of the whole "realm. And whereas the river (going to Lenne) had used to run "between certain banks, distant asunder twelve perches, at which "time all people had sufficient passage with their boats to and "fro, the fresh waters free course to the sea; the banks on one "side of the river were at the same time so low by reason of the "before specified floods, that the said river was then a full mile "in length" [misprint for breadth], &c., &c. This petition begged that the river might be confined within bounds.

1378. 2 Rich. II.—Nothing however was done on the above petition, for in this year we find the same people making a similar presentment of the trouble and expense arising from the same cause. Whereupon it was advised that at South Lenne the width of the river be reduced from 40 perches (1 perch = 16 feet) to 34 perches, and the river of Secchithe (Secchy or Nar) from 5 perches to 1 perch, and the banks be heightened and maintained in a proper condition.

1419. 8 Hen. V. In this year the banks are stated to be "broken and in decay." The New Powdike was made for a protection.

Various other commissions were issued from time to time, but none of material importance until 1530.

1530. 22 Hen. VIII. In this year it appears that Marshland was again drowned, owing to the malicious destruction of parts of the New Powdike.

1555. 3 Mary. An important ordinance was made respecting the maintenance of banks and drains; and a similar one in

1565. 8 Eliz., which treats of the whole drainage of the district.

1566. 9 Eliz. A similar presentment made, in which, amongst other matters, the damage arising from the gotes (sluice gates) in the Well river is mentioned. Power is given to remove these gotes and prevent the erection of new ones.

1570. 12 Eliz. "But notwithstanding all this care and cost, " so outrageous were the storms and tempests which did beat " upon these sea-banks, that on Monday and Tuesday, the second " and third of October, in the year 1570, they made several " breaches in them, whereby all Marshland, together with the " town of Wigenhale, was overflowed with salt water; so that " from old Lynne unto Magdalen Bridge there were not left ten " rods of the same bank firm and whole, to the extraordinary " damage of the whole country."

1596. 39 Eliz. In this year it was stated at a session of sewers, held at Beaupre Hall, "that in regard of the neglect of keeping " the water of Rightforth lode, within the crests of the same, the " grounds on the north part of the said lode were, in time of " great inundations, overflown; which occasioned the inhabitants " thereof, for avoiding of the water, to cut the Old Powdike, " and to issue the said water into Marshland Fen, to the great " surrounding of the same, and extraordinary loss to the inhabi- " tants and commoners there."*

We have now sketched from authentic records the struggles which were made down to the death of Elizabeth to render the fens secure and profitable lands. The silting up of the estuaries, owing to neglected outfalls; the careless manner in which the sea-walls were maintained; the impracticable method pursued in the system of drainage, which consisted in each district endeavouring to do the best for itself irrespective of the necessities of its neighbours, had resulted, as all such partial proceedings must, in bringing the Fenland into a worse condition than had ever before been known. Whether we look to Lincolnshire, Marshland, or the Great Level, one story only reveals itself, and that a tale of deterioration.

All this time, and since, the tidal currents had been bringing great quantities of sand and mud into the Wash and estuaries and depositing it there. The outfalls of the rivers thus choked from without no longer served to discharge the rainfall of the district, and hence the disastrous condition of the land at the close of Elizabeth's reign.

But the time had come when more comprehensive schemes were propounded and carried out, and as these commenced in the reign of the first Charles we may here appropriately close this section.

* The quotations respecting Marshland are from Dugdale.

CHAPTER V.

HISTORY OF THE FENLAND (*continued*).

IV.—THE RECENT PERIOD.

Under this title we shall include the space of time between the accession of Charles the First and the present day.

In tracing this eventful period we shall divide the Fenland, as in the former section, into Lincolnshire, the Great Level, and Marshland. The Great Level in the General Drainage Act, 1663, 15 Chas. II., received the title of *The Bedford Level,** by which it has since been known. This title we shall, to avoid confusion, apply throughout the present section.

Towards the close of the memorable reign of Elizabeth (1600. 43 Eliz.) an Act for draining all the drowned lands in England was passed; a magnificent scheme worthy of that era of great deeds. But the death of the Queen occurring in 1603 the design fell through. James the First revived the scheme, but nothing whatever was done in the matter.

Lincolnshire.—1603. 1 Jac. I. Thomas Lovell, Esquire, had towards the close of the previous reign undertaken to drain "Deping, Spaldying, and Pinchebec south fens, Thurleby fen, "Borne south fen, and Crouland fen (alias Gogisland fen)," he being "a man skilful in like works, wherein he had been beyond "the seas much used and employed." In this year it was again agreed that for a third part of the land drained and made summer and winter ground, he should enter upon the work. But it appears that he was unsuccessful. It is worth noticing that about three hundred acres in Deeping, Spalding, and Crowland fens, and forty acres in Bourn and Thurlby fens were to be left for "lakes and sikes."

1637. 13 Car. I. The Earl of Exeter and adventurers undertook to drain the said fens, again with no success.

1638. 14 Car. I. The above fens "did then remain drained," and the commissioners "decreed that the said should be surveyed "by the appointment of Sir William Ayloff and Sir Antony "Ayloff, undertakers, and six commissioners of Holand and "Kesteven," and the fens drained.

"After which, divers gentlemen . . . became adventurers "for the exsiccation thereof; and in order thereto, caused the "river of Welland from Waldram Hall to Spalding, and thence

* Much misconception exists respecting the name *Great Level*, it being ordinarily supposed to apply to the whole Fenland. This mistake is made by Smiles in his Lives of Great Engineers, and strange to say even on the Rivers Commission map published in 1874. This map too shows the great meres as being still in existence! Many modern maps mark the fens as bogs, and some show the waters in East Fen which were drained in 1802! The topography of Central Africa is often more correctly delineated than that of the Fenland.

"to the out-fall to be made deeper." Drains were cleared, sluices erected, and partition dikes made. "By which works the "water was so well taken off, that in summer this whole fen "yielded great store of grass and hay; and had been made "winter ground in a short time; but that the country people, "taking advantage of the confusions throughout the whole "kingdom, which ensued soon after the convention of the late "long Parliament (as is very well known) possessed themselves "thereof; so that the banks and sewers, being neglected by the "adventurers, it became again overflowed, and so remaineth at "this time" (1652). (*Dugdale.*)

Respecting the fens adjacent to the R. Witham there are but meagre records from the time of Elizabeth to a comparatively late period. In Mr. W. H. Wheeler's work upon the fens of South Lincolnshire we read—"About the beginning of the 18th "century numerous breaches are reported as existing on the "banks (of the Witham) from neglect, through which the waters "ran in and out of the fens; and the lands continued in a "drowned state, and the navigation completely lost, till the year "1761."*

In the year 1720 the Earl Fitzwilliam constructed the North Forty-foot drain, for the drainage of land lying north of Kyme Eau. This drain discharged itself at a new sluice a little above Boston, and thus "withdrew from the Witham a great quantity "of water which used to find its way into the river at the sluice "at Langrick, much to the detriment of the channel above "Boston, and very little to his own benefit, for it appears that so "ineffectual was the new drainage that one of the tenants cut "his own banks to rid himself of the water, and let it flow into "Holland Fen."

1761. 2 Geo. III. In this year Mr. Langley Edwards devised a scheme for the improvement of the river and drainage, and an Act was passed "for draining and preserving certain low lands, "lying on both sides of the river Witham, in the county of "Lincoln, and for restoring and maintaining the navigation of "the said river from the Highbridge in the city of Lincoln, "through the borough of Boston to the sea."

Mr. Wheeler's remarks upon this Act are as follows:—"The "district now included in the Witham commission is that tract "of land lying on either side of the river, extending from "Lincoln in the north to the town of Boston on the south, "stretching eastward as far as the higher grounds in Freiston, "Butterwick, Bennington, Leake, Wrangle, and Friskney, and "bounded on the west by the Cardyke. . . ." The East Fen was not included in the first Act, but was added in the year 1801 (41 Geo. III.).

For the purposes of the Act the level was divided into six districts.† The first, comprising the fens on the south-west side of

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* Wheeler, Fens of S. Lincs., p. 44.
† See Plate III.

the Witham, extending from Lincoln to Dogdyke; the second, Holland Fen and the adjoining lands, bounded by Dogdyke and Kyme Eau on the north, the Witham on the east, and south and west by Swineshead, Heckington, and Brothertoft; the third district comprised the Fens on the north-east side of the Witham, stretching from Lincoln to Tattershall; the fourth district, the Wildmore and West and East Fens; the fifth district, fens in Anwick, North Kyme, Ruskington, Dorrington and Digby; the sixth, fens in South Kyme, Great Hale, Little Hale, Heckington, Ewerby, Howell, and Swineshead.*

A Navigation Commission was also appointed, separate from the Drainage Trust, whose functions were the restoration of the navigation.

The works carried out under this Act "consisted of straightening the course of the river Witham, by making a new cut "from Boston to Chapel Hill, and cleansing, widening, and "deepening the river from that place to Stamp End, near "Lincoln; the fishing weirs and other obstructions which had "hitherto hindered the full course of the waters were removed; "the sides of the river were embanked, and the water prevented flowing on the adjacent lands, while its discharge was "affected by the cleansing and deepening of the Kyme Eau, "Billinghay Skerth, the Bane, and other tributaries and side "drains. The new cut from Boston to Chapel Hill was laid out "by the engineer in a direct line, between those two places, but "to oblige one large proprietor the channel was turned from "its proper direction so as to run by Anton's Gowt; and to "accommodate another it was made to go off thence at a sharp "angle towards Langrick."† Once more private interest was allowed to over-ride the public good.

The Grand Sluice was also erected, to stem the tide, between Lodowick's Gowt and Boston Bridge, and was opened in 1764. A new sluice was also made at Anton's Gowt for the discharge of the West and Wildmore Fen waters.

The Witham and adjacent lands were at once benefited by these works, but the East and West Fens still remained drowned. Soon, however, the deleterious effects of damming tidal streams began to manifest themselves. The tidal currents, checked at the sluice, deposited the silt and mud with which they were laden, and the back-scour being, to a large extent, destroyed by that erection the river channel began to silt up faster even than it had been allowed to do by neglecting the outfall alone. Mr. Wheeler, who enjoys unusual advantages in studying these effects, says that "previous to the year 1800, in average winter seasons the water "never fell below nine feet six inches on the cill, and in floods rose "considerably higher; while in summer time, there not being "back water sufficient to remove the deposit, it accumulated to "such a degree as to completely close the doors."‡ So far our author is quoting the remarks of Chapman, but that he is of the

* Wheeler, *loc. cit.*, p. 46.
† Wheeler, *loc. cit.*, p. 48.
‡ Wheeler, *loc. cit.*, p. 51.

same opinion appears from his Report to the Boston Harbour Commissioners on the Boston Harbour and Outfall, in October 1870. After showing that the bed of the river has been raised "to a height of ten or eleven feet above the natural bed of the "haven, and so high that a low spring tide could not reach "the town," and bringing forward a scheme for improving the outfall, he remarks, "With regard to the silting up of the "upper part of the haven during a dry summer, I am not pre-"pared to say that even if the training and enclosure works here "proposed were carried out this deposit would be entirely pre-"vented, although, by fixing the shifting sands of the Scalp, it "would remove the great source from whence all deposit is "brought, and therefore a very considerable improvement would "be effected. Yet the deposits can never be entirely prevented "while the natural back scour caused by the free run of the "tides is stopped by the Grand Sluice."

In consequence of this silting up of the channel, "the drainage "also becomes defective. The most perfect system of interior "drainage is useless unless it has a good outfall or discharge "for its water. The outfall of the Witham being blocked up in "summer, and being so much higher than formerly in winter, the "lowlands could not get rid of their water by natural means, "but had to resort to pumping, the power being supplied by "steam-engines. All the low-lying districts on the Witham "provided themselves with engines before or in the beginning "of the present century."†

1811. 52 Geo. III. An Act was passed to transfer the powers vested in the Commissioners of Navagation to a Company of Proprietors, and Mr. Rennie recommended a number of improvements, including a new cut from Horsley Deep to Washingborough, which were carried out. The cut from Tattershall to the Bane was also made at this time.

1830. 1 Will. IV. Mr. Rennie, in two reports, speaks of the defective drainage, and cites as causes, the obstructed state of the outfall, and the deleterious effects of the Grand Sluice.

1846. 9 Victoria. The rights and liabilities of the Company of Proprietors were given up to the Great Northern Railway Company.

1862. In the spring of this year, owing to an unusually heavy rainfall,‡ the bank of the South Delph burst, and a large tract of land in Branston Fen was inundated.

1865. 27 Vict. Another Act was passed in this year "for the "further improvement of the drainage and navigation of the "river Witham," under the provisions of which the river was scoured out and deepened, and the cills of the sluices lowered in the river, Barling Eau, Billinghay Skerth and their tributaries,

* Report of W. H. Wheeler, Esq., C.E., to the Boston Harbour Commissioners, on the Scheme for Improving the Outfall of the River Witham by Fascine Training Works in the Scalp Reach. Boston. J. G. Buck, 1870.

† Wheeler, Fens of South Lincolnshire, p. 51.

‡ 19·98 inches, the average being 22·38 inches. See Fenland Meteorological Circular and Weather Report, vol. i., p. 19, 1874.

and also those of the Sleaford and Horncastle navigation, together with those belonging to the parishes of Timberland, Metheringham, Stixwould, Dunston, Branston, and Washingborough.

Notwithstanding these works, Mr. Wheeler, in 1867 writes as follows:—"The heavy rainfall of the last few months,* following three unusually dry seasons, has reduced some parts of the Fens in this district to a most deplorable condition. A large tract of rich corn land in the East Fen has been completely under water; and, viewed from Keal Hill, the level is described as having the appearance of one extensive lake, the course of the drains being undistinguishable from the submerged lands. Occupiers have even been obliged to use boats to pass from one part of their farm to another, and to convey the root crops stored in the fields to the sheep penned for the time in the stackyard. In Holland Fen and the Black Sluice District, many hundreds of acres have been flooded, a considerable portion of the wheat sown completely destroyed, and the land so injured as to be rendered unfit for spring cultivation. . . . In short, the Fens have been in a worse condition this winter than ever since their reclamation.

"The quantity of rain that has fallen has doubtless contributed in a very great degree to the existing state of affairs; but there have been seasons as wet† as the present when the same evils have not ensued; . . . . and it must be evident that the drainage is becoming gradually more and more defective."‡

In the same Report it is stated that in July 1866 the silt had accumulated so as to stand above the cills of the sluices, which were originally level with the bed of the river. The heights above the various sluices, &c. were as follows:—

Locality.	Depth of Silt on Cill.	Above Hobhole Cill.
	ft. in.	ft. in.
Grand Sluice - - - - -	4 0	9 0
Black Sluice - - - - -	9 5	10 0
Maud Foster Sluice - - - -	4 3	7 6
Hobhole - - - - - -	3 6	3 6
Scalp Reach, 1 mile below Hobhole -	—	2 9
Elbow Buoy, 2¼ miles below Hobhole -	—	1 0

* Rainfall in 1864 was 14·94 inches.
" " 1865 " 25·79 "
" " 1866 " 25·58 "
" " 1867 " 25·94 "
In May 1867, 1·54 inches fell in one day, being more than had been recorded in the same time during 20 years registration.

† Rainfall in 1828 was 28·59 inches.
" " 1830 " 25·90 "
" " 1839 " 28·48 "
" " 1841 " 27·26 "
" " 1848 " 32.64 "
" " 1860 " 30·69 "

‡ Remarks on the State of the Outfall of the River Witham, with Suggestions for it Improvement. By W. H. Wheeler. Boston: R. M. Dinwall, 1867.

The effect of the freshets in scouring the channel will be seen from the following table, which shows that while the river above Hobhole was benefited, the channel below that point was rendered worse than before. Between June 1st, 1866, and January 31st, 1867, 24·24 inches of rain fell and gave rise to freshets.

Locality.	Bed of River above Cill.	Bed of River below Cill.	Bed of River above Hobhole Cill.
	ft. in.	ft. in.	ft. in.
Grand Sluice - -	—	1 0	4 0
Black Sluice - -	1 6	—	2 1
Maud Foster Sluice -	—	1 0	2 3
Hobhole - -	5 3	—	5 3
Scalp Reach - -	—	—	3 3
Elbow Buoy - -	—	—	2 0

The reasons for this decay of the outfall below Hobhole will be dealt with when we come to consider the question of the silting up of the Witham more particularly.

In treating of the Witham and adjacent fens, I have in all cases preferred to quote the opinions of Mr. W. H. Wheeler, C.E., because his practical knowledge of the district is unequalled, and because I fully endorse his opinions respecting the deleterious effects of improving interior drainage at the expense of the outfall.

We will now turn to East, West, and Wildmore Fens. One of the best accounts of the state of these fens is given by Gough in his edition of Camden's Britannia, published in 1789, before their enclosure. Speaking of West Fen, he says it is "the place "where the ruffs and reeves resort in greatest numbers; and many "other sorts of water fowl, which do not require the shelter of "reeds or rushes, migrate hither to breed; for this fen is bare, "having been imperfectly drained by narrow canals, which inter-"sect it for many miles."

East Fen, he remarks "is quite in a state of nature, and "exhibits a specimen of what the country was before the intro-"duction of draining. It is a vast tract of morass, intermixed "with numbers of lakes, from half a mile to two or three miles "in circuit, communicating with each other by narrow reedy "straits. They are very shallow, none above four or five feet "deep, but abound with pike, perch, ruffs, bream, tench, dace, "eels, &c."

In Dugdale's "Embanking" these lakes are shown and named, and as they then formed a prominent feature, while their very sites are now obliterated, I have traced them in Plate III. and appended the names. The map bears date 1661, and the scale is about ⅜ inch = 1 mile. As an instance of the little known aspect of the fens to the outside world I may mention that in a large wall-map of Great Britain, published only a few years ago, the East Fen was represented as being still in the state now under consideration!!

"The names of all such Deepes in the East Fenne, as containe "any quantities of water."

1. *Stock Water.*
2. *Groope.*
3. *Kealecote sikes.*
4. *Stickford sikes.*
5. *Rogger.*
6. *Popple poole.*
7. *Keale Haven.*
8. *Mose water.*
9. *Steven water.*
10. *Fisher bind hole.*
11. *Little park croft.*
12. *Great park croft.*
13. *Muggill.*
14. *Great Goodin.*
15. *Girdle Gate.*
16. *Cherry hurn.*
17. *Long Water.*
18. *Brighley.*
19. *Bamb weare.*
20. *Silver pitt.*
21. *Coot mouth hole.*
22. *Wash Ballock.*
23. *Harts Booze.*
24. *Gibhurne nuke.*
25. *Gowple.*
26. *Dwitmouth.*
27. *Salter gate.*
28. *Gasp Water.*
29. *Burnt meere.*
30. *Burnt meere holes.*
31. *Ell lode.*
32. *Faire Fishes, S.*
33. *Faire Fishes, N.*
34. *Emholme.*
35. *Thorow fare.*
36. *Keale dikes, W.*
37. *Keale dikes, E.*
38. *Swinham lade.*
39. *Domine.*
40. *Matlade.*
41. *Matlade flottons.*
42. *Jewel water.*
43. *The Skires.*
44. *Cow mouth.*
45. *Robb water.*
46. *Middle water.*
47. *Dobbin.*
48. *North lade.*
49. *Jack water.*
50. *King's fishing.*
51. *Smith nuke.*
52. *South lade.*
53. *Bill water.*
54. *Bill water Clotton.*
55. *Madghill water.*
56. *Goodin draughts.*
57. *Beane sike.*
58. *Leake meere.*
59. *Starr gate.*
60. *Kyme pitts.*
61. *Small pits, not considerable.*

In checking these deepes on the map it will be seen that there are two numbered 45, one of which should be 55, which I cannot say. No. 59 is missing. The spelling, &c. is copied exactly.

1630. 6 Car. I. At a session of sewers this year it was declared, amongst other things, that the fens now under consideration were, for the most part, surrounded. It was, therefore, decreed that the cuts leading to the natural outfalls at Wainflet haven, Black gote, Symon's gote, Maudfoster gote,* New gote, and Auton gote, be enlarged and deepened. Whereupon Sir Antony Thomas and participants undertook the drainage of these fens.

1634. 10 Car. I. In this year it was declared that the undertakers should receive the reward of land as agreed upon, the fens being satisfactorily drained, there being "not more than sixteen "hundred seventy and three acres" that remained drowned.

Seven years afterwards the commoners rose, and "in a riotous "manner fell upon the adventurers, broke the sluices, laid waste "their lands, threw in their fences, spoiled their corn, demolished "their houses, and forcibly retained possession of the land." The adventurers, however, "had the law" of these mal-contents and were successful.

The East and West Fens remained in the imperfectly drained condition in which Sir A. Thomas left them until the year

1800. Mr. Rennie then, at the request of the Witham Commissioners made a survey and reported on their condition.

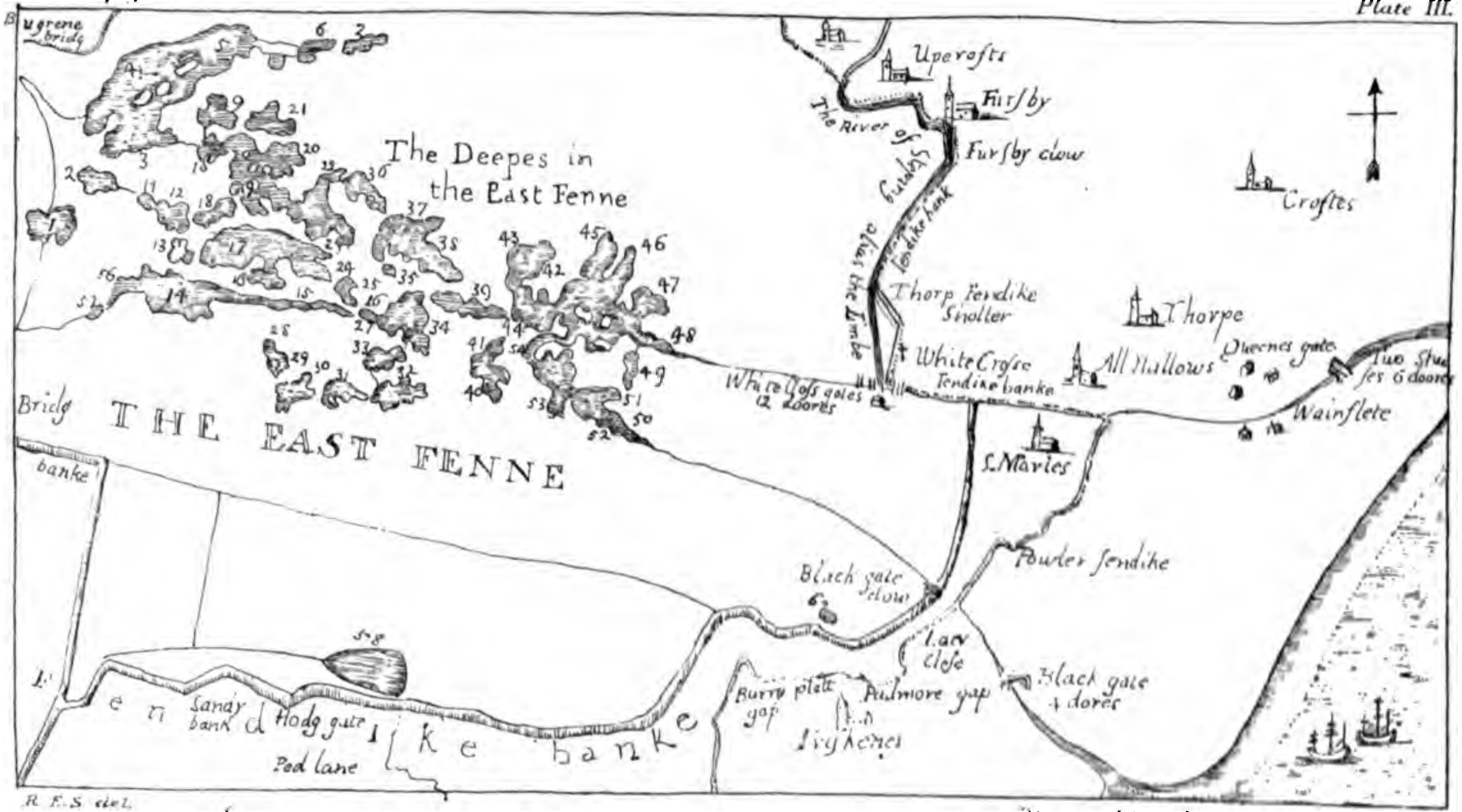
Three Acts were obtained in respect of the drainage of these fens, of which we need specify nothing save their dates, 1801, 1803, 1818.

In Mr. Rennie's reports in the year 1800 it is stated that

* Dugdale originates the mistake that the Maud Foster's Drain was made at this time. It is, however, mentioned in the Corporation Records of Boston as early as 1568, and in the following year it was ordered that "the surveyors of the haigh-"waies" do attend to the completion of the "new dreyne."—Thompson, Hist. Bost., p. 200.

To face page 40.

Plate III.



R. E. S. del.

THE EAST FEN BEFORE DRAINAGE.
(After Dugdale, A.D. 1661.)

Wildmore and West Fen discharged their water through Anton's Gowt, the cill of the sluice being two feet above the cill of the Grand Sluice. Other waters coming from Kirby, Revesby, Mareham, Tumby, and Coningsby, also passed through this sluice, "but in times of flood the Witham over-rode the waters "from these parts, and they were driven back through Medlam "drain and West House Skye to Cherry Corner, whence they "found their way by Mill Drain or Stone Bridge Drain to Maud "Foster's Gowt,"* whose cill was three inches below that of the Grand Sluice.

Three opinions were expressed by different parties respecting the mode of draining. One desired that the East Fen waters should be discharged through the Maud Foster Sluice; another advocated a new cut to Wainflete Haven, which was undoubtedly the ancient direction of drainage; and the third, which was finally adopted, left the West and Wildmore outfall at Anton's Gowt and Maud Foster's Sluice, but conveyed the East Fen waters by a new cut (called Hobhole drain) to a new sluice near Fishtoft Gowt.

The Act of 1801 was amended by another in 1803, and a final Act in 1818. Under these Acts Mr. Rennie constructed the following works:—"The highland water was taken up by a "catchwater drain skirting the boundary of East Fen. This "drain commenced near Little Steeping, and discharged its "waters into the West Fen catchwater drain at Cherry Corner." A catchwater drain was also made skirting the highland round the West and Wildmore Fens. "It commences near the junction "of the River Bane with the Witham, in the parish of Coningsby, "and passing through Tumby, Mareham, and Revesby to "Hagnaby, thence turns south to Cowbridge, receiving the "East Fen catchwater at Cherry Corner," where it discharges into the Stonebridge Drain, and into the Maud Foster Drain at Cowbridge. Near this place a new cut was made, which passing under the catchwater discharged into Hobhole Drain at Freiston Common. Down it the waters pass when they rise within two feet of the surface of the fen. By an Act obtained in the year 1867 the Witham Commissioners have power "to allow the "stop doors to remain open for the six winter months, so that the "West Fen waters will be discharged at Hobhole instead of "Maud Foster as formerly."

The waters of East Fen were conducted by a new cut commencing near Toynton, passing through the centre of the Fen and discharging at Hobhole, and hence called the Hobhole drain. The cill of the sluice at Hobhole was laid 5 feet below that of Hobhole, or 2 feet below the then average of low water spring tide. Barlode Drain was scoured, deepened, and continued to Hobhole Drain; Lade Bank Drain was cleansed, enlarged, and continued eastward to the parish of Friskeney; the River Steeping was straightened, widened, deepened, and embanked, and the

* Wheeler, Fens of S. Lincs., p. 77.

Great Steeping Beck, and other drains, received similar attentions.

The West Fen waters were provided for by a straight cut from Cowbridge to Mount Pleasant (where it joins the Medlam Drain), it then runs west to Newnham Drain. This cut is called West Fen Drain. Medlam Drain, the principal outlet for the West Fen waters, commences at Revesby and, as just stated, is continued to Mount Pleasant. Another cut, called Frith Bank Drain, extends from Cambridge to Newnham Drain and along Castle Dyke and Long dyke.

"The general surface of the lowlands," says Mr. Wheeler, "was, at the time of the completion of the drainange, about eleven "feet above the cill of the Maud Foster Sluice, but a portion "of the surface of Wildmore Fen was a foot lower than this. "The surface of the highest part of East Fen was about the "same level, but a great deal of it was a foot lower, and the "lowest parts, for the Deepes, were only nine feet above Hobhole "Cill."

The drainage of the fens, as already narrated, was completely effective. Mr. Bower, reporting to the Bedford Level Corporation, in 1814, says, "It is satisfactory that every wished for "object in the drainage of the whole of the fens and of the low- "lands adjoining, is effectually obtained, aud the lowest land "brought into a state of cultivation. The East Fen Deeps are so "perfectly drained, and so confident are the proprietors of this, "that part of them now forms a considerable farmyard; but "stronger proof of this than mere assertion have now been had. "There have been within the last five years several extraordinary "floods, which have not in the smallest degree affected the works "or low lands; and at this moment of time, when the low lands "of every part of the Kingdom are overflowed with an ice- "flood, the East, West, and Wildmore Fens and low lands "adjoining are perfectly free, and as ready for all agricultural "purposes as the high country lands." "However true this "statement may have been," continues Mr. Wheeler, "at the "time it was written, it is scarcely correct now. Two causes "have conduced to to the alteration. By the complete drainage "of the spongy soil of the East Fen, and its consolidation from "working, the surface has subsided from one to two feet. On the "other hand, the channel of the outfall from Hobhole to the "Deeps has been raised from its former level by the deposit of "silt, arising from the general encroachment of the sands on this "coast, and the neglect of proper training works. To such an "extent has this occurred that low-water level of spring tides, "which at the time of the erection of Hobhole sluice,* stood only "two feet on the cill, now is constantly from six to seven feet, and "in times of flood as much as eight and even ten feet; so that,

* Mr. Bower writes before the final completion of the drainage. Hobhole Sluice was opened. however, September 3rd, 1806 the new Mandfoster Sluice was opened in 1807. Mr. Wheeler writes in 1870,

Geological Survey of England and Wales.

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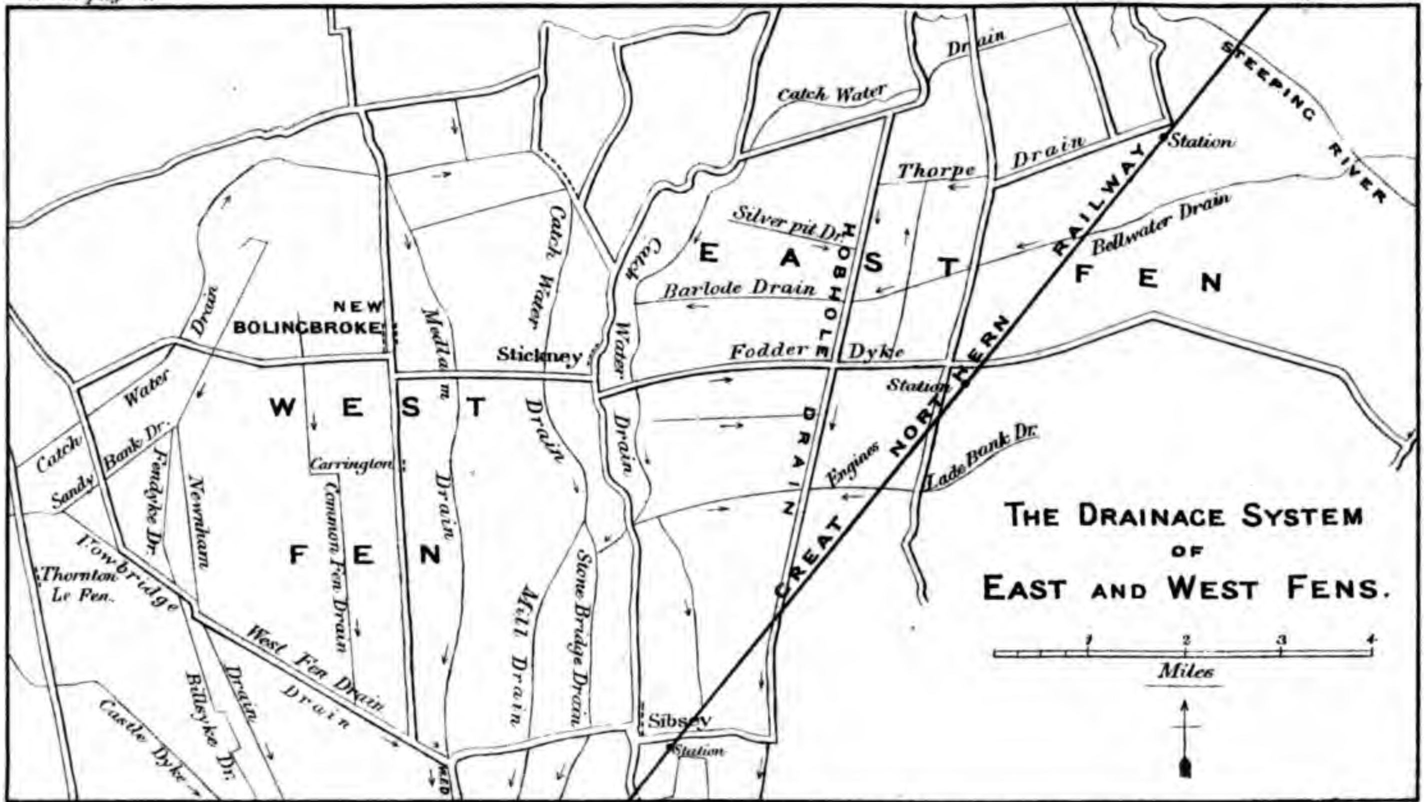
Plate IV.



S.B.J.S. del.

F. Dangerfield Lith. London

" owing to the subsidence of the land on the one hand, and the " deterioration of the outfall on the other, the good effects " originally felt by this drainage are in a great measure neutra- " lised, and in wet seasons the low lands are liable to be flooded, " and the crops destroyed."

The drainage continued to grow more defective until in the year 1866, owing to the heavy rainfall, the fens in question had reverted almost to their pristine condition. Great part of East Fen was for weeks under water, and the level was described "as " having the appearance of one extensive lake, the course of the " drains being undistinguishable from the submerged lands. " Occupiers, in some cases, had even to use boats to pass from " one part of the farm to the other, and the roots stored in the " fields were rendered quite inaccessible."

During this year the Commissioners decided on applying to Parliament for powers to enable them to erect an engine at Lade Bank. The Act, called the "Witham Drainage Act," received the Royal Assent on the 15th July 1867. Two pairs of high pressure condensing engines, working two of Appold's centrifugal pumps, were thereupon erected at Lade Bank on the west side of Hobhole Drain. Each pump can be worked independently by its pair of engines, and each is constructed to lift the water 6 feet above the drainage level.

Hitherto these engines seem to have answered their purpose admirably, and I think it unlikely that the land will subside much more, as the peat is quite thin, generally under 3 feet, in the area they drain. Unless, however, the outfall is kept good the silting up of the river bed must seriously affect their efficiency, and it is to this source of danger that the Commissioners must direct their attention.

It has been stated previously that Rennie's system of drainage was the same as that pursued by the Romans, and there can be no doubt that if a similar plan had been adopted for the rest of the fens, the almost ruinous expense of maintaining the works would have been in a great measure obviated.

The Bedford Level.—Several minor schemes for draining parts of the Bedford Level were proposed and carried out during the reign of James the First. Of these we may particularly cite a Commission for the general draining as containing perhaps the first geological survey on record. It bears date 1605, 3 Jac., and contains the following:—

" In order therefore to this great work, direction was given to one Mr. Richard Atkins, of Outwelle, (a person whose observations on these fenny grounds are very notable,) to make search, with an augur of xi. feet long, on the skirts of the New Leame, from Guyhirn to Stanground stafe, to find the soil thereof at eight feet deep: Whereupon he began so to do on the second of April, and found the first place on the north side, 2, 3, 4, and 5, all moor.
6. At mile and half tree, moor.
" 7. } All moor.
" 8. }

" 9. In the Leame, moor. 10. On the north side, moor. In Knarlake moor, at eleven feet deep. 12. On the south side against Knarlake, all moor.

" 13. In the Leame, moor. 14. On the north side all moor to 8 feet.

" 15. In the Leame, moor, 9 feet deep.

" 16. By Lord's dike end, black moor mixed with earth.

" 17. In the Leame, the like. 18. On the north side, the like.

" 19. On the south side of Lipney holt, against the hill, mixed earth.

" 20. Westward, a furlong black moor, mixed. 21. The like.

" 22.

" 23. Against East-tree, mixed moor. 24. Nigh Cotes, moor on both sides.

" 25. Against Cotes, all moor. Above Cotes, on the north, moor, by Basually hill.

" 26. At Stonhill doles, moor. 27. Against Calves Croft south, Bássa gravel, north, moor.

" 28. Between the Leame and the lake against the mills, moor.

" 29. Between Great Hill and Stone Hill gravel, moor mixed.

" 30. Between Stone hill gravel and Eastlong lots, all clay aloft, and gravel at 2 feet 8 inches.

" 31. More westwards in the river, gravel and silt, at 4 feet.

" 32. On the north side, at North Ee, gravel, the like.

" 33. At North Long-lotts, all clay aloft.

" 34.

" 35. By Bradley fen, clay and mixed earth aloft, about 3 feet.

" 36. By Bradley fen to the Leames end, such like above, but rank moor all the way under.

" The searches made from Earith bridge to Plawlis were :—

" At Erith bridge, within lx. poles of the bridge, at the first ham there, at 2 feet and 2 feet and a half, clay; but after, under the same, at 8 and 9 and 10 feet, and upwards, is all red moor; and so from thence all the way over Sutton Fen, by Ee Fen, Many Fen, and Westmore, to Wellney turf ground, all red moor; and likewise to Cotehirn, nigh Franks dike end, so till within lx. rods, where at five feet it is mixed with silt, and at the water side clay. The like for 60 or 80 rods over Welln Ee green, and after right over to Mayd lode, at the head of Mr. Skipwith's ground, all vile moor, by the whole tract."*

In this same year (1605), on the 13th July, William Hayward, Gent., Surveyor, upon his Oath, at Wisbech, delivered the result of his survey of " the true Content or Number of Acres in the Fens " described in the general Plot," being a total of 307,242 acres.†

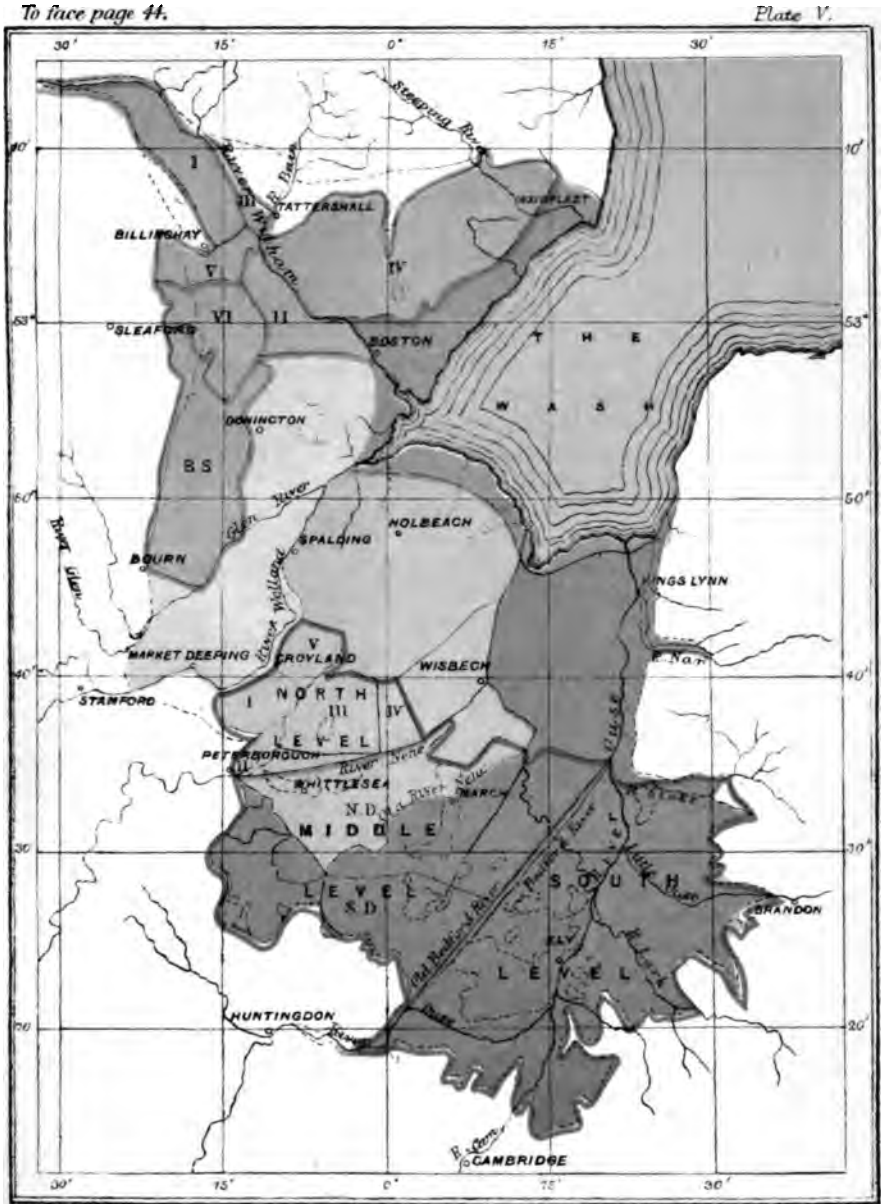
1630. 6 Car. I. It was not, however, until this year that any great scheme was entered into for draining the whole level. A contract was entered into with Sir Cornelius Vermuyden for this purpose, and as recompense he was to receive 95,000 acres of the surrounded lands. The jealousy of the fen-men was at once

* Dugdale, pp. 378–9.

† Ib., p. 382.

GEOLOGICAL SURVEY
OF ENGLAND AND WALES.

To face page 44. *Plate V.*



J.B. & S.B. J.S. Dangerfield Lith. 22 Bedford Street, Covent Garden.

DRAINAGE MAP OF THE FENLAND.

aroused in consequence of Vermuyden being a foreigner, and the contract was broken. A contract, usually called the Lynn Law, was accordingly entered into with Francis, Earl of Bedford, according to the terms of which he was to receive 95,000 acres, but 40,000 acres were to be devoted to maintaining the works in an effective condition, and 12,000 acres were to be allotted to the crown, leaving for the Earl 43,000 acres as his share.

Thirteen others joined with the Earl in the enterprise, and the work was entered upon with despatch. The principal drains made by them were:—

1. The old Bedford River, extending from Earith to Salters Lode, a distance of 21 miles. It was made 70 feet wide.
2. Sam's Cut, from Feltwell, in Norfolk, to the River Ouze.
3. Sandy's or Sandall's Cut, near Ely, 2 miles long and 40 feet wide.
4. Bevill's Leam, from Whittlesea Mere to Guyhirn, about 10 miles in length and 40 feet in breadth.
5. Morton's Leam, from near Peterborough to Guyhirn, about 15 miles long. This leam was only enlarged at this time, for it was constructed by Morton, Bishop of Ely, who was consecrated in 1478.
6. Peakirk Drain, 10 miles in length and 17 feet in breadth.
7. New South Eau, from Croyland to Clow's Cross.
8. Hill's Cut, near Peterborough, about 2 miles long and 50 feet in breadth.
9. Shire Drain, from Clow's Cross to Tyd, and so on to the sea. This was only cleaned out, as it is an old drain.

The above works were solely designed with the intention of making the fens "summer lands," and no idea was entertained of rendering them "winter lands" also.

1637. 13 Car. I. A session of sewers, held at St. Ives on the 12th of October 1637, decided "that the Earl of Bedford at his "own great cost and expense both well and sufficiently drained "all the said fenny, low, and late surrounded grounds of the said "great level . . . according to the true tenor and true intent "of the said act or law of sewers made at King's Lynn." The 95,000 acres were accordingly allotted to the Earl of Bedford, with the proviso that 40,000 acres, duly specified, should bear the cost of maintaining the works in an efficient state of repair. No mention is made of the 12,000 acres which were to be set apart for the King. Indeed the whole adjudication is a most singular proceeding, for it is certain that the works executed did not fulfil their object, and that the omission of the adjudication of the King's acres was not according to the Lynn Law; but it is rendered still more singular from the fact that His Majesty's surveyor-general assisted in the work, and yet allowed the royal rights to be infringed.

Complaints were speedily made by the fen-men against the adjudication, and their rancour was further stimulated in consequence of the Earl having taken into his service Sir Cornelius Vermuyden whose project had before raised their patriotic ire. The whole of the subsequent proceedings reflect but little credit upon any of the parties concerned, and the result was ruin to most of the adventurers, for although 40,000 acres were adjudicated to them, the great tax imposed upon the whole 95,000 acres, amounting to 142,500*l.* per annum, rendered it about as profitable as game preserving.*

1635–6. 14 Car. I. In this year the celebrated survey by Hayward was made, which gives the area of the Bedford Level as 305,681 acres.† The area included in the "Act for the Draining "of the Great Level of the Fens" in 1649, was, however, only 304,772 acres.‡ The King graciously undertook to drain the level more effectively, and commenced operations. Little more than a beginning was made, for the only works executed were:—

1. A bank on the south side of Morton's Leam from Peterborough to Wisbech; a navigable Sasse at Stanground; and part of the north bank of the above Leam.

2. A new river was cut between the Horseshoe at Wisbech and the sea, 60 feet broad and about 2½ miles in length, banked on both sides.

3. A sluice in the marshes below Tyd, upon the outfall of the Shire Drain, "which afterwards was swallowed up in the quick sands."

Soon after this the civil war broke out and the King lost his life.

1649. 24 Car. I.‡ The same year in which King Charles was executed, William, Earl of Bedford, the son and heir of Francis, Earl of Bedford, the former adventurer, was declared to be the undertaker of the drainage by "that Convention then sitting at "Westminster, and then called by the name of a Parliament," and he was to receive the 95,000 acres aforesaid on condition of rendering the level good winter ground.

This was the undertaking which finally set the question of the drainability of the level at rest, for the works were entered upon with spirit and crowned with success. Unfortunately, however, for the district Sir Cornelius Vermuyden's plan, founded upon his Dutch and Hatfield Chase experience, was carried out. This remarkable man had acquired a large portion of the 95,000 acres given to Francis, Earl of Bedford, under the St. Ives Law, in payment of work executed by him. The new company strenuously opposed his claims but he beat them upon every point, being in virtue of his claims master of the position. Nevertheless, this does not afford a just excuse for adopting his plans, and it was pointed out at the time how different were the conditions under which the low lands of Holland and England existed. The former lay below the ordinary level of the sea, and had no natural drain-

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* The total cost to the Earl and his colleagues of the works executed between July 10, 1631, and August 10, 1638, was 131,170*l.*

† Wells, Hist. Bed. Lev., vol. i., p. 2.

‡ This seems to be a different survey from that of 1605, in which the area is only estimated at 300,000 acres at the least. Wells. Hist. Bed. Lev. vol. 1., p. 89.

§ In legal documents the reign of Charles II. is considered to have commenced on the execution of his father, and all Acts passed during the Commonwealth are termed "pretended Acts," and declared void unless re-enacted after the Restoration.

age; the latter lay entirely above mean tide level and possessed an adequate drainage system of its own. What should have been done, and what I think all modern engineers and most of those of the past agree upon, was to have directed the chief attention to the improvement and maintenance of the existing outfalls, and then have so led the drainage works that their waters, augmenting those of the rivers, should materially conduce to keeping the outfalls clear. This was not done at the critical moment and can never be remedied, and the result has been immense expense and the necessity for new main cuts.

The touches of party spirit which enliven the works of writers on the drainage of the Level are a study in themselves. Dugdale almost ignores the existence of Cromwell, under whose government this great work was accomplished,* and Wells long afterwards could see no wrong in confiscating the King's 12,000 acres to give them to the Earl of Bedford, but sees a nefarious, unjust, and illegal claim on the part of the Commonwealth Government when they demanded 3,000 acres for the good of the State. This claim was set aside on the adventurers threatening to abandon the work if it were persisted in; yet when, on the restoration of the Stuarts, 10,000 acres were "restored to the Crown," nothing approaching extortion is hinted at by the historian of the Bedford Level.

We will not follow the adventurers through their difficulties with Vermuyden, which were by far their greatest troubles, but give a brief account of the works executed from the designs of the obstinate Dutchman, which exist to this day.

He divided the Bedford Level into three sections, and named them respectively, the North, Middle, and South Levels.

The *North Level* comprises the district between the River Welland and Morton's Leam. With it is included the district called Great Porsand, Portsand, or Postland, which adds 7,451a. 1r. 28p. to its area. The boundaries are Morton's Leam from Peterborough to Guyhirn, Old Southeau Bank from Guyhirn to Clow's Cross, the Old South Holland Drain from Clow's Cross to Dowsdale Bars, Shephay and Willow Banks from Clow's Cross to Cate's Cove Corner, the Asendyke from Cate's Cove Corner to the Welland at Brotherhouse, the River Welland from Brotherhouse to Peakirk, and the highland from Peakirk to Peterborough. The total area is 48,398 acres, or 75·622 square miles.†

The *Middle Level* lies between Morton's Leam and the Old Bedford River. Its boundaries are Morton's Leam from Peterborough to Guyhirn, Hob's Bank from Guyhirn to the Twenty Foot River, the Twenty Foot River to Coldham Bank, Coldham

* Cromwell had a large personal interest in the Fen, and one of his titles was Lord of the Fens. He represented Cambridge town in the discussions on this Act, and was opposed to Vermuyden's scheme.

† Of the North Level and Portsand only 39,622A. 1R. 36P. are taxable land.—Newborough, 5,276 acres; Flag Fen, Sutton, St. Edmunds, Great and Little Commons, about 2,500 acres, being exempt by Act 27 Geo. II.

and Laddus Banks to Upwell, the high road from Upwell to Three Holes Bridge, the roads bounding Outwell Low Fen to Mullicourt Priory, the Well Creek from Mullicourt Priory to Salter's Lode Sluice, the Old Bedford River from Salter's Lode Sluice to Earith, and the highland from Earith to Ramsey, and Ramsey to Peterborough. The area contains upwards of 150,000 acres, or above 234 square miles of fen-land.

The *South Level* lies between the Old Bedford River and the highlands bordering the Fens, and its boundaries cannot be more concisely stated. The area is about 12,000 acres, or 18·75 square miles.

The division of the Bedford Level into three separate districts with distinct and independent powers, was one of the first mistakes committed at this time. The divisions have no foundation in nature, but are quite arbitrary, and their interests are so interwoven, that their separation was as injudicious as it was unnecessary.

The *North Level* works consisted of embanking the Welland from Peakirk to Croyland, scouring and re-opening the drains made by the former Earl, and cleaning out the Wisbech river for the space of two miles. The main drain of this level was the Shire Drain, and the outfall Tyd Gout.‡

The *Middle Level* drainage works of greatest importance were:—

1. The banking of the River Nene from Standground to Guyhirn to protect the Level from the flood-waters of Northamptonshire.
2. The embanking of the Ouse from the highlands of Over to the Hermitage near Earith.
3. The formation of the New Bedford, or One Hundred Feet River, from the Hermitage to Denver; its object being to take the upland waters from their natural channel and convey them more directly to their outfall. A great bank was made on the south side of the New River, and another on the north side of the old one, leaving a broad space containing 5,800 acres, for the flood-waters to bed in.
4. Vermuyden's Eau, or the Forty Foot Drain, extending from Welche's Dam to the River Nene, near Ramsey Mere.
5. Hammond's Eau, near Somersham.
6. Stoney Drain, near March.
7. Moore's Drain, or Twenty Foot River, also in the parish of March.
8. Thurlow's Drain, or Sixteen Foot River, extending from the Forty Foot to Popham's Eau.
9. Conquest Lode, leading to Whittlesey Mere.
10. Tong's Drain, or Marshland Cut, without the boundary of the Level, in order to obtain a quicker passage for the floods than could be obtained by the circuitous course by Well Creek and Salter's Lode.
11. Denver Sluice, erected to keep the tides out of the Ouse.

* The sluices formerly placed in the marshes, at an expense of 25,000*l.*, were by this time lost and abandoned.

The North and Middle Levels were, by an Act of Adjudication dated 26th March 1651, declared effectively drained, and the Earl and his colleagues were granted possession of "fiftie-eight thousand "two hundred acres, one rood and fifteen perches" in consideration of their work upon the 170,000 acres drained, which had cost 170,000*l.*

In the *South Level* the works were chiefly confined to embanking the Rivers Ouse, Cam, Little Ouse, Lark, and Stoke; and the deepening of the Ouse from Salter's Lode to Stow Bridge. Most of this Level was considered sufficiently drained by scouring out the existing brooks, and but few and unimportant acts were made. One pretentious one was indeed made from Salter's Lode by Denver, Downham to Stow Bridge. It was to have been named St. John's Eau after the then Lord Chief Justice, but on his declining the honour the title Downham Eau was given to it, though it is often mentioned under the former name.

The South Level, completing the Bedford Level, was declared drained on the 26th of March 1653, the area of the Washes being sworn not to exceed the following quantities:—

	A.	R.	P.
"The Wash of Stoake River	400	00	00
The Wash of Brandon River	800	00	00
The Wash of Mildenhall	400	00	00
The Wash of New Ouze	5,800	00	00
The Wash of Neane	3,500	00	00
The Wash near Elie	1,000	00	00
The Wash of Grant	200	00	00
	12,100	00	00

From this period no material works were executed until the year 1678 when the following order was made:—"That for the speedier "cleansing and scouring of draynes, the four surveyors of the "Level do forthwith buy each of them a mill, made for that "purpose."*

This is the first mention of draining by mills in the fens, and it thus appears that only twenty-five years after the completion of the drainage system the drains were incapable of discharging naturally into the main cuts. This is attributed to "the growing up" of the artificial rivers, which ambiguous phrase I take to mean the effect of the settling down of the land through the withdrawal of water. On no other hypothesis can we understand why a remedy for the evil should be sought in lifting mills, which, by the way, were probably not wind-mills but horse-mills placed close to the river.

It was not, however, until the year 1727 that the drainage by mills became imperative and general. The historian of the Bedford Level thus describes their mode of operation:—"Certain "proprietors of any given quantity of land, agree to apply to "Parliament for a local act. The boundary is set forth, and

* Wells, Hist. Bedf. Lev., vol. i., p. 426.

" subdivision dikes are made, for draining the estate of each owner. " These division ditches empty themselves into a main drain, cut " at the general expense of the owners (commonly called the " Mill drain), and run through the whole district, which is em- " banked all round with a mound of earth, raised at a height " proportioned to the quantity of water required to be excluded. " The mill drain terminates at one end, near a river, upon the " banks of which the water mill is erected, and thus, by means of " a circular wheel, the water which has found its way into the " mill drain, is thrown from thence into the river, whence it passes " to the outfall, and onwards to sea. The number of mills " in each district depends of course upon its extent, and the head " or quantity of water required to be discharged. This artificial " system has continued for many years; but in modern times,* the " great improvement in the general or exterior drainage of the " country, has led to many practical advantages. The first plan " adopted in this respect, was the erection of what are termed " 'double lifts'; that is, first, one large mill is erected near the " main river, and then a smaller one at some distance behind; the " one mill, by first raising the water from the mill drain to a cer- " tain height, and in certain quantities, lessens what is called the " head of water to be thrown by the first mill, and finally greatly " facilitates its operation."†

Now it is clear that for some reason the drains which at first naturally discharged into the rivers gradually lowered their water level until, first, horse-mills had to be erected to throw up the water, then windmills, and lastly, double-lift mills. The first were only four in number, and their erection was strenuously opposed, and they had to be abandoned. Hence we may conclude that the necessity, though felt by those best qualified to judge, was not sufficiently marked to be apparent to the occupiers at large. But fifty years afterwards the evil had so far increased that the land-holders spontaneously applied for permission to erect windmills as the only means of preventing a relapse into the former drowned conditions of the fens. Afterwards, the water level becoming still lower, the system of double lifts was adopted, single mills being found incompetent to the discharge of their ever-increasing burdens.

The reasons given for this state of matters were " the choking " up of the interior drains, the defective state of the rivers them- " selves, and the neglect to improve the outfalls to the sea." But Wells himself shows that the Bedford Level Corporation exercised a painstaking vigilance over the drains and rivers, and if the state of the country were owing to the causes cited, they would have cleaned out the drains and rivers, instead of erecting mills and making new drains. We know, in fact, that the discharge became defective *in spite* of this cleansing. The neglect of the outfalls was doubtless a *vera causa* in respect to the rivers, but there is direct evidence to show that the drains were lowered at the same

* Wells writes in 1830.

† Wells, *op. cit.*, p. 438.

To face page 30.

PLATE VI.

time that the river waters maintained or increased their level. In fact, from the moment the drainage works commenced the land began to subside, owing to the abstraction of water from the porous soil. Here, then, we have a natural and competent explanation of the phenomenon in question, yet it is a remarkable fact that until within the last few years no authority mentions the possibility of the subsidence of the land.

Water-mills became very general, and indeed were so numerous as to impart a peculiarity of the landscape. But in the early part of this century the intermittent and uncertain action of the wind was found too precarious a motive force to rely upon, especially as the evil had further increased, and steam mills began to be erected. They were simply large lifting wheels worked by steam, but the more modern ones, introduced about the year 1850, are centrifugal pumps. Windmills have now almost disappeared from the Lincolnshire fens, but they still linger in the Middle and South Levels.

The principal drainage works executed since the completion of the great scheme are the following:—

In the *North Level:* Postland, Portsand, Great Portsand or Porsand, containing 7,451 acres, was incorporated with this level by the Act 27 George II. (1754).

Owing to the deterioration of the river near Wisbech a deputation from the town waited upon the Corporation in the year 1721, and it was agreed that both parties should contribute towards a new cut (now called Kinderley's Cut), to turn the river under the Shire Drain Sluice (the outfall of the North Level), and confine it within narrower bounds. The people of Wisbech, however, repudiated their share in the expense, and when the cut was nearly completed they applied for an injunction to stop the Corporation from turning the waters into the new cut. The works remained intact until Nathaniel Kinderley, in the year 1751, revived the question, and a new Act was obtained, called the Tydd and Newton Drainage Act, under the provisions of which the work was effected. The cut, however, was not opened until the year1773.

An Act, called the Nene Bridge Act, was obtained in the year 1826, by Lord William Bentinck, for the erection of a bridge at Cross Keys across Sutton Wash, and the formation of an embankment at each end thereof. This was the beginning of those schemes of embankments which have resulted in the reclamation of the Wash in question, and the formation of the flourishing little town of Sutton Bridge. To guard against any defect of drainage owing to the contraction of the stream by the arches of the bridge, the North Level proprietors obtained a bill during the next session of Parliament, entitled "An Act for improving "the outfall of the River Nene, and the drainage of the lands "discharging their waters into the Wisbech River, and the navi- "gation of the said Wisbech River, from the upper end of "Kinderley's Cut to the sea, and for embanking the salt marshes "and bare lands lying between the said cut and the sea."

The works under this Act were done by Sir John, then Mr., Rennie. The funds were provided by the North Level Commissioners. The subsequent work of reclamation will be mentioned in a future page.

The last great work of this level was the construction of a splendid new cut, called the North Level Main Drain, from Clow's Cross to Tyd Gote, to supersede the old waterway by the Shire Drain. It was completed in the year .

In the *Middle Level* the principal new works executed are the following :—

1. The Wisbech canal, constructed under an Act obtained in the year 1793, from Wisbech to the River Nene at Outwell, a distance of nearly six miles. One object of this canal was to run the waters of the Nene to Wisbech outfall in times of pressure, and thus relieve the old channel.
2. The drainage of the meres, to be described in the next chapter. and entailing the construction of the Middle Level Drain.

In the South Level comparatively little has been effected in new drainage Acts. The River Ouse above Ely has been straightened by Sandy's or Sandall's Cut (1827), and forms the principal work to be noticed. The Eau Brink Cut, near Lynn, will be described in another chapter.

The whole system of drainage is now subservient to the artificial cuts, and the loss to the natural rivers is very great and disastrous. The Nene loses the waters of the North Level until some miles above Wisbech. The Ouse between Earith and Denver is robbed of its water to supply the Bedford River, and the Cam at its confluence is larger than the more important river, which indeed is little more than a good sized ditch. There can be little doubt that had the Roman system described in page 15 been adopted, and the rivers not been obstructed by sluices, the drainage of the land would have been equally well affected, without the present great perennial outlay, the navigation of the rivers vastly improved, and we should have been spared the melancholy sight of decayed waterside industry such as may be seen at Boston, Spalding, and Wisbech. As to the effect of the present system there cannot be a doubt respecting its efficacy for draining, indeed the Fens now suffer more frequently from drought than flood. It seems never to have struck people that the Fens could be too much drained, yet, in December 1874, I walked dryshod along the bottoms of drains that ought to have had six feet of water in them, and saw pits sunk four feet below the bottom to obtain water, which then only filtered in slowly. In February of that year the farmers of Boston were already carting water for cattle and domestic purposes, though Fen-men speak of the month as "February fill-dyke." Ely in autumn was for three days waterless, in consequence of the lowness of the river, and it is not unusual to see water pumped *into* the Fens to moisten the pasture in the vicinity of that city. Most of the young trees near Wisbech died in 1874, owing to the sock water being too low for the roots to reach it. The contrast between this state of affairs and that we have been describing is as great as can well be imagined, and there is but one remedy for a dilemma, almost as unfortunate as drowning, and that is the due regulation of the discharge. Hitherto the sole cry has been "get rid of the water," and now the counter cry of "give us water" is beginning to be heard; yet in all the Acts that have been passed relating to the Fenland not one gives power to store up water against times of drought. The means of mitigating this growing evil are discussed in Chapters IX. and XIX.

In concluding this slight epitome of the history of the Fenland it may be remarked that a great deal has been omitted which would have thrown additional light upon the disastrous scheme of Vermuyden. Indeed in going over the reports of the last two hundred years it is saddening to find how plan after plan had to be adopted to prevent a speedy relapse into natural conditions. Nor did any lengthy period elapse ere the futility of the works was discovered, and evidence is not wanting to show that even while the works were in progress suspicions of their inefficacy began to make their appearance.

I have omitted much mention of sluices and their action, as they will be referred to in the chapter on rivers; and it is hoped that this short sketch may prove sufficient to enable geologists to comprehend what was the original condition of the fens, what were the difficulties to be surmounted in draining them, and what the means adopted for that end. If it be argued that such an introduction is out of place I can only reply that such knowledge has been of vast service to me in my labours; and this I take to be the best proof of its utility.

CHAPTER VI.

WHITTLESEA MERE AND THE SHELL MARL.

Whittlesea Mere, the largest lake south of Windermere, was situated in the Middle Level about 4½ miles south-south-west from Peterborough and 2 miles east from Yaxley. Its greatest length from E.N.E. to W.S.W. was 2½ miles, its maximum breadth from N.W. to S.E. was 1¾ miles, its area varied from 1,000 to 1,600 acres according to the season and its circumference was 8¾ miles. The shape and general features may be seen in Plate VII., which is an accurate reproduction of the Ordnance Map made in 1824 (sheet 64).

A branch of the Nene River flowed through the Mere entering it by Arnold's Mouth; and, leaving it at the extreme south-eastern point, flowed south to Ugg Mere, and then east to Ramsey Mere, where the stream divided, one branch going south (The West

Water) to the Ouse, and the other north, by March and Friday Bridge, to the outfall at Wisbech.

The depth of water in the Mere was very little, varying at different times and in different seasons from about 2 to 5 feet.

"Mr. Golborne, in the year 1777, went through Whittlesey "Mere, and on sounding it, found the bottom in general very "even, with four feet and a half of water, and two feet of mud "under it."* When the drainage was begun in 1852 the average depth was found to be 3 feet, the bottom being 10 feet above the low-water mark gauge in the Ouse at Lynn Bridge.†

An admirable description of the "Drainage of Whittlesea Mere," by Mr. W. Wells, was published in the Journal of the Royal Agricultural Society of England for 1860, from which the following description of the Mere and some of the ensuing matter are culled. Special attention is directed to this interesting paper, not merely for the graphic description of the works, but also for the valuable economical remarks, and the appendices by Dr. A. Voelcker and "P. H. F." (Philip Henry Frere?).

"Around the shores a margin of silty deposit had been formed, "which, though often dry, was liable to submersion upon the "slightest rise of the water in the Mere. Beyond this margin "of silt, which varied in breadth from 50 to 500 yards, and "was valuable for the excellent reeds it grew, there extended, "especially towards the south and west, where the level of the "surrounding land was lowest, a large tract of peat-moss, which "though generally free from water during summer, was constantly "flooded in winter. On the north and east sides the level of the "surrounding land was higher—sufficiently high, indeed, to be "cultivated by the aid of windmills, and, approaching more nearly "to the borders of the Mere, left less room for either the inner "circle of silty reed-shoal, or for the outer circle of peat-moss.

"In addition to the area contained in the Mere, the reed-shoals, "and the peat-bog, there was much adjoining low land, more "or less under cultivation, which would naturally be included in "any scheme for the draining of the water and waste land on "which they bordered." It must be remembered that the adjoining area for miles was covered with peat, as shown by the Geological Map accompanying this volume, but it was only in the immediate vicinity of the Meres that, at this time, the deposit assumed the nature of a bog.

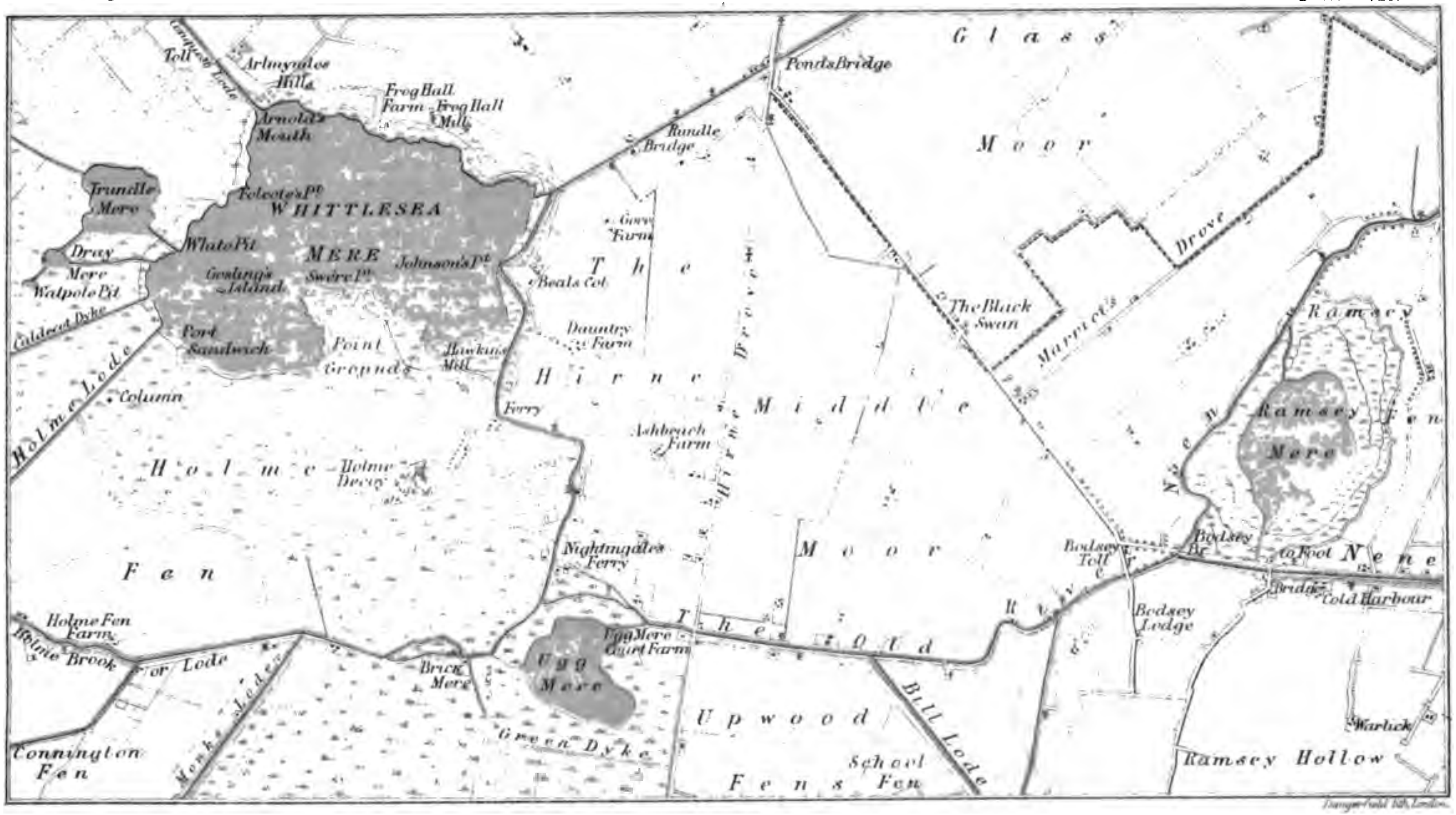
This sheet of water naturally enjoyed considerable celebrity. Its expanse and shallowness rendered it an unparalleled skating-ground, and the freezing of the Mere was the signal for a general merry-making to all the country-side. Fen-men have always been noted as fast, though not elegant, skaters and the greatest adepts brought their "ice-pattens," as skates are called in Fenland, and competed for supremacy, and great was the triumph of the district that carried off the palm. Ice-boats also glided over the smooth

* Wells, Hist. Bedford Level, vol. i. p. 450, 1830.

† Wells, Drainage of Whittlesea Mere. Journ. Roy. Agric. Soc. Eng., vol. xxi, p. 134, 1860.

To face page 54.

Plate VII.



THE OLD FEN MERES.

surface of the Mere, the shores were lined with stalls and booths, and bands of music cheered the spectators. In summer boating and fishing facilities drew plenty of visitors, though the former pastime savoured somewhat of danger, for the Mere was liable to sudden storms. Indeed tradition asserts that Canute, who lived at Bodsey, lost two of his sons upon the lake and was himself in great danger in crossing it. Apart from these causes Whittlesey Mere was renowned among entomologists as the habitat of the splendid butterfly *Polyommatus dispar*, a closely allied species to the continental *P. Hippothöe*, which flitted in hundreds about the reed shoal, and being found nowhere else was spoken of as "the "glory of English cabinets." It is now entirely extinct, more than thirty years having elapsed since it was last taken. It appears to have died out before the drainage of the Mere, having been probably exterminated by an epidemic of "dealers" when the larva was discovered. The swallow tail, *Papilio Machaon*, the most majestic native butterfly, also abounded here, as in many other places in the fens, but has long been unknown around Whittlesey, and, so far as I know is at present confined to one spot, where happily it is still plentiful and shows no signs of being speedily annihilated. Other insects have also been blotted from the fauna of the Mere, but the two mentioned are the most prominent examples.

But the Mere was more than a place of pastime and entomological research, for the 200 acres of reed-shoal afforded valuable material for thatching, 1,000 bundles of reed worth 1,000*l.* being annually obtained. The sedge which grew outside the reed-shoal was cut every three years and produced about 1*l.* per acre, which added, say, 100*l.* per annum to the Mere profits, and the 1,200 or 1,300 acres of peat bog was valued at 2*s.* per acre, or 30*l.* per annum, for sedge-cutting and rough pasturage. If to this we add 30*l.* as the computed value of the fishery, we have 1,160*l.* as the yearly value of the Mere and the boggy land around it.

Mr. W. Wells, in the paper before quoted, gives the following estimate as "a fair approximate representation of what the "produce of the district is worth, both in money-value and in "the food it will yield for man and beast":—

			£
600 acres	of wheat	at 4 qrs. per acre = 2,400 qrs. at 40*s.* -	4,800
500 ,,	oats	,, 6 ,, ,, = 3,000 ,, 20*s.* -	3,000
150 ,,	seeds	150 beasts at 3*l.* increase of value in	
150 ,,	coleseed	a year - - - - -	450
100 ,,	mangold	400 sheep at 1*l.* ditto - -	400
200 ,,	wheat	at 3½ qrs. per acre = 700 qrs. at 40*s.* -	1,400
200 ,,	oats	,, 5 ,, ,, = 1,000 ,, 20*s.* -	1,000
1,000 ,,	grass	100 beasts at 3*l.* increase of value	
100 ,,	green crops	in a year - - - -	300
		1,000 sheep at 1*l.* ditto - -	1,000
3,000 Acres.		Total value of the produce	£12,350

The value of the produce has consequently increased twelvefold, and if the above sum were applied solely as interest on the capital expended a handsome profit would accrue. Unfortunately for the drainers the land is taxable by the Middle Level Commissioners, and a tax averaging 12*s*. 3*d*. per acre was imposed under the Middle Level Acts of 1844 and 1851, under which the Middle Level Drain was constructed as described elsewhere. As these works were for the improvement of a natural drainage, and the water level does not admit of its being so drained, it seems rather hard that the Mere and its vicinity should be saddled with a share of the 430,000*l*. expended on the said works.

The drainage of the Mere was commenced in 1851, but it is necessary to understand the relation of the levels to the Middle Level datum for the comprehension of the *modus operandi*:—

"For purposes of navigation a minimum height of 10 feet of " water was maintained throughout the Level; that is to say, 10 " feet above the low-water-mark gauge in the Ouse at Lynn " Bridge, from which all the calculations as to the height of water " in the Middle Level are taken. The bottom of the Mere being " 7 feet above the gauge, there remained 3 feet as its ordinary " depth* of water. When the great Marshland Cut† was " opened,‡ and the connecting dykes up to the Mere deepened, " the water throughout the level was reduced to 5 feet on the " gauge, giving therefore a fall of 2 feet from the bottom of the " Mere. This was quite sufficient to create a free flow of the " waters by the new passage or cutting through the bank, and " accordingly for many days the stream continued to discharge " itself into the exterior river. At no time after the first twenty- " four hours was there any rush or torrent, but as the weight of " water behind diminished, the current became less and less rapid, " until at the end of three weeks a sluggish stream was with " difficulty maintained through the shoals to the place of exit. " Fortunately a favourable wind prevailed, and assisted materially " in propelling the water over the higher ground which existed " between the point of discharge and the low places in the middle " of the lake where the water lingered the longest.

"This outpouring of the contents of the Mere was doubtless so " far a natural drainage, but the winter-level rose frequently to " 10 feet on the gauge, so that but for the surrounding banks the " old 3 feet of water would soon have returned to its accustomed " place.

"The present state of things is this:—The bed of the Mere " has sunk from being 7 feet above datum (the gauge at Lynn) " to 3 feet 6 inches; from this, as the least depth that is con- " sistent with the proper cultivation of soil, 2 feet must be " taken, leaving 1 foot 6 inches as the corresponding level on the " gauge; and as the water is held up in summer to 5 feet 6 " inches for navigation, and cannot in winter be run lower than " about 4 feet 6 inches even with the additional fall obtained " by the Norfolk Estuary works, it will be readily seen that it

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* See p. 54, which gave 4·5 feet as the average depth from an actual survey in 1777.

† Now called the Middle Level Drain.

‡ In 1851.

"is hopeless to expect ever to obtain a natural drainage for the "Mere and the surrounding land."*

One of the then newly-invented Appold pumps was erected by Messrs. Easton and Amos in December 1851, worked by a 25-horse engine, and capable of lifting 16,000 gallons per minute with a 6-foot lift. All through the summer of 1852 active measures were taken to bring the tract into a fit state for agriculture, dykes were made, roads marked out, and the boundaries of farms arranged.

On the 12th of November in the same year, the rivers, being swollen with the heavy rains which had fallen, breached the newly-erected banks and "in a few hours Whittlesea Mere was itself again." "It was reckoned that 1,000 acres were covered again "with water to a depth of 2 feet 6 inches, and that if the pump "could raise 20,000 gallons a minute, it would take twenty-three "days incessant pumping to clear off that amount. This calcula-"tion proved correct, and in little more than three weeks the "land, but certainly not *terra firma*, was again everywhere "visible."†

The banks were now fortified, the work of reclamation resumed, and the main dyke completed. This dyke, as may be seen on the Ordnance Map, started near Holme Station, and passed directly through the bed of the Mere, a distance of 3½ miles. From this a number of smaller dykes branched off through the silty bed of the Mere into the surrounding bog, which being thus tapped yielded an incessant though moderate amount of water to be discharged by the engine.

The natural consequence of this withdrawal of water ensued, viz., the land subsided and the drains losing depth required to be continually emptied to prevent their overflowing the land. The engine performed this task in a few hours, then enjoyed a short respite, and had again to perform its disproportionate task. To obviate this uneconomical expenditure of steam-power the capacity of the main dyke was much enlarged at the lower end, thus forming a reservoir for the waters to bed in till such times as sufficient was accumulated to call forth the energies of the pump to a degree commensurate with its capabilities.

"The effect of this network of drains was quickly visible. The "bed of the Mere was soon covered with innumerable cracks and "fissures, deep and wide, so as to make it a matter of no small "difficulty to walk along the surface, while in the surrounding bog "the principal effect was the speedy consolidation of its crust, "which, by the end of the first summer afforded, even in those "places which had been long impassable, as safe and firm a "footing for a man, as it now does throughout almost its whole "extent for a horse."†

Coleseed and Italian rye-grass were the first crops taken, and in the ensuing year oats and wheat. "The wind," says Wells,

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* W. Wells; Journ. Roy. Agric. Soc. Eng., vol. xxi., p. 138.

† *Ibid.*, pp. 139, 140, 141.

" which, in the autumn of 1851 was curling the blue water of " the lake, in the autumn of 1853 was blowing in the same place " over fields of yellow corn " (p. 141).

The natural discharge for the waters of the Mere was evidently by the Nene, but it was considered that the point of discharge was too distant from the sea and the water would be liable to over-riding in times of flood by the freshets. In this view I cannot coucur; and as regards the Wisbech outfall am of opinion that it would be very difficult indeed to pour too much water through it. Everything which has been done in the way of drainage in the Bedford Level has benefited the Lynn outfall and generally at the expense of that of Wisbech. The drainers, however, met with " moral difficulties " in the case of the Nene which did not supervene in regard to the Ouse, and once more a natural drainage was abandoned for an artificial one. Prefix " im " to the adjective which qualifies " difficulties " and the real state of things will be much more apparent.

It now remains for us to describe the more directly geological phenomena of the Mere. Its bed and the reed-shoal with a slight border beyond is covered with a white shell-marl to a depth of 2 to 4 feet. An analysis of this marl by Dr. A. Voelcker gives the following composition:—*

Moisture	9·31
Organic matter (peat)	17·34
Oxides of iron and alumina	1·01
Phosphoric acid	·03
Carbonate of lime	64·77
Magnesia†	·30
Sulphate of lime	1·87
Insoluble silicious matter (sand)	5·37
	100·00

This marl is, of course, found over the beds of Trundle and Dray Meres and Walpole Pit, and is continuous with that of Whittlesey Mere, showing that they originally constituted but one sheet. The waters, therefore, began to contract in area before the drainage of the fens, and thus afford another proof of the grudual desiccation of the Fenland. Camden, in his map of the " Great Levell Drayned," shows them thus corrected, but as in his " Map of the Great Levell representing it as it lay drowned," he shows the connexion by narrow channels we may assume the former to be merely the result of chartographic inaccuracy. Indeed he shows in this latter case that Whittlesey and Ugg Meres were similarly joined, which they certainly were not, or the marl would be continuous between them, which is not the case.

The general section in the bed of the lake may be taken as—

1. Shell Marl	4 feet.
2. Peat	2 feet.
3. Marine Clay.	
4. Brown Peat.	
5. Marine Clay.	

* Journ. Roy. Agric. Soc. Eng., vol. xxi. p. 149. 1860. As an Appendix to Mr. Well's paper.

† Carbonate of ?

The composition of clay No. 3 is given by Voelcker as :—

Organic matter and water of combination	6·23
Oxides of iron and alumina	9·61
Phosphoric acid	·42
Sulphate of lime	1·04
Carbonate „	13·58
Magnesia*	1·51
Potash and soda	1·53
Insoluble silicious matter	66·08
	100·00

The material was first dried at 212° F., by which means the organic matter and water were driven off. Among the insoluble silicates in this and the next analysis, I presume alumina silicate (clay) is reckoned, otherwise the materials would be sand and not clay.

The same authority gives as the composition of clay No. 5 :—

Moisture	2·52
Organic matter and water of combination	4·70
Oxides of iron and alumina	10·68
Phosphoric acid	·16
Sulphate of lime	·25
Carbonate „	11·74
Carbonate of magnesia	2·12
Potash and soda	1·32
Insoluble silicious matter	66·51
	100·00

The three analyses were made from specimens taken from the bed of the Mere by Mr. Wells.

The marl is of a white friable nature but is much decomposed by the operations of agriculture. Its boundaries, like those of fen beds generally, can only be approximately determined as the deposit dies out with a "feather edge." Over the surface of the land numbers of fresh-water shells still remain and will attest the former presence of the Mere for some years to come. They consist of the common species such as—

Pisidium amnicum.
Sphærium (Cyclas) corneum.
Bithinia tentaculata.
Succinea putris.
Limnea peregra, &c.

but the introduced bivalve *Dreissina polymorpha* does not occur, though it is found abundantly on the site of Ugg Mere, and living in the branch of the Nene which flowed through both lakes; it is also wanting on the site of Ramsey Mere. The formation of this marl on the bed of the lakes is a question not very readily solved, for the geographical distribution is peculiar. Whittlesey, Trundle, Dray, Ugg, Ramsey, Stretham, and Soham

* Carbonate of?

Meres lie within the Bedford Level and in the peat district, and upon their sites this deposit is found.

Moreover in the South Level a deposit of shell marl is very generally found at from one to two feet below the peat surface. It is a white friable material full of fresh-water shells, of which the following species were obtained:—

Planorbis complanatus.
P. spirorbis.
Bithinia tentaculata.
Valvata piscinalis.
Limnea stagnalis.
L. auricularia.
L. peregra.
Succinea putris.
Bulla ?
Sphærium (Cyclas) corneum.
Pisidium amnicum.

It can be traced in dyke-sections from Burwell Fen by Stretham Mere, Barraway, Quaney, and Burnt Fen to near Lakenheath. It is not absolutely continuous but appears, as might have been anticipated, to have formed in shallow meres or lakes. It attains its maximum development in Sedge Fen south of the railway near the Cross Bank. It is there dug for manure, and known as "chalk marl," and being got in trenches some of which are at right angles to others the features of the deposit can be admirably studied: The maximum thickness of the marl is 3 feet 3 inches but for more than two square miles it does not sink to less than two feet. The pure white of the marl and the dark colour of the over and underlying deposits make the sections very striking. Here and there a line of peaty material marks a cessation of the formation, and the perfect evenness of these lines attest how quietly the marl was formed. Not a stone or patch of clay or other foreign matter can be found, and the fresh-water shells seem to be pretty persistent throughout, though here and there perfect nests of *Lymneæ* and *Bithiniæ* are discovered. The mass is jointed so as to form large lozenge-shaped masses, and the main joints are very regular.

The roots of *Chara* can be seen in it, and the seeds obtained by careful examination. Indeed I have no hesitation in attributing the whole of the shell-marl to the decay of *Chara* of various species. These plants are still found living in the neighbouring dykes where, so far as my observation goes, they form dense masses to the exclusion of other plants. Only one species (*C. flexilis*) is perennial, the rest, 15 in number, are all annual. The axes of two species, *C. vulgaris* and *C. hispida*, are encrusted with carbonate of lime. The plants do not, I believe, live, or at any rate do not thrive, in muddy water, and on dying decompose with a fœtid odour which is regarded as one of the sources of malaria. The carbonate of lime forms a deposit at the bottom of the water. One season's deposit is usually only a white stain, but under exceptionable circumstances an appreciable thickness is formed. For example, in the ditches in Barwell fen, where the

Charas thrive luxuriantly, a deposit of from two to four inches was formed last summer (1874) on the evaporation of the water during the drought.

Applying these facts to the sections in Sedge Fen, we see that the peaty lines mark breaks in the growth of the *Chara*, during which the peat-forming plants grew, but not in force. The most feasible explanation of the deposit seems to be that the marl formed in shallow meres, when the aquatic plants were almost entirely routed by the great luxuriance of the *Charas;* that occasionally, in very dry seasons, the water dried up, and a covering of sedge and other plants grew upon the sites and, decaying, formed the peaty lines described. That the water was completely evaporated seems proved by the fact that the lines in question are too slight to have been formed of moss (*Hypnum*). With succeeding rains *Charas* again throve, and so the deposit went on year by year, the plants forming a paradise of food to the fresh-water molluscs, until the enormous thickness of over three feet of pure white marl was produced.

I am not aware that any such deposit has been formed in the beds of old lakes north of Whittlesey, and I have certainly never met with such myself.

How is it that the northern half of the Fenland is thus free from the shell-marl which formed so readily in the south? So far as geographical causes are concerned we see no reason why the lakes and sikes which made Deeping Fen such a formidable task to the drainers, or the assemblage of lakes in East Fen, should not have formed a similar deposit; and the former is situated in the peat district. Yet they are perfectly barren in this respect. It will be noticed that the analysis* gives nearly 65 per cent. of calcium carbonate in the marl, all of which must of course have been present in the water. Although all water contains this material it may very well happen that the amount in many cases would be insufficient to produce a deposit containing so large a percentage as the one in question. The almost entire absence of alumina shows, moreover, that the water was very free from argillaceous mud.

We may conclude that for shell-marl to have been deposited the following conditions must have obtained:—

1. The water must have been charged with more than an ordinary amount of calcium carbonate.
2. The water must have been almost entirely free from mud.
3. Some cause must have favoured the deposition of the carbonate.
4. The water was unfavourable for the growth of peat, though molluscs, fish, and the ordinary aquatic plants throve in it.

The calcium carbonate might be derived from the chalk, the Cam being the chief lime-bearing stream. Whittlesey, Ugg, and Ramsey Meres were supplied by the Nene, which besides interlocking with the Cam, flows through the calcareous beds of the Middle Oolites. This, however, does not account for the whole

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* On p. 58.

difficulty, for the Welland, which passes through Deeping Fen, though flowing through the Lias for the greater part of its course receives the drainage of a large calcareous Oolitic area. The Witham in like manner is supplied with lime by its tributaries, so that we must look to some other source for the complete explanation of the anomalous distribution of the shell-marl.

Deeping Fen is crossed by the Welland, which flows through the Oolites also, but runs through the Lias to Stamford owing to the beds being thrown down by extensive faults. Its waters may therefore be reasonably expected to show a deficiency of lime as compared with the Nene. The East Fen derives its waters from the Kimeridge Clay and Neocomian sands of Lincolnshire, so that it is not likely to be overcharged with lime. In this way the limitation of the marl may have been determined, but it is, to say the least, a mere speculation.

The freedom from mud offers no such obstacle, for the fen rivers have deposited by far the greater portion of their sediment before they enter the Fenland, forming the rich pasture lands of the Welland and Nene, which are justly renowned as grazing districts. Even in times of flood the deposit is not sufficient to stain the grass appreciably as may be noticed any winter in the river "washes."

The extraction of the lime, and the exclusion of the peat-forming plants, are accounted for by the vigour of the Charas.

But this only removes the difficulty one step further. The question now to be solved is, "How is it that the Charas only "luxuriated in this particular area?" The same difficulty attends the explanation of the geographical distribution of the plants as of the marl, and I have not discovered the clue of the maze.

CHAPTER VII.

RIVERS OF THE FENLAND.

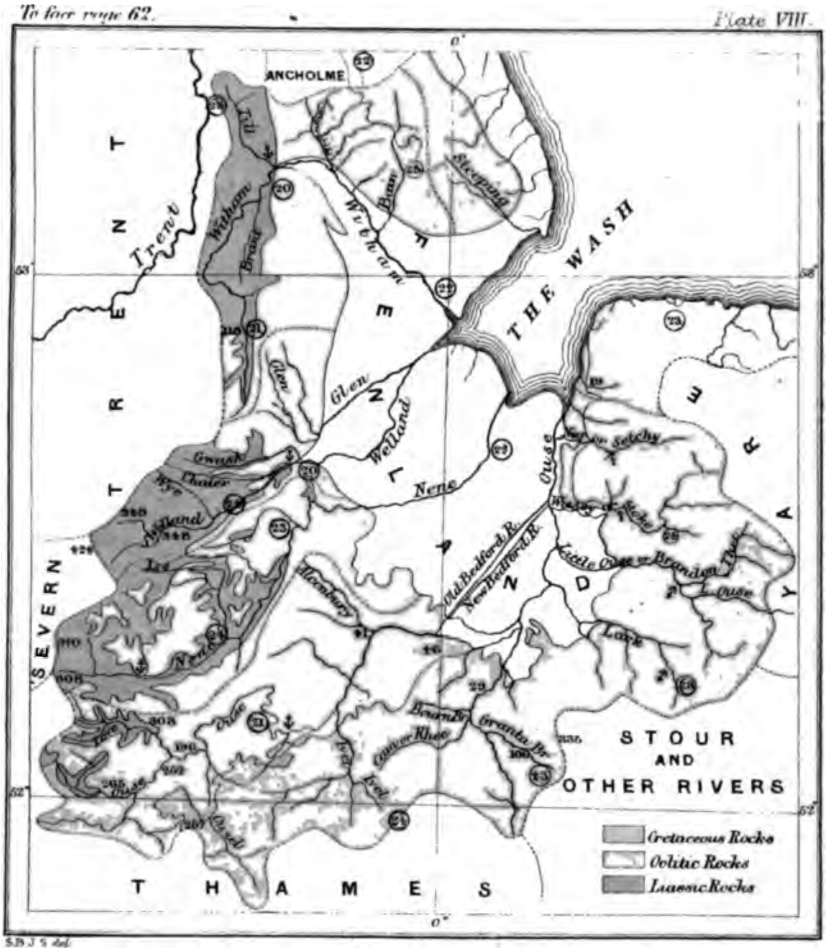
In treating of the rivers of the Fenland we shall briefly describe their features, and take one, the Witham, and enter more particularly into details.

Plate VII. shows the rivers, and their relation to the geological features of the catchment basin. The following table gives the lengths and areas, as determined by the Ordnance Survey and the Rivers Commission, the former bearing date , the latter 1874:—

GEOLOGICAL SURVEY
OF ENGLAND AND WALES.

To face page 62.

Plate VIII.



S.B.J.S. del.

Catchment Basin of the Fenland Rivers.

Boundaries of Catchment Basins . . . .

Dangerfield, Lith. 22, Bedford St. Covent Garden.

TABLE showing the LENGTHS of the FENLAND RIVERS, and the AREAS of their respective BASINS.

Name.	Ordnance Survey.		Riv. Com.
	Length.	Area.	Area.
STEEPING - - -	18		
Tributaries - - -	—	101	
Other small streams - -	—		
WITHAM - - - -	40		
Till - - - - -	14		
Bain - - - - -	24	1,079	1,050
Brant - - - - -	13		
Langworth - - -	9		
Other small streams - -	—		
WELLAND - - -	42		
Gwash - - - - -	19		
Glen - - - - -	31	760	708
Chater - - - - -	15		
Other tributaries - - -	—		
Other small streams - -	—		
NENE - - - - -	100		
Old Nene - - - -	42		
Ise - - - - -	22	1,077	1,132
Other tributaries - -	—		
Other small streams - -	—		
OUSE - - - - -	143		
Little Ouse - - -	37		
Lark - - - - -	28		
Cam - - - - -	30		
Brook - - - - -	10	2,607	2,960*
Rhee - - - - -	15		
Ivel - - - - -	18		
Ouzel - - - - -	19		
Tove - - - - -	21		
Other tributary streams - -	—		
NAR - - - - -	35		
Tributaries - - -	—	131	
Other small streams - -	—		
WISSEY - - - -	28		
Tributaries - - -	—	243	
Other small streams - -	—		

* This includes the basins of the Nar and Wissey. The area of the Steeping is not stated.

STEEPING.

The Steeping rises in the upper portion of the Neocomian system, to the strike of which it flows parallel, and enters the Fens by Little Steeping, and the Wash at Gibraltar Point. The village of Little Steeping and the town of Wainflete are placed at its entrance and exit from the fens. In the year 1412, 13 Hen. IV., "The King by his attorney impleaded William Leveryk of "Irby, and Isabell his wife, for making of a ditch in a certain "place in Waynflete, called Haledale, by means whereof four "sewers which passed the fresh waters from Bullingbroke and "other towns adjacent in East fenne and West fenne became "obstructed," &c.* from which it appears that the waters of those fens discharged into the Steeping, and this continued at least till 1540, as appears from a pamphlet by Dr. Browne of Boston, written before 1560. But in 1630, 6 Caroli. I., it seems from a decree of a session of sewers that these fens discharged by Wainflete, Black Gote (north of Fiskney), and Maudfoster Gote, the present outlet; and such is the state shown in Dugdale's map dated 1661.† It thus appears that the passage of water from the western fen towards the Steeping was gradually decaying between the 15th and 17th centuries, and at the same time the waters were being conveyed to the south as a more expeditious course by the Maudfoster Drain. This is interesting in connexion with the change in the course of the R. Witham to be presently described.

The next river in geographical order is the Witham, but as it will be described in detail further on nothing need be said about it at this place.

WELLAND.

The River Welland rises in the Lower Lias Clays near Sibbertoft, and divides Northamptonshire from Leicestershire, Rutland, and Lincolnshire. It passes by Rockingham and Stamford, and entering the fens near Deeping, flows through Spalding to the sea. It cuts through the Marlstone Rock-bed at Little Bowden, and again near Medbourne, and thence flows through the Upper Lias Clay to Barrowden, from which place to Ketton its channel lies chiefly in the Lincolnshire (inferior) Oolite Limestone to Ketton, crossing the Ketton fault at an angle of about 45°. It then flows through Upper Lias Clay, Northampton Sand, and Lincolnshire Oolite Limestone to Stamford, cutting across the faults of that district. Where its bed is in clay a fine expanse of alluvium borders it, forming celebrated grazing land. A mile east of Stamford it receives the waters of the Gwash, and above Spalding those of the Glen, these tributaries being the only ones directly connected with the fens.

The Welland is the only river of the fens that has preserved its ancient course with anything like integrity, and the position of the Roman banks below Spalding show that the size of the river was not much greater when they were erected than now. Up till the time of the great drainage of the Bedford Level, in the 17th century, however, the river branched at Croyland, an arm flowing south-eastwards to a branch of the Nene at Noman's-landhirne whence it flowed into Cross Keys Wash. This latter branch was called the South Ea, and is at present known as the South Holland or Shire Drain. In Dugdale's time (1660) this seems to have been the principal course of the Welland, for

* Dugdale, p. 162.

† See Plate IV.

he says that the Welland " divideth itself into two branches [at " Croyland Bridge]; the one leading by South Ea towards " Wisbeche the other *in a most slow course*, to Spalding and " Surflet."* This branch is now entirely unused and is a mere ditch as far as Noman'slandhirne. For convenience we will call it the South Ea branch,† though the South Ea itself is the part of the Nene into which this arm of the Welland fell.

The South Ea branch, though a natural one, was in old times only a slaker* by means of which the surplus waters in times of flood, passed out of the main channel. It only became of importance, when, through neglect of the river below Spalding, the main channel had decayed. That this is true is evinced by the Roman banks, and by numerous records. Thus in the year 1118 18 Hen. I.) the Abbot of Croyland got into trouble with the Lord of Deeping for poaching in the Welland. Whereupon he said, amongst other things, that " there is a certain river, called Welland, " running *time out of mind* from the boundary called Kenulf-stone " in the west, unto the site of the abby within the said town: " and so from the same abby, to Brotherhouse, towards the " north." And again, " that the course of the fresh waters, flow- " ing from the west, in the said fen, did then run, *as always they* " *had used to do*, from the same fen into the said river of Welland, " and so to the sea."‡ In the reign of Henry III. (1216–72) a presentment was made " setting forth that there were two courses " of water, in the common river of Crouland; the one nearer, " [by Spalding] the other more remote [South Ea branch]: And " that the nearer current was the right channel, and of sufficient " depth, wherein they that did go with barges and boats might " well pass to and fro, but that the Abbot of Crouland had, by " planting willows thereon, so obstructed and straightened [nar- " rowed] the said course of that stream that boats and barges " could not pass as formerly they had."‖ This is the first mention of the decadence of the Spalding channel I have met with.

Having made that point clear we will pass on to consider the state of the river.

In the year 1337 (10 Ed. III.) an application was made to the Abbot of Croyland to make a road from Croyland towards Spalding. " Whereupon the Abbot by his letters signified to the King, that " the distance betwixt the great bridge within the town of Crou- " land and the said place called Brother-house (within which " space these dangers in passage were) was no less than three miles " and in a fenny soil, upon the one side of the River Weland; " where by reason of the lowness of the ground in a moorish

* Dugdale, p. 176.

† A slaker was a branch in which the water flowed sometimes in one and sometimes in another direction according to which of the streams with which it was connected had the higher water-level.

‡ That the S. Holland Drain was called the South Ea appears from a presentment in 1437, which describes the South Ea between Throckenholt, Clowes Cross, and Guyhirn; and in the next year from Noman's land. It is here stated to have been formerly called the Old Ee.

§ Dugdale, p. 195.

‖ Dugdale, p. 212.

' earth,* it would be a difficult matter to make a causey fit and ' durable for passengers, because it could not be made otherwise " than upon the brink of that river, where there was so much " water in winter time, that it covered the ground an ell and a " half in depth, and in a tempestuous wind two ells."†

In the year 1367 (40 Ed. III.) the town of Spalding was accused of neglecting "to scour and repair a certain running river " called Welland, from the house of William atte Touneshende, " of Spalding, unto a place called Brother-house:" to which it was replied "that the river mentioned in that presentment then was, " and long had been, an arm of the sea, whereinto the tides did " ebb and flow twice in 24 hours," and therefore they ought not to scour it.

The next important event recorded in the history of the Welland happened in the 17th Jac. I. (1620), when, for improving the navigation of the river from Stamford downwards, a cut was made on the north side of the original channel from the east end of the town of Stamford to the river beyond Market Deeping, within which space no less than twelve locks were erected. The cut was nine miles and a half in length, sufficiently broad to admit boats of seven feet beam, and deep enough for boats carrying fourteen tons.

Before this work was executed, in the reign of Elizabeth, the river was in a very bad state, but was improved when Deeping Fen was drained by Sir William Aylof and Sir Anthony Thomas in the reign of the first Charles, as related in Chapter V. At this time the river was cleaned, deepened, and banked, the banks being made wide apart, so as to leave a broad space or Wash, in some places a mile apart, in which the flood-waters lay. Vermuyden, in the year 1650, on draining the Bedford Level, greatly enlarged and strengthened the bank from Peakirk, by Croyland to Brother-house, on the top of which a road is maintained. The object of this work was to protect the North Level from the flood-waters of the Welland.

In the year 1794 (34 Geo. III.) an Act was obtained for improving the outfall of the river Welland, &c., and a new cut was made from the Reservoir, below Spalding to Fosdyke.

For over forty years nothing was done for the improvement of the Welland outfall, notwithstanding that in the year 1815 Mr. Thomas Pear reported that below Fosdyke Bridge the river was so defective that neap tides failed to reach Spalding, although fifteen miles lower down, at the junction of the Witham and Welland, they rose fifteen feet. In the year 1835 the outfall was in so bad a condition that, in dry seasons, there were only a few inches of water at Fosdyke. Mr. Jas. Walker, C.E., thereupon devised a scheme for the benefit of the river, which was carried out by Mr. Beasley. Mr. Wheeler, writing on this question, says: —" The plan adopted by Mr. Walker for training the river was

* The peat has now (1874) almost vanished from this place through the effects of cultivation.

† Dugdale, p. 212-3.

"first proposed to him by Mr. Beasley, and was found to be so "simple and inexpensive as compared with other methods, and "at the same time so effective, that it has since been used in all "similar works in the estuary. It consists of barrier walls, or "banks made of thorn faggots about six feet long and three feet "girt, which are laid in the water in courses varying in width in "proportion to the depth, and as each course, which is weighted "with clay, sinks, others are laid on till the bank is raised to about "half-tide level. The branches of the thorns interlaid one with "another, and the silt brought up by the tides rapidly deposits "amongst and at the back of this fascine work, and thus a solid "embankment is formed, of sufficient strength and tenacity to "withstand the strongest tidal current."*

By the year 1838 the fascine work had been carried a mile and a half below Fosdyke Bridge, with such good results that vessels drawing eight feet of water could more readily reach Fosdyke, than those of three feet draft did before. The fascine training was subsequently continued for about a mile further, and in this condition the outfall now remains.

The waters of the Witham and Welland flowed into Lynn Well, but the effect of the improvements of the outfall of the latter river so strengthened its current that, impinging on the waters of the former almost at right angles, it forced them to take a northerly course through Boston Deeps.

NENE.

The river Nene rises in the Lower Lias Clays near Daventry in Northamptonshire, and cutting through the scarp of the Middle and Upper Lias, flows in the clays of the latter past Northampton to near Thrapston, where it enters the Oolites, its bed, however, being mostly in the Upper Lias Clay as far north as near Sutton, from which point it flows through Oolite rocks to Peterborough, where it enters the fens. Its present course from Peterborough is north of Whittlesey, by Guyhirn, Wisbech, and Sutton Bridge to the Wash.

In tracing the branches of the Nene through the fens considerable difficulty has been experienced owing to the paucity of records previous to the formation of Morton's Leam in the reign of Henry VII. This difficulty does not appear to have presented itself to previous writers, probably because they had no occasion to deal with the past otherwise than as old acts influenced the present state of things. Some of the branches seem to be readily made out, and all writers have mentioned two in addition to Morton's Leam. One of these flowed northwards from Peterborough to Noman'slandhirn, and was, in that part, called the Muscat River, or Cat's Water. From Noman'slandhirn it was known variously as the South Ea, South Holland Drain, and Shire Drain, and entered the estuary at Tid Gote. A smaller branch from Noman'slandhirn united with the Welland at Croyland,

* Wheeler, Fens S. Lincs.

and has been described previously as the South Ea branch of the Welland. It seems, however, to have flowed sometimes one way and sometimes another, and hence may be considered to have formed part of both rivers.

The other branch flowed south by Horsey Bridge, through Whittlesey Mere, thence by Bodsey Bridge, near Ramsey Mere, past Benwick, through March to Upwell and Outwell, and thence along the Well Creek* to the Ouse at Salter's Lode, and so to Lynn. Both these branches are still in existence, and their courses, therefore, indisputable.

But if the northern branch entered the Wash below Wisbech if the southern one did not pass out by that town at all, and if Morton's Leam, and its continuation is an artificial cut, what water flowed through Wisbech before the Leam was cut? We shall abundantly prove in the sequel that the Ouse formerly discharged above Wisbech, but to do this it must have intersected the southern branch of the Nene, about Upwell, and indeed have flowed with it to Outwell, whence the Well Creek passed to the east, and the Ouse continued northwards. The geographical configuration of the country renders this in the highest degree improbable, for the Well Creek would form an angle of about 135° with the confluent streams, and would hence have to flow, as it were, backwards, as in the diagram Fig. 1. It is common enough

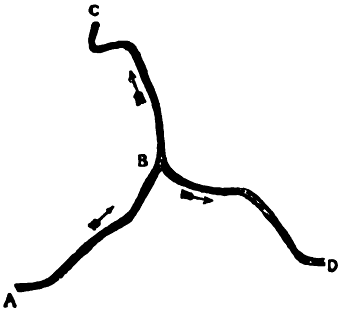


Fig. 1. DIAGRAM to show supposed Course of Ouse and Well Creek.

A B C Ouse. B Confluence of Ouse and Well Creek. B-D Well Creek.

for two streams to *join* at such an angle, which would then be 45° and not 135°, but I know no instance of streams *separating* in such a way, and believe it to be next to impossible.†

We may, therefore, be pretty confident that when the Well Creek flowed to Salter's Lode, the Ouse did not run by Wisbech; and on the other hand when the Ouse ran by Wisbech the Well Creek did not flow eastwards. This is tantamount to saying that

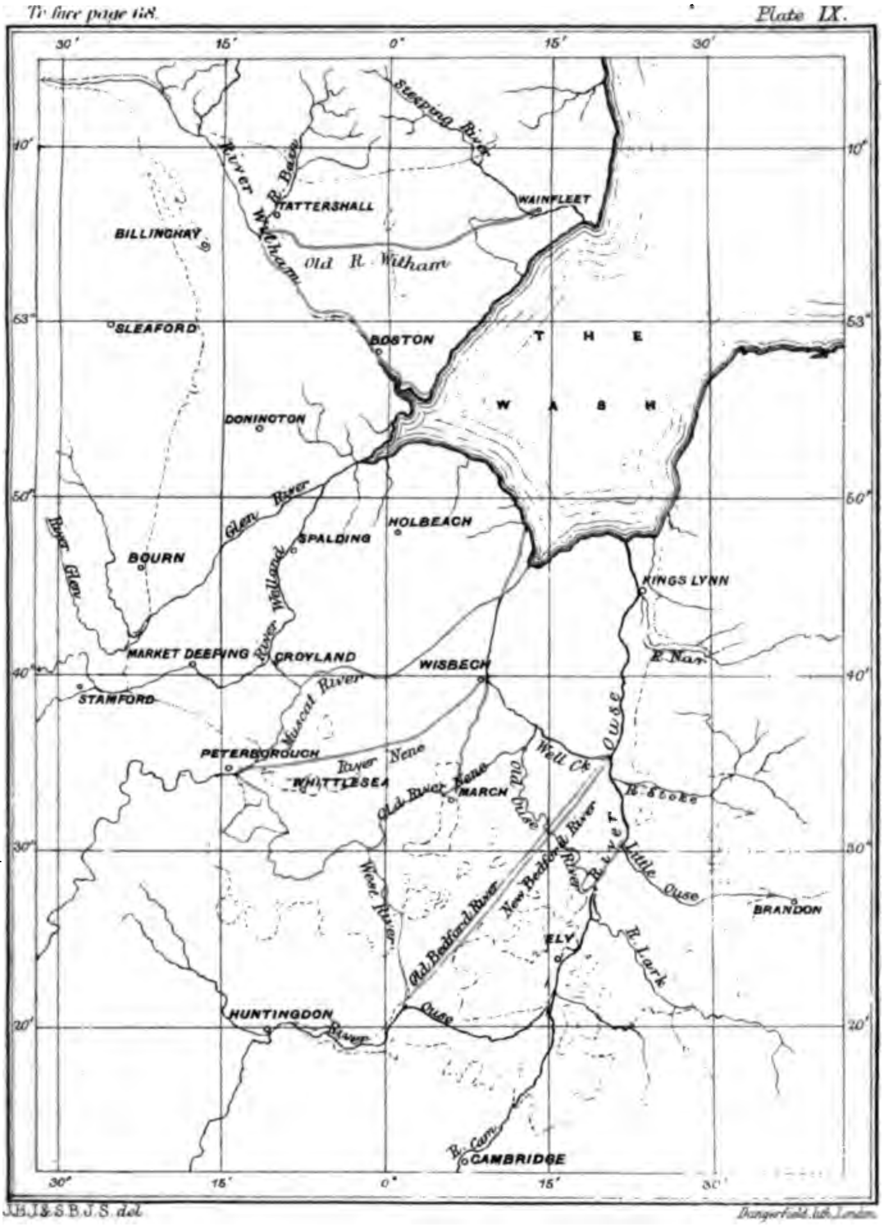
* It must be noticed that the *Wisbech River* was called the Well Stream as early as 1283 (13 Ed. I.), as appears from presentments of that date. This must not be confounded with the Well Creek, which extends from Outwell to Salter's Lode.

† Mr. Tylor has shown that the angles of tributaries increase from the source to the mouth of the main river, but they never exceed a right angle. Geol. Mag., vol. ii. 1875.

GEOLOGICAL SURVEY
OF ENGLAND AND WALES.

To face page 68.

Plate IX.



J.B.J.& S.B.J.S. del.

Dangerfield lith. London.

CHANGES IN THE COURSES OF
THE FENLAND RIVERS.

one of these channels decayed before the other was formed. Which became obsolete is readily shown, for while the Well Creek course remains to the present day, and was formerly of great importance, as numerous Acts of Parliament show, the time when the Ouse ceased to flow is unknown. The southern branch of the Nene, therefore, must have flowed, with the waters of the Ouse through Wisbech. The Well Creek may and probably did flow westwards into the Nene for some time previous to the decay of the Ouse channel. The decay of this Wisbech Ouse, as we will term it, will be discussed when we treat of that river.

Let us now consider the northern branch of the Nene, for it also presents a difficulty. If we trace the course of the South Holland Drain, or South Ea, from Dowsdale to Clow's Cross, we find the channel a simple one, but at the latter place a furcation takes place, one branch going south to Guyhirn, the great banks of which still exist, and are alone called South Ea Banks on the Ordnance Map, and the other passing northwards to Tid Gote as before mentioned. The identity of the name of the Guyhirn section with that from Dowsdale to Clow's Cross, would lead to the inference that the waters flowed to the south. There is no doubt that this is a natural stream-course, and the question arises as to where the waters went beyond Guyhirn, if the river from that place to Wisbech is entirely artificial. Dugdale says, "divers other currents of it (the Nene) there are, by and through "the bounds of Thorney, chiefly Knorlake, the Wride, and "South Ea, which have heretofore discharged themselves into "the sea (as some suppose) by Clow's Cross, but are of later "time, since the New Leam was made by Bishop Morton,* from "Standground to Guy hyrne, and so to Wisbeche, their chiefest "and best passage hath been by that channel."† This implies that there was formerly no river between Guyhirn and Wisbeach, and that the South Ea flowed *northwards* from the former place to Clow's Cross as it does now. The course may have been as he supposes, yet, in the year 1437 (16 Hen. VI.), we find mention of the "river of Wisbeche" from Guyhirn to the sea;‡ and again in the year 1438 (17 Hen. VI.) we find it stated at a session of sewers held at Wisbech "that there was a certain sewer "called South Ee, but anciently Old Ee, whereby the water "of Nene and Welland ought to pass from Noman's land, in "Croyland, unto Dowdesdale, in the same town,§ and thence "by South Ee dyke unto the east end of the field of Thro-"kenhold, in Leverington, near the Crosse in Leverington; "and thence into the sewer called Fendiche, in Leverington "and Wisbeche, unto the river of Wisbeche, at Guyhirne."

* Between the years 1478-90. Armstrong in Hist. Port King's Lynn says in the latter year, and cites a Commission showing that the leam was not in existence in the beginning of that year, p. 20.

† Dugdale, p. 176.

‡ Ib., p. 320-2.

§ Here and afterwards in the quotation the township, or parish, and not the town itself is meant.

And at the same time they presented "that one part of "the water of Nene descended from the bridge at Peter-"borough unto Thorney barre aforesaid; thence to Noman's "land in Croyland" . . . . "And they said that the other part "of Nene which passeth from Peterborough bridge aforesaid "unto Wodeshed in Wytlesey, thence to Wittlesey brigge, thence "by Wittlesey to Wardiscote, in Wittlesey, and thence unto the "great river of Wisbeche."*

From this it is clear that there was so early as 1438 a connexion between Peterborough and Wisbech, through Whittlesey and Guyhirn. This seems to have escaped the notice of previous writers on this subject, and we find Sir John Coode, C.E., in the present year (1875) quoting Mr. Page's report of 1860, wherein it is stated that Morton's Leam "was the first direct channel "between Peterborough and Wisbech." †

We may, therefore, safely conclude that the branch of the South Ea from Clough's Cross to Guyhirn communicated at its northern end with the main stream going to Tyd, and at Guyhirn with a smaller river going to Wisbech, and the stream was sometimes in one, sometimes in the other direction.

Other branches also existed, but before endeavouring to trace them it is as well to notice that the names were applied quite arbitrarily to the different streams, and not only was the same stream known by different names, but the same name was applied to different streams. It may be of assistance to tabulate these names.

1. *Wisbeche River.*—The stream which flowed through Wisbech no matter whence it came. First mentioned in the year 1339; still in use. In 1437 applied to the river between Guyhirn and Wisbech.

2. *Wellstreame.*—Applied to the Wisbech river in the year 1253.

3. *River of Welle.*—The old course of the Ouse from Littleport by Welney to Outwell. Used between the years 1340–1566.

4. *Utwell,* "for so that great river of Ouse, which had for-"merly passed that way, was then called." (Dugdale's note to the course of the river through Wisbech in the year 1292.) This seems to be an allusion to the Ouse waters which "formerly "passed that way."

5. *Wellen Hee.*—The old course of the Ouse from Outwell by Welney to Littleport. Used in the year 1331.

6. *River of Wise.*—The same as Wisbech river. Used in the year 1339, &c. Wise = Ouse. Hence Wis-bech.

7. *Use.*—Used in the year 1437 for the Wisbech River.

8. *Great Ee.*—The branch of the Nene from Peterborough by March, &c. Used in the years 1528–48, &c.

9. *Avon.*—Camden calls the Nene by this name in the year

* Dugdale, p. 328.

† Report on the River Nene and Thorney Lordship by Sir John Coode, p. 6

1586, as did Leland before him. Tacitus called it the Antona, a corruption of Aufona.

10. *Well Creek.*—The course of the Nene from Outwell to Salter's Lode. Sometimes to the Wisbech river.

We may also notice—

11. *River of Elme.*—From Friday Bridge to Wisbech. Used continually between the years 1340–80. It is called Wisbech river in 1339.

12. *Elme Ee.*—The river of Elme. Used in the year 1437.

13. *South Ea.*—Applied to the Cardyke in the year 1315, but with this exception the term is used as in this work.

The branches of the Nene that have not yet been traced are: 1. The river of Elme. 2. The Wride. 3. Knarlake. 4. Well Creek. The three last mentioned have been alluded to before.

The *River of Elme* or *Elme Ee.*—There is no stream now known by this name, and the southern part of its course is doubtful. The earliest notice I know of it is in a session of sewers in the year 1340 (14 Ed. III.),* but no particulars as to its course is given. It is also mentioned in the years 1348–52–53–56. But in the year 1380 (4 Rich. II.) at a session of sewers mention is made of "the river of Elme, at Fryday bridg."† The last mention of this river is in the year 1580 (23 Eliz.)‡; but again no details are given.

This river was most probably a branch from the Nene near March, and ran pretty much along the course of the Wisbech Lower Road by Friday Bridge to the river at Elm, and as such is laid down on the map Plate VIII. It could never have been of much importance, and was probably allowed to decay before the great undertaking of the fens during the Commonwealth.

The *Wride* and *Knarlake* were two branches of which little record remains; a part of the former has been straightened, and is still used as a drain, into which the Buke Horn Drove Drain falls. The Wride was a branch from the Muscat, and joined the Guyhirn branch of the South Ea. The course of the Knarlake is not determinable, but I think it not improbable that it was the branch which was superseded by Morton's Leam.

Well Creek.§—This is the branch of the Nene from Outwell by Nordelf to Salter's Lode, concerning which a good deal has already been said. Some time previous to the year 1292 the waters of the Ouse were diverted from the Wisbech channel to the Little Ouse at Littleport, whence they flowed to Lynn. The immediate result of this act was that the Wisbech outfall, now receiving only the waters of the Nene branches, began to silt up, and by the year 1315 || the main course of the Nene from Outwell was by

* Dugdale, p. 308.
† Ib., p. 316.
‡ Ib., p. 346.
§ There was of old, *i.e.*, at the time of the Conquest, a great mere called the Wide, in the Fens of Upwell. See p. 90.
|| Dugdale, p. 301.

the Well Creek to the Ouse at Salter's Lode; Wisbech having lost the main waters of the Nene also. But in this year (8 Ed. II.) an attempt was made to divert these waters to the Wisbech channel, and the scheme met with great opposition from merchants who "were hindered from passing with their ships, boats, "and other vessels, from the town of Lenne and Yakesle, Holme, "and other places lying in the counties of Huntendon and "Norfolk."*

I cannot but think that the Well Creek was at first a branch flowing from the Little Ouse at Salter's Lode to the Great Ouse at Outwell, otherwise we cannot meet the difficulty stated on p. 68. When both Great and Little Ouse passed to Lynn, the water began to flow in the opposite direction, a phenomenon by no means uncommon in the branches of the fen rivers; and as the Wisbech outfall decayed the importance of the Well Creek increased until, as we have seen, it became, in the 14th century, the great water-highway between Lynn and the Midland Counties.

We find indeed much mention of the silting up of the Wisbech channel, as for example, in the year 1340 [47 Ed. III.] when works were ordered to be done "for hindering the sand brought "up by the tides from choaking up of the said sewer."† Again in the year 1391 [15 Rich. II.] the people of Elm complained amongst other things that "forasmuch as the soil, where the "inhabitants and tenants of the said town used to have their "antient sewers, was so much heightened by the silt of the sea, "that those sewers were utterly lost." It is further stated that the commissioners of sewers appointed to view the above were also to investigate the cases of "the sewers in Wisebeche, Elme, "and Welle, so choaked up with silt as abovesaid."‡ The condition of the Wisbech outfall continued to grow worse, and in the year 1437 [16 H. VI.] it is presented that "by reason that the "river of Wysebeche had for many years past been so filled up "with silt and sand, brought in by the sea-tides" that the waters of Oldfield in Elm could not have passage that way.

This was the climax of the misfortunes of Wisbech as a seaport. Naturally the metropolis of the fens, and the best point of discharge for its waters, we have seen it deprived successively of the waters of the Ouse and Nene till a mere creek dribbled out to sea, leaving a great tract of green marsh within the wide bounds of the Roman banks. The channel was so silted up as to be incapable of discharging the ordinary waters of the adjacent land, and the neighbouring fens were almost continuously drowned or held on so precarious a tenure as to excite apprehensions for the security of even the smallest agricultural outlay.

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* Dugdale, p. 301. Boats had in consequence to turn southwards down the old course of the Ouse, by Welney to Littleport, and thence up the main stream to Lynn. See p. .

† Dugdale, p. 313.

‡ *L. c.*, p. 317.

Soon after this time John Morton, Bishop of Ely, during the years 1470–86, devised and carried a bold scheme for improving at once the drainage of the fens, and the navigation of the river. His plan was to collect the waters of the Nene into one channel at Peterborough, and convey them by a new cut direct to Guyhirn and thence through Wisbech to the sea. It is singular that no contemporary records remain respecting the construction of this work. Thus Dugdale, whose splendid compilation of the records of ancient drainage stands without a rival, has no notice of *any* work executed between the years 1468 and 1528. Gough and Camden was equally silent, and though Armstrong dates the work as executed in the year 1490 he gives no authority to prove it.

It is most likely, however, to have been made during the time Morton was Bishop of Ely, for that he devoted much time to it is clear from his having erected a brick tower "that he might see "his workmen afar off in the Level," and his active subsequent career would not have afforded him the requisite leisure. Reasons have already been given for the opinion that the Leam was made pretty much along the site of an old water-course.

From a valuable record, dated 1614 [12 Jac. I.], it appears the Leam, called the New Leam or Morton's Leam, was made "xl. feet wide, and 4 feet or more deep (viz., from Stanground "stease to Guyhirn) being a course of xii. miles long at the least; "and continuing the same through Wisbeche, for the more speedy "delivery of the waters."* Insignificant as this cut was, it nevertheless served a certain purpose for a time, for in a report by Richard Atkins dated 1618, referring to the immediate effect of this work he says "then was the fall of the waters in Wisbech "so great, as no man would venture under the bridge with a boat, "but by veering through."† But this benefit was not of long duration, as might have been expected from the small size of the cut; and we find eighty years after its construction the following order (1570, 13 Eliz.) "That the sewer, called the New Leame, "from Knar lake to Stanground, being so grown up that no water "can pass in dry years, to the utter decay of Wisbeche River, "be diked 30 feet wide and 6 feet deep." That is to say the leam was made 10 feet narrower and 2 feet deeper, its sectional area originally being 40 ft. × 4 ft. = 160 ft., and its new area 30 ft. × 6 ft. = 180 ft. It is also stated that the Wisbech River was "greatly decayed, raised, and silted up, by reason of the flowing "and ebbing of the salt water."

During this period the old course of the Ouse from Outwell to Welney and Littleport had been receiving less and less water from the parent stream, until at last a portion of the Nene backed up the channel and what was originally the main course of the Ouse became a minor branch of the Nene. We accordingly find a presentment made in the year 1538 [2 Ed. VI.] in which, after

* Dugdale, p. 372. It need hardly be pointed out that this record is not citing contemporaneous history; the author seems to have had access to some account of the making of the Leam now lost.

† Quoted in Walker's History of Wisbech, p. 115.

describing the course of the Nene as far as Outwell, it is represented that "there the said river, dividing itself into two branches, "whereof the one returneth south-eastwards, and is called the "south branch, unto a certain old decayed sewer in Welney "called Mayd Lode; thence unto another old decayed sewer "between Welney aforesaid and Lytilport, in the Isle of Ely, "called New Dike, and Creke Lode, in Sotherey aforesaid; "thence unto Lytilport Chaire aforesaid, and so to the aforesaid "great river of Ouse, and so to the north seas at K. Lynne." Although the Welney River is not mentioned by name in the above extract, the waterway can have been no other for it is the only stream going by Maid Lode, &c.; and it is clear that the course was not along Maid Lode, for that Lode extended from north of Welney across Pulver and Sedge Fen to the Ship Lode which joined the Ouse opposite the mouth of the Wissey.

Morton's Leam was again allowed to go to ruin, and when the Great Level was undertaken in the year 1631 we find Dugdale reporting "Morton's Leame . . . . . new made," * as though the work had to be done all over again. In the year 1721 Kinderley† proposed and nearly completed the first effectual works for the improvement of the outfall. "It is to be remembered "that at this time the river's end, which is now twelve miles "below Wisbech, was four miles and a half below the same "place. From that point marshes began to swell on each "side of it, extending from half-a-mile to two or three miles "wide, among which the river took its course in a very "irregular line. During the tide the marshes were covered, "but as the waters began to ebb the overflow gradually "sunk into the channel. By a singular mistake these large "marshes were held to be preservative of the outfall, by dis-"charging their tide into the channel. This channel having "nothing but loose moveable silts and sands to confine it, varied "continually, sometimes dividing itself into two or three parts,‡ "and a gale of wind was sufficient to cause a considerable differ-"ence in its course. It was, therefore, always necessary to "engage pilots up to Wisbech, even by vessels in the habit of "trading thither; for there was no part of the North Sea more "dangerous in rough weather than these sands and uncertain "channels, which were the cause of frequent wrecks to the small "barges that ventured among them at certain seasons."§

To avoid this uncertain and dangerous waterway Kinderley proposed a cut at the then river's end by the South Holland Drain Sluice, and the work was commenced by the North Level Commissioners with the approval of the Corporation of Wisbech. Before the work was quite completed the latter body altered their opinions, and violently opposed the scheme, and even went to the

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* Dugdale, p. 410.

† This name is spelt Kindersley on the Ordnance Map.

‡ Kinderley says, "the channel changed its course a full mile, by degrees from "west to east, in two years' time from June 1721." Quoted by Walker and Craddock.

§ Walker and Craddock, Hist. Wisbech, p. 170.

extremity of demolishing the work, and finally put a stop to the proceeding. It was eventually revived and successfully carried out in the year 1773, and exercised a remarkably beneficial effect upon the river.

When the old works were stopped attention was directed to the defective state of Morton's Leam and the present course of the river was made, called Smith's Leam, from Peterborough to Guyhirn. This was in the year 1716.

Kinderley's Cut, however, was not continued, as he proposed, three miles below the river's end, and was soon found to be incompetent to the great task laid upon it, and although "the first fresh "that came down ground it from seven or eight feet to fifteen or sixteen feet" * deeper, and the water at Wisbech was lowered from four to five feet, the river at Wisbech still continued defective. The blame of this cannot be laid upon Kinderley for only half his scheme was carried out, and even that was of great service, and subsequent works showed that his plan was a valuable attempt in the right direction.†

We find Mr. Wells writing on the state of the river in the year 1804 to the following effect:—"The state of the river Nene . . . "had long been a subject of general complaint; so much so, that "a respectable alderman of Lynn facetiously observed, that he "regularly attended the river Nene meetings, until he saw on his "way thither persons making hay in the bed of the river, after "which he thought such attendance perfectly unnecessary."‡

The next work for the improvement of the river was a new cut, called the Nene Outfall Cut, from the end of Kinderley's Cut to Crab Hole, thus straightening the river and removing it from its old channel among the shifting sands. This great work was devised by Rennie and Telford and carried out by Joliffe and Banks, at a cost of 200,716*l.* It was opened in June 1830; the Sutton Bridge being made before the waters were diverted into their new channel. The dimensions of the new cut are as follows:—

—	At Crabhole.	At Kinderley's Cut.
	Feet.	Feet.
Width at top - - - -	300	190
„ *bottom* - - -	250	140
Depth at low-water - - -	24	24

"As the contractors had calculated that the flux and reflux of the tide would scour out from four to five feet of the bottom, some

* Letter from Tycho Wing to Mr. Golbourn, the engineer of the cut. Dated June 19th, 1776. Quoted in Walker and Craddock Hist. Wisbech, p. 176.

† By this cut 7457·5 acres of the old channel and green marsh were laid bare which were vested in the Bedford Level Corporation.

‡ Wells, Hist. Bedf. Level, p. 720.

x Beardmore, pp 236 – 238.

disappointment was experienced on finding that it became rather deteriorated. In fact, the ebb was so directed into the large bay between the embankment and the upper end of Kinderley's Cut. where the new channel commenced that much of its scouring power was lost, and hence it became imperative to construct a dam across the old channel at this point, to throw the whole force of the ebb through the new cut. The experiment was eminently successful, as not only the four or five feet upon which the contractors had calculated were scoured out, but nearly twice that amount. The effect of the opening of the cut on the bridge, which had been constructed previous to the letting in of the water, was prodigious, and became to the proprietors an object of extreme anxiety, as it was in danger of being washed down. To prevent this immense quantities of stone were thrown in, a practice which has continued ever since to the prejudice both of drainage and navigation, as there is a fall of from two to three feet occasioned by this ridge of stones; besides, the water precipitated over it at the ebbing and flowing of the tide, has scooped out holes on each side of the bridge from 28 to 30 feet deep at low water. The effect of these holes is to create a series of eddies, especially on the flowing of the tide, so as to render a vessel almost unmanageable, under which circumstances serious accidents have frequently occurred, occasioning damage to the vessel or the bridge, and sometimes to both. To show how far this scour proceeded beyond the calculations of the engineers employed, it may be stated that a sluice constructed immediately above the bridge at an expense of 4,000*l.* for the purpose of warping up that part of the old channel which lies above the embankment, was never used as the channel became so low that the tide seldom or ever reached the cill; this occasioned some disappointment, as, besides the expense of erecting the sluice, the lands intended to be improved by its operation remained comparatively sterile and valueless. This extraordinary scour rendered it necessary to protect the banks of the new channel with stones, amounting in quantity to 100,000 tons, at an expense of 32,214*l.* As a set-off against this, however, was the immense saving in the excavation, which, had it been performed by manual labour, would have amounted to double what it actually cost."*

Spring tides rose only 4 feet at Wisbech before these works were executed, whereas now (1875) they rise 15 feet.

The River Nene below Kinderley's Cut made a detour towards the Norfolk side and it was proposed to straighten the river by a new cut, to be called Woodhouse Marsh Cut. The work was quite independent of the great Outfall works just described. The agricultural distress at the time threw large numbers of able-bodied labourers upon the Poor Rate, and they were employed upon this cut, which, in consequence, obtained the name of Pauper's Cut, by which it is still known. It was opened on the

* Walker and Craddock, Hist. Wisbech, pp. 463–4. The lower part of this cut is called Tycho Wing's Channel, but it is part of the Outfall works, and was constructed at this time.

7th of May 1832. A dam across the old channel was first attempted to be made with loose silt, the original estimate being 300*l.*, but after spending 1,000*l.* the contractor gave up in despair, "leaving it in a worse state than when he began, as the "flux and reflux of the tide over the materials thrown in to form "a dam had gulled holes on each side to the depth of twenty to "thirty feet." Mr. Cubitt then recommended the use of sand-bags, but the sand oozed out and the bags floated away, puzzling the labourers to account for the behaviour of a river into which they could throw sand bags for weeks without rendering it any shallower. Stones were then tried successfully, and the following account by Mr. N. Walker, who took part in the proceedings, is quoted at length as a splendid example of how fen-men grapple difficulties when they undertake them :—

"On the morning of the 7th of May 1832—everything being prepared for the trial—three gentlemen, who had taken a lead in promoting the scheme, went down to the works to witness the operations, and with the determination to get the dam closed, if possible, before they returned. In addition to the regular labourers, the assistance of several farmers with their teams was procured, and the work progressed with great spirit till tide time, which happened about noon, when the dam was so far advanced as to allow teams to pass along the top from one side to the other in apparent safety. But, at this critical moment, the elements seemed to conspire once more to frustrate the attempt. A gale, which had blown from the north-west during the morning increased with the rising of the tide, and added four or five feet more than had been calculated upon to its height. The dam, so hastily constructed, was but ill-adapted to resist this extraordinary pressure and tumult of waters, and began to give way, and in a few seconds the whole was laid prostrate by the raging elements, while those who had beheld its progress during the morning with satisfaction stood almost petrified on witnessing this instant demolition of their favorite work, which but a few minutes before they had looked upon as almost completed. The superintendent and workmen giving up all for lost adjourned to dinner, while the members of the corporation remained gazing upon the desolation before them, exposed to the bitterness of a storm that seemed more like November than May. However, when the tide became stiller, as it approached high-water, it occurred to them that with promptitude the dam might yet be taken before the strength of the ebb. Accordingly all hands were summoned to their post, and after considerable reluctance, even on the part of the superintendent, operations were resumed with increased vigour, and before the ebb acquired its strength the waters were forced into the new channel, the bed of which was six feet above that of the old one. At first the waters found their way but slowly through this new course, but in a short time the stream acquired the force of a mountain torrent, tearing up the soil with tremendous power, and in a few hours the cut was completed so far that the gentlemen who had come down to witness the operations had the pleasure of seeing two vessels sail through before they left the spot, and this undertaking, which had caused so much anxiety and expense, completed, without interrupting the navigation for a single tide."*

The effect of the Nene Outfall works upon the river at Wisbech was immediate and beneficial. The bed was lowered from ten to twelve feet by the scour alone; thus effecting an improvement without the extra cost that Rennie had considered necessary, and estimated at 56,544*l*. Valuable marshes were also enclosed, the consideration of which is referred to a future page.

Since the construction of the great works just described little has been actually done† towards improving the river, though numerous schemes have been projected. Indeed from the date of the earliest records nine-tenths of the history of fen drainage works consists in obtaining valuable advice and rejecting it. It cannot be hoped that rivers like those of the fen can ever be left alone and maintain themselves in an efficient condition, but the results of the Outfall works show how much can be done by attending to those seaward parts of the rivers; it is astounding to see the present river, and then picture to oneself its state during the six centuries over which its history extends.

The present condition of the river is thus stated by Sir John Coode, the results being thrown into a table for convenience. The data were from simultaneous observations, by trained observers, at low-water of the spring-tide September 26th, 1874, when from the dryness of the season a minimum of fresh-water was in the river. The tide rose 21 feet 4 inches at Sutton Bridge, and the soundings were taken at the deepest part of the channel:—

DEPTH of RIVER NENE in 1874.

Between	Maximum.	Minimum.	Mean.
	ft. in.	ft. in.	ft. in.
Peterborough and Cross Guns -	2 ·9	0 8	—
Cross Guns and Wisbech - -	12 3	2 6	6 0
Wisbech and Sutton Bridge - -	14 0	2 0	5 9

"It will be obvious," says Sir John, "from these facts . . . . . that the present channel is encumbered with many abrupt obstruc-

* Walker and Craddock, Hist. Wisbech, pp. 461–2. The North Level Main Drain and New South Eau were constructed in connexion with the Outfall works, as described on p. 52.

† The river was cleaned out and deepened between Baxter's and Guyhirn, in 1849, and a new bridge replaces the obstructive one at Sutton Bridge.

tions and irregularities, the prejudicial effects of which will be evident when it is considered that the *minimum* depth along the river course is the measure of its efficiency for purposes of navigation and drainage."

SECTIONAL AREA of RIVER NENE in 1874.

Position.	Distance from Towers in Miles.	Sectional Area at High Water in Square Feet.	Sectional Area at Low Water in Square Feet.	Approximate Area at High Water compared with the Area at the Towers.	Approximate Area at Low Water compared with the Area at the Towers.
The Towers -	—	8,660	1,770	Say 1·0	1·0
Walton Dam -	8	3,980	740	·5	·5
WalderseaSluice	13·25	1,550	210	·2	·125
Guyhirn Bridge	16·25	1,080	170	·125	·100

The above table supplies us with the sectional area of the river, and with the following tidal tables is taken from Sir John Coode's valuable report (1874), as are also the tidal observations. These cannot but be of interest to geologists, and as they occur in a private report which may not be easy of access, I may be pardoned for introducing them here, which is done with Sir John Coode's kind permission.

The neap-tide observations were made on September 21st, 1874, when the water rose 8 feet 11 inches at Sutton Bridge. The spring-tide observations were made on September 26th, 1874, which rose 21 feet 4 inches at the same place.

From the spring-tide observations it appears that the duration of the ebb at Sutton Bridge was 9·25 hours, and that of the succeeding flood 3·5 hours; also that the fall of the ebb for the first 4·5 hours was 17 feet 3 inches, and for the remaining 4·75 hours only 6 feet 3 inches. The tide rose with great rapidity and regularity. "The following table shows the inclination of the " surface of the River Nene at spring tides between Stone Ends " and Peterborough at 6 a.m. on 26th September, being the time " of *high*-water at Stone Ends, and the commencement of the " flood at Cross Guns:—

" INCLINATION of the SURFACE of the RIVER NENE during SPRING TIDES in 1874.

From	To	Distance in Miles between the two Places named.	Inclination of Water Surface.	
			Fall towards Peterboro'.	Fall towards the Sea.
			Inches per Mile.	Inches per Mile.
Stone Ends - -	Sutton Bridge -	4·29	2·3	—
Sutton Bridge -	North Level Sluice	1·95	6·1	—
North Level Sluice	Horse Shoe Bend -	4·36	—	0·7
Horse Shoe Bend	Wisbech Bridge -	1·12	5·3	—
Wisbech Bridge -	Phillip's Brewery	·51	17·7	—
Phillip's Brewery -	Waldersea Sluice -	2·30	16·6	—
Waldersea Sluice -	Guyhirn Bridge -	3·12	14·4	—
Guyhirn Bridge -	Cross Guns - -	3·19	·6	—
Cross Guns - -	Dog-in-a-Doublet	4·66	Ebb still running down.	5·2
Dog-in-a-Doublet -	Northey Gravel -	2·44		2·9
Northey Gravel -	Peterboro' Bridge	2·79		Level.

" The mean gradient between Stone Ends and the lower side of Wisbech Bridge was a little over 2 inches per mile, falling towards Peterborough, and at the same moment between Wisbech and Guyhirn Bridges it was 15½ inches per mile, falling in the same direction; at this time it was high water at Stone Ends, and the commencement of the flood at Cross Guns whilst the last of the ebb was still running down between the Cross Guns and Dog-in-a-Doublet.

" Turning now to the question of the ebb; the following table shows the inclination of the River Nene between Stone Ends and Peterborough at 3 p.m., on 26th September, being the time of *low-*water of the spring tide of that day at Stone Ends:—

" INCLINATION of the SURFACE of the RIVER NENE during SPRING TIDES in 1874.

From	To	Distance in Miles between the two Places.	Inclination of the Water Surface towards the Sea.
			Inches per Mile.
Stone Ends - -	Sutton Bridge - -	4·29	1·9
Sutton Bridge - -	North Level Sluice -	1·95	7·2
North Level Sluice -	Horse Shoe Bend -	4·36	14·5
Horse Shoe Bend -	Wisbech Bridge -	1·12	1·8
Wisbech Bridge - -	Phillip's Brewery -	·51	5·9
Phillip's Brewery -	Waldersea Sluice -	2·30	11·4
Waldersea Sluice -	Guyhirn Bridge -	3·12	8·7
Guyhirn Bridge - -	Cross Guns - -	3·19	4·1
Cross Guns - -	Dog-in-a-Doublet -	4·66	4·5
Dog-in-a-Doublet -	Northey Gravel -	2·44	2·0
Northey Gravel - -	Peterboro' Bridge -	2·79	Level

"These results show that the minimum low water inclination was under 2 inches per mile, whilst the maximum was 14½ inches.

"It will be seen* than whilst the tide *ran down* or ebbed at Stone Ends to the extent of 6 feet 11 inches for the two hours between 6.30 and 8.30 a.m., it *ran up* or flowed at Cross Guns in the same period to the extent of 6 feet. During this interval there must have been two strong currents in the Nene running in opposite directions, viz., the ebb making towards the sea, and the flood running towards Peterborough, the slack water zone between the two, advancing upwards in the meantime from the North Level Sluice to Guyhirn Bridge; of course the same action goes on until high water in the upper portion of the river, the flood gradually decreasing and the ebb increasing."

These peculiarities are not noticeable in neap tides, probably in consequence of their small extent. In commenting upon these anomalous phenomena Sir John Coode remarks :—

"In my opinion the immediate cause of the anomalous tidal development of the Nene may be attributed *to the insufficient duration of the flood tide,* to which I have already alluded; the primary cause of this lies, beyond doubt, in the shoals at the outfall, and the tortuous course of the channels, up which the early flood has to fight its way, being at the same time further resisted by the last of the downward ebb, so that by the time the flood reaches Stone Ends, which point must be regarded as the mouth of the river proper, a considerable period has elapsed, necessitating a great velocity in order to fill the upper districts in the limited time before high water, so rapidly does the flood rise that the insufficient sectional area of the channel at Wisbech—considerably reduced by shipping lying alongside the wharves and in mid-stream—is quite unequal to the filling of the channel above Wisbech Bridge at the same rate as the tide rises below that point, hence the declivity of say two inches per mile below Wisbech, and of 15½ inches per mile above it, but the upward tidal wave has acquired a certain momentum, and although throttled and impeded in passing through Wisbech it retains sufficient velocity to carry it eventually as far as Dog-in-a-Doublet, or when there is but little fresh water in the river, even between it and Northey Gravel, although it arrives there later than it should have done and rises to a less height; meanwhile the tide has not only risen to its full at Stone Ends, but has already been ebbing there for no less than 3 hours 15 minutes; 45 minutes thereafter the tide turns at Dog-in-a-Doublet also, and it is then ebbing throughout the whole length of the river. At 12.45 p.m., on 26th September, it was practically low water at Stone Ends, but the ebb lingered on until the flood came in at 3.15 p.m., or 2½ hours thereafter; had the river been in proper train this period of tidal inactivity would have been added to the duration of the floods, and the time of ebb and flow would then have been more nearly equalized than at present.

"Although, as I have stated, it was practically low water at

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* Reference is here made to a beautiful diagram, showing the extent to which the tide was ebbing and flowing in different parts of the river at the same time.

Stone Ends at 12.45 p.m. (Spring Tide of 26th September), further up the river the ebb was not so forward, for in consequence of the obstruction caused by Walton Dam and the insufficient depth at Pauper's Cut, its progress seawards was retarded; in fact, the channel is never thoroughly drained of the water which, if the river course were properly regulated, ought to run out at each spring tide, Walton Dam penning it back in one case, and the Outfall to a most serious extent in the other, this will be evident from . . . . . the table relating to low water (p. 80) which gives the inclination immediately inside the Outfall as 1·9 in. per mile, and at the back or upper side of Walton Dam as 1·8 in. per mile, whereas the incline between Horse Shoe Bend and North Level Sluice at the same time was no less than 14½ in. per mile, or eight times as great in one case as in the other."

Sir John Coode then directs attention to the differences in the heights of high water, and in the range of tide at various points on the river, which afford some remarkable results :—

TIDAL RANGE in the RIVER NENE in 1874.

Tidal Gauge at	Neap Tide, 21 Sept. 1874.		Spring Tide, 26 Sept. 1874.	
	Tidal Range.	Level of High Water compared with that at Stone Ends. + Above. − Below.	Tidal Range.	Level of High Water compared with that at Stone Ends. + Above. − Below.
	ft. in.	ft. in.	ft. in.	ft. in.
Stone Ends - - -	8 10	0 0	20 1	0 0
Sutton Bridge - -	8 11	+0 1	21 4	−0 4
North Level Sluice -	8 9	−0 1	20 2	−0 5
Horse Shoe Bend -	8 1	+0 5	15 10	+0 3
Wisbech Bridge -	7 6	+0 1	14 11	−0 3
Phillip's Brewery -	7 5	+0 4	Gauge washed down.	
Waldersea Sluice -	6 7	−0 4	11 11	−1 9
Guyhirn Bridge -	4 6	−0 6	8 11	−2 5
Cross Guns - -	1 8	−0 8	6 7	−3 4
Dog-in-a-Doublet -	0 0	−0 10	2 10	−5 2
Northey Gravel -	0 0	+0 7	1 2	−6 4
Peterborough Bridge	Not taken.		0 2½	−6 10½

"The above results establish the fact that the level of the water at Peterborough Bridge at high water of the spring tide of 26th September was practically 7 ft. *below* high water at Stone Ends; also that on the neap tide of 21st September, high-water at Cross Guns was 8 in. below high-water at Stone Ends. The difference of 7 ft. at springs is due in a considerable degree to the short duration of the flood arising from the obstructions at the Outfall, and to the state of the channel at and near Wisbech, to which I have previously adverted."

This heaping up of the tide I may remark is the modified form

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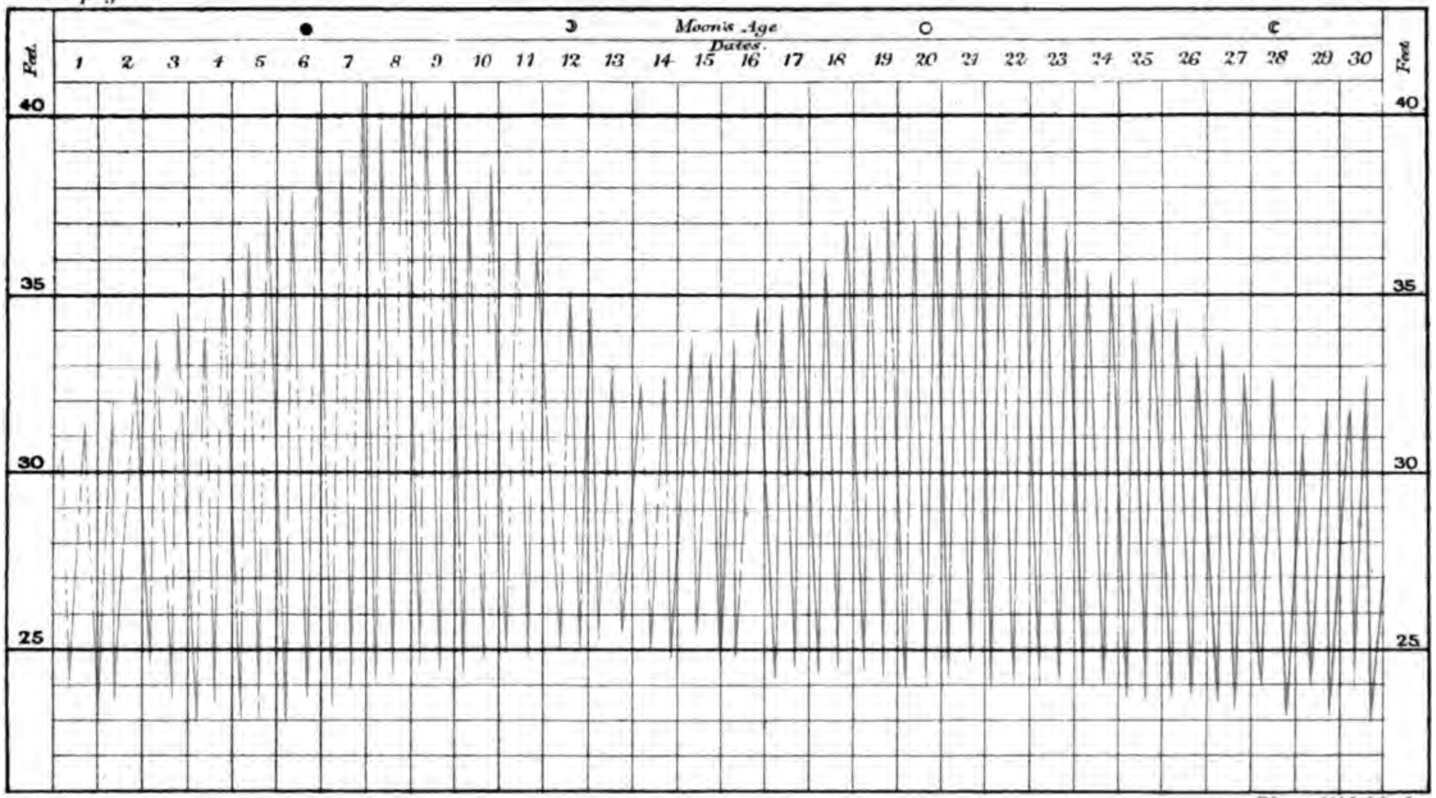
Plate X.



S.B.J.S. del.

F. Dangerfield Lith. London.

Tides in the Nene at Wisbech.
April, 1875.

of the bore which formerly formed in the river at every spring tide. This bore was common to the Nene and Witham, but I do not know that it occurred either in the Welland or Ouse. It is caused by the retardation of the tidal wave from bars, and insufficient and crooked channels, and as these are removed the bore diminishes. In these rivers it was called the *Eager, Aigre,* or *Hygre,* and its effects were so well known that special preparations were made for it by the craft lying in the streams. In the Nene it vanished on the opening of the Outfall Cut, prior to which it used to rush up to Wisbech as a "cake" of water from 1 to 4 feet high. In the "History of Wisbech," by Messrs. Walker and Craddock the following interesting note occurs:—
"Old Ralph Thoresby, who appears to have visited Wisbech "about 1680, thus notices the Eager at that time: 'This morn- "'ing, before we left Wisbech, I had the sight of an Hygre or "'Eager, a most terrible flush of water, that came up the river "'with such violence that it sunk a coal vessel in the town, and "'such a terrible noise that all the dogs in it did snarl and bite "'at the rolling waves, as though they would swallow up the "'river, the sight of which (having never seen the like before) "'much affected me, each wave surmounting the other with "'extraordinary violence.'—Diary, vol. i. p. 12." *

The range of Ebb Tides.—I was very much struck with the following statement by Professor L. D. B. Gordon, C.E., respecting the R. Witham: "It is evident that the height of the "water on Hobhole Cill does not vary much with the tides, *but* "*is usually lower during neaps than during springs*, both there "and at the Grand Sluice."† The italics are in the original. This was new to me, though Captain Beechey, R.N., cites an analogous phenomenon in the Severn, above Lidney, attributing as the cause that "at spring tides there is more water thrown "into the river than can escape before the return of the follow- "ing tide."‡

I examined all the published records of the tides with a view to satisfy myself as to this strange fact, but found the height of low water was seldom registered, and never with sufficient regularity to afford safe data for the investigation. Thereupon I wrote to Mr. W. H. Wheeler, C.E., of Boston, whose intimate acquaintance with the Witham would, I thought, enable him to settle the question so far as that river was concerned. He replied that "if "the low water at Hobhole is lower at neaps than springs, it is "a fact unknown to me. At Clayhole, 3 miles lower down, "there is a very great difference, the average low water at springs "being 90·14 feet above datum, and at neaps only 101·29 feet, "giving a difference of 11·15 feet."§

* Hist. Wisbech, p. 29.

† Report to the Commissioners of the Admiralty on the Lincolnshire Estuary Bill, 1851, p. 14.

‡ Remarks upon the Tidal Phenomena of the River Severn. By Capt. T. W. Beechey, R.N., F.R.S., London, 1851.

§ Datum 100 feet below Ordnance Datum.

I then wrote to Mr. S. H. Miller, F.R.A.S., of Wisbech, who kindly obtained for me copies of the traces of the self-registering Tide Gauge in the Nene at Wisbech, for the two months April and July 1875, which I selected because the former was very dry, the river consequently low, and the effects of the tides, therefore, comparatively uninfluenced by the fresh water; while the latter month was very wet, and the tidal influence much interfered with by strong freshets. The results of my investigation are as follows:—

For the present purpose we may divide all tides into springs and neaps; this division is made by equally dividing the number of tides among springs and neaps, remembering that along this coast the highest springs generally occur four transits after new and full moons.* The two plates, X. and XI., are constructed from the traces; the April tides being shown in daily range, the July tides having the daily heights of high and low water connected by a line; the phases of the moon are indicated by the usual astronomical symbols.

If we take the highest and lowest spring and neap ebbs for the year it is at once seen that the ebb of springs is often less than that of neaps. The following table shows this forcibly, the heights being above Nene Valley Datum:—†

EBB TIDES in the RIVER NENE at WISBECH, 1875.

Lowest Spring Ebbs.	ft.	in.	Lowest Neap Ebbs.	ft.	in.
January 22 - -	25	0	January 15 - -	24	6
			„ 31 - -	24	6
February 7 -	24	4	February 14 -	23	9
„ 22 -	24	6	„ 26 -	24	6
March 8 - -	24	3	March 18 - -	24	6
„ 21 - -	24	0	„ 31 - -	23	0
April 6 - -	23	2	April 13 - -	24	6
„ 21 - -	24	0	„ 27 - -	24	3
May 15 - -	23	9	May 12-13 - -	23	0
„ 20 - -	23	3	„ 26 - -	23	6
June 4 - -	24	0	June 11 - -	23	1
„ 20 - -	23	9	„ 26 - -	23	6
July 4 - -	24	6	July 10 - -	24	0
„ 20 - -	24	9	„ 26 - -	28	6
August 4 - -	25	9	August 10 - -	24	1
„ 18 - -	24	9	„ 23 - -	25	5
„ 31 - -	24	6			
Mean - -	24	2	Mean - -	24	3

* The actual highest tides in April occurred after the fifth and second transits, in July after the second and sixth transit.

† 74·84 feet below Ordnance Datum.

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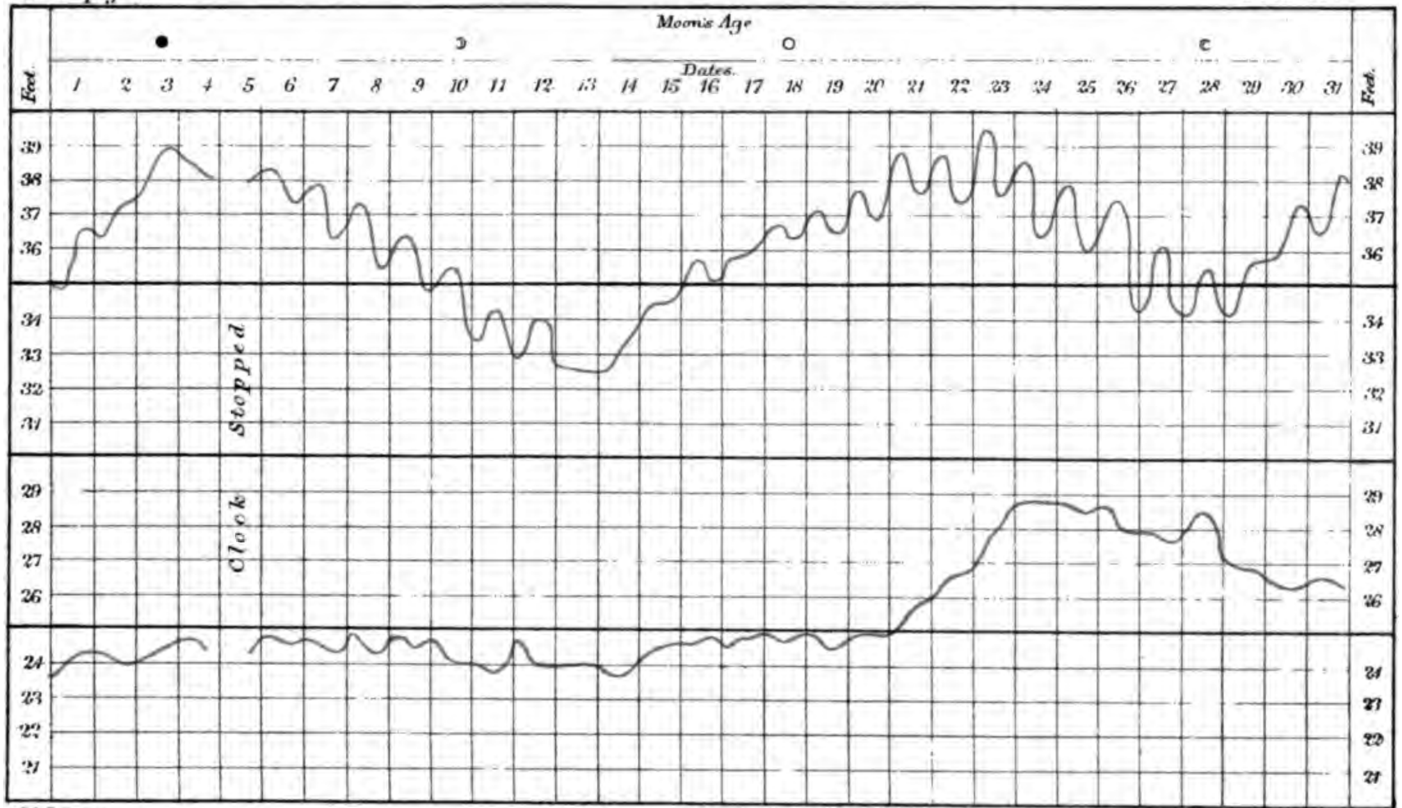
Plate XI.



S.B.J.S. del.

C. Bungerfield Lith London

Tides in the Nene at Wisbech.
July, 1875.

From this table we see that the means of the lowest spring and neap ebbs are nearly alike, the springs being only 1 inch below. But the height of the neap ebb of July 26th was exceptionally great owing to heavy rains. If we eliminate this we find the mean spring ebbs are 24 ft. 2 in., and the neap ebbs 23 ft. 11 in., showing that the spring ebbs average 3 inches higher than neaps. This result, however, is unsatisfactory from the limited data at command; we will, therefore, examine the April and July tides more particularly.

April Tides.—During April 57 high tides were registered at Wisbech. The mean height of high-water was 35·8 feet, and of low-water 24·1 feet. The mean height of low-water springs was 23·9 feet, and of neaps 23·8, the slight excess being in favour of the former; the numbers are however practically equal, as is forcibly shown by the range of low waters on Plate , which compared with the fluctuating high-water line is almost straight. The lowest spring ebb was 23·1 feet, the lowest neap ebb 23·0, again showing a slight excess for the former. The highest spring ebb was 24·8 feet, the highest neap ebb 24·7 feet, the greatest excess of spring ebb over neap ebb was 1·8 feet, and the greatest excess of neap ebb over spring 1·6. These figures are very close, and as April was exceptionally dry (following a very dry season too) the maximum tidal influence was experienced. Hence we are justified in asserting as a fact no less strange than true that:—

The heights of low water in the River Nene at Wisbech during spring and neap tides are practically equal, and the spring ebbs are sometimes as much higher than neap ebbs as the latter are normally above the former.

On the 8th, 9th, 10th, and 11th, the wind blew from the N.N.E. and N.E., and its influence in keeping up the water might seem to account for the height of the spring ebbs at those dates; but equally high ebbs occurred with the wind S.E., S.S.E., N.W., N., and N.W., later on in the month during the full-moon springs.

It is clear then that the water cannot ebb as fast as it flows, and the cause is evidently the defective state of the channel to seaward of the Stone Ends.

The curious fact thus eliminated is not only interesting from a scientific point of view, but from a practical aspect. *It ensures that a maximum quantity of silt shall be deposited in the channel,* and what that means has been abundantly shown in this work.

July Tides.—During this month 59 high-waters were recorded at Wisbech. These tides show admirably the effect of a heavy rainfall in the river, and a glance at Plate . is sufficient to prove that the river is quite incapable of discharging the excess. On page of this volume the dates and quantities of rain are recorded for the month of July. The chief fall occurred from the 15th to the 25th, and *the height of low-water rose steadily from 24·6 feet on the former to 28·9 feet on the latter date,* as shown on the plate. Nor by the end of the month was the excess of water completely voided, low-water on the 31st being 26·5 feet above datum.

The mean height of the new-moon springs was 24·4 feet, of the succeeding neaps 24·2 feet, showing a slight excess in favour of the former as in the case of the April tides. These were normal tides. Then came the rains, which continued through the full-moon springs and half the succeeding neaps. The mean height of low-water of these springs was 25·4 feet, and of the neaps 27·3 feet, or taking those only of the rainy days 28·8 feet. From these data we learn that although low-water springs for this month had a mean of 24·9 feet, and that of the neaps 25·7 feet, this result was *abnormal,* being entirely due to the overplus of fresh-water which the river was incapable of discharging as fast as it was received. An increase of water in an ordinary river causes an increased velocity proportionate to the addition; this is not the case with the lower reaches of the Nene, and we could thence predict that the outfall was obstructed even if we did not know such was the case.

CHAPTER VIII.

RIVERS OF THE FENLAND (*continued*).

THE GREAT OUSE. x

The Great Ouse rises not far from Brackley and Towcester on the borders of Oxfordshire and Northamptonshire in the Lower Oolites, and flows roughly parallel to their strike through Buckingham, Olney, Bedford, St. Neots, Huntingdon and St. Ives, into the Fens, after traversing the great Boulder Clay district of Huntingdon.

From St. Ives it flowed to Earith, near which place it divided into two branches; one, called the West Water, going north-north-eastwards to the Nene at Benwick; the other, called the West River,* taking a semicircular course round the island of Ely, by that city to Littleport, whence it originally passed up what are now called the Old Croft and Old Welney Rivers by Welney to Upwell, where it received the waters of the Nene and West Water, and so flowed through Wisbech to the sea.

At present the course is very different. At Earith the New Bedford River conveys most of the water direct to Denver, the northern branch is quite grown up, and the original main channel, the West Water, is a mere ditch along which a small boat can only with difficulty be rowed.

Near Thetford the Cam adds its burden to the Ouse which at once becomes a respectable stream, and flows to Littleport, whence

* The names West Water and West River were, however, interchangeable.

x Beasmore p. 239.

it passes to Brandon Creek, where the Little Ouse joins it, and the rest of its course is along the channel of that river by Downham Market to Lynn. The Lark enters the Ouse between Ely and Littleport, the Wissey near Hilgay, and the Nar at Lynn. The old channel of the Ouse from Littleport to Wisbech is nearly obliterated.

The decay of the Benwick branch dates from the formation of the Bedford River in the year 1631; and, as it seems never to have been of much importance, may be briefly dismissed.

Previous to the great undertaking, however, the West River had deteriorated; and, in the year 1618, we find its current reversed, for Sir Clement Edmunds presents "that the river of " Ouse, in time of floods, had in former times certain slakes, or " by-sewers, to receive part of the water wherewith it was over " charged; whereof the West-water at Erith brigge, was one, " which now, for want of cleansing, falleth into the Ouse, whereas " it should pass from it."*

Not so, however, with the river between Littleport and Wisbech, which we shall call throughout the Welney River, for its obstruction and the conveyance of the waters into the channel of the Little Ouse was an important event in the annals of the Fenland. Insufficient as the drainage system was before the 13th century, it was, nevertheless, made dependent upon the natural drainage system; and the alteration of the Ouse was the first deviation from this plan, and was followed by such disasters that for four hundred years afterwards the wails of fenmen whose lands were surrounded ascended to high places.

In treating this question it will be well to assure ourselves firstly that the waters of the Ouse did formerly flow through Wisbech; and secondly that the present channel between Littleport and Brandon Creek (or as these places are called in old records between Littleport Chaire and Rebeck or Priest's Houses) is an artificial cut, and not a natural water-course.

As to the first point the universal testimony of fenman is in its favour, and the name Wisbech has long been derived from *Wise* or *Ouse*, and *bech*† which may be a form of *beck*, a stream, still used in Lincolnshire and in the north of England. The earliest record of the name Ouse as applied to the Wisbech river is in the year 1294 [21 Ed. I.] when we read of a commission sitting at Utwell "and taking into consideration what ought to be done for " restoring those waters of Utwell (for so that great river of Ouse,

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* Dugdale, p. 308.

† It has been suggested that this termination is from the French *bouche*, a mouth. But *Wisbeche* is so named in the charter (authentic) of Wolfere to the monastery of Medehamstead (Peterborough), A.D. 664, long before Norman names were used in England, and however applicable this explanation may be to Wis-bech, it would be out of place as applied to such places as Hol-bech, Land-bech, Water-bech, &c. The termination be-*a*-ch is an error, unfortunately perpetuated on the Ordnance map. It is *never* used in any old writing, and never by fen-men. In the same way the Neue is often written Nen by outsiders, though always written and pronounced Nene by dwellers on its banks.

" which had formerly passed that way, was then called) to their " due and ancient course."* Dugdale is here quoting the register of Ramsay, but whether the parenthesis is his own or in the original MS. I cannot say. This commission, however, was instituted to turn the waters from the *Well Creek* to Wisbech, and we have already shown that the Well Creek could not flow eastwards while the Ouse waters were discharged at Wisbech.

On the second point we may cite the straightness of the channel between Littleport and Brandon Creek, a very sure sign, in the fens, of an artificial cut;† and a passage quoted by Sir H. Hobart on this point, wherein he speaks of an old record, vouched by Mr. Hexham, surveyor to the Earl of Arundel, in which a separate name is given to this cut "à le Chaire per *Heming's lode,* usque " Gnat's lode end." It may be urged that a passage by water between Brandon and Ely was open as early as the 10th century, for the body of St. Withburga was removed by water from Brandon to Ely.‡ This is quite true, but the monks did not come down the Ouse, but across small interlacing water-courses that can even now be traced through the fens, far away from the channel in question.

This question was so admirably stated by Sir Henry Hobart, Lord Chief Justice of the Common Pleas, in the year 1617 [15 Jac. I.], that the entire passage may be here reproduced:—

" So long as the outfall of Wisbeche had its perfect being, the whole river of Ouse had there its perfect outfall, from whence the town seemeth to have taken its denomination, *viz.*, Ouse or Wisbeche. Thither then came the first branch of Ouse, from Erith, by the course now called the West Water, to Benwick; where meeting with a part of Nene (which then was very small, the greatest passage being, in those days, by Crouland, South Ea, Wride stream, and other courses about Thorney) fell together by Great crosse, or Plant-water, to the north seas at Wisbeche. The other part of Ouse, being the second branch, fell down from Eryth to Harrymere, and there meeting with the River Grant from Cambridge, passed so united to Ely; thence to Litleport Chaire, and so by Welney and Welle to the said north seas at Wisbeche, where it met with the former branch from Benwick.

"Then, as it seemeth, there was no river between Litleport Chair and Rebech, which is a place by Priests houses, where Ouse parva, or Brandon water, falleth in; but divers lodes, lakes, and dikes, as S. Edmund's lode, Gnat lode, and Dockey lode, which took their natural fall into a great meer by Welle, called the Wide; and from the Wide, by divers tracts, as Webwinch lake, Aldy lode, Old Smal lode, Cheselbeche, Warbeche lode, Smal lode, and so into the river at Upwell, and thence, with the same branch from Litleport, to the north seas at Wisbeche.

* Dugdale, p. 400.

† Stream courses in level places (deltas, fens, &c.) are invariably very crooked. —See Tylor, Geol. Mag., vol. ii. 1875.

‡ Liber Eliensis, l. ii. c. 29. Quoted in Bentham's Ely, p. 76–7.

"But Wisbeche outfall decaying, and the passage of Nene by Crouland likewise failing, through the decay of Spalding River, and other hindrances; the West water, or first branch of Ouse, with Nene united, waxed weak in the passage, and so fell down by Marche to Welle; and not finding passage by Welle at Shrewes nest point, the most part thereof turned back again to Litleport, by the old forsaken second branch of Ouse, and holdeth that course to this day.

"This second branch of Ouse, with Grant united, lying thereby debarred of passage by Wisbeche, means were made to let it fall from Litleport Chair to Rebech, by a lode, which at the first seemed to be called Hemming's Ea, and so in Ouse parva's chanel, passed to Salter's lode, and thence to Lynne; whose chanel, not long before that time, was not above six poles wide, being then by true presentment said at that time to be both sufficient for the haven and vessels thither resorting by the inlet of the salt water; and large enough to pass away the fresh, as by the proceedings of a fair commission thereof, in an. 1378, may appear.

"Then began the waters from above Welle, and all thereabouts, to seek their passage by that tract to Lynne, Wisbeche chanel, and so as low as the Crosse Keys, which was over the face of the marshes betwixt Welle and Wisbeche, and so downwards towards Tirington, utterly thereby decaying, as to this day may yet be seen. But the people of Marshland, finding themselves overcharged by these waters, upon complaint made to King Edward the First, obtained a commission, an. 21 Edw. I.,* to have the waters of Welle (which anciently had their outfall by Wisbeche) to be brought and carried *in debitum & antiquum cursum*, &c. Then were there three stops made, *viz.*, the first at Fendike, about Upwell town's end (near where Popham lode sluice now standeth) 2. at Small lode bridge; and, 3. at Outwell bridge, and order taken for opening of the river from Welle to Elme floodgates, upon the confines of both countries, at the costs of the people of the Isle, and of Marshland indifferently."†

This admirable account is fortified by a separate examination of each point raised, viz.:—

" 1. To show that the river of Ouse had its outfall at Wisbech, " besides what is before expressed.

" 2. That there was sometime no river between Litleport Chair " and Rebbech.

" 3. That the waters of the Isle should not, nor of old did, fall " down from Welle upon Marshland eastward, nor unto " Welle Fens in Norff.

" 4. That there was a Mere in Welle, called the Wide.

" 5. That the waters had their course from Gnat lode towards Welle."

These I have deemed of sufficient importance to be reproduced, and they will be found in the Appendix.‡

* A.D. 1294. † Dugdale, p. 394. ‡ p. 249.

It will be noticed that the lodes, St. Edmund's lode, &c. are represented as draining the country about Rebech towards Welle; that the utter decay of the Wisbeche channel is described as we have proved in treating of the river Nene;* that the Nene waters turned down Welney river; and that Marshland was drowned.

Of the "great meer called the wide" hardly any record remains. Indeed almost all we know of it is that Hereward fled thither from William the Conqueror, when the Isle of Ely was betrayed into the hands of the Normans.† It had certainly no existence in A.D. 1295, or 200 years afterwards.

Of the date at which the Great Ouse was turned into the present channel no direct evidence is available, but I think an examination of unsearched original documents would throw much light upon the question. We know, however, that it was prior to the year 1294,‡ since in that year an attempt was made to turn the waters of the Welney river into the Wisbech channel by shutting them out of Well Creek. We also know that the Welney river decayed until, so far from being the main branch of the Ouse, it became a branch of the Nene about the year 1538,§ and continued so until the fens, being finally drained, its course was closed for ever. Of the geological importance of this Welney river a great deal will be said in a future chapter.‖

We must now turn to the Lynn River and see what were the effects of the increased body of water sent through the town to the sea upon the channel and neighbouring fens. When we bear in mind that Lynn Haven received the drainage of only about 200 square miles, whereas the Ouse drained an area of over 2,700 square miles, or was 13·5 times as large, and that the drains of what are now the North and Middle Levels and Marshland were set out for draining into the Wisbech channel, we can understand how vital was the change. Nor can we wonder that for four hundred years, or until the time of the great drainage, the condition of the fens grew worse and worse, and Marshland, through which the water flowed, suffered a series of surroundings comparable only with the great floods now devastating parts of France (July 1875).

Accordingly we find in the year 1294 (21 Ed. I.) distinct mention of the damage accruing through the alteration of the fen-waters, which by this time could not pass from Upwell to Wisbech, in a "grievous complaint," by the people of Marshland. Whereupon "the said King being informed, that in case the fresh waters, "coming by Utwell, could have their course to the sea, in such "sort as that they might not mix with the waters running in "Mershland; this country of Mershland, by that severing of "them, would be much amended; he commanded the said com-"missioners that they should forthwith go to the town of

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* p. 68, *et seq*. † A.D. 1069.

‡ Sir John Rennie, in a report dated 1840, says the inhabitants *made* this cut, in 1292, in order to save their lands. This is evidently a mistake. 1292 should also be 1294, for it was the 21st Ed. I.

§ p. 73. ‖ Chap. XII.

" Utwelle, and there take order, that the said fresh waters so " descending that way should have their due and antient course " to the sea, as formerly, so that this country of Marshland might " have its drain to the sea by the same outfall." * It is to be noticed that in this and subsequent petitions that the object is *not* to turn the Ouse waters from Littleport to Wisbech, for that seems to have been given up as impossible, but to preserve the Nene channel through the latter place, the Nene having made its way down Well Creek to Salter's Lode. This leads me to think that "Hemming's lode" was made so long before 1294 that the Wisbech channel had silted up, and the Nene deserted it, in the interval; nor do I see how any other explanation will account for the facts. Bearing upon this point is an opposition by the "Abbot of S. Edmundsberry" to a similar proposition in the year 1337, who claimed right of fishing in Well Creek under a grant from King Canute† (1017-30), upon which Walker and Craddock remark:—"The Creek is an artificial cut; and this specification of " a grant of a fishery shows us that drainage had commenced in " this part of the Fens as early as the reign of that monarch. " We do not know but it also proves that the course of the Ouse " by Wisbech had, as early as that date, been altered; as the " Creek, whether intended for navigation, or drainage, would " have the effect of carrying part of the waters of the Nene to " Lynn, instead of allowing them to pass by Wisbech."‡

Although I do not agree with the authors that Well Creek is an artificial cut (it being crooked instead of straight, and most inconveniently planned for conveying the Nene waters to the Ouse), or that the Well Creek must necessarily have acted as they state, I think it is not unlikely that the change in the river courses may have been effected before this time. This would allow something under two hundred years for the alteration in the course of the Nene, seeing that in the year 1329 the main course of the Nene is stated to have been *anciently* "directly from " Peterborough unto Lenne." §

We need not follow the Marshlanders through their continuous troubles, but must notice that they suffered as much from the water which passed by Lynn as from that which could not pass by Wisbech, as the list of inundations in the Appendix shows.‖

In the year 1362 [36 E. III.] the inhabitants of Marshland " exhibit a doleful petition to the King," showing *inter alia* that " whereas the river (going to Lenne) had used to run betwixt " certain banks, distant asunder twelve perches, at which time " all people had sufficient passage with their boats to and fro, " the fresh waters free course to the sea; the banks on one side " of the said river were at that time so low, by reason of the " before specified floods, that the said river was then a full mile

* Dugdale, p. 246.
† Dugdale, p. 307.
‡ Hist. Wisbech, p. 108, note.
§ Dugdale, p. 301.
‖ p. 290.

"in length"* [misprint for breadth]. Nothing seems to have come of this petition, for in the year 1378 [2 R. II.] another petition stated "that the said water, by reason of its extraordinary "breadth, after the banks on the one side thereof had been worn "away, had so great a power upon the bank on the other side, "that all the towns in those parts were frequently overflowed."† At the same time it was presented that the river at South Lynne "did then contain itself forty perches in breadth." Again in the years 1565‡ and 1618 we find Lynn haven represented as being wider than before.

It thus appears that at Lynn, as might have been expected, the river formed a much larger channel than before it received the Great Ouse waters. One consequence was that the buildings adjacent to the river were washed away. Thus the church of Old or West Lynn was "swallowed up by the waters";§ Tilney lost its church, parsonage, manor house, twenty messuages, and 100 acres of land, were lost between the years 1277–1337.‖ The Marshland towns lost 700 acres of land between the years 1285–1325.¶ Wiggenhall lost 10 messuages and 100 acres of land in the year 1337, and Tilney seven messuages and 10 acres of land, at the same time.** In the 1613 the sea bank at Terrington broke, and the water destroyed 13 houses and damaged 1,042 more; the salt-marshes outside the bank were much wasted away, 100 acres having been destroyed within 30 years, and the total damage to Marshland at this time was assessed at no less than 37,862*l*.††

The lands so destroyed are described as being "utterly lost for ever," but it is needless to remark that they, with much more, have been added to the country since then by embankments.

Up to a certain point the increasing size of the Lynn river was of direct benefit to the town, which we find, in consequence, rapidly rose in importance; and, had the river been retained within reasonable bounds, nothing but good would have resulted. But the river, as we have seen, was allowed to hollow out for itself a wide estuary,‡‡ in which the stream lost much of its force, and, thereupon, the haven began to silt up, notices of this action being found as early as the year 1350 [44 E. III.], when "the "Mayor, Aldermen, and Constables of Lenne were commanded "to view the ditches compassing that town; which, by reason of "its situation upon an arm of the sea, were, through the ebbing "and flowing of the tides, filled up with mud and other filth, to "the great damage of the town."

* Dugdale, p. 260. Armstrong, p. 6, says in 1332, which is an error.
† Ib., p. 261
‡ Ib., pp. 271, 281.
§ Richards' History of Lynn.
‖ Dugdale, p. 255.
¶ Ib., p. 250.
** Ib., p. 255.
†† Ib., p. 276.
‡‡ Rivers always *widen* their channels in preference to deepening them.—See Tylor, Geol. Mag. vol. ii. 1875.
§§ Dugdale, p. 291.

The size of the estuary thus formed can be seen on the Ordnance Map, and also on the Index Map to this volume. Had the river been properly trained the vast expenses of the Eau Brink Cut, made to supersede the wide, semicircular channel between Wiggenhall and West Lynn; and the New Cut to the outfall would have been saved.

The next change of importance to the river Ouse was the construction of the Bedford Rivers, by which most of the upland waters were conveyed direct from the Hermitage at Earith to Denver, along a course of 21 miles, instead of 32 miles as by the natural river. This plan was projected by Sir John Popham in the year 1605,* but his scheme was not carried out. In the year 1631, Sir C. Vermuyden, under the Earl of Bedford constructed the Old Bedford River, and this being found not to fulfill its object, he made the New Bedford River, parallel with it, in the years 1650–1, leaving a great space between the two rivers, for the waters to bed in during floods. The object of these rivers was the more speedy delivery of the waters to Lynn haven, an end which might have been attained, at less expense, probably, by improving the outfall, which indeed had eventually to be done at almost ruinous expense. Much as Vermuyden's plan was opposed at the time, it is but fair to his memory to state that the objections were principally directed to his plan of leaving washes, instead of, by confining the streams, forcing the waters swiftly forwards, and the improvement of the outfalls is never mentioned by his opponent. Vermuyden in truth recognised the fact that in times of heavy rain the freshets could not get away, accepted this state of things as inevitable, and provided washes that, when the rivers were full, the waters might spread harmlessly over them instead of bursting the banks and devastating the country. Modern opinion and experience show that, had the outfall been improved, the waters could have been delivered without endangering the banks. The improvement of the outfall was not at that time recognised as the great thing to be done.

But the Bedford Rivers were, in my opinion, a great mistake, since the natural channel was amply sufficient had the outfall been improved, and the abstraction of so much water from the waterway between Cambridge, Ely, and Lynn cannot be deemed other than a disaster, and I am not at all certain but that in time to come it will be deemed expedient to abandon the artificial river.†

The bed of the New Bedford River was 8 feet higher than that of the Ouse at Salter's Lode, in consequence of its greater fall (it being 10 miles shorter than the Ouse between its extremities), and from its flowing over higher ground. Hence the waters, in times of flood, would have turned up the Ouse, into the South Level, instead of flowing to Lynn. A great sluice was, therefore, erected across the Ouse at Denver which served the purposes of

* Dugdale, p. 383.

† I say *river* because the Old Bedford River is practically obsolete, its outlet being sluiced.

shutting the tides out of Ouse, directing them into Bedford River, and preventing the Bedford River waters flowing upwards. To prevent the water flowing into the Middle Level by Well Creek another sluice was erected at its mouth, and thus arose Denver Sluice* and Salter's Lode Sluice. The erection of these sluices was the first direct influence the Bedford River had upon the Ouse. No similar erection in the world, has, I suppose, been more fruitful in controversy than Denver Sluice. It is not our province to go into these matters fully, but simply to show what were the effects of damming back a silt-laden tidal river flowing through a level country like the fens. The scour of the Bedford River waters, with that of the old Ouse when the sluices were opened, were relied upon to keep the channel of the river between the slucies and the outfall free fron silt. But it speedily appeared that such an effect could not be produced with the diminished and divided volume of water, flowing in part intermittently, and the river began to silt up below the sluice.

Another evil effect of the Bedford River was that the waters of the Middle Level, passing by Well Creek, and of the South Level by the Ouse, were over-ridden by those of the Bedford River whose bed was 8 feet above that of the Ouse at Well Creek, until their waters were swollen to the same height as those in the Bedford River, by which time much of the surrounding land was drowned. To relieve the Middle Level the adventurers made Tong's Drain from the Well Creek at Nordelph to the river below Stow Bridge, thus carrying the water below Denver Sluice. A similar cut was made for the relief of the South Level, called Downham Eau, from the south side of the sluice to Stow Bridge. The former work, so far as the Middle Level was concerned, proved a success. But the removal of so much water from the river between Denver and Stow, caused that part of the channel to silt up until "its bottom became to be on a hanging level with "the bottom of the Bedford River, *i.e.*, it silted and grew up in a "little time from eight to ten feet,"† the direct consequence of which was that the outlet of Downham Eau was "lost and abandoned," and the South Level instead of being benefited became habitually drowned.

Mr. Rennie, reporting upon a proposal to reopen Downham Eau in the year 1812, makes the following pertinent remarks:—

"The advantages which have arisen to the Middle Level by making the Tong's Drain, have been used as an argument in favour of this project; and it is said that similar advantages will arise to the South Level from opening St. John's Eau.‡ The cases, however, appear to me quite different, and the arguments derived therefrom do not apply to the case in question.

"The Tong's Drain is not used for the purpose of running off

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* Denver Sluice and Salter's Lode Sluice were made in the years 1652–3. Walker and Craddock make Lynn and Cambridge petition against them in the year 1649 instead of 1695. Hist. Wisb., p. 158.

† Hist. Nav. Lynn, p. 84.

‡ Downham Eau.

the floods of the Hundred Feet River,* but for that of the downfall water; and for this it serves two purposes, namely, as a reservoir to contain a large quantity of downfall water, while the river gates are shut, and by these cuts the length of the drain is shortened; the former it does to a great extent. The reservoir being large and the land low, a large quantity of water therefore accumulates near the sluice, and it runs off quickly when the water in the river subsides; and the distance being much shorter, the fall of a mile is thereby increased in a greater ratio than it will be by St. John's Eau.

"As a reservoir to contain flood-water from the old Ouze, St. John's Eau is scarcely worth naming, though, in its present state, it answers the purpose to a considerable extent for the waters from Roxham Drain, and from the lands near Downham; and as it is never intended to be used except when the water rises to full 10 feet 6 inches above the cill of the pen doors, at Denver sluice I fear, at that time, its mouth will be over-rode by the waters of the Hundred Feet."†

There is indeed another radical difference between these two drains. In the Tong's Drain the waters come from an independent district to the river, but in Downham Eau, the waters are those of the Ouse itself, which are abstracted from the river, and conveyed *by a longer course*, to the river again thus lessening the fall. Had this point been noticed, the drain, which can never be of service as originally designed, would not have been cut, and much expense would have been spared. Thus we see that the immediate effects of the Bedford River were the necessity for sluicing, 1, the Ouse; 2, the Old Bedford River; 3, Well Creek; which proved insufficient to preserve drainage, and the construction of Tong's Drain and Downham Eau, the latter on most unscientific principles. Tong's Drain, though a success, is no triumph, for it was only an expedient to obviate the damage caused by the Bedford River. The combined effect of these works was to insure the deterioration of the river above and below Denver Sluice, and call forth the remonstrances of Lynn, Thetford, Cambridge, and the South Level generally, as we have before shown.

Year after year complaints were made to show that the drainage of the South Level was utterly destroyed, and navigation impeded, and Denver Sluice and Hermitage Sluice were proposed to be abolished, but without success. Denver Sluice was modified in the year 1682, so as to afford a better water-way, but for years such was the local opposition to it, that the corporation had anxiously to guard it by night and by day.

The towns of Lynn, Thetford, and Cambridge, in the year 1695, petitioned against Denver Sluice, and showed that Lynn Roads had silted up from two fathoms to two feet, or 10 feet, and that the tide only flowed three hours, instead of five, as before the erection of the sluice. It was also represented that the river above the sluice was decaying, for "where boats and barges

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* Bedford River. † Rennie, Report, 1812.

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ing of the estuary and neglect of training, and the construction of the Bedford River and its collateral works greatly facilitated the growing evil. It is my firm belief that had the Bedford River never been made, and had early attention been paid to the outfall, the original river would have amply sufficed for drainage and navigation, and a vast outlay would have been spared.

Badeslade aud his party have been taunted with demanding the re-erection of the sluice, as though they thereby admitted their case to have been upheld on false grounds. This is unfair, for if the river had been restored to its former volume, by allowing the downfall waters to flow into it as of yore, and the dam at Denver been removed the evils they complained of would have been materially diminished. But this was not done, and they had no alternative but to solicit the re-erection of the sluice as the only means left to them of getting rid of waters of the Middle Level, &c., now that their own river was robbed of its strength.

There is no doubt that the blowing up of Denver Sluice (the Bedford River being in existence) was a disaster, for it reduced the South Level, which was so well drained by nature that the adventurers found it unnecessary to devote much attention to it,* to a condition unparalleled for drowning in the history of the fens.

For thirty-seven years matters remained in this condition, but the sluice was eventually rebuilt by Labelye, a Swiss engineer, and opened in the year 1750, from which time it has remained comparatively intact.

The Ouse, however, was in a worse condition than ever, and though the South Level was relieved of the Middle Level waters, it could not void its own, and remained constantly liable to surrounding. At the same time the channel of the river continued to silt up below the sluice and the Middle Level waters were discharged with increasing difficulty, until it too was drowned, and the historian of the Bedford Level says that "in "the year 1777, both the Middle and South Levels were in a "most deplorable condition, and the debt of the corporation, as "well as the state of the arrear roll, most alarming."†

In the year 1720, Kinderley called attention to the great bend Mr. Natha[illegible] of the Ouse below Lynn, within whose broad area the river lost itself, and suggested a straight cut from Eau Brink to Lynn as the best means of improving the state of the river. This is the origin of the Eau Brink Cut scheme, and was a step in the right direction, but it was strenuously opposed by the people of Lynn who saw in this wide bight their only safe-guard. They argued that the proposed cut would lessen the quantity of water brought in by the tides, and so conduce to the silting up of the haven. It was not until the year 1792 that the Court of Sewers decided upon undertaking the work, and an Act was obtained for that purpose in the year 1795. So violently was it opposed, however, that nearly 12,000*l.* were spent in obtaining it, and the tax laid upon

* Wells, Hist. [illegible] 742.
† *Ib.* p. 748.

the land for making the cut was swallowed up in law expenses. In the course of the next twenty-one years five other acts were obtained, and finally the cut was made; it being completed in the year 1821.* "It shortened the course of the old river two "miles and a half, and the low-water mark at its upper end "shortly after fell between four and five feet, and subsequently "two feet more, in consequence of an improvement in the work. "The low-water mark continued subsequently to fall until it "reached its maximum of seven feet. The drainage sills of "Denver Sluice were laid six feet lower, and a corresponding "improvement was felt in all the low lands of the Middle and "South Levels.

"Thus its effects, though less than was anticipated by those "who expected a deluge rather than a river, have made a mani-"fest change in the South Level. The tide, which hardly lifted "itself into the Bedford, now penetrates almost to the end of it;† "that river has deepened considerably; and the channel of the "Ouse, formerly so silted below Denver, was speedily cleansed "by the increased spread and body of the tide that flowed "through it. Had the cut been carried into deep water beyond "Lynn harbour, its effects would have been much more "effective."‡

In the year 1827 the Ouse was straightened by a new cut, called Sandys Cut, from Ely to Littleport Bridge, and the old circuitious route round Padnall Fen closed.

The suggestion as to the continuance of the Eau Brink Cut has since been acted upon, and the New Cut has been made direct from Lynn to Vinegar Middle. The old wide estuary has thus been abandoned and is silted up, the river is vastly improved, and great areas of marsh are reclaimed.

Looking back upon the history of the Ouse we can see how strange its fortunes have been, and how vastly Lynn and the fens generally might have been benefited, even after the river had assumed its Lynn course, if only the outfalls had been attended to, and the river been confined within moderate bounds. The great expenses that have ensued from this neglect and from mistaken ideas of the proper system of drainage might have been avoided and the country have enjoyed the benefit of the saving. It is, indeed, a forcible reminder that we cannot change the course of nature, but that by watching her operations we can learn how to adapt them to our service.

* Hist. Wisbech, p. 165. Engineers sometimes twit geologists for being unpractical, *i.e.*, not looking at things from a money point of view. May they not take a little quiet fun out of them, by remembering that these practical men estimated the cost of the Eau Brink Cut at 15,000*l.*, and found its actual expense was 300,000*l.*, or *twenty times* their estimate?

† Written in the year 1849.

‡ Hist. Wisbech, p. 165.

CHAPTER IX.

RIVERS OF THE FENLAND (*continued*).

THE RIVER WITHAM.

Name.—The River Witham was known to the ancient Britons as the *Grant-Avon*, or "Divine River," and it is probable that divine honours were paid to it, since Druid rites were often connected with a river or lake, perhaps as typical of the "stream of life."* Leland mentions the river under the names *Eya* or *Eye*, which, he says, means "water," and *Rhee*, that is "river." It, however, appears to have been called in his time the *Lindis*, a name having an obvious relation to *Lindum*, the Roman name for Lincoln,† which was itself most probably derived from the British (Llyn dûn ?) The name Witham must also have been applied to the river in Leland's time, for we find it called the *Wyme* as early as 1281.‡ The word *Witham*, as applied to a town, is of frequent occurrence, and has been derived from the Saxon *withe*, a willow, and *ham*, a village, but whether in the present instance the river takes its name from, or gives it to, the village of that name at its source, cannot be ascertained.§

Some of the reverence with which the Witham was looked upon by the early Britons, must have fallen upon it in later times, for more religious houses were erected upon its banks between Lincoln and Boston than upon any similar stretch of river in the kingdom. No less than 12 monasteries existed within the space of 16 miles.‖

Course.—The source of the River Witham is generally described as being about a mile south of the village of South Witham, 10 miles south of Grantham. The most distant source, however, is two-miles-and-a-half from this point in a south-westerly direction, and lies immediately east of Market Overton. The former of these sources is situated upon the Lincolnshire (*Inferior*) Oolite, Limestone, the latter upon the Northampton Sand.

From its source the river runs almost due north to Grantham, passing from the Oolites on to the Lias. North of Grantham it takes a sharp bend to the west, and from Claypole runs about north-north-east, roughly parallel to the strike of the Oolites, up to Lincoln. At Lincoln it turns almost at right angles and cuts directly through the scarp of the Oolites, here about 240 in height.¶ This remarkable bend finds a parallel in the River

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* Oliver, Religious Houses on the Witham, pp. 30–31.

† Leland, Colect. IV., 33.

‡ Placit. de quo Warr, 1281.

§ See Thompson, Hist. Boston, p. 353, 1856.

‖ Oliver, *op. cit.*

¶ Lincoln Cathedral is 215 feet above the sea, the county Asylum 237 feet, the bed of the canal is 3 feet above Ordnance datum. Taking the two latter numbers it gives 234 feet for the depth of the Witham gorge.

Trent, which makes a precisely similar cut through the Oolites and Chalk on joining the Humber. Such phenomena point clearly to a time when the rivers flowed at much higher levels than at present, before the scarps of the secondary rocks were formed, and when those rocks covered a far larger area—for the natural flow of a river is down the slope and not over the hill.*

From Lincoln the Witham runs east for about six miles, then gently turns to the south-east and so enters the Wash below Boston. The course is peculiar since the river returns upon itself, as it were, in the latter portion of its course, so as to bring the mouth of the river considerably nearer the source than the most northerly point it attains (Lincoln).

The entire length is 68 miles, and the distance between its source and mouth only 28 miles.

It is with the eastern and southern reaches that we are more particularly interested in this memoir, that is to say from Lincoln, where it enters (or rather makes an arm of) the fens to the Wash into which it discharges. This is nearly one half of its entire length.

Tributaries.—The principal tributaries of the Witham are the Brant River, rising near Houghton, and, after a northerly course of 11 miles, entering the Witham between Aubourn and South Hykeham. Another considerable tributary joins the main stream north of Bardney after a southerly run of 10 miles. It is called the Langworth River and has its source near Buslingthorpe. The last and most important tributary is the Bain which takes its rise at Kelstern and, flowing south, enters the Witham at Tattershall, passing through Horncastle on its journey of 25 miles. Numerous small brooks, or *becks* as they are locally termed, are received by the Witham, but possess no feature demanding special attention.

The Brant flows over the Lias plain, parallel with the Oolite scarp; the Langworth is confined principally to the Oxford Clay; but the Bain rises from under the Chalk and runs across the Cretaceous, Neocomian, and Upper Oolite rocks, into the fens.

Basin.—The water-parting of the River Witham on the north follows a wavy line whose trend is easterly and afterwards south-easterly. The easterly portion extends from Springthorpe, south of Market Rasen to Kelstern; thence south-east to Belchford, at which point it touches the water-parting of the Steeping,† and passes by Little Steeping to near Friskney. On the west the line which separates the basins of the Trent and Witham has a direction about north, and roughly parallel to the strike of the New-Red Marl. The southern line can only be said to be a natural water-parting up to the border of the lowland, as the various rivers formerly interlaced among the fens, and the existing drainage arrangements have little relation to the obscure

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* See Ramsay, River-courses of England and Wales, Q. J. G. S., vol. xxviii., pp. 153–5.

† The East Fen waters drained into the Steeping before 1540. Pamphlet by Dr. Browne of Boston, written before 1560.

divisions that once obtained. This portion of the water-parting passed by Buckminster, where it bends south by Market Overton, and, embracing the source of the river, follows its course pretty closely as far as Somerby, at which point it turns to the east, and from Dembleby there cannot be said to be a natural division. The artificial separation, however, runs south-south-east by Falkingham, Kirkby Underwood to Bourn, thence along the Glen and the Old Hammond Beck to Boston.

This last portion of the line embraces a tract of fen known as the *Black Sluice District,* drained by the South Forty-Foot Drain which discharges into the Witham through the Black Sluice at Boston. Most of this district formerly drained into the Welland, or into the Glen, a tributary of that river. Since about the year 1352, however, the waters have been discharged in the Witham, for in that year we find a presentment was exhibited against the towns of Bourn and Morton for turning the water northward to Boston, instead of allowing it to run eastward to the sea.*

The total area drained by the River Witham is stated by Mr. W. H. Wheeler, C.E., the engineer to the Witham Commissioners, to be "about 680,392 acres (1,063 miles nearly)†, of which 414,988 acres are high land, and 265,404 fens, or lands "drained by artificial cuts."‡

Rainfall.—The size of a river depends upon the amount of rain falling upon its basin. The whole of the rainfall, however, is not discharged from the land by the river, for a portion sinks into the rocks according to their porosity, and supplies the springs and natural reservoirs, and a still larger proportion is directly returned to the atmosphere by evaporation. The former abstracted amount cannot be estimated; and, as to the latter, though "evaporators" constitute part of the stock of an ordinary meteorological observatory, their results are worse than useless, as may be judged by the fact that they nearly all agree in making the evaporation greater than the rainfall! This is the necessary result of their construction. They are merely pans of known area in which *open water* is placed, and from which it evaporates. The result they give is the amount which would be abstracted from the given area *if it were a shallow lake,* and is in no sense a measure of the effect upon a district composed of various rocks, under different agricultural conditions, clothed with many kinds of vegetation, irregularly wooded, and drained under several systems. To determine the amount of evaporation under such circumstances demands of the investigator a mode of experiment adapted to the specific exigencies of the case; the principle of which must be a means by which the loss of water from a soil or rock, covered or not with vegetation, and saturated to the same degree as in nature, may be determined. This degree of saturation is continually varying, and an instrument to merit the name of *Evaporimeter* must be so contrived as to meet this difficulty.

* Placit. de quo Warr, temp. Ed. III.

† All but 72 acres.

‡ Wheeler, Fens of S. Lincs., 1868, p. 40. Keith Johnston gives the area as 052 sq. miles (Phys. Atlas), and the length as 89.

This subject will be treated at length in a future chapter, and it is only because of the great importance of the subject that allusion is here made to the matter. It is difficult to over-estimate the importance of an accurate knowledge of rainfall and evaporation in a district such as this, where the value of the land depends entirely upon the discharge of sufficient water to prevent drowning, and the holding up of sufficient to avoid parching. In the sequel it will be seen how little has been done in this matter, and what disastrous consequences have ensued from a lack of this peculiar knowledge.

The stations within the basin of the Witham at which the rain fall has been registered are as follows:—

Bracebridge, near Lincoln, with a fall of	- -	21·945 inches.
Branston „ „ „	- -	24·3 „
Boston „ „	- -	22·380 „
Grantham „ „	- -	21· „
Haydor, near Sleaford „ „	- -	22·680 „
Horncastle „ „	- -	20·580 „
Spilsby „ „	- -	26·7 „

with which we may compare the following, as being very near to the Witham basin:—

Irnham, between Sleaford and Stamford, with a fall of	20·6 inches.
Witham-on-the-Hill, near Bourn „ „	21·409 „
Pode Hole, near Spalding „ „	20·611 „

The usual manner in which the average rainfall of an area is obtained, is to add the totals obtained at rainfall-stations within the area and divide by the number of stations. This, however, is obviously incorrect, since all stations whether close together or far apart from each other have the same value. For instance, in the above list Branston with 24·3 inches fall and Spilsby with 26·7 inches have an equal influence with the other stations, though their great rainfall is of a purely local character. The principle I have adopted is explained in the chapter on Meteorology. This applied to the River Witham basin gives the average rainfall as 21·244 inches. Mr. Wheeler takes the rainfall at Boston during the years 1828–66 inclusive, as the basis of his calculations on the discharge of the Witham, which gives an average of 22·68 inches. The acreage of the Witham basin is 680,392, and the quantity received under the two estimates is as follows:—

RAINFALL in the BASIN of the RIVER WITHAM.

Rainfall, 22·68 Inches.		**Rainfall, 21·244 Inches.**		**Difference per Acre.**	**Difference in Basin.**
Tons per Acre.	*Number of Tons in Basin.*	*Tons per Acre.*	*Number of Tons in Basin.*		
2,090·544	1,558,467,813·248	2,145·517	1,549,792,262·468	145·027	98,675,550·780

It will be seen that the difference between the two estimates amounts to more than 98½ millions of tons in the course of the year.

Mr. Wheeler has calculated the discharge of the Witham on the assumption that the rainfall over the whole basin is the same as that of Boston, and that of this amount 4·5 inches finds its way to the outfall. This latter estimate, which gives as the loss by evaporation about 80 per cent. of the fall, has been obtained "by "a comparison with results attained, by very careful observations, "made in rivers in similar districts."* Mr. Wheeler also assumes that "the whole of the rain that falls in an average season, during "the four summer months," is disposed of by evaporation, and his results are given in the following table :—

DISCHARGE of the RIVER WITHAM.

District.	Point of Discharge.	Area.		Average Discharge per Second. W. H. WHEELER, C.E.		Average Discharge per Second. S. B. J. SKERTCHLY.	
		Acres.	*Acres.*	*Cubic ft.*	*Cub. ft.*	*Cubic ft.*	*Cub. ft.*
WITHAM: High Lands above the Grand Sluice.	Grand Sluice	414,998		286·4		312·5	
Fen Lands; districts Nos. 1, 3, and 5.	Ditto - -	33,897	448,835	23·3	209·7	25·3	337·8
BLACK SLUICE: Fen Lands -	Black Sluice	46,215		31·9		35·7	
Holland Fen and Districts Nos. 2 and 6.	Ditto - -	30,646		21·2		23·1	
High Lands adjacent.	Ditto - -	57,490	134,351	39·6	92·7	43·1	101·9
FOURTH DISTRICT: West and Wildmore Fens.	Maud Foster Sluice.	27,743		19·2		20·8	
High Lands adjacent and east of Hagnaby Beck.	Ditto - -	21,330	49,073	14·7	33·9	16·0	36·8
EAST FEN and 5,000 Acres.	-		34,833		23·9		26·1
COURT OF SEWERS DISTRICTS.	Various Sluices.		13,000		9·4		10·2
		Total -	680,302	Total -	469·6	Total -	512·8
		Ann. discharge in tons, 274,628,041,630					

Note.—The differences in our two estimates arise from differently computing the value of an inch of rain. My data are as follows :—

1 cubic inch of water weighs	- - -	252·458 grs.
1 „ foot „ „	- - -	997·137 oz. av.
No. of cubic inches in one gallon	- -	277·2738

See Table XIX. Appendix, p. 305.
Both estimates are from the rainfall at Boston.

* Report on Outfall of the R. Witham.

These results have been very carefully worked out, and may be taken as a sample of the best work of its kind. The remarks which follow are not made in the spirit of captious criticism, but merely to show that before perfectly reliable data can be obtained much remains to be done. I shall, however, use my own estimate of the rainfall in the Witham basin, as the more accurate.

Mr. S. H. Miller, of Wisbech, has, since January 1873, made careful observations upon the influence of certain soils upon evaporation by means of the evaporimeter jointly designed by us. His experiments have been made upon Peat, Warp, Fen clay, and Humus, or ordinary vegetable mould, with the results shown in the tables in the Appendix.* To show how these results are applicable to such districts as the Fenland I have worked out the following results respecting part of the Witham basin:—

1st, 3rd, and 5th Districts contain:—

Peat	31,475·71	acres.
Silt	484·33	,,
Gravel	968·48	,,
Highland Clay	968·48	,,
Total	33,879·00	

2nd, 6th, and Black Sluice Districts contain:—

Peat	17,080·23	acres.
Silt	39,853·84	,,
Gravel	17,080·23	,,
Highland Clay	2,846·70	,,
Total	76,861·00	

East, West, and Wildmore Fens and 5,000 acres contain:—

Peat	7,179·92	acres.
Silt	45,472·85	,,
Gravel	2,846·70	,,
Total	62,226·00	

The tables in the Appendix show that the evaporation compared with the rainfall from—

Peat	is 72	per cent.
Silt	,, 71	,,
Clay	,, 69	,,
Humus	,, 75	,,

the complements of which, or the quantity dischargeable by rivers from—

Peat	is 28	per cent.
Silt	,, 29	,,
Clay	,, 31	,,
Humus	,, 25	,,

* Pp. 302–3.

The year 1874, however, was exceptionally dry, and only the first five months of the year 1875 have elapsed, so that the above averages, though extending over 29 months, are not, I think, so reliable as those for the year 1873 alone. That year was a fair average one, the rainfall being within 5 per cent. of the mean of a long series of years. I shall, therefore, use the results of the year 1873 in the following remarks; they are as follows, for—

Peat - - - - -	65 per cent.
Warp - - - - -	65 „
Clay - - - - -	59 „
Humus - - - - -	70 „

and the complements are, for—

Peat - - - - -	35 per cent.
Warp - - - - -	35 „
Clay - - - - -	41 „
Humus - - - - -	30 „

Now Mr. Wheeler's number gives about 80 per cent. for the evaporation, and 20 per cent. for the quantity discharged from the surface in a liquid form. We see that so far as the fen soils are concerned this is considerably too great an evaporation, and moreover that it is equal to the evaporation from the surface of water in an exceptionally dry season. His estimate of the quantity of water to be drawn off is consequently too small; but when the extra evaporation from vegetation is added, the result will in all probability exceed even his estimate.

To show the effect of geological structure upon evaporation and drainage I have calculated the evaporation from the districts of the Witham basin which lie within the fens. With a rainfall of 21·244 inches, and evaporation as above the discharge from—

Peat - - - -	is 7·435 inches.
Silt - - - - -	„ 8·073 „
Clay - - - -	„ 8·710 „
Humus - - - -	„ 6·373 „
Warp - - - -	„ 7·435 „
Gravel - - - -	„ 8·710 „

Here I have taken silt as equal to the mean of clay and warp; and gravel as equal to clay, that material having the greatest influence of any substance we have hitherto experimented upon. The silt evaporation is probably close to truth, but the gravel is purely conjectural. I have also considered highland clay (Oxford and Boulder Clay in these cases) as having an equal influence to fen clay. The following are the results obtained:—

A. *1st, 3rd, and 5th Districts* contain of—

Peat - -	92·857	per cent. =	31,475·71 acres.
Silt - -	1·429	„	484·33 „
Gravel - -	2·857	„	968·48 „
Clay - -	2·857	„	968·48 „
	100·000		33,897·00

B. *2nd, 6th, and Black Sluice Districts* contain of—

Peat	- -	22·222	per cent. =	17,080·23 acres.
Silt	- -	51·852	„	39,853·84 „
Gravel	- -	22·222	„	17,080·23 „
Clay	- -	3·704	„	2,846·70 „
		100·000		76,861·00

C. *East, West, and Wildmore Fens* and 5,000 *acres* contain of

Peat	- -	11·538	per cent. =	7,179·92 acres.
Silt	- -	73·077	„	45,472·85 „
Gravel	- -	15·385	„	9,573·23 „
		100·000		62,226·00

From these tables it follows that the average discharge of water is from—

A. 7·544 inches.
B. 8·096 „
C. 8·097 „

These figures give us as the annual discharge from—

A. 930,724,485·64 cubic feet.
B. 2,258,828,576·168 „
C. 182,895,343·686 „

The discharge per second is, therefore, from—

A. 29·513 cubic feet, as against 25·3 cubic feet.
B. 71·301 „ „ 58·5 „
C. 57·996 „ „ 46·9 „

the second column of figures being the quantities discharged from the same districts on the supposition that 4·5 inches only find their way into the river.

Although I do not quote these figures as final, yet it seems to me that upon the basis of the above calculations, the future drainage of the fens must be conducted, as it is alone possible to obtain a correct estimate of the proportion of rainfall discharged by rivers by computing the influence of the different soils and of vegetation upon evaporation. The experiments of Mr. Miller and myself, with this object, are not yet sufficiently advanced to be of practical value, but the above example shows the method we are pursuing.

History of the Witham.—We are only concerned with that portion of the Witham which lies between Lincoln and the outfall. Lincoln (*Lindum*) was a most influential city in the times of the Romans, and a large water trade was carried on by means of the river, and the two artificial cuts, Car Dyke and Foss Dyke, the former of which connected the Witham with the Welland and the Nene, and the latter joined the Witham with the Ouse. In a previous chapter we have shown that at this time the course of the river was very different from the present one,* it having

* P. 12.

flowed from Dog Dyke by Howbridge, through East Fen to Wainfleet, where the important town of Vainona formed a protection to the outfall and a port for the vessels trading to Lindum.

This old course can still be traced across the gravel lands to the silt lands of West Fen, where, the deposits being identical, its further course is indistinguishable. The general appearance of

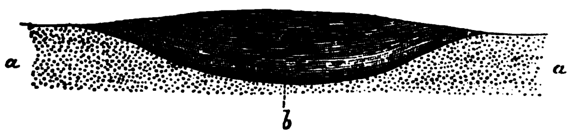


Fig. 2.—Silted-up Channel of old River Witham.

a. White sand. *b.* Peat. *c.* Clay and warp.

the section is shown in Fig. . The layers of clay and warp fill up the old course with the exception of a thin bed of peat, 6 inches in thickness, which reposes on the sand.

In these early times vessels of considerable burden traded to Lincoln. Dugdale states that "Great vessels have anciently come "up from Boston to that city, as the inhabitants thereof do, by "tradition, affirm; and as may be seen by large ribs of them, "which, within memory, have been there digged up."* A large anchor was also found at Lincoln "at a considerable depth," and a boat fastened by a chain and lock to a post "many yards higher" than the middle of the Witham valley.† These facts (although there is nothing to connect them with the Roman occupation) show that the river was of old broader and deeper than now. The date at which the Wainflete channel decayed and was abandoned cannot now be determined. All that can be said concerning it is that it took place between the times of the departure of the Romans and the Norman Conquest. It is probable that the Boston Channel, though of minor importance, was in existence at the same time as the Wainflete; but it gradually increased in size as the latter decayed. It need scarcely be said that not a drop of water has passed down the old channel for nearly 2,000 years.

The earliest notice of the Witham I know is about the year 1240 (Hen. III.), when Hant Huntre Fen‡ was divided into townships, which is a proof of the efficient state of the river.§ But in the year 1248 or 1250 this fen was flooded, owing to the decay of the river banks, and in the year 1258 the banks were ordered to be repaired.‖

1365. 39 E. III.—A presentment in this year declares "that "the chanel of this river, in Wildemore, near Coningesby, was

* Dugdale, p. 168.
† Beaut. Eng. and Wales, vol. ix. p. 561.
‡ Now called Eight Hundred Fen.
§ Oliver, Relig. Houses on the Witham, pp. 60, 72.
‖ Ib.

"and rendered useless and unprofitable, to the great loss of the "respective owners thereof, the decay of trade and commerce, "and the depopulation of the country; and that in the judgment "and opinion of experienced engineers and persons of known "skill and ability, the navigation of the said river Witham, and "the outfall thereof into the sea, were capable of being restored "and maintained, and the said low lands and fens of being drained, "cultivated and improved."* The district included within this commission was divided into six districts, as stated on page .

Under this Act the river was straightened by a new cut from Boston to Chapel Hill, and cleansed, widened, and deepened from that place to Stamp End, near Lincoln, the weirs and other obstructions were removed, the river banked, and various tributary streams and dykes were cleaned and deepened. "The new cut "from Boston to Chapel Hill was laid out by the engineer in a "direct line between those two places; but to oblige one large "proprietor the channel was turned from its proper direction so "as to run by Anton's Gowt; and to accommodate another, it "was made to go off thence, at a sharp angle, towards Langrick. "(*Chapman's Facts and Remarks.*) The dimensions of this cut, "as set out in the Act, were 80 feet top and 50 feet bottom, the "top diminishing to 58 feet at Chapel Hill, the depth being on "an average 9 feet 6 inches. At the lower end of the cut was "erected a 'grand sluice,' for stemming the tide, ... the "floor whereof was 3 feet at least lower than the floor of the said "[Lodowick's] gowt, and its capacity, or clear water-way, was "50 feet wide, with three pairs of pointing doors to the seaward, "to shut with the flow of the tides, (a fourth opening being built "by the Navigation Commissioners) and also pointing frames, "provided with drops, or draw doors, on the land side, to be shut "occasionally in order to retain fresh water in dry seasons for "the use of cattle and the navigation. The top of the draw-"doors being gauged to such a height as to retain the water of "the river not higher, at ordinary seasons, than 2 feet below the "medium surface of the lowest lands that drain therein." † The sluice was opened on the 15th October 1766.

It is well to notice that the draw-doors were gauged to retain the water at an average height of 2 feet *below* the surface of the lowest lands; for an opinion prevails that banked rivers, such as those we have been describing, flowing through a dead flat silt up their beds until they are *above* the level of the surrounding lands, the banks having to be continually raised to prevent overflowing. The Fen rivers, the Po, the water-ways of Holland are continually cited in proof of this assertion; but it is certainly untrue of the Fen rivers and, I believe, equally without foundation in other cases.

1811. 52 Geo. III.—The benefit expected to arise from the erection of the grand sluice was not obtained, but we will for the present defer the consideration of the effects of this structure, and

* Wheeler, Fens, S. Lincs., p. 46.
† Wheeler, Fens, S. Lincs. p. 48.

proceed to describe the alterations made in the river channel. In the year 1811 Mr. Rennie proposed a scheme for improving the state of the river above the grand sluice by scouring, widening, and deepening the river from that place to Lincoln, making a new cut from Horsley Deeps to Washingborough, erecting locks at Horsley Deeps and Stamp End, constructing a weir at the head of Bargate Drain in Lincoln to provide for the flood waters, and scouring out various drains near Lincoln. These works were carried out under an Act of 52 Geo. III., and during their progress several canoes were found.*

1846. 18 Vict.—At this time the rights and responsibilities of the navigation were transferred to the Great Northern Railway Company, whose line from Boston to Lincoln was constructed upon the banks of the river. From this date the navigation above the grand sluice lost its importance, the traffic being conveyed by trains instead of boats.

1865. 27 Vict.—In this year an Act was obtained "For the "further improvement of the drainage and navigation of the "River Witham," under the provisions of which the river has been scoured and deepened from about six miles above Boston to Horsley Deeps, the bottom being made on a dead level throughout this distance. Other minor works in cleansing and improving tributaries and lowering the cills of sluices were also perfected.

We must now describe the alterations which have been made in the river below the Grand Sluice.

1812. 51 Geo. III.—The first of these works was executed under the provisions of an Act obtained in the year 1812, but not carried out until the year 1825. A new straight channel was then cut from the Grand Sluice to the Iron Bridge. This materially improved the river *at Boston*, but the state of the river below Maud Forest Sluice was so bad that little advantage to the navigation was obtained. It is indeed singular that, notwithstanding the numerous decided opinions of eminent engineers, works were first constructed as far from the outfall, instead of as close to it, as possible.

1827. 6 Geo. IV.—A new Act obtained in this year empowered the Harbour Commissioners to cut a straight channel through Burton's Marsh, 800 yards in length, to cut off the great bend of Wyberton Roads, and shorten the river a mile and a half. This was accomplished between the years 1828–33; and the cut is shown on Plate IX. near the date 1866, which is that of the enclosure of the old channel for agricultural purposes.

1841.—Rennie, who planned the above work, also proposed to straighten the river up to Skirbeck church; but this part of the scheme was not carried out until the year 1841, when a new channel was made and trained with fascine work by Capt. Beasley. The same gentleman in the year following, trained the west bank of the river from nearly opposite Maudfoster Sluice to Slippery Gowt, and from that time the only work has

* Fens, S. Lincs.

been repairing and extending the fascine training and enclosing marshes.

Course of the Witham from Hobhole to deep water.—The description of the course of the river from its outfall to the German Ocean we shall take verbatim from Mr. Wheeler's works:—

"The Witham enters this Estuary [the Wash] at the end of the new cut at Hobhole, and pursues a devious course in a southerly direction through shifting sands to the point known as the 'Elbow,' where it is met by the Welland. The distance from Hobhole to the Elbow by the present course is about three miles, the channel varying in width from a quarter of a mile to a mile. On its east side is a hard bed of Clay,* called the Scalp, and on the west it is bounded by salt marshes lately enclosed. The course of the river through this channel varies with the strength of the ebb and flood tides; in summer, when there is no fresh water issuing from the river, the flood tides prevail, and keep the channel to the east along the hard bed of clay composing the Scalp; in winter, when heavy freshes are running down the river, the current opposite Hobhole is driven from its natural course by a barrier erected for the purpose of sending the waters into Hobhole Sluice; it then strikes against the embankment of the enclosed marsh, runs for a short distance along the Scalp, from which it is reflected towards the west, gradually working its way by washing down the bed of sand, six to seven feet in height, thrown up in the summer months, till at the end of a wet season the channel will have altered its natural course from three quarters of a mile to one mile. At times it will vary as much as 80 to 100 feet in one tide. At the end of the Scalp the Witham is joined by the Welland, which infringes on the waters of the Witham at a right angle and diverts it from its natural course, causing the stream to turn in a north-easterly direction, and forming a long elbow; the two streams combined continue together to deep water at Clay Hole. Below this the streams again divide, the north channel running in a line parallel with the coast for about fifteen miles past Frieston, Butterwick, Bennington, Leverton, Leake, Wrangle, Friskney, and Skegness, where it passes out into the German Ocean; it is divided from the other or south chanel throughout its whole length by high beds of sand, the depths of water varying from about one and a half to six fathoms, and decreasing towards its exit at the Outer Knock buoy, where there is a bar with only a depth of nine feet of water at low water spring tides. The width of the channel alters in nearly the same proportion, from a quarter of a mile to a mile and a quarter, but is contracted again at its outlet to about a quarter of a mile.

"The other channel, leaving the north-easterly direction a little below Clayhole, flows down what is termed 'the Maccaroni,' making an acute angle with its former course; and after running

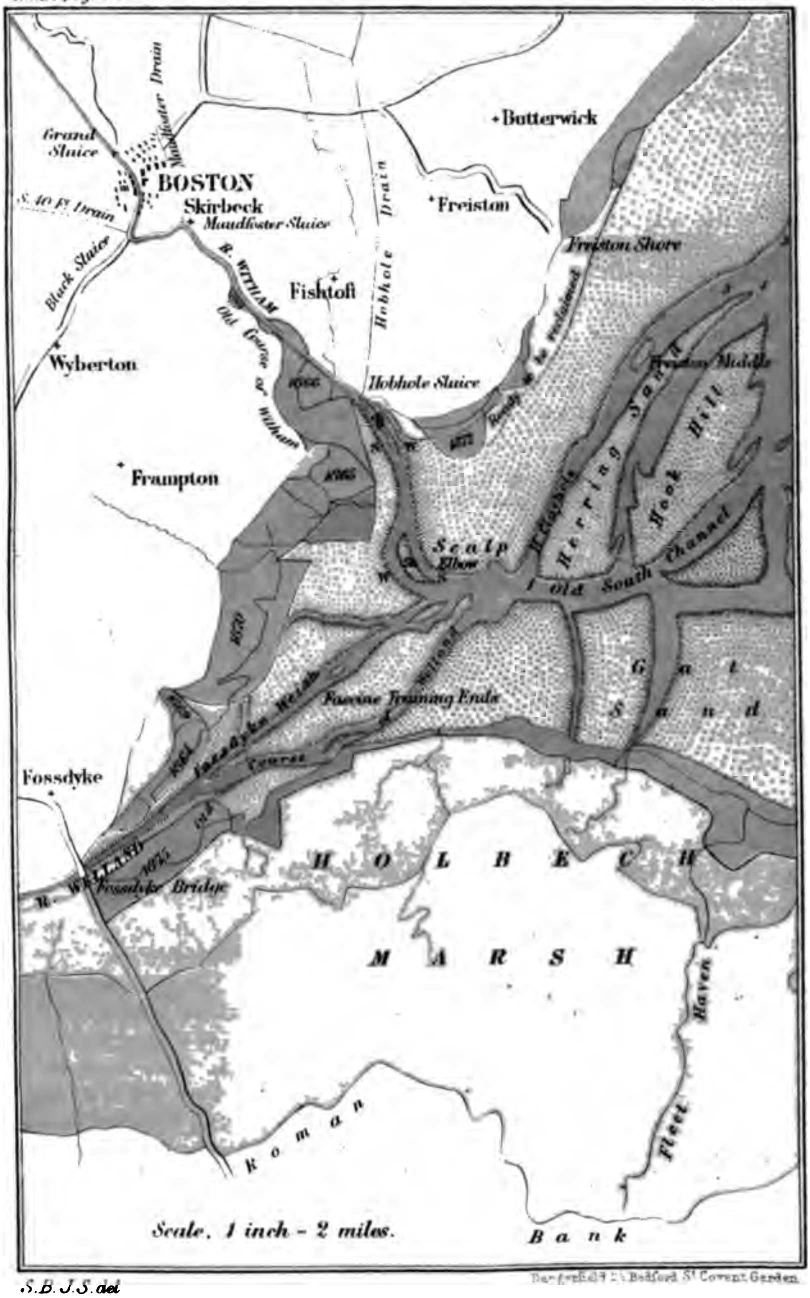
* This is Boulder Clay.

GEOLOGICAL SURVEY

OF ENGLAND AND WALES.

To face page 112.

Plate XII.



S. B. J. S. del.

OUTFALLS OF THE

WITHAM AND WELLAND RIVERS.

in this direction for a mile and three-quarters it doubles back up the Gat Channel into Lynn Well. The depth of water in the Maccaroni is from one to two fathoms, in the 'Gat' it increases to six fathoms, and continues deep water all through Lynn Well, the bed of the estuary in places being as much as eighteen fathoms below the surface of the water.* The length of the north course is about twenty miles, and by the south, by vessels going in the same direction, is about seven miles longer. Through these two channels the greater part of the waters of the Witham and Welland have to flow before reaching the ocean.

"The present course of the waters of the Witham and Welland round the Elbow to Clayhole is not the ancient or natural course, but is caused by the two streams meeting at nearly right angles. The alterations which have been made during the last century in the Witham, have been the means of withdrawing the back scour of the tidal waters which used to have a free run for twenty miles or more up the river, and of the large reservoirs formed by the windings of the river and the creeks and sands which are now embanked marshes.† The abstraction of water has considerably altered the strength of the Witham stream; and the Welland, having still the free run of the tides, has to a certain extent prevailed over the larger river, and driven it from its natural course. On reference to ancient plans and charts, and from information obtained from old sailors, it appears that the channel originally, after leaving the Scalp, continued with an easy curve in a south-easterly direction past the Herring Sand, through the Maccaroni, into Lynn Well. This is termed the old south channel, and was the regular course for vessels navigating the deeps. It is still partially open, and is used by fishing smacks and other vessels of light draught; and through it a part of the waters of the Welland find their way to the sea.

"From this description of the estuary, it will be obvious that the great obstruction of the free current of the downfall waters is the great mass of shifting sands‡ with which they have to contend. The channels continually varying as the sands are affected by the winds, the tides, or the floods, the waters exhaust their strength in forcing their way through them, and the power which should be employed in deepening and scouring is lost by the waters being spread over a wide surface instead of being concentrated in a single channel of uniform width. The better to illustrate this, it may be mentioned that an ordinary tide will take three hours to reach Hobhole Sluice after it is flood in Clayhole, a distance by the present winding course of four and a half miles; and as soon as it reaches the confined channel of the Witham, its

* The greatest depth is 26 fathoms, a quarter of a mile north-west of Lynn lightship.

† Capt. Huddart's plan, dated 1793, shows no course open from Elbow buoy to Clay Hole. Mr Rennie in his Report, dated 1822, says, "The communication "between Boston Haven and Clay Hole is principally maintained by the Maccaroni "or South Channel; or else by the Elbow Channel across Clay Hole; this latter, "however, is only suited for vessels drawing little water." The Ordnance Map, dated 1824, does not show a channel from the Elbow into Clay Hole. Hence it appears that it is only since about 1830 that this has been the principal channel.

‡ Marked *sh* on Plate XII.

speed increases to such an extent that it flows over the same distance of four and a half miles, and reaches the Grand Sluice in less than an hour. The difference of level between Hobhole and Clayhole in the year 1799, was three feet three inches, in a course of four miles, or nine and one-third inches per mile. In 1822 the course had lengthened to five and a half miles, and the waters were so held up by the filling of the river with sands that the fall had increased to five feet two inches. The present rate* of inclination in the surface of the water from Hobhole to Clayhole is about eight feet, or at the rate of twenty-one and one-third inches per mile. Spring tides rise 25 feet at Clayhole, and flow from four to five hours; neap tides rise about 16 feet. The semidiurnal period, during which the state of the ebb will allow the discharge of the free waters, is from five to six hours, dependent, of course, in a great measure, on the state of the haven. Spring tides ebb out at Clayhole about four feet lower than the neap tides.† The rise of the tide and the depth to which the ebb flows out is greatly affected by the wind. A strong north-west wind causes the tide to flow higher and longer; a south-east wind, on the contrary, causing a bad tide. The winds will make a difference of from three to six feet in the height of the tides."‡

With reference to the shifting sands between Hobhole and Clayhole, Mr. Wheeler, in a report to the Boston Harbour Commissioners, makes the following pertinent remarks:—

"The tidal and fresh waters coming from opposite directions round the elbow of the channel, naturally seek a different course, and having nothing to oppose them but light sands, easily moved, each prevails as circumstances make the one or the other master.

"In summer, when there is no fresh running down the Witham, the tidal water has the mastery, and keeps close to the clay foreshore on the east side of the Scalp. The shape of the channel from Elbow to Hobhole being something like the letter S. In winter, where strong freshes are running, the tidal water is overcome, and the channel gradually works its way to the west, turning over an immense mass of sand, until at the end of a wet winter, its position is nearly half a mile more westerly than in the previous autumn. As soon as the rainy season ends, and the supply of back-water ceases, the tidal water begins to cut its way to the east, gradually washing away the intervening sands which presents a foreshore eight or ten feet above low-water mark. As the water undermines the bottom of this steep, it falls in immense masses into the channel, and being thus broken up and mixed with the water, is carried by the tide into the upper part of the haven, where, owing to the absence of back-water and consequent want of scour, it settles, and gradually raises the bed of the river. In the past dry summers, the deposit has reached to a height of ten or eleven feet above the natural bed of the haven, and so high that a low spring tide could not reach the town.

* Mr. Wheeler writes in the year 1868.
† See Appendix, p. 295.
‡ Fens of S. Lincs., pp. 162-5.

"The effect of this on the navigation of the river is so obvious as scarcely to need pointing out. Ships of the smallest burden must wait for a spring tide to get to the town at all, and those that in winter can without difficulty reach the quays have to lie below in deep water and receive or discharge their cargoes into barges. To the drainage the effect is still more detrimental. When the floods come in winter, instead of being able quickly to pass away to the sea, they have first to remove the enormous mass of deposit spread over upwards of four miles of river to a depth varying from ten feet at the upper end, to four or five feet at the lower end, and having escaped over this, there is the additional hindrance to their course in cutting out a fresh channel in the Scalp Reach, and in so doing turning over some millions of tons of sand. No quantity of rain that falls, even in the wettest winter, can make a good river in its present condition, because the very water that scours out the upper reach carries the channel amongst the shifting sands of the Scalp to a point whence it has to be moved back by the tides in the ensuing summer.

"It is a self-evident fact, that for good drainage an uninterrupted flow of the waters must be provided, that any impediment is so much hindrance to the rapid discharge of the water. That a channel which will let its water pass away at the rate of three miles an hour, and with a depth of eight feet of water, must get rid of the floods in a much shorter time than one that to struggle through sands at the rate of one-third the former speed, and with a depth of at the most three or four feet.

"The channel is still further obstructed by a bar above Clayhole, locally known as 'Clay Hummocks,' which prevents the water passing away.

"The sill of Hobhole Sluice is level with low water of spring tides at Clayhole, yet, owing to this bar, the water never under any circumstances, even at the lowest ebbs, stands lower than four feet eight inches on the sill; and while there is this depth of water on the sill of this sluice, the channel is so nearly dry at a point two miles below it, that there is not sufficient water for a boat drawing four inches to pass over.

"From what has been already stated it will be plainly seen that the great deposit brought into the river in summer time is owing to the shifting sands in the Scalp Reach.* So well is this understood by the fishermen and sailors, that the expression is common, 'A good Scalp Reach a bad river;' meaning that when the channel is scoured out down to the clay below Hobhole, then the river above is in bad condition, being filled with the sand washed out of the Scalp."†

Effects of the Grand Sluice.—Prior to the erection of the Grand Sluice the tidal waters had a free run of from ten to twenty miles above the town of Boston, but this was, of course, stopped in the year 1766, when the sluice was finished. The

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* Mr. Wheeler is not here taking notice of the warp which is always carried in by the tide, but only settles in still water about high-water mark; for which see p. 176.

† Report on Boston Harbour and Outfall, 1870, pp. 9–12.

result is that the river below the sluice has lost the beneficial effects of the tidal scour above that point. Before the Grand Sluice was erected the tide ran through Boston three and a half hours at the rate of about four miles an hour; now the tides at the Sluice only rise for one hour and a half. During an average spring tide about 31,680,000 cubic feet of water* passed the site of the sluice twice a day, and of this quantity of water the river is robbed by the sluice. As in the case of Denver Sluice, so with the Grand Sluice, the river below the obstruction began to deteriorate. Almost every engineer since its erection, and some during its progress, have condemned the sluice. Elstobb at the time, and Rennie, Chapman, Telford, Stephenson, and Hawkshaw since have written against it, and not without serious cause. A few years after its erection ten feet of silt had accumulated against the doors, which could not be opened in consequence; navigation was stopped and drainage became defective. With the improvements of the channel towards the outfall the state of things grew better, but the river is surely and uninterruptedly silting up; and, though this must take place under any circumstances until the outfall below Hobhole is improved, the evil would be greatly lessened by the removal of the Grand Sluice.

The following table, from Mr. Wheeler's pamphlet on "The "State of the outfall of the River Witham," shows the height of the water on the different cills at low water, the variations being caused by the varying height of the deposit. It will be seen that the general tendency is towards silting up, *i.e.*, the water stands higher than formerly:—

TABLE showing the HEIGHT of the WATER on the CILLS of the SLUICES on the RIVER WITHAM at DIFFERENT DATES.

Date.	Grand Sluice.	Black Sluice.	Maud-foster Sluice.	Hob-hole Sluice.	Observer.	Remarks.
	ft. in.	*ft. in.*	*ft. in.*	*ft. in.*		
Relative levels of cills.	5 0	0 7	3 8	0 0	Hawkshaw	The cill of new sluices taken as datum.
1799 - -	—	—	8 0	5 2	Bower.	
1800 - -	—	—	6 8	2 6	„	
1814 (Feb.) -	—	—	7 0	2 0	„	
1818 (Oct.) -	—	—	—	3 3	Rennie.	
1822 - -	—	—	7 10	5 2	Giles.	
1823 - -	—	—	—	2 3	Farnsworth	Extraordinary low water.
— - -	—	—	—	5 2	„	Average height.
1838 (Nov.) -	—	—	—	3 8	Reynolds & Lewin.	
1860 (Feb.) -	—	—	—	7 10	Lewin.	
1867 - -	7 8	11 0	6 10	8 5	Wheeler -	Low-water neap tides.
Average level of floods at present time.	8 6	11 6	8 0	8 0	„ -	At low water.
High floods -	14 0	—	10 6	12 4	„ -	During tide time.

\ₓ Mr. Wheeler informs me that the levels in the top line are not correct now, whatever they have been originally. By levelling he finds the relative levels as under:—

Hobhole Cill - - - - - - -	0·0 feet.
Black Sluice - - - - - - -	1·38 „
Old „ - - - - - - -	4·62 „
Maudfoster - - - - - - -	2·45 „
Grand Sluice - - - - - - -	4·12 „

* Wheeler, Outfall of the R. Witham, p. 42.

GEOLOGICAL SURVEY
OF ENGLAND AND WALES.

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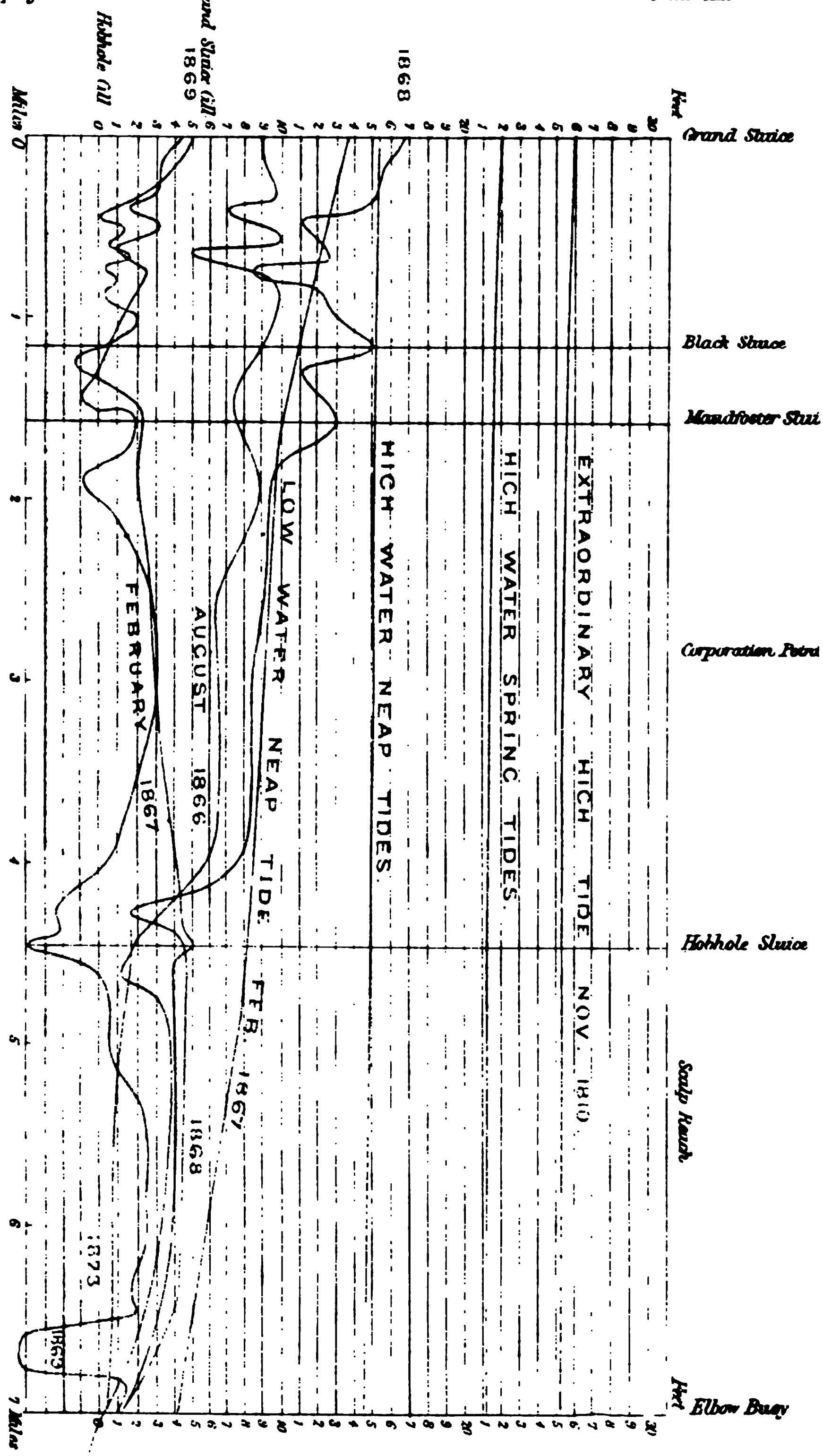
Plate XIII.



SECTION OF BOSTON HAVEN.
1866 - 67 - 68 - 69

Mr. John Rennie reported in October 1802 that the river was blocked up with silt, 10 feet having accumulated on the cill of the grand sluice, and all communication between the river above and below Boston was stopped because the sluice doors could not be opened. The cill of Hobhole sluice was laid in the year 1806 2 feet below low-water spring tides at Hobhole, and by the year 1816 the water is reported as standing 3 feet 3 inches on the cill, showing an accumulation of 15 inches of silt in 10 years. At the present time the accumulation is nearly 4 feet.

Plate XII. shows the variation in the bed of the river for the years 1866–7–8–9, and affords a more striking illustration of the evil effects of the grand sluice and shifting sands near Hobhole than words can convey.

The rainfall at Boston for the years 1864–9 is as follows:—

1864 = 14·94 inches.		
1865 = 25·85	„	
1866 = 25·58	„	
1867 = 25·94	„	
1868 = 22·84	„	(Wisbech).
1869 = 26·52	„	(ditto).

Thus we see that the year 1864 was very dry; 1868 had a fair average rainfall, and 1865–6–7–9 were wet.

In 1864 Mr. Hawkshaw reported that "outside the doors of "the Grand Sluice there was an accumulation of mud and sand "10 to 11 feet in height above the cill. The water in the drain "then standing about 7 feet 6 inches above the cill, so that the "mud outside was about 3 feet higher than the surface of the "water inside, and that the condition of the river at the other "sluices was equally bad in proportion." Such is the state to which the river is brought during a season when no freshes run to prevent the excessive accumulation of silt. It is not too much to say that if the Grand Sluice were so used as to admit all but very high spring-tides such a state of things would be unknown; and if, further, the river were trained to some distance below Hobhole the condition of the river would be as perfect as possible. Silt must always accumulate in the channel, and require removing (for every gallon of water is laden with sediment) but the lamentable state to which the river is now often reduced would certainly not be repeated.

The river bed, then, in the year 1864 was raised from 10 to 11 feet, there being no fresh water to assist the sluggish current of the ebbing tide. The next year, 1865, supplied a large quantity of fresh water, but not sufficient to clear away the deposit of the previous year. In July 1866, Mr. Wheeler found the height of the deposit to be as shown in the following table:—*

* The following figures do not quite agree with those shown on the plate, the latter being of slightly different dates. Both tables are from Mr. Wheeler's pamphlet on the State of the Outfall of the River Witham.

Locality.	Above Natural Level.	Above Hobhole Cill.
	ft. in.	ft. in.
Grand Sluice - - -	4 0	9 0
Black Sluice - - - -	9 5	10 0
Maudfoster Sluice - - -	4 3	7 6
Hobhole - - - -	3 6	3 6
Scalp Reach, 1 mile below Hobhole -	—	2 9
Elbow Buoy, 2¼ miles below „ -	—	1 0

Between June 1st, 1866, and January 31st, 1867, there fell at Boston, 24·24 inches of rain; and from the following table it will be seen that although the river above Hobhole was well scoured out, the channel below that point was in a worse state even than before.

Locality.	Relation to the Natural Level.	Above Hobhole Cill.
	ft. in.	ft. in.
Grand Sluice - - -	−1 0	4 0
Black Sluice - - -	1 6	2 1
Maudfoster Sluice - - -	−1 0	2 3
Hobhole - - - -	—	5 3
Scalp Reach, 1 mile below Hobhole -	—	3 3
Elbow Buoy - - -	—	2 0

Commenting upon these facts Mr. Wheeler observes that "the "whole force of the freshes has been exhausted in altering the "channel and turning over the vast quantities of sand alluded "to" [below Hobhole].

During the year 1868, the river silted up to a greater extent than ever, as is shown on Plate XIII., but the succeeding year being happily (in this case) a very wet one the whole of this deposit was scoured out, and the river greatly improved. It is, however, obviously ill-advised policy to allow the channel to silt up during ordinary and dry seasons and trust to exceptionally wet ones to clean away the deposit. How much better it would be to prevent the accumulation as far as possible only fen-men know, and the plain facts herein cited show that this can only be done by allowing all tides but extraordinary high ones a free run up the river, and by training the channel through the shifting sands below Hobhole.

CHAPTER X.

THE WASH.

The Wash is the great bay into which the fen rivers flow. It is the *Metaris Æstuarium* of the Romans; and, perhaps for no other reason, it is still called an estuary. It is, however, no more the estuary of the fen rivers than the German Ocean is the estuary of the Ouse or Thames. An estuary is the seaward continuation of a river-channel, a breach of the coast from the land side. A bay is an indentation of the land, a breach of the coast from the sea-side. The Wash is of the latter character, that is, a true bay and not an estuary. The estuaries of the fen rivers are now enclosed marshes; and the Wash, whatever parts of its area may formerly have been, holds no such relation to the rivers, nor are any of the fen beds delta deposits.

The width of the mouth of the Wash from Hunstanton Light to Gibraltar Point is exactly 12 miles; the length, from the centre of a line joining the above points to Fleet Haven, is 14·8 miles; the greatest length, from Hunstanton Light to Fosdyke Bridge, is 23 miles; the greatest breadth, from near South Wootton to the Witham outfall is 18 miles, and the area is 250 square miles, measured within the line drawn from Hunstanton Lighthouse to Gibraltar Point.

Configuration.—The configuration of the Wash is peculiar. Roughly speaking it is a shallow bay with an average depth of say 5 fathoms but having a deep hollow (Lynn Well) in the centre ranging from 15 to 26 fathoms. The eastern and western shores are fringed with sands sloping very gently to seaward from high-water mark. The base (under which term we shall speak of that portion lying between the Ouse and Welland outfalls) is blocked with immense accumulations of sands broken by shallow channels and sending out spurs in a north-easterly direction.

In describing the Wash, however, we must include much more than the Wash proper as above defined. It will be seen by reference to the Index Map that on the east a great shoal, called Burnham Flats to the south, and Docking Shoal to the north, extends about 12 miles north of the Norfolk coast. On the west a less perceptible shoal broken by Boston Deep, extends beyond Boston Bar and Long Sand. At the base this shoal still continues and joins that first mentioned. The great shoal we have described in three sections is bounded to seawards by the five-fathom line, and averages perhaps two fathoms in depth. Parts of it are dry at low water; such are—

The Woolpack	- - 1 foot	above low water springs.
Middle Bank -	- - 5 feet	,, ,,
Sunk Sand -	- - 5 ,,	,, ,,
Doghead Sand -	- - 6 ,,	,, ,,
Outer Knock -	- 5 to 9 ,,	,, ,,
Long Sand -	- 3 to 8 ,,	,, ,,
Roger Sand -	- 2 to 11 ,,	,, ,,

Hook Hill	2 to 8	feet above low water springs.		
Herring Sand	4 to 10	,,	,,	,,
Mare Tail	2 to 8	,,	,,	,,
Westmark Knock	7 to 10	,,	,,	,,
Whiting Sand	5	,,	,,	,,
Thief Sand	8	,,	,,	,,
Seals Sand	6 to 11	,,	,,	,,

The above sands are unconnected with the shore, the following directly join it:—

Stubborn Sand	8	feet above low water springs.		
Ferrier, Bulldog, and Vinegar Middle Sands	1 to 14	,,	,,	,,
Daseley's or Pandora Sand	3 to 11	,,	,,	,,
Beaumaris Sand	7 to 14	,,	,,	,,
Middle Bank	8	,,	,,	,,
Breast Sand	8	,,	,,	,,
Hull Sand	9 to 11	,,	,,	,,
Gat Sand	6 to 11	,,	,,	,,

Between Long and Roger Sands and the flats outside the coast is the channel known as Boston Deeps,* at the entrance to which is a bar having only $1\frac{1}{3}$ fathoms of water at Low-water springs. Inside the bar the soundings are $4\frac{1}{2}$, 5, 6, 7, 6, 5, and $4\frac{1}{2}$ fathoms as far south as Clayhole, where the water shoals again to 1 fathom. Boston Deep is therefore a basin whose lip is 1 fathom below the Admiralty datum; but it is merely a score out of the great shoal.

Very different is the peculiar basin called Lynn Well. Lynn Deeps is the name given to the deep water of the middle of the Wash (over 5 fathoms), and Lynn Well occupies a central position therein, extending beyond their limits for about three miles. The Well commences opposite the Long Sand upon a line drawn from Hunstanton Light and the southernmost Long Sand buoy in Boston Deeps, and runs pretty evenly for eight miles and a half in a north-easterly direction, with an average breadth of about three quarters of a mile. Within this area soundings are never less than 15 fathoms, the greatest depth being towards the southern end.† On all sides the water shoals very decidedly, but less so towards the north-east. The Well is thus a decided basin and not merely the deepest part of the bay, for the seaward lip is clearly discernible. Unlike Boston Deeps the Well lies entirely below the level of the great shoal.

The configuration of Lynn Well is such that if it were hollowed out of hard rock it would be called a "lake-basin," and it lies in the united continuations of the fen river-valleys, which is also a peculiarity of such basins. It is, however, scooped out of clay; and, though this in itself is no reason why it should not be a glacial "lake-basin," it is very probably only a basin in the Boulder Clay of East Anglia, which, as we shall show in the sequel, belongs to the early part of the glacial epoch, and not to the latter part, during which, I take it, the lake-basins were formed, and of which period few records are found in this area. The

* I believe this term is only used in the Wash. It is evidently of Northern origin —from the Danish *dyb* allied to the Swedish *diup*, a deep place.

† The extreme depth is 26 fathoms, half-a-mile N.N.W. of the Well light-ship.

origin of this singular depression is to be found in the anomalous set of the tides in the Wash, which we now proceed to describe.

The tide which fills the Wash runs southwards through the German Ocean, and, spreading across the mouth of the Wash, pours its water into the bay sideways, the flood tide running in a S.S.W. direction on the west coast, and W.S.W. on the east side. The direction of the tidal currents is shown in Plate I., the frontispiece to this volume. The ebb tides run in nearly opposite directions, or N.N.E. and E.S.E. Off the Knock and the Hook of Long Sand it is high water on full and change at 6h.;* springs run 5 miles an hour, ebbs 2¼; springs rise 23 feet, ebbs 14 feet. When the flood overflows Long Sand the tide runs strong from the E. Near the Woolpack and Sunk Sand the flood runs W.S.W., and the ebb E.S.E. The tide thus flows down The Wash coasts so that it is high water at Boston and Lynn at about the same time, and about half-an-hour before high water at Wisbech. The following table of the tides of August 1875 shows this clearly:—

TIDE TABLE showing the TIMES of HIGH WATER at BOSTON, WISBECH, and LYNN.

Date.	Time of High Water at					
	Boston.		Wisbech.		Lynn.	
1875.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
August 1 -	6·25	6·49	6·55	7·23	6·3	6·27
„ 2 -	7·12	7·35	7·48	8·11	6·50	7·13
„ 3 -	7·56	8·17	8·33	8·54	7·44	7·55
„ 4 -	8·38	8·59	9·15	9·35	8·16	8·37
„ 5 -	9·17	9·35	9·55	10·14	8·55	9·13
„ 6 -	9·54	10·12	10·32	10·49	9·32	9·50
„ 7 -	10·30	10·49	11·5	11·23	10·8	10·27
„ 8 -	11·9	11·30	11·40	11·58	10·47	11·8
„ 9 -	11·52	—	—	0·36	11·30	—
„ 10 -	0·48	1·21	0·58	1·24	0·26	0·59
„ 11 -	1·57	2·35	1·55	2·30	1·35	2·13
„ 12 -	3·15	3·35	3·13	3·58	2·53	3·13
„ 13 -	3·54	4·28	4·39	5·15	3·32	4·6
„ 14 -	4·59	5·25	5·30	5·47	4·37	5·3
„ 15 -	5·37	6·9	6·16	6·42	5·15	5·47
„ 16 -	6·27	6·44	7·4	7·24	6·5	6·22
„ 17 -	7·2	7·20	7·43	8·2	6·40	6·58
„ 18 -	7·38	7·46	8·20	8·37	7·16	7·34
„ 19 -	8·14	8·32	8·53	9·10	7·52	8·10
„ 20 -	8·50	9·9	9·28	9·46	8·28	8·47
„ 21 -	9·28	9·47	10·5	10·23	9·6	9·25
„ 22 -	10·7	10·28	10·40	10·59	9·45	10·6
„ 23 -	10·50	11·16	11·19	11·41	10·28	10·54
„ 24 -	11·44	—	—	0·29	11·22	11·54
„ 25 -	0·53	1·37	0·58	1·32	—	1·15
„ 26 -	2·22	3·9	2·10	2·56	2·0	2·47
„ 27 -	3·32	3·52	3·49	4·41	3·10	3·30
„ 28 -	4·31	5·4	5·21	5·38	4·9	4·42
„ 29 -	5·32	5·56	5·55	6·25	5·10	5·34
„ 30 -	6·19	6·40	6·52	7·16	5·57	6·18
„ 31 -	7·0	7·18	7·38	7·59	6·38	6·56

* That is to say the tide is part of the 6 o'clock cotidal line.

It is clear that the tidal stream flowing down the two coasts in different directions must complicate the tides in Lynn Deeps, and such we find to be the case, and to it the formation of Lynn Well is due. On Plate I. a diagram is placed in the centre of the Wash to illustrate this point, and the singular fact is brought out that in the Well *the tide is always flowing*, and *completely boxes the compass in the course of twelve hours*. Flood and ebb are each divided into quarters, and the direction of the stream is as under, the current continually flowing at a rate of from 2½ to 3 knots, and the rise of spring tides 24 feet:—

TIDES in the WELL.

Time.	Tide.	Direction.
1st quarter -	Flood -	N.W.
2nd " -	" -	N.E.
3rd " -	"	E. to S.S.E.
4th " H.W.	"	
1st " -	Ebb	
2nd " -	"	S.W. to W.N.W.
3rd " -	"	
4th " L.W.	"	

It appears, then, that in the middle of the Wash the tidal currents screw round and round, forming, if such an expression be admissible, a slow whirlpool, whose obvious effect is like a carpenter's centre-bit to bore a hole. In this way Lynn Well was formed; and if the limit to which the current acts is not reached (and it is to some extent a surface one), is still in process of deepening.

Another important result of this tidal action is that the suspended matter with which the waters are laden is not deposited in the bed of the Well, for the matter accumulates only at slack-water, which never occurs there. The only deposit which can take place in that locality is what is shoved along the bottom; accordingly we find the bottom to consist mostly of coarse shingle.

Lynn Well affords an example of an apparent lake-basin, due entirely to tidal action. Many of the submerged basin-like hollows occur off our coasts, have the lips formed by bars, and these again need not be due to ice-action. It is necessary, especially in little-known regions, carefully to examine the nature of the lip of suspected lake-basins and the set of the tidal currents, especially as such basins commonly occur in friths, where complicated tides are most frequent. It by no means follows, however, that a basin is not due to ice-action, even where complicated tides are shown to obtain; if the Well, for instance, were a submerged lake, the tides would still behave as they do now.

Mr. Godwin-Austen long ago showed that the channels of some of our rivers were continued out to sea. This is true of the united channels of some of the Fen rivers, for a glance at the Admiralty charts shows that a channel bordered by the 10-fathom line runs seaward for at least 24 miles beyond the mouth of the Wash. The great bank, whose highest portions are known, off the Norfolk coast, as the Dudgeon Shoal, Race Bank, Docking Shoal, and Burnham Flats, forms a great submerged peninsula 24 miles long, and from 16 to 20 miles broad, which marks the extent of an ancient coast-line. Similarly on the Lincolnshire coast a great shoal, having the Inner Dowsing Sand, the Protector, and other overfalls, as its highest parts marks an old coast-line running almost due north from about 10 miles east of Ingoldmells beyond the Humber, from whose mouth it is distant 20 miles. Between these great shoals the submerged channel above-mentioned runs.

Speaking generally, the bottom of the Wash is composed of fine and coarse sand and shingle. The sand is silicious, of a white, brown, or grey colour, and in many places full of black specks, some of which are ilmenite, but most of them fragments of peat. Rounded, flat pebbles of hard peat, bored by pholades, are also found, and are not unfrequently cast up on the sands, chiefly on the Lincolnshire coast, and most abundantly north of Wainfleet. These peat masses attest the former seaward extension of the peat, a question to which we shall return.

The sands proper, or those which rise above low-water mark, consist of fine sand and gravel. The Gat Sand, for instance, near Batchelor's Brawn, consists of fine sand, but in other places the sand is coarse, with scattered pebbles, and at about nine inches below the surface the material is fine gravel. The sand on the north and south sides of the Thief Sand is fine, hard, and of a yellow colour; but on the highest portions the material is very fine, almost like silt, with patches of clay. Fragments of hard peat are washed up on this sand, and specs of the same are abundant in the sand itself in some places. Long Sand is composed of a fine hard sand, with pellets of clay interspersed. In places the sand becomes coarser and full of dead shells. This generally happens where the bank is lower than usual.

I do not believe the Long and Roger Sands are merely banks of sand and gravel, but look upon them as hills of clay—Kimeridge or Boulder Clay—covered with those materials. If so, they are the modern counterparts of such ancient islands as Whittlesey and Eastrey.

The coast from the mouth of the Witham northwards is formed of very fine silty sand or clay, and round the base of the bay only, at some distance from the mainland, is good hard sand to be found. As we proceed northwards the coast gets sandier, till at Skegness a beautiful stretch of sandy beach forms the pride of the Great Northern Railway watering-place. The silt above mentioned is the only Wash deposit besides sand and gravel. It is only found about high-water mark, and consequently hugs the shore. As a separate chapter will be devoted to this deposit, its further consideration is postponed.

That the sands of the Wash are continually increasing has been known as long as the bay has been navigated, and is attested by their great present extent as compared with their former area. But the sands not only increase but *shift*. The great masses, such as the Gat and Long Sands, do not, it is true, alter their position greatly, but the channels are so variable that boats carry sounding poles and use them daily. A fisherman would not think of going down certain channels from which he had been absent a week or two without sounding.

The deposit now forming in the Wash is almost entirely brought up by the sea. The rivers bring only an inappreciable quantity of sediment from the highlands beyond the fen, even in times of flood. This is shown by the fact that when the land is drowned by freshets the grass is never soiled, although the flood may be out for weeks. The fact is, most of the sediment is thrown down before the rivers enter the fen, and in this way are formed the alluvial meadows for which the Ouse, Nene, Welland, and, to a less extent, the Witham are renowned. If the rivers brought down sufficient material to form deltas they would be situated at the entrance to the fens, and not at the true river-mouths.

The origin of the sea-borne detritus is not difficult of detection. The water flows down the coasts of Yorkshire and Lincolnshire, which are rapidly wasting, and to this source we must look for the ceaseless supplies of sand and silt which daily encroach upon the waters of the Wash. Most of the material, especially the coarser gravel and sand, is, I believe, almost certainly carried along the bottom of the sea, and not rolled along the beach or suspended in the water. The finest material, which forms silt, is chiefly suspended in the water. I have taken samples of water across the Wash from off Heacham to Wainfleet, and in every case have found traces of fine sand or clay, or both. The specimens were taken from the bottom and at half depth, and it was my intention to have run a series of such lines, preserved the water, and endeavoured to estimate the quantity brought into the Wash by the tide. Unfortunately for this investigation the week set apart (August 5–10th, 1872) was very stormy, and only one line could be run, and that under unfavourable circumstances. The smack was pitching so heavily that we could only filter out the sediment and stow away the filter-paper, a proceeding which prevented any precise determinations. Still, although we cannot yet say how much sediment is brought in by the tides, the fact was established that an appreciable quantity is so carried in suspension.* The quantitative results obtained are unreliable in

* It may be useful to describe the method taken to obtain the water samples. A fourteen-pound lead and lead-line were used in the ordinary manner. After many trials a common soda-water bottle was hit upon to hold the water. It was stropped and snaked like a buoy, with a loop left at the bottom for the line to be attached to. The stropping was carried up to the neck of the bottle, and the ends left about four inches above the neck. These ends were run through a sound cork and formed a loop at its top. When the cork was in the bottle the strings of the stropping were loose, when the cork was pulled out they held it fast. The line was so attached to the bottle that in heaving no strain was on the cork. When the lead grounded a smart jerk freed the cork, the bottle filled and was drawn up. The jerk of the cork could be distinctly felt in 25 fathoms water, and the whole worked admirably. The cost of such an apparatus, including everything, is about *3s. 6d.*

consequence of the way the smack had on her at the time of heaving. It takes a minute or so for the bottle to free itself of air, and unless the vessel is steady at the time this cannot be had. Often the bottle came up, especially in shallow water, only half full, and always the contents hissed and frothed with the imprisoned air like the delectable liquid the bottle was formed to contain. Calm weather is all that is requisite to ensure success, and that I did not get.

The interesting questions relating to the date of the breaching of the chalk barrier across the mouth of what is now the Wash, and the denudation of the area, will be discussed in a separate chapter.

CHAPTER XI.

BICKER HAVEN.

Bicker Haven was an arm of the sea extending from the estuary of the river Welland to the south-eastern extremity of Bicker. Its extreme length was 5½ miles, its breadth opposite Gorbertown three quarters of a mile, and its mouth 1¼ miles; its area about 8½ square miles.

It is now completely silted up, and has been for several centuries, but was an open sea-way during the Roman occupation, for they enclosed it with a sea-wall like the rest of the coast. Remains of this bank are still traceable, and the boundaries of the haven, as shown on the Geological Survey Map, sheet 70, and on the index map to this memoir, have been laid down by its means.

Bicker Haven received the waters of a considerable portion of the fens lying west and north of it. The Skirth, Gillsyke, and Ouse Mer Lode were natural streams discharging into it. The Skirth united with Kyme Eau and drained the lands around Kyme and Sleaford; the Gillsyke drained the fens to the north towards the river Witham; the Ouse Mer Lode drained the land around Donington and Horbling. None of these drains now flow down its site.

The earliest accounts of Bicker Haven consist of notices of salt pits, provided we admit the authenticity of the Saxon charters of Croyland, which I think cannot be done. Still, even though these documents were forged in 1415, the notices are valuable as showing the existence of salt pits there, since the compilers would not dare to mention places that did not exist, or that were of recent construction. The earliest is the charter of Earl Algar, dated 810, which mentions "in Drayton . . . four salt pits." This place is immediately south of Swineshead. Then follow the charters of King Wichtlaf (A.D. 833), King Bertulph (A.D. 851), King Beorred (A.D. 868), each mentioning four salt pits in the parish of Sutterton; and, lastly, King Edred, who cites four salt pits in Drayton. There are remains of salt pits still observable in Sutterton parish, but I know no trace of them towards Drayton. It may be, as the same number is always given, and the two localities are never cited together, that they refer to one and the same spot. This is the more probable, since the pits at Drayton are mentioned in Domesday as belonging to the abbey of Croyland, and Sutterton is not cited as containing pits. They are not mentioned in King Edgar's charter of 966.

By far the most important record is found in the Register of Peterborough, quoted by Dugdale, which is of especial interest as turning upon the question of the silting up of the Haven, and worthy of verbatim quotation.

"In the year of our Lord 1342, 16 Edw. III., the Abbot of " Swineshevėd and Sir Nicholas de Ry, knight, did implead the " Abbot of Peterborough for 340 acres of marsh, with the appur- " tenances, in Gosberchirche, viz., the Abbot of Swineshevėd for " 200, and Sir Nicholas for 140, by two writs. . . . The Abbot " of Swineshevėd and Sir Nicholas de Ry did set forth their " claim to that marsh, affirming that it did belong to them of " right, by the custom of the country, because that it was in- " creased and grown to their own ancient marshes by addition of " sand, which the sea had by its flowings cast up; insomuch as " by that means coming to be firm land, they said that they " ought to enjoy it as far as Salten Ee . . . . Whereunto the " counsel for the Abbot of Peterborough answered, that the " custom of this province of Holand, as stated by the plaintiffs, " ought thus to be understood and qualified, viz., that when, by " any such addition of any silt or sand, there should happen an " increase of land, and, by the seas leaving thereof, become firm " ground, it ought to belong unto him to whose firm and solid " ground it first joined itself, without any respect whether it grew " directly to it, or at one side. And they farther said that the " before-specified marsh did originally join itself to the ancient " marsh of the said Abbot of Peterborough, whereof that monas- " tery had been seised time out of memory, as it appeareth by " Domesday Book, where it is recorded that the Abbot of Peter- " borough had 16 salt pans in Donington. Moreover, in the " charter of King Richard the First there were confirmed to the " said Abbot three carucates of land, with salt pans and pastures, " and all their appurtenances, in Holand: So that the said soil, " increasing by little and little, ought not to belong unto the " Abbot of Swineshevėd and Sir Nicholas, according to the " custom of the country, because that a certain part of Salten " Ee, which was not then dry land, did lye betwixt the old marsh " belonging to the said Abbot of Swineshevėd and Sir Nicholas, " and the marsh whereof they presented so to be disseised: " Which part of Salten Ee could not at all be drained, because " that the fresh waters had used to run through that place from

"the parts of Kesteven to the sea, until Geffrey Abbot of Peter-
"borough (predecessor to the then Abbot) did, for the better
"draining of the province of Holand, by his deed indented, grant
"unto the said country a certain sewer, directly running to the
"sea, through his own land, by which means, though the ancient
"sewer in another place became less than it had wont to be, by
"reason of the non-usage thereof from the time that the said new
"sewer was granted. Nevertheless it remained at that time
"sufficiently open, and the sea did flow and ebb by it, and
"therefore it served sufficiently for a division, because that
"anciently, by the current of the fresh water as aforesaid, and
"the checking thereof by the sea, which continued till that day,
"it could neither be drained nor stopped; and that beyond that
"boundary the said Abbot of Swineshevd and Sir Nicholas could
"not, by the custom of the country, for the reason aforesaid,
"claim or challenge anything."

After considerable delay it was agreed that Sir Nicholas should, upon receipt of 40*l*., yield all title to the said marsh to the Abbot of Peterborough. "And as to the future increase of ground, "which might happen to either party, that it should be enjoyed "by him to whose land it did lie most contiguous." This agreement was made May 17th, 1343.

Nevertheless, in 1349, "there was a presentment exhibited unto "the King's Bench, by divers wapentakes in this county, against the "said Abbot of Peterborough, for purchasing 300 acres of waste "ground in Gosbercherche, without licence from the King; where-"unto the Abbot pleaded that this land was not purchased by him, "but gained from the sea; it being the custom of the country, and "so had been time out of mind, that all and singular Lords posses-"sing any manors on the sea coast had usually silt and sand, more "or less, cast up to their lands by the tides, and that this land, so "supposed to be purchased, was acquired in that sort." Verdict accordingly. Nevertheless, it was not until the year 1366 that the matter was finally set at rest.*

We may, ignoring the Saxon charters, consider it proved that between the Roman occupation and the middle of the 14th century, a period of 13 centuries, Bicker Haven had dwindled from an arm of the sea to a mere tidal stream called Salten Ee, and that between the 11th and 14th centuries at least 340 acres had become firm ground in the parish of Gosberton alone. It is fair, then, to conclude that the portions of the Haven north of this were already converted into land, but its possession occasioned no dispute, as the new land had accreted to the holdings of proprietors so as to clearly indicate to whom it should belong. Respecting the portions south of Gosberton, it is certain that the breadth must have been considerably reduced by this time, or the water-way would not have been spoken of merely as serving for a division.

I cannot but think that an additional piece of evidence against

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* Dugdale's Imbankment, pp. 234–8.

the authenticity of the Saxon charters is afforded by the mention therein of "four salt pits in Sutterton" as early as 810. It is certain that no salt works ever existed outside the banks, and it is highly improbable that at that time sufficient land had accreted to have permitted the formation of salt pans inside the banks, whereas, if the charters were forged in 1415, no such difficulty arises, for in 1314, the "river of Biker" was directed to be kept open to a breadth of 24 feet from Donington to Gosberton, which clearly shows that the haven was then reduced to a tidal stream liable to be clogged up by neglect.

When the haven became finally dry throughout its extent does not appear, but it no longer discharges water, and Risegate Ea, once a tributary, now is carried across its bed into the Welland.*

The site is covered with the ordinary sandy facies of the silt, and is of a whiter colour than usual, and often very loose. The wells in the vicinity are still brackish, and the land seems to have still a considerable quantity of salt in it, if, indeed, one may rely upon the statement that worms will not live in it, which seems borne out by the small amount of vegetable soil upon the site.

CHAPTER XII.

THE PEAT.

Under the general designation of Peat we shall describe not merely the great deposit which forms so large a portion of the surface of the Fenland, but several subterranean beds only exposed in pits or well-sections. These lower beds are irregular in extent and are not, as was formerly imagined, mere extensions of an Upper Peat beneath the silt, or a single stratum to which the term Lower Peat could be applied.

Area.—The Peat extends along the western edge of the Fenland from Lincoln to Croyland in a direction roughly north and south, and is only discontinuous between the Heckington Eau and Helpringham, a distance of about 3½ miles, where the gravel abuts directly upon the silt.

From Croyland the boundary runs south-east to Pear Tree, north of March, and thence eastwards and northwards into Marshland where it reaches the eastern border of the Fenland. South of this line the entire fen area is covered with peat up to the gravel boundary.

* In the year 1357 Gosberton and Surflete "were almost drowned by an arm of "the sea" (Dugdale, p. 238), which may mean either the Haven or the River Welland, probably the latter. The precarious nature of the ground in Elizabeth's time is shown by the fact that the gote in the sea dyke at Surflete sank bodily into the quicksand in the year 1573.

The continuity of this great mass of peat is broken by the silted-up estuary of the ancient Ouse, now called the Croft River. This old estuary is traceable by its marine silt from near Outwell to beyond Littleport.

The extent of the peat land just described, together with the small outlying patches north-west of Wisbech and east of Stickney, is nearly one half of the fen area. The precise amount cannot be determined in consequence of the boundaries being very obscure, for the peat thins out insensibly along its borders, and because the practice of "claying" the land, and the effects of cultivation and drainage have rendered more indistinct boundaries which even originally faded away rather than terminated in definite lines.

Method of Mapping.—In mapping the peat it was found necessary to adopt more or less empirical data for the determination of boundaries. For instance, over the gravel area of Deeping Fen a thin pellicle of peat, varying in thickness from one to six inches, encroaches upon the gravel, which, though giving a black or "moory" aspect to the soil, is not sufficiently pronounced to obscure the true gravelly nature of the subsoil. In this case the line has been so drawn as to indicate the division between decided peat-land and gravel.

Similar remarks apply to the junctions upon the Norfolk and Suffolk side, but in this instance the problem is complicated by the uneven surface of the sand and gravel. In the little hollows peat has grown; atmospheric agents have worked down many of the small elevations of loose sand and spread the material over the peat, which in consequence appears to be interstratified with sand. Furthermore the true moss-peat has so intermingled with the moory turf now forming in the sodden hollows that it is impossible to discriminate between the ancient peat and its modern type. In this case an arbitrary line has been drawn showing the boundary of the true peat land, and on the highland side of this line the area is coloured as gravel, with a note to indicate the debatable nature of the ground.

Yet another case may be cited, the boundary between the peat and silt. We have above described how the peat dies away along its margins, but at its junction with the marine beds a fresh complication arises. It must be remembered that the Fenland has been, and is still, the battle ground of salt and fresh water. Sometimes the sea has pushed its lines into the country of fresh water for a time, sometimes the rivers have invaded the district of of the sea. The marks which the sea put upon the land were, in the latter period of the conflict, beds of light flocculent silt, which fell in a thin, pink and silvery sheet at high-water slack of each tide.

The cognisance of the fresh-water was peat. Whenever fresh-water stagnated, peat grew. And, as the sea was continually damming itself back, by piling up its silt beds, the peat followed its retreating footsteps until the changing climate had so altered as to have become unfavourable to its growth. Many times the sea burst its self-erected barriers and swept their *débris* back into the peat country, and hence we find along the margin occasional banks of silt overlying the peat. This is no imaginary record. If the peat were still growing, the same thing would take place again now, and such hillocks were left when the sea broke into Marshland in 1862.

But the peat had to compete with a more formidable foe than the sea: the climate was growing drier; the waste soon became more rapid than the growth, and eventually peat ceased to grow at all, save in a very few favoured, sheltered nooks. At present there is no evidence of the formation of peat under natural conditions in the Fenland, with the solitary exception of a slight moory deposit near Eriswell and Mildenhall in Suffolk; where in a dank valley, the sedges and rushes thrive luxuriously, their matted roots decaying into a fibrous mass, black when sodden with water, but light-brown when dry, which is dug in slabs and used for fencing. As the peat advanced towards the sea, it did so with continually diminishing vigour, and finally died upon the march. Hence one of the reasons for the obscure nature of the boundary. It was beaten in the struggle against climate, and the thin edges, like fallen outposts, attest how hardly it succumbed.

In proof of this decay of peat, the Lincolnshire boundary may be adduced. It was formed upon marine silts in the latter days of what we may term for convenience, the peat period. Hence we might conclude that, being formed subsequently to most of the peat, it would be thin. Such we find to be the case, and over much of the area it has wasted almost entirely, and only left a moory trace on the land to attest its former presence. Beneath the protecting grass-land it may still be found, and deep ploughing brings up the less decayed fragments to tell of its existence. On such tracts, evidence of peat is accepted, which would be ignored in more favoured spots. It is clearly more correct to show these decayed outposts than to ignore them, and hence they are inserted in the map.

Throughout the peat-area, then, the boundaries are not rigidly correct, but are only approximately true, and even if six-inch maps were used, the exactitude could not be much enhanced, since the actual aspect is, as it were, blurred, like a drawing upon blotting paper.

General Aspect.—The physical features of the peat-land present a marked contrast to the gravel and silt lands. The perfect flatness of the landscape and the absence of scattered trees are among its most striking peculiarities. Trees are not wanting in many places, but they are almost exclusively lines of aspens and willows along the banks of the great drains. The absence of hedge-rows gives to the scene a strange openness, which imparts a singular sense of dreariness and coldness to the scene. Standing upon the battlements of Croyland Abbey, from whence by far the best view of the Fenland can be obtained, we see to the west the hills of Lincolnshire like a thin blue cloud on the horizon. Between, lies the peat-land of Deeping Fen, with its fine drains

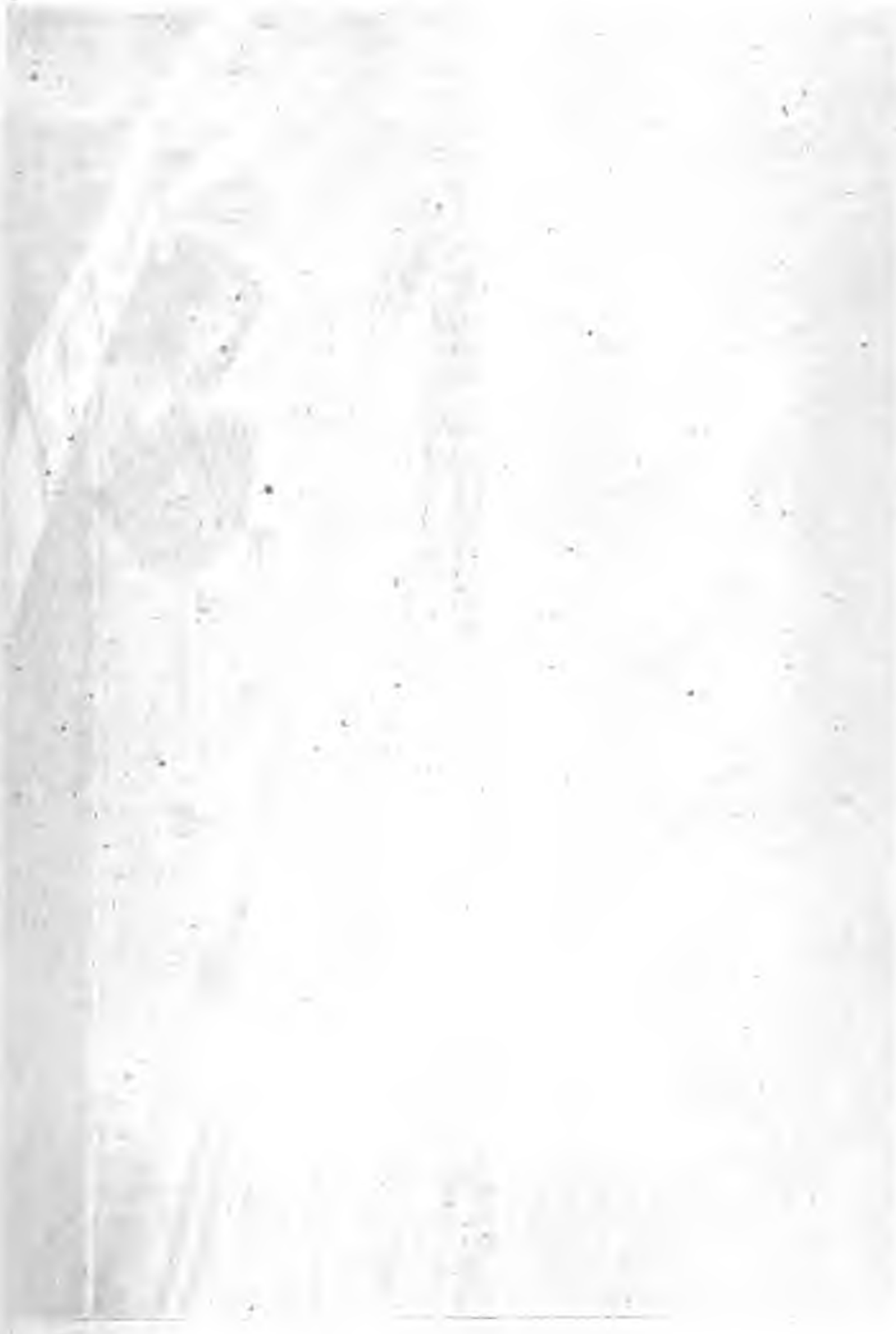

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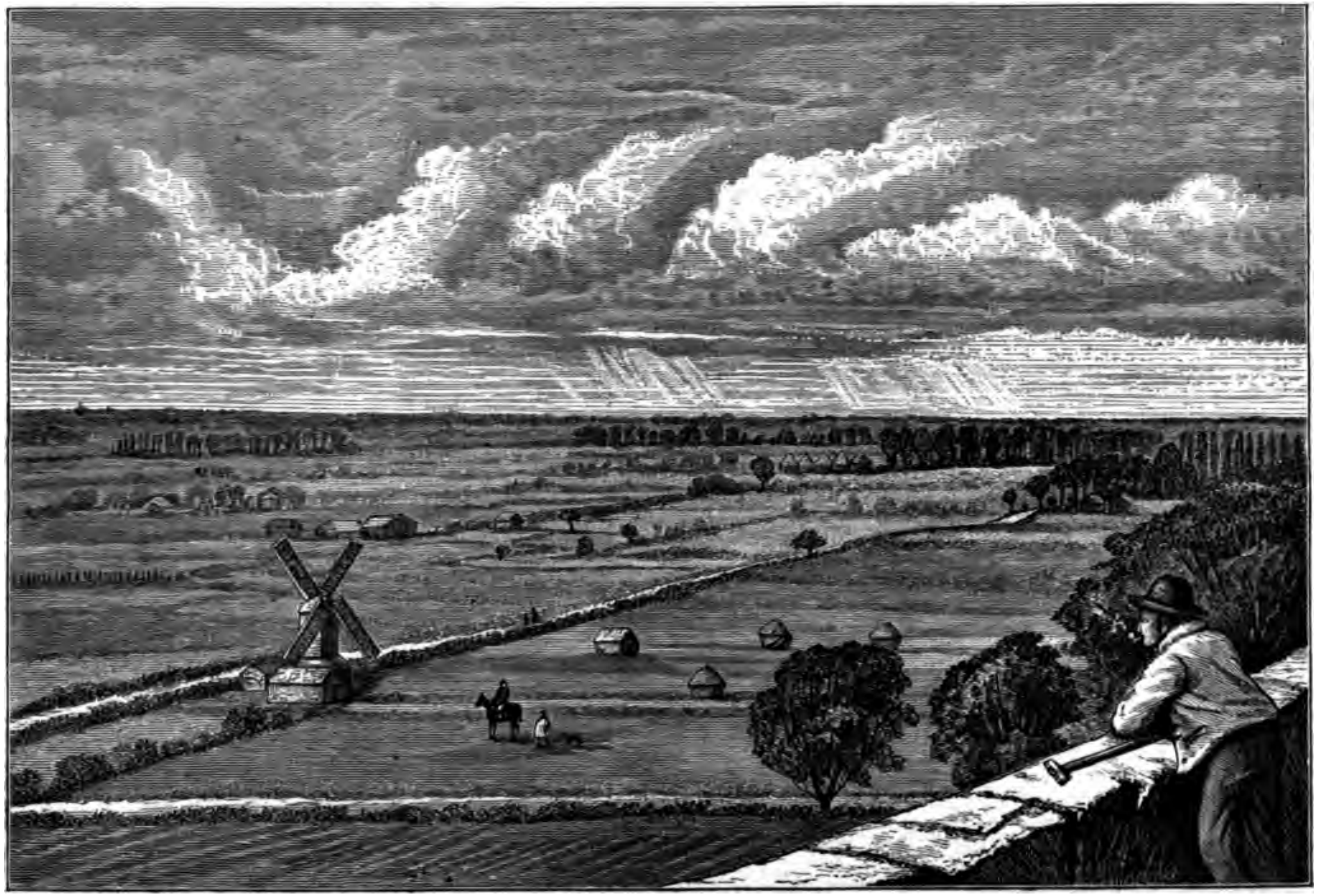
PLATE XIV.

GEOLOGICAL SURVEY OF ENGLAND AND WALES.



THE FENS FROM CROYLAND ABBEY, LOOKING NORTH.

38075.

and graceful colonnades of aspens, and singularly free from habitations. To the south the islands of Whittlesey and Thorney rise from the plain, conspicuous alike from their elevation and the clumps of trees which cover them. To the north and east we gaze deep into the Fenland which reaches the horizon. The splendid tower of Boston shows in the extreme north, and under peculiar atmospherical conditions, the coast-line of the Wash itself may be seen; but the air must be laden with moisture, the day warm, and the sun low in the heavens for the production of this phenomenon. Under these circumstances the distant landscape is, as it were, tilted into the air by refraction, as I observed in company with my late colleague Mr. J. W. Judd, F.G.S., during the summer of 1870. The land we scan in this direction is the silt; and, even from this elevation, the difference between it and the peat is apparent. Towns and villages, clumps of trees, and hedgerows, an undulating surface, which elsewhere might not be noticed but which is very clear by contrast with the sea-like flatness of the peat, and a general absence of the cold, dreary ensemble of the latter deposit, proclaims the difference in geological structure.

This difference of aspect may, however, be felt more strikingly upon the plain than above it, for the transition from peat to silt is usually more or less abrupt. One of the best localities for observing this change is at Upwell. I select this spot, not because the actual difference is there more apparent, but because it bursts upon us more unexpectedly than at most other places. Going down the lane on the north side of Beaupré Hall, the undulating silt, well studded with trees, lies on either hand. Suddenly an open, treeless landscape opens before one, creating a sensation akin to that experienced on unexpectedly coming upon the coast we thought was miles away. I mention these features because, although they are not strictly geological phenomena, they are, nevertheless, dependent upon the geological structure of the district, and are of immense value to the field geologist; but I would remind the reader that these things are not to be realised at once, but only become apparent after some little experience in the wonderful atmospheric effects of fen landscapes: then they are vivid enough.

The blackness of the soil is, of course, one of the best criteria of peat land. But even this cannot be implicitly relied upon, for where the peat is very thin it is often extremely difficult to judge between the traces of peat and the dark brown of a vegetable soil. Morover, the colour is often a deep ruddy brown, and then the embarrassment is doubly increased, for the clays and silts assume just this colour when worked up into soil. Again, it is absolutely impossible to judge of colour towards sunset, especially when, as more often happens here than in most places, the whole landscape is tinged with golden beams. In the fens it is not unusual for sundown to infuse its radiance *into* the atmosphere, and not merely gild the sky. At such times geological mapping is impossible. The above remarks apply solely to places in which the peat is thin, but as it is precisely through such spots that the geological boundaries run, I have deemed it necessary to point out a source of error to the field-worker which, though it may seem a slight thing to others, is regarded by me as a very important fact; and I believe every one who maps in the fens will arrive at a similar conclusion.

When the peat is over a foot in thickness there is not the slightest difficulty in determining its presence. The land is coaly black; and, even when crops cover it, the drains, which everywhere intersect it, reveal its presence; and when in autumn these are choked with sedge, rush, reed, and *Jacobea*, the water-rats, always turn out sufficient material to satisfy their biped brethren.

The long roads, again, possess distinct peculiarities in their blackness and straightness. I allude to the bye-roads and not to the highways or *rampars*, for these latter are raised above the general surface, are gravelled, and rank amongst the finest in the kingdom. The bye-ways, on the other hand, are merely broad, straight pieces of uncultivated land. In summer they are passable, for the dry peat crumbles into dust and renders the surface tolerably smooth, but when the rains of winter fall vehicles sink to the axles in the spongy mass, and the roads become practically useless. I have seen six horses try in vain to drag a loaded tumbril across a road; and have known a riding horse to be bogged and have to be shot to save it from death by cold and starvation. These roads, commonly called *droves*, are peculiar to the peat-land.

A strange and unmistakeable odour arises from the peat both in summer and winter.

In winter the land is sodden with rain, the dykes are full, and the country becomes almost impassable. In summer all is dry and parched, the minor drains are empty, and the dwellers in the fens are often reduced to straits for want of drinking water. In the early summer mirages are not uncommon, and I have only observed them on the peat-land.*

Nearly all the land is arable, but a few grass fields, or *grounds*, occur, as in the fens north of Bourn. But the over-draining of the fens is rapidly destroying the pastures, and farmers are reluctantly compelled to break it up.†

Such is the general aspect of the peat-land, a division of the Fenland possessing more peculiarities than any other, and here covering a greater area than any similar deposit in Great Britain. So rare are stones over this land that an occasional pebble or brickbat is a godsend to thrushes and blackbirds, and the broken snail-shells lying in profusion around show how alive the birds are to the value of the curiosity.

Thickness.—Roughly speaking the peat is thicker in the south than in the north. The greatest thickness attained by the peat, so

* See Nature, vol. i. 1872. Detailed accounts of Fen Mirages will be given in my forthcoming work upon "The Fenland."

† Engines are being used in the Middle Level to pump water *into* the Fen to irrigate the pasture land (Dec. 1874).

far as I have ascertained, is 18 feet, in the parish of Earith, inside the Wash bank, 648 feet north of the bridge at Mr. B. Vipon's house. A like thickness was pierced in the parish of Warboys, 780 yards from the Plow Puttock Drove. In both these places the peat reposes immediately upon the gravel, the marine silts and clays being entirely wanting. It seems, therefore, that after the deposition of the gravel no return of marine conditions took place in these localities, and the peat therefore represents the different peat beds as well as the intercalated marine beds of other localities. Indeed we shall presently show that from towards the end of the gravel period climatal conditions became favourable to the growth of peat, which began to grow whenever physical conditions permitted. The gradual silting up of the great bay which now forms the Fenland, and the intermittent irruptions of the sea have resulted in the production of many local deposits of peat which are now buried entirely. What peat beds show is the prevalence of land, or rather, stagnant fresh-water conditions, and the thickness of the deposits affords a rough measure of the time those conditions lasted; the thicker the bed the longer being the period. But here we must guard against error by limiting the comparison to neighbouring areas, for it would clearly be wrong to estimate the length of time required to form a foot of peat in the neighbourhood of Croyland as equivalent to the time required for such a growth in the vicinity of Ely. In the former case the peat is younger in date and did not form under such favourable circumstances, and consequently grew slower than in the latter. Again the lower beds are compressed by the weight of the superincumbent beds, and the upper bed is reduced in thickness by drainage and cultivation, so that the approximations are but crude.

In the arm which stretches up to Lincoln and forms the valley of the Witham the peat occasionally attains a thickness of from six to eight feet, and the same may be said of the lesser branch running from Billinghay towards Metheringham. Eastwards and southwards it thins out rapidly.

From Heckington to Deeping Fen the peat is thin, seldom attaining a greater thickness than three feet, and is more frequently less than a foot.

South of Deeping Fen it becomes much thicker, and in the vicinity of Whittlesea, Yaxley, and Ramsey is over ten feet. The average thickness of the peat in the Bedford Level may be taken at about six feet, but it is very variable. In Marshland it is seldom more than a foot and runs some distance under the silt.

Nature and Composition.—Most of the upper peat is too much decomposed and too thin to be available as fuel. From Helpringham, near Heckington, as far south as Thorney no peat is dug, and over most of this area it seldom attains a thickness of two feet. North of this district, about Digby and Billinghay, it is being rapidly consumed, and in Digby Fen, now being drained by Mr. W. H. Wheeler, C.E., it is considered of so little value as to be given away for the trouble of cartage. Over the whole of the peat area south of Thorney it is largely dug and fetches a good price. The method of digging will be presently described.

The upper portion of the peat is in all cases much weathered and appears as a black or deep brown-coloured material, showing no trace of vegetable structure, and rapidly crumbling into cuboidal fragments. Where the underlying clay is within a few feet of the surface it is dug and spread over the peat soil for the purpose of affording solidity, and the soil is greatly improved by the process. This claying of the land will be described in the sequel, and is here alluded to as one of the causes of the rapid disappearance of the peat. So rapidly does cultivation, combined with 'claying,' destroy the peat, that over large areas the former presence of that deposit is only attested by the moory character of the soil. Within the last 20 years it has vanished from considerable tracts in the neighbourhood of Bourn, Spalding, and Croyland, and there can be little doubt that 20 years hence the peat boundaries drawn by me will include areas over which scarcely a trace of peat will be found. Another important cause of this wasting away as found in the excessive drainage-system now in vogue. The land is rapidly settling down, and the peat, deprived of its moisture, shrinks into a much smaller bulk than it previously occupied.

Where the peat is comparatively thick, as in the Isle of Ely, the weathering is seldom apparent to greater depth than one foot. Beneath this layer the peat is of a fibrous nature, more or less compact, showing vegetable tissues in the shape of fragments of aquatic plants, especially reeds, rushes, and rootlets of willows and sallows. In colour it varies from jet black, through deep-brown to russet, and in consistency is soft enough to allow the finger to be pushed into it. It is so elastic that the ground quivers when stamped upon, and a horseman galloping down a peat road causes it to shake bodily. When a spring rises through it (as at the Browhill Spring, in Rippingale Fen, north of Bourn) the peat absorbs a quantity of water and swells into a boss, which yields like a sponge when trodden upon.

The lowest portions of the peat are seldom used as fuel, being for the most part composed of moss (*Hypnum*) which forms a very light, open-textured, golden-yellow material, in which the moss appears but little altered.

The following description of the peat at the Turbary, northwest of Coveney, near Ely, may be taken as a sample of the peat sections in the Fenland. The peat is dug to a depth of four feet, and the fresh section appears quite black, with the exception of the upper 10 or 12 inches, which are of a dark chocolate-brown. This upper brown portion consists of an amorphous mass of roots, rushes, &c., with elytra of marsh and aquatic beetles, and remains of other insects, and differs from the underlying material in not being bedded. The lower three feet are composed of black turf, in which the vegetable structure is obscure. It contains roots of reeds, flags, rushes, sallows, &c., and forms the best fuel. At the bottom the peat is almost exclusively composed of moss (*Hypnum*) and dries of a yellow colour, having much the appearance of golden bird's-eye tobacco, but the colour is not distinct until the peat is dry. The moss tissue is perfectly preserved, and quite friable when dry. These lower portions of the peat separate easily in their line of bedding. A white efflorescence appears upon the peat when dry, which is probably sulphate of lime, since small crystals of selenite are not unfrequently to be observed among it.

My friend Mr. A. Grugeon has kindly examined a specimen of peat from Coveney, which showed both the dark and light varieties. He reports as follows :—

"There appear to be numerous rushes without any of the interior cells remaining, although plenty of large loose cells float out from the mass. They do not, however, possess the stellate form of rush cells, which may be owing to their liberation from their cylindrical confinement, an opinion I am inclined to entertain from their large size. Numerous threads of *Conferva* occur, and *Hydrodyction utricularis* abounds. Leaves, calyptra and seta of moss of at least two species occur, and one rough surfaced seta like *Hypnum acetabulum*, but the habitat is not that of this plant. Nuclei of *Chara* occur sparingly, and two kinds of diatoms, one a most beautiful form. Spore cases of *Lastrea* are plentiful, and as perfect as when first gathered. A few bundles of spiral vessels attest the presence of phanerogamous plants, but the species are not determinable.

"The brown peat is all moss of one kind, and appears to be a strong-growing form of *Hypnum fluitans*.

"Throughout, the remains of coleoptera and hymenoptera are found. This is only the result of the examination of a piece of peat the size of a hazel nut, but I shall continue to investigate the matter, but it is very slow work."

It is remarkable that the true bog moss *Sphagnum* does not occur in the Fens either recent or extinct in the peat. Its place is taken by the *Hypnum* above described.*

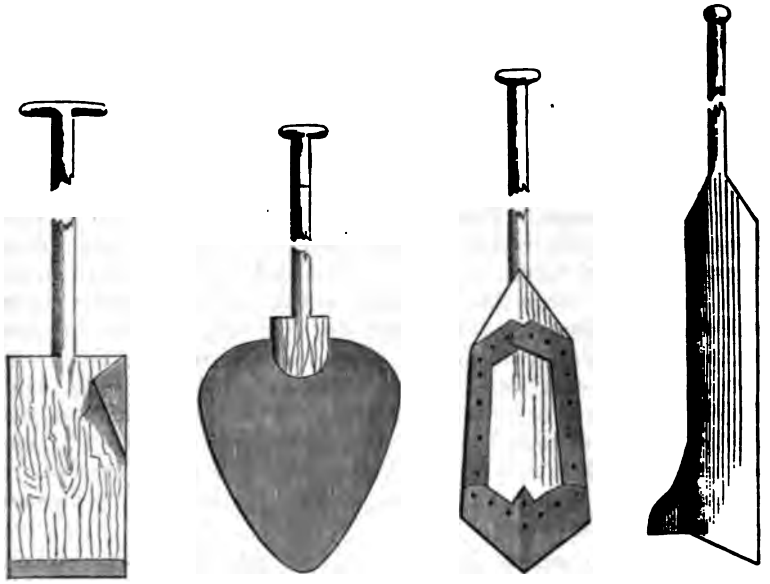
Method of Digging.—We have above alluded to the fact that only in neighbourhood of [illegible] and in the Isle of Ely is peat dug for fuel. Some parts of [illegible], [illegible], and [illegible] Fens contain turf of sufficient thickness to afford fuel, but it is not utilised. The best spots to observe the mode of getting peat are in the vicinity of Ely. The largest turbary is in [illegible] Fen, about eight miles south of Ely, and a large one occurs at Coveney, four miles west of the city.

The peat is dug in parallel trenches about a yard in width and five or six yards apart. The upper foot of weathered material is

* Dr. R. Angus Smith describes a peat from [illegible] which was composed of *Hypnum*. Proc. Lit. and Phil. Soc. Manch. [illegible]

first dug, and comes away in amorphous lumps, called *hods*. These are sometimes sold, and they burn well, but from their unwieldy shape are not much in request.

Beneath the "hoddy turf" the material is soft and unweathered, and is dug at once into brick-shaped blocks called *cesses*. The tool with which the cesses are dug is called a *becket*, represented in Fig. 3. It is a wooden spade of a rectangular shape, quite flat,



a. Becket. *b.* Fly Tool. *c.* Tip Tool *d.* Irish Slane.

Fig. 3.—Peat-digging Tools.

and shod with iron. An iron notch projecting at right angles to the plane of the blade cuts into the peat, and forms the side of the cess. The workman stands above and drives the becket almost vertically into the soft peat, keeping the blade parallel with the side of the trench, and at such a distance that the notch is just covered. This operation is performed entirely by the arms, the foot never being used in digging turf.

The cess thus cut is raised in the becket and deposited by the side of the trench in an oblique direction. The workman then moves backwards, digs another cess, places it beside the other, and so on. About every fifth cess is laid on the top of the others, in order that the line may not overtake the digger. In this way the whole length of the trench is passed over, and the cesses are placed in rows on the side.

If the ground is to be dug two cesses deep, the first lot is dug before the second is touched. It is usual to dig the cesses two or three broad, in which case, of course, the whole breadth is got before touching the lower peat. In Fig. 4 a portion of a trench is represented in which the cesses are dug two broad. The cesses are shown at *a*, and on the right is one cess laid upon the others

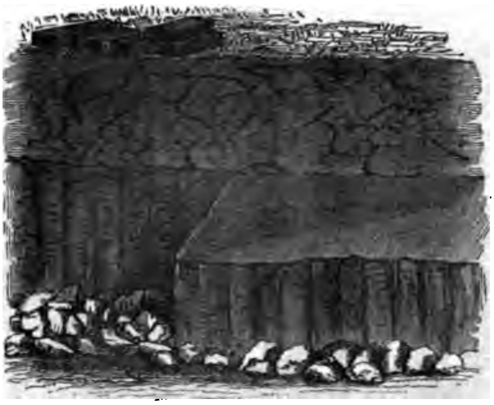


Fig. 4.—*Turf Trench.*

a. Cesses in rows, as dug.
b. Hoddy portion.
c. Good turf, showing marks of the becket.
d. Platform of turf on which the digger stands. The dotted line shows the direction in which the cess is dug. Here the digging is two cesses broad.
e. Hods thrown into dug-out trench.

as described. The hoddy portion is shown at *b*, and the good turf at *c*. At *d* the platform of turf in the process of being dug is represented, and the dotted lines show the outlines of two cesses, the notch of the becket cutting along the short line. The sides of the trench show the marks of the becket, and the digging is so accurately performed that they are perfectly vertical. As the turf is cut back the broken cesses and hods are thrown into the trench, as at *e*.

The size of the cess depends upon that of the becket. The largest I have seen are dug at Isleham, in Suffolk, 12 miles south of Ely; they measure, when dug, 20 × 5 × 4 inches. Very small cesses are also dug at the same place, measuring only 12 × 3 × 2 inches. The average size may be taken at about 9½ × 6¼ × 4 inches, which is the size at Manea. At Coveney they are somewhat larger, 12 × 4 × 3 being about the size.

A good digger, working from 4 a.m. to 6 p.m., will dig from 8,000 to 10,000 cesses.*

In some places, as at Salter's Lode Sluice, at the junction of the Well Creek with the river Ouse, south of Downham Market, in Norfolk, the peat is not compact enough to hold together when cut vertically. In such cases the peat is dug from the trench by means of a *pricker* which is a sharp iron spade, and a broad becket. They are cut in the opposite direction to the cesses above described, as is represented in Fig. 5. They split in the direction of their broad flat service, and are of about the same size as ordinary cesses.

* See Appendix B. p. 251.

At the same spot some turf is dug in the usual manner, and indeed this practice is adopted wherever the bed is sufficiently

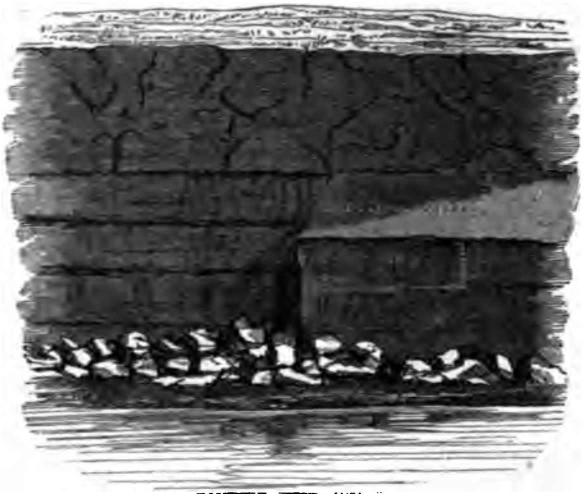


Fig. 5.—Turf Trench.

a. Hoddy portion.
b. Good turf, showing tool marks.
c. Platform, with dotted line showing shape of block.

compact to allow of its being done. In the process just described the pricker cuts the block vertically, and the notched becket cuts the horizontal and side sections, so that each block requires two operations instead of one.

There is a confusion of terms as applied to the blocks. Over most of the peat area the terms *hod* and *cess* are used as I have used them in describing the usual mode of digging. In the neighbourhood of Downham Market, as, for example, at Salter's Lode Sluice, the terms *hod* and *cess* are used indiscriminately for the flat blocks cut at two operations, and what are elsewhere called *cesses* are there termed *turves*. Near Brandon the term *hod* is applied to larger cesses. It may be mentioned that the word *peat* is quite unknown among the agricultural population of the fens. The substance is called *turf*, and where thin, or so weathered as to be unfit for fuel, the term *moor* is applied. It is usual to speak of "moory land," "black land," or "fen" where the soil is peaty. The word "fen" has, however, come to be used merely in contradistinction to "high land," but it is an unsafe term to use in speaking to the labourers, for though among themselves they talk of "down the fen," it seems to be tacitly understood that to outsiders or inquirers "there are no fens now."

When the turf is dug it is of a soft nature, and full of water. It is dried in the open air before sale. The usual time occupied in drying averages about three months, but in wet seasons, such as the year before last, 1872, it scarcely dries at all. It is dug in the spring and summer months, and allowed to stand in the rows in which it is first placed for about three weeks. The cesses are then turned over, and sometimes built into larger rows, and allowed to stand for a month. At the expiration of this term they are built into large stacks of about 10,000 cesses, and in five weeks or so, according to the weather, are ready for sale and use. The stacks are called *reeks*, and are built by placing four cesses lengthways and four crosswise against them, and so on, the courses so alternating that those placed lengthways lie upon those placed crosswise. The cesses are not placed close together, but spaces of about an inch left between, in order that a free current of air may circulate through the reek. The top of the reek is sometimes covered, but usually left open to the weather. When removed to the premises of the consumer the peat is always put under shelter, for if at all moist the whole reek will crumble to dust in a provokingly rapid manner when frosty weather sets in. My own experience is that it is not cheaper than coal when it can be obtained for 7*s*. per 1,000, even though coals are 35*s*. per ton, but it certainly makes most enjoyable fires when mixed with coal.

Peat is sold by the 1,000 cesses, and the price varies from about 5*s*. to 15*s*. per 1,000, according to quality, locality, &c. In the vicinity of Ely the cesses average about 10*s*. per 1,000 at the present time (Jan. 1874), while at Downham they are fetching 15*s*. for the same quantity. The term "thousand" does not necessarily mean a thousand, for the large cesses are counted as two each, so that 1,000 large cesses is only 500 in reality. This is a very rough way of calculating, for it is clear that the largest cesses, measuring $20 \times 5 \times 4 = 400$ cubic inches, contain much more than double the material of small cesses, measuring $12 \times 3 \times 2 = 72$ cubic inches, but no more accurate mode of estimating bulk is used. Small cesses cost as a rule about 2*s*. per 1,000 more than large ones. The reason for this is that they are more expensive to dig. They are, however, preferred for domestic purposes, since they are much more convenient. A thousand cesses should weigh about a ton, and, roughly speaking, they are equal to about half a ton of coals.

The peat burns with a bright glow, a dull flame, a faint empyreumatic odour, and much more quickly than coal. Very little smoke is produced, but a great deal of ash of a rusty-brown colour is formed. It is usually burned upon open hearths, but can be used in stoves, provided the pieces are loosely packed. Peat is the favourite fuel of the Isle of Ely, and in some places it is usual in hiring domestic servants to state whether it is used in the kitchen or not, and as very little soot is produced, they are willing to take service on lower terms where peat is so consumed, there being less cleaning required. Moreover, it is usual to "bank fires" at night by covering a few pieces of burning turf with ashes, when it will remain alight many hours. In some cottages the fires are never allowed to go out during the winter months.

Peat below the Silt in the Isle of Ely.—The peat of the Isle of Ely is continued beneath the thin covering of silt which hides it in the neighbourhood of Wisbech and Lynn. In walking eastwards from Thorney along its boundary, the peat will be seen to die away upon the surface of the marine silts and clays. As we approach Boarden House Bridge thin patches of silt encroach upon the dark peat soil, and at the eighth milestone a creek of silt runs across the road at the *same level as the peat surface*, viz., six feet above Ordnance Datum or four feet below the high-water spring tides at Wisbech. Thence to the bridge at Guyhirn the peat occupies the surface, and is seen three feet in thickness in the ditches close to the bridge. The land here rises about four feet, and the elevation is formed by the imposition of marine beds upon the peat.* In Guyhirn itself, the section is—

1.	**Warp** or **Silt**	2 feet.
2.	**Clay**	1 foot.
3.	**Peat**	

as may be seen at the junction of the road from Tholomas Drove.

The boundary of the peat then runs east to Cherry Tree Hill, at which point it curves southerly, and passing by March, Stonea, and Welney runs to Littleport. Starting again from Cherry Tree Hill, which is a slight elevation of about seven feet formed by the marine beds (indeed anything up which water will not run is called a *hill* in the fens), and crossing the marine beds in an easterly direction, we again come upon the peat running in a southerly direction. From a mile east of Outwell, the line passes by Mullicourt Priory, Nordelph, and Welney, meeting the other peat boundaries at Littleport. This triangular space is occupied by marine beds, and, running right into the heart of the peat country, maps out the tidal depositions of the ancient Ouse River, whose decayed channel may be traced in the miserable ditch called the Croft River, which still separates the counties of Cambridge and Norfolk. This estuary will be described in another place.

The whole of this marine area lies a few feet higher than the adjacent peat land; and the peat, tolerably continuous beneath it, extends northwards to the coast and westwards as far as Gedney Hill, never more than 8 feet from the surface and generally within 4 feet. In Plate XV., the area of the peat is shown by colour. The lighter portions show the area over which it is covered by marine beds, the darker tint marks the peat surface, and the white portion is the area of marine silts. The old estuary of the River Ouse is seen to the north of Ely.

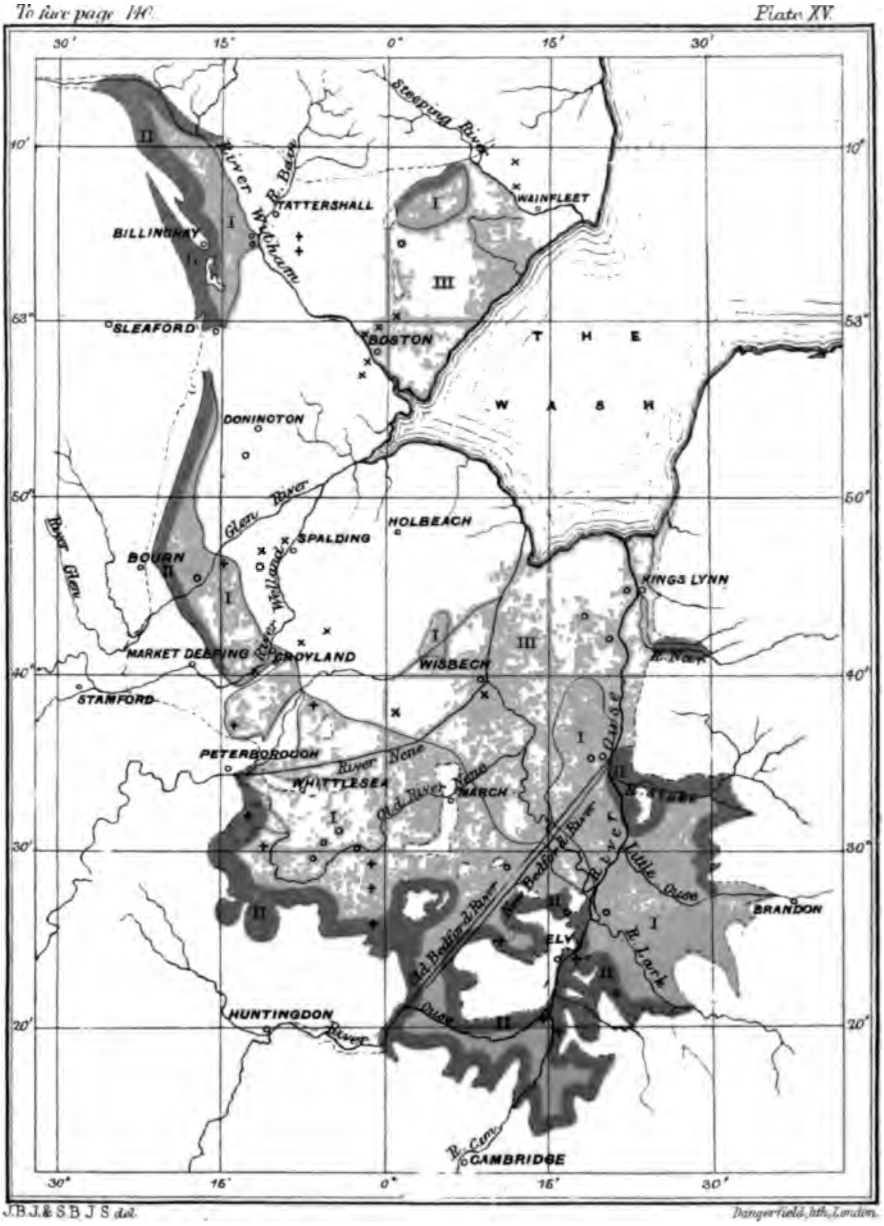
Over the light shaded area, the peat is generally known as the *Moor Floor*, but I prefer not to give it a special name as it is merely a continuation of the upper portion of the true peat.

Starting from the windmill by Cherry Tree Hill Farm, and walking eastwards along the road to Pear Tree Hill station, we pass in succession the edges of the peat *c*, Fig. 6, a marine clay *b*, and the fine sandy warp or silt *a*. Beneath the peat another bed of marine clay *d* is seen. A little east of the station the clay

* See Section No. 2, Plate xxiv.

GEOLOGICAL SURVEY
OF ENGLAND AND WALES.

To face page 140. Plate XV.



J.B.J.& S.B.J.S. del. Dangerfield, lith. London.

PEAT AND BURIED FORESTS OF
THE FENLAND.

bed *b* crops out again. Proceeding still easterly, we find the peat at intervals beneath the marine beds, and at Three Holes

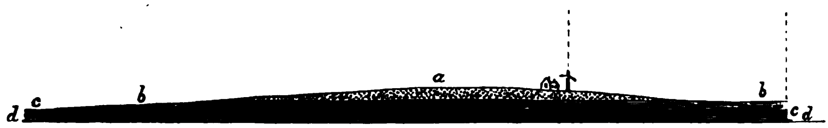


Fig. 6.—*Section across Pear Tree Hill.*

a. Silt or Warp. *b.* Clay. *c.* Peat. *d.* Clay.

N.B.—The vertical scale of this cut is vastly exaggerated.

Bridge on Pophams Eau at Upwell, we come upon a fine series of sections which extend at intervals of about 50 yards as far as Nordelph, a distance of three miles.

We will describe these sections somewhat in detail since they occur in a peculiar district, viz.: one in which the marine and fresh water beds have alternated in rapid succession. It must be remembered that the marine beds above the peat are the deposits of the old Ouse, which formerly debouched into the Wash at Wisbech. In Fig. 7, five sections are given reaching from the top of the bank to a foot or so below the water-line. No. 1, is at the junction of Popham's Eau with the Middle Level Drain; No. 2, is 100 yards further east; No. 3, 50 yards east of No. 2; No. 4, 60 yards east of No. 3; No. 5, 50 yards east of No. 4.

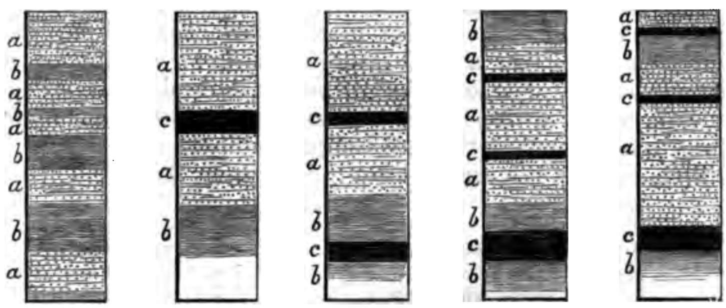


Fig. 7.—*Sections along Popham's Eau.*

a. Warp. *b.* Clay. *c.* Peat.

Section No. 1.—In this section 15 feet of laminated sandy silt or warp, and marine clay are seen without any trace of peat. At this point, therefore, the peat beds are cut away, or have never been deposited. The locality is half a mile east of the old river, here called the Old Welney River, and it is probable that we are in the bed of the ancient river itself; for in estimating the size of the old stream we must not judge by the present configuration of the surface but draw our inferences from the geological data which point out the physical geography of the past. At the time when these beds were formed the mouth of the old river was probably south of Wisbech.

Section No. 2.—At this point the section is as follows:—

1. **Laminated Silt**	-	5 feet.
2. **Peat**, black and carbonised	-	6 in. to 1 foot.
3. **Laminated Silt**	-	4 feet.
4. **Clay**	-	2 „

In bed 1 many specimens of *Scrobicularia piperata* occur, some quite young. The un-marked portion of the figure was obscured and it is probable the lowest bed of peat seen in the remaining sections occurs here also. It is to be particularly remarked that *the peat marks a break in the succession of marine deposits;* which break must have been of some years' duration to admit of the formation of the bed. Again the fine laminated silt above and below the peat is a tidal deposit and is only formed in shallow water, as we shall show in a future chapter. The clay at the base of the section may be deposited in deeper water. Hence this section shows us a gradual silting up of the channel, and, after the period of land conditions, as gradual a warping up of the newer channel

Section No. 3.—The section at this spot shows:—

1. **Laminated Silt**	-	5 feet.
2. **Peat**, mixed with **Clay**	-	4 inches.
3. **Laminated Silt**	-	4 feet.
4. **Clay**	-	3 feet.
5. **Peat**, pure and black	-	1½ feet.
6. **Clay**	seen to	1 foot.

In bed 1 *Scrobicularia piperata*, and *Cardium edule* are found. This section is similiar to the above and almost the same remarks apply to it. The top bed of peat is thinner, and being mixed with clay shows that a great struggle had to be maintained with the salt water. The lower bed of peat is intercalated in a deposit of clay, which evinces more sudden change from salt to fresh water conditions than the case before described.

Section No. 4.—Here we have the following section:—

1. **Clay**	-	2 feet.
2. **Silt**	-	1 foot.
3. **Peat**, mixed with **Clay**	-	3 inches.
4. **Silt**	-	4 feet.
5. **Peat**, mixed with **Clay**	-	3 inches.
6. **Silt**	-	3 feet.
7. **Clay**	-	1 foot.
8. **Peat**, pure and black	-	1½ feet.
9. **Clay**	- seen to	1 foot.

Scrobicularia piperata and *Cardium edule* are found in beds 1, 2, 4, 6, and 7.

We have now two thin beds of peat under the same conditions as described in Section No. 3. The lower peat bed still persists.

Section No. 5.—This spot affords the following section:—

		Ft.	In.
1. **Silt**	-	0	9
2. **Peaty Clay**	traces to	0	3
3. **Clay**	-	2	0
4. **Silt**	-	2	0
5. **Peaty Clay**	-	0	6
6. **Silt**	-	5	0
7. **Peat**, pure and black	-	1	6
8. **Clay**	-		

In beds 1, 3, 4, and 6 *Scrobicularia piperata* and *Cardium edule* occur.

It will be noticed that the uppermost thin bed of peat in 4 and 5 are not the same.

Before continuing our sections let us see how far we are now justified in considering the beds to have been formed near the mouth of an estuary and bordering land close to the sea-level. The presence of the marine shells *Scrobicularia piperata* and *Cardium edule* at once declare the marine character of the deposits, and the dwarfed nature of the cockle shells proclaim the water to have been only brackish. In the thin peat beds no wood occurs save a few drifted fragments, but in a lowest bed, which being thicker shows the land conditions to have prevailed for some time, we find abundant roots, branches and pieces of stems of sallows and willows; just such trees as would first grow upon the dank water-side. The lowest bed of clay is part of what may be called the original marine deposit of the Fenland, and is considerably older than the overlying beds.

Journeying still further east we trace the thin bed of peat seen in Section No. 5, and the lowest bed, continuously as far as the avenue which abuts upon the Eau, 1 mile 7 chains east of Three Holes Bridge. The land is gradually sloping to the east, and at this point the section is as represented in Fig. 8, which is drawn to twice the scale of those in Fig. 7. The thin bed of clayey peat

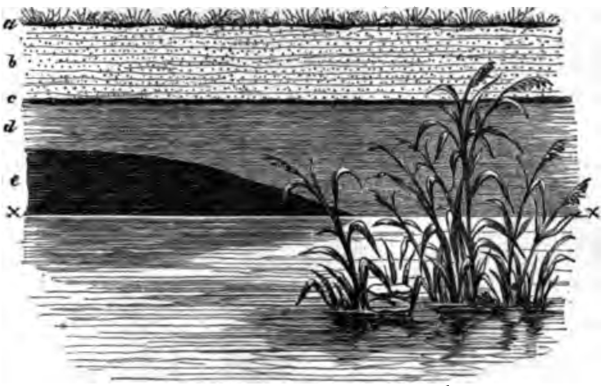


Fig. 8.—*Section at the Avenue on Popham's Eau.*

a. Traces of peat.	*d.* Clay.
b. Laminated silt.	*e.* Peat.
c. Peat mixed with clay.	× × Water-line.

is persistent, but the thick bed of peat ends abruptly with a feather edge. In the clay *d* I found the rib and humerus of a small mammal. Following up this drain we observe the peat to come on again, as shown in the following section, Fig. 9, which is somewhat generalised, the patches of peat being brought nearer together than is actually the case. I may premise that the beds can be seen below the water line, though they are not shown in

Fig. 9.—*Section along Popham's Eau.*

× × Water-line.

The letters A, B, C, D, E, and F mark particular points referred to in the text. Fig. 8 is an enlarged diagram taken near A; and Fig. 10 is a similar diagram taken at point C.

the figure. A is near to Fig. 8. Between A and B the peat is discontinuous. At B a lenticular mass occurs, the clay and silt beds arching over it. At C a small creek is intersected, of which the following, Fig. 10, is an enlarged sketch. At D the peat is again continuous for a hundred yards. At E the geat occurs with abruptly sloping ends, and overlaid like the trough at C by clay, with numerous fine seams of peat running through it. The little creek, intersected at C, is interesting. On reference to

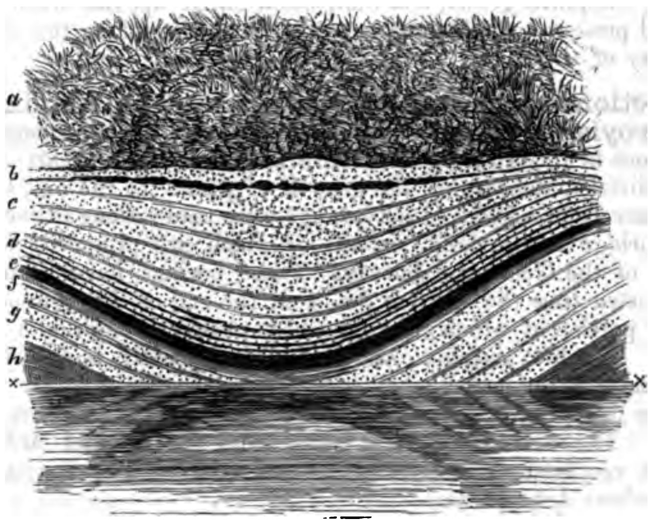


Fig. 10.—*Section on Popham's Eau.*

a. Overgrown bank.
b. Laminated silt.
c. Fine seams of peat.
d. Peat.
e. Clay.
f, *g*, *h*. Silt.
× × Water-line.

Fig. 10, in which it is represented on a larger scale, it will be seen that the peat is denuded on either side of the trough, and the section filled up with clays and silt. But above the peat, *d*, a number of peat seams, alternating with clay, *c*, occur. These clearly prove the alternating character of the country between marine and fresh-water conditions; and, moreover, that the climate was such as to favour the growth of peat. Indeed hundreds of sections throughout the Fenland render it certain that from the time when the gravel was deposited until comparatively recent times peat was formed wherever fresh-water stagnated. It is impossible to refer the growth of this material to any one period in the history of the Fens.

This series of sections proves that the silting up of the old Ouse estuary was an intermittent action; that the surface of the estuary was intersected by numerous creeks, and that peat immediately commenced to grow when the salt water left any portion of the surface for a time. On the shores of the Wash similar creeks abound, but no peat grows. A little salt water is not unfavourable to the growth of peat, for we often find small inter-bedded patches of marine silts full of cockle and mussel shells. Instances of this are found at Croyland, where in a thick bed of peat a seam of fine mussels was found by me in 1871, and between Aslackby Decoy Farm and the Car Dyke a seam of cockles may still be seen in the dykes. In Bourn Fen, again, cockle shells are found in the peat, and other instances might be cited. Hence we may assume that if peat could now grow in our area, it would be formed upon the higher patches of the salt marshes above the line where samphire grows, and that, when silted up, the creeks, &c., would present a similar aspect to those revealed along the ancient estuary of the Ouse.

Sections through the Peat District from Cambridge to Croyland.—I have been fortunate enough to obtain conclusive evidence of the truth of the above assertion, in the heart of the peat district, concerning the growth of peat. In the first half of the year 1836 a series of 18 borings were made along a line from Cambridge to Croyland, records of which are preserved in the office of the Geological Survey. These borings have been used in constructing the Section No. 4 at the end of this volume, the lower portion of which shows the beds passed through on a larger scale. The first six pierce the fen beds completely, but the others terminate in the gravel.

The following table shows the localities and nature of the sections. The descriptions are taken from the original MS., but where required short descriptions are added. The sections are from above downwards.

Bore No. 1.—*North side of R. Cam in Chesterton parish.*

	Ft. In.	Ft. In.
1. **Made Ground** - - -	—	4 0
2. **Black Peat** - - -	—	2 0
3. **Hard Gravel** - - -	2 0	
White Gravel - - -	4 0	10 0
Shingly Gravel - -	4 0	
4. **Solid Blue Clay** to - - -		5 0
		21 0

Bore No. 2.—*Side of Road from Willingham to Rampton in the parish of Rampton.*

	Ft. In.	
1. **Solid Brown Clay** with a white stone -	4 0	(Boulder Clay.)
2. **White Rock** and **Gravel,** very hard -	2 0*	
3. **Coloured Clay** - - - -	2 0	Boulder Clay?
4. **Blue Clay** streaked with white and small spots of Talc (?) to - - -	3 0	
	11 0	

* This is clearly gravel cemented into a compact mass by infiltration of water charged with carbonate of lime. Such a facies of gravel is generally called "rock," and often has to be blasted.

Bore No. 3.—*Side of R. Ouse in Willingham parish, near to Earith.*

	Ft. In.	Ft. In.	
1. **Brick Earth** - -	- —	2 0	Alluvium.
2. **Black Bog** - -	- 5 0	7 0	Soft Peat.
Black Peat, rather stiff	- 2 0		
3. **Shingly Gravel**, with **Sand**	- —	11 0	
4. **Blue Clay**, to - -	- —	1 6	
		21 6	

Bore No. 4.—*Ten feet between New and Old Bedford Rivers in Bluntisham parish.*

	Ft. In.
1. **Clay** - - - - -	2 6
2. **Sand** and **Clay** - - - -	7 6
3. **Gravel** and **Sand** - - -	2 0
4. **Strong Blue Clay** - - -	4 0
	16 0

Bore No. 5.—*Earith Wash,* 648 *feet north of the bridge at Mr. Vipon's house.*

	Ft. In.	Ft. In.	
1. **Yellow Clay** - -	- —	5 0	Marine Clay.
2. **Black Peat** - -	- —	18 0	
3. **Loam** and **Sand** -	- 2 0	7 0	
Loam and **Flint** -	- 2 0		
Gravel, Sand, and **Stone**	- 3 0		
4. **Blue Clay** to - -	- —	1 0	
		31 0	

*** This Bore is marked 4 A in the MS., and is distant only 278 feet from Bore 4.

Bore No. 6.—*Side of Old Bedford River,* 12 *feet from it, and* 29 *chains* 2 *feet north of the Brick Sluice Bridge at Earith.*

	Ft. In.	Ft. In.	
1. **Yellow Clay** - -	- —	2 6	Marine Clay.
2. **Black Peat** - -	- —	3 6	
3. **Light Yellow Clay** -	- 3 0	4 0	Marine Clay.
Coloured Clay -	- 1 0		
4. **Light Sand** and **Clay** -	- 2 0	5 0	
Clear Sand - -	- 1 0		
Gravel and **Sand** -	- 2 0		
5. **Solid Blue Clay** to -	- —	3 0	
		18 0	

*** This Bore is marked 4 B in the MS.

	Ft. In.	Ft. In.	
2. **Sand** and decayed wood	—	8 0	
3. **Brown Peat** and decayed vegetable matter	—	4 0	
4. **Black** and **Yellow Gravel** and **Stones** to	—	5 0	
		30 0	

*** This Bore is marked N in the MS.

Bore No. 15.—*Whittlesea Wash,* 300 *yards from North Bank.*

	Ft. In.	Ft. In.
1. **Dark Peat,** intermixed with dark Gravel	—	6 0
2. **Black Gravel** and **Blue Sand**	5 0	24 0
Blue Sand	14 0	
Gravel and **Stones,** very hard, to	5 0	
		30 0

*** This Bore is marked E in the MS.

Bore No. 16.—*On the Towing path under the North Bank on the south side of the R. Nene.*

	Ft. In.	Ft. In.
1. **Dark Brown Peat** with large stones	7 0	14 0
Black Earth, with **Gravel** and **Stones**	7 0	
2. **Sharp Blue Sand,** very hard	6 0	11 0
Yellow Gravel and **Stone,** very hard, to	5 0	
		25 0

*** This Bore is marked V in the MS.

Bore No. 17.—*North bank of R. Nene.*

	Ft. In.	Ft. In.	
1. **Rich Alluvial Soil**	10 0	22 0	Peat.
Black ditto, with **Galt** and **Stones**	6 0		
Brown Peat	6 0		
2. **Hard Gravel** to	—	5 0	
		27 0	

*** This Bore is marked 8 A in the MS.

Bore No. 18.—*Hartley's Drove, Thorney parish.*

	Ft. In.	Ft. In.	
1. **Peat**	—	3 0	
2. **Very soft Blue Clay,** or **Galt**		3 0	Marine Clay.
3. **Sand**	1 0	8 0	
Small Gravel and **Sand**	5 0		
Ditto very hard	2 0		
		14 0	

*** This Bore is marked 9 in the MS. From it the datum line of the section No. 4, Plate XXIV. was constructed, it being near one of the Ordnance Bench marks.

Bore No. 19.—*St. James' Drove, Croyland parish.*

	Ft. In.	Ft. In.	
1. **Very fine Mould** - -	—	2 0	Peaty soil.
2. **Fine Gravel** with coarse **Sand**	2 0	9 0	
Loamy Sand - - -	6 0		
Very hard and firm **Sand** to -	1 0		
		11 0	

*** This Bore is marked 10 in the MS. The following note accompanies it:—"At 11 ft. just breaking on to the gravel; although the gravel is 11 ft. "from the surface at this precise spot, yet there are several pits open in the "immediate neighbourhood where the gravel is within a foot of the surface, "and varying in depth from 2 to 4 feet."*

It is not necessary to describe in detail the above sections, but a few of the facts to which they sturdily point may be noticed. The first point is that the peat and silt do not form regular beds, but present every possible variation; and that the gravel alone is persistent. Secondly; while at some spots, as in No. 8, peat represents the whole fen series down to the gravel, in others it is subordinated to the silts and gravels, as in No. 6, or altogether absent, as in No. 4. Thirdly; the peat is often so intimately connected with the silts, that the beds have been recorded as peat and clay, as in No. 7. Fourthly; that occasionally, as in Nos. 7 and 14, the peat has commenced to grow before the end of the deposition of the gravel. Fifthly; that, while two beds of peat are shown in some places, the lower one is not continuous under the whole area but occupies a limited area.

The deductions from these facts are obvious; and, as I had arrived at the conclusions to be stated before the above sections came into my possession, they afforded a pleasant confirmation of the accuracy of my researches. Let us for the sake of convenience call the time during which the fen beds were being formed the "Fen Period," and the time of formation of the gravel the "Gravel Period," then the deductions are as follows:

1. Throughout the whole fen period the climate was favourable to the growth of peat, which formed whenever the sea had no access to a given area. Sometimes the alternation between marine and fresh-water conditions were very rapid.
2. That the alternations between marine and fresh-water conditions were very variable in the same and in different areas, and no classification such as Upper Peat, Buttery Clay, Lower Peat, &c. can hold good.
3. In the next chapter we shall show that even where the sea has not interfered with the growth of peat that substance has not gone on forming continuously, but that intervals of dryness of at least a hundred and fifty years' duration occurred in which trees grew upon the surface of the peat.

* This valuable series of sections seems to have been continued to Sleaford, but the commendable care taken to record the borings died away at Croyland.

The Lower Beds of Peat.—If we analyse the sections given in the Appendix which show peat beds we find them to be 93 in number; of these:—

58 reach the gravel, or pierce the fen beds;
9 are sufficiently deep to show the peat beds, though they do not reach the gravel;
22 are too shallow to show any low beds of peat if they exist; but
64 show only one bed of peat;
27 show two beds of peat.

Of those which show only one bed 43 have the peat at the surface.

The depths of the second bed of peat are as follows:—*

			Ft.	In.
No. 11.	*Soham*	at	5	0
,, 12.	*Wood Fen*	,,	8	0
,, 13.	*Burnt Fen*	,,	4	0
,, 23.	*Whittlesey*	,,	14	0
,, 24.	*Benwick*	,,	16	0
,, 27.	*Tongue End*	,,	6	0
,, 44.	*Croyland*	,,	5	6
,, 60.	*Ponder's Bridge*	,,	16	0
,, 61.	*Middlemoor*	,,	11	6
,, 63.	*Grassmoor*	,,	8	6
,, 66.	*Whittlesey Wash*	,,	21	0
,, 87.	*Tilney St. Lawrence*	,,	6	4
,, 91.	*Manea*	,,	25	0
,, 98.	*Tyd St. Giles*	,,	5	2
,, 101.	*Salter's Lode Sluice*	,,	15	0
,, 102.	*Nordelf*	,,	7	0
,, 107.	*Lynn*	,,	10	0
,, 111.	*R. Nene, Benwick*	,,	18	0
,, 112.	*Eaubrink Cut*	,,	17	0
,, 113.	*Sutton St. Edmunds*	,,	3	0
,, 146.	*Lade Bank Engine*	,,	7	6
,, 164.	*Quadring Low Fen*	,,	23	6
,, 167.	*Pinchbeck Bars*	,,	15	3
,, 170.	*Deeping St. Nicholas*	,,	20	0
,, 174.	*Dogdyke*	,,	10	0
,, 194.	*Star Fen*	,,	4	6
,, 208.	*Thorp Culvert Station*	,,	19	0

These depths by themselves are sufficient to show that the so-called "Lower Peat" is not one continuous bed, since we find the second bed to vary in depth from 4 feet to 25 feet; consequently they cannot be on the same horizon. Let us examine them a little more closely. On Plate XV. are laid down the sites of sections which pierce the fen beds and show peat. Where only one bed, and that at the surface, exists a St. George's cross (+) is placed; a single subterranean bed is shown by a St. Andrew's cross (×); two beds of peat are marked by a circle (o). If we allow a variation of 5 feet for a single bed, and consider all contiguous sections within 6 or 7 feet of the same level to belong to the same bed, a considerable latitude under the circumstances, we shall fairly test the theory of a "Lower Peat."

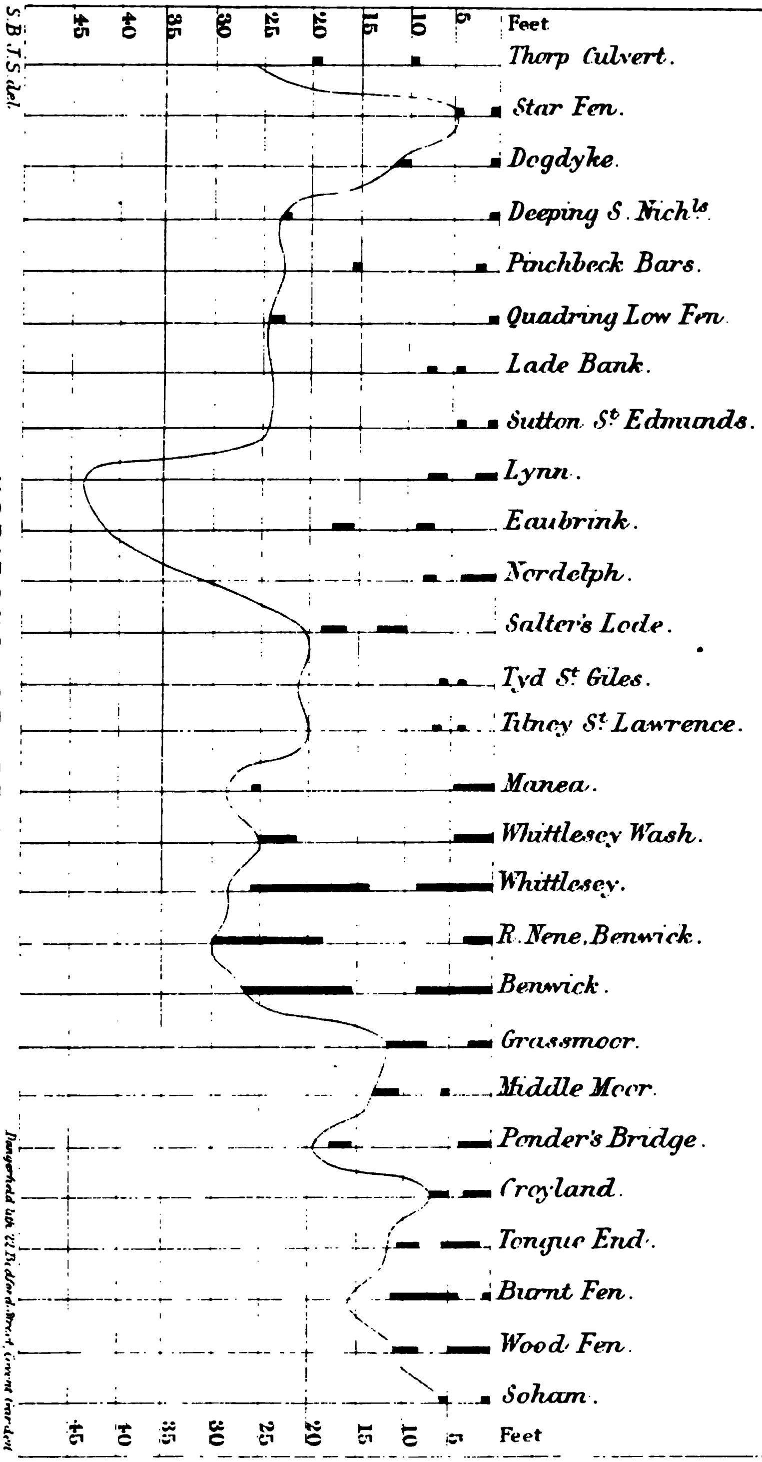
* The numbers refer to the numbers in the Appendix, page 252, &c.

GEOLOGICAL SURVEY OF ENGLAND AND WALES.

To face page 153.

Plate XVI.

HORIZONS OF PEAT BEDS.



Grouping the beds in this manner they seem to fall into three groups, as under:—

		Feet.
Dogdyke	at	10
Lade Bank	„	7·5
Spalding	„	8·75
„ *Common*	„	12
Star Fen	„	4·5
Tongue End	„	6
Croyland	„	5·5
Lynn	„	10
Salter's Lode (upper bed)	„	10
Tilney St. Lawrence	„	6·3
Burnt Fen	„	4
Wood Fen	„	8
Soham	„	5

The second group includes:—

		Feet.
High Bridge, Boston	at	13
Cow Bridge	„	13
Black Sluice	„	17
Grand Sluice	„	18
R. Nene, Whittlesey	„	14
Benwick	„	16
Ponder's Bridge	„	16
Middlemoor	„	11·5
Salter's Lode (lower bed)	„	15
Eaubrink Cut	„	17

The third group includes:—

		Feet.
Thorp Culvert	at	19
Spalding Low Fen	„	20
Pode Hole	„	24
Deeping St. Nicholas	„	20*

In this way we arrived at three distinct levels of subterranean peat, which is certainly nearer the truth than one. It will be noticed that the shallowest of these has the widest range, see on Plate XVI. The middle line is confined to the neighbourhoods of Whittlesey, Boston, and a solitary station at Salter's Lode. The lowest is confined to Lincolnshire, with a single exception at Manea, in Cambridgeshire.

If these represent three distinct beds of peat they are mere wrecks, for they are very much broken up. Thus at Dogdyke, where the upper bed occurs, it must be of slight extent, for it is entirely wanting half-a-mile to the south. At Thorp Culvert station, again, we have the lowest bed, but all round that place it is missing. Other examples can be made out from the map.

The complete elucidation of these subterranean beds must be left to local geologists, who alone can determine whether they are outliers of once wide-spread deposits, or merely isolated patches. At present I incline to the latter belief, there being so many undoubted cases of the rapid alternation of beds in short distances,

* These results are brought out more clearly in Plate XVI. in which the correlated beds are joined by a dotted line.

as may be seen, for example, in the enlarged sections No. 4, on Plate .

Shrinkage of the Peat.—The decay of the peat is largely facilitated by the abstraction of water by drainage. The peat beds are like so many huge sponges which, when relieved of the water they contain, shrink into much smaller bulk.

Over the Lincolnshire fens it is a matter of common observation that the clay, which 30 years ago was covered with from six to eight feet of peat, is now reached in dykes at depths of from three to five feet, and has hence become available for "claying." The opinion of the farmers is that "the clay grows," by which they understand (?) that in some mysterious manner the peat becomes converted into the "buttery clay," to be described presently. The simple explanation is that the operations of husbandry and drainage cause a diminution of volume which becomes very appreciable in the course of a generation.

Around Croyland old ague-stricken fen-men can still be found whose lustreless, opium-bleared eyes light up as they tell you of the glorious times of 70 years ago when they could run a pole ten feet into the moor without touching clay.

When the East and West Fens were drained in 1803 their general level was about eleven feet above the cill of Maud Foster Sluice, the lowest portions, however, being only nine feet above that point. In the year 1814 Mr. Bower, reporting to the Bedford Level Corporation, says: "It is satisfactory to state "that every wished-for object in the drainage of the whole of the "fens and of the low lands adjoining is effectually obtained, and "the lowest land brought into a state of cultivation. The East "Fen deeps are so perfectly drained . . . . that part of them "now forms a considerable farmyard; but stronger proofs of this "than mere assertion have now been had. There have been "within the last five years several extraordinary floods and high "tides, which have not in the smallest degree affected the works "or low lands, and at this moment of time, when the low lands "in every part of the kingdom are overflowed by an ice flood, "the East, West, and Wildmoor Fens and lowlands adjoining are "perfectly free, and as ready for all agricultural purposes as the "high-country lands."*

The above statement shows that the natural fall was amply sufficient for drainage purposes. The water on the cill at Hobhouse Sluice stood at two feet, the length of the drain is 14 miles, so that the fall was about eight feet in that distance, or about seven inches per mile. From the commencement of the undertaking the decay of the works began, for the fall was so slight that a diminution of a few inches seriously affected the value of the works. This at once took place, the peat gradually but uninterruptedly subsided, the stream of the Hobhole Drain, never appalling in its velocity, grew more and more sluggish, until the drain became quite incapable of discharging any extraordinary rainfall, and finally the ordinary amount of water was too great to be got rid

* Wheeler, Fens of S. Lincolnshire, p. 85.

of, and the Fens in question seemed to be steadily approaching their pristine condition. This, however, was not entirely, nor even principally, due to the shrinkage of the peat, for the River Witham itself was silting up, and by the year 1866, while the peat had diminished in thickness by two feet, the silt had accumulated to a depth of four feet, and the water in consequence continually stood six or seven, and in flood times even 10, feet upon the cill. In 1867 an Act of Parliament was obtained which enabled the commissioners to erect at Lade Bank "two pairs "of high pressure condensing steam engines, working two of "Appold's centrifugal pumps," which easily raised the water and maintained the district in a state of perfect drainage. As the peat shrunk two feet in 60 years (from 1806 to 1866) the rate per annum is 0·4 of an inch, and 40 inches in a century.

It must be remembered that the peat in this district is not very thick, being always under 10, and often less than 3 feet.

A much more striking example of the effect of drainage is afforded by the Fens in the vicinity of Whittlesey Mere, in which locality the peat is from 15 to 20 feet in thickness.

The bottom of the mere at the commencement of the drainage works was seven feet above datum,* and in 1860, or 9 years afterwards, it was reduced to three feet six inches, the shrinkage was therefore at the rate of 4·66 inches per annum. In the peatland adjoining the effect was still more noticeable. Three piles were driven in the lowest parts of the bog deep into the Oxford Clay beneath, and then cut off level with the surface of the ground. In 1860 these piles projected respectively 42, 59, and 73 inches* from the surface, showing a mean shrinkage of peat 6·4 inches per annum. An iron column graduated into feet and inches, was sunk into the solid clay in the adjoining bog, with its capital level with the ground. When I measured it on August 25th, 1870, 7 feet 8 inches were exposed. The inscription on the capital is "Level of the Ground in 1848," so that in the 22 years that had elapsed the peat had subsided 92 inches, or at the rate of 4·18 inches per annum. As might have been expected the compression was quickest at first, and has gradually become slower. This year, May 24th 1875, Mr. Wells noted the height of the column above the surface as 7 feet 9 inches, thus giving a further compression of 1 inch in 5 years, or only 0·2 inches per annum.

In a letter, conveying the above information, Mr. Wells writes: "I do not think, with our present drainage power, the land will "go down much more. If we could drain more of the water out "of the surrounding peaty district the level of the land would "rapidly subside, but we have a height left to contend against "varying from 5 ft. 6 in., which scarcely gives drainage to the "land, to 9 ft. and 10 ft. which the water in the outer drains "(into which we pump our Whittlesea Mere water) reaches in

* (The low-water mark gauge in the Ouse at Lynn Bridge); *see* W. Wells on Whittlesea Mere. Journ. Roy. Agric. Soc., vol. xxi. 1860.

" very wet weather . . . . The Middle Level Board have just " decided upon a series of levels being taken throughout the whole " district, which will be interesting, as shewing any alterations in " level which may have occurred, not in a small separate basin " like ours here, but throughout the Middle Level district " generally, since the improved drainage of the fens was established " in 1848." These valuable data are not yet obtained, or they would have materially assisted us in discussing the mean rate of compression.

Mr. Marshall of Ely informs me that the Hilgay Fen drainage-mill wheel originally dipped 6 feet when the land was *bright*, that is, just glistened with water, and 26 years afterwards it only dipped 20 inches under similar circumstances, showing a compression of 52 inches in that time, or an average of 1·7 inches per annum.

In Wood Fen, between Ely and Littleport, 20 years ago, the drains were maintained with 5 feet of water in them; their bottoms were peat and few trees, and no clay were found. Now (1874) the peat is completely dug through to keep the dykes at the same depth, the trees form a serious obstruction to the dykers, and only 2 feet 11 inches of water can be maintained. This gives a compression of 37 inches in 20 years, or an average of 1·9 inches per annum.

From such isolated cases it is not possible to deduce any accurate law which regulates the compression of peat, but the following table and remarks will nevertheless be of value, and will probably not be found far wrong when more extensive data are at command:—

TABLE showing the COMPRESSION of PEAT by DRAINAGE.

No.	Locality.	Dates.	Time.	Thickness.	Total Compression.	Annual Compression.	Total Compression per Cent.	Annual Compression per Cent.
			Years.	Feet.	Inches.	Inches.		
1	East Fen -	1806–66	60	6	24	0·4	33·3	0·55
2	Whittlesey Mere	1851–60	9	18	42	4·7	19·5	2·2
3	" "	Do.	9	18	59	6·6	27·3	3·0
4	" "	Do.	9	18	66	7·4	30·5	3·4
5	" "	Do.	9	18	73	8·1	33·8	3·7
6	" "	1848–70	22	18	92	4·18	42·6	1·9
7	" "	1848–75	27	18	93	3·44	43·0	1·59
8	Hilgay - -	—	26	10	52	5·2	43·3	1·7
9	Wood Fen -	1854–74	20	8	37	1·85	38·5	1·9

The observers of the above were:—

No. 1. W. H. Wheeler, C.E.
2–5. W. Wells.
6. S. B. J. S.
7. W. Wells.
8. W. Marshall.
9. S. B. J. S.

The mean annual percentage compression from the above data is 2·215, which under similar circumstances may be taken as the rate for a long series of years. By similar circumstances is meant low-lying peat in which very little fall can be obtained for the drains; for it is clear that if drains could be cut deep into or through the peat the compression would be more rapid.

The rate at which the land sunk around Whittlesey Mere was about 3 per cent. for the first 10 years, and 1 per cent. for the next 10 years, and by applying these quantities to the case of Wood Fen we find the compression there was at about the same rate. At Hilgay the rate was somewhat less, and in East Fen still less.

CHAPTER XIII.

THE BURIED FORESTS.

Buried trees, the remains of a great forest, have long been known to occur in the fens, and their position was described as being at the base of the "Upper Peat;" but no one seems to have suspected the existence of more than one forest, though we shall show that at least five occur. The earliest notice I have found of this subterranean forest is by De la Pryme, in 1701, who remarks that the trees are "of most of the sorts that this famous island "either formerly did, or that at present does produce, as Firrs, oaks, "birch, beech, yew, wirethorn, willow, ash, &c." And further remarks that their roots are mostly imbedded "in their natural postures," and that the larger ones lie with their tops mostly directed to the N.E., while smaller trees seem to lie indifferently in all directions. He then gives measurements of some of the larger trunks, as an oak 4 yards [? feet] in diameter, and 40 yards long.*

In 1796 De Serra and Sir Joseph Banks examined and described the Submarine Forest on the Lincolnshire coast at various points in the Hundred of Calcethorp. Their observations may be summed up almost in the words of De la Pryme.†

Nearly all subsequent writers have derived their information from the above two papers, but an honourable exception must be made in favour of the little work by the late Dr. Porter, on "The "Geology of Peterborough."‡

The occurrence of trees at the new sluice at the fall of the Hammond Creek into Boston Haven was noticed in the year 1702.

* De la Pryme on Trees found under Ground in Hatfield Chase, Phil. Trans., vol. xxii., No 275, p. 980.

† De Serra on a Submarine Forest on the East Coast of England. Phil. Trans., vol. 89, p. 145. 1799.

‡ The Geology of Peterborough and its Vicinity. By Henry Porter, M.D., F.G.S. Peterborough. 1861.

Other writers have noticed the existence of these trees, but not in such a manner as to call for a special notice in this place. Their names, &c. will be found in the bibliographic list in the Appendix.

Description.—It will be unnecessary to describe in detail the numerous localities in which the buried forest may be studied. They are almost as wide spread as the peat itself, and possess, as a rule, no distinctive features. I would, however, cite Digby and Bourn Fen in the north, and the neighbourhood of Ely (Downham, Coveney, and Littleport) in the south, as places where the forest may be best studied.

There is, however, a difference between the two first named and the last mentioned localities, namely, that whereas in the one the trees lie pretty constantly in one direction, they point in several directions in the other. This distinction we shall presently find to be a valuable one in determining the causes which led to the destruction of the forest.

The following is a list of the localities in which the *roots* of the trees may be best seen in situ :—

1. Sheet 70. *Digby* and adjoining Fens.
2. „ 64. *Bourn Fen.*
3. „ 64. *Deeping Fen.*
4. „ 51 N.W. *Coveney* and *Downham, West Fen.*
5. „ 69. *Wood Fen, Littleport.*

The greater number of the trees are *oaks*, some of which attain very large dimensions, as, for instance, that quoted by De la Pryme. A description of some very large trunks was sent to the "Stamford Mercury," by Mr. J. S. Padley, for a copy of which I am indebted to my friend Mr. Chas. Spreckley, late of Bourn The writer states that a Mr. Wilson "remembered the large oak. "tree, which was found in a field at the south-east corner of the "parish of Bardney, near the River Witham in 1803, then called "the Twenty Acres. . . . . The tree in question was 90 "feet long in the bole, 16 feet in the girth, and contained 1,440 "cubic feet of wood; 70 feet before a branch went off; and "there were several extremely large branches containing many "solid feet of wood, so that it is fair to suppose that the whole "might have contained 1,600 cubic feet.* Mr. Wilson led me "to the place where the tree was found, and there is still a hole "in the ground, although the land has been ploughed. It fell in "a south-east direction, across the fence between Bardney and "Southey. It was all heart except a little of the bark on the "under side: it was the sight of the neighbourhood, and people "came from afar and near to see it. . . . . A great many "oak trees have at times been found in the same field and those "adjoining, but more lately since Mr. Sharp became the owner.

* The proportions of this tree would seem to indicate that it grew surrounded by other trees of different species, whose altitude probably did not exceed 70 feet. Otherwise, according to the natural habit of the oak it must have branched at a much lower point, and would not have attained the given stature. Or, on the other hand, if the neighbouring trees were oaks none of them could have acquired a girth of 16 feet.

" He has been underdraining the land, and has raised many oak
" trees within the last three or four years, some from 70 to 80
" feet long, squaring from 3 to 4 feet.* He found three trees, or
" poles, in particular, two of them were 90 feet long, and squared
" 1 foot in the middle; the other, 63 feet long, and squared
" 1 foot 6 inches at the bottom and 1 foot at the top. The
" three trees mentioned were straight, and tapered to the top, and
" all the wood found is heart of oak, and free from sap, except
" the first mentioned."†

Large oaks lying in all directions are found in the peat in Soham Mere. One was said to be 2 feet 6 inches in diameter, and another was described as being 90 feet long and nearly 4 feet in diameter.

The straightness of the trees noticed in the above account is distinctive of all the trunks found in the peat, and would conclusively prove their forest growth, even if the numbers were not so great as to preclude any other idea.

In Ring Moor, near Billinghay, I made the following measurements of an oak :—

Length from root to end of trunk - - -	36 feet.
Height of stool where severed - - -	3 „
Greatest diameter of trunk - - -	30 inches.
Height of first branch - - - -	18 feet.

The trunk was very straight. Bark was preserved on the stool and all along the *under* side of the trunk where it lay in the turf. This bark was carbonised and crumbled into cuboidal fragments. Boulder clay was still seen filling the interstices of the root.

Again, in Ruskington Fen oak trees are very numerous, and without exception straight. The bark is preserved on the under side of many of them. In one trunk of 18 inches diameter I counted 117 annual rings. All the trees are broken off from 2 to 3 feet from the ground, which is about the thickness of the peat in this fen, and the fracture is very uneven; and I may remark that after examining many thousands of trunks I have not in a solitary instance discovered any marks of tools, though the workman, and nearly all writers on this subject, described such cases as being the rule. It is chiefly upon this erroneous foundation that the theory of the destruction of the forest by the Romans is founded.

In the case of Ruskington Fen the coincidence between the height of the severed poles and the thickness of the peat is peculiarly interesting since this and the neighbouring fens are not drained and the peat has consequently suffered less. This spot

* This length I take to be inclusive of the ramifications. The more slender poles would indicate a state of crowding of similar trees, which came into existence contemporaneously. It is probable they were in the full force of their vegetative vigour when they were killed, consequently they would have a large quantity of sap wood, probably from 4 to 5 inches; this would add 8 or 9 inches to the diameter, and adding 6 inches for the quantity abstracted in squaring the trunks would have a diameter of about 2 feet 8 inches at the base.

† "Stamford Mercury," Feb. 18th, 1870. J. S. Padley, dated Feb. 15th.

will be again referred to when we come to consider the age and distinction of the trees.

At the same place a few *birch* trees are found, and their bark is invariably preserved. A few *elms* are also found; the bark remaining, but the wood has become rotten like touch-wood.

In South Kyme Low Ground I measured the thickness of the annual rings of an *elm* whose trunk was 14⅛ inches in radius. The number was 138 and the thickness as follows:—

	Years.	In.
Growth	0 to 10	$2\frac{3}{40}$
	10 „ 20	$1\frac{15}{40}$
	20 „ 30	$\frac{32}{40}$
	30 „ 40	$1\frac{9}{40}$
	40 „ 50	$1\frac{7}{40}$
	50 „ 60	$1\frac{11}{40}$
	60 „ 70	$1\frac{2}{40}$
	70 „ 80	$1\frac{2}{40}$
	80 „ 90	$\frac{32}{40}$
	90 „ 100	$\frac{28}{40}$
	100 „ 110	$\frac{18}{40}$
	110 „ 120	$\frac{22}{40}$
	120 „ 130	$\frac{18}{40}$
	130 „ 138	$\frac{24}{40}$

In Anwick Fen oak, elm, birch, and willow are found, but the majority of the trees are oaks.

Passing to the southern district near Ely we find in West Fen numbers of trees, oaks, elms, and willows, averaging about 20 feet in length, and quite straight. There seems to be no general rule as to the point at which they have broken off, some being severed just above the bole, others are torn off by the roots. One tree, a birch, was charred at the base, but upon this point more will be said presently.

Finally, then, the trees composing the forest were oak, elm, birch, yew, willow, and sallow, of which the oak was by far the most numerous. The trees in some cases attained colossal dimensions, but as a rule they are not remarkable for size. The roots are in many places seen to be in situ, and the beds penetrated by rootlets are boulder clay, fen clay, and occasionally gravel. A yew obtained by Mr. Marshall, of Ely, from Hilgay, penetrated into the sand, and then spread its roots out almost horizontally so as to keep within the sand, which is thin at that spot.

State of the Wood, &c.—The timber is in all cases stained through lying in the peat, but the colour varies from almost black to grey. The wood of the oaks is often sufficiently sound to be available for rough work. It is used for fencing, gates, and other purposes, but it will not do for posts as it soon rots when stuck in the ground. The greater portion, however, is fit for nothing but fuel, and it is usual to see stacks of gnarled roots and great logs of timber piled near the cottages showing by their black colour whence they come. The birch trees are rotten, but their papery bark preserves its silvery lustre, like its congeners in North America, after the wood has crumbled away.

Most of the trees are mere trunks, broken off above the bole and at the fork, so that to the length observed we may generally add a quarter to obtain the original height of the tree.

The preservative character of the peat is shown by the presence of bark upon the *under* side of the trunks, where the tree was in contact with the peat, and between the buttresses at the base of the trunk. The bark has evidently wasted from the upper surface in consequence of decay having set in before the tree was covered up with peat.

The oaks are in all cases stained black; the yews retain their peculiar brown colour, and the timber of the firs is as white and sound as if from living trees; the odour of turpentine is distinctly perceptible in cutting the wood.

Direction of the Trees.—On the Geological Survey Map, showing the Fenland, I have in many cases laid down the direction of those trunks which, being exposed in dyke-sections, are unlikely to be disturbed. Unfortunately this excellent plan was not adopted at first, hence the absence of such marks from Sleaford to Peterborough. Where the head of the tree is seen it is indicated, but where it is absent or not exposed the direction of the trunk only is given. Still in most of these latter cases the position of the head can easily be made out.

Sufficient trees are, however, indicated to make this fact apparent, that the direction in which the trunks lie is almost invariably N.E. and S.W., varying scarcely a point either way, the heads being directed to the north-east.

A remarkable exception to this is, however, to be seen in the immediate neighbourhood of the island of Ely (*i.e.*, the high land on which Ely, Downham, &c. are situated). Thus in West Fen, near Downham, I found four trees, oaks and elms, lying within short distances of each other, whose heads bore N.E., N.W., N.E., and E. In the fen near Wood House, Chitisham, two trees, close together, bore respectively N.E. and E. by S. In Middle Fen, between Stuntney and Quaney two trees bore N.E. and N.N.E. These examples are sufficient to prove that in this locality the direction of the trees is not nearly so constant as in the open fen, but the prevailing direction is still north-easterly.

The direction of the trunks is often very clear in consequence of their intersecting the smaller dykes which bound the grounds. In such cases it is usual to leave the trunk so as to form a natural bridge across the dyke. Examples of this are abundant in West Fen.

In speculating upon the causes of the destruction of this forest, the direction of the trees must be constantly borne in mind. But this is exactly what most of the writers on the subject have omitted to do, and hence the opinion has prevailed that the forests were cut down by the Romans in order to destroy the hiding places of the Britons.* We shall show presently how untenable

* I here refer to the fens alone, for the influence of the winds has long been recognised elsewhere.

this position is, and how much older than the Roman period is the peat, which is itself for the most part more recent than the forest.

The direction of the trees in the Fenland agrees with that observed in the mosses of England and Scotland, and, as was first pointed out by Rennie in 1807, this is the direction of the prevailing winds. "If," says he, "in any moss they (the trees) lie "in one direction, the probability is that they have been overset "by the wind." This opinion has been endorsed by nearly all succeeding authors, and we will now proceed to show how true it is in regard to the buried forest of the Fenland.

Many of the dykes and droves are bordered by fine-grown aspens, and they slope towards the north-east. When a long line of these slender trees is seen thus bowed in one direction, the appearance is very striking. This north-easterly trend is towards the sea, but on the coast itself the sea breezes exercise their influence, and the trees all bend away from the water, as may be seen to perfection at Hunstanton. In Fig. 11 a group of trees sloping in the usual direction is represented; it was sketched in the neighbourhood of Holbech.

Fig. 11.—*Trees near Holbech.*

Among the islands of the Isle of Ely this unity of trend is not so noticeable, the reason plainly being that the winds eddy among the islands, and thus lose to some extent their normal direction.

The analogy between the lie of the buried trunks, and the trend of the living trees is perfect, and we may express it by saying that *the trees of the buried forest lie in the same directions as the living trees would take if free to fall.*

* Rennie on Peat. Edin., 1807.

But we can conclusively prove this statement by reference to the recorded observations on the winds of the fen-land.

Table I. in the Appendix shows the average number of days per annum on which the wind blows from the given point. For the Boston station the observations have extended over the seven years, 1864–70 inclusive, and at Wisbech over the ten years 1861–70, also inclusive. It will be noticed, however, that at Boston all winds between N. and E. are grouped as N.E.; between E. and S. as S.E.; between S. and W. as S.W., and between W. and N. as N.W.

Tables II. and III. show the distribution of the winds throughout the year, and Table IV. the percentage value of each wind per annum.

Hence it appears that the S.W. wind prevails in the fenland, the nearest rival is the N.W., but the S.W. wind has the advantage in the proportion of nearly 2 : 1; the N.E. wind is next in order, but the proportion is still more favourable to the "souwester." The chances are therefore greatly in favour of the trees falling in a N.E. and S.W. direction, and indeed the modern trees when uprooted take this course.

We must, however, distinctly remember that the casual uprooting of a tree in a gale, and the gradual decay of old forest monarchs will not account for the presence of the great numbers of trees which constitute the buried forest. The trees must have died *en masse*, and remained for years standing as the shadeless skeleton of a once dense forest before they succumbed to the influence of the wind. The agency of man was not, as we shall see, the cause of this universal death, for the trees are mostly *broken* off and never cut. A pseudo-level appearance is often presented by the broken stumps, in consequence of the peat having filled up the irregularities of the fracture; and this together with the uniform height of the stumps undoubtedly gave rise to the opinion that the trees had been cut down.

Another supposition is that the forest was destroyed by fire, and the old writers confidently assert that numbers of trees show signs of having been burned down. This again is a misconception, and seems to have arisen from the blackness of the oak wood, and still more from the carbonaceous appearance of the decayed bark, but it is certainly not true that to this agent we must ascribe the loss of the forest. Burned stumps are indeed to be found, notably in Wood Fen, between the highlands of Ely and Littleport. My attention was directed to this place by Mr. W. Marshall, of Ely, who showed me specimens of undoubted charcoal obtained by himself. I carefully examined the locality, and on one occasion was accompanied by Mr. Marshall Fisher, also of Ely. We found many burnt stumps in situ and several trunks slightly charred, but Mr. Fisher's conclusion was that the burning was of recent date, and in this opinion I am compelled to acquiesce. The reason for rejecting the notion of ancient burning is as follows. It is the custom over the peat district of the fen, to dig holes and set fire to the peat which burns gradually across whole fields, and in autumn the entire surface of the ground may be seen burning,* seldom with flame, often with little smoke, and so quietly that I have sometimes walked unwittingly into the smouldering ashes. The burning peat fills the atmosphere with a peculiar haze, locally known as "fen smoke," whose presence is often annoyingly indicated, at Ely at any rate, by the impossibility of getting clear photo-heliographs for days together. The object of the process is to obtain at little cost the valuable manure afforded by the peat ash, and the peat smoulders for weeks. Now the fire must often penetrate to the stumps and trunks of the buried trees and char their *upper* surfaces, especially in such localities as Wood Fen, where the trees are within one or two feet of the surface. Out of about 50 charred trees not one showed the slightest trace of fire except upon the upper surface, even the trunks being quite untouched beneath. If the trees had been destroyed by fire they would be charred *all round*, and as this is never the case we may dismiss fire from the probable causes of the destruction of the forest.

Another, and much more probable, cause is the chilling effect of the growth of peat, to which indeed we are inclined to ascribe the destruction of the forest. That the peat itself, and not the stagnant water, proved so deadly is probable; for in the great Matto of the Amazons, and in other localities, trees thrive though several feet of water cover the ground for months at a time. It is difficult not to ascribe some influence to the peat, because the trees have often broken across at a height corresponding with the thickness of that deposit. If we imagine a tolerably well drained forest-land converted gradually into a shallow pool, in consequence of the rivers being no longer capable of discharging the flood waters, and the fast growing *Hypnum* and other mosses, with bog plants of many species, taking the place of the green sward, whose decay instead of producing wood soil form dank peat, which clings around the trunks of the trees and arrests the ascent of the sap by cooling the trunks to the heart-wood, we can understand how the forest's vigour is checked, and its enfeebled life at length utterly destroyed. For a time the leafless oaks would sturdily maintain their ground, but the fell influence of the sodden peat, eating into the stems which had no power to resist, would undermine their strength and they would yield to the unceasing pressure of the wind, and falling, be entombed in the material which, their destroyer in life, became their preserver in death.

Peat itself is not an unkindly soil for the growth of trees as is observable to perfection both here and in some of the Irish and Danish bogs where definite horizons of trees are seen, showing that when the waters abated and the bog became tolerably firm ground the land yet again supported trees in abundance; but to this question we shall return directly.

* This practice is I believe not general on peaty soils, though the advantages are great. Only one case is mentioned in the Vienna Exhibition Report (1875) on Peat, in which the process is adopted on the Continent.

It is interesting to observe that much as the physical features have changed, and the meteorological condition too, the fickle wind which bloweth where it listeth has been constant, and as steadily blew from the south-west over the old forest as it does now over willows, aspens, and anemometers.

Origin of the Forest.—The earliest records combine to prove that the Fen border-land, especially in the counties of Huntingdon, Cambridge, and Lincoln, were covered with forests, and there can be no reasonable doubt that such was their condition long anterior to the dawn of that civilisation which everywhere distinguishes itself by a mania for cutting down trees. So long, however, as the waters, salt or fresh, held dominion over the lowlands the forests stopped upon the borders; and the saplings, which spread so industriously, and the seeds which are strewn so widely met with no encouragement until the land became firm. Then indeed they grew and throve, creeping down into the fens as the waters retreated, and thus accounting for the fact that the true forest of timber trees is confined chiefly to the vicinity of the highlands, and only the moisture-loving willows, sallows, and alders decked the open country.*

We have seen that throughout what may be called for convenience "the fen period," (from the gravel upwards), the climate was favourable to the production of peat. But there were intervals, even when the sea held no sway, in which it did not form, or at least only in limited areas. It was during these respites from aqueous dominion that the forests grew, and the longest of them was not very long anterior to the termination of the peat growth, for we find at from four to eight feet over the Isle of Ely and Lincolnshire a wide-spread multitude of oaks, &c. They grew for the most part upon a thin layer of peat and sent their roots down into the fen clay and when that is thin, as in Ring Moor, near Billinghay, into the older beds, in this case consisting of Boulder Clay.

In the neighbourhood of Ely a succession of forests can be clearly made out, as was pointed out to me by Messrs. Marshall and Marshall Fisher of that city; both diligent observers of fenland phenomena, who having lived therein for many years, have enjoyed great opportunities of observing the exact position of the trees.

The former gentleman assures me that the yews (*Taxus baccata*) are invariably found in the lowest positions, rooted in fact in the sand, which is found at a depth of from ten to twelve feet. The following sketch is from a drawing by him

* It has been shown (p. 22) that the most ancient forest of which we have historic proof was not, in the fen, a *woodland*, and that the trees did not reach the border of the low lands. We cannot point to any part of the buried forest as a relic of historic woods; but, on the contrary, we can be certain that they are remains of far older ones. In this the peat of the Fenland seems to differ from much of that of Scotland, which Mr. J. Geikie has shown to contain timber of Roman and more recent date. Peat grew in force in those northern regions long after the climate had ceased to favour its production in the fens.

made on the spot, and shows, moreover, the peculiar manner in which the roots spread out instead of sending down a tap-root deep into the ground. This feature is common to the oaks and firs in the district, and seems to show that the trees found nourishment alone in the particular beds which they traversed.

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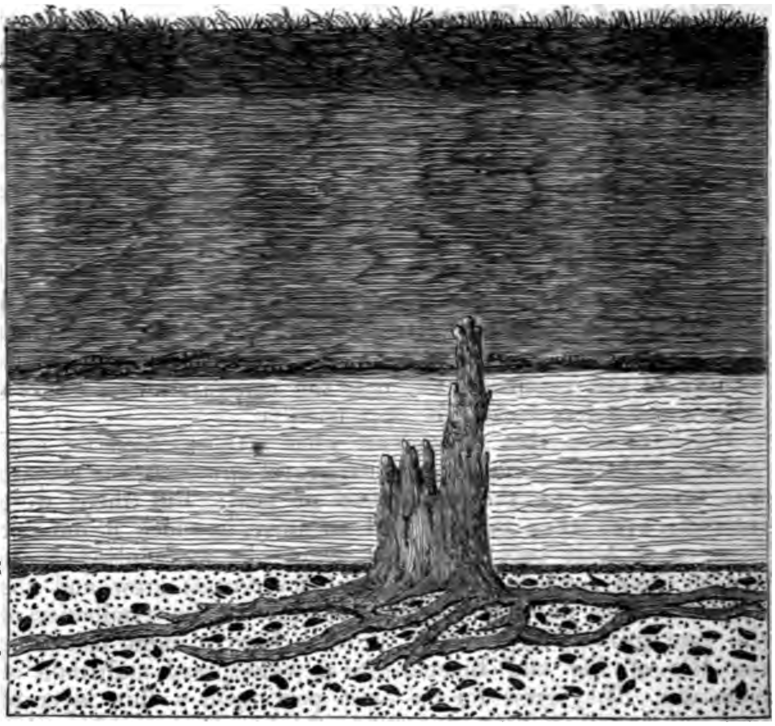

Fig. 12.—*Marshall's Yew.*

1, 2. Peat.
3. Do., full of twigs.
4. Clay.
5. Peat, with twigs.
6. Gravel.

In the neighbourhood of Hilgay the yews are abundant in the sand, but this bed is not continuous, and where the fen base is formed of Kimeridge Clay the yew gives place to oak.

The exposure at Hilgay I have not been fortunate enough to observe, but on the 7th December 1874, in company with Messrs. Marshall and Fisher, I visited Wood Fen between the highlands of Ely and Littleport and, with the assistance of the workmen, we obtained highly satisfactory evidence of the succession of forests. We carefully examined the fen from the Ely side to its centre, and at right angles also; and, wherever it seemed necessary, had the trees dug out or the fen beds bottomed.

The peat at first lies directly upon the Kimeridge Clay, upon which a few stones are scattered giving a somewhat boulder-clay-like appearance to the upper foot or so. The peat gradually thickens from one to eight feet, and at about three quarters of a mile west of the high-road fen clay comes on about two feet thick, underlaid by 10 inches of the fetid peat known as "bear's muck."

The general result of our investigation may be thus stated. At the base of the peat, with the roots bedded in the Kimeridge Clay, a forest of oaks is found. The trunks are broken off about three feet from the roots, and the trunks lie generally very nearly N. and S., but with exceptions. Some of these trees are of fine proportions, measuring three feet in diameter, are quite straight, and very seldom forked. Under their roots the Kimeridge Clay is often preserved, as if the general level had been reduced by denudation before the formation of the peat.* The workmen are of opinion that the trees in falling have prised up the clay, but in most instances the trees have not been overthrown, but broken off. It was quite striking to see clay thrown up on to the bank by the men who were deepening the dyke whenever an oak was found. As the clay approached the surface the oaks, of course, came up with it, and on the margins of the fen the stumps were within two instead of full eight feet of the top. We will call this forest No. 1.

At an average height of two feet above forest No. 1 the remains of another are found, consisting of oaks and yews, the former often rivalling their more ancient brethren in magnitude; the latter generally but two or three inches, though occasionally a foot, in diameter. That forest No. 1 had succumbed to deadly influences before the growth of the trees in question is proved by the newer trees being sometimes seated upon the broken stumps or astride the prostrate trunks of the older trees; indeed the trees in all the forests to be noticed seem to possess a partiality for such strange situations. Mr. Marshall observed that he had in Switzerland sometimes seen as many as four young firs astride a fallen trunk. Fig. 13 represents a yew upon the stump of an oak,

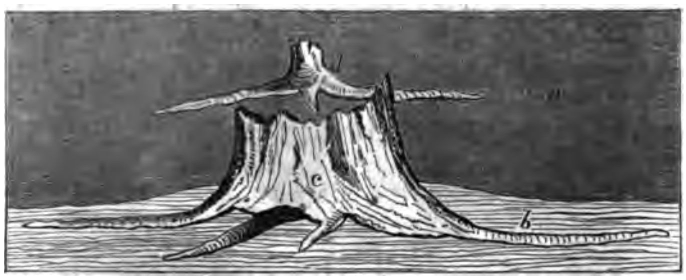

Fig. 13.—*Yew growing upon Oak in Wood Fen.*

a. Peat, 6 feet. *c.* Oak.
b. Kimeridge Clay. *d.* Yew.

and also the underlying clay preserved beneath the latter as before mentioned.

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* See Fig. 13.

The trees do not lie so regularly as in the lower forest, and many trunks lie across the older ones at right angles, or from E. to W. We will distinguish this forest as No. 2.

Three feet above forest No. 2 lie the remains of another, in which the trees are all firs, probably *Pinus sylvestris* (Scotch fir), but as we could not find cones, the species is doubtful. Some of these firs must have been of colossal dimensions; one was quite 3 ft. 6 ins. in diameter at the base of the trunk. Similar undoubted evidence of the relative age of this forest is to be obtained and in Fig. 14 an uprooted fir is shown which grew over an oak

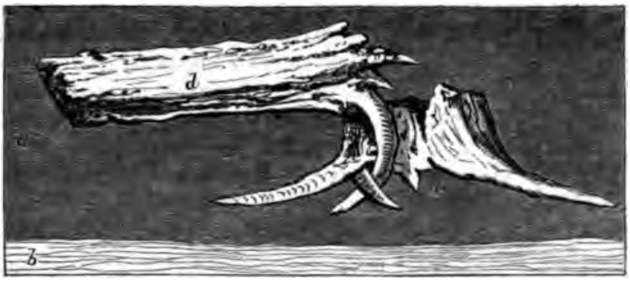


Fig. 14.—*Fir clasping Oak, Wood Fen, near the old "Blue Boar."*

a. Peat, 5 feet. *c.* Oak.
b. Kimeridge Clay. *d.* Fir.

and sent a great root right underneath it, which has been twisted in the fall, but has not given way. This forest will be distinguished as No. 3.

Immediately above it, and (now) close to the surface, is a yet newer line of firs, exclusively confined to the Ely side of the fen. The trees are all small, and in a dyke alongside a small spinney four are seen astride of the older ones. Fig. 15 represents one of

Fig. 15.—*Fir astride Fir, Wood Fen.*

a. Peat. *b.* Fir. *c.* Fir.

these, the cut end of the lower tree having been severed in making the dyke. This we shall call forest No. 4.

Numerous remains of sallows, willows, and alders are found in the peat close to the surface, and may be termed forest No. 5, but it is probably of historic date, and the trees are of the same species as those now growing in the fen, which are very probably their immediate descendants.

It is therefore clear that in the Isle of Ely the following succession of forests is determinable. The depths given are maxima, for, as the fen beds thin towards the highlands, the forests become crowded together.

5. **Sallow** (*Salix cinerea*) **Willow** (*Salix*, several spp.) **Alder** (*Alnus glutinosa*)	in peat at	-	1 foot.
4. **Fir** (*Pinus sylvestris?*)	,, ,,	-	2 feet.
3. **Fir**	,, ,,	-	3 ,,
2. **Yew** (*Taxus baccata*) **Oak** (*Quercus robur*)	,, ,,	-	6 ,,
1.* **Oak**	in clay at	-	8 to 10 ,,
Yew neighbourhood of Hilgay	in sand at	-	8 to 10 ,,

The only species in the above table not now living in the district is the fir, if the determination of the species be correct.

This succession, however, does not hold good over the rest of the Fenland; for, as a rule, trees of several species occur together. Thus De Serra and Sir Joseph Banks mention birch, fir, and oak as occurring together in the "forest bed" at Sutton on the Lincolnshire coast, which, though not in the Fenland itself, is in its northern extension. Mr. Frere, too, in his notes to Mr. Well's paper on Whittlesey Mere describes Scotch fir, birch, and hazel as being found in a bed of peat, underlying clay, at a depth of 20 feet.†

Although the succession of species did not, probably, obtain generally over the Fenland, the succession of *forests* did. Thus in the Isle of Ely we see evidence of five successive forests, in this case each characterised by its own species.

In the following table I have arranged, in as close geographical sequence as possible, the list of localities at which evidence of buried forests have been obtained. Where the forests are close to the surface only a very few typical localities have been selected, for the trees often lie so thick together that the difficulty would be to select a spot from which they are absent. Where, however, the trees lie deep and are only reached in isolated sections every case known to me is cited.

* It is to be noticed that the oak and yew do not occur together as in No. 2, but occupy separate areas dependent upon the nature of the subsoil.

† Section No. 73, Appendix, p. 264.

TABLE of BURIED FORESTS.

No.	Locality.	Trees.	Depth.	Thickness of Fen Beds.	Nature of Base.	Observers.
			Feet.	Feet.		
1	Irby - -	Oak -	7	22	Clay -	S. B. J. S.
2	Thorp Fendyke	„ -	7	30*	„ -	„
3	Thorp Culvert -	„ -	10	25	„ -	„
4	Stickney -	„ -	4	6	Sand -	„
5	Lade Bank -	„ -	7	10*	? -	W. H. Wheeler.
6	Digby Fen -	„ Elm, Birch, Hazel.	10	10	Clay -	S. B. J. S. and W. H. W.
7	High Bridge, Boston.	„ -	14	14	Sand -	S. B. J. S.
8	Grand Sluice, Boston.	„ -	18	18*	„ -	W. H. Wheeler.
9	Star Fen - -	„ -	5	5	Gravel -	S. B. J. S.
10	Bourn Fen -	„ Yew -	3	10	Clay -	„
11	Deeping St. Nicholas.	? -	20	+30	„ -	„
12	Lynn - -	Alder, Hazel	13	43	„ -	S. Smith.
13	Eaubrink Cut -	„ „	20	+20	„ -	C. B. Rose.
14	Walsoken -	Sallow -	6	+12	„ -	S. B. J. S.
15	Croyland - -	„ -	6	7	Sand -	„
16	Hilgay - -	Oak, Yew -	10	10	Clay or Sand.	W. Marshall.
17	Felldale Drove -	"Timber trees."	26	28	Clay -	Railway Boring.
18	Glassmore -	Oak -	2	12	„	Dr. Porter.
	„ - -	„ -	12		„	
19	Whittlesey Wash	? -	21	25	Gravel -	Railway Boring.
20	„ Mere	Fir, Birch, Hazel.	21	21	Clay -	P. H. Frere.
21	Manea - -	Oak, Yew -	25	?	? -	S. B. J. S.
22	Warboys Fen -	?	12	18	Peat -	Railway Boring.
23	Wood Fen -	Oak, Fir, Yew, Sallow, Alder.	1, 2, 3, 6, 10	10	See p. -	S. B. J. S.
24	West Fen, Ely -	Oak -	3	?	Clay -	„
25	Soham - -	„ -	5	5	„ -	„

* An asterisk attached to a number signifies that the depth is doubtful. The plus sign prefixed to a number signifies that the depth is certainly greater than stated.

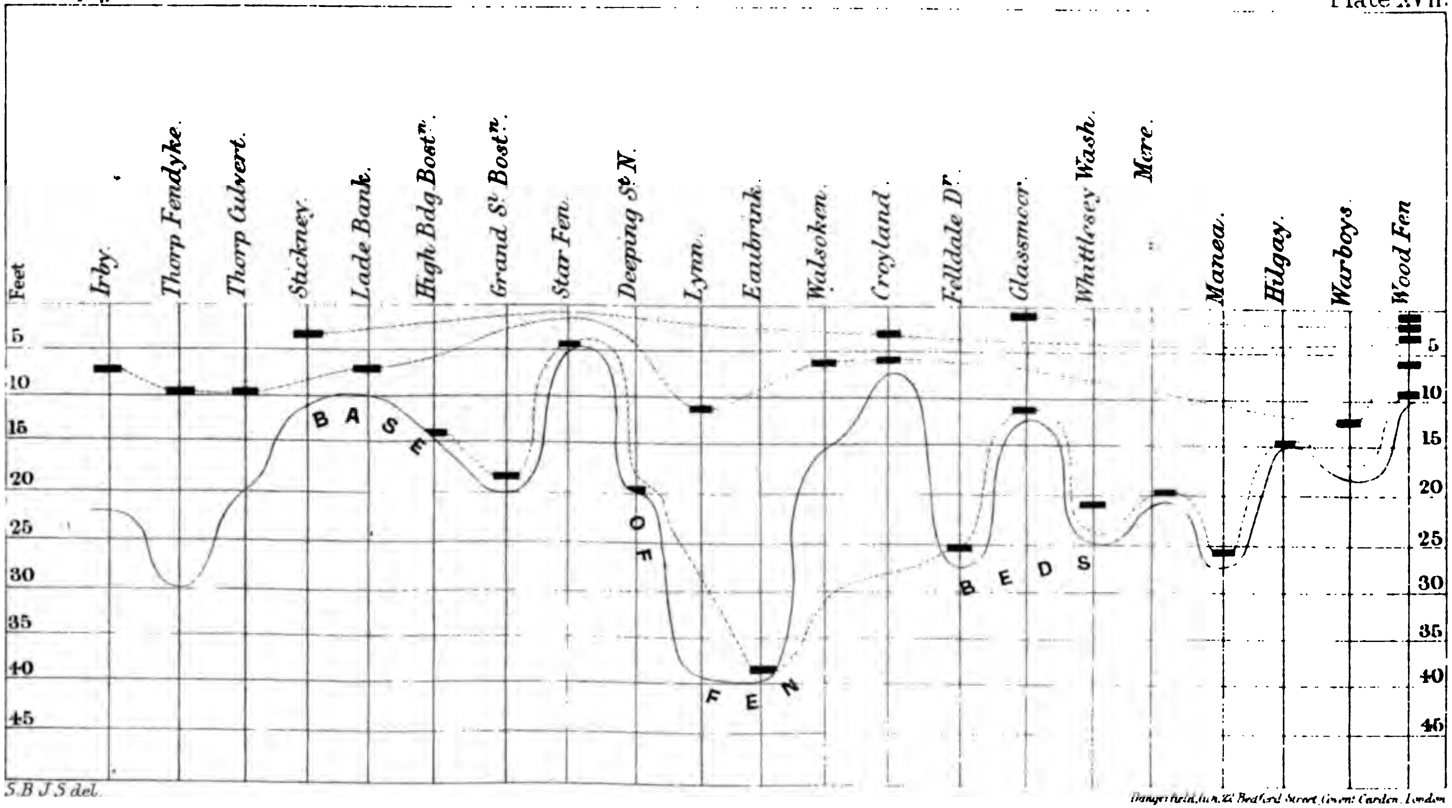
In the above table the thickness of the fen beds is the depth down to the gravel, or to the clay, where that deposit is wanting. By "nature of base" is understood the character of the soil in which the trees grew.

The opinion that there was but one bed of "Lower Peat" was found to be untenable when the levels were discussed; and so, in like manner, the accepted idea of "*the* Buried Forest." We have proved that near Ely there are five successive forest-beds, and the table shows that some of these have representatives in other parts of the fen. To illustrate the present state of our knowledge of these old forests I have drawn a diagram, Plate XVII., in which the base of the fens is shown by a continuous

GEOLOGICAL SURVEY OF ENGLAND AND WALES.

To face page 170.

Plate XVII.



HORIZONS OF THE BURIED FORESTS.

line, the horizons of the forests by thick black strokes, and a dotted line joins those that, in my opinion, *may* be contemporaneous. I emphasise the word *may* because this is one of the nice questions that remain to be worked out by local geologists, for hitherto the very existence of these successive forests has been unsuspected.

It will be noticed that I have grouped the forests into four horizons, corresponding to the lowest four at Wood Fen. Of these I have connected all that lie upon the basement bed of the fens; and, whether they are actually contemporaneous or not, they show that after the formation of the gravel a well-drained land surface existed. The next horizon includes the trees which occur at about 10 feet from the surface; the third those about 5 feet from the surface; the fourth those nearer the surface than the third. Whether these correlations will stand the test of increased knowledge cannot be predicted, but the agreements are sufficiently pronounced to justify the present classification.

The presence of these forests enlightens us still more respecting the climatal and physical conditions of the "fen era." They show us that, even where a continuous bed of peat, say 20 feet thick, occurs, we must not hastily assume that it has grown uninterruptedly. The trees themselves lived sometimes for more than a century, and to this time must be added an even longer period to allow of the extension of the forests from the highlands. Forests spread very slowly, and in most cases where clearings have been made and abandoned, centuries elapse before the trees obtain the mastery in the struggle for existence. The "hold" which plants have upon the soil is not sufficiently realised, and lands which have become differently circumstanced from natural or artificial causes, may always be recognised by the almost artificial distribution of the new plants. For example, wherever human habitations have been raised nettles grow, and though the abodes may be rased and the land be left uncultivated the nettles are almost indestructible, and will grow to the exclusion of almost every other plant. Thus I have often seen the sites of old habitations preserved hundred of years after the fabric has disappeared.* Another example of this persistence of plants is found in the Ivy-leaved Toad flax, *Linaria cymballaria*, which affects old walls. I know of an example in which some monastic buildings were destroyed all but the base of one wall about the time of the dissolution of the monasteries. This fragment of a wall is overhung by a hedge, and hidden from below by a luxuriant growth of ferns and umbellifers, yet there, and there only for miles around, is the plant in question to be found.

One more illustration will suffice; and this to prove the peculiar mode in which new lands become clothed with vegetation. When the railway was made from Chichester to Littlehampton the old canal was abandoned and the water drawn off, so that only a moist

* In Arundel Park, Sussex. The absence of nettles is one of the best proofs that the New Forest is natural.

bed remains near Chichester. This is completely filled with marsh plants, but their distribution is strikingly peculiar. The common plants *Epilobium hirsutum, Poa aquatica, Typha latifolia and T. angustifolia,* and which naturally live intermingled, have each obtained exclusive possession of certain areas in a most singular manner, looking like planted beds. How long will they take to mix?*

When we consider the gradual change from bog to dry land and its influence upon the flora, we shall be the better able to appreciate the interval of time between the cessation of the growth of peat and the commencement of that of timber. First, the purely acquatic plants would die out, and the marsh plants would have a greater area to live in. As the soil became drier other plants would die, those which required most moisture going first; until at length most of the marsh plants would vanish. In the meantime the upland plants with a moisture-loving habit would push their way into the desiccating fen, and at length a "meadow-land" flora would establish itself. But how about the trees? Willows, sallows, and alders would hold their own for a long time, and even increase their bounds; and all these things are against the advancement of timber-trees. Nevertheless they do spread—how slowly none hardly can tell. We are, then, more likely to err by under-estimating the duration of the "peat breaks," than by ascribing to them too great a duration.† Whether the dryness of the soil arose from better natural drainage, or from diminished rainfall cannot be determined: both suppositions involve difficulties. The former requires greater oscillations of level than I see grounds for admitting, the latter involves no less variation in climate. That the climate has grown gradually drier, the cessation of peat-growth proves; and the present *may* be one of the dry periods. The direction of the fallen trees shows that the prevalent winds are the same as heretofore, and the S.W. wind is the rain-bearing wind. This is another point that extended research only can settle.

We have shown in Chapter III. that the ancient forest of Kesteven, &c. was not a woodland, but merely open country; and the questions we have been discussing furnish weighty evidence against the destruction of the buried forests by the hand of man. These forests, and most of the peat, are far older than the historic period, and older too than any British forest-clearing race.

* It is to be noticed that these plants have strong creeping roots, by means of which they push all weaker things out of their way, and so secure the best places. Nature and human nature are so much alike. See some admirable remarks on forest growth in Belt's Nicaragua.

Mr. Marshall informs me that the following plants have become extinct in the Bedford Level within the last 25 years, *Senecio palustris, Cineraria palustris, Malaxis paludosa,* and *Liparis Lœseleii,* and the following are fast dying out, *Statices aloides, Villarsia nymphæoides, Cladium mariscus,* and *Teucrium Scordium.*

† Since writing the above I find M. Axel Blytt has arrived at precisely similar conclusions respecting the peat beds of Norway. "On the Immigration of the Norwegian Flora during alternating Rainy and Wet Periods." Christiania, 1876.

CHAPTER XIV

THE FEN SILT.

Nomenclature.—In treating of the peat we were obliged to discuss many questions bearing upon the silt: such points will not be again noticed, and this chapter will be devoted to questions solely pertaining to the silt.

I have preferred simply to call this deposit Fen *silt* as a comprehensive term embracing the different phases the deposit assumes. Mr. De Rance and others have termed similar deposits elsewhere "Scrobicularia clay," from the prevalence of *Scrobicularia piperata*. I have not adopted this term because such clay is only one aspect of the fen marine beds. Neither have I accepted the well-known fen term "buttery clay" for similar reasons. "Warp," again, is open to the same objections; whereas the term *silt* equally applies to the sandy and clayey facies, referring only to the mode of formation, and not to mineralogical or palæontological accidents.

It has been hitherto supposed that beneath the peat a bed of unctuous clay, locally known as "buttery clay," was universally found, and that the sandy warp was a perfectly distinct thing. I shall show that this clay, the Scrobicularia clay and the warp are only phases of one deposit, that there is no distinct "buttery clay," that all the beds I include as silt are of marine origin, and that, there have been multitudinous oscillations between land and marine conditions. This last case, however, has been pretty fully worked out in speaking of the peat.

The buttery clay acquired its spurious importance from the fen having been first studied in South Lincolnshire and the neighbourhood of Cambridge where indeed it is tolerable persistent, but when a wide area is examined it appears that this is only a local character. Prof. Seeley, Prof. Sedgwick, Dr. Porter, Mr. Bonney, and others have adopted it as a determinable bed, but the proofs of its local character are so abundant and indisputable that I hope my name "Fen Silt" will be allowed to supplant the others. It is true that buttery clay in its typical character can be easily discriminated, but it merges into Scrobicularia clay on the one hand, and sandy warp on the other.* Indeed the latter clay often only differs from the former in the presence of the bivalve from which it derives its name.

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* Mr. Bonney admits this, but does not recognise the existence of the great clay and warp deposits to the east. Geol. Cambridgeshire, p. 58.

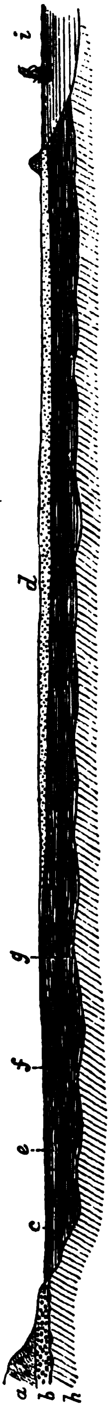

Fig. 16.—*Supposed section across Fenland.*

a. Boulder Clay. *b.* Gravel. *c.* Upper Peat. *d.* Warp. *e.* Buttery Clay. *f.* Lower Peat. *g.* Clay not named.* *h.* Old Rocks. *i.* Sea.

Speaking generally, it had been assumed that the section of the fen deposits was as in Fig. 16. But we have already shown that such does not represent the facts of the case. Indeed it is impossible to give any general section, for the peat and silt alternate in complicated manners, according to the locality. Sections 1, 2, and 3, Plate XXII., give the actual lie of the beds through Sleaford and Boston, Bourn and Spalding, Peterborough and Wisbech respectively.

Description of Beds.—The Fen Silt can be most readily described under two facies: clay and warp.

The clay varies in colour from light to dark-blue and purple, but is often mottled blue and purple. It is generally tolerably free from sand, and is what brick-makers call "light" clay, or shrinks considerably on firing. It is always mixed with sand or warp for brickmaking, but even then shrinks greatly. The following examples will show this:—

1. *Mr. Leak's Brickyard on the high road to Kirton, in Wyberton parish.*

Size of mould	-	10½ to 10¾ inches long.
,, burnt brick	-	9 inches.
Shrinkage per cent.	-	14·3

2. *Boston East Brickyard, High Bridge Drain.*

Size of mould	-	10×5×3¼ inches.
,, burnt brick	-	8½×4¼×2⅝ inches.
Shrinkage per cent.	-	27·7

3. *Cow Bridge Brickyard, Boston. Mr. J. Thornley.*

Size of mould -	-	10×5×3¼ inches.
,, burnt brick	-	9×4½×3 inches.
Shrinkage per cent.	-	25·2

4. *Brickyard close to above.*

Size of mould -	-	10×4½×3¼ inches.
,, burnt brick	-	9×3×3⅜ inches.
Shrinkage per cent.	-	37·2

* According to Mr. Bonney the Lower Peat is not underlaid by clay. Geol, Cambridgeshire, p. 57.

5. *Bettinson's Brickyard, Howbridge Drain.*

Size of mould - - -	$10\frac{1}{8} \times 4\frac{3}{4} \times 3\frac{1}{4}$ inches.
„ bricks (dry) - - -	$9 \times 4\frac{1}{4} \times 3$ inches.
„ „ (burnt) - -	$8\frac{3}{4} \times 4 \times 2\frac{3}{4}$ inches.
Shrinkage per cent. - - -	38·3

6. *Star Fen Brickyard, Heckington.*

Size of mould - - -	$10\frac{1}{3} \times 5\frac{1}{4} \times 3\frac{1}{2}$ inches.
„ bricks (dry) - - -	$8\frac{3}{4} \times 4\frac{1}{4} \times 2\frac{5}{8}$ inches.
„ „ (burnt) - -	$8\frac{5}{8} \times 4\frac{1}{4} \times 2\frac{5}{8}$ inches.
Shrinkage per cent. - - -	50·7

7. *Gilder's Brickyard, Holbeach.*

Size of mould - - -	$10\frac{1}{8} \times 5\frac{1}{4} \times 3\frac{1}{4}$ inches.
„ brick - - -	$9\frac{1}{8} \times 4\frac{1}{2} \times 2\frac{3}{4}$ inches.
Shrinkage per cent. - - -	34·6

8. *Andrew's Brickyard, Wisbech,*

Size of mould - - -	$10 \times 5\frac{1}{4} \times 3\frac{3}{4}$ inches.
„ brick - - - -	$9 \times 4\frac{1}{2} \times 2\frac{3}{4}$ inches.
Shrinkage per cent. - - -	43·4

9. *Walsoken Brickyard.*

Size of mould - - -	$10 \times 5 \times 3$ inches.
„ brick - - - -	$9\frac{1}{3} \times 3\frac{1}{4} \times 2\frac{3}{4}$ inches.
	43·4

These examples show the character of the clay for economical purposes. The bricks are very poor, being soft, friable, and often ill-shaped and cracked. They are generally burnt in kilns, but often, when farm-buildings are about to be erected, the clay is dug on the spot, and the bricks are fired in clamps.

The clay often contains carbonaceous markings, and fragments of wood, and occasionally drifted trunks of sallow and willow. When wood is plentiful the bright blue phosphate of iron (*Vivianite*) occurs in amorphous earthy lumps and streaks, varying in size from fine specs to bits as large as a bean. Stones are exceedingly rare in it, nor is this to be wondered at when we remember that the clay is a tidal deposit brought up by the sea, and not material washed down from the adjacent land. It is seldom stratified, but generally breaks up into rounded lumps with a glistening surface. Its unctuous character in some places has caused the name "sheep's ointment" to be given to it, a nasty dark-blue substance which it much resembles; this, however, is only a local variety. When the roots of the reed (*Arundo phragmites*)* have penetrated it, it becomes very fetid and is then termed "bear's muck," which poetical appellation is also applied to it when full of peaty matter, and the stems of the coarse grass still known to fen-men by the Saxon name "lead" (Saxon lid, *Poa aquatica*). It is also frequently called "fen clay" to distinguish it from the "strong highland clay," Oxford or Kimeridge, as the case may be.

* These roots penetrate very deep, and pierce hard materials in an astonishing manner. I have seen one which had bored right through an oak trunk lying in the peat, and the roots may often be seen passing through sallow trunks.

The organic remains almost solely consist of *Scrobicularia piperata*, many in single valves, but a fair average with both valves in situ as when the animal lived. A few shells of *Tellina Balthica* occur, and in places dwarfed specimens of *Cardium edule, Mytilus edulis,* and *Ostrea edulis.* In some few places, as at Quadring, little *Rissoæ* are plentiful, and an occasional *Mytilus edulis* completes the list of shells. Here and there a few bones of *Bos, Sus,* whale, seal, and grampus are exhumed, but very sparingly. I have never found or seen a *Mya* or *Solen*, though they are common enough in the Wash, neither does the *Cyprina Islandica* occur, though it also lives in the bay. Foraminifera are exceedingly plentiful throughout both clay and warp, and are found right up to the borders of the highland, which is not the case with the mollusca.

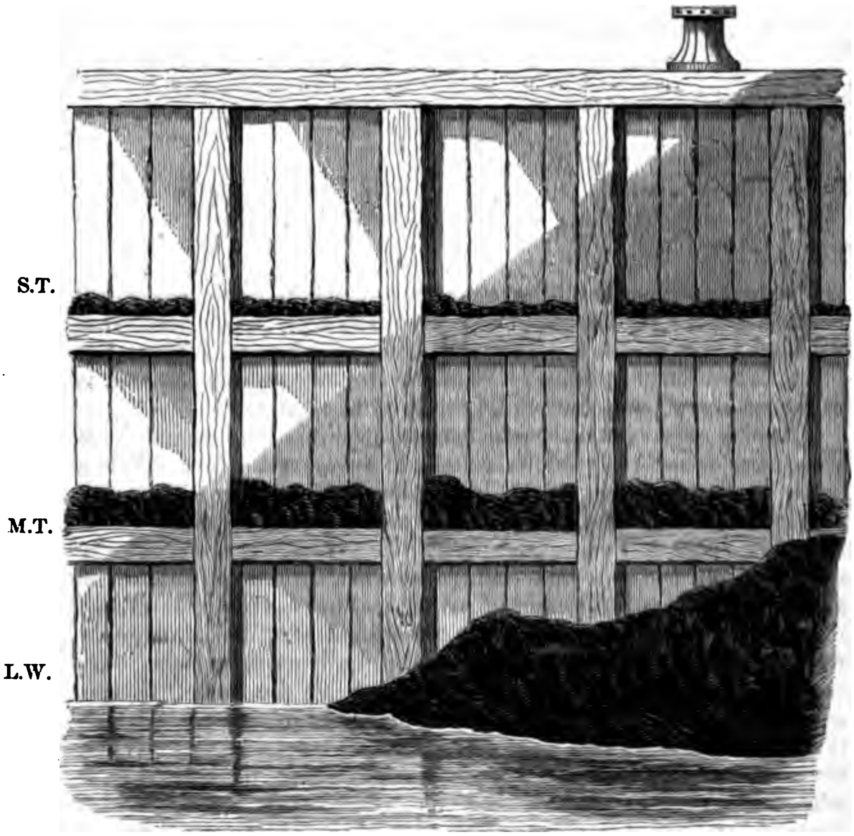

Fig. 17.—*Silt deposited on Timbers at Wisbech.*

S.T. = Height of Spring Tides.
M.T. = ,, Mean ,,
L.W. = Low Water Springs.

The warp is an exceedingly fine sandy deposit of a light reddish-brown colour, lying in fine laminæ which sparkle in the sun with fragments of mica and comminuted shell. It is not so widely spread as the clay, but forms most of the surface of the ground in the neighbourhood of the sea, fills up old creeks, forms little hillocks, and extends far inland in places, as may be well

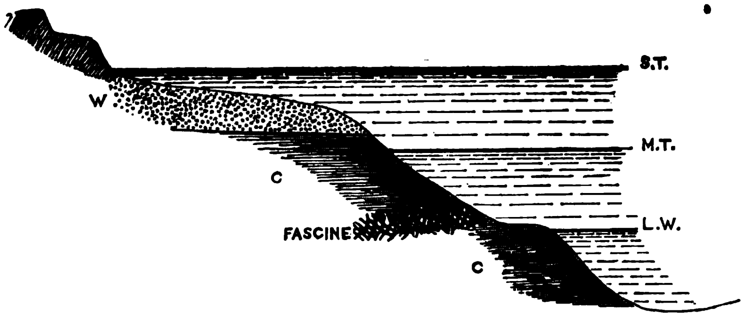

Fig. 18.—*Silt deposited on Natural Bed at Wisbech.*

S.T. = Height of Spring Tides.
M.T. = „ Mean „
L.W. = Low Water Springs.
W. = Warp deposited.
C. = Clay.

seen in a pit a little to the east of Counter Drain Station, [Section No. 152, Appendix.] The warp gives to the surface of the ground a ruddy tint, very distinct from the coaly peat-surface, and it is not unusual to hear of "red fen," and "black fen." It is very full of foraminifera, hardly a square inch being destitute of their remains.

That the different clays and warp are in reality but one deposit cannot be doubted by anyone who has watched the silt forming on the coast or in the rivers. Every variety can be observed in process of deposition. As a rule the clay is thrown down in deeper water than the warp, as may be observed along the timbered river-face at Wisbech. Thus, in Fig. 1, it is seen that the warp is deposited on the timbers and the Clay in the river bed. Fig. 18 shows that on the natural bed the warp is thrown down chiefly above the clay. Now these two materials are forming every tide, and the clay is often the exact counterpart of the "buttery clay."

But the same thing can be equally well noticed in the fen itself. Before the true relation of the fen beds had been determined I had written descriptions of sections which puzzled me much from their similarity to those in the buttery clay. One such is: "Witham Bank, close to the Black Sluice. Laminated light blue "clay with yellow markings very similar to ordinary buttery clay "is seen at this spot, 4.7.71." The abrupt change from clay to warp is shown in Sections Nos. 129 to 131, near Boston. In the first there are 11 feet of strong blue clay, and no warp; in the second the section is all warp and no clay. The alternation of warp and clay is shown in Section No. 174, at Dogdyke, where 6 feet of clay are underlaid by 3 feet of warp. The intersection of the clay by a creek filled with warp is shown in Section No. 175, at Howbridge Drain where in one part of the pit 6 feet of clay are found, while at another part the clay is completely cut away by a creek filled with warp. The gradual transition of clay into silt is seen at Postland, near Croyland, Section No. 36. In the western portion of the pit the silt is blue clay, which passes insensibly into brown sandy warp on the east. We have thus given examples of every graduation between the clay and the warp, and numerous other cases might have been cited, and many may be culled from the list of sections in the Appendix. There can be no doubt that the "buttery clay," is only one facies of the silt which covers about 500 square miles of the surface of the Fenland. Even if these sections are not sufficient proof, the actual survey would render this evident, for it is impossible to proceed on the old assumption, and the peat-lines across Deeping fen would clear up any lingering doubts that might have remained.

In the chapter on the Wash we have stated that the silt is derived from the sea, and that it is still in process of formation. The coarser material, sand and gravel, is deposited first, and the finer matter, silt, only in still water. On the coast the deposition is slightly different from that in the estuaries. In the former case the sand is deposited nearly up to high-water mark. The water which overflows the bank is then only the end of the flood, the slack, and the beginning of the ebb, consequently the current is never strong. During the slack the flocculent matter which forms silt is deposited, and the slight movement of the ebb and flood is not sufficient to disturb it. When the bank is in this way raised a little higher the Glasswort (*Salicornia herbacea*) locally known as Samphire, begins to grow. Its stems greatly facilitate the deposition of silt, which now rapidly accumulates, until at length only very high spring-tides can overflow it. It has now become salt-marsh, and the typhical marsh flora establishes itself. The "samphire marsh," is always distinguished from that which, having become covered with verdure, is called "green marsh." They occupy determinate levels as under:—

Samphire Marsh	- -	8·6 feet above Ordnance Datum.
Green Marsh	- -	11·0 „ „

or referred to low-water springs,—

Samphire Marsh	- - - -	18·54 feet above.
Green Marsh	- - - -	19·86 „

The present level of the highest part of the green marsh, just outside the banks, near the Witham, is 13·25 feet above Ordnance datum, and 23·11 feet above low water springs at Clayhole.

In the estuaries the silt is deposited over the entire bed at high-water slack, and when the river is good most of this is cleared away during the ebb; but when the river is defective it accumulates, as we have seen, with disastrous certainty.

The surface of the warp laminæ are often ripple-marked, but even where this is not apparent to the naked eye, it can always be detected by the microscope. As the ripple-marks are always broadside-on to the stream, they afford a means of determining the set of the currents which have deposited the silt in the interior of the fenland. To accomplish this, however, an immense number of specimens must be examined, and the points of the compass marked on them before they are removed from the ground.

The disengagement of air from the dry silt on the rising of the tide often causes the surface to assume a "pimply" appearance, and flakes float away and are carried to higher levels. Sometimes, when the water is still, its surface is covered with floating fragments of silt, and a considerable quantity must thus be removed in the course of years.

The accretion of land has been going on in some part of the fenland from the earliest times. In estimating the rate of this accretion, we must remember that not thickness only, but horizontal extent, must be taken into consideration. We have no data for estimating the rate of pre-historic accretion, but the rate since the Roman occupation can be approximately estimated.

On the Index map, and still more vividly on the Geological Survey map yet to be published, are laid down the embanked lands; the Roman bank being coloured red, the land enclosed before the end of the 17th century blue, in the 18th century pink, in the 19th century bright green, the present green marsh and samphire dull green. Most of these details are from Prof. Gordon's Admiralty Report on the Lincolnshire Estuary Bill, 1851; but the recent inclosures have been kindly laid down for me by Mr. W. H. Wheeler, C.E., of Boston.

The original position of the Roman banks, in reference to the sea, cannot now be determined; hence we are unable to say how much (if any) land was reclaimed by them. The following are the approximate quantities reclaimed during the subsequent periods:—

EMBANKED LANDS.

Date in Centuries.	Acreage of Enclosures.	Maximum Breadth in Miles.	Minimum Breadth in Miles.	Position.
2nd to 17th	35,000	4·5	2·07	Entirely along the base.
18th	19,000	1·7	0·92	Base, and E. Holland.*
19th	10,000	1·0	0·60	" " "
2nd to 19th	64,000	5·0	Base 3·45 E. H. 0·44	

Four points require consideration in this question:—*First*, that on each side of a line, called the Axis of Accumulation, (shown on the Index map), which runs from about Lynn Knock to Whaplode Church, the accretion has been nearly equal, as is shown by the

* East Holland, in Lincolnshire.

area of the embanked lands, marsh, and barren sands; and that the watershed is roughly parallel with this axis.* *Second*, that along the Norfolk coast the accretion has been *nil*. *Third*, that along the base of the bay the accretion has been most rapid. *Fourth*, that the accretion on the East Holland coast has been small, and the inclosures, with the exception of about 1,200 acres south of Wainfleet, have been made in the present century.

With respect to the Axis of Accumulation, we notice that the sands lie closer to it on the Holland than the other coast, though the areas are equal. Prof. Gordon remarks that, "On this axis "of accumulation Herring Sand, Hook Hill, Mare Tail, Roger "Sand, and Long Sand are being gradually shoved up to Holbech, "Moulton, Gedney, and Fossdyke sea-banks; and, in the course "of time, after various temporary changes of direction, as it were "struggles for independent existence, the sea channels between "Mare Tail and the adjacent Hook Hill Sands have closed up, "these sands being no longer islands, but united to the main body "of the sands on the Holbeach shore. The exact movement of "the sands since any remote period cannot be ascertained, there "having been only one accurate survey of them as a whole; but "if we give the compilers of early charts credit for having laid "down only such channels and sands as existed, these charts "afford strong evidence that the movement of the sands referred "to has taken place gradually. The rate of this movement of the "sands towards the sea banks within given periods depend mainly "on the changes in the relative positions or advances of the sea "banks. Each successive advance is a cause of acceleration—is "a new impetus to the motion in question."†

It is here clearly pointed out that the effect of sea-banks is to facilitate the accretion; hence in estimating the rate of accretion by means of the sea-banks it must be remembered that the results are greater than they would be on an unwalled coast-line.

Taking the quantities given in the foregoing table we obtain for the base of the Wash the following rates of accumulation:—

ACCRETION along the BASE of the WASH.

Dates.	Maximum Rate per Ann.	Minimum Rate per Ann.	Mean Rate per Ann.
	Feet.	*Feet.*	*Feet.*
Between 2nd and 17th centuries -	15·84	1·76	7·29
During 18th century - -	89·76	21·12	48·65
„ 19th do. - - -	70·41	13·20	31·68
Mean rates for 1,700 years - -	59·00	3·88	10·73

* This fact was pointed out and the term applied by Capt. Vetch in his Report on the Norfolk Estuary Scheme, 1849.

† Report on Linc. Estuary Bill, p. 6.

The mean rates in the above table are obtained by measuring the breadth at every mile, and taking the average of these measurements. This is obviously more correct than taking the mean of the greatest and least breadths. The average rate of accretion for the base of the Wash, between the rivers Welland and Ouse, is therefore 10·73 feet per annum. The effect of embanking green marsh in promoting the accretion of silt is shown forcibly in the above table; thus, between the 2nd and end of the 17th centuries, no new banks were raised, and the rate varied between 15·84 feet and 1·76 feet, with an average of 7·29 feet; whereas in the 18th century, when embanking was actively pursued, the rate reached a maximum of 89·76 feet, the minimum being as high as 21·12 feet (or greater than the maximum for the preceding 1,500 years), and the mean was 48·65 feet, or more than three times the maximum of the long antecedent period. These new lands, be it remembered, are not inclosed till they have become green marsh, so that the above rates show the actual increase of dry land, and not that which has been reclaimed from the tide-way. Indeed, as yet, the only lands inclosed are green marsh, and though at least two admirable schemes have been brought forward to reclaim the banks below high-water mark, they have fallen through, like most comprehensive fen-schemes, for want of pecuniary support, and from short-sighted local opposition.

The accretion along the sides of the Wash has been very much slower. Indeed, so far as the Norfolk coast is concerned, it may be regarded as *nil*, for with the exception of the marshes at the mouth of Wolverton Creek, inclosed in the 18th century, no land has been embanked along that coast. At the present time a fringe of green marsh extends from Hunstanton Station southwards to North Wooton, with a minimum breadth of about 2 chains, a maximum by Wolverton Creek of 0·75 mile, and a mean of 0·213 mile. As this coast is protected by banks of Roman-date, we have an average rate of accretion of but 0·66 feet per annum.

On the Lincolnshire (East Holland) coast the rate of accretion is somewhat greater, and with one exception, all the enclosures since the erection of the Roman banks have taken place during the present century. The exception consists of an enclosure, made last century south of the River Steeping, of about three miles in length by an average breadth of 0·4 miles. The mean breadth of accretion, including green marsh, along this coast is 0·59 miles, which is pretty evenly distributed, the maximum being less than 1 mile, and the minimum than 0·25 mile. This gives as the average rate of accretion 1·83 feet per annum.

The mean annual rates therefore stand as under:—

			Feet.
Base of Wash	- mean rate -	- =	10·73
East Holland Coast	- do. -	- =	1·83
Norfolk Coast -	- do. -	- =	0·66

Comparing these rates we have,—

Base of Wash -	- - - - =	100·00
East Holland Coast	- - - - =	17·05
Norfolk Coast -	- - - - =	6·15

that is to say, the rate of accretion along the base of the Wash is nearly six times as fast on the East Holland coast, and more than 17 times as rapid as on the Norfolk coast. The rate along the East Holland coast is nearly three times as great as along the Norfolk coast.

The table on p. 179 shows that 64,000 acres of land have been enclosed during the past 1,700 years. In the year 1839, Sir John Rennie proposed a grand scheme for enclosing and reclaiming 150,000 acres of land, and training the river to a common outfall in Lynn Well. Three Acts of Parliament were obtained, in the years 1846–9–51, to carry out the scheme in a modified manner, but the works were never executed. This quantity of sand is sure to become dry sooner or later. If the rate for the last 1,700 years be taken as a basis of calculation, it would take about 4,000 years to silt up naturally; but as we may be sure embankment will go on as green marsh is formed, the rate for the two last centuries may be safely accepted as nearer the mark. At this rate it would take about 1,000 years to silt up. By enclosing this area at once and warping the land, it would be entirely converted into good land in, say 50 years. But long before that time much would have become grassed over; and I have no hesitation in saying that had Rennie's scheme been carried out at the time the Acts were obtained, and at the estimated cost, a dividend would have been paid ere this, and it would go on steadily increasing for many years. The public advantages of this work would be very great; the rivers, united in the centre of the Wash, would be able to maintain their channels tolerably free from deposit; the food produce of so large an area would be of great value; and if, as I would suggest, a belt of woodland was formed round the new coast, the rainfall of the fens would lose much of its present spasmodic character, and be more evenly distributed through the year. The engineering difficulties of the scheme, though great, are by no means insurmountable, and as the silt land is some of the richest in the kingdom, one cannot but regret that the matter fell through for want of funds and the hearty co-operation of the fenlanders.

Fauna.—The fauna of the silt is essentially quaternary in character, as might be expected. The following list embraces all the species I have seen or found records of:—

Foramnifera, numerous species.	*Balæna.*
Mytilus edulis.	*Phocæna Orca.*
Ostrea edulis.	*Phoca rituliна.*
Cardium undatum.	*Sus scrofa.*
Scrobicularia piperata.	*Bos longifrons.*
Tellina Balthica.	*Bos urus.*
Littorina littorea.	*Cervus*, several species.
Rissoa.	*Castor fiber.*

The remains of land animals are not plentiful, consisting only of isolated bones, and it is to the peat we must look for the list of the mammalia of the fens. The silt beds forming on the shores contain the same species, but with the addition of *Mya arenaria* and *M. truncata*, both of which are common. The great assemblage of Wash shells, however, are confined to the sands and gravels.

The only shells that do not appear dwarfed are *T. Balthica* and *S. piperata*. The mussels, cockles, and oysters, are generally quite small and well grown, and average sized specimens are far from common.

CHAPTER XV.

THE GRAVEL.

Introductory.—The gravels are the oldest of the true fen beds, and, like the silt, are still in process of formation in the great bay of the Wash—the seaward continuation of the Fenland. Roughly speaking gravel crops out around the whole of the Fenland, broken only here and there, as to the south of Peterborough and upon the Norfolk boundary, and forms an elevated bank from 10 to 30 feet above the mean level of the fens.

It likewise forms the basement bed of the fen deposits, being met with in nearly all the sinkings which penetrate to the oolitic or cretaceous rocks below the fen strata. To this there are few, and very unimportant, exceptions, of which the most considerable are along the Norfolk edge, and one or two local and very limited areas in the neighbourhoods of Holbeach and Whittlesey.

The gravel, as will be abundantly shown in the sequel, is newer than any glacial deposits of the neighbourhood.

The gravel is undoubtedly marine, nevertheless a careful search along an outcrop of 50 miles in Lincolnshire alone has failed to discover a single marine organism. At March and in its vicinity, however, the gravel is highly fossiliferous, and an attempt has been made to show that the deposit is older than the boulder clay, but the evidence is not only highly unsatisfactory, but, interpreted by the light of other areas, is diametrically opposed to the facts of the case. At Nomanslandhirne, south of Croyland, shells are again found, also at Eye, Peterborough, and Whittlesey. In the two latter places a curious intermixture of freshwater and marine shells is found. Here and there, as at North Kyme mammoth teeth are found, and in an isolated patch at Ely, now nearly removed, large numbers of mammalian remains, including *Bos longifrons*, were found.

The material of which the gravel and sand is composed is that of the neighbouring rocks. Thus, along the Lincolnshire coast oolitic limestone forms the basis with a slight admixture of flints, coal-measure sandstone, and other foreign rocks derived from the Boulder Clay. In Cambridgeshire flint forms the mass of the material, with a like scattering of Boulder Clay stones throughout.

The whole of the highland boundary of the gravel has not yet been mapped to the south and north, as it was not deemed advisable to wait for its completion before the publication of this memoir, since the district will be surveyed for the geology of the older rocks. There seems to be, in the north, evidence of the intermingling of the true fen-beds with sands and gravels which appear to be of pluvial origin; this will be further alluded to in the sequel.

I think we can class the fen gravels in three divisions. 1. The remains of old valley gravels, usually fossiliferous, and probably of interglacial age, as at Whittlesey, March, &c. 2. The true marine gravels of the fen, forming beaches and the floor of the fen-basin, always unfossiliferous, as on the Lincolnshire border. 3. Flood-gravels which cover the hills in the north and run down into the true beach gravels. I shall, however, describe the gravels geographically, as the most convenient method of discussing their peculiarities.

Gravel between Heckington and Peterborough, including that of the Islands.—We will select this area for minute description, for it is the least complicated and includes typical features of all the fen gravels and sands. The exposures are frequent and good, and the boundaries accurately traceable.

The first point to notice is that the gravel extends up the valleys which open into the fen without interruption or variation of character, of which the best instances occur near Heckington and Swaton. The obvious interpretation is that some of the valley-gravels and those of the fen are contemporaneous.

Around Heckington itself the gravel is very irregular, varying from a few inches to several feet in thickness in the course of a few yards. It is here superposed on Boulder Clay, as shown in Section 193, and attains a height of 46 feet above mean sea-level at Heckington, and of 56 feet at Sleaford. This latter may be taken as the maximum height of the fen beds above the sea, and as the gravel extends to a depth of about 30 feet below datum, we have a maximum thickness of about 80 feet for the fen deposits, though they never attain to more than 40 feet at any one point.

From Heckington, southward, the gravel, along its outcrop, is a stratified deposit, seen to a depth of from 6 to 15 feet, with an average thickness of perhaps 10 feet. Much of this gravel is merely the result of the washing out of the argillaceous matter from the Boulder Clay. Thus in a pond half-a-mile east of Heckington,* the gravel is reduced to 2 feet, and is sometimes altogether missing; and on the road from Great Hale to Heckington 3 feet of gravel, full of chalk-stones, is seen reposing upon Boulder Clay. This dubious material, as will be seen by reference to Section I., Plate , lies upon an elevation of Boulder Clay; but it is directly continuous with good thick gravel in the lower ground. In Heckington itself it is found to a depth of 7 feet in places. Thus, in Star

* No. 193, Appendix.

Fen* good gravel is found under 5 feet of peat and fen clay. The gravel runs in a thin band westward to Asgarby parallel with the high road, and thickens and spreads out about Sleaford, sending one branch northward to Dorrington and another south-westward to Wilfsord.

In Great Hale the water is obtained from wells sunk in the gravel, which here lies in pot-holes in the Boulder Clay. The irregularity of the deposit is shown by two wells in the village; one, a private well, yields a constant supply from 8 feet of gravel; and another, which was to have been the "village" well, was sunk and bored to a depth of 100 feet without finding any gravel, or piercing the Boulder Clay. It is clearly impossible that this is "pre-glacial" gravel in the usual acceptation of the term. Good gravel is also seen to a depth of from 5 to 6 feet between Winkhill and the Walk, and pits occur at the latter place.

At Swaton another valley runs into the highland near Spanby towards Osbornby, where it furcates. A pit is open on the Holland Road, near the cross road to Swaton, of which the following description, taken from my note-book, was written in 1870:— "The gravel is, in character, very similar to the 'fen gravel' of "the district to the south, being composed for the most part of "pebbles of the neighbouring oolitic rocks, with a large per- "centage of flints and a fair quantity of pebbles and boulders of "older rocks. The gravel is tolerably evenly stratified, but is "contorted in places. It is what is called 'strong' gravel, but "contains wavy seams of silicious sand. At one part it is stained "for some distance with carbonaceous matter, and a piece of "willow wood was found embedded in it. This I take to be a "fluviatile condition of the marine gravel of the fens."

Thence southwards, by Horbling and Billingborough, the gravel continues of the same character, narrowing in its outcrop and overlapped on its eastern edge by the peat. At Sempringham it runs up a little valley for a mile. At Pointon, Millthorp, Rippinggale, and between Haconby and Morton, other small valleys contain gravel. It is everywhere of much the same character, consisting of pebbles of oolitic limestones, angular weathered flints, and a few pebbles of older rocks, such as coal-measure sandstone.

The Dunsby Drove crosses a lenticular shaped area, in which the gravel is reduced to a mere trace, and the Cornbrash limestone is quarried beneath. A similar section is seen upon the Dyke drove further south.

The only noticeable variation in this gravel from Heckington to Market Deeping is seen in a pit south of Dowsby, near the 103 milestone. The deposit is here a sandy gravel; the sands are siliceous, and the pebbles mostly chalk. So prevalent is the chalk, that the section is quite white. In other respects it is like the ordinary fen gravel, into which it passes laterally. The chalk pebbles are mostly well-waterworn, and some of the larger ones

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* Section 194, Appendix, C., p 287.

are striated. A trail of sandy clay from one to two feet in thickness, but very variable, overlies the sand and gravel beneath the soil. At first sight this section might appear to bear out the glacial theory of the formation of the gravel, but it is palpably only an instance of the dependence of the composition of the gravel upon the local rocks—the Boulder Clay happened to be the formation from which the pebbles were derived, and some of them were very little modified in the translation from one bed to another. It is as illogical to infer the glacial date of this piece of the gravel as it would be to call the same deposit further south an oolitic bed, because it is chiefly made up of fragments of limestones of that age.

In the town-pit, at Bourn, denuded patches of Boulder Clay, are sometimes exposed lying *in situ* upon the Cornbrash limestone as shown in Fig. 19. The gravel is there seen to overlie the clay,

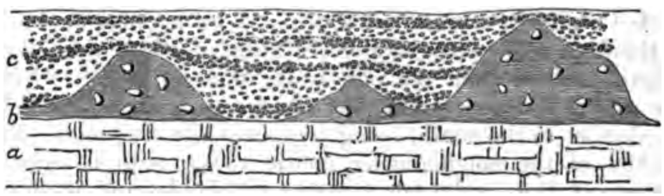

Fig. 19.—*Bourn Town Pit.*

a. Cornbrash Limestone. *b.* Boulder Clay. *c.* Gravel.

and, as shown by the eroded nature of the clay, is of much more recent origin. The gravel is here composed mostly of fragments of oolitic limestone, with flints sparingly scattered throughout.

South of Bourn the gravel outcrop spreads out and attains its greatest spread around Market Deeping, where it is 7 miles broad.

At Thurlby, the gravel is well seen* to a depth of 7 feet. The mass of it consists of well rounded pebbles of oolitic limestone, with a considerable quantity of ironstone (Northampton Sand), and flints. Some of these latter are quite black, and have undergone scarcely any decomposition. Pebbles of quartz, coal-measure sandstone, and other foreign rocks occur more sparingly. Fragments of carbonised wood occur in the upper beds.

At Kate's Bridge, 1¼ miles to the south, many more flints are found, and worn fragments of hornblende schist occur. Ironstone is abundant, but oolitic limestone pebbles are very rare. At Baston, ¾ of a mile to the south-east, the beds are again of the ordinary "fen gravel" nature. The composition is thus described in my note-book (1870):—"The gravel is fine, sandy, and covered "with two feet of soil. It is of the usual fen character, consisting "chiefly of oolitic limestone, ironstone, flint, with occasional "pebbles of older rocks and a few rolled specimens of *Gryphæa* "*arcuata, Belemnites gracilis, B. puzosianus* (*Oweni*), *Ostreæ*, &c. "In places it is cemented into compact beds by oxide of iron."

* See section, No. 64, Appendix.

The "cementing" above alluded to can be well studied around Greatford, where it is well known by the name of "iron-gravel." It is an intensely hard conglomerate, often requiring the aid of gunpowder to break it up in making drains, &c. It may here be mentioned that the gravel near Eastrey, upon the Roman road, has become cemented since it was laid down, and is broken up and used as road-metal. The workmen, judging from the colour assert that the cementing material is blood!

A quarter of a mile north of the Town gate, Market Deeping, the gravel is singularly free from sand. The following is the composition:—

Inferior Oolite Limestone.	*Bunter (?) Sandstone.*
Great Oolite Limestone.	*Quartz* (white and pink).
Cornbrash Limestone.	*Hornstone.*
Ironstone (Northampton Sand).	*Greenstone.*
Flints (angular and waterworn).	*Carboniferous Limestone.*
Coal-measure Sandstone.	

The order is that of their relative abundance. The first four form the greater portion, and of the last three but few specimens were found.

At Peakirk gravel is dug to a depth of 18 feet.* It presents no features that call for special mention, being of the usual character, roughly stratified, and in places stained with carbonaceous matter. A fine antler is said to have been found in it some years ago. From Peakirk a remarkable tongue stretches through the fens to Croyland, as shown in the Index Map to this memoir. It is nowhere overlaid with peat, and was formerly the only firm communication between Croyland and the highland. Its historical interest has been noticed in Chapter III. It crosses High Drove and Alderlands Drove, and is very narrow at the latter spot. North of Wright's Drove, and thence to beyond Croyland, it is dug for gravel. The material is of the usual character, and in a pit west of Kenulph's Drove the sand at the bottom contains fragments of shells, of which the only recognisable species is *Turritella communis*.

Returning to the main mass, the gravel is traceable along the edge of the fens to the High Drove. It is then missing for about two miles (the Oxford Clay being exposed in the drains), but comes on again at Eye. The gravel outcrop now loses the regularity which has marked it hitherto, and forms singular outspread patches, but a few feet above the fen-level. In the pits at Eye, and in the railway-cutting, the following shells occur in the gravel:—

Turritella communis.	*Mytilus edulis.*
Buccinum undatum.	*Tellina Balthica.*
Ostrea edulis.	*Cyprina Islandica.*
Cardium edule.	*Pholas dactylus.*

A tongue about a mile in length, runs directly north at Eye Green.† The gravel is coarse, subangular, and rudely stratified;

* Section No. 40, Appendix. † Ibid. No. 38.

its composition is the same as most of the fen gravel, the only noticeable feature being the presence of granite, of which I found one subangular specimen. The underlying sands are evenly bedded and contain many marine shells and carbonaceous stains. The species I collected were :—

Turritella communis.	*Ostrea edulis.*
Littorina littorea.	*Cyprina Islandica.*
Aporrhais pes-pelicani.	*Tellina Balthica.*
Buccinum undatum.	*Mactra edulis.*
Trochus.	*Pholas dactylus.*
Cardium edule.	*Serpula.*
Mytilus edulis.	

Of the *Cyprina* only one fragment, part of a hinge, was found. The shells as a rule are in fair preservation, the *Cardium* being the most abundant.

At Northam House, a few hundred yards north of the above pit, a similar section is exposed, with the gravel cemented into hard masses with carbonate of lime. Shells are not at all numerous, only *Cardium edule* and *Mytilus edulis* having been found. The gravel all round this place reposes immediately upon Oxford Clay.

Eastward of this little spur is a larger one, stretching northwards along the Cat's Water as far as Namanslandhirn, where three counties join. At this latter point, and in its vicinity, marine shells are again found. I collected the following species :—

Turritella communis.	*Tellina Balthica.*
Buccinum undatum.	*Cardium edule.*
Trophon clathratus.	*Mytilus edulis.*
Littorina littorea.	*Ostrea edulis.*
L. rudis.	*Cyprina Islandica.*
Purpura lapillus.	*Cyrena fluminalis* (*consobrina*).

The last-mentioned shell is tolerably abundant, and though I do not think much faith can be placed upon the determination of climate from a few shells, I think the most frigid glacialist would not claim *Cyrena fluminalis* as a boreal shell. *Cyprina Islandica* is still living in The Wash, and cannot therefore be cited as any evidence of arctic conditions.

Thorney is an "island" about a mile eastward of this spur. It consists of Oxford Clay overlaid by gravel, which appears to be unfossiliferous.

Around Peterborough the gravel is very irregular in its distribution, as shown in the Index Map to this memoir. It passes into the true river-gravels of the Nene. As might be expected much alluvial matter is here associated with the gravel, and at New England, close to the engine-depôt, a kind of *loess* is seen.* The following description is from my note book (1870) :—

"The gravel is not stratified, but exhibits faint traces of false-bedding. The pebbles present no features other than are usual in these gravels, but the intermixed clay, or loess, is full of com-

* Section No. 33, Appendix.

minated shells, land and freshwater. Fragments of a small oyster occur, but the pieces are not large enough to show whether it is a derived shell or not. Many of these fragments are doubtless derived, for recognisable pieces of *Ostrea Marshii*, and rolled pieces of *Terebratula digona* occur. One small spiral shell, apparently a *Valvata*, was found, but it crumbled immediately, and before it could be determined. This shell débris gives to the clay very much the appearance of Boulder Clay, and there are lumps of clay containing no shells, but plenty of chalky matter here and there in the pit. This is doubtless Boulder Clay, and it occurs underlaid and overlaid by the gravel."

It is clear then that this is not pre-glacial, or "lumps" of Boulder Clay could not get *into* it.

We now come to the two important islands of Whittlesey and Eastrey, which rise about 30 feet above the level of the Fens. Like Thorney, they are bosses of Oxford Clay, entirely covered with gravel, which attains a thickness of from 8 to 12 feet. The greatest length of Whittlesey island is 3·5 miles, and its maximum breadth 2·1 miles. Eastrey is somewhat smaller, measuring 2·5 miles by 0·5 mile. Numerous pits are open in both, but it is unnecessary to describe each in detail. A very important one is open at the brick-kilns (marked on the Ordnance Map) a mile west of Whittlesey. Above the Oxford Clay, from 8 to 10 feet of sand and gravel are seen. The upper portion of the section consists of a sandy, unstratified loam, with a few interspersed pebbles. The lower portion is a series of well-bedded sand and gravel, contorted as shown in Fig. 20 (p. 190), but the section is very irregular.

The contortion suggests the crumpling of the gravel beds subsequent to their formation by grounding ice, and I have only noticed it in gravels which seem to be the remains of river-valley beds, and to be older than the true beach-gravels, into which they merge. They are, however, undoubtedly newer than the Boulder Clay of the district, and are not pre-glacial in that sense, though, as will be shown presently, they may be interglacial.

In a pit close to where the railway crosses the Peterborough road there is another pit, noticeable as having yielded teeth and bones of *Elephas primigenius*, a skull and some teeth being preserved in the Museum at Peterborough. The contorted beds are even more marked than at the last locality, but the quantities of rolled Oxford Clay fossils so striking there are here wanting. Fragments of chalk are not uncommon.

Immediately west of the town a pit shows false-bedded, stratified sands and gravels, of from 6 to 12 feet in thickness. It yields the following marine shells:—

Buccinum undatum.	*Mytilus edulis.*
Trophon clathratum.	*Cardium edule*
Tellina Balthica.	*Ostrea edulis.*
Cyrena fluminalis.	

Half a mile from this spot near the gasworks a similar pit is

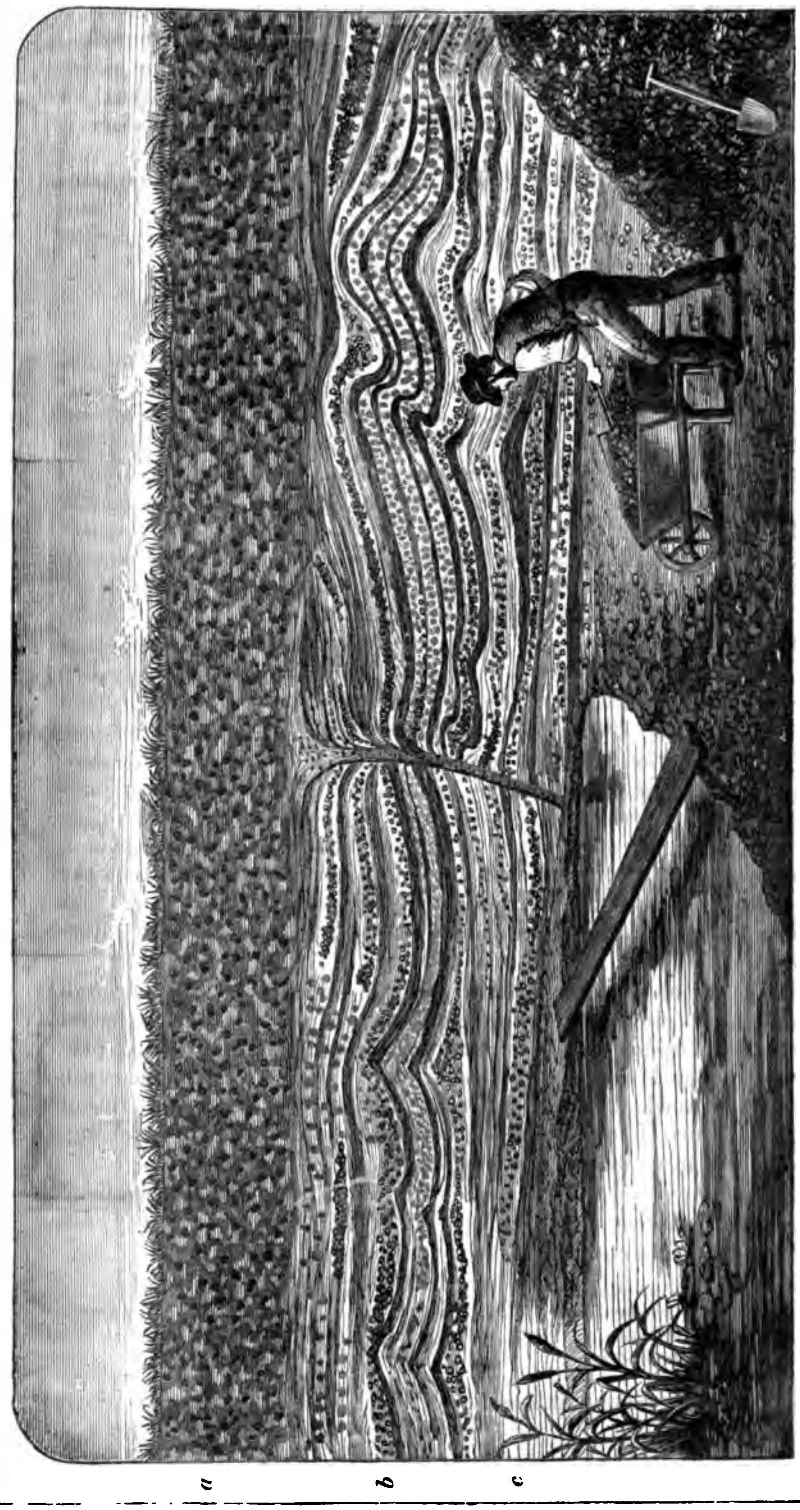

Fig. 20.—Gravel Pit, one mile West of Whittlesey (South side).

a. Loess-like loam. b. Contorted sands and gravels. c. Evenly stratified ditto.

remarkable for containing freshwater shells. I collected the following species :—

Turritella communis, fragments.	*Pisidium* sp.
Cardium edule, fragments.	*Bithynia tentaculata*.
Cyrena fluminalis.	*Valvata piscinalis*.
Pisidium amnicum.	*Planorbis spirobis*.

The shells are found abundantly throughout the section, and are undoubtedly *in situ*.

On Eastrey island the gravel can be well seen at Eastrey, Coates, and Eldernell, but shells are rare. The contortion is not so marked (and is often absent) as round Whittlesey. In a large pit half a mile west of Eldernell the lie of the beds is well shown. My description in 1870 was as follows :—"The gravel is beautifully and evenly stratified, and the materials, which vary in coarseness from fine siliceous sand to coarse gravel, with pebbles three inches in diameter, are sorted according to their respective sizes. The materials of which it is composed are the same as is usual in fen gravels, being for the most part oolite limestone and ironstone, with many flints and a fair quantity of pebbles of older rocks, such as quartzite and coal-measure sandstone. Some of the beds are stained of a rich brown colour with oxide of iron, but this action seems to have been simultaneous with the

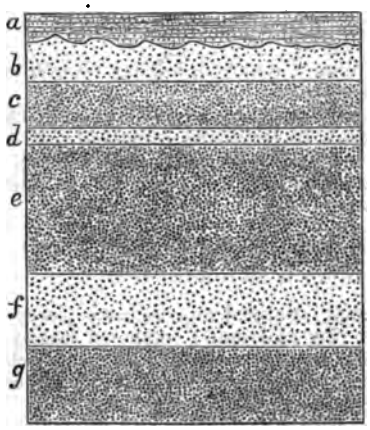

Fig. 21.—*Pit at Eldernell.*

a. Soil with pebbles.
b. Fine yellow gravel.
c. Fine brown gravel.
d. Fine white gravel, without sand.
e. Coarse brown gravel, finer at base.
f. White gravel and sand.
g. Fine brown gravel.

"deposition of the beds, as almost white layers alternate with the brown beds, giving the section a most beautiful banded appearance." See Fig. 21.

The beds are not fossiliferous at this spot, but near the South

Bank, a quarter of a mile to the east, shells are very abundant, though the following are the only species found:—

Turritella communis.	*Mytilus edulis.*
Littorina littorea.	*Ostrea edulis.*
„ *rudis.*	*Tellina Balthica.*
Cardium edule.	

The gravel of the March and Chatteris islands caps the high-land, and descends into the fen just as is the case at Whittlesey and Eastrey, and whatever remarks are applicable to the one are equally suitable to the other. Mr. Seeley has, however, attempted to show that the March deposit is intercalated in the glacial series, that is to say, it is overlaid and underlaid by glacial clay. Sections 95 and 96 in the Appendix are typical of the deposits at March. In Hutchinson's brickyard, close to the railway station, the east side of the pit shows, in descending order:—

1. **Whitish-grey Silt** or **Warp,** bedded, with—
   Scrobicularia piperata.
   Tellina Balthica.
   Ostrea edulis.
   Cardium edule.
   Mytilus edulis.
2. **Kimeridge Clay.**

The silt is the ordinary fen silt we have described, and at this point the gravels are wanting, and the subjacent bed is Kimeridge Clay.

On the west side of the pit the section is:—

1. **Gravel,** now almost removed, formerly from 6 to 20 feet in thickness, full of marine shells.
2. **Boulder Clay.** Dark blue in colour, almost like Kimeridge Clay, of which it seems to be chiefly composed. It contains a considerable number of rounded and striated chalk-pebbles. 6 feet thick.
3. **Kimeridge Clay.** Dark blue clay full of *Ostrea deltoidea* in the upper 4 feet.

At Pape's brickyard, Lion Lane, March (Section No. 96, Appendix), the section is as follows:—

1. **Gravel.** Rudely stratified and in some places false-bedded; much mixed with clay and sand; composed largely of chalk and oolite limestone-pebbles, with small flints, and pebbles of quartz, coal-measure sandstone, &c.; very full of broken and whole marine shells. 6 feet thick.
2. **Yellow Clay,** with gravel stones and striated chalk and lias limestone pebbles. 4 to 5 feet thick.
3. **Kimeridge Clay.**

We thus see that the gravels are underlaid by glacial clay, which, however, is very thin. But Mr. Seeley cites a boulder clay *above* the gravels, which, however, he says is "not very characteristic." It is said to have been "a foot or so thick," and to have contained fragments of septaria, "a bough of a tree,"* &c. I cannot but think this must have been merely a patch of detritus, and much more powerful evidence is certainly

* Seeley, Sketch of the Gravels and Drift of the Fenland. Q. J. G. S., vol. xxii., p. 470, 1866.

required to establish so unique a phenomenon as a boulder clay above the fen gravels. Mr. Seeley also cites a thin bed of boulder clay intercalated towards the base of the gravels. This certainly no longer exists at the spot or anywhere in the neighbourhood, and cannot have been other than an isolated patch which is not proved to have been *in situ*. Finally, then, we must conclude that this attempt to show the glacial age of the March gravels has utterly failed. It is in every respect similar to the other fossiliferous gravels of the fens, and, like them, newer than the glacial clays of the district.

Gravel from Whittlesey to Ramsey.—Along the fen margin from Horsey Hill, south-east of Peterborough, no gravel is found except very small patches, the Boulder Clay being immediately in contact with the peat, except in a few spots around Yaxley and Ramsey, where the Oxford Clay peeps from beneath the drift. It is to be especially noticed that no sands or gravels underlie the Boulder Clay at these points.

The gravel occurs in Farcet Fen, forming an outlier of peculiar shape, as shown on the Index Map to this memoir. The following descriptions are from the note-book of Mr. J. W. Judd, F.G.S., who made a preliminary examination of this part for the Geological Survey in 1869:—" At Blackpool Hill a good section of fen " gravel is seen."*

" The gravel here is mainly composed of chalk flints in small fragments, but no fragments of oolitic rocks are abundant. Of boulders I found one mass of basalt about six inches in diameter, and a few fragments of mica-schist and quartzite. The extraneous fossils were—

Gryphœa dilatata *Belemnites Puzosianus* " *hastatus*	Very abundant.
Ostrea acuminata *Gryphæa arcuata* Chalk sponges	Less abundant.

" Apparently, from the workmen, contemporaneous shells are very occasionally seen in this gravel, but I did not succeed in finding any. This gravel appears to be the result of the destruction of the light-blue Boulder Clay with chalk detritus, and of the Oxford Clay beneath it, probably by means of *marine denudation*.

" Many of the flint pebbles are encrusted with carbonate of lime, and hard masses of the gravel, cemented by the same material, occur in the gravel. This is probably due to the gradual solution of the fragments of chalk which originally formed a large portion of the gravel. A little distance from this pit the light-blue boulder clay with chalk detritus is dug, and the gravel is very thin.

" Precisely similar sections of these gravels are seen to the north-east of Arlmynades Hill, and by the Crow Tile Farm.

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* Section No. 62, Appendix.

Everywhere the gravel appears to be from 5 ft. to 8 ft. thick. It is always small and similar to that described."

"Gravel is also seen about half-a-mile down Oakley Dyke, and also at Suet's Hill. The gravel is here covered by about 18 inches of impure peat."

Mr. Judd's observations are interesting as having been made before the true relation of the gravel to the fen deposits was recognised, but he clearly discriminated between these gravels and the glacial gravels with which both of us are so familiar in the highland.

The principal gravel area near Ramsey occupies the whole of the northern part of the island. A pit half-a-mile south-west of Bodsey Lodge, shows a series of stratified false-bedded sands and gravels intercalated seams of mottled clay. The material is chiefly flint and oolite limestone with a few pebbles of foreign rocks, and a great quantity of rolled specimens of *Gryphæa dilatata.*

Half-a-mile south of the Forty Foot Bridge there are numerous old gravel-pits of similar character. The gravel contains a larger percentage of flints and chalk-stones than is usual on the Lincolnshire border. At the great Gault Hole Pits close to the Forty Foot Bridge the gravel is seen overlying Oxford Clay to a depth of six feet.

Gravels from Somersham to Cambridge, &c.—About Somersham the gravel again occupies the borders of the fens and passes into the valley-gravels of the Ouse and Cam. It soon dies away on the east side of the latter river, and the chalk is in immediate contact with the peat. It is unnecessary to describe this area in detail, since it has not yet been mapped completely, and will be described in another memoir. It is generally composed of small weathered flints and pebbles of hard chalk, and is more or less evenly stratified. Its outcrop occupies a considerable area around Waterbeach.

Gravels and Sands around Mildenhall.—From about Crow Hall along the fen border a thin deposit of sandy gravel is seen which spreads out towards Mildenhall Fen, and round Beck Row. At East Fen Common, Soham, the deposit is chiefly fine sand interspersed with brown and red flints. It is dug to a depth of 6 feet without being bottomed. Between Beck Row and Eriswell the material is blown sand, and all the flints and other pebbles are beautifully polished, just as takes place on the deserts of Africa. The appearance is very striking. From this place I obtained a fine flint "core." The loose sand forms an undulating surface, in the hollows of which peat has formed, and at many places the sand has blown over beds of peat and thus seems to be of newer date, but there is no doubt it is mere wind drift.

These sands and gravels extend northward to the valley of the Little Ouse, thence along the fen edge to near Hockwold Grange. They are then wanting as far as White House, north of Methwold, from which place they extend to Stoke Ferry, on the river Stoke, and then westward towards Fordham. This section has not been mapped in detail, but I feel sure most of it is not true fen gravel, but the fenland portions of the great mass of sands, gravels, and brick-earths of West Norfolk and Suffolk, which yield such fine stone implements, most probably far older than the true fen beach gravels.

The remarks applied to the sands at Beck Row apply to the sands at Hockwold, where the generalised section from north to south is shown in Fig. 22. The sand is fine and silicious, and

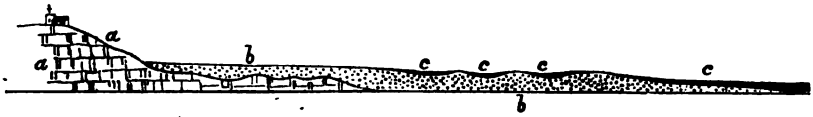


Fig. 22.—*Section from Hockwold to the Fen.*
a. Lower Chalk. *b.* Sands. *c.* Peat.

the little patches of peat between the hummocks are too small to map. The sand varies in colour from white to full red with carbonaceous stains, and includes numerous small and a few large flints.

At Lakenheath the gravels are finely developed and yield numbers of flint implements of palæozoic type. The surface of the chalk further inland is worn into the curious curves so well known to workers in chalk districts. Fig. 23 is an outline drawing of one such case:—

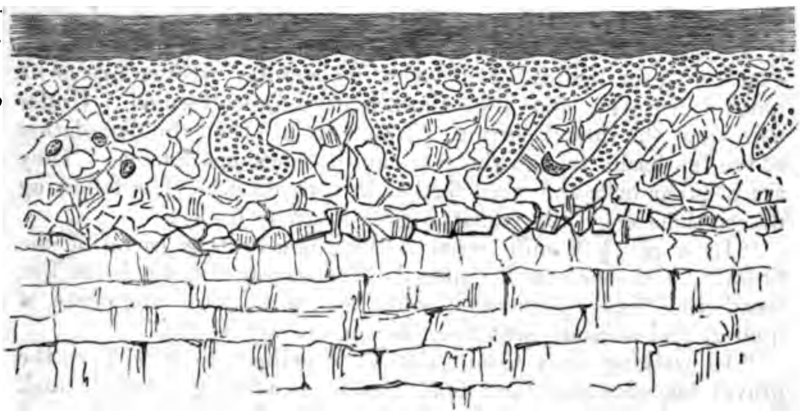
a
b
c
d


Fig. 23.—*Chalk-surface at Lakenheath.*
a. Soil
b. Chalk-rubble and Gravel.
c. Rubbly Chalk.
d. Solid Chalk.

At White House, between Methwold and Stoke Ferry, the gravel again comes on and forms a bank on the edge of the fen. It is full of flints, some of which are very large and irregular; and in its upper portion shows no trace of bedding. The material is generally finer below and contorted, but the whole section is extremely irregular.* Fig. 24 shows one facies of the pit:—

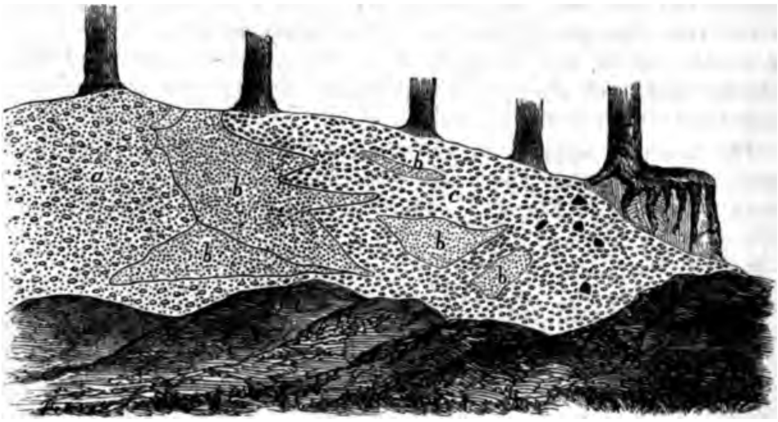


Fig. 24.—*Gravel Pit at White House.*

a. Sand and gravel indiscriminately mixed.
b. Sand. *c.* Gravel. *d.* Talus.

Gravels on the North edge of the Fenland.—These gravels and sands are not entirely mapped, except around Tattershall, but their fen border has been carried as far east as Irby. South of that town they extend into Wildmore Fen, across West Fen by New Bolingbroke, and thence by Stickney, Toynton, Steeping, and Irby. They consist of fine sands and gravels, and though like the ordinary fen gravel in character, differ from it in running back into the country over the hills and into the valleys. At present I am inclined to think their inland extension is a flood gravel; that is, a deposit formed by land-floods during excessive rain, which swept over the country irrespective of its natural features, and after those features were formed. Under this view the inland portion is newer in date than the denudation of the fen-basin, though the rest may be contemporaneous. They are peculiar beds and need further investigation.† The following descriptions are taken verbatim from my note books:—

"In a pit ½ a mile west of Mareham-le-Fen gravel of the ordinary fen character is exposed. It is composed of angular but weathered flints, pebbles of oolite limestone, with fragments of quartz, coal-measure sandstone, &c. in a sandy matrix."

"In walking from Coningsby by Reedham to New York the gravel becomes more and more sandy (speaking generally); and, from a very flinty material, passes into a sand containing scattered flints, chalk, and other pebbles. Occasional seams of clay occur, and at the Catchwater Drain Bridge the boulder clay, blue and full of chalk, is exposed at a depth of about eight feet."

Gravel and sand much mixed up with boulder clay are seen on the road leading from Hundle Houses in a S.E. direction.

* These beds will be described in extenso in the description of sheet 51.

† They seem to be the analogues of the wide-spread sands and gravels around Brandon, which yield palæolithic tools.

"Several wells in New York, from 12 to 16 feet deep, passed entirely through boulder clay. This clay, then, lies irregularly, being sometimes covered with as much as 10 feet of sand and gravel, and sometimes reaching the surface.

"On the road above mentioned, at the private road leading to the farm on the south of the main road, boulder clay comes to the surface, or is only covered with a foot or so of doubtful sandy material. But at a farmhouse 10 chains south of the main road a well gives no clay in section but—

Sand and Gravel Silt "Cement"	9 feet.

This cement is said to be very hard, but I could get no idea of its nature from my informant. Behind the house are several pits whence clay has been dug, everywhere overlaid with sandy gravel. The clay is described as being silty, with a few chalk-stones in one or two spots.

"Down the road leading from Bunker's Hill to Gipsy Bridge the boulder clay is seen more or less constantly in the dyke bottoms, covered almost everywhere with from 6 inches to 3 feet of sandy gravel, to within about a mile of Gipsey Bridge where the silty fen-clay comes on.

"Along the road from Coningsby to Kirkby-super-Bain pink sand with scattered flints is seen running down to the river and into the gravel with which it seems to be continuous. It extends to the top of the hill, at the summit of which is a pit in the boulder clay. This clay is of a very dark blue colour, with much chalk and many septaria, all of which are striated. The clay is overlaid by a slight covering of the sandy gravel above mentioned, patches of which are seen in the upper part of the clay and are intersected pipes. The pit is about 60 feet above the fen-level.

"At Tattershall Castle the material is a gravelly sand, and the surface of the ground appears to be nearly white from the number of flints scattered over it."

Westwards, the gravel and sand run up the valley of the Witham, but their boundaries have not been traced.

In a pond south of Tattershall Lodge fine silicious gravelly sand is seen lying on boulder clay. The sand is stained, and in places cemented, with oxide of iron immediately below the soil. The bed is about 4 feet thick, but the section is not clear. Where the stream coming from Cold Harbour crosses the road from Tattershall Lodge pits have been dug for clay. From 3 to 5 feet of gravelly sand are seen to overlie the boulder clay, which is of the dark colour before noticed. A very good section is seen on the Church Farm, 15 chains S.S.E. from Kirkstead Church. Under about 6 inches of soil, gravel from 0 to 3 feet in thickness lies upon an eroded surface of boulder clay, which is seen to a depth of 12 feet. The gravel is sandy, unstratified, and nearly everywhere stained and cemented with oxide of iron close to the surface. It lies irregularly, filling up hollows in the eroded surface of the clay, and is sometimes altogether wanting. The clay is not worked up into the gravel, as happens in some places.

At the farmhouse a little S.W. of the above is a well about

12 feet deep, dug entirely in gravel. This house is only slightly higher than the level of the land at the above pit. Similar pits have been opened elsewhere on this farm, and the gravel is found to lie very irregularly, varying from 1 to 20 feet in thickness.

Woodhall Spa shows about 3 feet of gravel above boulder clay, and between the Spa and Tower-i'-Moor there is a large pit in which gravel is dug to a depth of 12 feet. The material is sandy, with much chalk and flint. On the Moor the sand is about 4 feet thick and is absent from the valleys.

Some of the above sections bear out our remarks upon the March gravel. They show how masses of boulder clay may become mixed up with gravel without being contemporaneous with it.

Gravel at Billinghay and Kyme.—Along the spur of highland at Billinghay runs a patch of gravel, broken in continuity around Walcott. It stretches from the level of the fen up the hillside towards Timberland. I could not find any break between the gravel at the level of the fen and that which occurs on the hill, in passing up from Billinghay, but it does not occur on the east and west slopes: thus it seems to run up the spur in the direction of its length. It attains an altitude of from 40 to 50 feet above the fen. In this it agrees with the beds we have described as occurring round Tattershall. If it really belong to them considerable denudation valleys of the Witham and Scroby Beck must have taken place since its deposition. In a pit on the road from Billinghay to Walcott the gravel is seen to a depth of 5 feet. It is singular,in consisting almost entirely of pebbles of the older rocks, beneath which are seams of fine, clean sand. The composition of the gravel is very like that preglacial gravel which we called "pebble-gravel" in the highlands of South Lincolnshire, but differs from it in containing chalk-pebbles. It, however, always overlies the boulder clay.

Another gravel, which presents a similar peculiarity of composition, is found near Howbridge Drain, near to Bunker's Hill. Its description is deferred to this place that it may be compared with the Billinghay gravel. The following is the description in my note book:—

"At the Howbridge Drain, between New York and Hundle Houses, the gravel and sand are at the surface. Where the drain is joined by the Sandy Bank Drain, 3 feet of silt repose on the gravel, and this is the case as far as Bunker's Hill; it is, in fact, part of the old channel of the Witham, described before.* Two hundred yards north of Bunker's Hill, near the road, there are gravel pits. The gravel has been dug from N. to S., and the silt was seen to thin away from 10 feet to nothing in the course of a hundred yards. The gravel varies in thickness from 10 to 15 feet, and is everywhere underlaid by dark blue boulder clay with chalk-stones. The section is given in the Appendix No. 177. The surface of the boulder clay is very irregular, rising from 3 to 5 feet nearer the surface in some

* P. 107.

places than in others. The gravel surface is also irregular, and the fen-clay always fills up the hollows, and steadily increases in thickness towards the south.

"The gravel immediately above the boulder clay is always *very* much coarser than that nearer the surface, and it varies from a coarse shingle below to fine sand above.

"The composition of the gravel is strikingly peculiar, especially in the coarser beds. Large angular flints, rounded masses of fine-grained granite, boulders of black quartzite a foot square, large pieces of coarse grit, and large waterworn lumps of *soft* chalk are some of its peculiarities; a piece of travertin was also found. Masses of light-blue, finely laminated shale, like the paper-shale of the Lias, nodules of clay-ironstone enclosing a nucleus and fragments of red ochreous material are not uncommon. Belemnites and shells of oysters from the Oxford and Kimeridge Clays occur in fragments. The following is a list of the rocks I observed:—

Granite.	*Lias Limestone.*
Greenstone.	*Great Oolite Limestone.*
Mica-schist.	*Ironstone.*
Coal-measure Sandstone.	*Chalk.*
Bunter (?) Sandstone.	*Flint.*
Quartzite.	

"This remarkable assemblage of rocks can only have been derived from the boulder clay. The gravel is, however, long subsequent to it in date, as the eroded surface of the clay attests.

"From the bridge over the Newnham Drain to a quarter of a mile east the boulder clay is within 3 feet of the surface, and the sand is nearly, and in places entirely, absent. When present it is mixed up with a slight trace of moor, which extends from Moor Houses all along this road to New York, where the gravel comes on thicker again."

Two pits, one S., the other N., of Thorp Tilney, show about 5 feet of finely stratified gravel, in which the pebbles are well rounded, and consist chiefly of fragments of the older rocks, flints being uncommon. The sand is silicious, very ferruginous, but with occasional white seams. The pit to the N. of the village has a similarly constituted gravel, with red and white bands, but it is contorted like the gravels at Whittlesey. Both these pits lie about 50 feet above the level of the fen.

The gravel about Kyme can be studied in several pits. One at the North end of North Kyme Causeway is extensive, and shows 6 feet of gravel, which though not bottomed, is probably not much thicker. In composition it is about a mean between the peculiar gravel we have been describing and typical fen-gravel, for it contains pebbles of Palæozoic and other rocks, and waterworn flints in about equal proportions, pebbles of oolitic limestone being not uncommon. The gravel shows a slight tendency to stratification in places, but the pebbles generally are not sorted into sizes. In another pit, near Spinney, north of North Kyme, the gravel is again full of pebbles of old rocks, but intermixed with much sand. But in a pit on the east side of the road at the junction of roads south of North Kyme, the character is more like that of ordinary fen gravel, containing much chalk and few pebbles of the older rocks.

The gravel at Kyme forms an island in the fen with a height of from 20 to 30 feet. Beneath the gravel occur boulder clay and then Oxford clay. At Mr. Foreman's new farmstead in South Kyme Low Ground, near the village (section 184, Appendix), gravel occurs in a well. The clay immediately beneath the gravel is certainly boulder clay containing chalk stones. I did not see it *in situ*, as the well was bricked in, but think it cannot be more than 10 feet thick at this place. The new boring commenced at 20 feet in laminated red and blue clay; and it ended at 40 feet in very dark-blue laminated clay, which is Oxford Clay; there is, however, a slender chance of its being Kimeridge Clay. The workmen described this clay as containing chalky matter, but in such terms as to lead me to infer that it was only shelly matter. Nevertheless, the boulder clay is certainly 50 feet thick at Kyme Vacherie, on the North Kyme spur; for at that place a well was sunk to that depth, which ended in blue clay with chalk stones. (Section 182, Appendix.)

On the west side of the Scroby Beck valley, from Digby to opposite Timberland, there is an isolated patch of typical fen gravel at the fen level. It is well exposed in an extensive pit between the branch road west of Digby Grange and the plantation marked in the Ordnance map. The pit is from 3 to 5 feet deep. The first foot of the section consists of sand, stained to a dark tint for the upper few inches. The gravel, which occasionally rises to the surface, is regularly stratified, contains few seams of sand, is slightly false-bedded in places, but for the greater part lies in perfectly horizontal layers. The composition is very different from "pebbly" gravel so often described, being almost exclusively composed of good-sized fragments of flat, waterworn flakes of oolite rock. Flints, and pebbles of older rocks occur very sparingly. I found a fragment of decomposed bone in the midst of the section. It is difficult to conceive this gravel to be of the same age as that on the Billinghay spur, at so much higher a level above it, and so different from it in composition.

Age of the Fen Gravels.—Mr. Evans, F.R.S., in his magnificent work upon the Stone Implements of Great Britain, makes the following remarks upon the gravels of the southern fens:—

"At Eriswell a gravel of the same character as that near Mildenhall occurs on the slope of the hill towards the Fen; but in it, as yet, no implements are recorded to have been found. At Lakenheath, however, they occur in the gravel now capping the hill overlooking the Fen, as well as on the slope. Owing to the distance of these beds from any existing rivers, Mr. Flower has found great difficulty in reconciling them with any theory which would account for their presence by the action of rivers. If, however, we regard the great denudation of the fen country as subsequent in date to the deposit of the gravels, it appears to me that any difficulty on this point vanishes. That this denudation was in fact, at all events in part, subsequent to the deposit of the gravels, is proved by the position of the beds at Shrub Hill, which there cap a small area of Gault, and which, being above the general level of the fens, can hardly have been deposited in the position they now occupy when the configuration of the country was at all like what it is now. Such beds must, on the contrary, have been deposited in the bottom of a valley, and it appears as if in this case, by their superior hardness to the clay around them, or from some other accidental cause, they had protected this small spot from tidal action, which in the adjacent river, previously to the construction of Denver Sluice, extended nearly as far as Brandon."*

In commenting upon the age of these gravels we must bear in mind two essential points; firstly that all the beds over-lie the glacial deposits; secondly that the river-gravels may have extended far beyond their present fen-ward limits before the final denudation of the fen basin. It is pretty certain that during and subsequent to the formation of the glacial clays of this district, and to the formation of the present river-systems, this part of the coast was joined to the continent, and consequently much of what is now occupied by marine deposits and sea was dry land. At such an epoch the river-gravels might be formed far out into the fen area if not into the present basin of the North Sea, and we might expect to meet their remains as isolated patches in the fen, and in this way the outliers of gravel could be accounted for. But the presence of marine shells so near the highland as Peterboro' and Over at once negatives this idea and we are compelled to look upon them as marine or at least estuarine beds. Nevertheless they may have been formed in the wide estuaries of the fen rivers subsequent to the breaching of the chalk barrier, and before the last denudation of the fen basin, and this is the view I at present hold. They seem, in fact, to form the shore-line of that ancient inter-glacial sea which submerged Moel Tryfaen 2,000 feet. On this supposition the curious mixture of land and fresh-water shells occasionally met with can be accounted for, and I think more reasonably than by the agency of land floods sweeping them into the sea. An example of the admixture of marine and fresh-water shells is found in the brickyard a few yards west of the gasworks at Whittlesey as before described. It should also be noticed, in confirmation of the above view, that these gravel islets lie along the courses of the present or ancient rivers Welland, Nene, and Ouse.

More will be said upon the age of these gravels in the next chapter.

Fauna of the Gravel.—The extension of the river-gravels into the valleys does not come within the scope of this work, yet it is in those localities that the richest harvest of fossils is obtained, excepting, of course, marine shells.

The table which follows gives the shell fauna in typical localities. The lists from March, Chatteris, and Hunstanton were kindly given to me by Mr. F. W. Harmer, F.G.S., of Norwich,

* Evans, Stone Implements, pp. 596–7. See p. 208.

and are the names of the shells in his own collection. Mr. Seeley* adds to them:—

Astarte crebricostata,	*Scalaria communis,*
Mya arenaria,	*Pleurotoma (Bela) turricula,*

but Mr. Harmer's list includes 27 species not cited by Mr. Seeley.

The other localities are from my own observation. Under the heading "Eye" are included the finds in several pits:—

SHELLS of the FEN GRAVELS.

—	Croyland.	Nomansland.	Northam H.	Eye.	Whittlesey.	Eldernell.	March.	Doddington.	Chatteris.	Peterboro'.	Hunstanton.
Ostrea edulis - -		×		×	×	×	×	×			×
Mytilus edulis - -		×	×	×	×	×	×	×	×		×
„ *modiolus* - -							×				
Nucula nucleus - -											×
Cardium edule - -		×	×	×	×	×	×	×	×		×
Artemis lincta - -							×				×
Astarte sulcata - -							×				
„ *borealis* - -											
„ *compressa* - -									×		
Tellina Balthica - -	×	×		×	×	×	×	×	×		×
Mactra ovalis - -				×			×		×		×
„ *elliptica* - -											×
„ *solidula* - -							×				
Mya truncata - -							×	×			
Tapes pullastra - -											×
Scrobicularia piperata -							×				×
Corbula gibba - -							×		×		×
Cyprina Islandica -				×			×	×			×
Rhynchonella psittacea -							×				
Cyrena fluminalis - -		×			×				×		
Pisidium amnicum - -					×						
„ *sp.* - -					×						
Dentalium entalis -											×
Buccinum undatum -		×		×	×		×	×			×
Nassa reticulata - -											×
„ *nitida* - -							×				×
Purpura lapillus - -		×					×	×			
„ *var. imbricata* -							×				
Trophon Bamfius -							×				
„ *clathratus* -		×			×		×	×			
Mangelia rufa - -							×				
„ *pyramidalis* -							×				
„ *turricula* -							×				
Turritella communis -	×	×		×	×	×	×	×			
Natica Alderi - -							×				
„ *helicoides* - -							×				
„ *catena* - -							×				
Littorina littorea - -		×		×		×	×	×			
„ *rudis* - -		×				×	×	×			
Trochus cinerarius -				×			×				
Aporrhais pes-pelicani -				×			×				
Lacuna crassior - -							×				
„ *vincta* - -							×				
Hydrobia ulvæ - -							×				
Pholas dactylus - -				×							
Bithynia tentaculata -					×						
Valvata piscinalis -					×						
Planorbis spirorbis -					×						

* Quart. Journ. Geol. Soc., vol. xxii., p. 470, 1866.

The vertebrate fauna, so far as I have ascertained, consists of:—

Rhinoceros tichorhinus	- Comberton.
Bos longifrons -	- Barnwell, Ely, Waterbeach.
„ *primigenius* -	- Barnwell, Stetchworth, Waterbeach.
Equus fossilis -	- Barnwell, Ely, Kyme, Chatteris.
Cervus - -	- Barnwell, Ely, Kyme, Peakirk, Ramsey.
Elephas primigenius -	- Barnwell, Kyme, Whittlesey, Chatteris, Ramsey.
„ *antiquus* -	- Barnwell.
Hippopotamus -	- Barnwell.
Felis spelæa - -	- Barnwell.
Sus scrofa (wild boar)	- Manea.
Balæna - -	- Waterbeach, Kyme.

Flint implements in the Gravels.—Mr. Evans has well observed that no flints implements have been found in the valley gravels north of the River Little Ouse, and a careful examination of many miles of the Fen beach and doubtful gravels confirms this opinion. The localities from which implements have been obtained are Cambridge and Chesterton, on the Cam, in valley gravel,* Isleham and Mildenhall, on the Lark, in doubtful gravel, Lakenheath and Brandon, in the neighbourhood of the Little Ouse.† The implements are all of palæolithic type, and many are figured by Mr. Evans. In some of these localities they are moderately plentiful, but I have never seen or found an implement from the gravel beds of the north. Mr. Marshall Fisher of Ely has an implement said to be from the gravel of Little Downham, three miles north of Ely, and Mr. Marshall, also of Ely, has another.

This we can say for certain that no flint implements have been found in the true marine fen gravels, that they have been found in the gravels which are probably remains of valley gravels, that all the implements are of the palæolithic type, and the fauna is pleislocene, and not prehistoric, like that of the true fen beach gravels. I think, therefore, we are justified in drawing the following conclusions:—

1. That no stone implements (as yet) are known to belong to the "gravel period" of the fens, but that the more ancient valley gravels and their remains yield them in tolerable profusion.
2. That the people who used them lived on the banks of the streams in preference to the coast.
3 That by the time the denudation of the Fenland had converted that area into sea the palæolithic people had migrated.

It is true that this assumption of the inland character and migration of palæolithic man, subsequent to the formation of the boulder clay, rests upon negative evidence, but that evidence is so peculiar as to merit consideration, and, moreover, if the hypothesis be true, nothing but negative evidence can be forthcoming.

* These gravels I believe to be inter-glacial. April 1876.

† Only those localities on the edge of the Fen are enumerated. Most of the specimens come from far up the valleys.

The peculiarity consists in the entire absence of implements from the true beach-gravel and the presence of implements only in the remnants of the gravels of valleys which still yield plentiful supplies of implements higher up the rivers, beyond the reach of the former sea.

The absence of intermediate stages between the palæolithic and neolithic implements in England has often been commented upon, and the Fenland affords new testimony to the fact. This peculiarity has been ascribed to the emigration of the palæolithic people from the country, which remained depopulated till the immigration of the neolithic folk.

Mr. J. Geikie, F.R.S., of the Scotch Geological Survey, in his work "The Great Ice Age," boldly solves this break by interposing the glacial period wholly or in part between the palæolithic and neolithic implement-bearing beds. He recognises the fact that the palæolithic gravels of this district overlie boulder clay, but claims for that deposit an age which dates towards the beginning of the glacial period, and shows that we have no relics (such as boulder clays) of the latter days of the glacial epoch. He argues that all we can say is that the gravels in question are newer than the boulder clay of the district, and that till it can be shown that the boulder clay marks the close of the glacial epoch, we are not justified in claiming the gravels as post-glacial. If we admit the force of Mr. Geikie's reasoning, the anomalous distribution of palæolithic tools receives a ready explanation. I have proved the palæolithic gravels of the fen to be newer than any glacial clay in the district, yet probably much older than the true beach gravel; but I have no facts to produce which negative Mr. Geikie's assumption, neither have I any to prove it. It accounts for the facts at least as well as any other hypothesis, and for some of them better. If it be true we may look for palæolithic implements in the Whittlesey, March, and Kyme gravels, for they are old river or estuary deposits, belonging to the last inter-glacial period, but they will probably be much rolled.

The true fen gravels belong to the denudation period in which the fen basin was again scooped out,* and the peat and silt beds to the subsequent, still existing period of deposition.

The neolithic people immigrated during this latter period, and not until some considerable amount of peat and silt had been formed.† Mr. Evans figures numerous implements from the turbaries of the fen, especially from Burwell. Those cited below have not before been noticed and are given as being from new localities. Fig. 25 is an unsymmetrical rather rudely-chipped, barbed arrow-head found in the peat at Bourn, Lincolnshire, by Mr. C. Speckley, late of that place, about eight years ago.

Fig. 26 was found by me at Edenham, near Bourn, in 1871. It was on a raised mound, and though not belonging to the fen

* See Chap. XVII.

† This is one of the reasons which lead me to ascribe the date of the beach-gravels to the close of the glacial period. See table of strata.

Fig. 25.—*Flint arrow-head from Bourn Fen.*

Fig. 26.—*Celt from Edenham.*

proper, is here figured because a very similar one was found in the peat at Kate's Bridge (Fig. 27), south of Bourn, which, doing

Fig. 27.—*Celt from Kate's Bridge.*

duty with bits of spar on a "grotto," was not obtainable for scientific purposes. Both were formed of a dark-green slate or hornstone, and neatly polished. The stones were evidently boulders, for mine still shows portions of the original weathered surface. This implement is now in the Museum of Practical Geology.

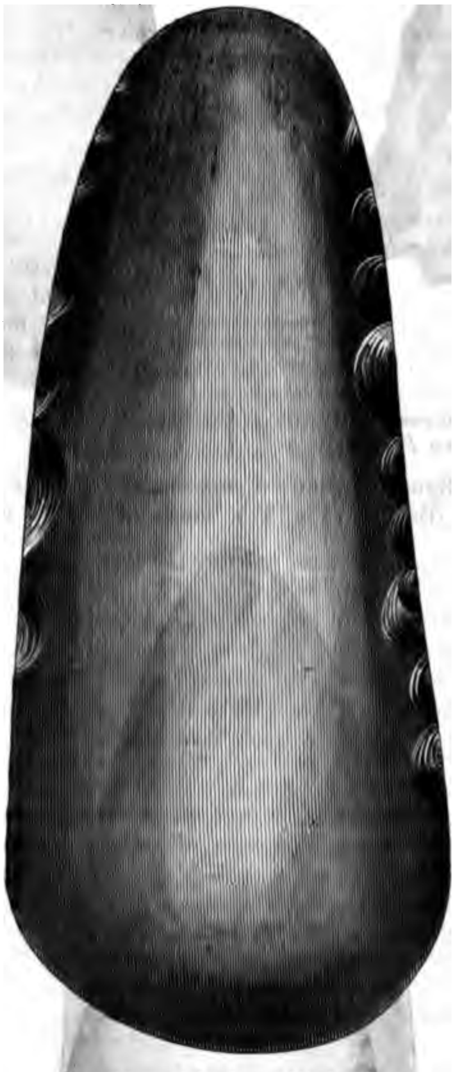


Fig. 28.—*Celt from Digby Fen.*

Fig. 28 represents its natural size of a splendid polished flint celt found in the peat at Digby, south of Billinghay, Lincolnshire, by workmen. It is 5½ inches long, 1½ inches at the butt, and 2½ inches at the cutting edge. The ends are beautifully rounded and the sides show the characteristic conchoidal fracture of flint. The surface is polished and the cutting edge unchipped, elliptical, and worked to a true line. I was not able to obtain possession of this fine celt, which is now probably lost to science.

Fig. 29.—*Flint arrow-head from Chatteris.*

Fig. 29 is a beautiful chipped arrow-head found in buttery clay at a depth of 4 feet from the surface by Mr. Fryer, of Chatteris. It is of black flint and singularly perfect. The chippings are exquisitely fine, and the whole surface is worked over. It still remains in Mr. Fryer's collection.

Of bronze implements several socketed celts have been found in the vicinity of Ely and near North Kyme, but they call for no special notice being of common types. They were all, I believe, found on the surface. The Ely specimens are in the collection of Mr. Marshall Fisher, of Ely, and the Kyme ones belong to Mr. Mugleston, of Billinghay.

The implement found by Mr. Spreckly, Fig. 24, is the rudest of these specimens, but it is of undoubted neolithic type, so that we may safely say that the break between the old and new types is complete and abrupt in the fens.

It is worthy of remark that all the implements hitherto found have been in the vicinity of highland, and it thus would seem that their possessors though possessing boats never went far from shore.

In conclusion, I would state that I have by no means completed my examination of the gravels as completely as is necessary, and some of the views herein enunciated may require modification when the beds are better understood, but I do claim to have sufficient acquaintance with them to hold strenuously the views I have here put forward. The following points may be considered as definitely settled:—

1. The fen gravels are all newer than the glacial clays of the district.
2. The pre-glacial gravels are readily distinguishable from those of the fen, and never crop out in that area.
3. Much of the fen gravels are undoubtedly marine, even where no marine organisms have been found in them.
4. Flint implements are not found in the beach gravels of the fens, but only in the doubtful beds which are very probably old valley-gravels which have escaped denudation.

Since the above was written I have surveyed in detail the gravels in the basins of the Little Ouse and Lark, from which a splendid series of flint implements of palæolithic types have been obtained, and this additional experience has confirmed me in the opinions advanced respecting the inter-glacial age of the palæolithic beds, and the pre-neolithic date of the true fen gravels. Moreover, as I hope to show in detail in a future memoir, the mass of the gravels in the river-basins in question have no essential relation to those rivers, but are part of a wide-spread deposit which covers almost the entire face of the country, sweeping over the high land and down into the vales, capping the highest hills in the counties of Norfolk and Suffolk, and forming the lowest ground also. The deposit is essentially of local origin, as is shown by the ingredients which constitute its mass, and seems to have been formed during intense floods which gave rise here and there to temporary streams, on whose sites alone is the material stratified. In this respect this deposit seems to be the counterpart of those sands and gravels to the north of the Fenland which I have all along spoken of as *flood*-gravels.

The great break between the faunæ of the old inter-glacial gravels and the true fen gravels, and the magnitude of the interval which separates the palæolithic from the neolithic ages, an interval which, so far from seeming likely to be bridged over, appears to me to be extending its bounds, irresistibly point to the conclusion that between the two epochs some great cosmical change had occurred which rendered our land unfitted to the wants of the lion, the elephant, and palæolithic man, and, as the area was not submerged, it seems legitimate to point to a recurrence of glacial conditions as the cause, and the onus of finding some other explanation rests with those who deny the inter-glacial age of the Old Stone Folk. Mr. J. Geikie has admirably expounded this view.* Mr. Tiddeman has, it seems to me, *proved* man's glacial age in his papers on the Victoria Cave,† and my own researches in the fens led me to similar conclusions which extended experience daily tends to confirm. I look, then, upon the marine relics of the old river gravels as the most southern extension hitherto found of that great submergence of the glacial period which left its records upon the mountains of Wales, Northumbria, and Scotland, and upon the barren beach-gravels of the fens as subsequent, though still glacial, deposits of a time still unfitted to the wants of man.

In accordance with these views I have ventured to insert the accompanying map, Plate XVIII., whereon the gravels are tinted according to their respective ages so far as they have been determined, and this is done in the firm conviction that further investigation will confirm their truth.

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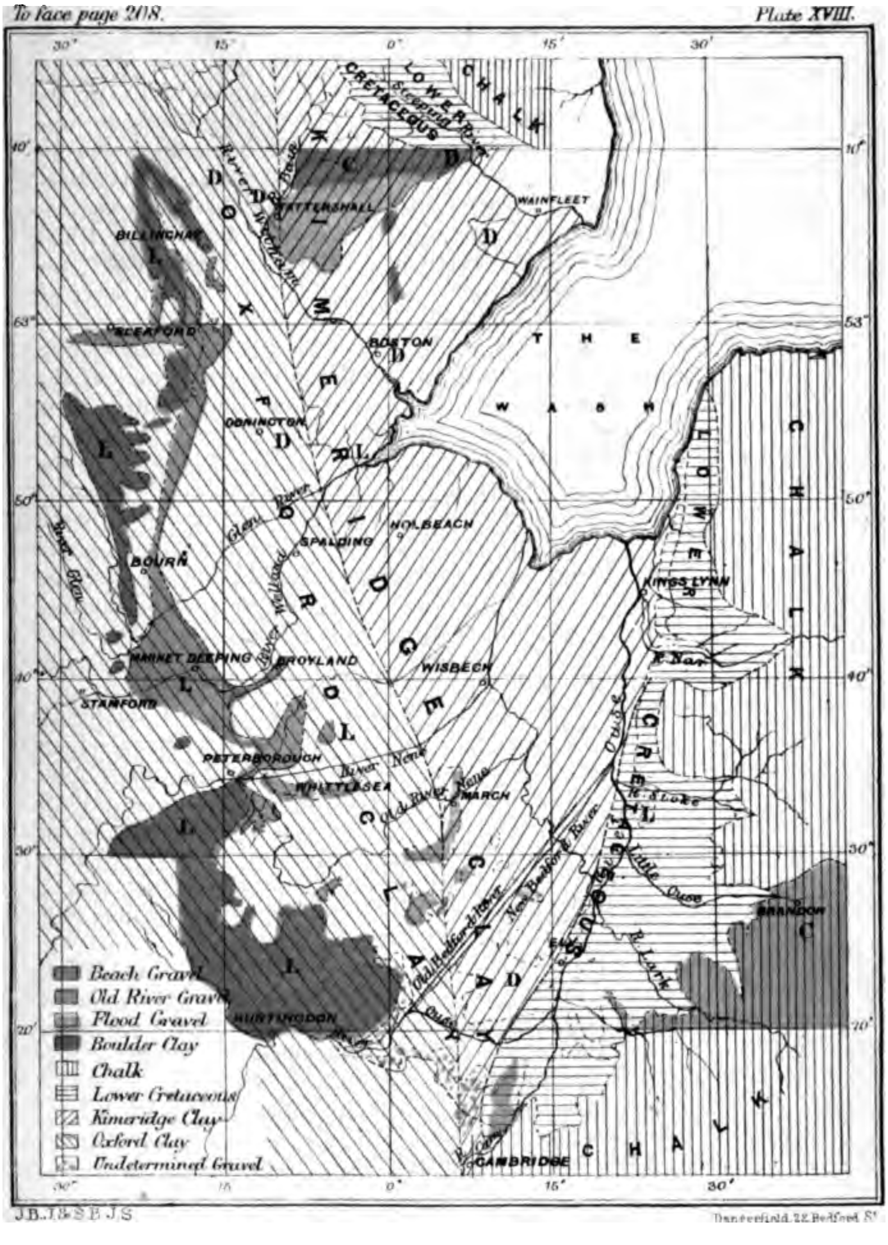
* Great Ice Age.

† British Association Report, 1875; meeting, 1876.

GEOLOGICAL SURVEY
OF ENGLAND AND WALES.

To face page 208. Plate XVIII.



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THE
GEOLOGICAL RELATIONS OF THE GRAVELS & BOULDER CLAY
OF THE FENLAND.

CHAPTER XVI.

THE BOULDER CLAY.

The remarks which follow have no pretension to exhaustiveness, for the boulder clay cannot be well studied in a locality such as the Fenland, where the beds are nearly always covered by other deposits, and exposed only in small sections. But this very paucity of exposure gives a value to the following notes as recording characters which may not be again seen, and could only be observed on an extensive survey. I may add that I am familiar with the glacial deposits of the counties of Lincoln, Leicester, Rutland, Northampton, Cambridge, Norfolk, and Suffolk, having mapped considerable areas therein, and, therefore, my remarks must not be taken to embody the results derived from a study of the clay beneath the fens alone.

I am not aware of any published account of fen boulder-clay, yet it underlies most of that area and is in some places surprisingly thick. Boulder clay comes down to the "fen edge" along the northern boundary around Steeping and Tattershall; along the west from Billinghay to Swaton; along the south from Peterborough to St. Ives.

Irby.—(Section No. 198, Appendix.)—The boulder clay is here of a blue colour full of small and large chalk stones, some of which are so soft that the workmen use them for writing purposes. Basalt, quartzite, Neocomian Sandstone, and flints (many quite black) occur, and many of the pebbles are striated. It was dug to a depth of 12 feet, and 2 feet of sand were found beneath. The clay is, hereabouts, often overlaid by sands and sandy gravel, which rise in small hillocks from 10 to 20 feet in height. The clay is said by the workmen to "come up in banks," that is, its surface is irregular.

Thorp Culvert.—(Sections Nos. 197, 200, 202, Appendix.)—In the brickyard close to the station about 6 feet of boulder clay like that just described overlie sand and gravel. In Mr. Scarborough's brickyard the boulder clay is said to have been sunk into 37 feet without being bottomed. At Thorp Fen Dyke a well by the side of the old river was sunk through 40 feet of boulder clay, which is said to have been very clean, and water was got in the sand below, but it was unfortunately salt.

Firsby.—The boulder clay can be well seen in the railway cutting at this place. It is peculiar in being of a reddish colour, breaking into cuboidal fragments and possessing much of the character of fen clay—for which I at first mistook it, as it is in places quite free from extraneous matter.

It, however, contains a remarkable assemblage of rock-fragments, amongst which are Silurian limestone, basalt, greenstone, and a very hard, red, jaspery gritstone. Some of these boulders are striated, which is itself a noticeable feature, since it is generally only the softer rocks, such as chalk, that are glaciated. Chalk, flint, Inferior Oolite Limestone, Keuper Sandstone, Coal-measure Sandstone, and a few fragments of slate occur. The chalk is mostly soft, which is again peculiar, and not striated, but the harder pebbles retain striæ. Here and there chalky masses occur which are quite friable.

Some of the stones are 4 inches in length, but the greater number are small well-rounded pebbles of soft chalk. The larger stones, as is usual in boulder clay, have one or more flattened surfaces.

I found a single rolled specimen of *Trophon clathratus* in the clay.

Mareham-le-Fen.—This village stands on the border of the fen. A quarter of a mile north of the clunch pits are opened in a remarkable kind of boulder clay. The material is almost entirely chalk, which is indeed burnt for lime, and occurs in all states of aggregation from a fine powder to large rounded boulders a foot square, nearly every fragment being striated. Flints are numerous, unworn, and large, with their white cherty coating remaining and scratched. A few brown waterworn flints also occur. Other rocks are found very sparingly, such as coal-measure sandstone, quartzite, greenstone, and basalt, all of which are striated. Waterworn masses of laminated dark but Kimeridge Clay are also found, and in places predominate so a to give their colour to the section.

Between Coningsby and Kirkby-super-Bain.—The boulder clay, here overlaid by sands, is a dark blue clay, with much chalk and many boulders and septaria, all of which are striated.

Bed of Witham above Tattershall.—The bed of the river is in boulder clay of the above character, but the chalk pebbles are alone scratched. Three large boulders were taken out near Kirkstead, the first two of which are of Lias Limestone, the last of hard sandstone. The measurements are as follows:—

No. 1. 6 ft. 9 in. × 4 ft. 8 in. × 2 ft. 4 in.
No. 2. 4 ft. 6 in. × 4 ft. 0 in. × 1 ft. 9 in.
No. 3. 4 ft. 2 in. × 2 ft. 6 in. × 1 ft. 9 in.

Mr. Wheeler, of Boston, first described these boulders to me, and I subsequently measured them myself.

Kirkstead.—(Section No. 196, Appendix.)—The boulder clay is seen below the gravel, and is of a dark-blue colour, but of a greenish tint towards the top, where from the frequent occurrence of flints and striated chalk pebbles, its glacial character is very apparent. Below it is blue in colour, and the numerous *scattered* septaria give it very much the appearance of Kimeridge Clay. On digging into it, however, moderate-sized pebbles of striated chalk, rounded flints, and pieces of inferior oolite limestone may be found; and the clay is seen to be not laminated but compact *with fragments of laminated clay with rounded edges—clay pebbles in fact—strewed profusely through it.* A single pebble of New Red Marl (?) was found.

Billinghay.—The boulder clay is here dark blue, and contains much chalk from fine grains to well rounded, striated pebbles. Unrounded fragments of shell, and other rocks occur.

New York.—All round this place the boulder clay is of the dark-blue character described in the above localities.

Boston.—(Sections Nos. 118, 119, 120, 121, 122, 123, 124, 132, 134, Appendix.)

Around Boston, boulder clay of the dark-blue character can be occasionally seen in several of the brickyards at depths of from 15 to 26 feet from the surface. The fen beds around are much thicker than this and Boston seems to stand on a submerged bank of boulder clay of which the islands of Sibsey and Stickney to the north are the only parts which appear at the surface.* The attempts to supply Boston with water in the years 1746 and 1828, by means of deep wells, have afforded very valuable sections. The former of these (No. 134) was sunk to a depth of 173 feet and was still in "clay with very small handstones,"—this can scarcely be other than boulder clay. The complete record of the deeper sinking in the year 1828 (No. 135.) has been happily preserved, and is given in full in the Appendix. The "shells" so often mentioned in the record I take to be large *Gryphææ* and pieces of *Ammonites* which are very plentiful in the boulder clay at Boston, from which Mr. Wheeler preserved specimens from the borings he has made. They are all glaciated. At a depth of 583 feet the record is "clay, shells and flint," and the latter substance can hardly have been mistaken for any other material. Hence I believe the whole of this section of 572 feet to be in quarternary beds. At the depth of 486 feet shingle and sand begin to appear in the section, and these beds I take to be the pre- or inter-glacial beds. Reduced to its simplest expression the section gives :—

	Ft.	In.
Fen Beds - - - - - - -	24	0
Boulder Clay - - - - - -	460	0
Pre- or Inter-glacial Beds - - - -	88	0
	572	0

The rock 1 foot 7 inches thick, reported as reached at a depth of 509 feet, was probably a large boulder. It took four days to pierce, which would not have been the case had it been a septaria in the Kimeridge Clay.

The whole aspect of the boulder clay indicates terrestrial origin, and if the above interpretation be right, it shows that the land during the glacial period was relatively 460 feet higher than at present. The lower 80 feet may be, and probably are,

* See Section 1, Plate XXIV.

marine. In the neighbourhood of Bourn, Lincolnshire, on the Bytham and Edenham Railway, the following section can be measured:—

	Ft.	In.
Boulder Clay - - - - - -	?	
Sand and Gravel - - - - -	16	6
Boulder Clay - - - - -	33	0
Sand and Gravel, seen to - - - -	88	6
	138	0

The upper bed of boulder clay is part of the great mass of light-blue chalky boulder clay, which attains a thickness of 300 feet in north Northamptonshire and Huntingdonshire. The parallelism between the two sections is close, and is further increased by the fact that the sands and gravels in the inland locality are local, which is also the case at Boston, for the boulder clay, as we shall presently see, lies directly upon the Kimeridge Clay at Holbech and Lynn. The dark-blue colour of the boulder clay is very different from the light-blue clay of the highlands of Lincolnshire; but this is not sufficient difference to warrant their separation for light-blue clay occurs in the fens, at Fossdyke for example, and dark-blue clay occurs in the highland, as at Irnham, where it is certainly continuous with the light-blue deposit.

Fossdyke, near Spalding.—(Section No. 135, Appendix.) —A well 326 feet deep has been sunk at Forsdyke by Messrs. S. F. Baker and Sons, of Southwark Bridge Road, to supply the coastguard station with water, which it need scarcely be said was not accomplished. Sand and gravel were found to a depth of 57 feet (fen beds included), then 37 feet of yellow sandy clay, probably a form of the above, then came 51 feet 6 inches of light blue clay with chalk stones, and then 159 feet 6 inches of dark clay with septaria bands (Kimeridge). At this spot, then, the Boulder Clay, only 51 feet thick, is of the light-blue kind, and is not underlaid by gravels. The details were kindly supplied me by Messrs. Baker.

Bicker.—(Section No. 146, Appendix.)—The boulder clay is here dark-blue, and full of chalk and other stones.

Donington.—Around Donington, as at Bridgend Causeway, light blue chalky boulder clay can be occasionally seen in the dykes. At Donington brickyard (Section No. 152, Appendix) the workmen told me that a "yellow clay full of chalk-stones that burns white," had been found at the bottom of the pit at a depth of 16 feet. This may be the top of the boulder clay. A good section is seen at Blotoft Farm, on the 40 Foot Drain (Section No. 154, Appendix). The clay is of the light blue kind, and contains many angular flints, some of large size and striated, also quantities of chalk from small grains to boulders 4 inches in diameter, some of which are beautifully polished and striated. Boulders and pebbles of older rocks occur in tolerable abundance.

Lynn.—(Section No. 107, Appendix.)—A well 623 feet deep was dug at this place about the year 1812 which passed through the boulder clay into the Kimeridge Clay, but, unfortunately, the only record I have been able to obtain lumped the two clays together.

Hilgay.—(Section No. 118, Appendix.)—The boulder clay at this place is mottled yellow and light blue, becoming darker blue with a few yellow mottlings at about 4 feet deep. It is very like Gault in appearance, and very free from boulders; chalk, millstone grit, and quartzite pebbles occur, none exceeding the size of a walnut. It is used for brickmaking, burning dirty-white and forming good bricks, but of uneven colour. At a depth of 12 feet, according to the workmen, many stones, said to be limestones, are found; these are very likely septaria.

Croyland.—(Sections Nos. 45, 46, 51, Appendix.)—In digging a fishpond near the town, boulder clay was found at a depth of from 15 to 20 feet. It is light blue and full of chalk and flint. It has been bored to a depth of 20 feet. Similar sections reveal like clay; one at the steam-engine house, close to the Wash Bank, contained large stones, described as taking nine men to lift. Specimens of clay were brought to me from this place and from the Fan-Tail Mill. The former was a tenacious, greenish clay, full of chalk and flint; the latter was similar in colour but free from foreign matter. No stones were found in it on sinking a well, and the clay turned out was made into bricks.

The clay at March and Kyme has been described in the previous chapter, and that at Ely scarcely comes within the scope of this work, it being on the highland.

Age of the Boulder Clay.—The age of the boulder clay —for there is but one—which underlies the fen cannot be determined in the locality, but only by correlating it with other localities.

Messrs. Searles Wood, Jun., and Harmer describe the quaternary beds exposed near Cromer as below, the beds being in natural order, being numbered from below upwards—

1. **Forest-beds.**
2. **Pebbly Sands** and **Laminated Beds.** The *Bure Valley Beds* of S. V. Wood, containing shell-patches at Runton, Weybourn, &c.
3. **Cromer Till,** with erratics.
4. **Contorted Drift,** with masses of marl and chalk.
5. **Sand** and **Rolled Gravel.** The *Middle Glacial* of S. V. Wood, containing southern shells.

Above bed 5 come, according to S. Wood, in the same order—

6. **Great Chalky Boulder Clay.**
7. **Purple Boulder Clay with Chalk,** which passes up into
8. **Purple Boulder Clay of Yorkshire, without Chalk.**

These latter beds form the Upper Glacial Beds of Searles Wood. There can be no doubt that the fen boulder clay belongs to No. 6, *i.e.*, the Upper Boulder Clay of Wood. Messrs. Wood and J. Geikie have, however, shown strong grounds for believing this Upper Boulder Clay to be older than the Middle Glacial Sands and Upper Boulder Clay of Lancashire. Mr. Geikie thus correlates the beds, the oldest being at the top :—

1. Till of North Wales, &c.; lower and middle glacial of East Anglia.
2. Lower (brown) boulder clay of Lancashire, &c.; chalky boulder clay of East Anglia; boulder clay of Northumberland coast. Perched blocks at high levels.
3. Older morainic debris; perched blocks; gravel and sand on opposite mountain valleys. [Not represented in the East of England.]
4. Middle sands of Lancashire, Moel Tryfaen, &c.
5. Upper boulder, or stoney clay of Lancashire; Nar Valley beds; Hessle gravel and clay, erratics.
6. Valley moraines.*

This correlation appears to me to be soundly established, and if so, it proves, as Mr. Geikie has pointed out, that the east of England did not partake of the last great glacial depression which left its marine records upon the Welsh mountains 2,000 feet above the present sea level, although, as I have shown, this period was one of slight depression in the fens, as shown by the old marine fossiliferous gravels at Whittlesey, &c. On this hypothesis the sand, gravel, and clay series below the boulder clay at Boston belong to the Middle Glacial of Searles Wood, and the earliest inter-glacial epoch of Geikie; the old river-gravels of March, Whittlesey, &c. belong to the last inter-glacial* epoch of Geikie, and are contemporaneous with the higher boulder clays and fossiliferous sands of Wales and Lancashire; the flood gravels on the northern edge of the fen are of the same age. The true beach and floor gravels of the fen are still newer and may be post-glacial,† and belong to the subsequent period of excessive rainfall which Mr. A. Tylor calls the Pluvial Period, and the peats and silt still more recent.

This classification, which is adopted in the subjoined Table, seems to me to afford the readiest solution of the characters of the fen deposits, but much more work must be done before it can be deemed firmly established; and I would add, before it can be overthrown.

I was of opinion that recent researches had proved the boulder clay to be of terrestrial and not of marine origin; but the contrary opinion having been advanced in some recent papers, it may be well to enumerate the phenomena which have led me to look upon the boulder clay of this area as a local formation, although the facts are similar to those already advanced by other observers in different localities.

Stated in the simplest manner, the boulder clay can only have been formed by shore-ice, by icebergs, or by an ice-sheet. That it is not a shore deposit is at once proved by the wide area over which it is found. If it be the transported matter of icebergs it must possess certain peculiarities and be devoid of others. Icebergs are the wrecks of land ice, and the rocky material they carry is derived from the gathering-grounds of the parent ice;

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* Great Ice Age, pp. 425–6.

† That is to say, subsequent to the ice-age in the Fen area.

hence if the boulder clay be iceberg drift its components must be those of the *distant gathering-grounds*, and not those of the rocks it falls upon as the berg melts away. Now the boulder clay under consideration has received the name of the Great Chalky Boulder Clay, from the very extensive region over which it is found, and from the chalk pebbles which it nearly always contains. It runs far inland, and most frequently caps the hills; and it has been traced to a height of over 300 feet above the sea, with a thickness of more than 300 feet, although it has been very much denuded. If it be an iceberg drift, the gathering-grounds of the parent ice must have been to a great extent on the chalk, and that gathering-ground must have been also of great extent to permit the removal of so much chalk. Now at the most moderate computation the sea-level must have been at least 500 feet higher than at the present time to allow of the clay being deposited by floating icebergs at a height of 300 feet above the present sea. But if we suppose the sea to stand at the present 500 feet contour line, *very little chalk indeed will be left above water*, and this will consist of a few small islands, and an area of a few square miles of islands could never be the gathering-ground of great glaciers. Again, most of the argillaceous material of the boulder clay of the Fenland is derived from the Oxford and Kimeridge Clays, and *all* of those formations would be under water. Hence if there were no other proof forthcoming I should reject the marine theory of the origin of this boulder clay because there are no gathering-grounds for the glaciers.

A much more powerful argument is found in the relation of the materials which compose the boulder clay to the rocks upon which it lies. If it be of iceberg origin, as we have said, the clay can have no relation in composition to the rocks upon which it lies, except by accident. But the boulder clay does possess such a connexion; for, speaking generally, its bulk is composed of the similar clays, &c. to those upon which it rests; and the upholders of the marine theory will have to explain how icebergs acquired a "selective affinity". in shedding their burdens, by virtue of which they preferred to drop Kimeridge Clay débris upon Kimeridge Clay, and Oxford Clay detritus upon Oxford Clay.* It is peculiar that the boulder clay is dark upon the dark-blue Kimeridge Clay and light upon the light-blue Oxford Clay; and if this be not deemed sufficient proof by those who say mere colour may be deceptive (though all over the Fenland and vicinity the two clays are very distinct in colour), the *fossils* in the boulder clay show a large percentage of Kimeridge Clay species where that rock lies below, and of Oxford Clay fossils where that is the subjacent bed.

There is, however, one peculiarity to be observed, which I think is utterly inexplicable on the marine hypothesis, but a natural consequence of the terrestrial theory: namely, that what

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* This holds good wherever I have mapped this clay. Thus, the limestones and clays of the oolites and lias of Lincolnshire, Leicestershire, &c. impress their character so forcibly upon the boulder clay, that I have sometimes been in doubt as to whether it was boulder clay or some old rock brought in by a fault.

we may call the Kimeridge boulder clay invades the outcrop of the Oxford Clay, and the Oxford boulder clay does not come on until the Oxford Clay has fairly taken the ground. In like manner, upon the Chalk the boulder clay is much more chalky than elsewhere, and this feature it maintains over the narrow Greensand outcrop on to the Kimeridge Clay, as at Mareham, where indeed chalk boulder clay is burnt for lime.

It is quite impossible that icebergs should have dropped their burdens so geologically; but, if we look upon the boulder clay as the product of land ice all difficulty vanishes; for the ice, as it crept slowly south-westwards, would push its ever-gathering ground-moraine along, and in this way the detritus of one rock would be pushed on to the outcrop of another rock.* Mr. Tiddeman has given some magnificent examples of this invasion of the territory of one rock by the glacial detritus of another in Lancashire, where the succession of different coloured rocks is peculiarly favourable for the production of such phenomena in striking force. But even in this district such proofs of the local origin of the boulder clay are very clear. In the vicinity of Brandon, for example, the clay contains large unworn flints which can only be referred to certain layers (described at length in my Memoir on Gun-flints) in the immediate vicinity. These flints cannot have been transported more than a few miles, for the layers of flint are very local, and they have been exposed to but slight atmospheric influences, as is proved by their sound condition. When flints are at all weathered they are unfit for use by the flint-knappers; but many of the stones from the boulder clay are as readily worked as the flint fresh from the flint pits. It is clear that these stones, at any rate, cannot be iceberg drift, or the flints would have become weathered and be of foreign origin; neither can they be from a lateral or terrestrial moraine, or they would be unsound. Most of these very flints that I saw dug fresh and sound in November 1875 have become shattered by exposure to this winter's frost, and now (July 1876) are useless for knapping. Can they have been exposed for years on a glacier or an ice-berg? We are compelled then to assume that they formed part of a local ground-moraine. Again, the surface of the chalk is often worked up into the boulder clay, and great masses are to be observed here and there which have only been slightly moved from their original position. These facts are absolutely antagonistic to the marine theory, and in perfect accordance with the theory that the boulder clay is the product of land ice.

It must be here borne in mind that I am speaking of one particular boulder clay; for that bergs and shore-ice can form such clays is certain, but they possess features which distinguish them at once, and lack others which are only found in the land-ice clays.

* This S.W. trend of the ice is brought to light in consequence of the overlap of the cretaceous rocks in Lincolnshire, which alters the strike from N. and S. to N.E. and S.W. My friend, Mr. J. Geikie, informs me that all along the Scotch coast the trend of the ice was, as here, away from the sea, showing that the bed of the German Ocean was ice-blocked.

CHAPTER XVII.

THE DENUDATION OF THE FENLAND BASIN AND BREACHING OF THE CHALK BARRIER.

Before the Glacial Period the site of the Fenland Basin was very different from its present condition. The chalk and other cretaceous and neocomian rocks stretched from Hunstanton to Lincolnshire across what is now the mouth of the Wash, with an escarpment to the westward overlooking a gently indulating, somewhat low-lying plain occupied by the Kimeridge and Oxford Clays: eastward, chalk hills rolled away over the site of the Wash, and through this chalk barrier, as we will for convenience call it, the fen rivers flowed as the Wealden rivers now run in the south; the Witham finding its way by the site of Wainfleet, the united Welland, Nene, and Ouse through what is now Lynn Deeps, and the Little Ouse along the present course of its greater namesake. We might go further back to the time when the Witham began to saw into the Oolites at Lincoln, and with the other rivers was just attacking the chalk hills, but this would lead us beyond the scope of a work upon the fen beds.

The enlargement of the estuaries by the rivers probably went on simultaneously with a steady submergence which caused loss of land to the eastward of the chalk barrier. These actions resulted in reducing the barrier to outliers; one between the Witham and the three united rivers, the other between that united stream and the Little Ouse. As submergence went on the sea added its powers to that of the rivers and finally the chalk disappeared entirely. The sea was now brought directly in contact with the widespread outcrops of the yielding Kimeridge and Oxford Clays, and the denudation of the Fenland basin proceeded at a rapid pace. The clays were scoured away to the cretaceous rocks on the north, the harder oolites on the west, and the chalk again on the south and east. In some places, as in the north, west, and south-west, the further progress of the denudation was opposed by the Kimeridge and Oxford Clays themselves, they forming high land at those places. A few places withstood the action of the sea and their remains now form the "islands" we have described.

The depth of the basin was at least 600 feet at Boston, and almost certainly 1,000 feet if the Middle Glacial Sands are correctly designated as marine,* for these sands which were subsequently deposited go up to a height of 300 feet above the sea in Cambridgeshire; and if they were, as is most likely, deposited during a period of elevation the depth was even greater, and most of the land was submerged in the east of England. We have no evidence of the occurrence of till in the fen basin, and, as it would most likely have been reached in some of the many sections I

* The sands, &c., at Boston, if marine, must have been formed before those in the highlands, for they are not likely to have been deposited a thousand feet under water. It is by no means clear to me that they are not chiefly of fresh-water origin. An elevation of 600 feet, such as obtained when the boulder clay was deposited, would lay the whole bed of the German Ocean dry, as indicated below.

have seen, we may assume that it is absent. The till seems to be a true marine boulder clay; it occurs largely on the coast of Norfolk, and we may infer also in part of the fen area. It would, however, be pretty completely swept away during the great submergence when the basin was denuded unless that submergence was prior to the glacial period. We may, I think, take it as fairly shown that the destruction of the chalk barrier, and the original denudation of the fen basin occurred in late tertiary times, or at the beginning of the glacial period.

The Middle Glacial Sands, &c., as shown in the Boston section, indicate a mild period, in which water freely flowed; and also a period of elevation since they could not have been formed 500 feet below the sea. Before this elevation attained anything like its maximum glacial conditions had again set in, and the Boulder clay began to form. This great chalky-clay filled up the fen basin and the existing valleys, and covered all the country. It is found 400 feet thick upon the highlands beyond the fen and 500 feet below the present sea-level in the fens, as we have shown. Hence the elevation of the land must have been at least 500 feet above its present level, and England was united to the Continent across the present bed of the German Ocean.

Then followed the last inter-glacial epoch of J. Geikie, during which the rivers hollowed out new, or cleaned their old, channels. Palæolithic man flourished, and the climate, at first cold, was fitted to the wants of the mammoth and tichorhine rhinoceros; afterwards it became mild or even warm, and then cold again.* An excessive rainfall, or at least great floods caused by the retreating ice-sheet, caused denudation to proceed at a rapid rate, for Mr. A. Tylor has shown:—

1. That the erosive force (E) of a river increases as the fourth power of the velocity (V), or $E = V^4$.
2. That the velocity increases as the cube root of the quantity (q) of water, the slope remaining the same, or $V = \sqrt[3]{q}$

Hence, supposing the rainfall to be 27 times as much as at present, the rivers would flow with three times the velocity and with 81 times the erosive power.†

During this period, I take it, the valley-gravels of the fen-rivers were chiefly formed; and if the land stood at the same level as during the formation of the boulder clay, these rivers must have flowed united to join the extension of the Rhine in the centre of what is now the German Ocean. But this cannot have been the case or we should not find marine shells in those gravels close to the eastern "coast" of the Fenland. Hence we must conclude that the Last Inter-Glacial Epoch in this district was one of depression; that the depression was at least 50 feet, and that the fen-basin was partially re-excavated. This period was one of

* I have recently (August 1876) found palæolithic implements in inter-glacial brick-earth beneath the boulder clay, thus proving that man existed in the earliest part of the glacial period. See Memoir on Gun Flints, &c. 1876.

† A. Tylor, Action of Denuding Agencies, Geol. Mag., Sept. 1875. I would earnestly recommend all interested in physical geology to pay especial attention to his remarkable paper.

considerable length, during which the climate ameliorated to such an extent as to cause the migration of the cold fauna, and the introduction of forms belonging to warmer regions; among these we may cite *Felis spelea*, *Elephas antiquus*, and the shell *Cyrena fluminalis*. It is true we cannot, as yet, separate the gravels of the cold and warm periods; but, as Mr. J. Geikie forcibly argues, the mere presence of arctic and tropic forms attests a lengthened period, for annual migrations could never account for the admixture of faunæ.

Succeeding this mild period was the last glacial epoch; during which the north of England, Wales, and Scotland were submerged to a depth of 2,000 feet, and boulder clay, &c. were formed in those districts. No glacial deposits in our area mark this period, which even in Scotland does not seem to have been one of intense arctic conditions. Yet it was a period pregnant with importance to the Fenland, for during it the area was depressed to a depth of about 50 feet below the existing sea-level, the basin was re-excavated *in the boulder clay, &c.* to its present depth, and the beach-gravels of the borders, and the floor-gravels were deposited.

Then the glacial period came to an end, and the fen silts, peats, and buried forests were formed. The presence of peat in some places immediately upon the gravel shows that a land surface existed after the gravel was formed. As this peat is 30 feet below the sea-level the land must have stood about that much higher. The elevation cannot have been much more, for silt was being deposited in other parts of the area. Indeed the whole of the subsequent period seems to have been one of but slight oscillation of relative level, the high-water mark being about the height of the then surface, that is to say, the land gradually sank to its present level as the beds formed. I say "the land sank" as the readiest mode of expression, but it is by no means certain that it was not the sea which varied in level.

There seems, however, to have been at least one period of decided relative elevation, during which the peat extended into area of the Wash, and, perhaps, right over the site of what is now the German Ocean, uniting England with the Continent. Remains of this land surface are found in the submerged forests of the Lincolnshire coast at Sutton, the Norfolk coast at Hunstanton, and the peat-masses dredged up in the Wash. This was probably in the earlier part of the post-glacial period, but its true position requires extended observation before it can be definitely settled.

The above remarks are the result of a careful investigation of the fen beds, carried on for five years; and though some points must await future evidence, the main facts may be taken as proved. I have drawn up the following table in accordance with these views, and in connexion with it, would remark, that about beds 6 to 9 little doubt remains that they are correctly placed: the assumed ages of beds 4 and 5 are doubtful, and may be newer but certainly not older than stated. The rest follow as a natural consequence from the acceptance of Mr. J. Geikie's views upon the correlation of glacial deposits. These, as I have before stated, may to many appear unproved, but to me they afford the most philosophical explanation of the difficulties attending the fen gravels. I may add that Mr. J. Geikie himself could have had no idea of the application of his views to the fens; and these remarks may be taken as being equally an exposition of his work, and his work as an explanation of my difficulties.*

TABLE of the FENLAND BEDS.

—		Deposits.	Fossils.	Physical Conditions.	Remarks.
POST GLACIAL.		9. *Blown Sand* -	None - - -	As at present.	
POST GLACIAL.		8. *Peat* -	*Bos longifrons*, *B. primigenius*, *Megaceros Hibernicus*, *Castor fiber*, &c. Buried forests. Bronze, iron, neolithic implements.	Similar to present, but with greater rainfall.	Does not now grow under natural conditions.
POST GLACIAL.		7. *Shell Marl* -	Recent shells -	As above - -	In upper part of peat.
POST GLACIAL.		6. *Silt* -	Mammals as in No. 8. Whale, grampus, *Scrobicularia piperata* and other recent shells.	As above - -	Nos. 6 to 8 forming simultaneously in different areas.
GLACIAL PERIOD.	Last Glacial Epoch.	5. *Beach, and Floor Gravels.*	Deer. *Bos longifrons*, *B. primigenius*, &c.	Land submerged 50 feet. Climate cold. Rainfall probably excessive.	
GLACIAL PERIOD.	Last Glacial Epoch.	4. *Nar Valley Clays, &c.*	Recent marine shells, many not now living in the Wash.	As above - -	Only in Nar Valley.
GLACIAL PERIOD.	Last Inter-Glacial Epoch.	3. *Old Valley and Flood Gravels.*	Recent marine and freshwater shells, with *Cyrena fluminalis* and *Cyprina Islandica*. *Bos primigenius*, *Elephas antiquus*. *E. primigenius*, *Felis spelæa*, *Hippopotamus*, &c. Palæolithic implements.	Land higher than now, but coast-line not so far east. Climate first cold, then warm.	
GLACIAL PERIOD.	Second Glacial Epoch.	2. *Boulder Clay* -	None - - -	Land 500 feet higher than at present. Climate intensely cold. Ice-sheet. England continental.	
GLACIAL PERIOD.	Early-Inter-Glacial Epoch.	1. *Sands, Gravels, and Clays.*	Unknown. Palæolithic implements near Brandon.	Land probably much as at present. Climate temperate.	Only reached at Boston. Middle Glacial Sands, &c. Brick-earths near Brandon.
GLACIAL PERIOD.	First Glacial Epoch.	*Till* - -	None - - -	Land higher than at present. Intense glacial conditions. Ice-sheet. England continental.	Norfolk coast, &c.
GLACIAL PERIOD.	First Glacial Epoch.	*Late Tertiary* -	(Pliocene?) - -	Chalk barrier breached.	

*** I am anxious that the term ice-sheet be not mistaken for *ice-cap*. I see, as yet, no just grounds for believing in an universal polar ice-cap. Had such been the case surely the plains of Northern Siberia would have showed traces of such deposits.

* Mr. J. Geikie wishes me to state that I had independently arrived at similar conclusions to his own before his work appeared. This seems to me to go far to shew the probability of our views. Mr. Geikie, however, had worked out the question in far greater detail than I had done, and the merit undoubtedly belongs to him.

CHAPTER XVIII.

INUNDATIONS.

As much of the fenland lies below high-water line, and all is defended by sea-banks, it must necessarily happen that if any part of the banks give way the country is at once drowned. Nor is it from the sea alone that the land suffers, for the effects of long continued rain are as disastrous as the incursions of the sea—the fenland is still held by man against perpetual siege from the rivers on the one hand, and the sea upon the other. A table is given in the Appendix showing the dates at which memorable inundations have occurred, and the record is sufficiently doleful thus divested of all details. But when described as the pen of Kingsley has portrayed them, or still more forcibly engraven on the memory by actual experience the fenland comes to be thought upon as the land of floods. It is not our province to attempt such a description now; but the following brief description given by the jury for the hundred of Freebridge in Marshland, of the great inundation of November 1–2, in the year 1612, may be excused. After reciting the losses in goods, houses, crops and lands "ruinated by the rage of the sea" the recital proceeds:—
"In this distress the people of the town [Terrington] fled to the "church for refuge, some to hay-stacks, some to the baulks in "the houses, till they were near famished; poor women leaving "their children swimming in their beds, till good people adven-"turing their lives, went up to the breast in the water to fetch "them out at the windows: whereof Mr. Browne, the minister, "did fetch divers to the church upon his back; and had it not "pleased God to move the hearts of the mayor and aldermen of "King's Lynn with compassion, who sent beer and victual "thither by boat, many had perished; which boats came the "direct way over the soil to Terrington."*

To give some idea of the effects of such an inundation we will select one of the latest which has taken place (May 1862).

In the year 1847 the Middle Level Drain was constructed under an Act (7 & 8 Vict. c. 106. sec. 137.) to convey the waters of the Middle Level into the Ouse at a lower point than was effected by the previous drainage. "The outlet was by a great "sluice at St. Germains, the level of the cill being 6 feet below "low-water springs at that place, and 1 foot above the bottom of "the drain; the rise of the tides being about 19 feet." "The bed "of the drain is there of soft blue clay, and the sides, from the "bottom of the drain to the surface of the ground, consist of "variable thicknesses of soft blue clay, peat, yellow clay, and

* Dugdale, p. 277.

" surface soil. Of these materials the side banks above the " level of the ground are constructed."*

On the 4th of May 1862 the sluice gave way to the pressure of the tides; or, as fenmen say, it blew up. The catastrophe was described to me as having taken place in the dead of night, and the clashing together of the stone and iron-work made an awful noise and gave rise to great flashes of light which illumined the surrounding country like lightning. The piers and fragments of the sluice dredged from the bottom still lie around.

The tidal waters rushed up "and again poured down the drain " with great velocity, and throughout a distance of upwards of " 20 miles they ebbed flowed. This state of things lasted for a " few days, during which time much attention was devoted to the " banks, and several minor breaches were successfully stopped; " but at length the western bank of the Middle Level Drain " burst, at a point about 4 miles from the St. Germain's Sluice " [see Plate XIX.], inundating upwards of 9 square miles, " or about 6,000 acres of land."

"The level of high-water of spring tides in the river is, as before mentioned, about 19 feet above low water, but it was not more than 9 feet in the inundated fen, where, owing to the large area of the inundation, the rise and fall of the tide did not exceed 6 inches. The only interval of repose, therefore, was when the water in the Ouse was at the level of the water in the fen. This interval of repose was of very short duration. A few minutes scarcely elapsed before an inward or outward current (according to the state of the tide in the Ouse) became perceptible, which current rapidly increased in intensity. The velocity of the tide up the drain, and again out of the drain, amounted to about 6 miles per hour at spring tides, and 4 miles per hour at neap tides. The depth of water in the drain below low water spring tides was 7 feet; but the bottom of the drain in the neighbourhood of the dam, having been scoured away about 2 feet, the depth there at slack water was about 17½ feet.

"The drain throughout has also to be carefully watched, as the soundings revealed the existence of large holes in the bottom, as well as of considerable scour. In one place the drain had been scoured to a depth of 15 feet from its original bed, maintaining this depth for a length of not less than ¼ mile; and at other places it was discovered that the cast-iron culverts, some of which were of large size, passing originally several feet under the bottom of the drain, had been laid bare."

A cofferdam was built across the drain near its outfall, and afterwards the breach in the drain banks stopped, 25,000 cubic yards of material being used. The inundation water was then let off through the Marshland Smeeth and the adjoining Marshland Sewer.

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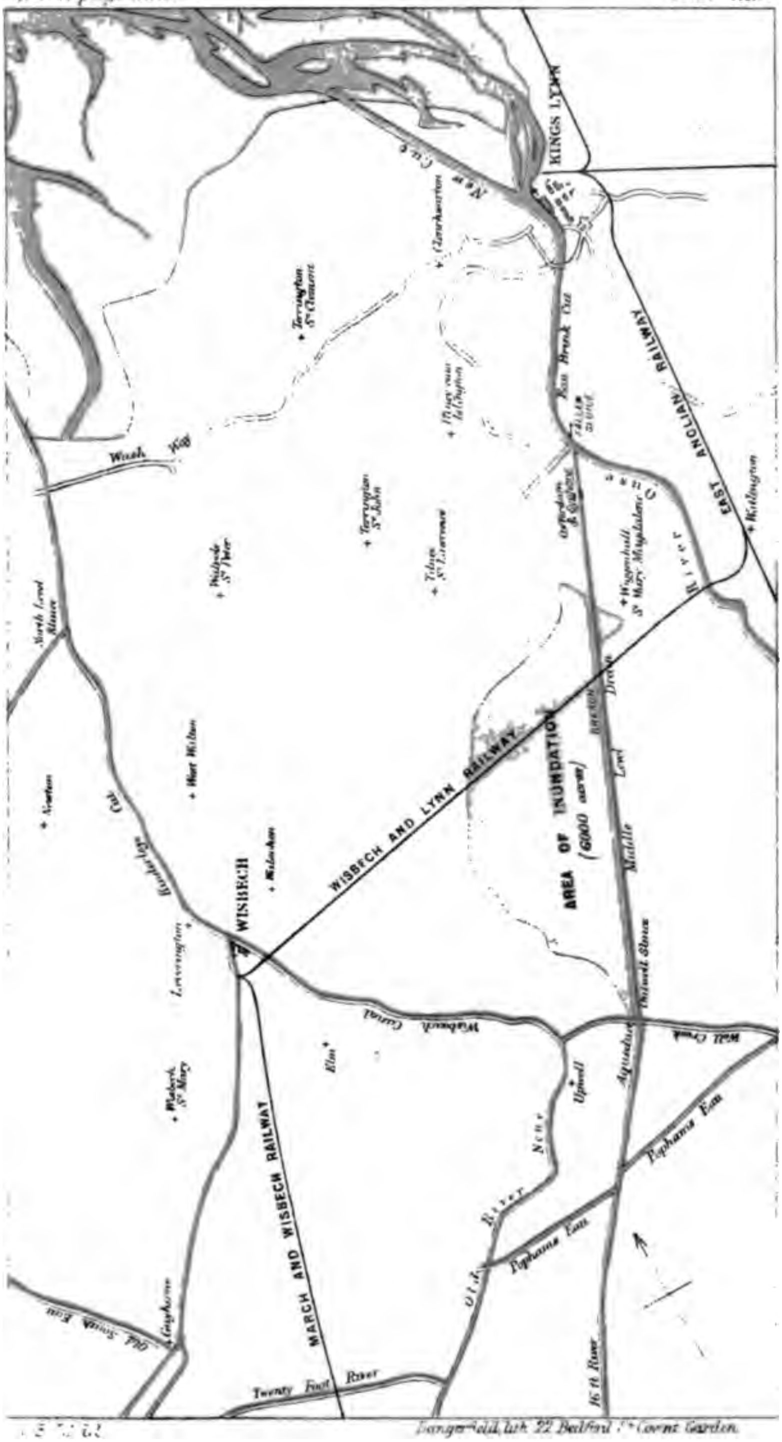
* Hawkshaw on the failure of the St. Germain's Sluice; Min. Proc. Inst. Civ. Eng., vol. xxii., p. 497, 1863. The succeeding quotations are from the same paper.

GEOLOGICAL SURVEY
OF ENGLAND AND WALES.

To face page 222. *Plate XIX.*



Bangerfield, lith. 22 Bedford St Covent Garden.

SCENE OF THE MARSHLAND
INUNDATION OF 1862.

Instead of erecting a new sluice Sir John Hawkshaw proposed and erected syphons to discharge the water of the Middle Level Drain. These are carried over the cofferdam and thus there is no fear of blowing up. "The number of syphons at present " erected is sixteen. These are laid across the dam at an inclina- " tion of 2 to 1 on either side, and horizontally over the top; " each end being terminated by a horizontal length containing " the upper and lower valves. The upper surface of these bottom " horizontal lengths is laid at a level of 1 foot 6 inches under low " water of spring tides,—so that the ends of the syphons are " always under water,—and the top of the syphon is 30 feet " above the same level. The total length of each syphon is about " 150 feet." The syphons are exhausted by three air pumps worked by a 10-horse stream engine, and one syphon can be worked at a time, or all exhausted together; but they can also be exhausted by filling them with water.

The extent of the works at the dam may be told from the following account, by Sir John Hawkshaw, of the material used:—

COFFERDAM.

Timber	90,693 cubic feet.
Iron	75½ tons.
Cement	432 casks.
Clunch	2,444 tons.
Sacks	36,524 in number.

SYPHONS.

Metal in one syphon, exclusive of pipes and connections	36 tons.
Total weight of syphons, &c.	610 tons.

The syphons appear to act admirably, and effectually discharged the great rains of the winter 1871–2. Nevertheless, it has just been decided to remove them and substitute another sluice, not indeed in the main drain, but in a new back cut. The reason given is that the water level can be reduced two feet by means of a sluice; this is doubtless true, but so far from being a matter for congratulation is one for regret. The water is already drawn off two feet to allow the land to receive its full benefit—but we will return to this question presently.

Warp is deposited on the grating on the Ouse side of the dam and is cleared away fortnightly. In summer when the fresh water is low it accumulates to a depth of two feet in this time, but when the fresh water is discharged in large quantities very little is preserved.

A great source of danger to any sluice is the force of the Ouse current. The river is gradually widening its channel: a man pointed out to me the site of a foreshore opposite the Outfall works upon which he used to play cricket as a boy 25 years before (1847), and of which only a narrow fringe remains.

The tidal waters which flooded the fen deposited a layer of warp upon the land, which in consequence produced but meagre crops for two or three years. Afterwards the cropping rapidly improved, and now the land is better than ever. The farmers received substantial compensation for their losses at the time of the inundation, and as their land was afterwards found to be richer, this disaster turned out to be (for farmers) one of those blessings in disguise which Christain fortitude enabled them to bear with little more than constitutional repining.

Fig. 30 is a view of the drowned fen, copied by my wife, from a rare photograph kindly lent me by my friend Mr. S. Smith, of Wisbech.

Fig. 30.—*Scene in Marshland during the Inundation.*

The summer floods of 1875.—The present summer will be memorable for the great floods which devastated parts of France and England. As they seemed to afford a test of the efficacy of the present system of drainage, Mr. Miller of Wisbech, at my suggestion, obtained notices from different parts of the fens, which were published in the August number of his valuable little journal "The Fenland Meteorological Circular," from which I cull the following observations. The early part of the year had been one of average rainfall, but the preceding year had been one of drought from which the land had scarcely recovered. In June, 1875, 3·276 inches of rain fell, which though above the monthly average made the total since January only 9·5 inches. In July the heavy falls occurred, as shown in the following table:—

DAILY RAINFALL in JULY 1875.

July.	Cherry Hinton.	Cambridge.	Ely.	Kettering.	Calcethorp.	Holkham.	Norwich.	Cossey.	West Dereham.	Wisbech.	Stag's Holt.
1	—	0·24	0·23	—	0·01	0·22	0·33	0·36	0·25	0·11	0·10
2	—	0·06	0·02	0·43	—	—	—	—	—	—	—
3	—	0·08	0·26	0·75	0·08	0·11	0·06	0·08	0·15	0·23	—
4	—	—	—	—	—	—	—	—	0·10	—	0·70
5	—	—	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	0·01	—	—
7	—	—	—	—	—	—	—	0·01	—	—	—
8	—	—	—	0·04	0·01	0·03	—	—	—	—	—
9	—	0·20	0·21	0·40	0·20	0·78	0·50	0·66	0·21	0·28	0·18
10	—	0·05	0·23	0·10	0·41	0·10	0·03	0·04	0·14	0·06	—
11	—	0·06	0·17	0·08	0·08	0·30	0·11	0·21	0·22	0·40	0·30
12	—	—	—	—	0·18	0·22	—	0·02	0·02	—	—
13	—	—	—	—	0·03	0·02	—	—	—	—	—
14	0·96	1·13	0·97	1·52	0·28	0·41	0·52	0·47	0·80	0·86	0·98
15	0·25	0·42	0·41	0·51	0·01	0·23	0·35	0·35	0·52	0·56	0·58
16	—	0·01	0·01	—	—	—	—	—	—	—	—
17	0·01	0·02	0·02	—	1·36	0·40	0·17	0·33	0·06	0·08	0·02
18	0·02	0·02	0·14	0·36	0·20	0·70	0·69	0·58	0·07	0·05	—
19	0·75	0·72	0·38	0·40	0·71	0·35	0·27	0·19	1·50	1·40	0·57
20	1·44	1·20	1·65	2·18	0·69	3·06	0·68	0·79	1·57	1·70	1·41
21	0·87	0·73	0·56	0·56	0·43	0·77	1·32	0·82	0·76	0·86	0·58
22	—	0·01	—	—	0·09	0·05	—	0·01	0·02	0·02	0·02
23	—	0·01	0·01	—	0·09	—	0·08	0·07	0·06	0·44	0·03
24	—	0·02	—	—	0·03	—	—	—	—	0·01	—
25	—	0·01	—	0 01	0·34	0·10	0·10	0·07	0·23	0·08	—
Total	533 *	4·99	5·27	7·34	5·23	7·85	5·34	5·06	6·60	7·14	5·47 †

* On 18 days. † Total 6·33 (?).

The following table shows the duration of the rain:—

DURATION of RAIN. JULY 1875.

Station.	Days.														Total Hours.
	1	3	9	10	11	14	15	17	18	19	20	21	23	25	
Norwich - -	7	2·5	8	0·5	2·25	1·4	8	2·5	3·5	1·5	15	7	0·25	0·5	72·3
Wisbech - -	7	3	4·5	1	5	8·5	24	0·5	1	8	9	8	2	1	81·5
Calcethorp -	—	—	—	—	—	—	—	5	2	7	12	10	7	2	—

From the above tables it is clear that the rainfall was both heavy and rapid. In the west of England dams burst, lands were flooded, houses destroyed, and lives lost. In France the details are a horrible tragedy. But what do we find in the fens, the land of floods?

Mr. King, of Lynn, writes:—"The effect of the great rainfall "was observable in the comparative saltness [freshness] of the "tidal waters of the Ouse at King's Lynn. Before the rains the "specific gravity had been registered as 1,022. On the 23rd it "was 1,014, and on the 29th, 1,002. On the 4th August it was "10 miles from Lynn before a specific gravity of 1,022 was "found in the waters of the Wash." No news of floods are cited "here.

Mr. Blanchfield, of West Dereham, writes:—"Now the fen of "this parish is generally considered the sink-hole of the neigh-"bourhood, but, paradoxically enough, we do not appear to have "had so much water upon it as on some of the higher lands." Again no evidence of floods.

Mr. Marshall, of Ely, writes:—"I don't believe the rain has "done the harm that people think." Still no floods have been "reported.

Mr. Ruston, of Chatteris, writes:—"Heavy floods; the Hun-"dred Feet washes flooded to a considerable depth. Fen drainage "engines required to work, which saved the drainage district "from sustaining much injury." Floods are here reported, *but only in the washes which were made to be flooded*, and the engines were quite capable of keeping the land clear.

At Chatteris very little damage was done. "The dykes were "full, but no land under water, although the Mepal engine was "not at work. This engine, which drains the Sutton and Mepal "level, is under repair." So reports Mr. Watt.

Mr. Dawbarn, of March, writes that "another engine, nearer "Welney, which throws the waters of Manea and Welney "district into the Old Bedford river, was under repair. No "practical inconvenience has been felt in this parish [March]. "The water in the River (Old) Nene never rose higher than "8 feet on datum, or 1½ feet above the ordinary summer level."

Mr. West, of Upwell, writes:—"It may be worth while to "compare the late flood with that of 1872. From Nov. 21st to "Dec. 18th in that year the total fall was 3·69 inches only. Its "effect was very trying, the water in the Middle Level river at "Upwell reached to 8 feet 7 inches on the gauge; and on the "same day, Dec. 18th, I witnessed, to my great surprise, a fall of "4 feet 3 inches at the syphons. In the present year, from "June 28th to July 25th, the total fall was 8·34 inches at "Upwell, but the water has never reached higher than 6 feet on "the gauge in the same river; and for the last week in the "month has never been above 4 feet, and sometimes below 3 feet, "while at the same time the Washes at Guyhirn and Welney "are flooded to a considerable depth." No floods here save in the Washes, and the syphons appear fully equal to the pressure laid upon them.

Mr. W. C. Little, of Stag's Holt, writes dolefully of the crops describing the ground as "sodden, and in many places a pool of water." But Mr. H. J. Little, of Coldham Hall, says, "It may "be said the rain has done more good than harm, for drought "was most severely felt up to June 28th, only 7·88 inches "having fallen from the beginning of the year to that date."

Mr. Wheeler, of Boston, writes:—"Owing to the absorbent "nature of the soil in this district, it was a week after the violent "floods of the west of England were reported that the result of "the rainfall was felt here and made any sensible effect on our "rivers. The Witham did not begin to rise until the 17th, and "then only a few inches. The water was at its highest on the "22nd, and then the rise was only three feet from what the "water had been standing previous to the rain. This must be "considered a very small rise seeing that the Witham drains "about 1,063 square miles of land, only about one third of "which is Fen, the height of the country at its source varying "from 200 to 300 feet above the sea. The Black Sluice Drain, "which takes the water from about 200 square miles, one half "of which is Fen, only rose one foot above its previous level. "The Glen, which takes the water from the lands bordering on "the Black Sluice district, owing to the greater elevation of its "watershed, and its imperfect outfall, rose to a height and filled "the river in some parts bank full, or within about eight inches "of the flood-line which broke the banks in April 1872. The "reservoir of the Boston Waterworks Company at Miningsby, "which receives the drainage of about 3 square miles, rose ten "inches, and the brook which feeds it (which is generally dry "in summer) commenced running. The engines in the lower "Fens, on the Witham and the East Fen, and in Deeping Fen, "had to get up steam to pump the water off the land and "prevent the crops being flooded. It is many years since such a "strong fresh has passed down the Witham as ran for a week "from the 19th to the 26th July."

From Woodhall Spa Dr. Cuffe writes:—"The crops in the "surrounding district have suffered very little injury, and there "is no land anywhere about here under water."

We find from the above reports that the fen generally suffered little from the rain, less indeed than the highland, and that the drainage system was amply sufficient to keep the water off the land.

It was different, however, at the embouchure of the rivers Cam and Nene into the fens. Around Cambridge and Peterborough large tracts of low land were under water, and this was also the case at Wereham and Wretton Fens in Norfolk, bordering on the Wissey. But in each of these cases it was the highland water which caused the floods, and not the fen waters.

Effect of the Modern System of Drainage.—Cultivated lands had so long suffered from an excess of water that an opinion seemed to have arisen that it is impossible to overdrain, and every possible means are adopted to rid the land of its moisture in the speediest manner possible. I think this action has already reached the limit of safety. The case of the fens suffering frequently from drought from possessing no means of storing water against the dry season, has been alluded to,* and the records we have been citing show two things very forcibly. First, that over most of the fen the drought was so great that the rains which recently fell were mostly absorbed by the soil, and only swelled the rivers moderately—so slightly indeed as to excite the surprise of observers. Secondly, that this slight excess was at once discharged, so that if the succeeding season had been very dry want of water would have been again experienced. People clamour for the very water in times of dryness which they have wantonly wasted in times of plenty; it is like destroying the surplus corn of a good harvest to ensure starvation after a bad one.

But the effects of excessive under-draining is equally apparent in the highland. The water which formerly slowly percolated through the soil and found its way little by little, weeks afterwards, into the streams, is now discharged in a few hours as though it was some pestilential visitation. The rivers, which, as Mr. Tylor has well shown,† are contrivances for ensuring uniform motion, are converted into torrents—a state of things quite abnormal and as deleterious as it is unnatural. The soil, too, suffers from more than drought for a greater quantity of soluble salts is carried away than was formerly the case, and the productiveness of the land is thereby diminished. These effects are only beginning to be felt, but they must go on increasing till they become a serious evil, unless the system of drainage is moderated. I might cite several cases which have come under my own observation, but one will suffice. Ely stands upon an island of Kimeridge Clay capped with Neocomian Sands. It has been renowned from the earliest times for its orchards, but since the land has been "effectually" drained, it has become more and more difficult to get young fruit trees to thrive, their roots not being able to reach the water. If the present state of things continues the orchards must inevitably fail. Drainage is undoubtedly one of the best sanitary agents, but if carried to excess it becomes positively injurious.

CHAPTER XIX.

METEOROLOGY.

A few notes are here given to explain as much of the meteorology of the fenland as is necessary to comprehend the climatal conditions under which the peat, buried forests, and shell-marl have formed. Nothing like a complete summary of the meteorology of the district will be attempted, and those who desire to be

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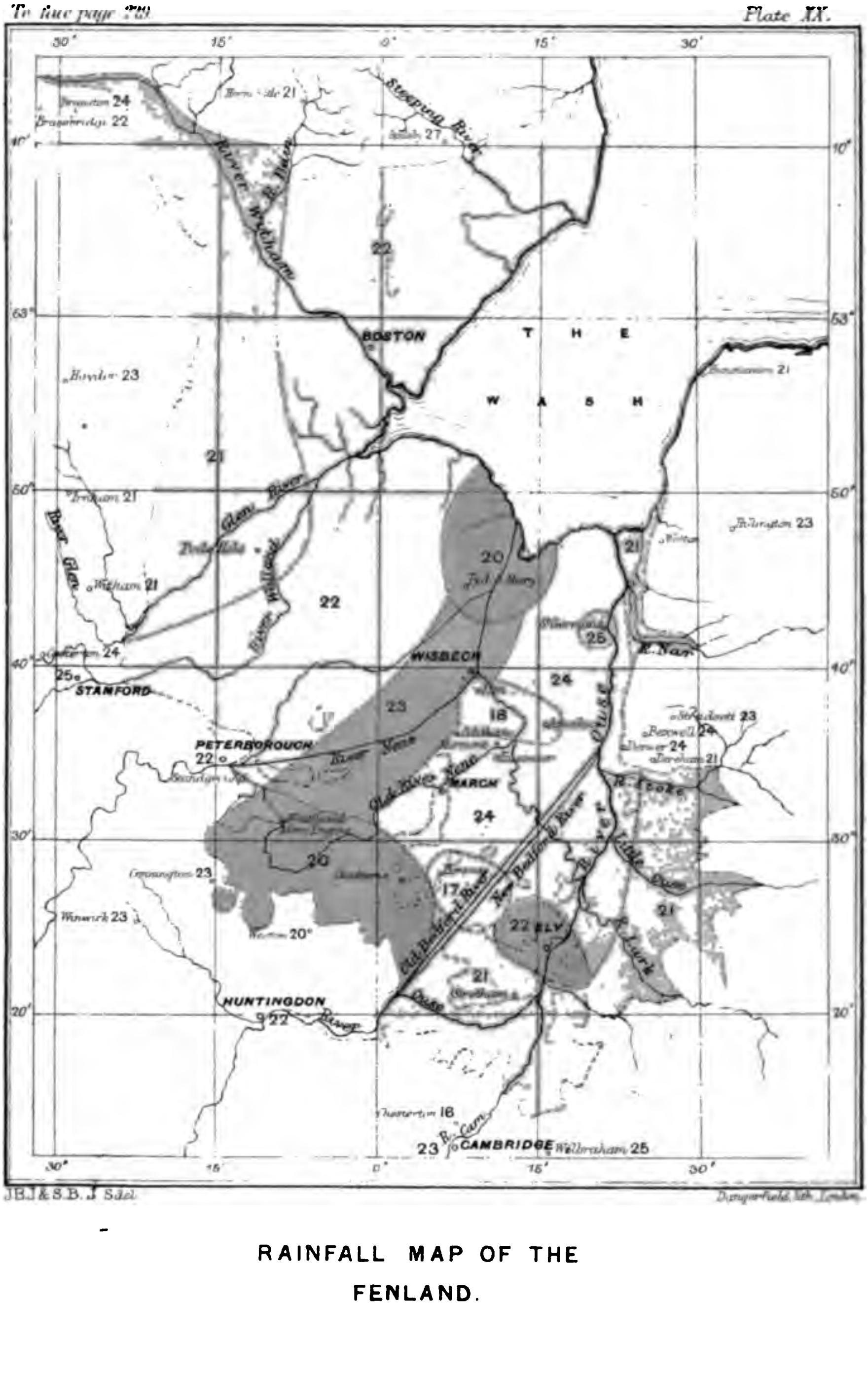
* P. 52. Since writing this Mr. Wheeler, C.E., of Boston, has communicated a paper to the Fenland Meteorological Circular, showing the necessity for storing the rain falling on roofs in the Fens for domestic *and agricultural* purposes. Oct. 1875.

† Geo. Mag. vol. ii. 1875.

GEOLOGICAL SURVEY
OF ENGLAND AND WALES.

To face page 280. Plate XX.



JBJ & SBJ Del. Dangerfield lith. London.

RAINFALL MAP OF THE
FENLAND.

made fully acquainted with its pecularities will find such information in a forthcoming work by Mr. Miller, of Wisbech, and myself, to be entitled "The Fenland, Past and Present." It is a tempting subject—for the weird beauty of the fens is nowhere so palpable as in its atmospheric peculiarities.

Rainfall.—The rainfall of the Fenland is less than that of any area of similar extent in the kingdom, and from the number of stations at which it is measured it can be computed with a tolerable approach to accuracy. The stations are given in Table XI. of the Appendix, and Plate XX. has been constructed to show the approximate distribution of the rainfall. The areas are coloured to show those in which the fall is the same within an inch, and though the boundaries are necessarily arbitrary, the peculiarities of the rainfall come out clearly. Thus it is seen that the least rainfall is around the Horseway Sluice and Elm; and the greatest fall occurs over the district bordering on the Ouse.

In computing the mean rainfall of a district the method generally pursued is to take the mean of the several stations within the area. This is obviously inexact, for an exceptional fall peculiar to a limited area has thus the same influence upon the whole as normal falls. The method I have adopted is to compute the percentage value of the areas in which a given annual rainfall occurs to the whole area: call the value so obtained r, and the annual rainfall R. Then the sums of

$$\frac{r \cdot R}{100} = \text{Average rainfall for the whole district.}$$

Applying this method to the fenland we find the areas of given rainfall are as follows:—

RAINFALL in the FENLAND.

Rainfall (R).	Percentage of Area to Whole (r).	$\frac{R \cdot r}{100}$.
Inches.		
17	1·75	·2975
18	1·32	·2376
20	10·96	2·1920
21	32·46	6·8166
22	32·89	7·2358
23	7·46	1·7158
24	12·28	2·9472
25	·88	·2200
	100·00	21·6625

The mean rainfall of the Fenland is, then, according to this method, 21·663 inches.

Table XI. is a list of all the rainfall stations in and near the fens. The observer or authority is in all cases given, for otherwise little reliance can be placed upon such records. Where the record of a small number of years only is to be obtained, I have reduced the observations to a mean. Where possible the years 1860–5, inclusive, are taken as giving an accurate mean.* Where only one year could be obtained I have brought the record to a mean by adding the quantity by which that year fell below the average. Thus for the year 1873 I add 5 per cent., that being the amount by which the fall of that year fell below the mean at Wisbech. Whenever these reductions are made they are inserted in the table with the letter *S* affixed.

Table V. shows that most of the rain falls with a S.W. wind. This does not necessarily show that wind to be the wettest, for it is the prevalent wind, and if only as heavily laden with moisture as other winds it would, in consequence, show an excess. But if we reduce the numbers in this table so that we can compare them with the per-centage value of the winds (Table I.) it is seen that the S.W. wind is *actually* the greatest rain-bearer. If for example we suppose that on each of a hundred days an average amount of rain fell, it would be thus distributed:—

—	N.E.	S.E.	S.W.	N.W.	—
Wind -	21·6	16·4	35·3	26·7	=100
Rain -	18·3	15·4	44·4	21·4	=100

showing an excess of rainfall for the S.W. wind over its excess of occurrence. Or, calling the S.E. wind, which is the driest, 1, we have the following values:—

S.E.	N.E.	N.W.	S.W.
1.0	1·2	1·4	2·9

showing that the S.W. wind is laden with nearly three times as much moisture as the S.E. wind.

Humidity.— Mr. Miller has kindly projected for me the curve showing the mean daily degree of humidity at Wisbech as reduced from 14 years' observations, years 1861–74, inclusive. This is given in Plate XXI., from which it is seen that December and January have the dampest atmospheres, May and July the driest, and between these two dry months June is comparatively damp; the atmosphere of that month being about 10 per cent. nearer saturation than the preceding and succeeding months.

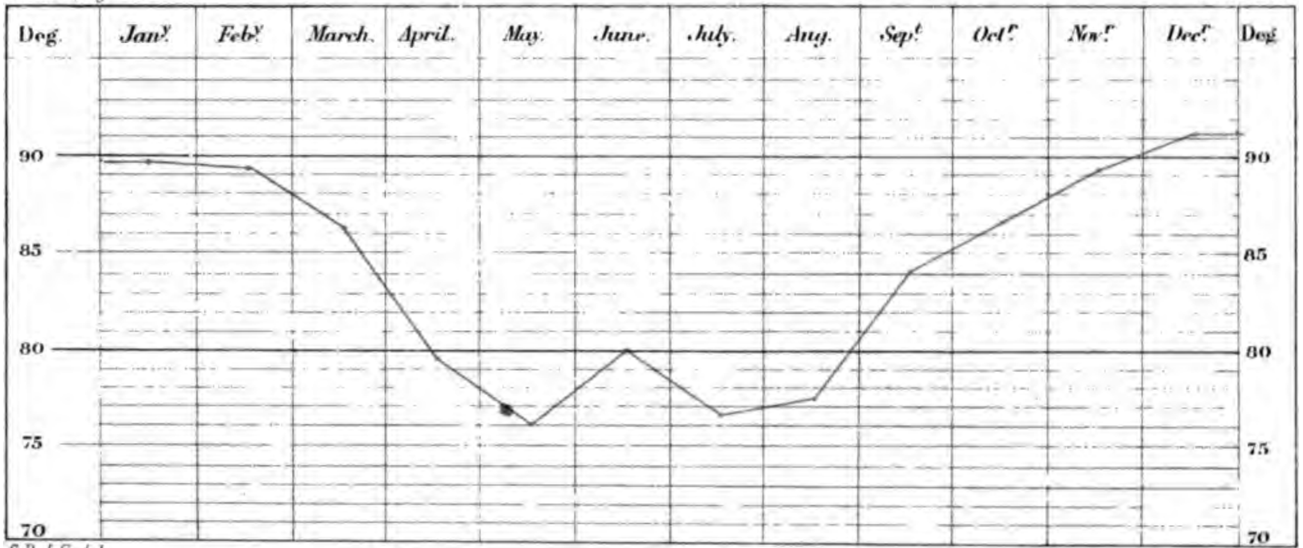
The maximum, minimum, and mean daily degree of humidity for Wisbech are given in Table XIII., and the mean for Boston in Table XII.

* See Symon's "Rain; How, Why, Where it is Measured."

GEOLOGICAL SURVEY OF ENGLAND AND WALES.

To face page 230

Plate XXI.



S.B.J.S. del.

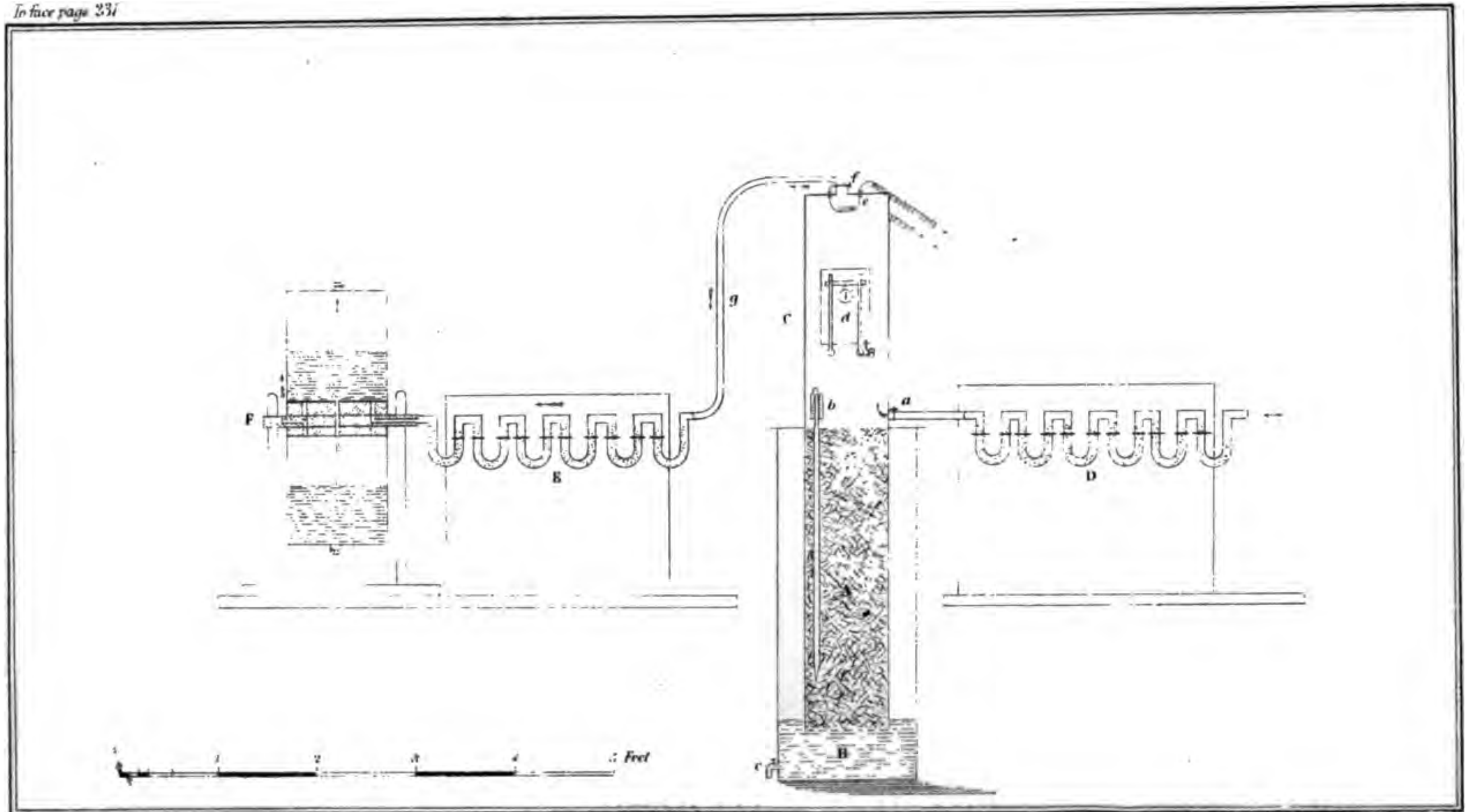
CURVE SHOWING THE MEAN DAILY DEGREE OF HUMIDITY, AT WISBECH.

Dangerfield. Lith 22 Bedford St Covent Garden

GEOLOGICAL SURVEY OF ENGLAND AND WALES.

Plate XXII.

In face page 231



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Dangerfield & Bedford St. Covent Garden.

THE NEW EVAPORIMETER.

Evaporation.—In the chapter on the River Witham some remarks were made upon the incompleteness of our knowledge of the effects of different soils and rocks upon evaporation. The quantity of water discharged by a river is the rainfall minus the quantity which soaks into the earth and the larger quantity returned to the atmosphere by evaporation. The character of the rocks forming a catchment basin exercises an important influence upon this latter point, and in order to determine the amount of this influence, I designed, jointly with Mr. S. H. Miller, F.R.A.S., the instrument *A B* shown in the centre of Plate XXII. Its object is to retain the soil to be experimented upon in as natural a condition as possible. It consists essentially of an outer cylinder *B*, within which is a inner cylinder *A* with a perforated base. The soil is placed in *A*, and carefully weighed, and the whole apparatus is sunk into the ground in the open air so that the brim is level with the ground. The excess of moisture drains through the perforated bottom of *A* into *B*, and in fine weather water rises by capillarity from *B* into the soil in *A*; to facilitate this action a sponge is placed in the bottom of *B* touching *A*, this is not shown in the figure. In this condition the instrument remains and is periodically weighed. Its pecularities consist in its means of getting rid of the excess of moisture during rain, and of acquiring moisture in seasons of drought. The former corresponds to natural drainage, the latter to the supply from beneath by capillarity.

That the condition of the soil is as nearly natural as can be is shown in two ways. Firstly, the underground temperature at one foot is the same in the instrument as in the natural soil; Secondly, the weight of the soil in the evaporator, even after months of trial, is practically the same as an equal amount taken direct from the ground.

The materials hitherto experimented upon are peat, warp, fen clay, and humus or vegetable soil, and the results are given in tables to . These show what is the actual evaporation from the substances named; but, being exposed to so many varying climatal conditions, it is impossible to deduce from them constants showing the actual effect one to each particular material.

To determine these constants I devised the apparatus shown in Plate XXII., which, however, shows merely the essential parts of the apparatus, and these to some extent "diagramised."

A. B. is the evaporimetor; *A.* being the inner and *B.* the outer cylinder.
C. is the receiver, having three sides of glass.
D. is a train of U-tubes, called the Supply Train.
E. is a similar train of U-tubes, called the Receiving Train.
F. is the Aspirator.
a. is a cock to close the Supply Train.
b. is a ground-thermometer.
c. is a tap to draw water from *B.*
d. is a dry and wet bulb hygrometer, and an aneroid barometer, both manufactured by Casella.
e. is a platinum coil: the source of heat.
f. is a cock to close the Receiving Tube.
g. is the Receiving Tube.
+ — are wires leading to the battery.
⋙⟶ shows the direction of the current of air.

The trains of U-tubes contain fragments of plate-glass moistened with pure sulphuric acid, and that end of the supply tube which communicates with the open air is plugged with cotton wool. The aspirator contains oil.

The method of working is as follows: By means of the aspirator, each compartment of which has a capacity of one cubic foot, a known quantity of air can be drawn through the apparatus when cocks *a* and *f* are open. The cotton wool cuts off all dust, and the supply train abstracts all the moisture, thus ensuring the air which enters the receiver *C* to be pure and perfectly dry. The receiving tube is carried into the centre of the receiver *C*, but is not so shown in the plate. The air laden with the moisture evaporated from the material in *A* passes by the receiving tube into the receiving train *E*, where the moisture is collected. The hygrometer and aneroid *d* show the temperature, hygrometric state, and pressure of the atmosphere in *C*, and the ground thermometer *b* registers the temperature of the material in *A*. A steady source of heat is supplied by the platinum coil *e* which can be regulated by altering the power of the battery, or in other ways as is found convenient.

Suppose an experiment to be about to commence. The U-tubes of the receiving train are each weighed separately. The temperature fixed upon is obtained. The receiving tube *g* is connected with the aspirator *F* and a quantity of air exceeding in bulk the capacity of the receiver *C* is drawn through. The cocks *a* and *f* are closed and the receiving train put in position. The cocks are then opened, the instruments read, and a given quantity of air is drawn through the apparatus by means of the aspirator, the time being noted. The cocks are then closed, and the U-tubes of the receiving train are weighed, and the increase of weight gives the amount of evaporation in the given time, which is readily reduced to inches.

By this means various materials can be submitted to precisely similar conditions, and their influences accurately compared; the effect of different temperatures can be ascertained, and thus the required constants be obtained. Simple as this apparatus is great difficulty has been experienced in getting the different parts made and much time was consumed before the present plan was adopted, When all was ready ill-health compelled me to desist from my labours when water and snow had alone been experimented upon, but I hope to resume the work almost immediately.

Several minor points are omitted from the above description and illustration, such as the gauge for regulating the supply of water in *B*, and the Air-meter for measuring the velocity of the current and thus checking the aspirator. For this latter purpose one of Casella's admirable little air-meters is used, and answers every purpose well.*

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* It is only just to Mr. Casella to record my high opinion of the instruments with which he has supplied me. Without exception they have proved in every way satisfactory. I would especially recommend his Roger's Field Aneroid to field geologists, as by it heights to within 10 feet can be at once read off, the correction for temperature being made by a sliding scale. I have tested these instruments rigidly, and can confidently recommend them.

As the area of the surface of A is 100 square inches it follows that an increase of weight in the receiving train of one grain is equal to an evaporation of about $\frac{1}{25000}$th of an inch, and as $\frac{1}{100}$th of a grain can be readily measured, an evaporation of only $\frac{1}{2500000}$th of an inch is a workable quantity.

The application of such results to the drainage of a district like the fens is obvious. By their means, the rainfall being known, the correct amount that ought to be discharged can be ascertained.

Winds.—In Tables I. to IV., Appendix F., p. 296, various details respecting the winds at Wisbech and Boston are given. As these tables are self-explaining we need not further allude to them than by pointing out the predominance of the S.W. wind throughout.

CHAPTER XX.

ISLANDS, BLOWN SAND, NAR VALLEY BEDS, WOODHALL SPA.

In this chapter are gathered together sundry odds and ends that did not fall naturally into other places, but yet required special treatment.

Islands.—The major islands, such as Ely, Whittlesey, &c., do not call for special notice here as their general characters have been described, but to the N.W. of Littleport several small elevations occur (some of which are only large enough to support a farmstead), whose composition is somewhat peculiar.

One of these extends from Grub's Farm to Butcher's Hill, near the road from Littleport to Welney, and about half a mile south of the Bedford river. It abuts upon the silts of the old Ouse, and its most complicated section is shown in Fig. 31. The greatest

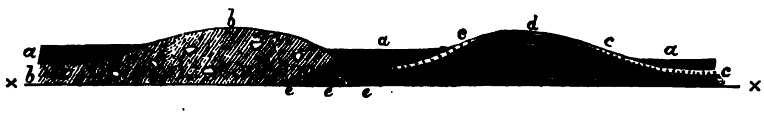

Fig. 31.—*Section of Island, along Road between Butcher's Hill and Grub's Farm.*

a. Peat.	*d.* Kimeridge Clay.
b. Sand.	*e.* Line of Septaria.
c. Boulder Clay.	× × Water line.

height of the section is about 15 feet, the length a quarter of a mile, so that the drawing is distorted. The section cuts two small spurs, between which peat is seen at a^1, the main mass of peat showing at *a a*. At *c* the island is composed of a mass of sandy and gravelly clay, containing many angular flints, large striated septaria, and chalk boulders. At *d* the Kimeridge Clay takes the ground, and is flanked by a thin bed of sand, *b b*.

The general section across the island is shown in Fig. 32, which follows the line of road by Butcher's Hill.

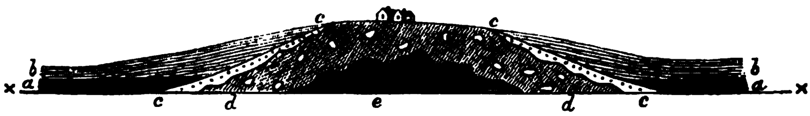

Fig. 32.—*Section across Butcher's Hill.*

a. Peat.	*d.* Boulder Clay.
b. Silt.	*e.* Kimeridge Clay.
c. Sand and gravel.	× × Water line.

The silt *b b* is fen clay, and a portion of the Old Ouse deposit; hence this part of the island stood within the channel. The peat is seen underlying the silt, and cropping out from beneath it on the S.W. The silt is banked up against the island, which is flanked with sands and gravels. These lie upon an eroded surface of Boulder Clay, which reposes upon the worn surface of the Kimeridge Clay.

Blown Sand.—Blown sand, forming dunes, occurs in three localities in the fens, around the head of Bicker Haven, near the shore at Friskney, and around Beck Row. The dunes are about 20 feet high, and composed of loose fine sand. Around Bicker they are overgrown with ordinary grass, but at Friskney the peculiar grass *Phleum arenarium* binds the particles together.

Nar Valley Beds.—These beds, which I have not yet had an opportunity of mapping, are described by Messrs. Rose and Trimmer.* They appear to extend "from Watlington, through "East Winch and West Bilney to Narford, a distance of nine "miles,"† rising from beneath the fen beds in the Nar Valley to a height of about 80 feet above the level of the river. The thickness of the deposit is not known, but exceeds 40 feet. The beds consist of blue clay, sandy clay, and brick earth, and contain numerous testaceous remains. Of these *Ostrea edulis* is by far the most common, and renders the deposit a valuable top-dressing for the land.‡

Sections Nos. 120 to 123 in the Appendix are from Mr. Rose's paper in the "Geological Magazine" for 1865, and the following list of fossils is also from his paper:—

Vermilia triquetra (on *Ostrea*); West Bilney.
Ostrea edulis; the majority large old shells; all localities.
Cardium echinatum; rare; East Winch.
,, *edule*; East Winch and West Bilney.
Corbula nucleus; East Winch and West Bilney.

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* Rose, L. E. D., Phil. Mag., vol. viii., p. 30, 1836. Geol. Mag., vol. ii. p. 9, 1865. Josh. Trimmer, Jour. Roy. Agric. Soc., vol. vii., p. 444. Jour. Geol. Soc., vol. xvii., p. 23.

† Rose, Phil. Mag., *ante*.

‡ Young, Agric. Surv. Norfolk.

Mactra subtruncata; East Winch and West Bilney.
„ *solida;* West Bilney.
Mytilus edulis; Pentney Warren.
Pecten varius; West Bilney and Walton Field.
Tellina solidula; West Bilney and East Winch
„ *proxima;* Tottenhill.
Cerithium reticulatum; West Bilney.
Turritella communis; West Bilney and East Winch.
Nassa incrassata; West Bilney.
Aporrhais pes-pelicani; abundant in all localities.
Littorina littorea; abundant, all ages, all localities.
„ *littoralis;* rare; West Bilney.
Natica nitida; abundant, all ages; West Bilney and East Winch.
Pleurotoma septangularis; rare; Pentney.
Scrobicularia piperata; Pentney.
„ *alba;* rare; Pentney.
Mya arenaria; a fragment; Pentney.
Montacuta bidentata; Pentney.
Hydrobia ulvæ; Pentney.
Pullastra decussata; rare; Pentney and Bilney.
Placunomia patelliformis; rare; Pentney.
Buccinum undatum; rare; Pentney.
Echinus miliaris (?) spines; Pentney Warren.
Balanus; one valve only; Pentney.
Elephas primigenius; teeth and vertebræ; E. Winch and Narford.
Rhinoceros tichorhinus; teeth, fragments; East Winch.
Equus caballus; teeth; East Winch and Bilney.
Cervus elaphus; antlers, fragments; West Bilney.
Bos; teeth; West Bilney.

These beds, as Mr. Rose has shown, are older than the true fen beds; and, I take it, newer than the oldest gravels, and probably contemporaneous with the beach gravels. Many of the shells do not live in the Wash, and the occurrence of the woolly elephant and rhinoceros is suggestive of inter-glacial age.

Woodhall Spa.—Near the fen border, in the neighbourhood of Horncastle, is a remarkable spa. About the year 1828, Mr. John Parkinson expended a great sum of money in sinking a shaft to a depth of 1,020 feet near Woodhall, in the vain hope of finding coal. At a depth of 510 feet a spring was struck, which now forms the spa. The water is salt, and contains a remarkable quantity of iodine and bromine, and the spa, now belonging to Dr. Cuffe, bids fair to become one of the most important in the kingdom. Unfortunately, no details of the boring are preserved.*

An analysis of the water was made for the Survey by Dr. Frankland, F.R.S., of which the following is a copy:—

" Royal College of Chemistry,
" South Kensington Museum,
" SIR, February 13, 1874.

" The analysis of the Woodhall Spa water has yielded the following results:

100,000 parts of the water contain:—

	Parts.
Total solids in solution - - - - -	2361·200
Organic carbon - - - - - -	·372
„ nitrogen - - - - - -	·532

* I have not yet had an opportunity of examining the salt spectroscopically, but in it will probably be found traces of the little-known metals erbuim, &c.—S.B.J.S.

	Parts.
Ammonia	·810
Nitrogen as nitrates and nitrites	·009
Total combined nitrogen	1·208
Chlorine	1425·000
Bromine	6·280
Iodine	·880
Arsenic	·016
Temporary hardness	20·000
Permanent do.	245·000
Total do.	265·000

"The water contains an unusually large proportion of iodine and bromine.

"I am, Sir,
"Your obedient servant,
"To the Director-General (Signed) E. FRANKLAND."
"of the Geological Surveys
"of the United Kingdom."

Roslyn Hole, Ely.—The remarkable assemblage of rocks in Roslyn Hole, Ely, has provoked a considerable amount of discussion, one party maintaining that the cretaceous rocks there found are faulted down to their anomalous position, the other accounting for their presence by considering them to be a great boulder brought down with the glacial clay. If any doubts remain as to which view is correct, they must be at once removed by the Rev. T. G. Bonney's exhaustive examination of the possibilities of faulting, in his admirable sketch of the Geology of Cambridge.* Such an extraordinary complication of faults is required, and they would be crowded into such a limited space, that this hypothesis must be abandoned; and a careful examination of the surrounding district, and frequent observations on the pits, which I carefully watched during a two years' residence at Ely, convinces me that no arrangement of faults could possibly bring the beds into their present position.

A plan of the pits is given on Plate XIII. from a survey by myself, and the boundaries of the different beds are represented by dotted lines. Chalk, Upper Greensand, and Gault are dropped into a narrow space hollowed out of the Kimeridge Clay, and boulder clay is seen *in situ* in the positions marked on the plan.

Before entering into a detailed description of the pit, I may briefly state that *I have seen boulder clay underlying all the cretaceous rocks*, and it can still be seen cropping out on all sides of the mass.

The north-western end of Roslyn end is in the direct line of the boundary of the Neocomian Sand, which occurs, indeed, *in situ* in the adjacent fields to the west. In following this boundary we come suddenly upon the mass of boulder clay in question; and, if the section were not open, the contour of the ground would not lead to the discovery of the drift beds. The beds, in fact, fill up a small valley which can be traced to the river on the east, and towards Little London on the west. A

* Notes on the Geology of Cambridgeshire, 1875.

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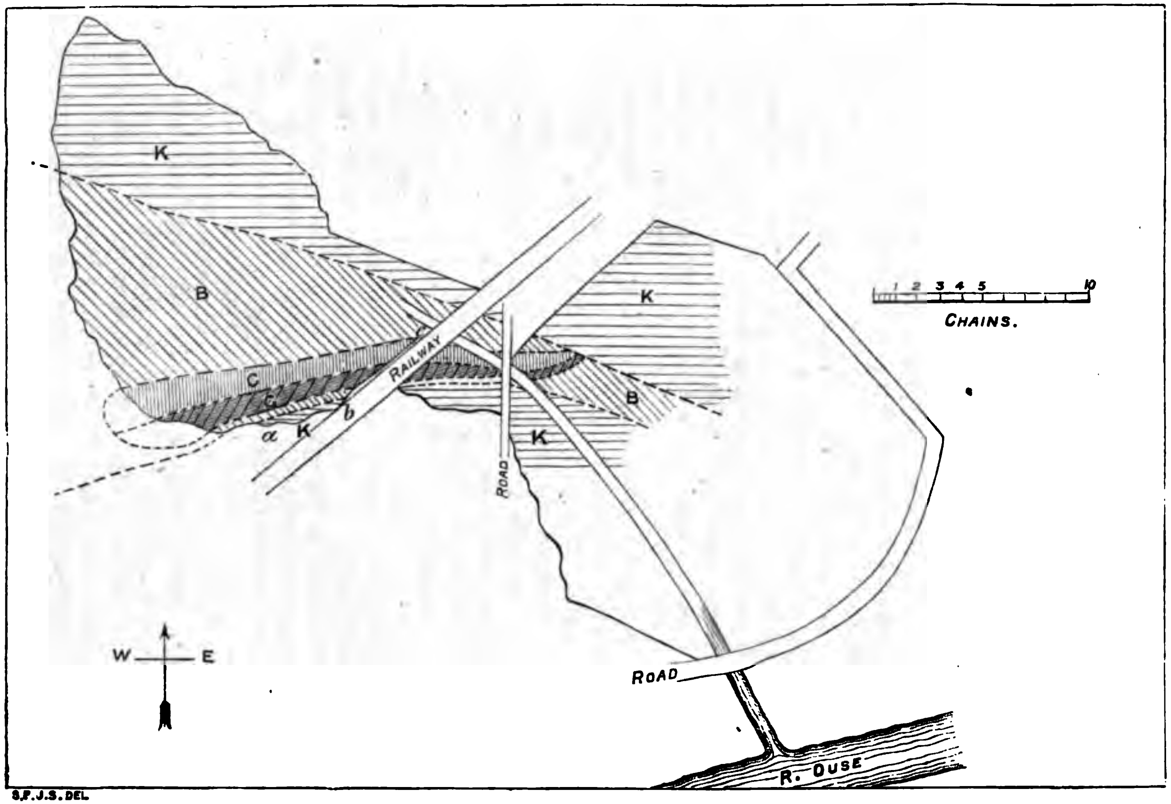
GEOLOGICAL SURVEY OF ENGLAND AND WALES.



PLAN OF ROSLYN HOLE, ELY.

B Boulder Clay. C. Chalk. G. Gault and Upper Greensand. K. Kimeridge Clay.

a. b. Site of Fig. 33. c. Site of Fig. 34.

similar old valley filled with boulder clay is intersected by the highway a mile east of Witchford.

Large masses of chalk are not peculiar to Roslyn Hole, for one occurs in the boulder clay in Witcham Fields five miles west of Ely, but it is of minor importance.

The pits can be most conveniently described in the portions which may be called the *Great, Middle*, and *Lower Pits.* The Great Pit lies to the north-west of the railway, and is the one which has been so frequently described. In it the exposures are generally pretty clear. It now measures 18 chains 44 feet by 7 chains 44 feet, and is approximately quadrilateral in shape. The Middle Pit lies between the railway and a bye-road. It is roughly triangular in shape, the base line along the railway measuring 4 chains 4 feet, and the perpendicular nearly 3 chains 20 feet. The sections are much obscured by vegetation, but the different beds can be easily determined by working along the sides of the pit with a hammer. The Lower Pit comprises the rest of the opening, and is rudely circular in shape with a diameter of about 15 chains. It lies chiefly at or near the level of the fens, and sections are very rarely exposed in it; but, owing to the dryness of the season, clay was dug from it in the summer of 1874, and I thus had an opportunity of studying its geological features.

In the Great Pit the Kimeridge Clay is seen *in situ* in a fine series of sections along the N.E. side, the southern half of the S.W. side, and the eastern half of the N.W. side. It is nearly horizontal over most of the pits, but on the S.W. side it is bent downwards towards the great erratic, as if by its weight, attaining an angle of 20° near the junction, as shown in Fig. 33. The junction of this clay with the boulder clay on the N.W. side of the pit is obscured by herbage, but the position is indicated by springs. Near the railway the Kimeridge Clay is seen to be bent down as before described, and as shown in Fig. 34. The Neocomian Sands are not seen *in situ* in the pit, but a fragment dipping at an angle of 30° was exposed in 1874, and is shown in Fig. 33. From this point, going northwards, we come upon the great boulder—gault, upper greensand, and chalk succeeding each other in their stratigraphical order. It is partly owing to this preservation of geological position that the idea of faulting arose; but one peculiarity has not been noticed, namely, that the dip of the Neocomian beds is about 30° to the east, whereas the newer beds are either horizontal or dip slightly to the south-east, which can hardly be accounted for on the theory of a fault. Again, as the figure shows, not merely the Neocomian Sands but part of the Kimeridge Clay itself is seen to be separated from the main mass and to dip with the sands. Both these rocks are *in situ* close at hand, whereas the upper cretaceous rocks are quite foreign to the locality, and the mode in which the former dip is very suggestive of a crushing, dragging weight such as the boulder would produce. It will, furthermore, be seen that the Kimeridge Clay does not abut at once upon the erratic mass, but

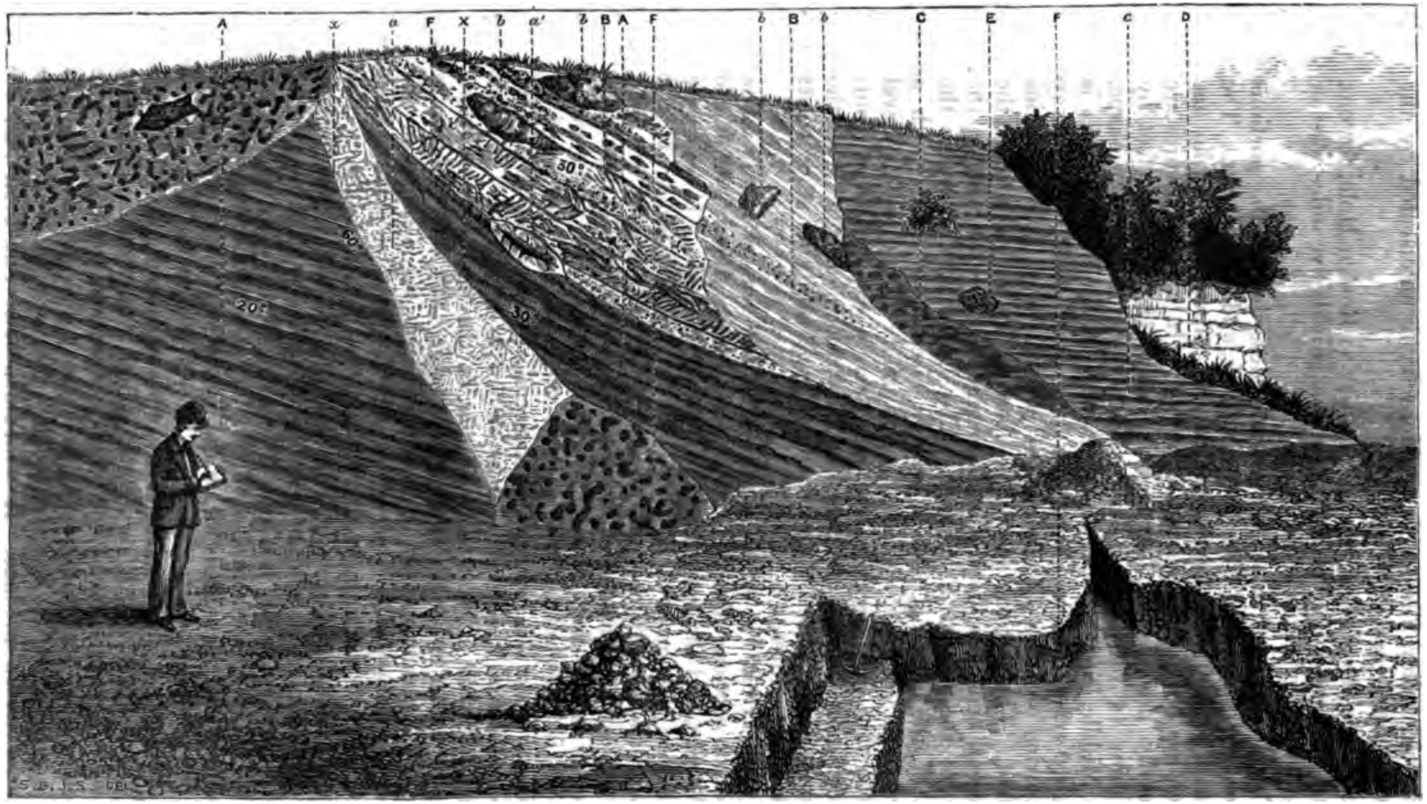


Fig. 33.—*The Great Erratic, Roslyn Hole, Ely.* (*See* references in List of Wood Cuts.)

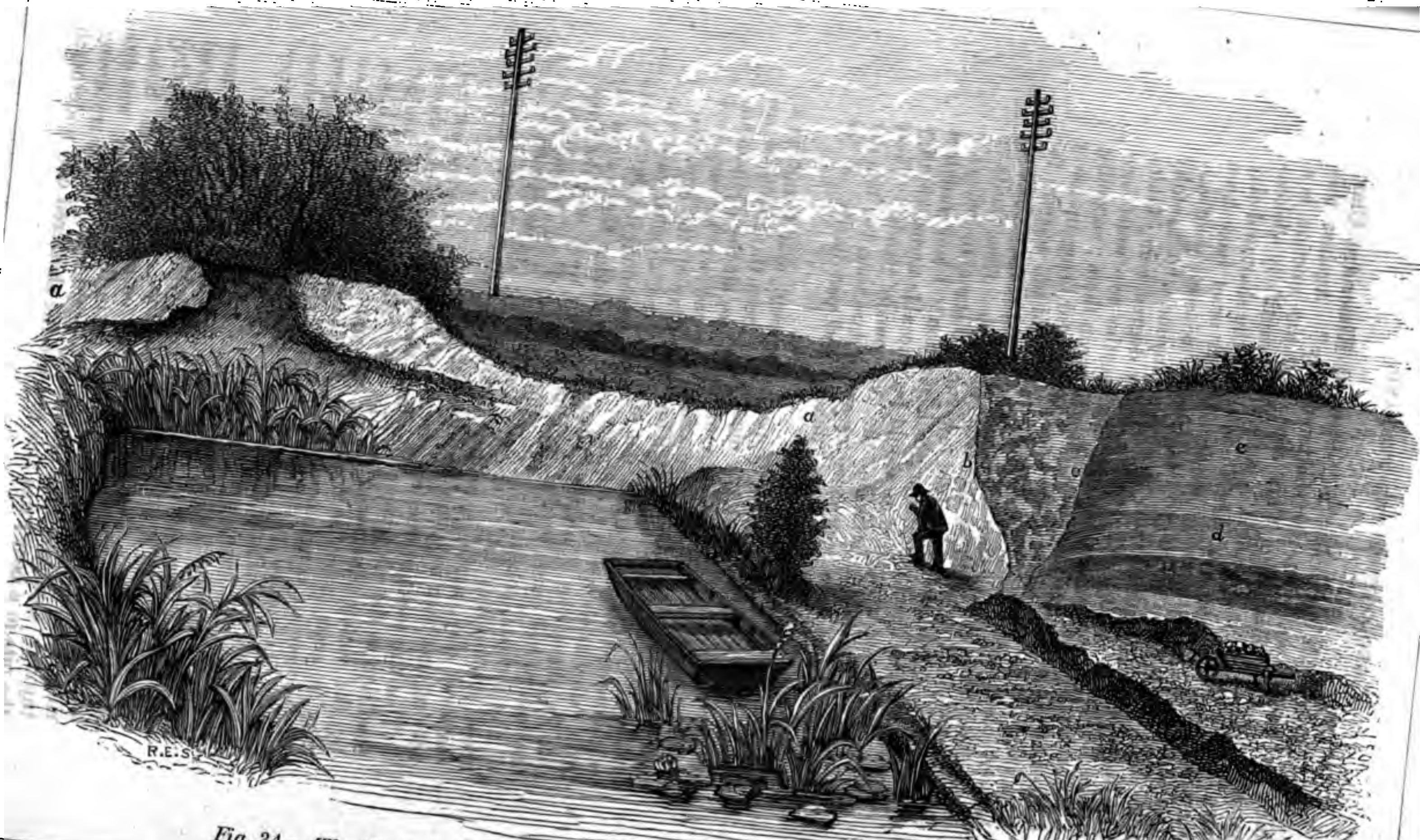


Fig. 34.—The Chalk Boulder at Roslyn Hole, Ely. (*See* references in List of W…

is separated from it by a mass of shattered Kimeridge Clay, which for brevity we will call "shattered clay." Against this shattered clay the Kimeridge Clay abuts, and the junction is a sharp line inclining at an angle of 60°, with beautifully slickensided faces, and a similar fault-like line bounds the shattered clay upon the other side, with an incline of 30°. It must have been some such appearance which led Mr. Seeley to assert positively that he had seen the actual fault-lines; but anyone who carefully studies them will see that they cannot in any degree, being faults, account for the phenomena; firstly, because the two must have faulted in the shattered clay which lies between them; secondly, from their hade they would cause an *upthrow* and bring up lower beds of Kimeridge Clay; and thirdly, they could not account for the difference of dip between the Neocomian and other cretaceous rocks; moreover, it would be necessary to suppose other faults on the opposite side of the pit, only a few yards distant, to bring the Kimeridge Clay back to its original position. I am confident such faults do not exist, or they would be traceable across country by interfering with the strike of the Neocomian Sands. These faults again must have been more recent in date than the boulder clay for they partake of every flexure and peculiarity of the cretaceous rocks.

If we look upon the Chalk, Upper Greensand, and Gault as a great boulder, and picture what must have been the effects of so huge a mass being transported by or under ice, all the phenomena of the pits receive ready explanations, nor can we be surprised that the Neocomian Sands and Kimeridge Clay of the immediate neighbourhood was dragged out of place and toppled into the little valley as shown in the figure. Neither should it surprise us that in places the Kimeridge Clay is bent under the weight of the transported mass, or that it should be cut away and the faces of the incision polished by the same agent. I say in places, for these suppositious fault-lines are very local. The presence of shattered clay, again, is readily accounted for, it being in fact nothing less than incipient boulder clay.

That the rocks in question are not so perfectly in their natural condition as the advocates of the fault theory assume is also shown by the section illustrated in Fig. 33. At B a seam of boulder clay is seen intercalated in the Neocomian Sands; at *b* a block of Neocomian conglomerate is imbedded in the said sands quite out of its normal position; and lastly, at E a mass of Upper Greensand is similarly lodged in the Gault clay. The facts show that the rocks have been disturbed, but not at all in the manner that faulted masses are dislodged.

The most direct proof of the erratic nature of the whole mass is that the boulder clay can, in favourable seasons, be traced beneath the mass and nearly all round it. Once more recurring to Fig. 33 it is seen that boulder clay occurs beneath the Kimeridge and shattered clays, and the pit in the foreground was dug through shattered clay into chalky boulder clay. By traversing the pits in a boat I was able to trace the shattered clay underneath the Gault and Chalk, and at more than one point the boulder clay was seen beneath the shattered clay.

Fig. 34 is a view of the great boulder close to the railway, the Chalk showing at *a*, the Gault at *b*, the boulder clay at *c*, and the Kimeridge Clay is seen *in situ* along the left side of the cut bent down as before described. The boulder clay is here seen to lie between the Kimeridge Clay and the Gault, and further to the right than the illustration extends boulder clay occupies a similar position.

Crossing the railway into the middle pit we again find the Chalk and Gault flanked by boulder clay which lies in a hollow in the Kimeridge Clay. The sections are obscure, but the beds can be determined with a little trouble.

The great boulder does not extend into the lower pit, but the boulder clay reaches the river in a narrow band, with Kimeridge Clay on each side.

In thus working round the pit it is seen that everywhere boulder clay is interposed between the great boulder and the undisturbed Kimeridge Clay, that the boulder clay is always found below the great boulder whenever its base can be seen, that the limits of the great boulder lie within the pits, so that it is bedded in boulder clay; and lastly, that the boulder clay fills a small valley in the Kimeridge Clay.

Examples of great boulders of marlstone in the boulder clay of Lincolnshire, first discovered by me, are described in Mr. Judd's memoir on Sheet 64. All these facts show that the Ely section, though peculiar, is not unparalleled, and that it is really a fine example of boulder clay, filling a narrow valley and containing an immense erratic mass.

Living Prawns in the Silt.—In the summer of 1873 I investigated a curious case of the entombment for a lengthy period of the ova of prawns in the marine silt. My friend, Mr. S. H. Miller, directed my attention to the case, and he accompanied me on my visit. I communicated the facts to "Land and Water," and sent specimens, which lived for a long time in the Brighton Aquarium.

At the Walsoken brickyard, near Wisbech, pits are sunk in the clay, and in the year 1859 a bed of fine sand or silt was pierced at a depth of 15 feet. From this bed a strong salt spring rose, the water of which was much more saline than that of the river in the vicinity, and this mixing with the fresh water in other parts of the pit, rendered it so brackish as to kill the pike, though the carp, tench, and insects seemed unaffected by the change. Shortly after this incursion of salt water, prawns began to appear in the pit, and the supposition is that their ova were embedded in the marine silt and kept alive by the salt water with which the bed was charged, and that the recurrence of favourable conditions of open water and light enabled them to hatch, and since that time they have abounded in the pits. The largest individuals are about 2½ inches in length, a size never attained in the river, nor, I believe, in the Wash itself.

The position of the pits is about three-quarters of a mile from the Roman banks, on the land-side, and a mile-and-a-half from the river Nene, up which the same species comes with the tide.

There are many pits in this district in which the water rising from the silt is brackish, but I have never met with another case in which marine organisms were found living, though I have examined nearly every pit within an area of 1,000 square miles. In some places a communication is kept up with the sea by beds of quick silt, and wells become distinctly brackish during high spring-tides. In the present instance such does not seem to be the case, and I am driven to the conclusion that the prawns must have been introduced accidentally, or that the ova were imbedded in the silt itself.

It is highly improbable that the prawns were introduced wilfully for the mystification of naturalists, for they are rarer than prawns about here, and the time of the appearance of the prawns just after the spring was tapped, and the fact of them all being very small at first are in favour of a natural mode of introduction. Neither is it probable that the ova were introduced by sea birds in one of their very rare visits to this pit, for the ova are carried by the females until they hatch, and could not become attached to the bird, neither could they have survived the process of digestion as some seeds do. Besides, considering the great number of open pits hereabouts which have been unused for years and so afford much better protection for sea birds, the introduction of prawns ought to have been more general on such a supposition. True, most of the pits contain fresh, or only slightly brackish water, but prawns seem to live almost as well in fresh as in salt water, and I have frequently noticed them miles above locks on tidal streams (as for instance in the Rife, near Bognor, Sussex), where the water is not even appreciably brackish. The prawns in question I kept for weeks in fresh water, and they were then killed by accident. Nevertheless, in no other pit have they been found, though they would hardly escape notice, since these spots afford valuable fishing resorts.

The balance of evidence is decidedly in favour of the burial of the ova in the silt, which is so quick as to be dangerous to stand upon, and would afford plenty of water for their preservation. The only difficulty attaching to this supposition is the length of time during which the ova must have lain dormant. The Roman banks are about 1,700 years old, and at least 3,000 years must have elapsed since the area of the pits, at the depth in question, were covered with sea-water. Yet I see no other explanation and am strongly inclined to believe such to have been the case.

Numerous cases of the prolonged vitality of seeds have been advanced, but they have not met with general acceptance in the scientific world.* Seeds of the beach-plum were dug from a

* Mr. Heathcote relates how one of the nuts found beneath the buried oak-forest near Connington germinated, and lived for some years, though its growth was stunted. This interesting plant died at Kew. Sir W. Hooker doubted its having

depth of 20 feet in sand at a distance of 40 miles from the sea in the state of Maine, which germinated and bore fruit, "which had "never before been seen, except immediately upon the sea-"shore." How old these were, who can tell? but I remember no similar instance of animal life being prolonged for ages.

Supposed Thermal Springs near Chatteris.—Mr. F. W. Harmer, F.G.S., read a paper before the British Association in 1870 on "Some Thermal Springs in the Fens of "Chatteris," in which he called attention to the high temperature of the water from certain wells in the neighbourhood of Chatteris. As this paper was only published in abstract I reproduce most of it here, that future investigators may have the facts at hand, and settle the point. I may, however, remark that my own opinion is strongly opposed to the hypothesis that the temperature is due to deep-seated agencies. Mr. Judd, F.G.S., seemed to favour the latter view, and stated at the meeting that numerous faults occurred in the neighbouring highlands, which might extend into the fens and give rise to fissures through which the warm waters welled up. With this view I cannot agree, for it would be singular that faults in hard beds, such as the oolite limestones, much more favourable to the production of open fissure than the tenacious Oxford Clay, should give rise to cold springs only. Neither do I think the district in question is faulted. Before the survey of the area was undertaken faults were believed to be much more numerous than I found them to be; and although I believe a great fault throws down the beds on the Lincolnshire border of the fens, and from which a series of fine springs issue, yet the waters so produced are always cold. Again, these "warm" springs are all very shallow, so far as is known, springing from the gravel at a depth of about 10 feet, and we must suppose either that the warm water has saturated those beds, or that the wells have accidentally struck the neighbourhood of the fissures in each case. The area over which the "warm" springs are found, too, seems to be against such a theory, as we should expect them to occur along lines and not over a wide area. Finally, as the Rev. O. Fisher has shown,† warm water is not infrequently pumped from farm-yard wells where they are shallow, and this I have verified in the neighbourhood of Ely, far away from the only fault. It is only fair to state that Mr. Harmer advanced this idea in his paper, but was driven from his position by the chemical arguments of Mr. F. Sutton, F.C.S., of Norwich, though he still considers the question unsettled.

Mr. Harmer writes as follows:—"The first of these farm-yard wells (which I will call No. 1) that I examined is in a yard belonging to Mr. W. Lyon, four miles due east of Chatteris, and

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come from the peat, but his only reason for his opinion was *the fact that it germinated*, although the Rev. J. H. Nowers, who obtained the nut from the peat, and grew the plant, is quite certain that there could have been no mistake. Remin., Fen and Mere. J. M. Heathcote. London, 1876.

* Vegetable Physiology, Pop. Cyc. Nat. Sci., p. 276, &c. 1841.

† Geol. Mag., vol. vii., p. 42, 1871.

three quarters of a mile due west of Welche's dam. The surface of the land at this point is, I suppose, slightly below the sea level, and apparently about two feet below the level of the water in Vermuyden's drain. The ground is consequently saturated with water, it being necessary only to dig down a spade's depth or so to reach it, and the ditches are full of water to about two feet from the surface of the land. The temperature of the water from the well on the 14th March 1870, I found to be 69° F., that of the air at the same time being 39° F., of the water in Vermuyden's drain 37° F., and of that in the ditches close by the yard 38° F., the water in both cases being covered with ice $\frac{1}{8}$ of an inch thick. I was informed that in sinking the well they had passed through, first, 5 or 6 feet of peat, then $1\frac{1}{2}$ feet of clay, on the surface of which and rooted into it are found all over the immediate neighbourhood numerous remains of oaks and willows, and finally a reddish sand, from which at a depth of from 8 to 10 feet, it would seem, the hot water was obtained. This bed of clay, which, underlying the peat, and often of greater thickness than in this case, is so constantly used in the fen for top dressing the land, seems to present one difficulty to the hypothesis that the heat is produced by the decomposition of the manure lying above it. The water is evidently heated only at the bottom of the well, as when one first begins to pump, the water comes out cold, and it is only after continuing to pump for a short time that the hot water makes its appearance. If the manure caused the heat that nearest the surface should be the hottest. Mr. Lyon informed me that though the farm had belonged to him for years, he had never known the water to be otherwise than hot, summer or winter, though in summer the greater comparative heat of the air made it less apparent.

About half a mile S.S.W. from Mr. Lyon's well is a pump similarly situated, but in this case it was fed from the surface water and not from the stratum beneath the clay. The water showed no such abnormal temperature as in the last case, though, as might be expected, it was higher than that in the exposed drains.

At the adjoining yard at Fortry Hall, about half a mile S. of the last, I found the underlying stratum again reached by a pump, (No. 3) situated similarly to the other. Here the heat was 66·5° F. The water from both Nos. 1 and 2 contained very much organic matter (see Mr. Sutton's analysis).

At another farmyard about 4 miles W. by S. from the last, and about $1\frac{1}{2}$ mile S. by W. from Chatteris, at Horsley Fen Drove I tested the temperature of the water from a well (No. 4) similarly shallow to No. 2, and found it to be 51·5° F. I was informed by a man in the yard that shortly before my visit an Abyssinian tube-well had been sunk to a depth of about 6 feet below that which I had tested, and that the water obtained from it had been warm.

No. 5 well, in a farmyard at Langwood Hill, two miles W. by N. from No. 1, and two miles E. by N. from Chatteris, differs somewhat from the others in being situated on a low outlier of gravel

The water was found to be 71·5° F., and so pure as to be constantly used for drinking purposes by the cottagers. It was 14 feet deep, and entirely in gravel. Allowing for the slight elevation, the water was at about the same level as in Nos. 1 and 3. I visited the place again on June 2nd, when the yard was not occupied by cattle, and found the temperature to be 70·75° F., while that of a shallow ditch close by was 71·5° F., and of the air in the shade 70° F.

Mr. F. Sutton, F.C.S., of Norwich, at my request, kindly analysed the water from Nos. 1, 2, and 5 wells, and also that of Vermuyden's Drain, and I give below his results.

I feel, with Mr. Fisher, the difficulties of any other than a chemical explanation, but I have called attention to the phenomenon because I think there is a *primâ facie* case for further investigation.

Mr. Sutton's analyses and remarks are as follows:—

No. of Samples.	Source.	Temp. at Source.	Total Weight of Solids per Gallon, in Grains.§
*1	Well	69·0° F.	207·89
†2	do.	66·5° F.	279·50
3	River	38·0° F.	109·62
‡4	Well	74·5° F.	60·74

"All the samples contained dissolved and suspended peaty matter, but none of them contained more than a mere trace of ammonia or nitric acid. The solid residue left on ignition consisted, in all cases, of carbonate of lime and magnesia, sulphate of lime, chlorides of sodium and calcium, the latterly probably derived mainly from sea-water.

"The best water for domestic purposes, in every respect, was No. 4.

"The question to be solved is—What causes the high temperature of the water in the wells? The idea first occurring to me on hearing there was so great a difference of temperature between the wells and the river was that, as the wells seem all to be situated in the neighbourhood of farmyards, a species of nitrification was going on in the soil of sufficient intensity to produce the rise in temperature—in which case, of course, there would have been some distinct evidence of it in the water itself. Such, however, was not the case in any instance, there being in none of the samples more than a mere trace of nitrates or ammonia.

"Another possible explanation offering itself previous to the examination of the saline constituents was that the proportion of salts being considerable some chemical decomposition might be

* No. 1. in the foregoing paper by Mr. Harmer, pp. 243–4.
† No. 3. in ditto.
‡ No. 5. in ditto.
§ The residue is after ignition at a low red heat to burn off peaty organic matter, &c.

going on between the acids and bases so as to cause a development of heat. But the qualitative analyses of these salts show that they are the same as exist in all ordinary waters, and are not of such a nature as to result in chemical decomposition. Moreover, the sample of water showing the greatest temperature contains by far the least amount of mineral matters.

"These suppositions failing to throw any light upon the matter, I am constrained to believe that chemistry can furnish no solution to the difficulty, so far, at least, as the local production of heat is concerned."

Human Remains in the Fenland.—In treating of the gravel we have shown that palæolithic implements are confined to those gravels which are probably the remains of old valley-deposits, that neolithic implements are found throughout the peat and silt, and that bronze celts are mostly found upon or close to the surface of the ground.

Several canoes have been dug up in different parts of the fens. They are chiefly hollowed trees, or what the Americans call "dug-outs," and decay very rapidly when exposed to the air. They have been found in the fens of Lincolnshire only, so far as I know, and the localities are Kyme, Billinghay, Langtoft, and Pinchbeck Bars. Of those found at the two former places the fact only is recorded. The Langtoft canoe was found about the year 1850, on a farm belonging to Mr. Whitfield, who described it to me as being hewn out of a single oak-trunk, the marks of the axe being clear both on the inside and the outside. The ends were rounded; the length was 48 feet; and the breadth inside where greatest 4½ feet. The tree was estimated to have contained 650 cubic feet of timber. Nothing was found inside save a few pebbles. This interesting relic was burnt because "it cumbered the ground." The canoe at Pinchbeck Bars was a more pretentious vessel, being made of rough planks fastened together with wooden pegs. It lay about 10 feet from the surface. Its measurements I could not obtain.

Urns of rude earthenware are not unfrequently found in the gravel, where they have been buried. I do not know of any being preserved, as they crumble with a touch. I found one in the gravel overlying Cornbrash in a pit close to the Car Dyke on the Dunsby Drove, north of Bourn, but could only obtain fragments, it having being partly destroyed by the workmen, who told me they had found several. Its form was slightly elliptical as shown in Fig. 35, and measured 10 × 15 inches at the broadest part and 16 inches in height. It was made of very ill-worked boulder clay, the fragments of chalk being plainly visible, and was adorned with quasi-straight lines crossing each other as shown, and with finger-marks. It was almost black, excepting a thin pellicle on the outside, which was red, and it contained burnt bones.

The more modern finds, such as those of Saxon age, do not within the scope of this work.

I have diligently sought for remains of lake-dwellings, but with meagre success. In two localities piles have been found, at Croyland, and between Ely and Stuntney. In the latter case they seem to have been merely a line of stakes, and cannot be cited as

Fig. 35.—*Urn found near Dunsby.*

lake-dwellings. The former I saw exposed at Croyland in the year 1870, in digging the foundation for a new draper's shop (Mr. Fillingham's). It was close to the edge of the gravel-bank on which Croyland stands. The stakes were of sallow and about 6 feet in length, and 3 to 5 inches in diameter, and pointed below very closely packed together, and they seemed to have been floored with brushwood upon which was laid gravel. The stakes were within 6 feet of the surface, and were overlaid with peat. The appearance was that of a causeway, which may have led to a platform on which a village stood. Immense quantities of bones, some tons in weight, were exhumed chiefly of *Bos longifrons*, *Sus scrofa*, and deer; beavers' teeth were also found. The human relics consisted of a single pin made of a bird's bone sharpened at one end, and scraped so as to form a head at the other, and a curious disc of jet about 1½ inches in diameter, and ¼-inch thick, with a square projection pierced with a large hole in the plane of the disc. It was ornamented with a rude intaglio figure something like a very rough St. Mark's winged lion, but I could not determine its character as it is damaged. It remains in the possession

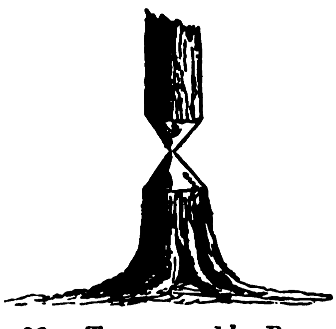

Fig. 36.—*Tree gnawed by Beavers.*

of Mr. Fillingham of Croyland. If this locality were excavated, the existence or not of a lake-dwelling would be set at rest.

I may remark that the Ely stakes are not the remains of a beaver dam. The stakes those animals cut are gnawed off so as to form an obtuse point as in Fig. 36. Beavers, again, do not construct dams in still water, such as the fens would abound in, but only in streams; and they never select running water when they can find still water. Hence I do not think they ever built dams in the fens.

I was told that many of the trunks in the bed of Ramsey Mere appeared to have been sawn off; but they are evidently only the levelled-up stools of trees in the buried forest, as described in the chapter on those forests.

Sir C. Bunbury described an undoubted lake-dwelling in Vol. XII. of the Geological Journal. It is situated outside the fen proper at Wretham, about five miles north of Thetford, in the valley of the Little Ouse. It was discovered on draining a small mere. He says "Numerous posts of oak-wood, shaped and "pointed by human art, were found standing erect, entirely buried "in the peat. . . . . Numerous horns of Red Deer have "been found in the peaty mud (as I was informed) at five or six "feet below the surface, seldom deeper; many attached to the "skull, others separate, and with the appearance of having been "shed naturally. What is most remarkable, several of those "which were found with the skulls attached had been *sawn off* "just above the brow antlers,—not broken, but cut clean off and "smoothly, evidently by human agency."

I may remark upon this that the neolithic flint pits at Grime's Graves, near Brandon, were worked with deer antlers, the brow tine being used as a pick.*

These are the only records I have been able to find bearing upon the question of the lake-dwellers: nor do I conceive the fen will ever yield many examples of this mode of existence, for the morasses themselves would have formed sufficient protection to the inhabitants of the islands in their midst.

Two lower jaw-bones and portions of four human skulls were dug up in the year 1818 about three miles south of Chatteris, in the bed of the West Water, embedded in dark brown peat, but nothing more is known of them. Mr. Marshall, of Ely, has in his possession a skull found in the fens near that place, which was exhibited at the Anthropological Society in 1874, but was pronounced to be comparatively modern.

Such is the scanty record of man's early occupation of the Fenland.

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* These interesting pits lie beyond the limits of this work, otherwise they would have been here described. Flints are still worked at Brandon in a similar manner and from the same beds. Is not this the oldest manufacturing locality in existence? In my memoir on Gun-flints, the great probability of the modern trade being a lineal descendant of the old industry is discussed, and the conclusion arrived at that the manufacture of flint-implements at Brandon has not ceased since neolithic times.

APPENDIX.

APPENDIX A.

Former Course of the Ouse.

Dugdale, pp. 395–6.

"To show that the river of Ouse had its outfall at Wisbeche, besides what before expressed."

1. The sea banks from Welle to Wisbeche.
2. Wisbeche Castle, founded "super flumen illud famosum, quod Welle " streme appellatur." (Regist. de Petroburg.)
3. "Situm est prædictum castrum, quod à pluribus paludibus et fontibus " principium habet, et per longos meatus in mare magnum juxta Wisbbeche " derivare liquidè comprobatur." (Regist. de Thorney, parte 3ª, p. 34.)
4. The people of King John perished in the water of Welle.

That there was some time no river between Litleport Chaire and Rebbech.

1. A record vouched by Mr. Hexham, surveyor to Philip Earl of Arundell; the tract of the river being of a clean contrary nature, *viz.* more straight than any of the Ouse in all the Fens from Ely to Wisbeche.
2. The imposing of the name of Heming's Lode in the description of Rack Fen, in the words of the record, *viz.* "à le Chaire per Heming's Lode, usque " Gnat's Lode End."

That the waters of the Isle should not, nor of old did, fall down from Welle upon Marshland eastward, nor into Welle Fens in Norff.

1. See the commission de anno 21 E. I.*
2. See the Leet Rolls de anno 29 E. I. pro Wadingstow fracto, in hiis verbis: " Reginaldus de Burgo fregit obstupationem de Wadingstow, fractam per " Breve Domini Regis, et reversit aquam extra rectum cursum suum ad mag- " num dampnum et nocumentum totius patriæ; ideo in misericordia iij. s."
See there some others amerced for the like; and in the next Leet how their pledges were amerced, and the offenders commanded to be attached.
3. See the Rolls of Upwell Lees, 12 E. II. *in fine*, divers amerced for breaking or hurting the banks of the Fen called the Fendike, between Welle and Wellenhee; and many presentments to prove that there were banks from Upwell to Wellenhee; and that they should not be broke nor cut, nor the water turned into the Fens near Marshland.
4. See the stopping of the waters of Welle from falling upon Marshland, upon the complaint of Marshland men made to the King, by whose commission they were stopped at Outwell Brigge, at Small Lode Brigg, and at Fendike Lake in Upwell, and at a place near the sluice at Upwell Town's End, on Popham Lode Head, sometimes called Wadingstow.
5. And upon the breach of the dam at Small Lode Bridge (by means of a complaint of Marshland men); see a commission sent down in 25 E. I. to inquire of the malefactors, and to punish them expressly, for breaking Small Lode Dam, and a writ of attendance directed to the sheriff to that purpose.
6. And that Small Lode Dam was, according to this commission, made and fortified again, appeareth plainly by divers presentments and punishments set forth in the Leet Rolls of Upwell after those days: only one of 12 E. II. shall suffice, *viz.*:—"Et dicunt, quod Walterus Jollyff consuetus est trahere batel- " lam suam ultra estupationem factam per Breve Domini Regis, apud le " Little Lode, per quod dicta estupatis deterioratur; ideo in misericordia " ij. s." See there four or five more amerced for the like. And that there were banks from Upwell to Welney aboard the great river kept, that the water should not fall into the Fens on Norfolk side, may be proved by very many presentments, almost in every king's time since Edward I., to King James, *viz.* in 1, 2, 22, 23, 24, 25 E. I. and E. II., 12, 15, 14, 18 E. II., 3, 4 E. III. &c., 2 R. II., &c.

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* This Commission sat at Upwell, to take "into consideration what ought to be done for restoring those waters of Utwell (for so that great river of Ouse, which had formerly passed that way, was then called` to their due and antient course."

I will only add one more old record to prove that the waters of the Isle should not fall into the Fens on Norfolk side, anno 24 E. I.

" —— Juratores dicunt, quod Adam Noach cidit communem dravam per " medium, juxta Hold Wellen-Hee, per quod cursus magnæ ripariæ, et " Hold Wellen-hee transversus est ex recto cursu versus mariscum, ad " grave nocumentum totius communitatis; ideo dictus Adam in miseri- " cordia, xij. d." And in the Leet following his pledge was amerced and pained to have it amended; and he himself distrained to answer to it.

So that where it is here said (and in many other places also) that the stream of the great river of Wellen-hee was turned out of his right course by cutting the fen dikes or droves, in this presentment and some others it is said that the water was turned into the Fen, so as to go out of the right course into the Fen, proveth plainly that there was no watercourse through the Fen for the water to pass by.

And in anno 1 Mariæ it was thus presented :—" ——Et quod nulla persona " abscindet Calcetum in aliquâ parte ejusdem, sive aliquorum aliorum Cal- " catorum, etc., sub pena foris facturæ pro quolibet tempore sic factum, " vi. s. viij. d."

And in the convocation for Cowstowe . . . the jury say thus :—

" —— Dicunt etiam, quo antiquo tempore, antequam aquæ Marisci de- " scendebant versus Wigenhale, sed postquam aquæ Marisci descendebant " versus Wigenhale nunquam fuit dictum fossatum aliqua salvatio, etc."

Whereby it appeareth, that antiently the waters of Upwell did not fall down towards Wigenhali, and so by Lynne.

That there was a mere in Welle called the Wide.

Robert de Swaffham, in his History of the Foundation of Peterborough, under the title, "De gestis incliti militis Herewardi," saith that Hereward fleeing William the Conqueror, "cum navibus suis, quas habebat benè armis " munitas, etc. in quoddam mare Wide vocatum, juxta Welle secessit, " magnum et spaciosum lateribus aquarum, et liberos exitus habens." The name and tract of which meer yet remaineth in the Fens of Upwell, Wide Lode being ordained to be cleaned by the same law that Small Lode was.

That the waters had their course from Gnat Lode towards Welle.

The tract to this day sheweth it; for the presentment by which Small Lode is so much urged saith, that Gnat Lode "incipit apud Hawkyns Bright, et " durat usque Fowe Lodes End." The Crosse end of Gnat Lode was Docky Lode; and in the same presentment it is said, that Wide Lode was in length a mile and an half and xv. furlongs, and that old Small Lode " incipit à Wide Lode," and continued towards Welle, to a place of late called Crosse-water against Nurses viij. acres end, by the space of half a mile and half a furlong, and there fell into Cheselbeche Lode, alias Small Lode, and from Seman's Goole came into the river a little below Upwell church.

Other branches there were, all tending their course towards Welle, and so to the north seas, at Wisbeche, as Webwinche Lake, Well Meere, Audley Lode, Wabeche Lode, Chesebeche Lode, Twane Lode, Saltham Lake, &c., as may seem by the tracts of many of them in the Fens of Welle.

APPENDIX B.

Notes from Mr. F. A. Paget's Report on the Utilisation of Peat and Peat Lands.

Vienna Exhibition Reports, Part II., 1875.

Size of Blocks.—The following are given for comparison with the fen cases :—

Brosowsky's hand peat-digging machine	14 × 6 × 5 inches.
At Oldenburg	12 × 12 × 4 "
" Huttenberger Eisen Gesellschaft	10 × 5 × 5 "
" Hoogenen Holland	9 × 2½ × 2½ "
" Ireland	10 × 5 × 5 "

Measurement in Germany.—A *rassmeter* is a nominal cubic meter, a *festmeter* is an actual cubic meter with no empty spaces between the bricks. The cubic contents of the empty spaces amount to 46 per cent. of the whole, or 30 per cent. when closely packed.

Drying of Peat.—At Johannisdorf the bricks weigh 13 zoll. lbs. wet and 2 to 2¼ lbs. dry. Average raw peat contains from 70 to 90 per cent. of water. Average dry peat contains at most 25 per cent., and well dried peat yields 10 per cent. of water when heated to boiling point. At Paklidimmer there are five principal kinds of peat, *viz.* :—1. Nearly homogeneous, shrinks one third in drying, weighs dry 565 kgs. per festmeter. 2. Contains rushes, wood, &c., shrinks one fourth, weighs 470 kgs. 3. Brown moss peat, shrinks one fifth, weighs 310 kgs. 4. Yellow moss peat, soft and felt-like, shrinks one sixth, weighs 245 kgs. 5. White moss peat, most recent formation, shrinks one eighth, weighs 180 kgs.

Comparative Value of Peat as Fuel.

Fowler & Co., Leeds, works erected in Hungary. Grate surface 50 per cent. greater than for coal.

Austrian Railway. Double weight of peat to be carried as compared with coal.

Dublin Steam Packet Co. Shannon, 1843. Good dry peat did half the work of coal; bad or damp peat one third less.

Illinois. 2½ tons of peat equal to 1 ton of good coal.

Hospelmoor and *Holbermoor*, Bavaria.

1 Bav. cu. ft. (0·02486 cu. met.) = 40 cu. ft. of ordinary peat - - - -	costs	26 to 32 pence.
50 kgs. = 1 centner, coal from Ruhr - -	,,	13⅜ ,,
50 ,, ,, compressed peat, Hpolmr.	,,	7⅓ ,,
50 ,, ,, ball turf from Aibling -	,,	7⅓ ,,

*** These results compare very well with my estimate, made before these appeared.

"From the examination of experience in other countries, and a consideration of the real value of peat as compared with coal, we have arrived at the following conclusion :—*that peat can only be sold at prices varying from one third to one fourth of the local selling price of average coal.*

"Now, as the cost of raising coal in (say) South Staffordshire, including all items whatever, except the lordship or royalty paid to the owners, ranges at the most from 5*s*. to 10*s*. per ton, according to the thickness of the seam, the depth, &c.; and as this cost covers both lump and slack coal, a very narrow and impossible margin is left for working peat, except even at remote places, where the cost of carriage adds considerably to the cost of coal. In fact, in a large coal-producing country like ours peat would have to compete, not so much with the practically more valuable coal in lumps, but with the much cheaper slack or dust of coal, or small coal, which needs little or no drying, and not much more labour to convert into bricks.

"When one bears in mind the high price of labour in Great Britain in relation to a material the varying conditions of which render it impossible to do without some intelligent labour; the inconstant nature of a very moist climate, under the influences of which a material containing at least five or six times its weight of water has to be moved and dried; the highly developed means of communication, bringing with them almost everywhere a fuel able to do as much work as twice the same weight of peat; that bringing half a ton of this competing coal, a material complete in itself, to the surface often only costs half-a-crown and less; it is difficult to hope, in spite of the present high prices of coal, that the production for fuel of peat, *per se*, can compete on a sound basis with the working of coal, even at considerable distances from the pit. On the other hand, land and space are extremely valuable, especially in England; wide areas now useless are covered with peat moors, heaths, morasses, and bogs; and if, as in Holland and some parts of Germany, the utilisation of peat as fuel were combined with a systematic utilisation of the surface and waste left by the extraction of the peat itself, possibly with a simultaneous application of the sewage of large towns, the question of peat and peat wastes might assume a very different aspect. While the extraction of coal generally ruins, by subsidence, the superincumbent land, the extraction of peat often raises its value. The extraordinary prosperity of the peat colonies of Holland and East Friesland is certainly a very important fact, deserving most careful study. Whether it could co-exist with a relatively low price of coal, or without the conditions of *la petite culture*, where each man is working for himself, are important questions. . . . . The Dutch realise great wealth out of their peat beds, through their industrious and patient habits; not by means of complicated machinery vainly attempting the impossible task of evolving a rival to coal."

I have not noticed the attempt made last year to introduce into the Norfolk fens M. Challeton de Brughat's method of dressing peat, because it did not seem to me a fair object for criticism. They managed to sink about 100,000*l*. in a year without making any fuel worth speaking of—a few truck loads or so (and what they made was found to stop the engines at Ely when it was tried), and only leave about 2,000*l*. worth of plant to satisfy the shareholders; so that the scheme lies beyond the province of *our* science at any rate.

A misconception exists in many places as to the nature of fuel and the possibility of manufacturing it profitably. Fuel is practically gas compressed into a solid, which when reconverted into gas evolves force which we utilise, the measure of this force being the measure of the mechanical power obtainable from the fuel. This force again, by the conservation of energy, is the mechanical equivalent of the force that has been expended in making the fuel. Now in the case of coal and peat this original work has been done chiefly by the sun and entirely without human agency, and twice as much work can be got out of coal as out of peat, *because twice as much work has been put into it*. To make fuel *de novo*, then, we should have to expend as much force as the fuel would produce when burned, and there could be no mechanical advantage, because *ex nihilo nihil fit*. To hope to make peat more valuable by mechanical appliances is equally futile, for the same reasons. Hence we can never hope to add to the work that can be got out of peat by putting more into it; what we put in we can take out again, but it bears no interest.

APPENDIX C.

Sections in the Fenland.

Note. The authority is quoted in each case wherein the measurement is not my own, and the quotations are given as nearly as possible in their original form.

No. 1. Sheet 51.

Crooked Drain near Norney, Ely.

	ft.	in.
3. Peat	11	0
2. Clay (fen)	3	0
1. Kimeridge Clay		
	14	0

No. 2. Sheet 51.

Waterden Fen, Ely.

	ft.	in.
2. Peat	0	6
1. Fen clay with sandy veins	4	0
	4	6

No. 3. Sheet 51.

Pit at the 70 milestone between Littleport and Ely.

		ft.	in.
4. Peat - - - - - - -		1	6
3. Sandy loam - - - - - -	0 to	1	6
2. Kimeridge Clay - - - - - - -		16	0
1. " Stone floor " (septaria bed) - - - -		1	3
		20	3

No. 4. Sheet 51.

Wardoe Hill, west side.

		ft.	in.
3. Peat, much decomposed - - - -	0 to	1	0
2. Sand, mixed with yellow and red clay -	0 to	1	6
1. Kimeridge Clay - - - - -	seen to	4	0
		6	6

No. 5. Sheet 51.

Road from Wardoe to Witcham Gravel.

		ft.	in.
3. Peat - - - - - - - -		0	4
2. Sand, white and yellow - - - -	2 ft. to	4	0
1. Kimeridge Clay - - - - - - -		2	0
		6	4

*** The sand passes vertically and laterally into a fine gravel on the one hand, and into a white sandy clay on the other. Under one of these forms it is visible on the whole of the edge of the fen nearly as far as Mepal, as well as under the peat.

No. 6. Sheet 51.

Fork of Rivers Ouse and Cam.

		ft.	in.
4. Peat - - - - - - -	2 ft. to	3	6
3. Loam, light blue and brown, with roots of reeds, &c. -		2	6
2. Coprolite bed of Neocomian sands, a pebbly deposit -		1	6
1. Kimeridge Clay - - - - - - -			
		7	6

No. 7. Sheet 51.

Wicken Lammas Ground.

		ft.	in.
3, 2. Peat, covered with a thin white, shelly alluvium -		2	0
1. Kimeridge Clay - - - - -	seen to	4	0
		6	0

No. 8. Sheet 51.

Grunty Fen Drain, Witchford.

		ft.	in.
5. Peaty soil - - - - - - -	4 in. to	0	6
4. Sand, white and drab - - - - - -		1	0
3. Clayey sand and gravel with many chalk-stones -	1 ft. to	4	0
2. Clay with sandy seams - - - - -	1 ft. to	4	0
1. Kimeridge Clay - - - - - - -			
	Say	5	6

*** Beds 2 and 3 are forms of the Boulder clay.

No. 9. Sheet 51.

Grunty Fen, north of Grunty Fen House.

		ft.	in.
4. Peat		traces	
3. Sand, white and brown		1	0
2. Clay with gravelly seams		3	0
1. Kimeridge Clay, with septaria	seen to	3	0
		7	0

No. 10. Sheet 51.

Grunty Fen. South side.

		ft.	in.
3. Peat		traces	
2. Clay, soft with a few flints		2	6
1. Kimeridge Clay	seen to	2	0
		4	6

No. 11. Sheet 51.

Near Castle's Farm, Soham Parish.

		ft.	in.
4. Peat		1	0
3. Sand (ochreous) and clay		4	0
2. Peat		1	0
1. Clay (Gault?)	seen to	1	0
		7	0

No. 12. Sheet 51.

Wood Fen.

		ft.	in.
4. Peat with sallows, firs, and oaks		5	0
3. Clay, fen		3	0
2. Mass of decayed roots and clay	0 to	3	0
1. Kimeridge Clay			
		8	0

No. 13. Sheet 51.

Burnt Fen near Cross Bank.

		ft.	in.
4. Peat		1	0
3. Shell-marl		3	0
2. Peat		8	0
1. Clay, fen	pierced to	3	0
		15	0

No. 14. Sheet 51. Railway Boring.

N. side of River Cam. Chesterton Parish.

		ft.	in.
4. Made ground		4	0
3. Black peat		2	0
2. Gravel		10	0
1. Kimeridge Clay	to	5	0
		21	0

No. 15. Sheet 51. Railway Boring.

River Ouse, Willingham Parish, near Earith.

	ft.	in.
5. Brick-earth (alluvium) - - - - - -	2	0
4. Black, boggy peat - - - - - -	5	0
3. Black, stiff peat - - - - - - -	2	0
2. Gravel and sand - - - - - - -	11	0
1. Oxford Clay - - - - - - -	1	6
	21	6

No. 16. Sheet 51. Railway Boring.

Between the Bedford Rivers, Bluntisham Parish.

	ft.	in.
4. Clay - - - - - - - -	2	6
3. Sand and clay - - - - - - -	7	6
2. Gravel and sand - - - - - - -	2	0
1. Oxford Clay - - - - - - -	4	0
	16	0

No. 17. Sheet 51. Railway Boring.

Earith Wash.

	ft.	in.
5. Clay, yellow - - - - - - -	2	6
4. Peat, black - - - - - - -	3	6
3. Clay, yellow and mottled - - - - - -	4	0
2. Sand, gravel and loam - - - - - -	5	0
1. Oxford clay - - - - - - -	3	0
	18	0

No. 18. Sheet 64.

Thurby Gravel Pit.

	ft.	in.
5. Peaty clay - - - - - - - - -	0	10
4. Ferruginous, sandy clay, with roots of plants - -	0	8
3. Dark-blue clay - - - - - - -	0	2
2. Light-yellow sand and gravel, with carbonised wood -	1	6
1. Coarse gravel - - - - - seen to	4	0
	7	2

No. 19. Sheet 64.

Kate's Bridge.

	ft.	in.
2. Gravel - - - - - - - 0 to	2	0
1. Kelaways beds of Oxford Clay - - - - -		
	2	0

No. 20. Sheet 64.

Bourn.

	ft.	in.
4. Sandy soil - - - - - - - - -	1	6
3. Gravel, in pockets - - - - - 0 to	6	0
2. Boulder clay - - - - - - 0 to	6	0
1. Cornbrash - - - - - - - -	10	0
In all	17	6

No. 21. Sheet 64.

Gravel Drain.

		ft.	in.
1. Gravel	seen to	6	0

No. 22. Sheet 64.

Two miles east of Bourn.
(Spreckley's Farm.)

		ft.	in.
2. Peat		2	0
1. Peat, mixed with clay	seen to	4	0
		6	0

No. 23. Sheet 64. Railway Boring.

South side of River Nene, near Felldale Drove, Whittlesey.

	ft.	in.
7. Black peat	5	0
6. Brown peat, with particles of decayed vegetable matter	3	0
5. Strong blue clay, with quantities of cockles	6	0
4. Black peat	8	0
Ditto mixed with a large proportion of fragments of timber trees	4	0
3. Coloured earth	2	0
2. Very hard sand and stones	1	0
1. Yellow gravel and stones	5	0
	34	0

No. 24. Sheet 64. Railway Boring.

Side of River Nene. Benwick Parish.

	ft.	in.
6. Black loam	2	0
5. Brown peat	7	0
4. Light blue galt	7	0
3. Peat	10	0
2. Dark sand	1	0
1. Hard flinty gravel	4	0
	31	0

No. 25. Sheet 64. Railway Boring.

South Bank of Whittlesey Wash, 10 *chains from Mill in Felldale Drove.*

	ft.	in.
8. Black peat	5	0
7. Peat and galt	5	0
6. Brown peat and decayed vegetable matter	5	0
5. Sand	4	0
4. Sand, with small flinty stones	2	0
3. Strong blue clay, with streaks of sand	5	0
2. Dark yellow gravel	5	0
1. Hard gravel and stone	3	0
	34	0

No. 26. Sheet 64.

Deeping St. James.

	ft.	in.
3. Soil	3	0
2. Gravel	10	0
1. Oxford clay		
	13	0

No. 27. Sheet 64.

Tongue End.

		ft.	in.
5. Soil	- - - - - - - -	2	0
4. Peat	- - - - - - - -	4	0
3. White silty clay	- - - - - - -	2	0
2. Peat	- - - - - - - -	3	0
1. " Soil " containing earthenware	- - - -		
		11	0

No. 28. Sheet 64.

Baston.

		ft.	in.
2. Soil	- - - - - - - -	2	0
1. Gravel	- - - - - - - -	4	0
		6	0

No. 29. Sheet 64.

Market Deeping.

		ft.	in.
2. Soil	- - - - - - - -	2	0
1. Gravel	- - - - - - - -	12	0
		14	0

No. 30. Sheet 64.

Cross Road.

			ft.	in.
3. Peat	- - - - -	1 ft. to	4	0
2. Silty clay	- - - - -	about	1	0
1. Gravel	- - - - -	seen to	4	0
		Say	7	0

No. 31. Sheet 64.

A quarter-of-a-mile south of Counter Drain Station.
(Well.)

			ft.	in.
3. Peat	- - - - - -	about	2	0
2. Silt and clay	- - - - - - -		9	0
1. Gravel	- - - - - - - -		0	0
			11	0

*** This section is obscure; there may be peat beds in the silt.

No. 32. Sheet 64.

Woodstone, near Peterborough.

			ft.	in.
1. Gravel	- - - - -	seen to	12	0

No. 33. Sheet 64.

New England, Peterborough.

		ft.	in.
2. Gravel, with marly seams	- - - - - -	6	0
1. Oxford Clay	- - - - - - -	0	0
		6	0

*** The gravel is fosiliferous.

No. 34. Sheet 64.

New England, near the previous pit.

		ft.	in.
4. Soil		1	0
3. Gravel, mixed with clay	2 to	5	0
2. Oxford Clay		3	4
1. Cornbrash	seen to	5	0
		14	4

*** The gravel is fossiliferous.

No. 35. Sheet 64.

Mr. Aikin's Farm, North Drove.

		ft	in
3. Peat			?
2. Clay			?
1. Gravel	at about	16	0

No. 36. Sheet 64.

Great Porsand.

	ft.	in.
5. Soil	0	6
4. Clay	2	0
3. Peat	0	3
2. Clay	6	0
1. Gravel and peat		
	8	9

No. 37. Sheet 64.

Kenulph's Drove, Croyland.

	ft.	in.
3. Soil	0	3
2. Land	2	0
1. Gravel	5	0
	7	3

No. 38. Sheet 64.

Eye Green.

		ft.	in.
3. Peaty soil	1 ft. to	2	0
2. Coarse gravel		1	0
1. Stratified sand		6	0
		8	0

*** These sands are fossiliferous.

No. 39. Sheet 64.

Toll-bar opposite Kenulph's Stone, Croyland.

		ft.	in.
4. Soil		0	3
3. Yellowish clay		1	0
2. Peat, full of wood		3	0
1. Clay	seen to	1	0
		5	3

No. 40. Sheet 64.

Peakirk.

		ft.	in.
1. Gravel - - - - -	seen to	18	0

No. 41. Sheet 64.

St. James's Drove, Croyland.

		ft.	in.
3. Peat - - - - -	6 in. to	1	0
2. Sandy silt - - - -	6 in. to	2	0
1. Sand and sandy gravel - - -	seen to	4	0
		5	0

No. 42. Sheet 64.

Immediately east of Croyland.

		ft.	in.
2. Peaty soil - - - - - - -		1	0
1. Sandy silt - - - -	seen to	4	0
		5	0

No. 43. Sheet 64.

St. James's Drain, 3 miles N. of Croyland.

		ft.	in.
2. Clay, bluish, with brown mottlings - - -		12	0
1. Peat - - - - - - - -		0	0
		12	0

*** The clay is fossiliferous.

No. 44. Sheet 64.

Triangular Bridge, Croyland.

		ft.	in.
6. Made grou. - - - - - - - -		2	6
5. Peat, full of bones and mud, with fragments of brick, &c.		1	0
. Ancient road, paved with coggles - - -		0	6
4. Silt, black and brown - - -	6 in. to	1	0
Marly clay, full of bones - - - - - -		0	6
3. Peat, full of sallow - - - - - -		1	6
2. Sand - - - - - - - -		0	4
1. Gravel - - - - - - - -		10	0
		17	4

No. 45. Sheet 64.

Croyland.

		ft.	in.
3. Made ground - - - - - - -		3	0
2. Gravel - - - - - - - -		12	0
1. Boulder clay - - - -	pierced to	12	0
		27	0

No. 46. Sheet 64.

Windmill, Kenulph's Drove, Croyland.

		ft.	in.
5. Soil		0	6
4. Silty clay		0	6
3. Peat, with a thin "coaly" layer at base		3	
2. Sandy silt		3	0
1. Boulder clay	pierced to	10	0
		17	0

No. 47. Sheet 64.

Mr. Wycke's Farm, St. James's Drove, Croyland.

	ft.	in.
2. Sandy silt, with one or two thin beds of peat	13	0
1. Gravel, with a "red scale" at the top, shingly below, not pierced	12	0
	25	0

No. 48. Sheet 64.

Whipchicken Farm, near Croyland.

		ft.	in.
4. Silt	from 10 ft. to	13	0
3. Peat		2	0
2. Silt		5	0
1. Shingle, full of salt water	pierced to	2	0
		22	0

No. 49. Sheet 64.

Cloot House, near Croyland.

		ft.	in.
2. Silt	8 ft. to	9	0
1. Peat, very fetid, full of water		0	0
		9	0

No. 50. Sheet 64.

Well half a mile nearer Brotherhouse than, No. 49.

		ft.	in.
3. Old well, section unknown		16	0
2. Gravel		3	0
1. Boulder clay, full of stones, with water (salt at high spring tides)	dug to	12	0
		31	0

No. 51. Sheet 64.

Steam Engine House, Welland Bank, Croyland.

		ft.	in.
4. Silt, white and marly		3	0
3. Small dark gravel		1	0
2. Shingly gravel		10	0
1. Boulder clay	opened to	3	0
		17	0

No. 52. Sheet 64.

Dowsdale Bank, near Noman's Land.

		ft.	in.
3. Silt, not very sharp		3	0
2. Clay		20	0
1. Small white gravel	pierced to	7	0
		30	0

No. 53. Sheet 64.

Noman's Land Hirn.

	ft.	in.
1. Gravel, turned out of river to a depth of	10	0

*** Very fossiliferous.

No. 54. Sheet 64.

Fantail Mill, Kenulph's Drove, Croyland.

		ft.	in.
4. Soil		0	6
3. Peaty clay, full of rushes, &c.		1	6
2. Soft blue clay		18	0
1. Greenish clay (Oxford Clay?)	pierced to	3	0
		23	0

No. 55. Sheet 64.

Gunthorp Bridge.

		ft.	in.
4. Peat		2	0
3. Sandy silt		2	0
2. Gravel	0 to	0	6
1. Oxford Clay			
		4	6

No. 56. Sheet 64.

Cuckold's Haven.

	ft.	in.
3. Soil	1	6
2. Gravel	4	6
1. Oxford Clay		
	6	0

No. 57. Sheet 64.

Brick Kilns, one mile west of Whittlesey.

		ft.	in.
2. Gravel		10	0
1. Oxford Clay	seen to	10	0
		20	0

58. Sheet 64.

Whittlesey; Road to Peterborough.

		ft.	in.
1. Gravel	seen to	8	0

*** The gravel is fossiliferous.

No. 64. Sheet 64. Dr. H. Porter.

Whittlesey Mere.

	ft.	in.
vel	2	0
k earth	1	0
clay	3	6
	10	0
ord Clay	0	0
	16	6

Porter's work was written in 1851, about the time of the drainage . The above section was probably to the north of the mere and gravel not *in situ*.—S.B.J.S.

No. 65. Sheet 64. W. Brydone.

Great Northern Railway Borings.

		ft.	in.
d at Peakirk	gravel found at	4	0
Drove Drain	,, ,, ,,	12	0
miles north	,, ,, ,,	30	0

No. 66. Sheet 64. Railway Boring.

Long Drove, Whittlesey Wash.

	ft.	in.
wn peat and vegetable matter	5	0
,, ,, blue clay	4	0
,, ,, pale sand	4	0
d and decayed wood	8	0
wn peat and decayed vegetable matter	4	0
k and yellow gravel and stones	5	0
	30	0

No. 67. Sheet 64. Railway Boring.

500 *yards from Long Drove, Whittlesey Wash.*

	ft.	in.
k peat, with dark gravel	6	0
k gravel and blue sand	5	0
e sand	14	0
vel and stones, very hard	5	0
	30	0

No. 68. Sheet 64. Railway Boring.

Towing-path, North Bank, South Side of R. Nene.

	ft.	in.
k brown peat, with large stones	7	0
k earth, with gravel and stones	7	0
p blue sand, very hard	6	0
gravel and stone, very hard	5	0
	25	0

No. 59. Sheet 64.

Near Gas Works, Whittlesey.

		ft.	in.
2. Gravel and sand	- - - - - -	10	0
1. Oxford Clay	- - - - seen to	5	0
		15	0

*** Marine and freshwater shells commingled in the gravel.

No. 60. Sheet 64.

New Church, Ponder's Bridge.

		ft.	in.
6. Peat	- - - - - - -	4	0
5. Blue clay	- - - - - - -	2	0
4. Sandy silt	- - - - - - -	10	0
3. Peat	- - - - - - -	2	0
2. Blue clay	- - - - - - 1 ft. to	1	6
1. Gravel, very dark, full of water	- - open to	3	0
		22	6

No. 61. Sheet 64.

Middlemoor Fen Engine.

		ft.	in.
5. Peat	- - - - - - -	5	6
4. Clean blue clay	- - - - - -	6	0
3. Peat	- - - - - - 2 ft. to	3	0
2. Soft clay with stones	- - - - 2 ft. to	3	0
1. Dark-blue clay	- - - opened to	2	0
		19	6

No. 62. Sheet 64. J. W. Judd.

Farcet Fen.

(Blackpool Hill.)

		ft.	in.
5. Black vegetable soil	- - - - - -	0	9
4. Silty bed	- - - - - - -	0	9
3. Dark ferruginous, clayey gravel	- - - -	1	6
2. Light coloured sandy gravel	- - - -	3	6
1. Oxford Clay	- - - - - -	0	0
		6	6

No. 63. Sheet 64. Dr. H. Porter.

Grassmoor, Whittlesey.

		ft.	in.
4. Black fen earth, with trees at base	- - -	2	6
3. Yellowish clay, or gault, with bones	- - -	6	0
2. Black earth, wood and reed roots, and thin seam of cockles at base	- - - - - - -	4	0
1. Oxford Clay	- - - - - - -	0	0
		12	6

No. 64. Sheet 64. Dr. H. Porter.

Whittlesey Mere.

	ft.	in.
5. Gravel - - - - - - - -	2	0
4. Black earth - - - - - - -	1	0
3. Silty clay - - - - - - - -	3	6
2. Peat - - - - - - - -	10	0
1. Oxford Clay - - - - - - -	0	0
	16	6

*** Dr. Porter's work was written in 1851, about the time of the drainage of the mere. The above section was probably to the north of the mere and the bed of gravel not *in situ*.—S.B.J.S.

No. 65. Sheet 64. W. Brydone.

Great Northern Railway Borings.

		ft.	in.
Welland at Peakirk - - -	gravel found at	4	0
South Drove Drain - - -	" " "	12	0
Ditto 4 miles north - - -	" " "	30	0

No. 66. Sheet 64. Railway Boring.

Long Drove, Whittlesey Wash.

	ft.	in.
6. Brown peat and vegetable matter - - - - -	5	0
5. " " " blue clay - - - - -	4	0
4. " " " pale sand - - - -	4	0
3. Sand and decayed wood - - - - - -	8	0
2. Brown peat and decayed vegetable matter - - -	4	0
1. Black and yellow gravel and stones - - -	5	0
	30	0

No. 67. Sheet 64. Railway Boring.

500 yards from Long Drove, Whittlesey Wash.

	ft.	in.
4. Dark peat, with dark gravel - - - -	6	0
3. Black gravel and blue sand - - - -	5	0
2. Blue sand - - - - - - -	14	0
1. Gravel and stones, very hard - - - -	5	0
	30	0

No. 68. Sheet 64. Railway Boring.

Towing-path, North Bank, South Side of R. Nene.

	ft.	in.
4. Dark brown peat, with large stones - - -	7	0
3. Black earth, with gravel and stones - - -	7	0
2. Sharp blue sand, very hard - - - -	6	0
1. Yellow gravel and stone, very hard - - -	5	0
	25	0

No. 69. Sheet 64. Railway Boring.

North Bank of R. Nene.

	ft.	in.
4. Rich alluvial soil - - - - - - -	10	0
3. Black ditto, with galt and stones - - - - -	6	0
2. Brown peat - - - - - - -	6	0
1. Hard gravel - - - - - - -	5	0
	27	0

No. 70. Sheet 64. Railway Boring.

Hartley's Drove, Thorney Parish.

	ft.	in.
5. Peat - - - - - - - -	3	0
4. Very soft blue clay or galt - - - - - -	3	0
3. Sand - - - - - - - -	1	0
2. Small gravel and sand - - - - - -	5	0
1. Ditto, very hard - - - - - - -	2	0
	14	0

No. 71. Sheet 64. Railway Boring.

St. James's Drove, Croyland Parish.

	ft.	in.
4. Very fine mould - - - - - - -	2	0
3. Fine gravel, with coarse sand - - - - -	2	0
2. Loamy sand - - - - - - -	6	0
1. Very hard and firm sand - - - - - -	1	0
	11	0

No. 72. Sheet 64. P. H. Frere.

Near Whittlesey Mere.

	ft.	in.
2. Peat - - - - - - - -	22	0
1. Clay - - - - - - - -		
	22	0

No. 73. Sheet 64. P. H. Frere.

Bed of Whittlesey Mere.

	ft.	in.
5. Silt (marl) and peat - - - - - -	3	0
4. Compressed peat - - - - - - -	2	0
3. Clay, blue, blackish below with numerous minute cockle shells - - - - - - - -	13	6
2. Peat, brown, with roots, trunks, branches, and leaves of Scotch fir, birch, and hazel - - - - -	2	4
1. Solid blue clay (Oxford clay) - - - - -		
	20	10

No. 74. Sheet 64. Sir J. Coode.

The Gores, Thorney.

	ft.	in.
3. Soil - - - - - - - -	4	6
2. Gravel - - - - - - - -	10	6
1. Clay - - - - - - - -	0	0
	15	0

No. 75. Sheet 64. Sir J. Coode.

Willow Hall, Thorney.

		ft	in.
6. Black soil	- - - - - - - -	0	9
5. Dry silt	- - - - - - - -	3	0
4. Coarse gravel	- - - - - - -	10	3
3. Silty gravel	- - - - - - -	2	0
2. Black soil	- - - - - - - -	0	6
1. Fine silt	- - - - - - - -	1	6
Not down to the clay.			
		17	0

No. 76. Sheet 64. Sir J. Coode.

Bar Pasture, Thorney.

		ft.	in.
3. Soil	- - - - - - - -	1	6
2. Gravel	- - - - - - - -	18	6
1. Clay	- - - - - - - -		
		20	0

No. 77. Sheet 64. Sir J. Coode.

Middle Farm West, Thorney.

		ft.	in.
3. Soil	- - - - - - - -	4	0
2. Gravel	- - - - - - - -	10	0
1. Clay	- - - - - - - -		
		14	0

No. 78. Sheet 64. Sir J. Coode.

Cat Water Farm, Thorney.

Old Well.

		ft.	in.
1. Gravel dug to	- - - - - - -	5	0

No. 79. Sheet 65.

South Bank, Eldernel.

		ft.	in.
3. Peat	- - - - - - - -	1	6
2. Gravel, sandy at base	- - - - - -	3	6
1. Oxford Clay	- - - - - seen to	2	0
		6	6

No. 80. Sheet 64.

Half a mile west of Eldernel.

		ft.	in.
1. Gravel, seen to	- - - - - -	7	0

*** A quarter of a mile to the east the gravel is fossiliferous.

No. 81. Sheet 64.

Gault Hole Pits, Forty-foot Bridge, near Ramsey.

		ft.	in.
2. Gravel	- - - - - - - 0 to	6	0
1. Oxford clay	- - - - - dug to	40	0
		46	0

No. 82. Sheet 65.

Andrews' Brickyard, Wisbech.

		ft.	in.
5. Silt	1 ft. to	2	0
4. Clay	3 ft. to	5	0
3. Peat		0	5
2. Clay		2	0
1. Silt, full of water			
		8	5

No. 83. Sheet 65.

Elm (now closed).

		ft.	in.
5. Silt		2	0
4. Clay		4	0
3. Peat		1	0
2. Silt		2	0
1. Clay	not pierced	17	0
		26	0

No. 84. Sheet 65.

St. Mary's, Wisbech.

	ft.	in.
3. Sandy silt	1	0
2. Peat	0	3
1. Clay	2	0
	3	3

No. 85. Sheet 65.

New Brickyard, near Railway, Wisbech.

		ft.	in.
5. Silt		1	0
4. Clay		6	0
3. Peat		0	7
2. Blue clay		2	0
1. Silt	opened to	6	0
		15	7

*** In bed No. 1 the live prawns occur, see p. .

No. 86. Sheet 65.

Walsoken.

		ft.	in.
5. Silt	0 to	1	0
4. Clay		5	0
3. Turf, with trees		0	6
2. Clay		6	0
1. Silt at bottom of pit			
		12	6

No. 87. Sheet 65.

Tilney St. Lawrence.

	ft.	in.
5. Silty clay	3	0
4. Peat	0	2
3. Strong blue clay	3	0
2. Peat	0	4
1. Blue sandy silt	3	0
	9	6

*** Fossils in bed 3. Wood in bed 2.

No. 88. Sheet 65.

Middle Level Outfall.

		ft.	in.
3. Silty clay - - - - - - - -		2	0
2. Peat - - - - - - - -		2	0
1. Strong blue clay - - - - -	seen to	4	0
		8	0

*** The clays are fossiliferous.

No. 89. Sheet 65.

Walpole St. Peter.

	ft.	in.
4. Clay - - - - - - - -	4	0
3. Peat - - - - - - - -	0	2
2. Clay - - - - - - - -	3	0
1. Blue silt at bottom of pit - - - - - -		
	7	2

No. 90. Sheet 65.

Emneth.

	ft.	in.
3. Clay - - - - - - - -	2	6
2. Peat - - - - - - - -	2	0
1. Clay and silt at bottom of pit - - - -		
	4	6

No. 91. Sheet 65.

Manea Fen.

		ft.	in.
3. Peat - - - - - -	4 ft. to	5	0
2. Clay - - - - - -	20 ft. to	21	0
1. Peat, with a creek intersecting it, oak and occasional yew said to occur - - - - - - -			
		25	0

*** The clay is fossiliferous.

No. 92. Sheet 65.

Murrow.

		ft.	in.
3. Red clay - - - - -	1 ft. 6 in. to	3	0
2. Peat - - - - -	3 in. to	0	9
1. Clay and silt, opened to - - - - -		15	0
	Say	17	0

*** Clay No. 1 is fossiliferous.

No. 93. Sheet 65.

Bishop Lands, near Murrow.

		ft.	in.
2. Peat - - - - - - - -		4	0
1. Gravel - - - - -	not bottomed	4	0
		8	0

*** This section is doubtful; clay probably intervenes between the two beds.

No. 94. Sheet 65.

Pear Tree Hill.

		ft.	in.
3. Clay	- - - - - - - -	2	0
2. Peat	- - - - - - - -	1	0
1. Clay	- - - - - - - -	2	0
		5	0

No. 95. Sheet 65.

Hutchinson's Brickyard, March.

East side—		ft.	in.
2. Silt, whitey grey	- - - - - - -	12	0
1. Kimeridge Clay	- - - - opened to	40	0
		52	0

West side—		ft.	in.
3. Gravel (now removed) in pockets	- - - 6 ft. to	20	0
2. Boulder clay, dark blue, with striated chalk, &c.	- -	6	0
1. Kimeridge Clay	- - - - - dug to	40	6
	Say	50	0

No. 96. Sheet 65.

White Lion Lane, March.

		ft.	in.
3. Gravel	- - - - - - - -	6	0
2. Yellow clay, with gravel stones, chalk and lias limestone, pebbles striated. This I take to be boulder clay, 4 ft. to		5	0
1. Kimeridge Clay as under:			
Yellow clay, with *O. deltoidea*	- - - - -	7	0
Layer of "clunch stones" (septaria)	- - - -	0	6
Blue clay	- - - - - - -	14	0
		32	6

*** I call this Kimeridge Clay because most of the fossils are of that age, but Oxford clay fossils are also found in it.

No. 97. Sheet 65.

Horse Moor, March.

		ft.	in.
3. Sand and clayey silt	- - - - - -	5	0
2. Black peat	- - - - - 2 ft. to	4	0
1. Clay	- - - - - - seen to	3	0
		12	0

No. 98. Sheet 65.

Tyd St. Giles.

		ft.	in.
5. Clay	- - - - - - - -	3	0
4. Peat	- - - - - - - -	0	2
3. Clay	- - - - - - - -	2	0
2. Peat	- - - - - - - -	0	3
1. Clay	- - - - - opened to	15	0
		20	5

No. 99. Sheet 65.

Downham Market.

(Bennet's Brickyard, S.E. of Railway Station.)

		ft.	in.
4. Soil, sandy		2	0
3. Ferruginous sandy bed, cemented into soft ironstone where long exposed	0 to	0	10
2. Siliceous sand and fine gravel	10 in. to	1	8
1. Kimeridge Clay, as under:			
Dark blue clay		30	0
"Stone floor" (septaria)		1	8
Dark blue clay			
		36	2

No. 100. Sheet 65.

Salter's Lode Sluice.

		ft.	in.
3. Clay	0 to	1	0
2. Peat	4 ft. to	6	0
1. Clay	seen to	1	0
	Say	7	0

No. 101. Sheet 65. Elstobb.

Salter's Lode Sluice (foundation).

		ft.	in.
5. Silt		10	0
4. Peat, firm		3	0
3. Bluish "gault" (clay) with roots			
2. Peat, very firm		3	0
1. Whitish clay			
	Say	25	0

No. 102. Sheet 65.

Nordelph Mill.

		ft.	in.
3. Peat		4	0
2. Light blue clay		3	0
1. Peat	seen to	1	0
		8	0

No. 103. Sheet 65.

Road from Stow Bridge to West Head, angle of road to Marshland Cut.

		ft.	in.
3. Silt		0	6
2. Peat, dug for fuel		2	0
1. Silty clay	seen to	2	0
		4	6

*** Bed 1 is fossiliferous.

No. 104. Sheet 65.

Black Bank Station.

		ft.	in.
4. Peaty soil	-	0	2
3. Mottled blue and brown clay, with flints	3 in. to	1	0
2. "Hoddy" peat	-	1	0
1. Dark brown peat	dug to	3	0
		5	0

*** Beds 1 and 2 are probably the result of cultivation.

No. 105. Sheet 65.

Littleport Plains.

South side—		ft.	in.
3. Peat	-	4	0
2. Gravel	0 to	2	0
1. Boulder clay	seen to	4	0
		10	0

North side—		ft.	in.
3. Silt	-	2	0
2. Peat	-	2	0
1. Boulder clay	seen to	4	0
		8	0

No. 106. Sheet 65.

Grub's Farm, north of Littleport.

(Drain intersecting a creek.)

		ft.	in.
3. Clay	-	3	0
2. Silt	-	1	0
1 Peat	seen to	2	0
		6	0

No. 107. Sheet 65. C. B. Rose.

Lynn.

(Mr. T. Allen's Well.)

		ft.	in.
8. Vegetable soil	-		
7. Loam [silt]	-	7	0
6. Peat	2 ft. to	2	6
5. Blue clay	-	8	0
4, Peat, with alder and hazel	2 ft. to	3	0
3. Blue clay, with marine silt and shells	about	30	0
2. Blue clay, with chalk stones	-	630	0
1. "Oxford," with septaria	-		
		680	6

*** This well was dug about the year 1835. The upper part certainly, and probably the whole of bed 1, is Kimeridge clay and not Oxford; bed 2 is Boulder clay.

No. 108. Sheet 65. Railway Boring.

Near Twenty-foot Drain, Warboys Fen.

	ft.	in.
7. Black peat - - - - - - -	5	0
6. Brown peat - - - - - - -	3	0
5. Light clay and peat - - - - - -	4	0
4. Sand and peat - - - - - - -	4	0
3. Blue sand - - - - - - -	1	0
2. Gravel and sand - - - - - - -	2	0
1. Hard gravel - - - - - - -	6	9
	24	9

No. 109. Sheet 65. Railway Boring.

780 yards north of Plow Puttock Drove, Warboys Fen.

	ft.	in.
5. Black peat - - - - - - -	6	0
4. Brown peat, with a deposit of wood - - -	6	0
3. Dark peat - - - - - - -	6	0
2. Sand - - - - - - - -	2	0
1. Hard gravel - - - - - - -	7	0
	27	0

No. 110. Sheet 65. Railway Boring.

North side of Forty-foot Drain, Benwick Parish.

	ft.	in.
7. Black peat - - - - - - -	4	0
6. Loam and peat - - - - - - -	2	0
5. Pale blue clay or "galt" - - - - - -	11	0
4. Light sand - - - - - - -	5	0
3. Blue clay - - - - - - - -	2	0
2. Sand and blue clay - - - - - -	1	0
1. Hard gravel - - - - - - -	4	0
	29	0

No. 111. Sheet 65. Railway Boring.

South Bank of River Nene, Benwick Parish, 5 *chains from Angle Bridge.*

	ft.	in.
7. Black loam - - - - - - -	3	0
6. Light blue galt - - - - - - -	15	0
5. Dark peat - - - - - - - -	2	0
4. Peat and decayed vegetable matter - - -	3	0
3. Black peat - - - - - - -	7	0
2. Sand - - - - - - - -	1	0
1. Gravel - - - - - - - -	4	0
	35	0

No. 112. Sheet 65. C. B. Rose.

Eaubrink Cut, Lynn.

	ft.	in.
6. Surface soil, brown clay, with sand - - -	4	0
5. Blue clay, with freshwater shells - - -	3	0
4. Peat, containing bones of ruminants - - -	2	2½
3. Blue clay like No. 5 - - - - - -	8	0
2. Peat, with alder and hazel bushes. The lower portions clay containing roots of marsh plants - - -	3	0
1. Dark blue clay, not cut through, a marine silt - -		
	20	2½

No. 113. Sheet 65. Rev. E. Trollope.

Sutton St. Edmund's Parish.

		ft.	in
3. Peat	- - - - - - - -		
2. Silty clay	- - - - - - - -	2	0
1. Peat	- - - - - - - -	0	0
	Say -	8	0

No. 114. Sheet 65.

Junction of Popham's Eau and Middle Level Drain.

		ft.	in.
1. Sandy warp and clay	- - - - to -	15	0

No. 114 A. Sheet 65.

Popham's Eau, a hundred yards east of above.

		ft.	in.
4. Warp	- - - - - - - -	5	0
3. Peat, black and carbonised	- - 6 in. to -	1	0
2. Warp	- - - - - - -	4	0
1. Clay	- - - - - - -	2	0
		12	0

No. 115. Sheet 65.

Popham's Eau, fifty yards east of above.

		ft.	in.
6. Laminated warp	- - - - - - -	5	0
5. Peat, mixed with clay	- - - - - -	0	4
4. Laminated warp	- - - - - - -	4	0
3. Clay	- - - - - - - -	3	0
2. Peat, pure and black	- - - - - -	1	6
1. Clay	- - - - - seen to -	1	0
		14	10

No. 116. Sheet 65.

Popham's Eau, sixty yards east of above.

		ft.	in.
9. Clay	- - - - - - - -	2	0
8. Warp	- - - - - - - -	1	0
7. Peat, mixed with clay	- - - - - -	0	3
6. Warp	- - - - - - - -	4	0
5. Peat, mixed with clay	- - - - - -	0	3
4. Warp	- - - - - - - -	3	0
3. Clay	- - - - - - - -	1	0
2. Peat, pure and black	- - - - - -	1	6
1. Clay	- - - - - seen to -	1	0
		14	0

No. 117. Sheet 65.

Popham's Eau, fifty yards east of above.

		ft.	in.
8. Warp	- - - - - - - -	0	9
7. Peaty clay	- - - - - traces to -	0	3
6. Clay	- - - - - - - -	2	0
5. Warp	- - - - - - - -	2	0
4. Peaty clay	- - - - - - -	0	6
3. Warp	- - - - - - - -	5	0
2. Peat, pure and black	- - - - - -	1	6
1. Clay	- - - - - seen to -	2	0
		14	0

No. 118. Sheet 65.
Modney Bridge, Hilgay.

		ft.	in.
3. Soil		1	0
2. Sand in pockets	0 to	2	0
1. Clay (boulder)	seen to	12	0
		14	0

No. 119. Sheet 65. C. B. Rose.
Denver Sluice.

	ft.	in.
7. A light brown sandy loam [warp]	14	0
6. Peat	2	0
5. Blue clay, including roots and small portions of peat	2	0
4. Peat, similar to No. 6	3	0
3. Similar to No. 7, but somewhat more argillaceous*	2	0
2. Dark ferruginous sand	3	0
1. Oxford Clay, dark blue, and very tenacious	5	6
	31	6

* "Immediately beneath the peat, on the surface of No. 3, a farthing of Charles II. and a pair of scissors were found." [These afford no proof of the modernness of the deposits, as they were evidently lost by the early drainers.—S.B.J.S.]

No. 120. Sheet 65. C. B. Rose.
East Winch.

		ft.	in.
3. Sand and loam		7	0
2. Light-coloured argillaceous earth		6	0
1. Blue clay (Nar beds)	opened to	10	0
		23	0

No. 121. Sheet 65. C. B. Rose.
West Bilney.

		ft.	in.
4. Soil			
3. Silt	4 ft. to	5	0
2. Peat, with roots		1	0
1. Brick-earth (Nar beds)			
		6	0

No. 122. Sheet 65. C. B. Rose.
Bilney Hall.

		ft.	in.
3. Sandy ochreous loam, with flints		1	0
2. Grey sandy loam		2	0
1. Blue argillaceous earth (Nar beds)	to	4	0
		7	0

No. 123. Sheet 65. C. B. Rose.
Tottenhill Brickfield.

		ft.	in.
3. Soil, with rounded and angular flints	3 ft. to	6	0
2. Blue brick-earth, with oysters and wood		12	0
1. Lower Greensand			
		18	0

No. 124. Sheet 65. F. W. Harmer.

4 miles west of Chatteris.

		ft.	in.
3. Peat, with oaks and willow roots at base, sticking into	-	6	0
2. Clay - - - - - - -	-	1	6
1. Reddish sand - - - - -	- dug to	3	0
		10	6

No. 125. Sheet 69. W. H. Wheeler.

Skirbeck Quarter, Boston.

		ft.	in.
1. Silty clay - - - -	down to	5	6
2. Blue clay, just touched - - -	- ditto -	7	6
3. Ditto about 9 inches - -	- ditto -	9	0
4. Silty clay - - - - - -	·ditto -	11	8
5. Ditto - - - - - -	- ditto -	14	3
Ditto - - - - - -	- ditto -	15	0
6. Soft buttery clay, more moist - -	- ditto -	17	10
Silty clay - - - - -	- ditto -	18	3
7. Peat, sandy at bottom - - -	- ditto -	19	7
8. Sharp sand, especially last 4 inches -	- ditto -	20	4
9. Sharp sand, greyish yellow, 8 inches thick; water rose - - - - -	- ditto -	21	3
10. Sharp sand - - - - -	- ditto -	22	2
11. Sand, clay, and small stones - -	- ditto -	22	8
12. Sharp sand - - - - -	- ditto -	25	6
Clay, with chalk stones just touched -	- ditto -	25	10

*** The top of this boring is 21·9 feet above low water in Boston Deeps. The section is continuous as given; generalised it is as under:—

	ft.	in.
4. Clay and silt - - - - - - -	18	3
3. Peat - - - - - - - -	1	4
2. Sand - - - - - - - -	6	3
1. Boulder clay - - - - - - -		
	25	10

No. 126. Sheet 69. W. H. Wheeler.

(*Nearer the road than the above.*)

		ft.	in.
4. Clay and silt - - - - - -	-	17	9
3. Peat - - - - - - -	-	1	6
2. Sand - - - - - - -	-	4	9
1. Boulder clay, - - - -	pierced to	0	6
		24	6

No. 127. Sheet 69.

Baptist Cemetery Lane, Boston.

	ft.	in.
4. Blue clay - - - - - - -	11	0
3. Peat - - - - - - - -	1	0
2. Gravel and sand - - - - - - -	3	0
1. Boulder clay, at bottom of pit - - - -		
	15	0

No. 128. Sheet 69.

Wyberton Chain Bridge, Boston.

		ft.	in.
5. Silt	0 to	3	0
4. Clay	8 ft. to	11	0
3. Peat		0	8
2. Sand and gravel	2 ft. 6 in. to	3	0
1. Boulder clay	dug into	3	0
		20	8

No. 129. Sheet 69.

Kirton Road, Wyberton, near Boston.

		ft.	in.
5. Silt		4	0
4. Clay		11	0
3. Peat	3 in. to	1	6
2. Clay and gravel, mixed		1	0
1. Boulder clay	at		
		18	0

*** The peat is sometimes wanting, and a bed of sand 1 ft. 6 in. takes its place.

No. 130. Sheet 69.

200 *yards south of above.*

		ft.	in.
4. Soil and silt		3	0
3. Clay, "turfy below"		11	0
2. Peat		1	0
1. Sand, not pierced	dug to	3	0
		18	0

No. 131. Sheet 69.

High Bridge Drain, near Boston.

		ft.	in.
East side—			
4. Silt		13	0
3. Peat, with tree roots	1 ft. to	1	6
2. Sand and gravel	6 in. to	6	0
1. Boulder clay (white sandy clay, with chalk stones)			
West side—			
4. Clay		13	0
3. Peat	1 ft. to	1	6
2. Sand and gravel	6 in. to	6	0
1. Boulder clay, as above			
		21	0

*** Note particularly the change from silt to clay.

No. 132. Sheet 69.

Sibsey (highland).

		ft.	in.
2. Boulder clay		31	0
1. Sand vein, water bearing	dug to	2	0
		33	0

No. 133. Sheet 69.

Cow Bridge, near Boston.

		ft.	in.
5. Clay	-	4	0
4. Silty clay	-	3	0
3. Clay, blue	-	6	0
2. Peat	-	0	6
1. Sand at bottom of pit	-		
		13	6

No. 134. Sheet 69.

Stickney.

		ft.	in.
5. Clayey silt	-	4	0
4. Peat, with trees	0 to	0	6
3. White siliceous sand	-	2	0
2. Dark gravel, mixed with clay and sand	-	6	0
1. Kimeridge Clay as under :—			
Dark blue clay	-	32	0
Very large septaria	-	2	0
Dark blue clay	-		
		47	0

No. 135. Sheet 69.

Fleet Low Gate, near Holbech.

		ft.	in.
East side—			
2. Silt and clay	-	8	0
1. "Sea sand"	-		
West side—			
2. Silt and clay	-	16	0
1. "Sea sand"	-		
		16	0

No. 136. Sheet 69.

Gedney.

		ft.	in.
3. Silt	6 in. to	1	0
2. Clay	-	6	0
1. "Clunch" silt, or fine sand	-		
		7	0

No. 137. Sheet 69.

Holbech. South end of town.

		ft.	in.
4. Red clay	-	3	0
3. Blue clay	3 ft. to	4	0
2. Peat	-	1	0
1. Silt, full of water	pierced to	2	0
		10	0

No. 138. Sheet 69.

Eight-sailed Mill, Holbech.

		ft.	in.
4.	Soil	2	0
3.	Silt	3	0
2.	Sand	6	0
1.	Clay, with shells, full of salt water	19	0
		30	0

*** Occasionally beds of peat are said to be met with in sinking wells in Holbech. I have not seen such a section.

No. 139. Sheet 69. T. Brailford.

Black Sluice, Boston.

		ft.	in.
5.	Warp of reddish brown clay	12	0
4.	Warp of blue clay	5	0
3.	Peat - 1 ft. to	1	6
2.	Sand (Woburn sand) - a few inches, say	0	6
1.	Kimmeridge Clay, containing chalk, gryphites, bullita, incurvata, &c.	7	0
		25	0

* This section is by a "geologist," the author of a sketch of the geology of the fens in Thompson's History of Boston. His Woburn sand is, of course ordinary fen sand, and the Kimmeridge Clay is ordinary Boulder clay.

No. 140. Sheet 69.

Holbeck Clough.

		ft.	in.
1.	Soil	2	0
2.	Silt	3	0
3.	Sandy silt, with cockles - to	2	0
		7	0

No. 141. Sheet 69. Partridge.

Boston (1746).

		ft.	in.
5.	Sand	3	0
4.	Made earth (old surface)	5	0
3.	Stones and gravel	3	0
2.	Clay	5	0
1.	Stones, rubble, sort of chalk	3	0
	Clay with very small handstones not pierced	173	0
		192	0

*** This curious specimen of a well-section is quoted by Thompson from the MS. of the Spalding Gentleman's Society. It is as unlike a faithful record as certain other historical data.

No. 142. Sheet 69. Thomson. Hist. Bost.

Market Place, Boston (1828).

Date.		Daily Progress.		Total Depth.		Strata.
		ft.	in.	ft.	in.	
May	3	12	0	12	0	Loose earth.
„	5	12	0	24	0	„ „ mixed with silt.
„	6	12	0	36	0	Very hard earth, mixed with stone.
„	7	4	0	40	0	Very strong, mixed with clay.
„	8	10	0	50	0	The same.
„	9	45	0	95	0	Clay and shells.
„	10	15	0	110	0	Dark clay and large flints.
„	12	20	0	130	0	The same.
„	13	20	0	150	0	Clay, stones, and shells.
„	14	4	0	154	0	Clay and large stones.
„	15	12	0	166	0	The same.
„	16	13	0	179	0	Very dark clay and stones.
„	17	11	0	190	0	Clay and stones.
„	19	28	0	218	0	Very dark clay and shells.
„	20	22	0	240	0	The same.
„	21	30	0	270	0	The same.
„	22	30	0	300	0	The same.
„	23	28	0	328	0	Dark clay.
„	24	22	0	350	0	Light slate-coloured clay, with large shells.
„	26	22	0	372	0	Dark clay and shells.
„	28	20	0	415	0	The same.
„	29	20	0	435	0	Dark clay.
„	30	18	0	453	0	The same.
„	31	17	0	470	0	Clay, with great quantity of shells.
June	2	10	0	480	0	The same.
„	3	2	0	482	0	The same.
„	4	2	0	484	0	The same.
„	5	2	0	486	0	Shells, shingle, dark clay, and sharp sand.
„	6	3	0	489	0	Remarkably fine sharp sand.
„	7	9	0	498	0	Ditto and dark clay.
„	9	7	0	505	0	Clay and very large shells.
„	10	1	0	506	0	Shingle, flints, and shells.
„	11	0	4	506	4	The same.
„	12	1	1	507	5	The same.
„	13	1	0	508	5	The same.
„	14	0	6	508	11	Rock. "It is supposed possible that some
„	16	0	7	509	6	The same. hard substance may have fallen in,
„	17	0	6	510	0	The same. causing the appearance of 'rock' at
„	18	0	6	510	6	The same. these depths."—MESSRS. TUXFORD.
„	19	7	0	517	6	Stones, mixed with clay.
„	20	5	4	522	10	The same.
„	21	7	0	529	10	Clay, shells, and flint.
July	30	18	2	548	0	Stone, shells, and rock.
„	31	7	0	555	0	Very dark clay.
Aug.	1	6	0	561	0	Very fine white sand.
„	2	5	0	566	0	The same.
„	3	6	0	572	0	A dark umber-like earth, soft and hard by turns.

This section generalised is as follows :—

	Bed		Group		ft.	in.	
1.	Fen beds	-	Post glacial	about	24	0	
10.	Clay and stones	-		,,	26	0	
19.	Clay and shells	-		,,	45	0	
18.	Clay and flints	-		,,	35	0	
17.	Clay, stones, and shells	-		,,	20	0	
16.	Clay and shells	-	Glacial beds	,,	110	0	
15.	Dark clay	-		,,	28	0	
14.	Clay and shells	-		,,	87	0	
13.	Dark clay	-		,,	38	0	529
12.	Clay and shells	-		,,	31	0	
11.	Shells, shingle, and sand	-		,,	2	0	
10.	Fine sand and dark clay	-		,,	12	0	
9.	Clay and shells	-		,,	7	0	
8.	Shingle, flints, and shells	-		,,	3	0	
7.	Rock	-		,,	2	0	
6.	Clay and stones	-	Pre- or inter- glacial beds	,,	12	0	
5.	Clay, shells, and flint	-		,,	7	0	
4.	Stone, shells, and rock	-		,,	18	0	
3.	Dark clay	-		,,	7	0	
2.	White sand	-		,,	11	0	
1.	" Umber-like earth "	-		,,	6	0	
					572	0	

No. 143. Sheet 69. S. F. Baker & Sons.

Coast Guard Station, Fossdyke, 1875.

		ft.	in.
5.	Depth of well at commencement of boring, partly in sand and gravel	21	0
4.	Sand and gravel	57	0
3.	Yellow sandy clay	37	0
2.	Boulder clay, light-blue, with chalk stones	51	6
1.	Dark clay (Kimeridge), with septarian bands, bored to	159	6
		326	0

No. 144. Sheet 69. W. H. Wheeler, C.E.

Sutton.

		ft.	in.
5.	Clayey warp	16	0
4.	Moor or peat - 3 ft. to	4	0
3.	" Soft moor, mixed with shells and silt " *	20	0
2.	Clay mixed with chalk stones	95	0
1.	Gravel		
		135	0

* The peat cannot be 20 feet thick. There are probably several thin beds intercalated in the marine series.

No. 145. Sheet 69. W. H. Wheeler, C.E.

Grand Sluice, Boston.

		ft.	in.
2.	Roots of trees " standing as they had grown " - at	18	0
1.	Shells similar " to those found in creeks ;" most probably *Scrobicularia piperata*, about the same depth		
		18	0

No. 146. Sheet 69. W. H. Wheeler, C.E.

Lade Bank Engines, East Fen.

		ft.	in.
5. Clay	-	4	0
4. Peat	-	0	6
3. Soft blue clay	-	3	0
2. Peat, with pieces of trees	-		
1. Hard clay, with chalk stones (Boulder clay)	to	30	0
		30	0

No. 147. Sheet 70. S.E.I.S.

Brickyard north of Spalding.

		ft.	in.
4. Silt	5 ft. to	6	0
2. Silty clay	7 ft. to	8	0
2. Peaty clay	4 ft. to	5	0
1. Clay, light blue "buttery"	about	1	6
		28	6

No. 148. Sheet 70.

Close to above, Spalding.

	ft.	in.
6. Soil	1	0
5. Silt	1	0
4. Clay	1	0
3. Silty clay	6	0
2. Blue clay	4	0
1. Peaty clay, at bottom of pit		
	13	0

No. 149. Sheet 70.

Spreckley's Farm, 2 miles east of Bourn.

		ft.	in.
2. Peat	1 ft. 6 in. to	2	0
1. Peaty clay, not pierced	-	4	0
		6	0

No. 150. Sheet 70.

Between Dunsby and Dowsby.

	ft.	in.
1. Gravel dug to a depth of	7	0

No. 151. Sheet 70.

Lane Dyke.

		ft.	in.
3. Clayey soil	-	1	6
2. Sandy gravel	-	4	0
1. Kelaways beds	seen to	2	0
		7	6

No. 152. Sheet 70.

Counter Drain Station.

		ft.	in.
2. Peat	-	1	0
1. Silt	-	3	0
		4	0

No. 153. Sheet 70.

Hoe Hills, Millthorp.

		ft.	in.
1. Gravel dug to a depth of	-	6	0

No. 154. Sheet 70.

Bicker.

		ft.	in.
2. Clay and silt (no peat)	-	13	0
1. Boulder clay	dug to	4	6
		17	6

*** In some of the wells all the fen beds are silt, in others all clay. The water is mostly brackish.

No. 155. Sheet 70.

Quadring.

		ft.	in.
4. Sandy silt	2 ft. to	4	0
3. Red clay	3 ft. to	4	0
2. Blue clay	9 ft. to	10	0
1. Peaty clay, with shells	-	0	0
	Say	16	0

No. 156. Sheet 70.

Gosberton.

		ft.	in.
2. Sandy silt	-	2	0
1. Clay	-	10	0
		12	0

No. 157. Sheet 70.

Bicker Fen Drove, half a mile west of Old Hammond Beck.

		ft.	in.
4. Soil	-	0	6
3. Light-blue clay	-	1	0
2. Sandy silt	-	2	0
1. Stiff blue clay, not pierced	-	4	0
		7	6

No. 158. Sheet 70.

Half a mile S.W. from Hoflet.

		ft.	in.
1. Sandy silt dug into	-	10	0

No. 159. Sheet 70.

Between Sutterton and Wigtoft.

	ft.	in.
4. Red clay - - - - - - - -	5	0
3. Sandy silt - - - - - - - -	0	2
2. Light-blue clay - - - - - - -	15	0
1. Peaty clay, with shells - - - - - -		
	20	2

No. 160. Sheet 70.

Donington.

	ft.	in.
4. Blue clay - - - - - - - -	13	0
3. Peaty clay - - - - - - -	0	9
2. Blue clay - - - - - - -	2	0
1. Boulder clay (?) (Yellow clay full of chalk stone.) -		
	15	9

No. 161. Sheet 70.

Syke Mouth.

South side—	ft.	in.
3. Soil - - - - - - - -	1	0
2. Clay - - - - - - - -	10	0
1. Peaty clay, at bottom of pit - - - -		
	11	0

North side—	ft.	in.
4. Soil - - - - - - - -	1	0
3. Clay - - - - - - - -	1	0
2. Silt - - - - - - - -	10	0
1. Peaty clay - - - - - - - dug to	6	0
	18	0

No. 162. Sheet 70.

Blotoft Farm.

	ft.	in.
5. Soil - - - - - - - -	1	0
4. Silt - - - - - - - -	4	0
3. Coarse sand - - - - - - -	0	3
2. Fine gravel - - - - - - -	0	3
1. Boulder clay - - - - - dug to	4	0
	9	6

No. 163. Sheet 70.

Horbling Fen Farm.

	ft.	in.
3. Peaty soil - - - - - - -	1	6
2. Clay, blue and laminated (Oxford Clay) - - -	59	0
1. " Rock bed," septaria course do. - - -	1	3
	61	9

*** It is probable that some Boulder clay overlaid the Oxford Clay.

No. 164. Sheet 70.

Farm at letter N. of North Drove in Quadring Low Fen.

		ft.	in.
4. Peat	- - - - - - - -	0	6
3. Clay	- - - - - - - -	23	0
2. Peat	- - - - - - - -	1	6
1. Gravel	- - - - - - - -		
		25	0

No. 165. Sheet 70.

Swaton.

		ft.	in.
1. Gravel, dug to a depth of	- - - - -	6	0

No. 166. Sheet 70.

Pennygate, between Spalding and Pinchbeck.

		ft.	in.
4. Silt	- - - - - 3 ft. to	5	0
3. Clay, with creeks of silt	- - - - - -	6	0
2. Clay and silt	- - - - - -	2	0
1. Peaty clay, very fetid	- - - - - -		
		13	0

No. 167. Sheet 70.

Pinchbeck Bars.

East side—

		ft.	in.
4. Silt	- - - - - - - -	2	0
3. Peat and blue clay	- - - - - -	0	3
2. Clay, with a few vegetable remains and shells	- -	13	0
1. Peaty clay, shells and leaves at bottom	- - -		
		15	3

West side—

		ft.	in.
4. Silt	- - - - - - - -	2	0
3. Peat and blue clay	- - - - - -	0	3
2. Silt	- - - - - - - -	7	0
1. Clay	- - - - - - - -	4	0
		13	3

No. 168. Sheet 70.

Pode Hole (closed 1856).

		ft.	in.
6. Soil	- - - - - - - -	1	0
5. Silt	- - - - - - 2 ft. to	10	0
4. Clay	- - - - - - 2 ft. to	13	0
3. Peaty clay	- - - - - - -	1	6
2. Blue clay	- - - - - - - -	2	0
1. Gravel and yellow clay at bottom	- - - -		
		27	6

No. 169. Sheet 70.

Deeping Fen.

		ft.	in.
4. Silt	- - - - - - - -	1	0
3. Peat	- - - - - - - -	0	6
2. Clay	- - - - - - - -	2	0
1. Silt	- - - - - - seen to	1	0
		4	6

No. 170. Sheet 70.

Deeping St. Nicholas.

		ft.	in.
3.	Peat	1	0
2.	Silt and clay	19	0
1.	Peaty clay		
		20	0

*** The bottom bed was described as "full of shells, crab's claes, stumps of trees, turf, and clay." In a well close by, at 30 feet, "quick" silt was reached.

No. 171. Sheet 70.

Spalding Common.

		ft.	in.
4.	Silt	2	6
3.	Blue clay, with a few traces of vegetable matter	9	6
2.	Peat intermixed with clay	1	0
1.	Clay, as above, not pierced	12	0
		25	0

No. 172. Sheet 70.

Bunker's Hill.

			ft.	in.
2.	Sandy gravel	6 in. to	3	0
1.	Boulder clay	dug to	16	0
			19	0

No. 173. Sheet 70.

Bunker's Hill, north of Windmill.

			ft.	in.
3.	Silty clay		4	0
2.	Peat		0	6
1.	White sand	seen to	1	0
			5	6

No. 174. Sheet 70.

Dogdyke

		ft.	in.
5.	Peat	1	0
4.	Clay	6	0
3.	Silt	3	0
2.	Peat	2	6
1.	Gravel	10	0
		22	6

No. 175. Sheet 70.

Bettinson's Brickyard. Howbridge Drain.

			ft.	in.
5.	Soil		0	6
4.	Silt	0 o	6	0
3.	Clay	0 o	6	0
2.	Peat		0	6
1.	Boulder clay			
			7	0

No. 176. Sheet 70.

Bettinson's Bridge. Howbridge Drain.

		ft.	in.
3. Gravel	- - - - - - -	5	0
2. Peat	- - - - - - -	0	6
1. Boulder clay	- - - - - -		
		5	6

No. 177. Sheet 70.

Half a mile south of junction of roads at Dogdyke.

		ft.	in.
4. Soil	- - - - - - -	0	2
3. Silty clay	- - - - - - -	1	6
2. Peat	- - - - - - -	0	4
1. Sand	- - - - - not pierced -	3	0
		5	0

No. 178. Sheet 70.

Long Dyke, quarter of a mile south of Cowbridge Drain.

		ft.	in.
3. Clayey silt	- - - - - - -	4	0
2. Sandy silt	- - - - - - -	1	0
1. Gravel	- - - - - -	3	0
		8	0

No. 179. Sheet 70.

Close to bridge of Coping Syke Drove over Long Dyke.

		ft.	in.
2. Peat	- - - - - - -	0	6
1. Gravel and sand	- - - - seen to	5	0
		5	6

No. 180. Sheet 70.

Twelve's Brickyard. Billinghay Dales.

		ft.	in.
3. Peaty soil	- - - - - - -	0	6
2. Clay and silt	- - - - - -	14	0
1. Quicksand full of shells	- - - - -	0	0
		14	6

No. 181. Sheet 70.

Billinghay.

		ft.	in.
3. Peat	- - - - - - -	1	0
2. Clay	- - - - - - -	4	0
1. Sand	- - - - - - -		
		5	0

No. 182. Sheet 70.

Walcott Drove.

(Junction of road east of Cardyke.)

		ft.	in.
4. Peat	- - - - - - -	1	0
3. Silty clay	- - - - - - -	1	0
2. Gravelly sand	- - - - - -	1	0
1. Boulder clay	- - - - - -		
		3	0

No. 183. Sheet 70.

Toft Hill.

		ft.	in.
2. Gravel and sand		10	0
1. Boulder clay			
		10	0

No. 184. Sheet 70.

Noman's Friend. New York.

		ft.	in.
2. Sandy gravel		3	0
1. Boulder clay	seen to	6	0
		9	0

No. 185. Sheet 70.

Bunker's Hill.

		ft.	in.
4. Peaty soil		1	0
3. Clay and silt	0 to	10	0
2. Gravel	10 ft. to	15	0
1. Boulder clay	seen to	10	0
		36	0

No. 186. Sheet 70.

Thorpe Tilney.

		ft.	in.
1. Gravel dug to a depth of		5	0

No. 187. Sheet 70.

Digby Dam.

		ft.	in.
3. Peat, dug for fuel		1	0
2. Clay		0	3
1. Silt	seen to	4	0
		5	3

No. 188. Sheet 70.

North Kyme Causeway.

		ft.	in.
1. Gravel dug to, but probably much thicker than		6	0

No. 189. Sheet 70.

Willow Bank. Kyme Low Ground.

		ft.	in.
3. Peat		0	6
2. Clay		1	6
1. Sand	seen to	2	0
		4	0

No. 190. Sheet 70.

Kyme Vacherie.

		ft.	in.
2. Sand		3	0
1. Boulder clay	dug to	50	0
		53	0

No. 191. Sheet 70.

Digby Grange.

		ft.	in.
3. Peat, decomposed		1	0
2. Sand and fine gravel		1	6
1. Clay	seen to	1	0
		3	6

No. 192. Sheet 70.

South Kyme Low Engine.

		ft.	in.
3. Gravel		4	0
2. Boulder clay	about	20	0
1. Oxford Clay	to	16	0
		40	0

No. 193. Sheet 70.

Half-a-mile east of Heckington.

		ft.	in.
3. Gravelly soil		2	0
2. Gravel	0 to	2	0
1. Boulder clay			
	Say	3	0

No. 194. Sheet 70.

Star Fen.

	ft.	in.
4. Peat	0	6
3. Clay	4	0
2. Peat, with trees and shells	0	6
1. Gravel	4	0
	9	0

No. 195. Sheet 70.

Six Hundreds near Heckington.

	ft.	in.
2. Silt and clay	10	0
1. Gravel		
	10	0

No. 196. Sheet 70.

Winkhill.

	ft.	in.
1. Gravel seen to a depth of	5	0

No. 197. Sheet 70.

Waith Common.

	ft.	in.
3. Peat, decomposed	1	0
2. Clay	0	2
1. Sand and gravel	3	0
	4	2

No. 198. Sheet 70. Dr. Cammack.

Great Northern Railway.

		ft.	in.
Crossing at South Drove Drain, gravel reached at	- -	12	0
Four miles further north „ „	- -	30	0

No. 199. Sheet 70.

Farm one quarter mile south of Counter Drain Station.

		ft.	in.
3. Peat	- - - - - - - about	1	0
2. Silt	- - - - - - - -	10	0
1. Gravel	- - - - - - - -		
		11	0

No. 200. Sheet 70. Dr. Cammack.

Well at Mr. Stubbs's, Market Place, Spalding.

		ft.	in.
5. Cellar, from level of street	- - - -	6	2
4. Silt	- - - - - -	2	6
3. Peat	- - - - - -	3	6
2. Clay	- - - - - - -	3	10
1. Silt	- - - - - - -	2	0
		18	0

No. 201. Sheet 83.

Mareham-le-Fen.

		ft.	in.
Gravel seem to a depth of	- - - - - -	4	0

No. 202. Sheet 70.

Rush Close.

		ft.	in.
3. Sand and gravel	- - - - - - -	4	0
2. White clay	- - - - - - -	3	0
1. Boulder clay	- - - - - - -	9	0
		16	0

No. 203. Sheet 83.

Kirkstead.

		ft.	in.
2. Gravelly sand	- - - - - 3 ft. to	5	0
1. Boulder clay	- - - - · seen to	12	0
		17	0

No. 204. Sheet 83.

Woodhall Spa.

		ft.	in.
3: Gravel	- - - - - - - -	3	0
2. Boulder clay	- - - - - - ?	10	0
1. Kimmeridge Clay	- - - - seen to	20	0
		33	0

No. 205. Sheet 84.

Thorpe Culpit.

		ft.	in.
3. Silty clay		5	0
2. Peat		0	6
1. Boulder clay	dug to	37	0
		42	6

No. 206. Sheet 84.

Irby.

	ft.	in.
6. Clay	4	0
5. Peat, with trees	3	0
4. Clay	2	6
3. Sand	1	0
2. Marly clay	12	0
1. Sand	2	0
	24	6

*** Nos. 1 and 2 *may* belong to the Boulder clay.

No. 207. Sheet 84.

Thorpe Culpit.

		ft.	in.
2. Clay and silt		5	0
1. Peat, intersected by creeks	2 ft. 6 in. to	6	0
		11	0

No. 208. Sheet 84.

Thorpe Culvert Station.

	ft.	in.
6. Silty clay	8	0
5. Peat, with trees	2	0
4. Clay	9	0
3. Peat and clay	0	3
2. Marly clay	.6	0
1. Sand and gravel	0	0
	25	3

*** Beds 1 and 2 *may* belong to the Boulder clay.

No. 209. Sheet 84.

Hubbard Hill.

		ft.	in.
3. Clay	6 ft. to	7	0
2. Marly silt	3 ft. to	4	0
1. Sand and stones	10 ft. to	12	0
	Say	20	0

No. 210. Sheet 84.

Thorp Fen Dyke.

		ft.	in.
5.	Soil	3	0
4.	Clay	4	0
3.	Peat, full of wood	3	0
2.	Clay, "clean"	30	0
1.	Sand, full of water		
		40	0

No. 211. Sheet 84.

New Bolingbroke.

			ft.	in.
2.	Gravel		4	0
1.	Kimmeridge Clay	dug to	16	0
			20	0

APPENDIX D.

List of Inundations.

F. *Fresh water.* **S.** *Sea water.*

Lincolnshire.

1257. **S.** Holland drowned; bursting of sea banks.
1242. **F.** Fens near Stickney drowned; land flood. ("Corpse" drowned, see p. .)
1277. **F.** Swanston and Dunnington, fens near, drowned; neglected sewers.
1278. **F.** Haut Huntre fen drowned; same cause.
1285. **F.** Boston and vicinity drowned; "great inundation;" neglected banks and dykes.
1286. **S.** Lincolnshire coast drowned; broken sea banks.
1292. **S. F.** Gosberkirk fens drowned; neglected sea banks and dykes.
1315. **F.** Kesteven fens drowned; neglected dykes.
1322. **S.** No localities given (Lincolnshire); sea banks broken.
1357-8. **S.** Gosberkirk and Surfleet drowned by "an arm of the sea;" that is, the Welland estuary.
1395. **F.** East and West fens, and fens by Leake, Wrangle, Friskeneye, and Waynflete drowned; neglected outfall.
1457. **F.** Dowsdale drowned; neglect of clough.
1574. **F.** Lindsey Level much drowned about this time.

Marshland.

1287. **S.** Tilney cum Islington drowned; sea banks burst by "raging sea."
1289. **F.** Marshland drowned; floods burst dyke banks.
1292. **S. F.** Marshland drowned; banks wilfully broken.
1294. **S. F.** ,, still drowned.
1295. **S. F.** ,, ,, ,,
1257. **F. S.** Marshland drowned; neglected sea banks and drains.
1334-5. **S. F.** Tilney cum Islington drowned; land floods and broken sea banks; great tempests

1335–6. **S. F.** **Marshland drowned; sea banks broken by heavy sea.**

Details—Wigenhale, 10 messuages and 100 acres, and other lands. **S.**
Walpole, 140 acres "for ever lost." **S.**
Walsokne, fresh-water floods. **F.**
Tilney, 7 messuages and 10 acres "for ever lost." **S.**
Torington, 1,000 acres. **F.**
West Walton, 120 acres. **S.**
Enemeth, 10 messuages and 100 acres. **S.**
Total, over 1,470 acres drowned.

1348–9. **S. F.** Wigenhale drowned; broken sea and dyke banks.
1378. **S. F.** Marshland frequently drowned by R. Ouse.
1422. **S. F.** Marshland drowned; land and sea floods.
1520. **S. F.** Marshland drowned; banks wilfully broken.
1569. **S.** Marshland (all), with town of Wigenhale, drowned; broken sea banks.
1607. **S.** Clenchwarton drowned: high tide.
1613. **S.** Nov. 1. "Late in the night the sea broke in, through the violence of a north-east wind meeting with a spring tide, and overflowed all Marshland, with this town of Wisbeche, both on the north side and on the south, and almost the whole hundred round about." Estimated damage, 37,862*l.*
1614. **F.** Marshland drowned; snows and resulting floods.
1618. **S.** Marshland drowned; sea flood from Ouse.
1270. **S. F.** Wirmegay, &c., drowned, 700 acres; sea and land floods.
1276. **S** Wirmegay, &c. drowned, 2,000 acres; sea flood.

Bedford Level.

1236. **S.** Wisbech drowned; high winds.
1253. **S.** Wisbech drowned; defect of banks.
1274. **F.** Wisbech, &c., drowned; neglect of banks, &c.
1290. **S.** Wisbech, &c., drowned; north-east winds and spring tide.
1328–9. **F.** Borough and Thorney fen drowned; freshwater floods, owing to clow at Utwell stopping well creek.
1330–1. **F.** Holland fen drowned; 60,000 acres of "moor and marish ground."
Crouland fen drowned, 2,000 acres.
Deping, Burgh, and Spalding fens drowned, 7,000 acres.
Kesteven fens drowned.
Fen drowned from Fen Drayton and Benwick to Outwell.
Fens from St. Neots to Benwick drowned.
North, Tanholt, and adjacent fens drowned.
All said to be the effect of the erection of Outwell dam in 1300.
1391. **S. F.** Elme drowned; storms and floods.
1580. **F.** Ladwers Common, Elme, drowned; defective banks.
1611. **S.** Dam below Stow bridge, broken by night tide, October 8.
1617–18. **F.** Much land drowned by heavy rains.

APPENDIX E.

HEIGHTS OF POINTS IN THE FENLAND, FROM THE ORDNANCE SURVEY OF ENGLAND.

The *datum level* for Great Britain is the mean tide-level at Liverpool ·8 inch above the level obtained from the self-registering tide gauge at that place. Add 0·068 ft. to obtain *actual* mean tide at Liverpool. Heights are given in feet above Ordnance mean tide-level.

The port of reference for the Fenland Coast is Hull, at which port the mean tide-level is ·038 ft. above that at Liverpool.

The first column gives the number of the B. M, in the Ordnance Report; the second the position of the B. M.; the third the height of the mark above or below the surface of the ground: and the fourth the uncorrected height of the B. M. above Datum. To obtain the actual height of the ground at any B. M. the figures in the third column must be subtracted from those in the fourth column where they are plus, and added where they are minus.

No. of Bench Mark.	*Position.*	Relation to Surface.	Altitude above Datum.
	Swaffham to King's Lynn.	Feet.	Feet.
621	Swaffham Church Tower - - - -	1·87	238·616
639	Narborough Church Tower - - -	3·17	53·234
643	8 Milestone from Lynn - - - -	1·27	34·794
646	West Bilney Church Tower - - -	2·88	54·378
650	East Winch Church Tower - - - -	3·30	73·780
653	4 Milestone from Lynn - - - -	0·98	140·943
655	Middleton Church Tower - - - -	3·60	117·905
664	South Gates, Lynn - - - -	2·15	20·327
	North Runcton Church Tower - - -	1·63	27·540
	Lynn Old Tower - - - - -	1·95	16·199
	West Lynn Church Tower - - - -	3·09	20·422
	King's Lynn to Sutton Wash and Holbeach.		
667	Wooden Bridge over River Ouse - - -	1·51	27·540
675	4 Milestone from Lynn - - - -	1·22	10·790
678	East end of Terrington - - - -	2·01	12·774
685	Cross Keys Public-house - - - -	1·95	15·518
690	Sutton Wash Metal Bridge - - - -	5·83	24·358
691	St. Matthew's Church, Sutton Wash - -	2·16	16·734
699	Robin Hood Public-house, Sutton St. Mary's -	1·48	12·750
703	Chapel Bridge, Sutton St. Mary's - - -	−5·36	7·723
705	1 Milestone from Sutton St. Mary's - -	2·32	11·296
711	Fleet Hard Gate, Bull Inn - - - -	1·35	14·612
714	1 Milestone from Holbeach - - -	2·91	13·447
718	Holbeach Church Tower - - - -	3·14	18·551
	Clenchwarton Church Tower - - -	1·56	15·434
	Terrington St. Clement's Church Tower - -	1·16	16·492
	Sutton St. Mary's Church Tower - - -	2·23	16·347
	Gedney Church Tower - - - -	4·23	20·894
	Fleet Church Tower - - - -	2·94	18·180
	Holbeach to Sutterton.		
721	Castle Hill Bridge - - - - -	1·75	11·285
724	Saracen's Head Public-house, junction of roads -	2·05	15·689
733	Mermaid Public-house, near Fosdyke - -	1·08	14·638
735	Fosdyke Wooden Bridge - - - -	−3·17	29·618
738	Fossdyke Church Tower - - - -	1·65	15·582
743	Sutterton Railway Station - - - -	1·86	16·054
746	Sutterton Church Tower - - - -	2·72	16·285
	Algarkirk Church Chancel - - - -	2·82	15·882
	Sutterton to Swineshead.		
746	Rose and Crown Hotel, Sutterton - - -	2·15	12·945
751	Junction of road to Donington - - -	1·72	14·349
760	Swineshead Church Tower - - - -	2·78	21·502
	Wigtoft Church Tower - - - -	2·45	16·268

No. of Bench Mark.	*Position.*	Relation to Surface.	Altitude above Datum.
	Swineshead to Sleaford.		
763	Junction of road to Boston - - - -	2·13	13·735
764	Swineshead Bridge - - - - -	3·85	15·565
767	9 Milestone from Sleaford - - - -	2·47	14·102
769	8 " " " - - - -	1·67	12·238
771	7 " " " - - - -	1·47	14·564
773	6 " " " - - - -	2·44	25·987
775	Junction of roads, Heckington - - -	1·85	42·822
778	4 Milestone from Sleaford - - - -	1·67	26·636
780	Bridge opposite road to Asgarby Church - -	−6·79	17·255
782	Kirkby Laythorp toll-house - - -	1·69	32·948
783	1 Milestone from Sleaford - - - -	2·95	40·871
787	Canal Bridge, Sleaford - - - -	0·75	48·344
788	Sleaford Church Tower - - - -	3·90	55·862
	Great Hale Church Tower - - - -	1·92	30·062
	Heckington Church Tower - - -	1·87	46·961
	Asgarby Church Tower - - - -	2·65	32·573
	Kirkby Laythorp Church Tower - - -	1·01	41·950
	Sleaford to Lincoln.		
801	Road to Branswell Church - - - -	1·61	119·740
805	Ashby Toll-gate - - - - -	1·70	159·477
808	Road to Navenby - - - - -	1·45	138·083
811	Road to Metheringham - - - -	1·53	174·222
813	Dunstan's Pillar - - - - -	1·79	195·375
817	Near 4 Milestone from Lincoln - - -	1·76	218·532
820	John Bull Inn, junction of roads - - -	3·00	241·556
826	St. Peter's Church Tower, Lincoln - -	2·28	25·841
	Branswell Church Tower - - - -	2·74	90·801
	Lincoln Minster, West front - - -	2·01	217·715
	County Asylum, West wing - - -	2·35	238·610
	Canal Lock, mark above bed of canal - -	11·75	16·206
	Swineshead to Boston.		
7	5 Milestone from Boston - - - -	2·16	11·801
10	4 " " " - - - -	1·85	11·352
12	Baker's Bridge - - - - - -	1·42	14·581
15	Old Hammond Beck Bridge, below battlement -	−9·50	6·836
16	South Forty-foot Bridge, above keystone - -	5·26	20·258
18	Cut Drain Bridge, below battlement - -	−2·50	15·576
21	High Street, opposite West Street, Boston - -	1·55	21·441
	High Bridge, Boston, below battlement - -	−1·83	24·101
	Boston Church Tower - - - -	2·78	19·743
	Boston to Wainfleet.		
25	Boston Union - - - - - -	1·14	12·527
26	Skirbeck Church Tower - - - -	2·42	16·926
29	Fishtoft Church Tower - - - -	4·16	22·286
34	Marine Hotel, Frieston Shore - - -	2·28	13·243
37	*Butterwick Sea End - - - -	2·55	14·122
38	*Bennington Sea End - - - -	0·28	10·243
44	*Sea Field Cottage, Leake Hurn End - -	2·36	11·217
48	*Grocer's shop, Wrangle Low Gate - -	3·52	13·524
56	*Groose Lane, Wainfleet Tofts - - -	1·68	14·028
57	Wainfleet Church Tower - - - -	1·57	17·064
	Friskeney Church Tower - - - -	3·27	15·857
	Parish's House, Lower Road, Friskeney Tofts -	2·32	10·344

* The position of these marks on the Ordnance Map is doubtful.

No. of Bench Mark.	Position.	Relation to Surface.	Altitude above Datum.
	Wainfleet to Sutton.		
59	Junction of road to Burgh - - - - -	3·07	11·744
62	Croft Church Tower - - - - -	3·49	15·549
65	Junction of roads, Croft Bank - - -	1·12	13·748
77	Ingoldmells Church Tower - - - - -	2·41	12·912
88	Hogsthorpe Church Tower - - - - -	2·28	20·479
87	Mumby Church Tower - - - - -	3·54	22·187
90	Huttoft Church Tower - - - - -	3·59	40·788
96	Sutton Church Tower - - - - -	1·75	10·788
	Thorpe Church Tower - - - - -	2·31	12·831
	Skegness Church Tower - - - - -	3·48	11·378
	Winthorpe Church Tower - - - - -	2·87	13·164
	Addlethorpe Church Tower - - -	3·00	14·419
	Anderby Church Tower - - - - -	1·82	22·032
	West Theddlethorpe Church Tower - -	8·72	15·200
	Peterborough to Wisbech.		
146	Edgerley Toll-house - - - - -	1·53	28·415
148	Eye Church Tower - - - - - -	1·79	29·327
149	4 Milestone from Peterborough - - -	1·22	25·147
150	Thorney Causeway Toll-bar - - -	2·39	15·674
157	13 Milestone from Wisbech - -	1·33	7·355
159	12 „ „ „ - - -	1·38	7·876
162	11 „ „ „ - - -	1·06	4·888
164	10 „ „ „ - - -	1·17	5·351
166	9 „ „ „ - - -	0·94	6·000
168	8 „ „ „ - - -	1·18	5·612
171	Guyhirn Chapel of Ease - - - -	1·75	10·987
173	Wright's House, Tholomas Drove - - -	1·49	8·917
177	3 Milestone from Wisbech - - - -	0·77	8·117
178	Wisbech St. Mary's Church Tower - -	2·49	12·990
180	2 Milestone from Wisbech - - - -	0·57	10·355
181	1 „ „ „ - - - -	1·14	11·201
	Fletton Church Spire - - - - -	2·89	32·580
	Standground Church Spire - - - -	3·81	35·925
	Peterborough Cathedral Spire - - -	3·77	31·671
	Thorney Church Tower - - - - -	2·70	24·306
	Wisbech Church Tower - - - - -	1·12	17·800
	Wheatsheaf Public-house, Wisbech - -	1·29	23·073
	Wisbech to King's Lynn.		
191	2 Milestone from Wisbech - - - -	2·62	12·595
193	3 „ „ „ - - - -	2·89	13·751
198	Walpole Highway Church - - - -	1·55	9·392
200	6 Milestone from Wisbech - - - -	1·55	8·775
203	7 „ „ „ - - - -	2·37	10·003
211	2 „ „ Lynn - - - -	2·65	15·368
213	1 „ „ „ - - - -	1·26	14·723
	Walsoken Church Tower - - - -	1·04	13·418
	Tilney St. Lawrence Church Tower - -	1·95	11·193
	St. John's Highway Church Tower - -	3·18	12·596
	Tilney All Saints Church Tower - - -	4·82	18·431
	Tilney cum Islington Church Tower - -	2·87	14·312
	Huntingdon to St. Ives.		
36	Hartford Toll-house - - - - -	2·20	38·847
41	Haughton Church - - - - - -	2·42	30·704
45	Bury and Stratton Toll-bar - - - -	2·54	32·385
46	St. Ives Church - - - - - -	2·50	28·178
	Fenny Drayton Church - - - - -	2·59	32·560
	Lolworth Church - - - - -	2·68	125·254

No. of Bench Mark.	*Position.*	Relation to Surface.	Altitude above Datum.
	St. Ives to Cambridge.		
48	House on bridge over River Ouse - - - -	1·26	43·150
52	Fenny Stanton Toll-gate, battlement of bridge -	4·31	26·303
53	Fenny Stanton Church - - - -	2·30	45·403
55	1 Milestone from Fenny Drayton - - -	3·16	44·241
61	Milestone, junction of road to Lolworth - -	2·83	60·543
64	„ „ „ opposite Five Bells Inn -	2·91	72·621
66	„ „ „ to Madingley - -	2·92	47·941
67	„ „ „ to Girton - -	2·65	51·873
71	House, north end of Cambridge - - -	1·08	72·239
72	Cambridge City Court House - - -	2·51	68·409
73	Bridge over River Cam - - - - -	1·29	29·115
74	Trinity College - - - - - -	2·52	33·095
	Dry Drayton Church - - - -	1·97	114·832
	Girton Church - - - - - -	1·76	74·779

Position.	Authority.	Altitude above Datum.
Miscellaneous Heights.		
Boston Church Tower, top - - - - -	Ordnance Survey	286·5
Walpole St. Peter Church Tower, ground - -	„	8·5
Lynn Church Tower, ground - - -	„	18·5
Ely Minster, ground - - - - -	„	51·6
Brandon - - - - - - -	„	163·9
Wisbech Self-registering Tide Gauge, datum -	S. H. Miller	−25·8
Boston „ „ „ „ -	W. H. Wheeler	− 8·7
Levels relating chiefly to the River Witham.		
Hobhole Cill - - - - - -	W. H. Wheeler	− 7·32
Black Sluice Cill - - - - - -	„	− 8·70
Old Black Sluice Cill - - - - -	„	− 2·78
Maudfoster Sluice Cill - - - - -	„	− 4·87
Grand Sluice Cill - - - - - -	„	− 3·20
High Water (mean), Boston - - - -	„	10·21
„ (springs), „ - - - -	„	13·34
„ 1810, highest known; mark on church tower.	„	17·93
„ (neaps) Boston - - - -	„	6·69
Low Water (neaps), Clayhole - - -	„	1·29
„ (springs), „ - - - -	„	− 9·86
„ „ „ below Black Sluice Cill	Calver	− 1·16
„ (mean) Hobhole - - - -	W. H. Wheeler	− 7·32
Admiralty datum for soundings* - - - -	Calver	−14·04
Boston Town, highest street - - - -	W. H. Wheeler	19·57
„ „ lowest „ - - - -	„	8·63
Top of Witham Banks above Grand Sluice, 1875 -	„	17·80
„ Sea Banks, average Frampton to Fossdyke -	„	20·00
„ „ Frieston - - - - -	„	20·62
Level of Marsh immediately outside the Sea Banks	„	13·25
„ Old Marsh, as soon as grassed over -	„	11·00
„ New or Samphire Marsh - - - -	„	8·68
Nene Valley datum - - - - -	„	−25·82
Lynn Free Bridge Gauge (datum for Ouse) -	„	− 5·82
North Level Sluice Cill - - - - -	„	− 5·82

* 34 ft. 1 in. below middle window, Nottingham Hotel, Friestone; the old B. M. on the hotel being 13·243.—W.H.W.

APPENDIX F.

METEOROLOGICAL TABLES.

TABLE I.

Winds of the Fenland.

Station.	Direction of Wind.							
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
Boston - -	–	82	–	61·7	–	131·5	–	100·3
Wisbech	28	47	26	40	33	104	33	54

*** This table shows the average number of days per annum on which each wind blows. The observations at the Boston station extend over the years 1864–1870 inclusive, and were made and kindly communicated by W. H. Wheeler, Esq., C.E., engineer, to the Witham Commissioners, &c. All winds between N. and E. are grouped as N.E.; between E. and S. as S.E.; between S. and W. as S.W.; and between W. and N. as N.W.; an arrangement not so useful for our purpose as the ordinary one. The observations made at Wisbech are records of the Osler's self-registering anemometer at the observatory of S. H. Miller, Esq., F.R.A.S., &c., for the years 1861–1870, inclusive. The two gentlemen named have supplied me, with great generosity, with all the Boston and Wisbech records, besides other valuable information.

TABLE II.

Distribution of Winds throughout the Year.

Boston, 1864–1870 (*inclusive*).

Month.	Number of Days on which each Wind blew.								Dominant.
	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	
January -	–	3·6	–	4·4	–	16·0	–	6·4	S.W.
February -	–	4·0	–	3·4	–	13·9	–	6·7	S.W.
March -	–	10·1	–	7·4	–	7·0	–	9·2	N.
April - -	–	8·1	–	6·6	–	7·0	–	8·3	N.
May - -	–	8·4	–	7·0	–	10·6	–	5·0	S.W.
June - -	–	7·0	–	3·9	–	7·5	–	11·6	N.W.
July - -	–	8·4	–	5·0	–	8·6	–	9·0	N.W.
August -	–	5·6	–	4·7	–	10·1	–	10·6	W.
September -	–	5·6	–	6·1	–	14·3	–	6·0	S.W.
October -	–	5·7	–	6·4	–	10·6	–	8·3	W.
November -	–	5·1	–	3·1	–	12·6	–	11·2	W
December -	–	4·4	–	5·4	–	13·3	–	8·0	S.W.

*** A slight error has crept into this table, which, however, does not affect the result, as may be seen by comparison with the Wisbech table No. IV. The error amounts in all to 4·5 days; January, for example, has only 27·4 days, and December 30·1 days. The dominant wind does not appear so clearly as in the Wisbech table in consequence of the grouping of the winds.

TABLE III.

Distribution of Winds throughout the Year.

Wisbech, 1861–1870 (*inclusive*).

Month.	*Number of Days on which each Wind blew.* N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	*Dominant.*
January -	1·3	4·3	2·0	5·8	4·2	8·3	2·1	3·0	S.W.
February -	0·8	3·3	2·6	3·4	2·9	8·8	2·4	4·0	S.W.
March -	3·4	6·7	2·1	2·8	1·9	5·9	3·0	5·2	N.E.
April - -	4·0	4·3	2·8	3·0	2·0	6·3	3·6	4·0	S.W.*
May - -	3·2	5·2	3·4	3·1	1·5	7·8	2·0	4·8	S.W.
June - -	3·8	3·6	1·2	2·2	2·1	8·6	3·1	5·4	S.W.
July - -	2·3	3·5	1·4	2·9	2·9	9·7	3·8	4·5	S.W.
August -	2·4	3·6	1·5	2·6	3·1	9·6	3·2	5·0	S.W.
September -	1·7	2·8	2·5	3·1	3·6	11·1	2·1	3·1	S.W.
October -	2·0	3·6	3·4	4·0	2·9	9·2	1·9	4·0	S.W.
November -	1·3	2·9	1·5	3·6	2·8	7·8	3·1	7·0	S.W.
December -	1·7	3·8	1·9	3·9	3·1	10·2	2·8	3·6	S.W.

* 28·2 days; there being two leap years.

TABLE IV.

Per-centage Value of the Winds.

Station.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
Boston - - -	–	21·6	–	16·4	–	35·3	–	26·7
Wisbech - - -	7·7	12·9	7·1	11·0	9·0	28·5	9·0	14·8

TABLE V.

Rainfall at Boston, 1854–1873.

* *Month.*	*Average Rain-fall. 20 Years, 1854–73.*	*Maximum Fall.*		*Minimum Fall.*		*Mean Total Number of Days on which Rain fell. 7 Years, 1867–73.*	*Quarter from which the Rain came. 7 Years, 1867–73.*			
	Inches.	*Ins.*	*Year.*	*Ins.*	*Year.*	*Days.*	*N.E.*	*S.E.*	*S.W.*	*N.W.*
January -	1·75	3·67	1867	0·60	1858	17·6	2·0	1·5	11·0	3·1
February	1·30	2·18	1855	0·25	1858	13·9	2·1	2·9	5·4	3·5
March -	1·50	3·23	1851	0·25	1856	16·6	6·3	1·7	5·0	3·6
April -	1·52	3·26	1859	0·20	1852	15·1	2·6	4·0	5·4	3·1
May -	1·83	3·86	1869	0·43	1868	12·4	3·9	1·7	4·2	2·6
June -	1·94	3·39	1852	0·45	1868	10·9	2·1	2·6	2·9	3·3
July -	2·27	5·73	1851	0·30	1864	11·4	1·9	1·4	6·0	2·1
August -	2·36	5·35	1860	0·51	1864	10·7	1·8	2·1	4·6	2·2
September	1·87	4·32	1852	0·30	1854	13·4	1·1	2·4	8·1	1·8
October -	2·30	4·68	1865	0·90	1861	17·6	1·3	2·4	10·0	3·9
November	1·74	4·32	1852	0·79	1867	15·1	3·0	1·6	7·1	3·4
December	2·00	5·87	1868	0·32	1873	19·0	3·6	3·3	7·4	4·7
Total -	22·38	–	–	–	–	173·7	31·7	27·6	77·1	37·8

*** From "The Fenland Meteorological Circular," Vol. I. p. 15, 1874. Wisbech.

Table VI.

Rainfall at Boston.

(*Averages.*)

For the Years (inclusive).	*Inches.*
1826 to 1867 - -	22·59
1831 to 1847 - -	22·80
1850 to 1866 - -	21·85
1858 to 1867 - -	22·15

Table VII.

Rainfall at Wisbech.

Year.	*Inches.*	*Year.*	*Inches.*
1859	26·26	1867	26·08
1860	30·86	1868	22·84
1861	21·26	1869	26·52
1862	21·32	1870	20·49
1863	19·30	1871	24·82
1864	16·00	1872	38·46
1865	27·44	1873	28·39
1866	26·39	1874	19·45

Table VIII.

Rainfall Stations for Comparison with Fens.

Station.	*County.*	*Rain.*	*Station.*	*County.*	*Rain.*
Uckfield - -	Sussex -	33	Cambridge - -	Cambs. -	23
Berkhampstead -	Herts -	28	Lynn - -	Norfolk -	–
Hertford - -	" -	25	Wt. Dereham -	" -	21
Oxford - -	Oxon -	25	Boston - -	Lincolnshire	22
London - -	Middlesex -	25	Grantham - -	"	21
Norwich - -	Norfolk -	25	Lincoln - -	"	20
Bury - -	Suffolk -	23	Wisbech - -	Cambs. -	23
Holkham - -	Norfolk -	23	England, mean of	all - -	33·25

Table IX.

Average Rainfall at 10 Stations.—1861 to 1870 (*inclusive*).

Station.	*County.*	*Rain.*	*Station.*	*County.*	*Rain.*
Holkham - -	Norfolk -	20·4	Northampton -	Notts -	23·5
Fakenham - -	Ditto -	25·0	Wellingboro' -	Ditto -	22·8
Bury St. Edmunds	Suffolk -	22·3	Grantham -	Lincolnshire	21·1
Royston - -	Herts -	22·2	Boston - -	Ditto -	21·9
Bedford - -	Beds -	21·0	Lincoln - -	Ditto -	19·7

· TABLE X.

Heaviest Rains at Wisbech in Twenty-four Hours.

Month.	1861.		1862.		1863.		1864.		1865.		1866.		1867.		1868.		1869.		1870.	
	Day.	*Rain.*	*Day.*	*Rain.*	*Day.*	*Rain.*	*Day.*	*Rain.*	*Day.*	*Rain.*	*Day.*	*Rain.*	*Day.*	*Rain.*	*Day.*	*Rain.*	*Day.*	*Rain.*	*Day.*	*Rain.*
January - -	...	...	...	...	6	0·51	...	...	27	0·80	...	...	...	...	...	...	...	...	...	...
February - -	...	...	...	...	...	...	...	...	17	0·61	...	...	...	...	...	...	12	1·01	6	0·69
March - -	...	...	...	...	...	...	6	0·43	...	...	...	...	...	...	...	...	19	1·05	...	...
April - -	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
May - -	12	0·74	...	...	...	...	7	0·58	...	...	...	...	10	1·62	...	...	8	0·72	...	...
June - -	10	0·76	...	...	6	0·54	...	...	...	...	...	...	...	...	...	...	...	...	...	...
„ - -	21	0·74	...	...	17	0·58	...	...	...	...	...	...	...	...	...	...	...	...	...	...
July - -	25	1·21	...	...	...	...	...	...	7	1·65	...	...	26	1·15	...	...	...	...	5	0·51
„ - -	...	...	16	... 0·66	...	...	...	...	18	0·65	...	...	...	...	...	...	...	...	...	...
August - -	...	...	17	...	3	0·58	...	...	24	0·93	12	0·53	...	...	26	1·80	7	0·65	27	0·64
„ - -	...	...	...	...	...	...	...	...	25	0·90	...	...	...	...	10	0·77	...	...	...	...
September -	...	...	...	..	...	...	16	0·72	...	...	...	3	1·00	...	...	...	...	...	5	1·19
October - -	...	...	...	...	...	...	...	...	10	1·37	...	...	...	...	3	0·87	...	...	...	...
„ - -	...	...	...	...	...	...	...	...	17	0·89	...	...	...	...	...	...	...	...	...	...
„ - -	...	...	...	...	...	...	...	...	19	0·83	...	...	...	...	...	...	...	...	...	...
November -	13	1·77	...	...	9	0·54	24	0·68	...	...	...	...	...	...	...	...	...	...	...	...
December -	...	...	...	...	...	...	...	...	...	..	...	...	...	...	28	0·67	17	0·66	13	0·62
„ - -	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	19	1·04
Number of hailstorms -	1	...	3	...	8	...	1	...	6	...	2	...	1	...	3	...	1	...	2	...

*** This table includes all the diurnal falls exceeding half an inch.

TABLE XI.

Rainfall Stations on Map.

Station.	*County.*	*Rainfall.*	*Observer or Authority.*	*Average how calculated.*	*Remarks.*
Bracebridge - -	Lincolnshire - -	21·945	Brit. Rainfall - -	1873 + 5 °/ₒ (S.) - -	Near Boston.
Branston - -	" - -	24·3	Ordnance Survey -	Doubtful - - - -	Near Lincoln.
Horncastle - -	" - -	20·580	Brit. Rainfall - -	1873 + 5 °/ₒ (S.)	
Spilsby - - -	" - -	26·7	Ordnance Survey -	Doubtful.	
Haydor - - -	" - -	22·680	Brit. Rainfall - -	1873 + 5 °/ₒ (S.) - -	Near Sleaford.
Boston - - -	" - -	22·380	W. H. Wheeler -	1854–70, inclusive.	
Irnham - - -	" - -	20·6	Ordnance Survey -	Doubtful - - - -	Near Bourne.
Witham-on-the-Hill -	" - -	21·409	Brit. Rainfall - -	1873 + 5 °/ₒ (S.) - -	Near Bourne.
Pode Hole - -	" - -	20·611	" " - -	Ditto - - - -	Near Spalding.
Tyd St. Mary's -	" - -	19·640	J. Tilson - -	1874 + 14·32 °/ₒ (S.) -	Near Wisbech.
Stamford - -	" - -	25·4	Ordnance Survey -	Doubtful.	
Gt. Casterton - -	Rutland - - -	24·0	" " -	"	
Peterborough - -	Northamptonshire -	21·6	" " -	"	
Wisbech - - -	Cambridgeshire -	22·696	S. H. Miller - -	1860–5 (inclusive) (S.)	
Elm - - -	" - -	18·382	G. J. Moore - -	8 months in 1874 corrected to 12 + 14·32 °/ₒ (S.)	Feb., June, Sept., Dec. missing = 37·9 °/ₒ of annual rainfall.
Elm (Coldham Hall)	" - -	22·521	H. J. Little - -	10 months in 1874 corrected to 12 + 14·32 °/ₒ (S.)	Jan. and May missing = 14·4 °/ₒ of annual rainfall.
Outwell (Aqueduct Sluice).	" - -	18·336	Middle Level Com. -	1874 + 14·32 °/ₒ (S.)	
Upwell (Euximoor) -	" - -	24·507	" " " -	1874 + 14·32 °/ₒ (S.)	
Marmont Priory -	" - -	18·711	" " " -	1874 + 14·32 °/ₒ (S.)	
March - - -	" - -	23·929	" " " -	1874 + 14·32 °/ₒ (S.)	
Standground Sluice -	" - -	22·454	" " " -	1874 + 14·32 °/ₒ (S.)	
Chatteris - -	" - -	20·235	A. S. Ruston - -	1874 + 14·32 °/ₒ (S.)	
Chatteris (Horseway Sluice).	" - -	16·656	Middle Level Com. -	1874 + 14·32 °/ₒ (S.) - -	Gauge 20 feet above ground; corrected to 1 foot, which is the height of other gauges.

Table XI.—*continued.*

Rainfall Stations on Map.

Station.	*County.*	*Rainfall.	*Observer or Authority.*	*Average how calculated.*	*Remarks.*
Ely - - -	Cambridgeshire -	17·449	W. Marshall - -	8 months in 1874 corrected to 12 + 14·32 °/。 (S.)	Jan. to April incl. missing = 22·9 °/。 of annual rainfall.
Stretham - -	" - -	21·1	Ordnance Survey -	Doubtful.	
Cambridge (Chesterton.)	" -	16·302	H. Tomlinson - -	1874 + 14·32 °/。 (S.) - -	The rainfall was only 14·26, which seems to be exceptionally small.
Cambridge - -	" - -	23·120	Observatory - -	1874 + 14·32 °/。 (S.)	
Trumpington - -	" - -	23·3	Ordnance Survey -	Doubtful.	
Wilbraham - -	" - -	24·9	" " -	"	
Chesterton - -	" - -				
Whittlesea Mere -	Huntingdonshire -	19·990	Middle Level Com. -	1874 + 14·32 °/。 (S.)	
Connington - -	" - -	23·2	Ordnance Survey.		
Wistow - - -	" - -	20·7	" " -	Doubtful.	
Winwick - -	" - -	23·0	" " -	"	
Huntingdon - -	" - -	22·281	Brit. Rainfall -	1873 + 5 °/。 (S.)	
Hunstanton - -	Norfolk - - -	21·2	Ordnance Survey -	Doubtful.	
Hillington - -	" - - -	22·806	H. Ffolkes - -	1873 + 5 °/。 (S.)	
N. Wootton - -	" - - -	20·978	W. W. Clarke - -	1874 + 14·32 °/。 (S.)	
Lynn - - -	" - - -				
St. Germans - -	" - - -	24·603	Middle Level Com. -	1874 + 14·32 °/。 (S.)	
Stradsett - -	" - - -	23·2	Ordnance Survey -	Doubtful.	
Downham Market, Bexwell.	" - - -	24·108	Brit. Rainfall - -	1873 + 5 °/。 (S.)	
Aqueduct Sluice -	" - - -	18·365	Middle Level Com. -	1874 + 14·32 °/。 (S.)	
Denver - - -	" - - -	24·3	Ordnance Survey -	Doubtful.	
W. Dereham - -	" - - -	21·347	C. Blanchfield - -	1874 + 14·32 °/。 (S.)	

*** Where only a limited series of observations have been made, I have reduced the results to a mean; such reduction is given in each case, and the letter (S) appended.

TABLE XII.

Humidity at Boston.
1867 to 1870.

Mean Daily Saturation.					
January	-	91·9	July	-	72·2
February	-	86·6	August	-	76·7
March	-	83·1	September	-	80·9
April	-	78·5	October	-	88·1
May	-	73·2	November	-	89·1
June	-	71·8	December	-	91·0

TABLE XIII.

Daily Degree of Humidity at Wisbech.

Month.	*Mean.*	*Max.*	*Min.*
	(0–100)	(0–100)	(0–100)
January -	89·9	95	78
February -	89·6	94	86
March -	86·5	94	82
April -	79·8	90	70
May -	76·2	85	64
June -	80·2	87	67
July -	76·7	88	64
August -	77·7	88	69
September -	84·2	93	76
October -	86·8	93	81
November -	89·5	94	83
December -	91·5	94	87

"There is an evident increase of humidity in June. The max. shows the highest monthly mean, and the min. the lowest, during the 14 years 1861–74. —S.H.M."

TABLE XIV.

Evaporation from Soils, &c.
Wisbech, 1873.

Month.	*Peat.* (α)	*Warp.* (β)	*Clay.* (γ)	*Humus.* (δ)	*Water.* (ϵ)	*Rainfall.* (θ)	*Notes.*
January -	0·52	0·49	0·57	0·47	0·78	1·88	Depth in inches in each case.
February	0·46	0·48	0·32	0·34	0·25	1·69	
March -	1·17	1·21	1·20	1·23	0·65	1·56	
April -	1·08	1·36	1·39	1·47	1·52	1·07	
May -	1·77	2·18	2·01	2·53	2·22	2·84	
June -	1·83	1·75	1·50	1·52	2·40	1·60	
July -	3·52	2·96	2·51	3·53	3·39	2·51	
August -	2·25	2·25	1·71	2·27	3·02	4·02	Ratio of evaporation from the surface of water to the rainfall $\frac{\epsilon}{\theta}=0\cdot71$.
September	1·59	1·49	1·59	2·04	1·23	1·87	
October -	0·56	0·58	0·47	0·43	0·64	2·39	
November	0·40	0·46	0·48	0·45	0·48	1·42	
December	0·18	0·13	0·13	0·10	0·23	0·54	
	15·33	15·34	13·88	16·38	16·81	23·89	

TABLE XV.

Ratios of Evaporation from different Soils to that from Water ($\epsilon=1$).

$\frac{\alpha}{\epsilon}$	$\frac{\beta}{\epsilon}$	$\frac{\gamma}{\epsilon}$	$\frac{\delta}{\epsilon}$
0·91	0·91	0·82	0·97

*** In this and the following table the signs α to θ refer to the substances mentioned in Table XIV.

TABLE XVI.

Ratios of Evaporation from different Soils to the Rainfall ($\theta=1$).

$\frac{\alpha}{\theta}$	$\frac{\beta}{\theta}$	$\frac{\gamma}{\theta}$	$\frac{\delta}{\theta}$
0·65	0·65	0·59	8·70

TABLE XVII.

Evaporation from Soils, &c. Wisbech, 1874.

Month.	*Peat.* (α)	*Warp.* (β)	*Clay.* (γ)	*Humus.* (δ)	*Water.* (ϵ)	*Rainfall.* (θ)	*Remarks.*
January -	0·21	0·11	0·18	0·11	0·230	1·284	Depth in inches in each case.
February	0·24	0·31	0·34	0·24	0·230	0·931	
March -	1·20	0·41*	1·41	1·06	1·000	1·106	
April -	1·45	1·48	1·70	1·89	1·710	1·138	
May -	1·53	1·63	1·59	1·54	1·940	1·528	
June -	1·49	1·70	1·97	1·76	2·950	1·627	
July -	1·38	1·66	1·99	1·95	3·700	1·311	Ratio of evaporation to the rainfall $\frac{\epsilon}{\theta}=$ 0·92
August -	1·88	2·57	1·95	2·54	2·380	2·063	
September	1·60	1·12	1·30	1·40	1·970	2·776	
October -	1·79	0·62	0·62	0·62	0·670	1·440	
November	0·21	0·37	0·23	0·10	0·610	2·215	
December	0·03	0·05	0·03	0·05	0·530	2·027	
	13·01	12·03	13·31	13·26	17·920	19·446	

* "I cannot understand how the silt in March 1874 showed so small a result. I have looked at it carefully and can't find an error. You will note the influence of the high temperature in May on *Peat* and *Humus* as compared with *Silt* and *Clay*.—S.H.M."

TABLE XVIII.

Evaporation from Soils, &c. Wisbech, 1875.

Month.	*Peat.*	*Warp.*	*Clay.*	*Humus.*	*Water.*	*Rainfall.*	*Remarks.*
January - -	0·94	0·94	0·87	1·01	0·420	2·048	
February - -	0·42	0·39	0·35	0·25	0·400	1·213	
March - -	0·85	0·92	0·85	1·30	0·980	0·444	
April - -	0·84	1·08	0·95	1·53	1·530	0·847	
May - -	2·16	1·95	1·88	2·33	2·670	1·610	
June - -	...	...	...	...	3·040	3·276	
July - -							
August - -							
September -							
October - -							
November -							
December -							

Table XIX.

The Rainfall and the Discharge by Rivers.

Rainfall.	*Number of Gallons.*		*Number of Tons.*	
Inches.	*Per Acre.*	*Per Sq. Mile.*	*Per Acre.*	*Per Sq. Mile.*
1	22622·584	14478430·720	100·994	64631·160
2	45245·096	28956861·440	201·988	129262·320
3	67867·644	43435292·160	302·982	193893·480
4	90490·192	57913722·880	403·976	258524·640
5	113112·740	72392153·600	504·970	323155·800
6	135735·288	86870584·320	605·964	387786·960
7	158357·836	101349015·040	706·958	452418·120
8	180980·384	115827445·760	807·952	517049·280
9	203602·932	130305876·480	908·946	581680·440
10	226225·480	144784307·200	1009·940	646311·600
15	339338·220	217176460·800	1514·910	969467·400
20	452450·960	289568614·400	2019·880	1292623·200
25	565563·700	361960768·000	2524·850	1615779·000
30	678676·440	434352921·600	3029·820	1938934·800

Table XIX.—*continued.*

Rainfall.	*Discharge per Acre in Gallons.*			
Inches.	*Proportion of Discharge to Rainfall.*			
	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$
1	3770·425	5655·637	7540·845	11311·274
2	7540·850	11311·274	15081·690	22622·548
3	11311·275	16966·911	22622·535	33933·822
4	15081·700	22622·548	30163·380	45245·090
5	18852·125	28278·185	37704·225	56556·370
6	22622·550	33933·822	45245·070	67867·644
7	26392·975	39589·459	52785·915	79178·918
8	30163·400	45245·096	60326·760	90490·192
9	33933·825	50900·733	67867·605	101801·466
10	37704·250	56566·307	75408·450	113112·740
15	56556·375	84834·555	113112·675	169669·110
20	75408·500	113112·740	150816·900	226225·480
25	94260·625	141390·925	188521·125	282781·850
30	113112·750	169669·110	226225·350	339338·220

Table XIX.—*continued.*

Rainfall.	*Discharge per Acre in Tons.*			
Inches.	*Proportion of Discharge to Rainfall.*			
	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$
1	16·832	25·248	33·665	50·497
2	33·664	50·496	67·330	100·994
3	50·496	75·744	100·995	151·491
4	67·328	100·992	134·660	201·988
5	84·160	126·240	168·325	252·485
6	100·992	151·488	201·990	302·982
7	117·824	176·736	235·655	353·479
8	134·656	201·984	269·320	403·976
9	151·488	227·232	302·985	454·473
10	168·320	252·480	336·650	504·970
15	252·480	378·720	504·975	757·455
20	336·640	504·960	673·300	1009·940
25	420·800	631·200	841·625	1262·425
30	504·960	757·400	1009·950	1514·910

Table XIX.—*continued.*

Rainfall.	*Discharge per Sq. Mile in Gallons.*			
	Proportion of Discharge to Rainfall.			
Inches.	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$
1	2413071·787	3619607·680	4826143·573	7239215·360
2	4826143·574	7230215·360	9652287·146	14478430·720
3	7239215·361	10858823·040	14478430·719	21717645·080
4	9652287·148	14478430·720	19304574·292	28956861·444
5	12065358·935	18098038·400	24130717·865	36196076·800
6	14478430·722	21717646·080	28956861·438	43435292·160
7	16891502·509	25337253·760	33783005·011	50674507·520
8	19304574·296	28956861·440	38609148·584	57913722·880
9	21717645·083	32576469·120	43435292·157	65152938·240
10	24130717·870	36196076·800	48261435·730	72392153·600
15	36196076·805	54294115·200	72392153·595	108588230·400
20	48261435·740	72392153·500	96522871·460	144784307·200
25	60326794·675	90490192·000	120653589·325	180980384·000
30	72392153·610	108588230·400	144784307·190	217176460·800

Table XIX.—*continued.*

Rainfall.	*Discharge per Sq. Mile in Tons.*			
	Proportion of Discharge to Rainfall.			
Inches.	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{1}{2}$
1	10771·860	10157·790	21543·720	32315·580
2	21543·720	32315·580	43087·440	64631·160
3	32315·580	48473·370	64631·160	96946·740
4	43087·440	64631·160	86174·880	129262·320
5	53859·330	80788·950	107718·600	161577·900
6	64631·160	96946·740	129262·320	193893·480
7	75403·020	113104·530	150856·040	226209·060
8	86174·880	129262·320	172349·760	258524·640
9	96946·740	145420·110	193893·480	290840·220
10	107718·600	161577·900	215437·200	323155·800
15	161577·900	242366·850	323155·800	484733·700
20	215437·200	323155·800	430874·400	646311·600
25	269296·500	403944·750	538593·000	807889·500
30	323155·800	484733·700	646311 600	969467·400

*** This table will prove useful in calculating the discharge of rivers from the rainfall and area of catchment basin. The data on which it is calculated are as follows:—

1 cubic inch of water weighs - - 252·458 grs.
1 cubic foot „ „ - - 997·137 oz. av. 62·33 lbs.
Number of cubic inches in gallon - 277·2738

This proportion of discharge to rainfall is given in simple aliquot parts, as my own experiments on the influence of temperature on evaporation from different soils are not sufficiently advanced to enable me to give the absolute constants for the fen soils, and Mr. Miller's tables, Nos. XIII., XIV., and XV., merely give the actual evaporation from them for the year 1873.

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APPENDIX H.

LOCAL AND OBSOLETE TERMS USED IN THE FENLAND.

Adventurer. One who drains fens. Usually the one who bears the risk. See *Undertaker*.

Becket. A notched iron tool used for digging peat.

"Bear's Muck." An euphonious term used to designate a deposit of clay full of fetid decaying vegetable matter.

Buttery Clay. A soft unctuous clay underlying the peat in Lincolnshire, &c. A variety of the marine beds. Also called *Fen Clay*, and *Sheep's Ointment*, from being like that parasite scourge in colour and texture.

Blow up. A phrase used to signify destruction by water. Thus Denver sluice "blew up," meaning was broken down by the water.

Bright.. Land covered with water so that the grass is just hidden, and the surface consequently shines. The depths of dykes, and the dip of lifting-wheels are measured from the bright surface.

Carr. A clump of trees in the fen. Used only in the Bedford Level.

Cess. A brick-shaped mass of peat as dug.

Cradge. To mend banks by simply tipping material on to the top. Hence *Cradge Bank*.

Cramp sedge. The sedges which covered much of the undrained fen, as now at Wicken. Used in the Bedford Level.

Claying. Covering peat land with clay for manure.

Clunch. In the Bedford Level the lowest beds of the Chalk. In Lincolnshire a stiff blue clay like the Oxford Clay. Round Chatteris it denotes very tough peat.

Counter Drain. A drain parallel with or "counter" to another drain.

Crike or **Creek.** An old watercourse filled up with silt. Crike is the ancient etymology, and is still in vogue.

Creachy. Clay full of stones. Applied to Boulder Clay in Lincolnshire.

Clow. A dam.

Croft. Enclosed lands on border of a stream. As the "crofts" on the Old Well River.

Dales. Low land bordering a river. Used only on the Witham.

Dales. In the Isle of Ely a corruption of *Delf*, a drain. As Swasdale.

Delf. An old Saxon term for drain. As King's Delf. Also a minor drain outside the bank of a main drain.

Dicey. Breaking into cuboidal pieces. Applied to clay. Used only in Lincolnshire.

Dyke. A drain. Originally a bank made by *digging* out the soil and piling it up. Now used to signify the hollow made, *i.e.*, the drain. An old term which has obtained its present meaning probably from the fact that all the original drains were banked or dyked.

Drove. An open roadway as distinguished from a *made* highway.

Drowned. Covered with water. Fens are "drowned," and Dugdale, speaking of a funeral procession which came to grief otherwise than was intended, says, "the corpse was drowned"!

Ea, Ee, or **Eau.** A stream or drain.

Eagre, Hygre, Aigre or **Aeger.** The bore in the fen rivers.

Fly-tool. A large, broad, leaf-shaped iron tool used for cutting the sides of drains. This seems to have been the shape of the old "dreyners" tools as one is borne by a figure serving as one of the supporters to the amrs of the Bedford Level Corporation.

Galt or **Gault.** Hard blue clay, such as Kimeridge clay, as distinguished from soft fen clay. Near Donington the term is applied to the warp.

Gote, Gout, or **Cote.** A sluice with doors. From *go out*. (Query hence *Gate*). As Guthram Cote, Symonds Gote.

Ground. Equivalent to field. The grounds are bounded by dykes and no hedges.

Grundgole. A hole (*gull*) made by the water on breaching a bank. Dug., p. 293.

Gravel. A bank across the bed of a river to hold the water up, *e.g.*, Northey gravel, Whittlesea. See *Hards*.

Haffs. Water-plants that choke up a dyke.

Hards. Used in the same sense as "gravels," which see, Dug., p. 400.

Hards. Highlands in the neighbourhood of the fens. Distinguished from being *hard*, or not liable to become boggy. Used in the Isle of Ely, as Soham Hards. Also occasionally used in the same sense as *Gravels*, which see, as in Dug., p. 400.

Hassock. The great tufts of *Carex Paniculata* which once abounded in the undrained fen. They were often used as stools in the neighbouring churches: hence the term hassock as applied to footstools? Cutting the clumps, which were sometimes seven feet high, away was termed hassocking. Hassocks are now extinct save near Eriswell and Wangford.

Highland. The high land as distinct from fen land.

Hirne or **Hurn.** Saxon for *a turning*, or bend. As Guyhirn, Leake Hurn.

Hod. The amorphous lumps of peat in which the top portion comes away. See *Cess*.

Holl. A dyke. ? Relation to Holland. Still used in South Levels.

Holt. A line of trees along a dyke.

Indikes. Protecting banks. Seemingly only used in Marshland.

Ings. Meadow lands? As Donington Ings.

Lake. A small shallow pool in the peat. Often merely a temporary lodgment of flood water.

Lid or **Lead.** Saxon term for coarse fodder, *Poa aquatica*, cut in the washes. Still in use.

Meer or **Mere.** A lake.

Moor. Peat, especially when thin and decomposed.

Outgang. The road or drove leading from a village into the fen. Only used in South Holland. As Baston Outgang.

Rampar. Allied to *rampart*. A raised highway in the fen. In Lincolnshire also applied to the highways in the highlands.

Rind. The border land. "Rind of Marshland." Dug., p. 275.

Roading. Clearing a river or dyke of weeds.

Roddam. Sandy silt. Used only in the Isle of Ely.

Surrounded. Covered with water. Not used, I believe, later than the 17th century. Equivalent to drowned, or flooded.

Sasse (Dutch, *sas*). A sluice, or lock.

Several. Land which is private property, as distinguished from common land. The same word is used in legal phraseology, "All and several."

Slaker, Syke. "A place for water to bed in." (Dugdale.)

Tip-tool. A wooden, iron-bound, narrow, T-handled spade used for dyking.

Turf. Peat. The word peat is unknown, save where education has modernised the tongue of the aborigines.

Undertaker. The actual master-drainers of the fens, who "undertake" and are paid for the work. See *Adventurer*. The undertaker was sometimes the adventurer also.

Waded. Weeded, *i.e.*, cleared of weeds.

Wind Catches. Floods caused by the wind holding up the water.

Wopenny. A fine for neglecting banks, &c. Dug., p. 293.

APPENDIX I.

LIST OF FOSSILS FROM THE OOLITE CLAY BENEATH THE FENS, THE COMBINED OXFORD AND KIMERIDGE CLAYS; FROM THE COLLECTION OF MR. S. SMITH OF WISBECH. BY R. ETHERIDGE, F.R.S., PALÆONTOLOGIST TO THE GEOLOGICAL SURVEY.

*** The points thus . . . indicate the absence of the species from the particular locality or formation.

Species.	*Whittlesey.*	*Ramsey.*	*March.*	*Tattershall.*	*Downham.*	*Ely.*	*Oxford Clay.*	*Coral Rag.*	*Kim. Clay.*	*Portland Beds.*
Serpula tetragona, *Sow.* -	.	.	×	×	.	.	—	.	—	
„ variabilis, *Sow.* -	.	.	×	.	.	.	.	.	—	—
Terebratula - - - -	×									
Rhynchonella inconstans, *Sow.*	.	.	×	.	.	.	.	.	—	
„ varians, *Schloth.*	×									
Exogyra virgula, *Defr.* - -	.	.	.	.	.	×				
Gryphæa dilatata, *Sow.* - -	×	.	×	.	.	.	—	—	—	
Ostrea deltoidea, *Sow.* - -	.	.	×	.	.	.	.	.	—	
Hinnites velatus, *Goldf.* -	.	.	×	.	.	.	.	—	—	
Avicula inæquivalvis, *Sow.* -	.	.	×	.	.	.	.	—		
Astarte ovata, *Smith* - -	.	.	×	.	.	.	.	—	—	
„ aliena, *Phill.* - -	.	.	×	.	.	.	.	—	—	
„ carinata, *Phill* -	.	.	×	.	.	.	—			
„ Hartwelliensis, *Sow.* -	.	.	.	×	.	.	.	.	—	
Arca æmula, *Phill.* - -	.	.	×	.	.	.	.	—	—	
Trigonia clavellata, *Sow* -	.	.	.	.	.	×	—	—	—	
Cerithium - - - -	.	.	×							
Pleurotomaria reticulata, *Sow.*	.	.	×	.	.	.	.	—	—	
Ammonites Lamberti, *Sow.* -	×	×	×	.	.	.	—	.	—	
„ perarmatus - -	×	.	.	.	.	.	.	—	—	
„ Duncani, *Sow.* -	×	.	.	.	.	.	—	—	—	
„ calisto, *D'Orb.* -	.	.	×	.	.	.	—	—		
„ Jason, *Rein.* -	×	.	.	.	.	.	—			
„ biplex, *Sow.* -	×	×	×	.	.	.	.	.	—	..
„ athletus, *Phill.* -	.	.	×							
„ Kœnigi, *Sow.* -	.	.	×	.	.	.	—			
„ Achilles, *D'Orb.* -	.	.	×	.	.	.	.	.	—	
„ Mariæ? - -	.	.	×	.	.	.	—			
„ mutabilis, *Sow.* -	.	.	×	.	.	.	.	.	—	
„ Eupalus, *Sow.* -	.	.	×	.	.	.	.	.	—	
„ Bakeriæ, *Sow.* -	.	.	×	.	.	.	—			
„ Eumelus, *D'Orb.*	.	.	×	.	.	.	.	.	—	
Trigonellites - - -	.	.	×	.	.	×	.	.	—	
Belemnites hastatus, *Montf.* -	.	.	×	.	.	.	—			
Plesiosaurus (centra) - -	×	.	×	.	.	.	—	.	—	
Pliosaurus („ and femur)	.	.	×	.	.	.	—	.	—	
Asteracanthus ornatissimus, *Ag.* - - - - -	.	.	.	.	×	.	.	.	—	
Pycnodus - - - -	.	.	.	.	×	.	.	.	—	
	9	2	27	4	2	3	11	11	25	2

APPENDIX K.

LIST OF SPECIES FROM THE FENLAND STRATA.

From data supplied by Mr. A. Bell from his own collection and that of Mr. Devick; by Mr. F. W. Harmer from his own collection; by Mr. A. Grugeon; the published lists of Prof. H. G. Seeley, F.G.S., and from specimens collected by the Author.

REVISED BY ROBERT ETHERIDGE, F.R.S.

GRAVEL.

A. Old Gravels of Palæolithic Age.

1. *Marine Species.*

Mollusca.

(*Polyzoa.*)
Flustra.

(*Brachiopoda.*)
Rhynchonella psittacea. *Chem.*

(*Lamellibranchiata.*)
Astarte borealis. *Chem.*
——— compressa. *Mont.*
——— elliptica. *Brown.*
——— sulcata. *Dacosta.*
Cardium edule. *Linn.*
Corbula gibba. *Olivi.*
——— nucleus. *Lam.*
Cyrena (Corbicula) fluminalis. *Müll.*
Cyprina Islandica. *Linn.*
Mactra ovalis. *Sow.*
——— solida. *Linn.*
————— var. elliptica.
Modiola modiolus. *Linn.*
Mya arenaria. *Linn.*
—— truncata. *Linn.*
Mytilus edulis. *Linn.*
Nucula nucleus. *Linn.*
Ostrea edulis. *Linn.*
Pholas dactylus. *Linn.*
Scrobicularia piperata. *Bellon.*
Tapes pullastra. *Mont.*
Tellina Balthica. *Linn.*
——— lata. *Gmelin.*

(*Gasteropoda.*)
Aporrhais pes-pelicani. *Linn.*
Buccinum undatum. *Linn.*
Dentalium costatum. *Sow.*
Lacuna crassior. *Mont.*
——— divaricata. *Fab.*
Littorina littorea. *Linn.*
——— obtusata. *Linn.*
——— rudis. *Maton.*
Nassa nitida. *Jeff.*
——— reticulata. *Linn.*
Natica catena. *Da Costa.*
——— helicoides. *Johns.*

Pleurotoma (Mangelia) pyramidalis. *Ström.*
——— rufa. *Mont.*
——— turricula. *Mont.*
Purpura lapillus. *Linn.*
——— ——— var. imbricata.
Rissoa (Hydrobia) ulvæ. *Penn.*
Scalaria communis. *Lam.*
Trochus cinerarius. *Linn.*
Trophon antiquum. *Müll.*
——— clathratum. *Linn.*
——— truncatum. *Ström.*
Turritella communis. *Risso.*
——— terebra. *Linn.*

2. *Estuarine Facies of the Gravel.*

PLANTÆ.
Chara.

ANIMALIA.
Mollusca.
(*Lamellibranchiata.*)
Sphærium (Cyclas) corneum. *Linn.*
——— calyculata?
Cyrena (Corbicula) fluminalis. *Müll.*
Pisidium amnicum. *Müll.*
——— Henslowianum. *Shep.*
——— pulchellum. *Jenyns.*
Unio littoralis. *Lam.*
——— pictorum. *Linn.*
——— tumidus. *Retz.*

(*Gasteropoda.*)
Ancylus fluviatilis. *Müll.*
——— lacustris. *Linn.*
Bythinia tentaculata. *Linn.*
Carychium minimum. *Müll.*
Clausilia biplicata. *Mont.*
——— rugosa. *Drap.*
Cochlicopa (Azeca) tridens. *Pult.*
Helix arbustorum. *Linn*, and several vars.
——— concinna. *Jeff.*
——— ericetorum. *Müll.*
——— fruticum. *Müller.*
——— nemoralis. *Linn.*
——— pygmæa. *Drap.*
——— pulchella. *Müll.*
——— rufuscens. *Penn.*
——— rotundata. *Müll.*
(*Zonites*) cellarius. *Müll.*
——— fulvus. *Müll.*
——— nitidulus. *Drap.*
——— nitidus. *Müll.*
——— radiatulus. *Alder.*
Hydrobia marginata. *Mich.*
Limnæa auricularia. *Brard.*
——— palustris. *Müll.*
——— peregra. *Müll.*
——— truncatula. *Müll.*
Planorbis carinatus. *Müll.*
——— contortus. *Linn.*
——— complanatus. *Linn.*

Planorbis glaber. *Jeff.*
——— nitidus. *Müll.*
——— spirorbis. *Müll.*
——— vortex. *Linn.*
Pupa marginata. *Drap.*
—— umbilicata. *Drap.*
—— pygmæa. *Drap.*
—— Moulinsiana. *Dupuy.*
Succinea putris. *Linn.*
Valvata cristata. *Müll.*
——— piscinalis. *Müll.*
——— *var.* antiqua. *Morris.*
Vertigo (Pupa) antivertigo. *Drap.*
Cochlicopa (Zua) lubrica. *Müll.*

Aves.
Cygnus ferus?

Mammalia.
Bos longifrons. *Owen.*
„ primigenius. *Bojanus.*
Cervus megaceros. *Hart.*
Elephas antiquus. *Falc.*
„ primigenius. *Blum.*
Equus caballus. *Linn.*
Felis leo, *var.* spelæa. *Goldf.*
Hippopotamus major. *Desm.*
Rhinoceros antiquitatis. *Blum.* (R. tichorhinus. *Cuv.*)
Sus scrofa. *Linn.*

B. Fen Beach and Floor Gravel.
Unfossiliferous.

PEAT.

PLANTÆ.
Betula alba. *Linn.*
Nana. *Linn.*
Chara.
Conferva.
Fagus sylvaticus. *Linn.*
Fraxinus.
Hydrodyction utricularis.
Hypnum acetabulum?
„ fluitans. *Dill.*
„ filicinum. *Vill.*
Juncus aquaticus.
Lastrea.
Pinus sylvestris. *Linn.*
Quercus robur. *Linn.*
Salix caprea. *Linn.*
„ repens. *Linn.*
Taxus baccatus. *Linn.*
Ulmus.

ANIMALIA.

Insecta.
Copris lunaris.
Donacea linearis.
Elater, sp.
Neuroptera, *indeterminable.*

Pisces.
Esox lucius. *Linn.*

Reptilia.
Emys lutraria Feltwell Fen .

Aves.
Ardea stellaris. *Linn.*
Cygnus musicus. *Becks.*
.. olor. *Gmelin.*
Fulica atra. *Linn.*
Pelicanus crispus, or P. onocrotalus. *McEnes.*
Podiceps cristatus. *Linn.*
Querquedula crecca. *Linn.*

Mammalia.
Bos longifrons. *Owen.*
.. primigenius. *Bojanus.*
Canis lupus. *Linn.*
.. vulpes. *Linn.*
Castor fiber. *Linn.*
Cervus capreolus. *Linn.*
,, elaphus. *Linn.*
,, megaceros. *Hart.*
.. tarandus. *Linn.*
Lutra vulgaris.
Martes abietum. *Gmelin.*
Sus scrofa. *Linn.*
Ursus arctos. *Linn.*

SHELL MARL.

PLANTÆ.
Chara.

ANIMALIA.
Mollusca.
(*Lamellibranchiata.*)
Sphærium (Cyclas) corneum. *Linn.*
Pisidium amnicum. *Müll.*
(*Gasteropoda.*)
Bithinia tentaculata. *Linn.*
Lymnæa auricularia. *Brard.*
,, perègra. *Müll.*
,, stagnalis. *Linn.*
Planorbis complanatus. *Linn.*
,, spirorbis. *Müll.*
Succinea putris. *Linn.*
Cochlicopa (Zua) lubrica? *Müll.*

SILT.

PROTOZOA. Foraminiferæ, very plentiful but not examined.
Mollusca.
(*Lamellibranchiata.*)
Cardium edule. *Linn.*
Mytilus edulis. *Linn.*
Ostrea edulis. *Linn.*
Pisidium amnicum. *Müll.*
Scrobicularia piperata. *Belton.*

(*Gasteropoda.*)
Bithinia tentaculata. *Linn.*
Helix pulchella. *Müll.*
Hydrobia (Rissoa) ulvæ. *Pen.*
Lymnæa peregra. *Müll.*
,, stagnalis. *Linn.*

Planorbis carinatus. *Müll.*
„ complanatus. *Linn.*
„ lævis. *Alder.*
„ vortex. *Linn.*
Physa fontinalis. *Linn.*
Valvata cristata. *Müll.*

Mammalia.
Balæna mysticetus. *Linn.*
Delphinus turtio. *Fabr.*
Orca gladiator.
Phoca vitulina. *Linn.*
Phocæna crassidens. *Owen.*
Trichecus rosmarus.

INDEX.

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