William Hayward's 1604 map of the Fens

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Hayward was commissioned to map the Fens and conduct a survey of land holdings, a cadastre, both of which he submitted to Commissioners of Sewers in 1605. They determined on a comprehensive drainage scheme for the peat fens that, although not implemented, closely resembled Vermuyden's scheme undertaken some decades later. The original map has been lost and we rely upon a 1727 manuscript copy of a 1618 copy of the 1604 document, at a scale of one inch to the mile. Scholars have not paid much attention to this seemingly incomplete map, largely, it would seem, because the purpose of the map as a planning tool has not been adequately recognised. Comparison with modern Ordnance Survey mapping shows that the 1604 map provides a commendably accurate representation of the waterways that can be matched and also the location of churches, which were presumably used for triangulation purposes. The map deserves to be more widely recognised as a valuable resource for studying the fenland waterways prior to the seventeenth century drainage works.

William Hayward was a notable surveyor whose professional life spanned almost fifty years from the late sixteenth century but little is known about the man and his life (Skempton *et al*, 2002, 308–309). Among the thirty-odd maps and plans attributed to him is the first map of the entire Fens, from the Ouse catchment in the east to the Welland in the west, generally dated 1604, and drawn at a scale of one inch to the mile, the map measuring 52×37 inches. Unfortunately, the original has apparently been lost and our knowledge is preserved as the 1727 copy by Payler Smyth of what appears to be an earlier copy. Subsequent unqualified references to the 1604 map are to the 1727 copy and a sample from the map is shown as Figure 1 (and Plate 4). Four other maps have been described as versions of the original (Silvester 2002), but inspection shows that these are more appropriately regarded as maps 'based upon' Hayward, not as renderings of the lost original.

The 1604 map has not hitherto been accorded the attention it deserves. Indeed, the list of Fenland maps published by Lynam (1936) in the Victoria History of the Counties of England dismisses the Smyth version as 'a very faulty copy', whereas a smaller scale map incorporating Hayward's survey, known as the Cotton map, he attributed to 1604 and describes as 'a very accurate, artistic and important map' (292 and 296). As will become apparent below, these assessments are mistaken.

The present paper has its origins in a study of the medieval network of navigable fenland waterways (Chisholm 2010). It was desirable to identify an early map as a point of departure that could be checked against place-name and other documentary evidence, for which purpose the earliest suitable proved to be Hayward's 1604 map of the Fens. One of the referees for the 2010 paper queried whether this was in fact the most appropriate rendering of Hayward's work and therefore the present paper examines that question in a manner not possible in the paper considered by the referee.

The purpose of the present paper, therefore, is to examine whether the 1604 map is indeed the most appropriate version of Hayward's work to use for enquiries about the Fens' rivers prior to drainage in the seventeenth century. Several issues will be discussed in the following order: the provenance of the 1604 map; the purpose for which it was drawn; the nature of the information portrayed thereon; a discussion of the other versions of the Hayward's work; and an assessment of the accuracy of the 1604 map.

Provenance of the map held by Cambridgeshire Archives

Cambridgeshire Archives (R59/31/40/1) holds Payler Smyth's copy of Hayward's map, drawn at a scale of one inch to the mile, covering the whole of the area generally known as the Fens. The map came to the Archives in 1959 from the office of the Great Ouse Catchment Board, successor to the Bedford Level Corporation and its predecessor bodies responsible for draining the Fens in the seventeenth century and then maintaining the drainage works. In 1727, the Corporation had commissioned Payler Smyth to make a copy of Hayward's work. Smyth claims that it is an exact copy of the 1604 map but, as Lynam (1934)

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***Figure 1**. Sample of Hayward's 1604 map at reduced scale of 0.6 inch to the mile, north to the right. Wisbech is at the right hand margin. See text for the straight dotted line shown bottom left. Reproduced by permission of Cambridgeshire Archives and Local Studies (R59/31/40/1). See also Plate 4.*

points out, there is an inconspicuous date of 1618 by the line scale, from which he infers the 1727 version was made from a copy dated 1618. The date occurs in the middle of the following text: 'A Scale of Milles Furlongs and Perches Ano 1618 at 16 ft Demie to ye Perch'.

So far as is known, the 1727 copy by Smyth is the only extant version of Hayward's map that is directly attributed to him. However, there is a record of other copies in existence in 1938 in the Fen Office of the Great Ouse Catchment Board at Ely. Palmer (1938) provides a selected list of the holding, derived from the inventory compiled by a Mr H I D Moore in 1934, beginning his account thus:

> *The chief treasures of the office are Payler Smith's copies of the maps of William Hayward, 1604, and Jonas Moore, 1654, both made in 1727. The list shows that the Fen Office has fifty-seven printed copies of Hayward's map ... The maps of 1604 and 1654 were thought to be originals until critically examined in recent years.* (Palmer 1938, 144.)

There then follows a listing of Hayward's maps that accounts for 54 of the 57 maps mentioned:

1. Five lithographed copies of Hayward's old map on canvas and 46 of the same on paper, giving a total of 51. These are described as maps of reduced size and of little importance.
2. A 'Plan of Fens by Hayward', 1604 on canvas.
3. A lithograph copy by Smyth of Hayward's survey (1604), 1727 on paper.
4. Hayward's original map of the Great Level undrained, 1604 on canvas.

The fourth item matches the description previously given by Fordham:

> *There is now hanging in the Fen Office a copy of Hayward's map described as "exact", by Payler Smyth, dated 1727* (Fordham 1908, ix).

Following this opening sentence, Fordham's, description precisely matches the map held by Cambridgeshire Archives, including the definition of a statute mile complete with the date 1618. No description of the second item on Palmer's list, 'A Plan of Fens by Hayward", has been found. As for the lithograph copies, these must be later than about 1798, because that was when lithography was invented (Singer *et al.* 1958, 626). With one exception, noted below, it appears that all these lithograph copies have also disappeared. Consequently, the focus of interest is the fourth item in Palmer's list, 'Hayward's original map of the Great Level undrained, 1604 on canvas'.

Fordham clearly recognised that the 1604 map is a copy, as did Palmer, and Lynam (1934, 1974) is right to point out that it was copied from a 1618 version. The inventory description of it as 'original' is to be interpreted as distinguishing the original copy from the other copies held at the Fen Office.

Fordham does not list any other Hayward maps at the Fen Office but a brief 1922 manuscript list of some documents there confirms the existence of the first three items recorded by Palmer and provides some useful further information relating to the fourth (Cambridgeshire Archives R.59.31). The map described by Fordham was hanging on the wall in the Board Room on rollers, described as 'Original Map of the Great Level (undrained) Hayward 1604'. Also included in this list is Moore's map, on rollers and hanging in the Office, listed as 'Original Map of Great Level (undrained) Moore 1654' (the Hayward copy noted by Palmer). This confirms that two maps, one each by Hayward and Moore, known to be Payler Smyth copies, were treated as originals to distinguish them from copies that must have been made after 1727.

Palmer based his list on a 1934 inventory re-arranged into three volumes, typed and bound (Tebbutt 1937). Volume three contains a list of maps that, for all practical purposes, contains material identical to the information reported by Palmer, including the error of identifying 3 above as a lithograph copy, instead of just 'copy', as in 1922. The map by Jonas Moore had been moved to the Board Room. As in 1922, the main Hayward map and the Moore map are described as 'original'. However, the 1937 list does not mention any Hayward maps other than the 54 listed by Palmer; presumably, therefore, Palmer's figure of 57 is wrong – the total should read 54.

The map acquired by Cambridgeshire Archives in 1959 is the map that hung on the wall, described above as 'original' (Philip Saunders pers. comm.). The Archives retain its box, which is clearly visible in a photograph of the Fen Office published by the Ministry of Agriculture and Fisheries (1948, 32), bearing the following title: 'Hayward's original map of the Great Level undrained 1604'. It is clear that Commissioners of the Bedford Level in 1727 considered Smyth's copy to be an accurate rendering of Hayward's original even though a 1618 version had, apparently, been used.

Skempton *et al.* (2002) suggest that the 1618 copy was made for the benefit of Atkins and Edmond, who in that year toured the Fens and submitted reports on the state of the waterways. Whether that was the case or not, the more relevant matter is that Hayward was still alive and active locally, subsequently becoming a Commissioner of Sewers. Therefore, it is reasonable to suppose that the 1618 version was accurately done, and it may be that it was a corrected map made by Hayward himself.

Some further brief comments about provenance are in order. First, Lynam (1936, 297) notes that the Ordnance Survey had reproduced Hayward's 1604 map. This must be a reference to the full-scale black-and-white photographic copy held by the British Library (BM Maps 1308. (9)). Another copy, in a very poor state, is held by the Wisbech and Fenland Museum, which also holds an unmounted lithograph copy, made by 'Martin Hood Lith. 8 Great Newport Street, London W.C.' (both maps catalogued as DII. 38); the scale of the lithograph is much reduced and the content simplified compared with the 1604 map. Presumably, the lithograph is one of the 46 unmounted lithographs noted by Palmer; if so, it is the only copy of any of Hayward's maps from the Fen Office

known to have survived other than the 1604 map held by Cambridgeshire Archives.

Lynam (1934, 1936) does not mention the other copies of Hayward's work at the Fen Office and evidently assumed that 'original' mistakenly meant original Hayward. This erroneous assumption is probably the basis for his dismissive assessment that Smyth had produced 'a very faulty copy' (Lynam 1936, 296). That assessment does not seem appropriate in the light of the preceding discussion. Given that Smyth also copied the 1654 map of the undrained Fens by Moore, it is clear the Commissioners wanted to preserve records of the area before the seventeenth century drainage works had been undertaken, and regarded the two maps made by Smyth as important documents for that purpose.

Purpose of the 1604 map

Although the existence of the Smyth map has been known for a long time (e.g. Fordham 1908; French 2001), scholars have hitherto been mainly interested in the route by which Hayward's work influenced later cartographers who published maps of the Fens, such as Hondius and Blaeu. Two other questions have been very largely ignored: what was the purpose for which the 1604 map was constructed; and what place did Hayward have in the development of surveying and cartography? For example, Barber's (2007) contribution to Woodward's monumental *The History of Cartography* emphasises the utilitarian nature of sixteenth and seventeenth century cartography in England, from defence of the realm to estate management, but altogether ignores Hayward and the potential significance of his work for large scale land drainage. Delano-Smith and Kain (1999, 80) mention the 1604 map but say nothing about its significance. Similarly, Darby's classic study of the draining of the Fens contains but one reference to the map, mentioning its location and part of the inscription but saying nothing about the map itself (Darby 1956, 30). In his later book (1983, 57 and Figs 31 and 32), he confuses the 1604 map with the reduced version drawn by Badeslade in 1724 (see below). At no point in either book does Darby discuss the nature and significance of the map made in 1604.

Recently, a start has been made in considering the context in which Hayward undertook his survey, its purpose and reliability, and therefore its significance in the history of the draining of the Fens. The earliest reference in this vein that has been identified is Silvester (1988–9, 40), who somewhat enigmatically notes that the map was made 'to accompany a survey of the Fens commissioned by Sir John Popham and others'. At the end of his essay, Silvester notes that:

> *It is through his efforts both drawn and written that the pattern of the southern fens was recorded and their reclamation and division plotted* (p. 42).

However the intervening text says nothing about the quality of the map, concentrating instead on the accompanying land and the survey Hayward undertook in 1636, of which Silvester notes that 'despite its inaccuracies' it was used for land allocations when the first drainage scheme was declared successful (p.41). The wording suggests that Hayward played an important role in the drainage of the Fens, but does so with tantalising brevity, and with the implication that the 1604 map is not reliable.

Willmoth has but three fleeting references to Hayward in her 1993 book about Sir Jonas Moore, whereas a 2009 paper contains several paragraphs, in which she emphasises the importance of his survey and the accompanying details of bounds and acreages:

> *Which became the basis for legal definitions of the Fenland as a drainable territory and hence the basis for the financial system and land redistribution that made wholesale drainage schemes possible. This unusual legal significance of the bounds gives Hayward's map and its successors a particular power. (Willmoth 2009, 14–15.)*

Skempton *et al*. (2002) take matters a major step further by drawing attention to Hayward's role in working with John Hunt in the years 1604 and 1605, thereby emphasising the role Hayward played in planning a comprehensive drainage scheme for the peat Fens. Hunt was a Commissioner of Sewers for the counties of Cambridge and Lincoln who, following the General drainage Act 1600, began exploring the feasibility of a comprehensive drainage scheme for the Fens. After his preliminary investigations, he informed King James I that more than 200,000 acres could be improved by drainage. In July 1604, the King appointed Hunt and Henry Totnall (and those they might employ) 'to take a view' of the Fens within precisely defined boundaries, boundaries that must have been supplied by Hunt. The King desired the Commissioners of Sewers for the Isle of Ely and six counties to assist them in their work. Meeting in July 1605, the commissioners received from Hayward 'The true Content or Number of acres in the Fens described in the general Plot …' (Dugdale 1772, 382). Smyth's 1727 copy of Hayward's map uses the same term, 'general plot', and includes an abbreviated account of the Fen boundaries as set out by James I. Smyth's map must, therefore, be a copy of the 'plot' submitted to the Commissioners in 1605.

Having received material from Hunt and Hayward, the Commissioners immediately decided to proceed, ordering Sir John Popham and three other named individuals to embark upon a comprehensive drainage scheme, to be completed within seven years. Although the project was soon abandoned, the scheme proposed by Hunt was:

> *A comprehensive and ambitious plan, and deserves to be recognised as the first design for a general draining of the Great Level … [bearing] a remarkable resemblance to the work actually carried out between 1631 and 1636* (Knittl 2007, 44; see also Dugdale 1772, 383–384).

The close similarities extended to the scheme undertaken from 1649. One feature of Hunt's scheme relevant in the present context is the proposal to dig a

new channel or channels from Earith to near Salter's Lode, providing 120 feet of waterway, to shorten the Ouse.

So far as is known, the scheme adopted by Commissioners of Sewers in 1605 was the first seriously practical comprehensive scheme to be proposed although, as Singer *et al.* (1957, 317) point out, Humphrey Bradley had suggested a comprehensive scheme in 1589. However, his proposal consisted of straightening the main rivers and directing waters to the main outfalls, 'without recourse, as he said, "to embankments, machinery, mills and inestimable expense"'.

Contents of the map

Considered in the context discussed above, it is appropriate to review the nature of the information contained in the Smyth version of Hayward's survey, starting with the significance of the written definition of the statute mile that has already been noted. The 'mile' used to be an uncertain measurement because there were several usages and it was only in 1593 that the 'statute mile' was defined by Act of Parliament (*Encyclopedia Americana* 1990, vol. 19 106). Therefore, the inclusion of the precise definition with the line scale amounts to a declaration that the survey had been done to a high standard using an exact unit of measurement. This is an implicit statement that the accuracy of the map could in principle be checked by anyone so minded and, more important in the present context, that accurate measurements could be taken from the map, something of considerable importance if it were to be used for practical planning purposes. Presumably, therefore, the original 1604 map included the written definition, which was then reproduced by the author of the 1618 copy. This presumption seems to be consistent with Hayward's practice of precision: his 1591 map of Marshland (Cambridge University Library, Atlas. 0.019.5) carries a double line scale, separately showing perches and furlongs, with 40 perches to a furlong and three furlongs to the inch (giving 2.66 inches to the mile); and his 1605 map of Outwell carries a line scale and a written definition, in perches and furlongs (Wisbech and Fenland Museum TMN.648).

The 1604 map is first and foremost a map of the watercourses and embankments – river banks, banks bounding fens, and sea banks; banks 'for more particular purposes' are shown separately. Second, it identifies the areas subject to flooding and the 'dry' uplands surrounding the fen basin and forming 'islands' within. Third, settlements are shown but generally they are not emphasised, though churches are prominently recorded even in areas otherwise lacking in detail. Fourth, causeways, public paths along watercourses and bridges are shown, but are not emphasised. Fifth, no attempt is made to portray the silt fens of Cambridgeshire and Holland in Lincolnshire, other than the churches, although Norfolk Marshland is shown in some detail. Because Hayward had surveyed Marshland in 1591 at one inch to three furlongs, or 2.66 inches to the mile, it was easy for him to include information for this part of the silt fens; the absence of information for the remainder of the silt lands suggests that this was not deemed necessary for the purpose in hand in 1604–5. Finally, the seaward limit is represented by the sea banks, with the salt marshes extending for an indeterminate distance to the coastline, which is not shown.

There is an important detail on the 1604 map tending to confirm it was indeed a working tool for drainage purposes. There is one dotted line that is unlike anything else on the map, running as a straight line from Earith to Salter's Lode, near what is now Denver Sluice. This alignment exactly matches that of the Old and New Bedford Rivers, the shortening of the Ouse critical for carrying upland water across the Fens, as agreed in 1605 and subsequently implemented in the 1630s and early 1650s. There are other dotted lines on the map that represent causeways (each with a parallel solid line) and land routes alongside watercourses (on embankments). The Earith-Salter's Lode line cannot represent a land route if for no other reason than it crosses and re-crosses waterways. Although one cannot exclude the possibility that Smyth added this line, it was probably included either on the 1604 original or by the cartographer who made the 1618 copy, for the reason that Hunt proposed the new cut and Commissioners of Sewers agreed in 1605.

The other maps identified by Silvester

Among the maps noted by Silvester (2002), there are two drawn at a scale of one inch to the mile, but neither of these fully replicates the information contained in the 1604 map. The National Archives at Kew hold a map (MPB 1/9) that originated from the Exchequer, with an ascribed date of about 1611. This map covers a smaller area than is encompassed by the 1604 sheet, bears no title or signature and gives no attribution for the source or sources used; there is a line scale but no written definition of the mile, and there is no key. The cartography is rather crude, detail shown on the 1604 map is not included, and there are some obvious differences from Hayward's 1604 map, of which only one need be mentioned. The Ouse between Ely and Prickwillow is shown following a markedly sinuous course all the way, whereas the 1604 map correctly shows a virtually straight alignment for the first half of the distance downstream from Ely (the course of the river as diverted in the early twelfth century).

The second one inch to the mile map is held by Cambridge University Library (MS Plan 589). The provenance is unknown, it is not dated, is not signed and has no key beyond the line scale, and it does not include the verbal definition of the statute mile found on the Smyth version. These details may have been included on that portion of the map at the left (south) that has evidently been removed, leaving a convex edge. Although it is obvious that the cartographer had access to Hayward's work, the map is patently

not an exact copy of the 1604 map; for example, the 'islands' within the Fens are presented in very generalised terms, whereas the 1604 map provides precise detail of the upland bounds. Other differences are the inclusion of some coastline and detail for the Holland division of Lincolnshire not shown by Smyth, and conversely the omission of some watercourses.

The other two maps are at scales substantially smaller than one inch to the mile. The earlier one is generally known as the Cotton map (British Library, Cotton Augustus I.I. 78), having been acquired for his collection by 1629, when the library was closed by order of the King (Sharpe 1979, 80). Drawn at a scale of half an inch to the mile, as shown by a simple line scale, the map has no title and neither the cartographer nor the sources are declared. Although recognisably derived from the work embodied in Smyth's map, it differs in covering a much larger area, including the coastline to the north, and extending further south and east into the uplands, which are graced with the graphic symbol for hills, as is the fenland ridge upon which Stretham and Haddenham stand, a usage familiar in the sixteenth and seventeenth centuries with the work of Saxton and Speed but not employed on the 1604 map, only colour shading being used.

The map bears no date but is said to have been made for Sir Robert Cotton, one of the Commissioners for Sewers in the period 1603–05 (Lynam 1936, 292; Skempton *et al*. 2002, 309). The British Library's online Integrated Catalogue (18 May 2011) states that the map was drawn about 1604, with the query 'after William Hayward?' No attribution is given for this dating. However, a new Catalogue of Archives and Manuscripts is being compiled to replace the existing catalogue (Julian Harrison, pers. comm.) and the entry for the Cotton map (18 May 2011) gives the following as the date '1st quarter of the 17th century'. There is no bibliographical reference for this revised dating.

Lynam (1934) attacks Hayward's 1604 map for 'incorrect' spelling of place-names, citing seven instances where the spelling is 'correct' on the Cotton map; all the variations are phonetic variants, something that should occasion no surprise for the early seventeenth century. He goes on to note that the Cotton map twice records Sir John Willoughbies, whom he identifies as Sir John Willoughby, who was knighted in July 1603 and died in January 1605, claiming that therefore the Cotton map was drawn in that period. Lynam does not consider an alternative explanation, that the Cotton map was drawn later and contains outdated information. Lynam (1934, 421) claims that the Hayward and Cotton maps are 'strikingly similar' but this is not so. The Cotton map is a cartographer's map, whereas Hayward's is the map of a surveyor. The Cotton map incorporates Hayward's topography, waterways, churches, and land ownership information that could only have come from Hayward's property survey completed in 1605, all the result of work commissioned in July 1604. In addition, the Cotton map extends the area beyond that needed for planning a drainage scheme, implying considerable further survey work. To assign a 1603 or 1604 date for the Cotton map is difficult to accept. The safe conclusion is that the Cotton map was drawn some time after Hayward had completed his 1604 map and survey, which were presented to Commissioners of Sewers in 1605, and before 1629, a conclusion consistent with the British Library's revised assessment.

The last map to consider was drawn in 1724 and first published in 1725 (Badeslade 1766, facing p. 15). Badeslade claims that his map is a copy of the 1604 map but this is not true. It is drawn at a scale of about one third of an inch to the mile and he records detail that was not included on the 1604 map notably for the Holland division of Lincolnshire and areas west of the Welland, plus the salt marshes and coastline beyond the sea walls. On the other hand, it appears that his reduced scale cartography faithfully reproduces most of the topographic features shown on the 1604 map, albeit with the reduction in accuracy and detail associated with the scale reduction. It is clear that Badeslade had access to the same material used by Smyth, and the coincidence in timing prompts the following speculation. Denver Sluice had 'blown up' in 1713 and there was a very vigorous debate as to whether it should be re-built. Badeslade was a strong opponent of Vermuyden's drainage scheme, his 1725 text (re-issued in 1766) being an extended polemic advocating the restoration of the 'natural' watercourses and no re-building of Denver. It seems likely that the Commissioners for the Bedford Level were aware of Badeslade's opinion and decided that they needed a full scale copy of Hayward's map (and the 1654 map by Moore) to assist arguments for re-building Denver Sluice, which was in fact resurrected in 1746–50 (Skempton *et al*. 2002, 397).

Note that all four maps considered above omit the straight dotted line on the 1604 map that runs from Earith to near Denver, marking the line of the Ouse diversion agreed (but not implemented) by Commissioners of Sewers in 1605.

From this brief review, it is clear that only one map can claim to represent the map originally drawn by Hayward in 1604, and that is the copy made by Smyth. Not one of the other four can be accorded a status higher than 'based upon' his work. Both the Badeslade and Cotton maps appear to include a good copy of Smyth's rendering of Hayward's work, but the substantially smaller scale renders them less useful as a research tool for the historical evaluation of the fenland waterways than the Payler Smyth copy held by Cambridgeshire Archives.

Is the 1604 map an accurate record?

So far as is known, nobody has directly tested the accuracy of Hayward's 1604 map, although there are two partial evaluations, one implicit and the other explicit. The implicit test derives from his survey of property bounds in the Fens, given to the Commissioners of Sewers in 1605, which yielded a

total of 307,242 acres (Dugdale 1772, 383). Some thirty years later, in 1636, he re-visited the problem, obtaining a figure of 312,668 acres, including an item for 797 acres for which no geographical location is given (Wells 1830, 233). If we assume that the second figure is more reliable than the first, then the total land area error in 1605 was 1.8%. This may show the 1604 map to have been surveyed with considerable precision, or that substantial errors were largely compensatory in nature. Silvester (1988–9) draws attention to inaccuracies in the 1636 survey of land areas, his source being Wells (1830, 243). Problems emerged when 95,000 acres were being allocated to Francis, Earl of Bedford, to recompense him for the cost of land drainage, the scheme at that time being judged successful. As Wells notes, some of the land allocations were challenged:

> *Commissioners have discovered sundry errors and inequalities in the said allotment or setting forth of the said ninety-five thousand acres … by reason of some mistakes in a survey before that time made of the said great level.*

The tenor of these comments implies that the 'mistakes' were neither numerous enough nor sufficiently serious to call in question the survey as a whole. Therefore, it seems reasonable to accept the 1636 figure of 312,668 acres as a reliable measurement of the total area for comparison with the earlier figure. The second test of Hayward's work is reported by (Silvester 2002, 14), that overlaying his 1591 map of Norfolk Marshland on a modern map shows Hayward to have been accurate, accuracy being a matter of visual judgement. If he worked accurately for that assignment, there is every reason for supposing he could do a good job on the larger enterprise. Our purpose, therefore, is to test whether that expectation is confirmed when tests are applied to the whole of the 1604 map.

Waterways

The initial focus of attention is the accuracy with which the watercourses are drawn, since it is clear that this was the matter of greatest concern in planning a drainage scheme. To make the comparison, it has been necessary to select those channels depicted by Hayward for which there is cartographic evidence shown on the OS Digimap base at 1:50,000, which omits some minor watercourses shown on the printed Landranger series. The OS evidence ranges from existing watercourses and relic drains to indirect evidence of former channels, such as roads, footpaths and county boundaries. Roads and footpaths may seem odd, but remember that river embankments provided dry avenues for pedestrians, those on horseback and stock; though not originally suitable for wheeled vehicles, in some circumstances they lent themselves to the construction of modern roads even though the channels themselves may no longer figure cartographically. The southern boundary of Lincolnshire is important because it was established in Saxon times along watercourses (see Astbury 1957, Fig. 2; Stenton 1971, 502), providing evidence for parts of Old South Eau and Shire Drain for comparison with Hayward's mapping..

The precision of this comparison is limited by a number of considerations, itemised below in no particular order of importance:

- We do not know the projection used by Hayward.
- His compass north orientation understandably differs from the present, because of movements in the position of the magnetic poles, and needs to be corrected.
- The process of copying is bound to introduce some error.
- The materials on which the original map and the copy or copies were drawn may have been unstable.
- A digital photographic copy of Smyth's version has been used for this comparison, and this may have introduced some distortion.
- It is possible that the position of watercourses was accurately surveyed in 1604 but the channels may have moved subsequently, either for natural reasons or because of human intervention.
- Roads and paths along embankments may diverge from the watercourse if the embankments were set away from the channel, leaving a washland for flood storage.

Given these considerations, and the scale of the 1604 map, it does not seem appropriate to adopt a formal quantitative comparison along the lines reported by Bendall (1992, 54–61). Instead, we have relied upon a visual cartographic comparison undertaken by Stickler, a professional cartographer, using the procedure described below, and the results are shown in Figure 2.

The procedure used for comparing Hayward's map of waterways with modern OS information was as follows. Cambridgeshire Archives had made available an electronic copy of the 1604 map at the original scale, in raster format, which was copied – or 'traced' – by hand, using a digital light pen in Adobe Illustrator graphics software. Hayward drew his map with north to the right, which in modern usage is reserved for the easterly orientation. Therefore, to conform to current practice adopted by the OS, the Hayward copy was rotated by 90° anticlockwise. Next, an extract was obtained from the OS 1:10,000 digital map, giving a second layer, to be combined with the Hayward layer, and exported to Illustrator vector format, with appropriate scale adjustment.

Then, for reasons to be explained below, Ely was chosen as the common reference point for locating the two maps. With a little experimentation, it became clear the Hayward map should be rotated by a further 6° about Ely, making a total rotation of 96°. This further adjustment was selected as providing the best fit between Hayward and the OS, judged by eye. The need for this additional rotation arises primarily from the variation over time that is known to exist in magnetic north and the convention adopted by the OS for relating grid north to true north (grid north is east of true north).

Figure 2 shows that there is no significant systematic error in Hayward's map. There is a good fit

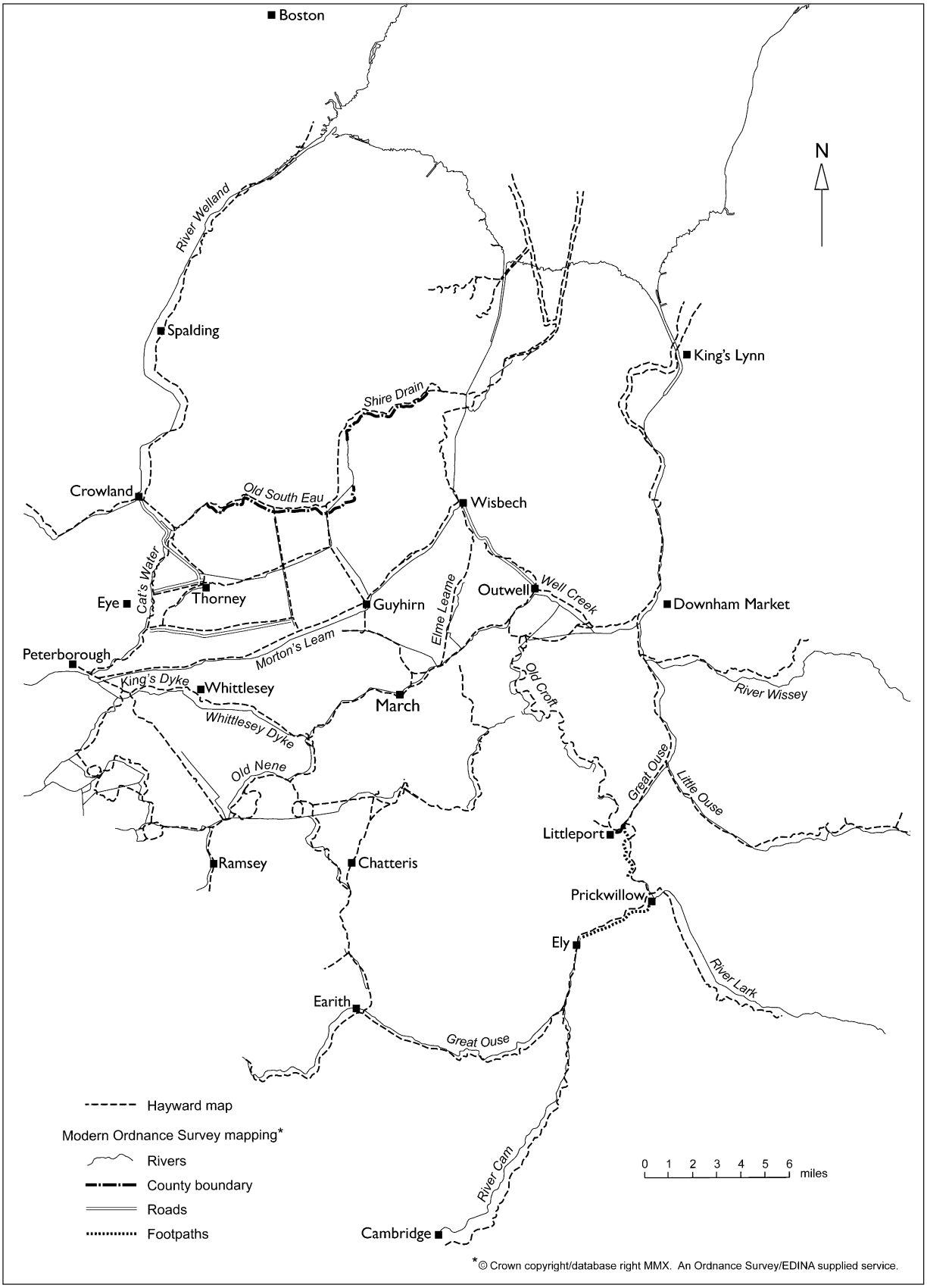

***Figure 2**. Hayward's 1604 waterways compared with modern Ordnance Survey cartography. NB The former course of the Ouse from Prickwillow to Littleport is represented on the OS base in part as the channel of the Lark and in part by a footpath.*

between his mapping and that of the OS through the greater part of the Fens from the Ouse near Ely to the lower reaches of the Welland, although there are some local divergences. The main discrepancies are: along the eastern borders, most notably for the Wissey and the Cam; and the Nene and Ouse outfalls, reflecting the dynamic nature of coastal processes and deliberate human intervention. For the area of concern in 1605, the peat fens (roughly the area between Wisbech, Ely, Earith, Peterborough and Thorney), Hayward's map provides a generally accurate portrayal of the watercourses, fully adequate for planning a comprehensive drainage scheme.

Triangulation and the churches

Let us now briefly consider the problem of triangulating the Fens. During the sixteenth century, European scholars and practitioners developed the concept of triangulation and the practical tools required for the purpose, including forerunners of the modern theodolite for measuring horizontal angles, and the plane table (Barber 2007; Bennett 1987; Lingren 2007; Richeson 1966; Singer *et al.* 1957). These developments were available to surveyors in England in the second half of the sixteenth century. Hayward had already surveyed Norfolk Marshland at 2.66 inches to the mile, this survey extending beyond Marshland as far south as Littleport (Skempton *et al.* 2002 mistakenly state that the survey was carried south to Ely). In addition, Hayward may have used John Hexham's 1589 map of the area covering Ramsey and Peterborough to Wisbech and the Welland, at a scale of 9.5 inches to five miles, or 1.9 inches to the mile (a reduced reproduction is contained in Skelton and Summerson 1971). Consequently, he had a good basis for extending his work across the Fens.

The prominence of churches on Hayward's map has already been remarked. It is also noteworthy that these buildings are recorded outside the area of interest defined by King James – the northern silt fens, along the eastern and southern margins and, to a lesser extent, beyond the Welland to the west. Their towers would have provided obvious triangulation points, possibly supplemented by temporary observation towers in the manner used in 1533 for a survey of towns near Brussels and Antwerp (Lingren 2007, 483), and we may infer that churches outside the peat fens are included for the following reasons. First, within the area defined by the King, churches were relatively few and the inclusion of the 'external' churches would have permitted a more accurate triangulation than would have been possible if restricted to the area contemplated for drainage. Second, once the extended triangulation had been completed further survey work would have been undertaken using plane tables and chains. Having fixed the positions of the external churches, surveyors would have had an enhanced choice of churches to use, thereby increasing the accuracy of the ground-based survey.

Ely cathedral would have been a prime vantage point, close to Littleport, which marks the southern limit of his 1591 Marshland survey. From Ely's tower, on a good day, one can see Boston stump on the other side of the Fens (Michael Young, pers. comm.), and this landmark is shown as the north-western extremity of the 1604 map. It is reasonable to assume that considerable care was taken to establish Ely's location accurately and therefore Ely was chosen as the reference point for locating Hayward's map over the OS underlay in compiling Figure 2.

Other than Littleport, the most southerly churches on Hayward's 1591 map are Downham Market and Denver on the eastern uplands, and Outwell and Upwell within the Fens. His triangulation could have been extended southwards to include Ely and Sutton, which has a very high tower. With these churches fixed, he would have been able to incorporate the whole of the rest of the Fens, converging on Boston along the silt Fens in the north and from the south and west. Adjustment would have been made for any closing error on Boston.

Such a procedure implies confidence in the measured baseline used for the 1591 survey. An alternative procedure would have required measuring a new baseline, which almost certainly would have included Ely, enabling the 1591 survey to be incorporated. Either way, it would have been impossible to obtain an exact horizontal distance between the pair of primary churches by chain over the distance that would have been involved. Therefore, Hayward probably identified a flat area of land across which a straight line of adequate length could be reliably measured, suitably near the two churches he had selected. If observation towers were built over both ends, and maybe elsewhere, a local triangulation could have been run that incorporated the two buildings to obtain an accurate distance between them for use as the base line for extending the triangulation.

The inference that churches were used as triangulation points invites the following question. For testing the accuracy of Hayward's map, why not compare the locations of the churches shown by Hayward with the locations recorded by the OS in 2010? The first problem is that churches portrayed by Hayward are schematic elevations, generally measuring at least 0.2 of an inch horizontally and vertically, equivalent to a square with sides of 352 yards. Second, we do not know how he positioned the symbols in relation to the surveyed triangulation points but we have assumed he was consistent.

We have proceeded by placing a rectangle over each Hayward church, including the tower, and identified the central point thereof as the centre of the symbol we have used, an open circle. All the churches shown by Hayward were then plotted with reference to the waterway system he portrayed, as shown in Figure 2. Obtaining the locations of churches as shown by the OS proved more troublesome. No digital data for the grid coordinates of churches could be found and it was necessary to have recourse to the OS 1:10,000 map. For each church shown, a rectangle was laid over the symbol, encompassing the tower or spire, and the six-digit grid reference was obtained by using the coordinate finder tool. These grid refer-

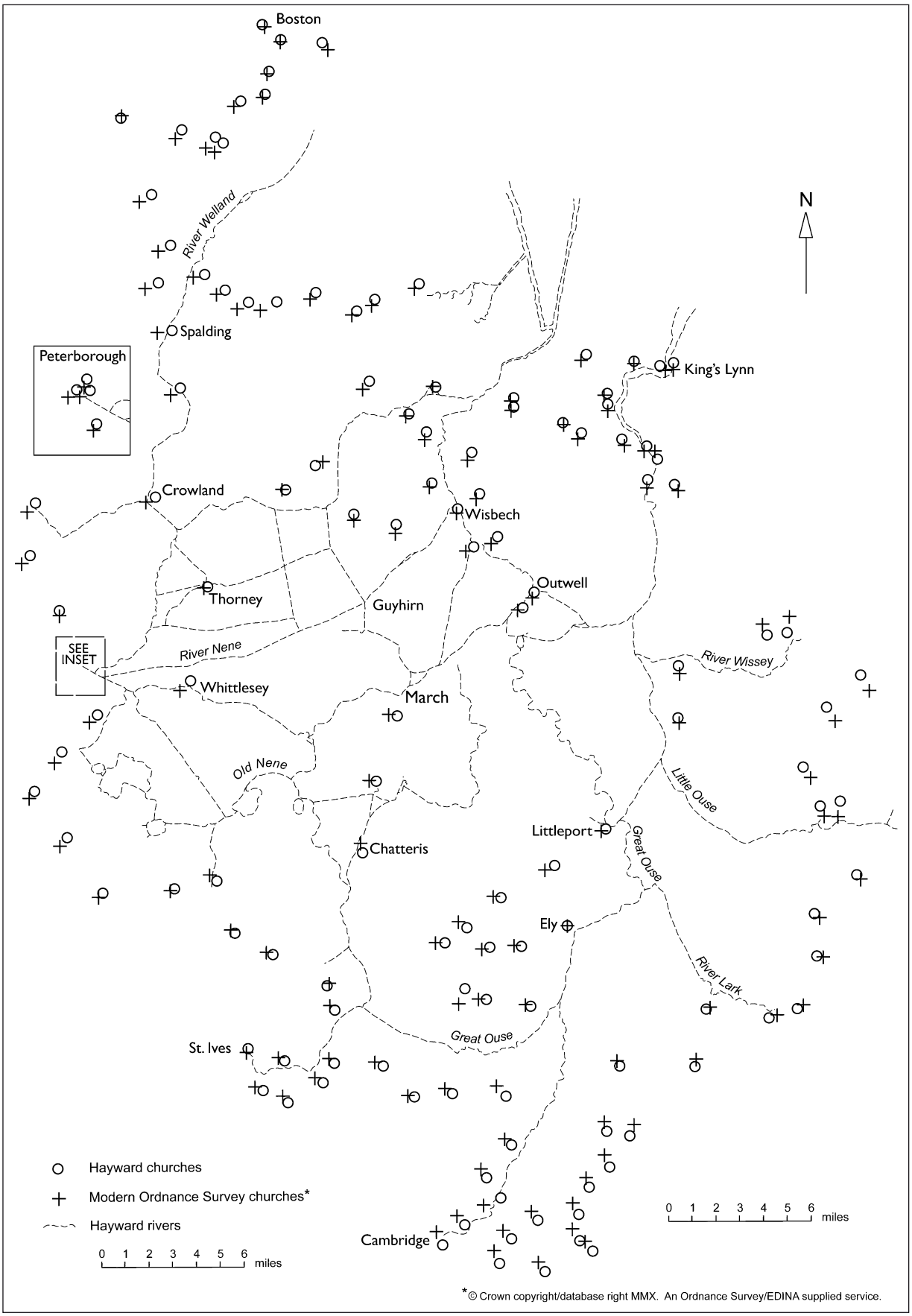

***Figure 3**. Hayward's 1604 churches compared with the locations shown by modern Ordnance Survey cartography.*

ences were added to the Geographical Information System (GIS) data, allowing the churches to be plotted as crosses centred upon the coordinates obtained. This plot was then laid onto the waterway layer from which the OS channels shown in Figure 2 were obtained, whereby the Hayward and OS church plots could be combined to give Figure 3. The effect of this procedure is to co-locate the Hayward and OS symbols for Ely, rotating Hayward by 96°, anticlockwise, an end result identical to that employed for Figure 2.

With the two distributions plotted in one diagram some editing was necessary, to eliminate OS churches for which there is no corresponding Hayward church, and *vice versa*. In addition, in four cases the modern church evidently occupies a site differing from that occupied in 1604, namely Eyberrye (near Eye), Holme, Mepal and Somersham; these churches have been eliminated. Figure 3 shows the locations of almost all of Hayward's churches and the corresponding OS locations.

With Ely as the common point of reference, the maximum error is for Northwold's church, on the extreme eastern edge of Figure 3, south of the river Wissey; in this case, Hayward erred by about 1,350 yards. Most of the errors are much less than this, and it is striking how little error there is at many of the map extremities – Boston, King's Lynn, Peterborough and St Ives. In some parts of the map, the discrepancies are consistent, as across the northern silt fens east of Spalding and in the vicinity of Cambridge, suggesting a single error carried forward for a number of churches. Chatteris and March display variable errors, possibly indicative of random divergence on account of church symbols having been located by Hayward in an unsystematic way. Overall, given that each Hayward symbol occupies a rectangle with sides of at least 352 yards, it is clear that his triangulation was indeed very good.

However, there is a puzzle. If Ely was used as one end of the church base line, we would expect a nearby church to show very close correspondence between Hayward and the OS, but this is not so, even for Sutton, the most prominent church west of Ely, overlooking the Fens. However, it would be unwise to place too much emphasis upon this puzzle. As we have noted, his church symbols are large; they also vary in the shape of the elevation portrayed, reflecting in part the architecture of individual buildings. In addition, and perhaps more important, the triangulation would have been valuable intellectual property, worth protecting. Therefore, we should not be surprised if Hayward deliberately placed one or more churches sufficiently incorrectly that another surveyor could not confidently use the 1604 map to reconstruct the triangulation.

It must be remembered that telescopes were not applied to survey instruments until the mid-seventeenth century, some fifty years after Hayward completed his map. The accuracy he achieved without the telescope is commendable.

Conclusion

At first sight, Hayward's 1604 map looks incomplete but this impression is erroneous. The map was prepared to assist the planning of a comprehensive drainage scheme for the peat fens, the bounds of which had been precisely defined in writing by James I, presumably on the advice of Hunt. Uplands surrounding the Fens were not directly relevant for any drainage scheme, but they were necessary for survey purposes. Taking the triangulation outside the area of interest would have enabled a higher degree of accuracy to be achieved than would otherwise have been possible, and provided essential reference points for the ground surveyors working with plane tables and chains. The relevant triangulation points are shown by the churches, including those located on the upland rim of the Fens and in the northern silt lands. For the purpose in hand, there was no need to devote resources to mapping detail around those churches; the inclusion of detail for Norfolk Marshland presumably was because this material was already to hand from the 1591 survey. Therefore, the 1604 map can be accepted as complete for the task as defined by King James, an essential tool for planning a drainage scheme.

The accuracy of Hayward's 1604 map has been tested in two ways, by comparison of waterway networks and the location of churches, in both cases comparing Hayward's cartography with that of the OS. His map is commendably accurate, an achievement that must be regarded as remarkable given the date at which the work was done.

The other four maps considered clearly incorporate information derived from Hayward's survey but they are not replicas of the 1604 map – they differ in the area covered, the detail shown and, in two cases, the scale used. None of these maps includes a written definition of the mile employed, nor do they include a summary of the bounds stipulated by James I. As tools for examining the pattern of waterways prior to the draining of the Fens in the seventeenth century they are inferior to the map drawn by Payler Smyth, which in all probability is a faithful rendering of the original map and is in any case the best that we have of the undrained Fens.

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Plate 4. *Sample of Hayward's 1604 map at reduced scale of 0.6 inch to the mile, north to the right. Wisbech is at the right hand margin. Waterways in blue, major embankments red and lesser embankments green. Land shaded dark green denotes 'islands' of dry ground. See text for the straight dotted line shown bottom left. Reproduced by permission of Cambridgeshire Archives and Local Studies (R59/31/40/1).*