RIVER AND WATER MANAGEMENT IN THE FENLAND

The Fenland is a landscape that reflects the interplay between environmental and social processes over centuries. This field excursion will examine the initial formation of the Fenland region, the draining of the Fens, and contemporary water management in the Fens, and will provide a useful background for the session on multi-purpose water management tomorrow, in which we consider institutional partnerships at the local scale.

The landscape

"When the spring tides flood into the Wash and run up the embanked lower courses of the Witham, Welland, Nene and Great Ouse, more than [3,100 km^2] of Fenland lie below the level of the water" (Grove, 1962, p.104). The Fenland is one of the most distinctive landscapes of Britain, maintained as a largely agricultural region as a result of embankment, drainage and sophisticated and complex river and water management similar to that most often associated with the Netherlands. Its uniqueness is captured in one of the great British novels of the last fifty years, *Waterland* by Graham Swift. The creation of this landscape began with reclamation and embankment in Roman Times, but was mostly achieved in the seventeenth century with the assistance of Dutch engineers. Cambridge itself is just south of the southern edge of the Fens, but the banks of the River Cam just NE of the city are only at 4.0-4.5m OD, although about 50km from the sea.

The basic framework: geology and topography

In the early post-glacial period, about 10,000 years ago, the sea stood over 30m lower than now, and the Fenland basin was drained by a system of rivers (early versions of the Cam, Ouse, and Nene) that reached a shrunken North Sea by a broad, shallow valley trending NE between Chalk escarpments in Lincolnshire and Norfolk. Beneath the (Cretaceous) Chalk, the geological sequence is of alternate clay and sandstone beds (as elsewhere in southern England); the Gault Clay, the Greensand (represented here by the Sandringham Sands), and the Jurassic Kimmeridge Clay. Within this broad valley, the gently undulating topography included hills capped with Sandringham Sand, such as that on which Ely now stands (see Figure 1; note that additional lettered Figures are appended to this handout).

During the cold, glaciated periods of the late Quaternary, there was also deposition of glacial till by ice, and the formation of gravel and sand floodplains by the rivers; some of these deposits still exist and form ridges, hills or terraces. For example, a ridge from Sutton through Wentworth to Witchford, SW of Ely is topped by glacial till (boulder clay), and Downham and Littleport are also located on hills of this material. In other locations, these deposits rest on the Cretaceous and Jurassic sedimentary rocks, and have been buried by the younger sediments described in the next section.

The post-glacial creation of the Fens

In the Flandrian, or Holocene, the history of the Fenland region has been dominated by an alternation between marine and terrestrial (freshwater) conditions as the relative elevation of the sea has varied. These changes arose from the interaction of post-glacial eustatic sea level rise, the effects of isostacy in southern Britain, and local tectonic influences. Initially, from about 10,000 to 6,000 BP, the sea-level rose continuously and the North Sea expanded. A rapid transgression of the sea into the lower reaches of the valley of the proto-Nene and Great Ouse created the Wash, and the gently-sloping valley above this became well-wooded after 6,000 BP, and had a poorly-drained, damp environment with freshwater fens and meres. This landscape was dominated by the development of extensive freshwater peats because of the poor drainage, which reached thicknesses of about 0.5-1.5 m. Trees - especially bog oaks - grew in this peat, and where the peat is at the present-day surface, the trunks of these have been revealed by ploughing (Figure A).

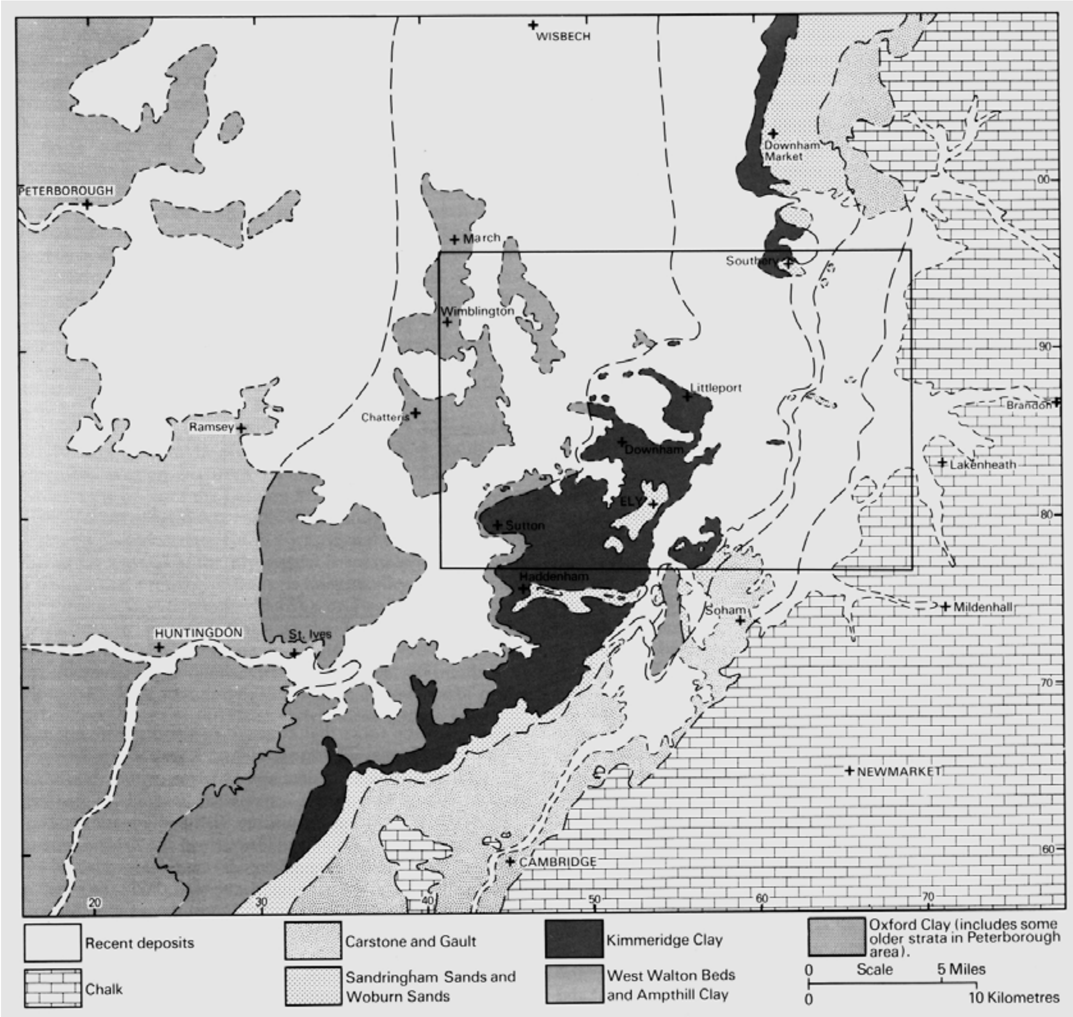


Figure 2 Geological sketch map of the Ely and adjacent districts of the region

Figure 1. Geology of Fenland (from Gallois *et al.* 1988)

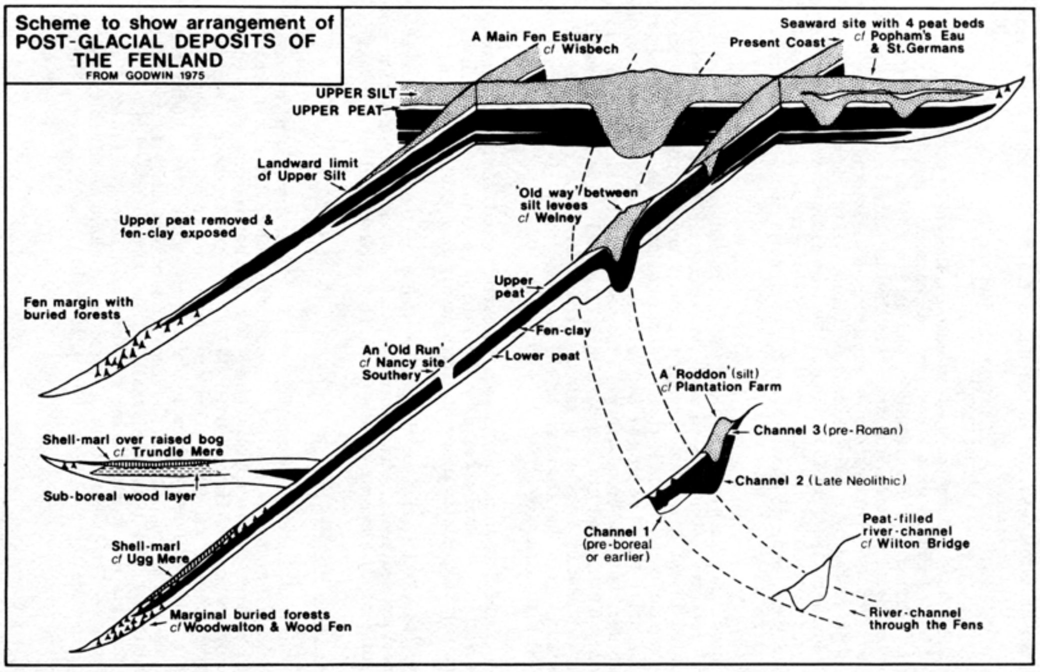


Figure 2. The Holocene stratigraphy of alternating freshwater peat and marine silt in the Fenland Basin (after Godwin 1978)

However, at about 4,700 BP (the Neolithic period, archaeologically) there was a rise in the relative elevation of the sea and a marine transgression occurred. Figure B shows a typical spatial pattern of depositional environments at a low-lying coast, and with a marine transgression occurring, these zones may be expected to migrate landwards. As a result, the peats were covered by an extensive deposit of marine silts and clays, with marine conditions extending as far south as Ely ("Recent Deposits" other than the alluvium in river valleys in Figure 1). These silts are known as the Barroway Drove Beds, and are the most extensive silts in Figure 2. Then, the sea retreated again (marine regression), and from about 4,000 to 2,050 BP, freshwater conditions were re-established and peat accumulated again, burying the marine silts and clays beneath up to 3m of peat. This is the "Nordelph Peat" (the older peat being known simply as the "Lower Peat"). A further transgression then occurred at about 2,050BP (in Romano-British times), covering the peat in the northern Fenland with another layer of silts. The general pattern of these deposits is illustrated in Figure 2. This also shows that closer to the coast there have been other smaller-scale transgression-regression phases; and that rivers passing through the deposits complicate the pattern. At the edges of the Fens, river channels may be peat-filled, whereas in the centre of the Fens they have thicker silts because their paths were inundated earliest as sea level rose. These sinuous, linear silty features passing through the peat fens are the so-called 'roddons' (see Figure Ca and Figure Cb and the text below). Figure 2 indicates that the southern Fens have peat at the surface (except where it has been eroded away by the wind; see below), and here the soils are black; in the north, silts at the surface result in much lighter coloured soils.

In Shennan 1986(II), the four-fold sequence of events described above (peat-silt-peat-silt) is shown to be more complex. Here, marine transgressions are "Wash" phases, and terrestrial periods are "Fenland" phases. Shennan identifies as many as eight transgressive Wash periods, not all of equal magnitude, duration, or spatial extent. Broadly, the Lower Peat equates with his Fenland I and II periods (6,300-5,400BP), separated by a transgression. The Barroway Drove Beds equate approximately with Shennan's "Wash III and IV", the Nordelph Peat with his "Fenland IV and V" (in each case, therefore, interrupted by the opposite tendency), and the Romano-British silts with Wash VI. What these differences reflect is the increased number of bore-holes and exposed sections analysed, many more radiocarbon dates, and a more rigorous basis for identifying transgression and regression, not only from changes between peat and silt deposits, but also in more subtle changes in the pollen and diatom assemblages. Shennan also compares the sea level history of the Fenland with other locations to infer a general and continuing subsidence of the region of the order of 1mm per annum since 6,000 BP. Clearly this has considerable implications for future coastal protection and water management in the Fenland, given that there is roughly a similar (1-2 mm per annum) eustatic rise in sea level associated with global warming (ice melt, warming of the ocean).

The drainage of the Fens

Drainage and reclamation of the Fens began at a very early date - indeed, to protect the Fens from marine encroachment, the "Roman Sea Bank" was constructed parallel to the present coast of the Wash and about 10-15 km SE of it, from Spalding to Wisbech (Figure D). This was probably an early mediaeval embankment (around 1100 AD), not a Roman one (Darby, 1983), but it roughly follows the limit reached by silt deposition in the Romano-British transgression. Since its construction, the salt marsh on the seaward side has been progressively reclaimed, firstly for salt production, and then for grazing. By 1700 the coastline had migrated through this reclamation ¾ of way from the "Roman Bank" to its present position; the rest of the reclamation post-dates 1700 (Figure D).

South of the "Roman Sea Bank", the Fenland was an inhospitable area of fens, meres, marshes and drainage channels until the early 17th century, with occasional "islands" where the pre-Quaternary rocks or glacial deposits projected above the Holocene deposits described in the last section. The people of the region lived from their freshwater aquatic environment - fish, eels, reeds and peat (there are no equivalents of the Norfolk Broads in the Fens, but evidence of late mediaeval turbaries shows in aerial photographs (Figure E); these exported peat for fuel to London). Fenland people were opposed to proposals to drain and reclaim the freshwater Fens (and indeed, rioted to attempt to prevent it), but in 1630, Francis, 4th Earl of Bedford, and 13 associates ("Adventurers"), engaged the Dutch engineeer Cornelius Vermuyden to begin draining the southern Fen. At the time, the River Great Ouse followed a course along the southern edge of the Fens to join the Cam and then turn north to the east of Ely on its route to the coast at King's Lynn.

The essence of Vermuyden's and later drainage works was to shorten the routes of channels and evacuate excess runoff more rapidly to the sea. In 1637, Vermuyden constructed the Old Bedford River from Earith to Salters Lode (Figure 3). This was 21m wide and 34km long, with a sluice at Earith to regulate flow in the river's original course, and at the lower end to prevent tidal inflow. The city and university of Cambridge petitioned against the downstream sluice in 1696, on the grounds that it impeded navigation and trade from King's Lynn. The Old Bedford River was supplemented by the parallel New Bedford River (the "Hundredfoot River") in 1651, with a washland between to take winter flood water. Today, this area - the Ouse Washes - is a Ramsar wetland reserve (http://www.ramsar.org), with an important migratory bird population (Figure F), and this has introduced some conflict between the flood management and conservation functions of the Washes. The downstream sluice was destroyed by floods in 1713, and tides again flowed into the southern rivers, until it was rebuilt as the Denver sluice in 1750, which was then rebuilt in 1834, 1923 and 1984. Figure 4 shows how the whole system of channels and the Washes interrelate, and the connections between the sluices at Earith and at Denver. The flows in the Fenland are today managed through the manipulation of the series of sluices at the Denver complex, which is illustrated in detail in maps and diagrams in Appendix 1.

There were many other channels constructed to drain other areas of the Fenland. For example, the Forty Foot Drain was also created in 1651 to drain water from the Old Nene to the Old Bedford River. In order to effect the connection, Welches Dam was constructed and a double channel was created with a Barrier Bank between the two, to protect the area to the west from flooding when the Ouse Washes were inundated. The new channels were the Counter Drain which formed the southern part of the Old Bedford River and the Delph River which formed its northern extension, and at the connection around Welches Dam, the two parallel channels thus created display a prominent kink (Figure G). Other main drains were the Pophams Eau (1603), the Sixteen Foot (1651) and Tong's Drain (1653). However, drainage works continued into the 19th and even the 20th centuries. In 1848 the Middle Level Drain linked to the downstream end of the Sixteen Foot Drain to transfer Nene waters directly to the Great Ouse near King's Lynn, where the Eau Brink Cut (1821) had already cut off a bend.

And in 1964, the Cut Off and Relief Channel scheme was completed to discharge flood waters from the Lark, Little Ouse and Wissey (rivers draining into the Eastern Fens from the Chalk escarpment) directly into the Great Ouse near King's Lynn, bypassing Denver Sluice (Figure H) at times when the Old Bedford River level below Denver is higher than the Great Ouse level above it. The Cut Off Channel can also be used in the reverse direction, to feed the Ouse-Essex water transfer scheme (Environment Agency, n.d.).

When the Fens had been drained, the silty Holocene deposits consolidated, and the peat dried out and shrank. It then became very susceptible to wind-blow, and there was very rapid wastage. In some places, the younger peat at the surface disappeared and the underlying Barroway Drove Beds (silts) were exposed. The shrinkage of the peat is also why the silty roddons appear as lighter-coloured ridges meandering throught the Fens (Figure Cb); they are often the best locations for buildings because the foundations are more solid.

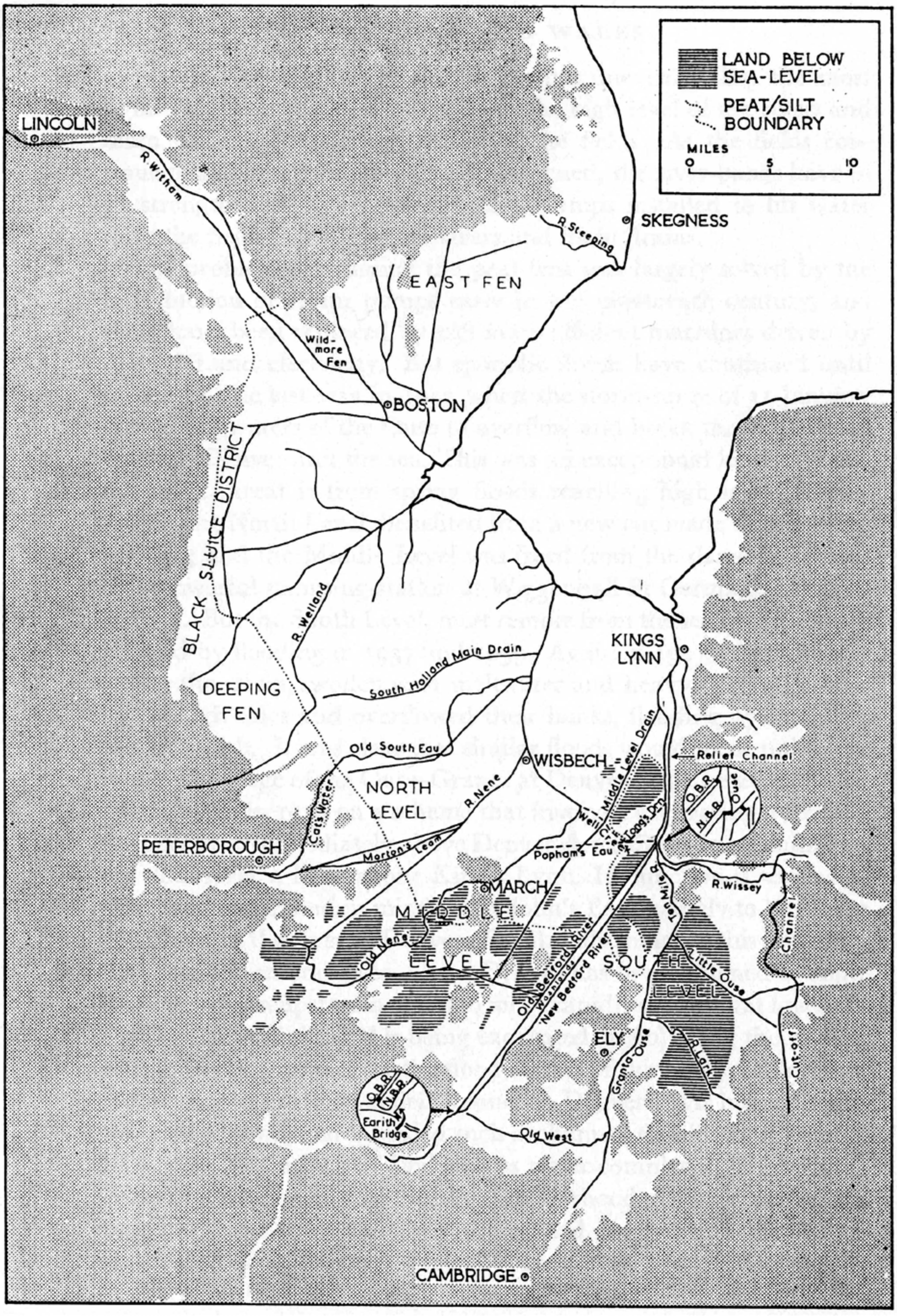


Figure 3. The 17th Century draining of the southern Fenland (after Grove, 1962).

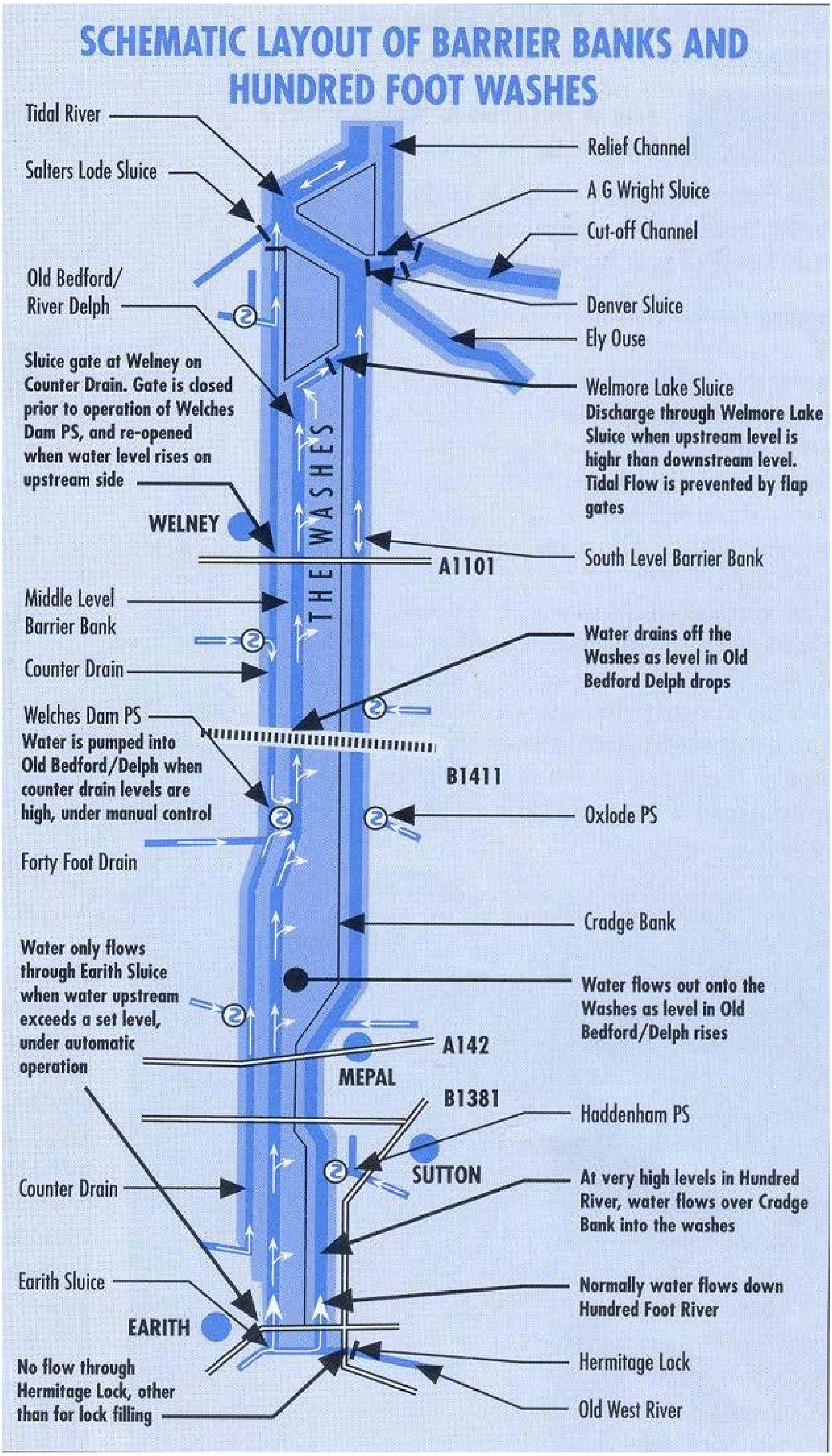


Figure 4. The layout of the Fenland drainage channels, Washes and barrier banks

The lowering of the peat surface has been recorded on the Holme Post in Whittlesey Fen (Figure I). This was a cast iron pillar from the 1851 Crystal Palace exhibition, driven 6.7m into the clay beneath the peat. Within 10 years, the peat level had shrunk by 1.5m (Hutchinson, 1980), and today about 4m of the post stands above ground level - a rate of lowering of about 2.5 cm a year. Because of this shrinkage and lowering, buildings in the peat Fen often display evidence of subsidence, and roads are often uneven (Figure J). Furthermore, this shrinkage has accentuated the elevation difference between the drained land and the main, embanked rivers, and has necessitated pumping of water from the former, originally by many windmills (Figure K), then by steam engines (as that at Sutton), and latterly by diesel and electric pumps. It is ironic that there is now a highly-contested scheme to build wind-power generating capacity in a landscape which was once littered with windmills (Figure K)!

The micro-management of water in the Fens: Internal Drainage Boards

The drainage works discussed above are those affecting what are today defined as "main rivers". These are the responsibility of the Environment Agency (which manages operation of Denver Sluice, and the flooding of the Ouse Washes; Environment Agency (n.d.)). However, there are many other drainage channels, and areas which drain into them, that are managed by the IDBs - Internal Drainage Boards.

Although many of the Internal Drainage Boards date back to the 17th century, today they are statutory bodies empowered under the Land Drainage Act of 1991 to undertake flood defence works for watercourses which have not been designated as "main" rivers, in specified districts with special drainage needs. They were established in particularly low-lying areas of England and Wales where flood protection and land drainage are necessary to sustain both agricultural and developed land use. The IDBs consist of elected members representing ratepayers and members appointed by local authorities. Where there is a special need for drainage works, Internal Drainage Districts may be established and are then administered by Internal Drainage Boards (IDBs). The activities of IDBs are largely funded by drainage rates levied directly upon owners and occupiers of property within the district which benefits from the work of the IDB (domestic, commercial, and industrial properties and agricultural land). The Environment Agency can charge the IDBs to finance work it undertakes to the benefit of those IDBs, and may raise a General Drainage Charge from occupiers of chargeable land (agricultural land and buildings outside an IDB, excluding rough grazing and non-commercial woodlands). Rates in the Fenland are currently about £2 per hectare.

IDBs practice complex water management in their Internal Drainage Districts. They drain water from agricultural land in drainage channels at lower elevations than the main rivers, and have to pump water up into those rivers. This is an expensive process, and water that enters their District therefore costs them money. For example, runoff from higher areas adjacent to an IDD may enter the drainage channels. Two strategies have been evolved to deal with this. One is the construction of "Catchwater Drains", which run approximately along a contour around a Fen "island" and intercept runoff from higher ground to prevent it entering the IDB. That around Witchford adjacent to Grunty Fen IDB is at about 2.5m, and was constructed in 1818. One of the IDB drainage ditches actually passes underneath this catchwater drain (Figure 5). The other is that IDBs can claim a "highland water payment" from the Environment Agency if runoff from higher ground enters the IDD and has to be pumped out again. This is indicative of the complexity of water management in the Fens, which is further reflected in the manner in which conservation of Fenland ecosystems today requires careful manipulation of water tables and levels in adjacent drainage ditches. We shall see evidence of this at Wicken Fen.

Conservation and Restoration in the Fenland

Wicken Fen Nature Reserve (305 ha) is one of only four areas of undrained fenland in East Anglia (Figure L). It is owned by the National Trust, and was one of the country's first reserves, established in 1899. It became the focus of ecological research that helped formulate ideas about conservation, particularly that conservation requires management (in this case, water management). It is a National Nature Reserve, a Site of Special Scientific Interest, a Special Area of Conservation under the EU Habitats Directive, and a Wetland protected under the international Ramsar Convention. A variety of habitats is managed at Wicken, where for conservation purposes, the most important are the sedge beds, reed communities (common, or Norfolk, reed - *Phragmites communis*) harvested for thatch, and Fen meadows; these habitats are relatively rare in Britain. Other important habitats are open water, droves and paths which provide access to the wetter areas, as well as drier grasslands, and damp and dry woodland (including alder carr).

A critical aspect of management of the reserve is that of water levels. Drainage of the Fens for agricultural purposes has lowered the regional water-table, and the Fens have dried through most of twentieth century. As noted above, drainage of peat has led to desiccation and oxidation and wastage of the peat, so that the surrounding arable land has lost height, leaving the nature reserve perched as an island above the level of the regional water-table. This increases water loss still further. The consequences for the Wicken's ecology were recognised from the 1960s. However, it is not just annual water amounts that are important but seasonal variations. A high summer water-table has been regarded as a priority because of the damage that low levels can cause to specific plant communities. The need for maintaining winter flooding was, for a time, less well accepted.

The strategy to keep the Fen wet has been two-fold – conducting water into the interior of the Fen through drainage ditches, and water-proofing the boundary banks to keep the water levels high (Lock et al., 1997). The entire northern boundary of the Fen was waterproofed by Anglian Water Authority in the late 1980s. In addition the southern area of the Fen has become an emergency flood storage reservoir to hold back excessive heavy rainfall from farmland. To achieve this other waterproof banks were created around the reserve. There are times in the past when water has had to be pumped into the Fen to replace that lost – a paradox in the context of the long-term history of attempts to drain the Fenland region. Within the reserve there are schemes which allow certain areas to be flooded at appropriate times, for example the main reed beds are flooded during February and March by abstracting water from Wicken Lode.

Wicken Fen exists as an isolated nature reserve, a situation typical of many of the country's prime sites for conservation. It is, however, increasingly recognised that this is not the best manner in which to protect landscapes, ecosystems, habitats and their biodiversity. To this end, the National Trust has a long-term vision to extend Wicken over the next 100 years (http://wicken.org.uk/). It hopes to acquire c.3700 ha of farmland to the south of Wicken and reverse the history of drainage by flooding the area (Figure M). The whole of the proposed new reserve lies within a single IDB and the wetlands would be restored by raising water levels through a reduction in drainage pumping and the use of sluices followed by natural regeneration of the newly created wetlands.

The National Trust does not own the land it wishes to acquire and will have to negotiate with some 120 different individuals, especially as the Trust does not have powers to purchase the land compulsorily. However, given that the land is already parcelled into drainage units, it should be possible to proceed with the restoration of the wetland areas as when land becomes available, so long as raising water levels does not have a detrimental affect on neighbouring land and properties. Experiments on some areas of formerly agricultural land have examined the potential for wetland regeneration. In addition to purchasing land it is possible that the Trust will be able to negotiate management agreements with some land owners and farmers to recreate wetland. Given the changing nature of the agricultural economy in future years (especially through reductions in the price support mechanisms of the EU's CAP) and increased incentives to farm land in a more environmentally-benign manner, it is hoped that some farmers might be willing to enter into partnerships with the Trust.

Conservation and the Ouse Washes

As noted above, the seasonally-flooded Ouse Washes have over the years become an important site for breeding (e.g. black-tailed godwit, snipe), migratory and wintering assemblages of wetland bird species (e.g. swans, teal, wigeon, gadwall and others). As a result, a major structure for land drainage and flood management has become a designated wetland under the Ramsar convention; it is a Wetland of International Importance under Ramsar criteria 1 (Ramsar Site No. 77). This means that its water regime now also has to be managed for conservation purposes, and in recent years this has become problematic, with a decline in the numbers of breeding and over-wintering birds. This is thought to reflect a number of factors: (a) an increase in the incidence of summer flooding, as well as high water levels in winter; (b) reduced effectiveness of gravity drainage because of siltation in the tidal river; and (c) a decline in water quality affecting communities of higher plants within the Washes (Posthoorn *et al*., 2001).

A wide range of strategies has been evaluated for reversing the decline in ecological status of the Washes, while maintaining their role in flood risk management (eg, reprofiling the Tidal river and/or the Hundred Foot River, installing a tidal barrier on the Hundred Foot River, diverting summer floods via the Old West River, attenuating summer flood flows, etc). Most are unable to contribute significantly or cost-effectively, and a integrated basin-wide solution is needed, combining upstream retention of flood water (including in the Middle Level Fen from which water is pumped into the Ouse system), improving water quality, and creating wetlands (as compensatory habitat) also in the Middle and South Levels. This shows that local problems often require a system-wide appraisal and solution (integrated river basin management); and also provides the broader context for the development of restoration projects such as the Great Fen project and the Wicken Fen Vision.

References

Darby, H.C. (1983) *The Changing Fenland*. CUP, Cambridge

Environment Agency (n.d.) *The Denver Complex*. Environment Agency, 12pp

Fowler, G. (1934) The extinct waterways of the Fens. *Geographical Journal* 83, 30-39

Gallois, R.W. (1988) *Geology of the area around Ely. Memoir for 1:50 000 geological sheet (England and Wales).* HMSO, London

Godwin, H. (1938) The origin of roddons. *Geographical Journal* 91, 241-250

Godwin, H. (1978) *Fenland: its Ancient Past and Uncertain Future*. CUP, Cambridge

Godwin, HC (1981) *Archives of the peat bog* (CUP)

Grove, A.T. (1962) Fenland. In J.B. Mitchell (ed.) *Great Britain: Geographical Essays*, CUP, Cambridge, 104-122

Hutchinson, J.N. (1980) The record of peat wastage in the East Anglian Fenlands at Holme Post, 1848-1978 A.D. *Journal of Ecology* 68, 229-249

Lock, JM, Friday, LE & Bennett, TJ (1997) ‘The management of the fen’, in LE Friday (ed.) *Wicken Fen: the making of a wetland nature reserve* (Harley Books), 213-254

Posthoorn, R., Kuijken, E. and Salathé, T. (2001) Ramsar Advisory Mission No. 49, Ouse Washes, United Kingdom. http://www.ramsar.org/cda/en/ramsar-documents-rams-ram49/main/ramsar/1-31-112^22936_4000_0__

Shennan, I. (1986) Flandrian sea-level changes in the Fenland I: The geographical setting and evidence of relative sea-level changes; *and* Flandrian sea-level changes in the Fenland II: Tendencies of sea-level movement, altitudinal changes, and local and regional factors. *Journal of Quaternary Science* 1, 119-153 and 157-179

Swift, G. (1983) *Waterland*. Heinemann, London

See also: Ordnance Survey Landranger Sheets 154 and 143; and http://www.multimap.com/map/photo.cgi?client=public&X=534915&Y=275394&width=500&height=310&gride=&gridn=&srec=0&coordsys=gb&db=&pc=&zm=0&scale=50000&right.x=6&right.y=98

Figure 5a. Witchford - from 1:50,000 map for Grunty Fen Catchwater; TL 50534 78261

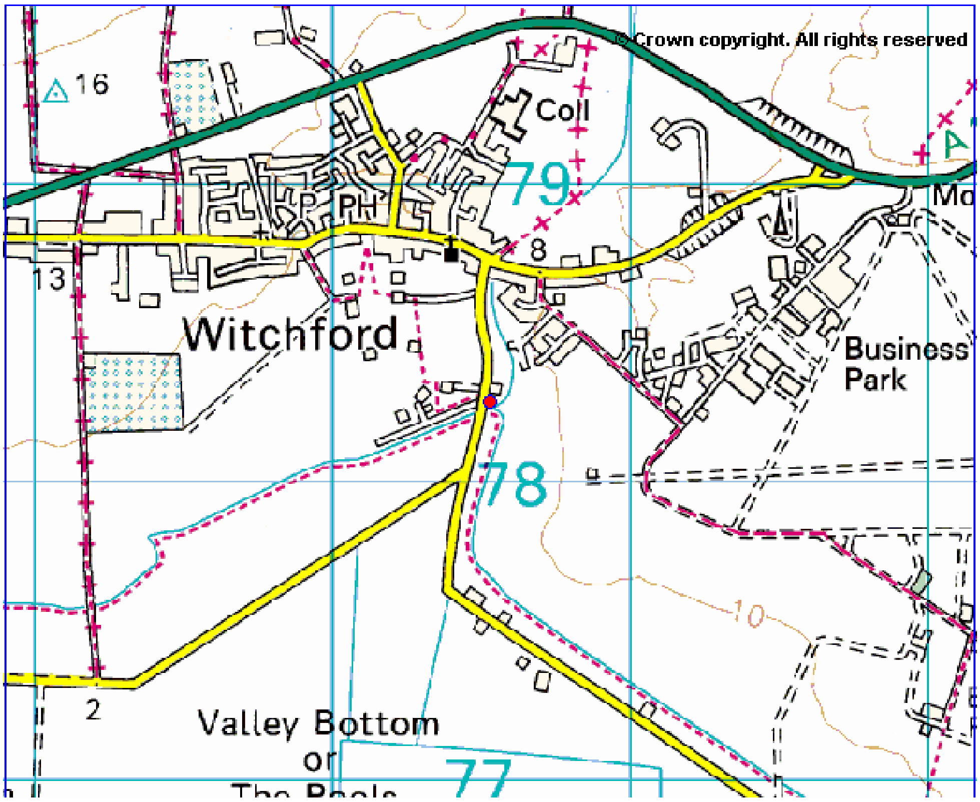
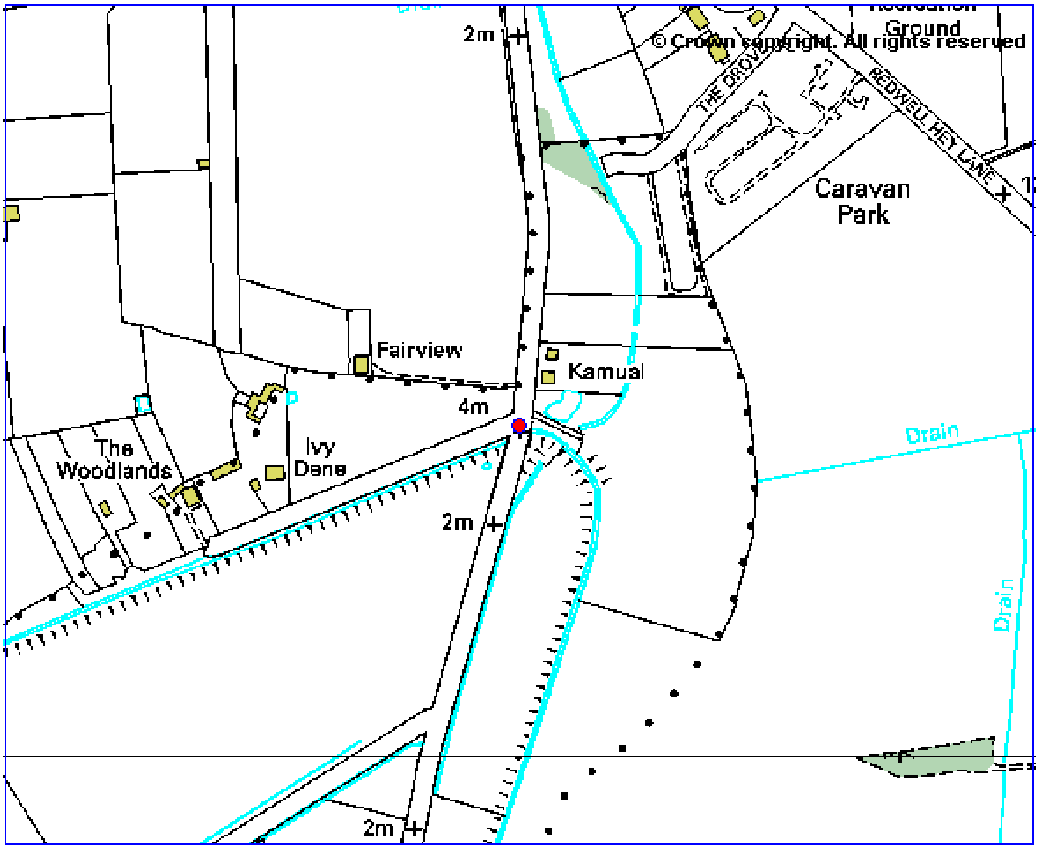


Figure 5b. 1:10,000 map for Grunty Fen Catchwater; TL 50534 78261



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ADDITIONAL FIGURES

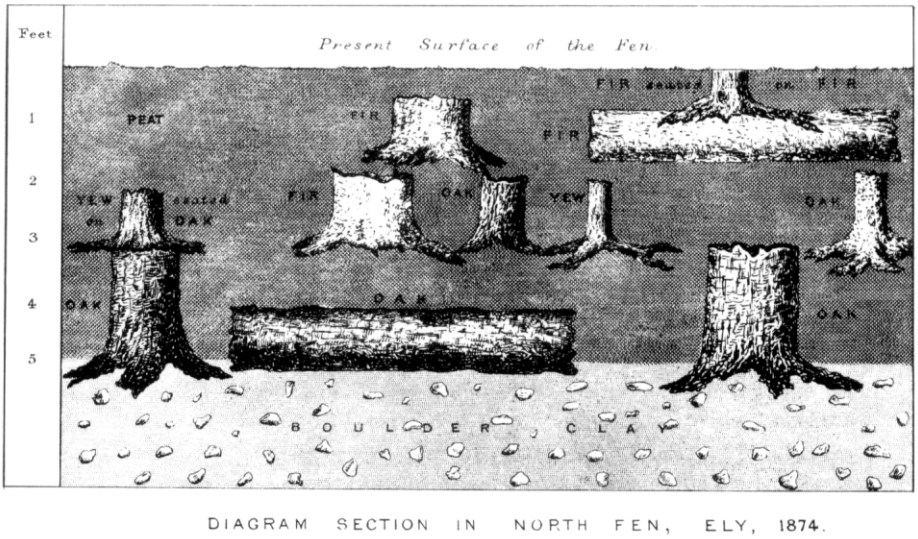
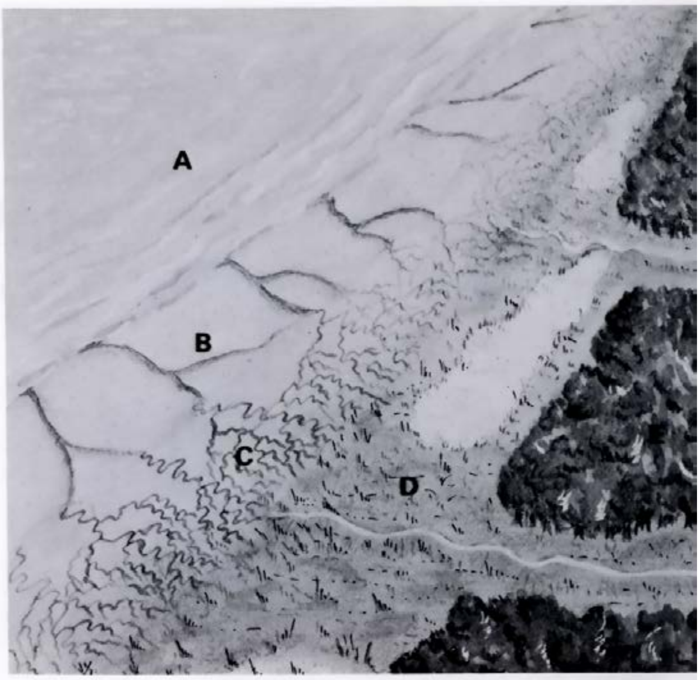


Fig. 27 Horizons of trees preserved in peat at Wood Fen (or North Fen) near Ely, 1874. Reproduced from S. H. Miller and S. B. J. Skertchly, *The Fenland Past and Present* (Wisbech, 1878) facing p. 304. The original oak trees were rooted in the basal clay. Later trees (oak, pine, yew) were smaller in size and rooted only in peat. One generation of trees could sometimes be seen among the fallen trunks of an earlier generation. In his discussion on p. 566 Skertchley speaks of North Fen between Ely and Littleport; this is now known as Wood Fen.

Fig. 28 'Bog oaks' along the roadside near Aldreth, April 1977.
Photo: M. J. Petty. These fossil remains include a variety of species, as may be seen from Fig. 27 above, but they are all generally called 'bog oak'. See H. Godwin, *Fenland: its ancient past and uncertain future* (Cambridge, 1978) 32–42.

Figure A

Figure 29 Presumed depositional environments of the Recent deposits of Fenland



Key to depositional environments and sediment types

- **A** Subtidal—mostly sand
- **B** Intertidal flat—silt with clay
- **C** Salt marsh—clay with silt
- **D** Peat fen and meres—peat and shell marl
- **E** Deciduous forest—erosional area

Figure B

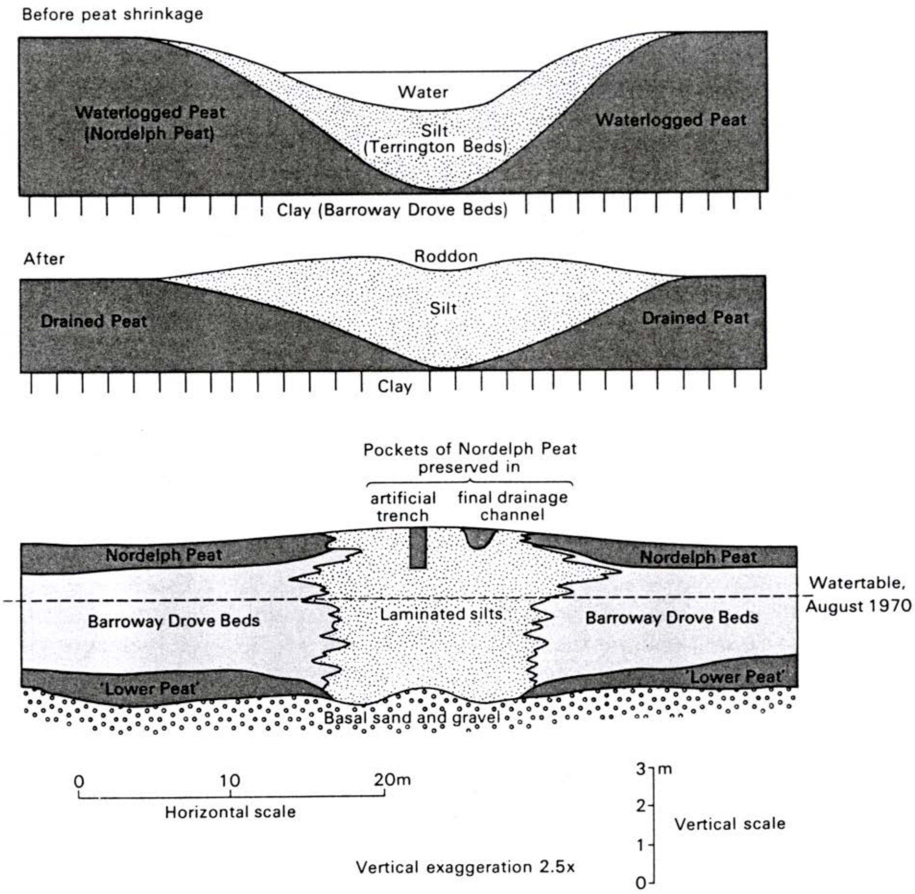


Figure Ca

Plate 9a Wastage of the Nordelph Peat has revealed a complex pattern of silt-filled tidal creeks within the underlying Barroway Drove Beds. As the peat continues to waste and the Barroway Drove Beds clays that enclose the silts consolidate, the silts are beginning to form low-relief roddons. View E across Methwold Fens from near Brandon Creek (Cambridge University Air Photo Library, AXI 46)

Figure Cb

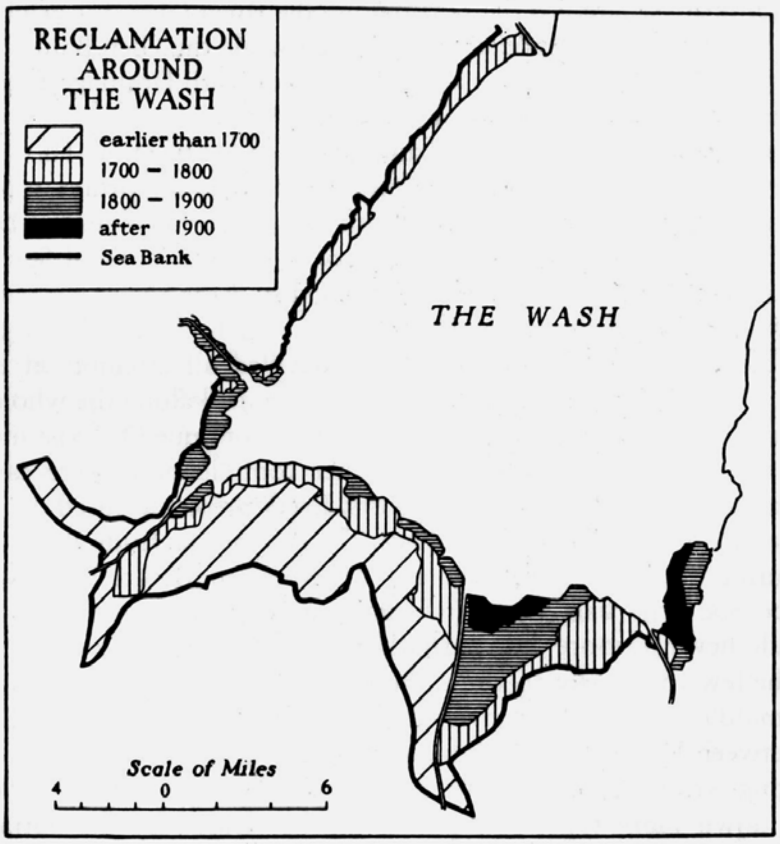


Fig. 93 Reclamation around the Wash.
Based on: (1) the map accompanying S. B. J. Skertchly, *The Geology of the Fenland* (Mem. Geol. Surv. 1877); (2) the map accompanying W. H. Wheeler, 'Fascine work at the outfalls of the fen rivers, and reclamation of the foreshore', *Min. Proc. Inst. Civ. Engineers,* XLVI (1876), 61; (3) W. H. Wheeler's map in *Royal Commission on Coast Erosion: First Report* (1907), Appendix XV; (4) J. E. Mosby, *Norfolk: Report of the Land Utilisation Survey* (London 1938), Fig. 48; (5) O. Borer, 'Changes in the Wash', *Geog, Jour.*, XCIII (1939), 495. Note the large nineteenth-century enclosure at the Nene outfall – see Fig. 87.

Figure D

Fig. 21 Evidence for medieval turbaries in Upwell Fen (476951) Norfolk, looking north-west (April 1955).
Photo: Cambridge University Collection. The straight line across the background is the Sixteen Foot Drain made in 1651. The narrow black bands represent balks of uncut peat between medieval turbaries filled with light-coloured river silt. This silt now stands about 4 feet higher than the black peat around. The former level of the peat surface before wastage was some 10 to 12 feet above that of the present day. See M. W. Beresford and J. K. S. St Joseph, *Medieval England: an aerial survey* (Cambridge, 2nd edn, 1979), 271–2.

Figure E

Fig. 120 The flooded Washland, looking north at Earith, March 1937.
Photo: Keystone Press Agency. Note the sharp line on the left which is the western boundary of the Washland (i.e. along the Old Bedford River). The bridge in the foreground crosses the New Bedford River, and the line of the road is marked by stakes and trees. The square pattern is an earthwork between the two rivers and shown up by the floods; it has nothing to do with the draining – *V.C.H. Hunts.* I (1926), 310.

Figure F

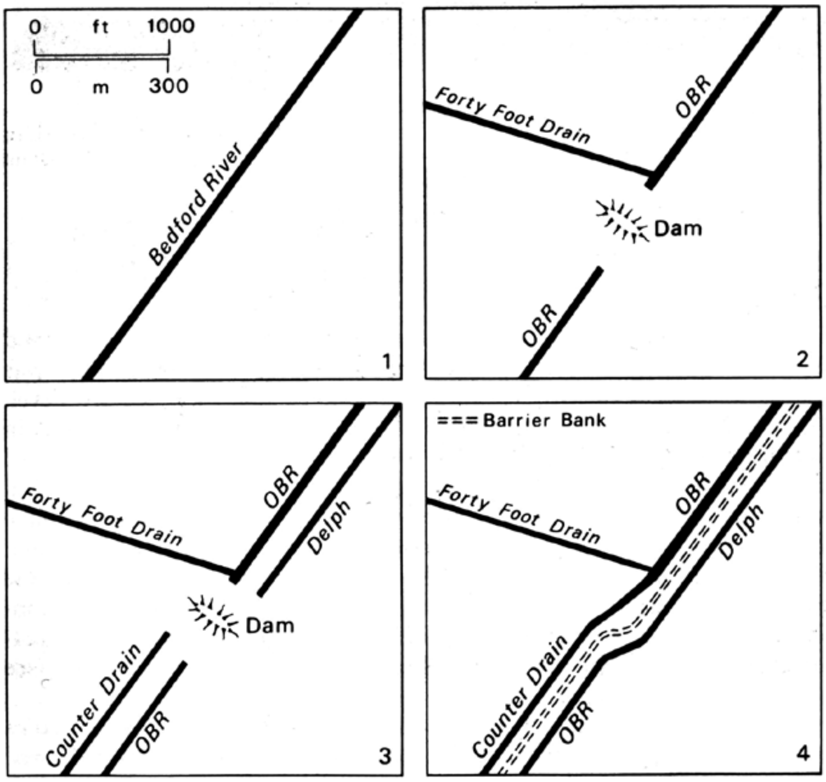


Fig. 43 The making of Welches Dam.
The diagram shows the effect of the Dam upon the alignment of the Old Bedford River (OBR).

Figure G

DENVER CONTROL STRUCTURES

- A Denver Sluice
- B A.G. Wright Sluice
- C Impounding Sluice
- D Residual Flow Sluice
- E Diversion Sluice

Figure H

The Holme Fen Post. A cast iron pillar, from the Crystal Palace Exhibition was erected in 1851 on the south west edge of Whittlesey Mere. It replaced the wooden posts which had been erected in 1848 to indicate peat shrinkage caused by drainage. The post was driven 6.7m through the peat into buttery clay until its top was flush with the ground. Within 10 years the ground level had fallen nearly 1.5m through shrinkage. A second post was erected in 1957 with its top at the same level as that of the original post. Plaques fixed to this post show the ground level at various succeeding dates. As one stands by the pillar now, on peat which actually quivers underfoot, it is difficult to realise that men who watched the last of the mere 120 years ago stood level with its top which is over 4m above today's ground level.

Figure I

Fig. 112 Lowered peat surface at the old vicarage in Prickwillow, near Ely, *circa* 1980. Photo: Anglian Water Authority. E. R. Kelly (ed.), *The Post Office Directory of Cambridgeshire* (London, 1879), 94–5 says that 'a *commodious* vicarage is in course of erection'. We may therefore ascribe the building to 1878–79, and it is marked on the O.S. 25 inch to one mile map of 1888 (surveyed in 1885). The brickwork was supported by beams laid on stilts driven through the peat into the clay beneath. At that time were two steps up to the front door. Since then another nine have been added from time to time as the surface of the surrounding land has become lower. The lowering has also resulted in a cavity beneath the ground floor of the house. I am indebted to the present owner of the house, Mr John Morley, for allowing me to inspect the lowering.

Figure J

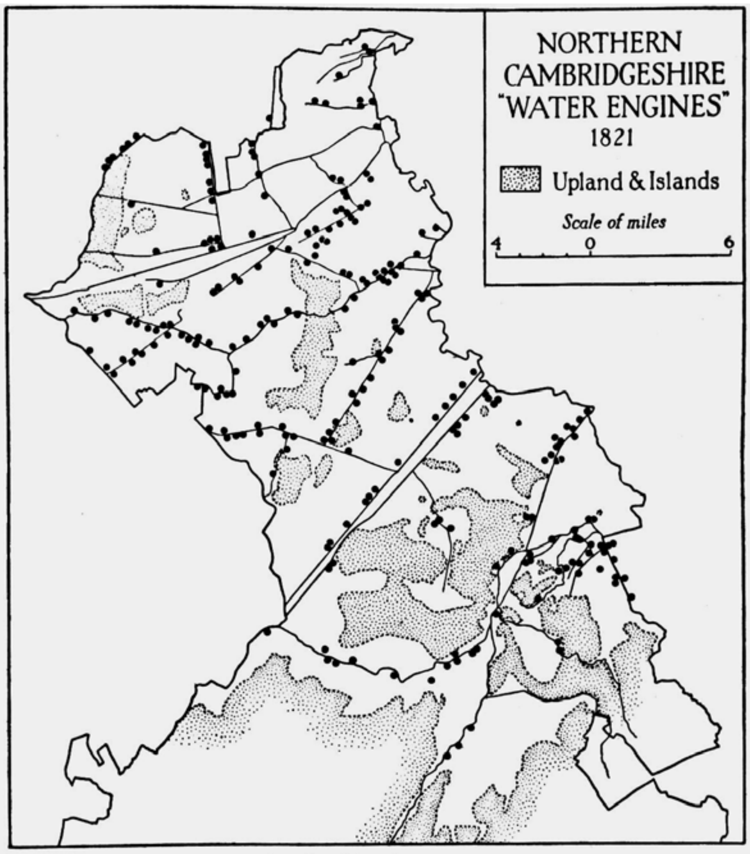


Fig. 94 Windmill pumps in Cambridgeshire in 1821.
The 'water engines' are taken from the 'Map of the County of Cambridge, and Isle of Ely. Surveyed by R. G. Baker, in the Years 1816, 17, 18, 19 and 20'. This was published in 1821. It provides a survey of the windmill pumps just before the time when steam-engines were first used for pumping. Only the relevant drains are shown.

Figure K

Figure L - Aerial image of Wicken Fen Nature Reserve

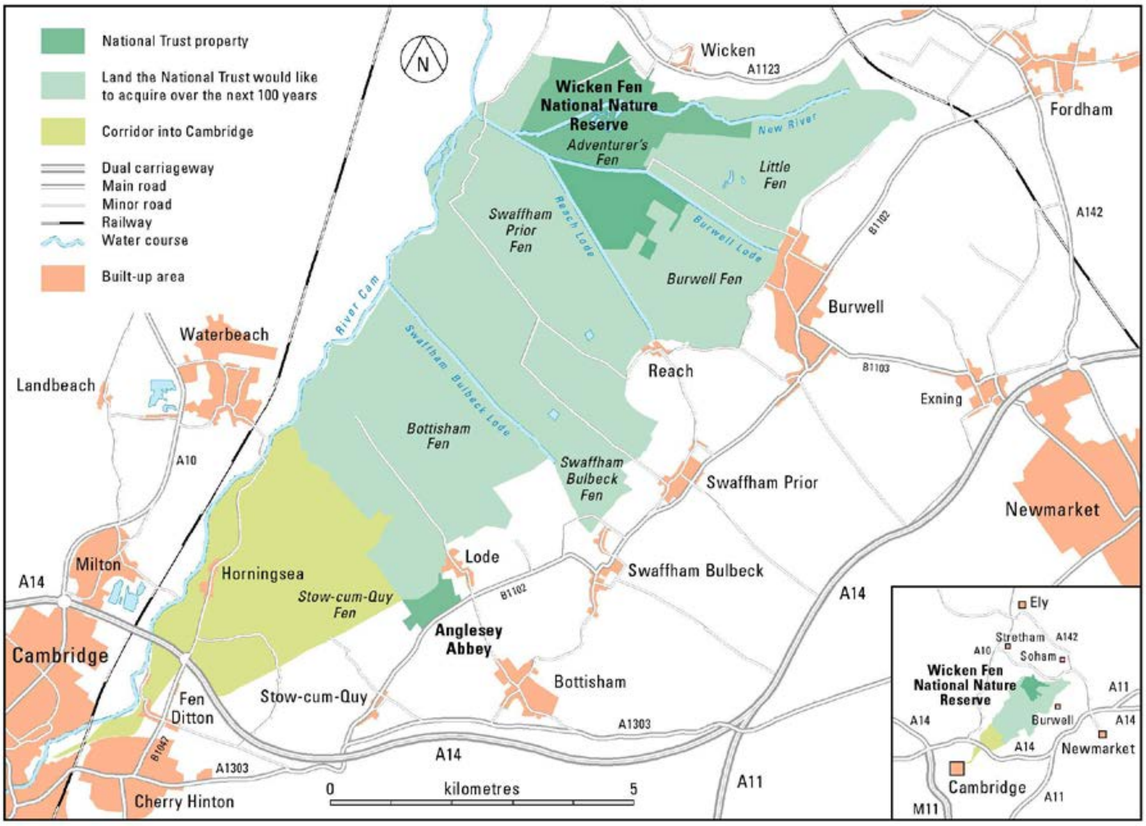
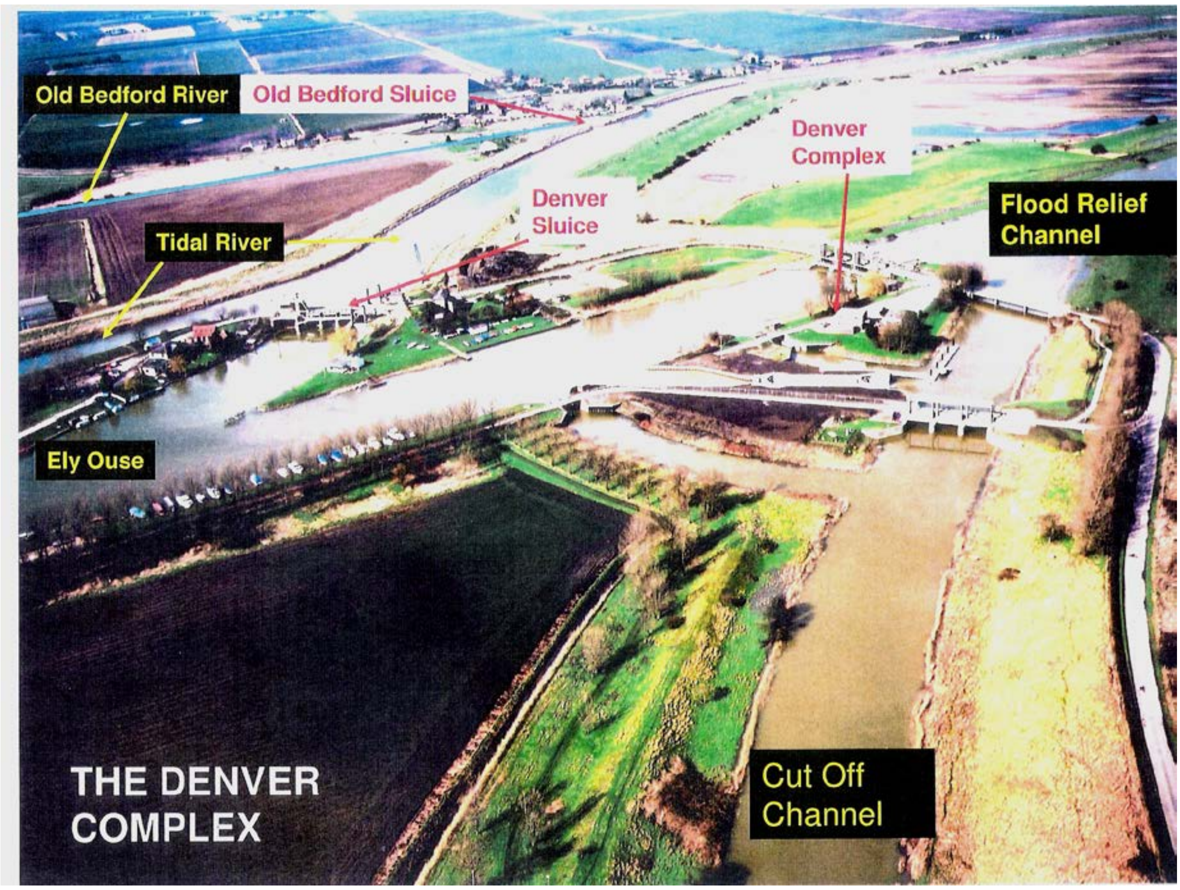
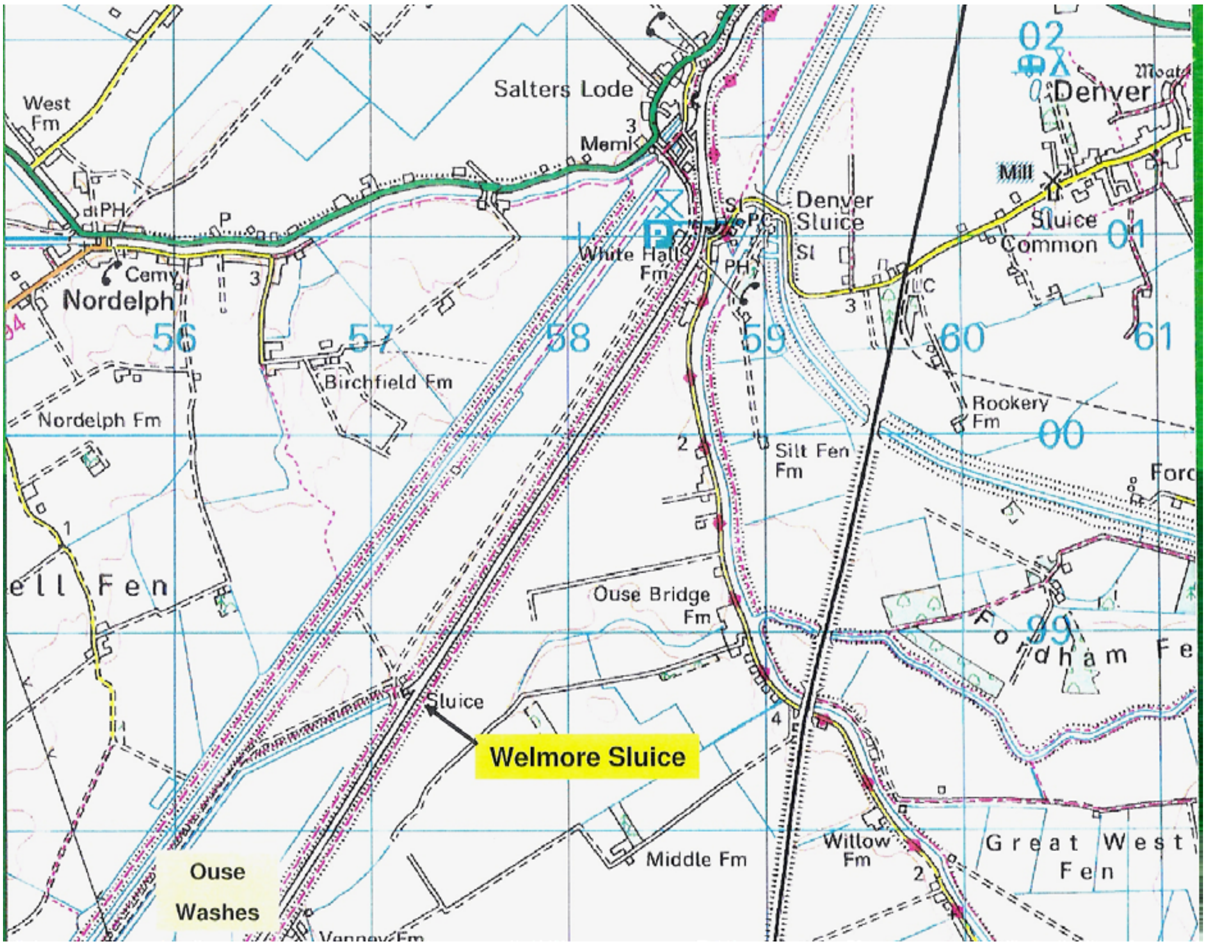
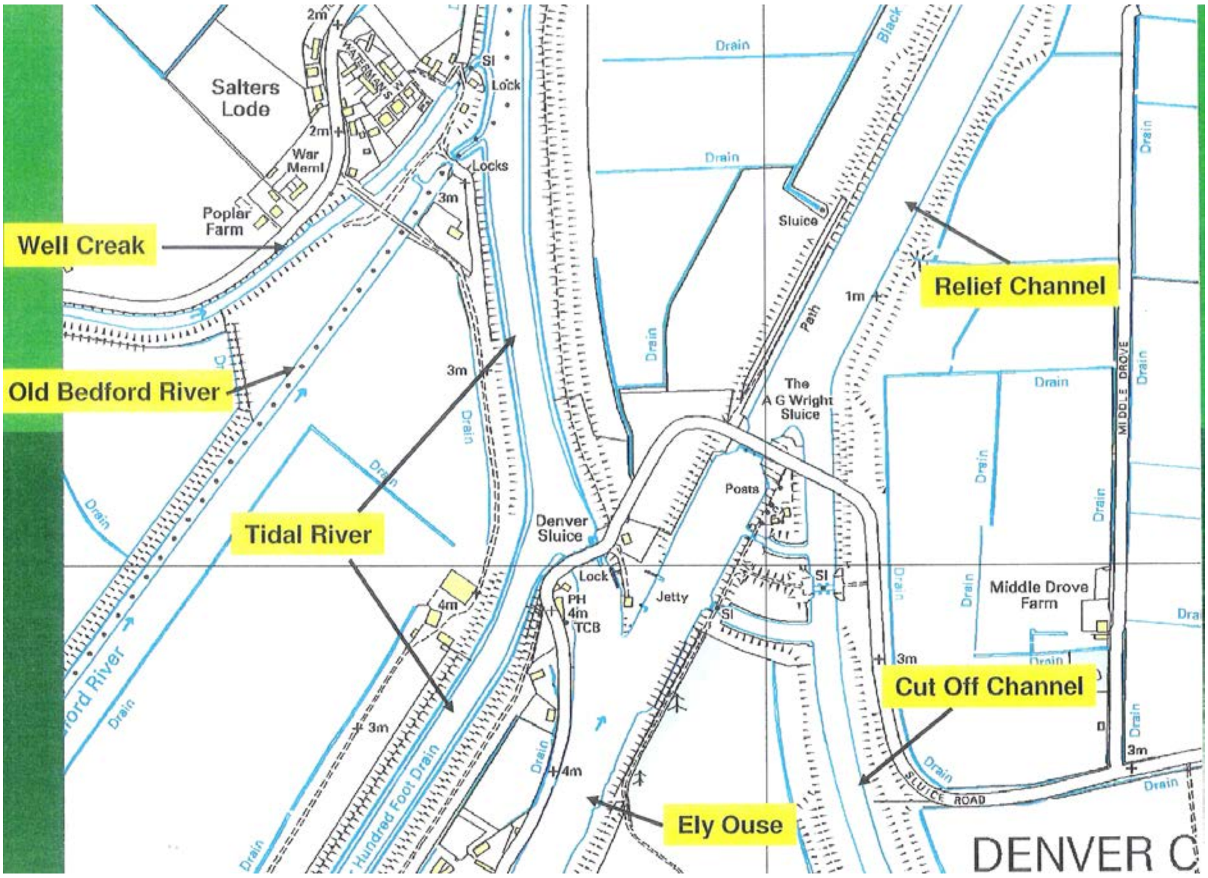


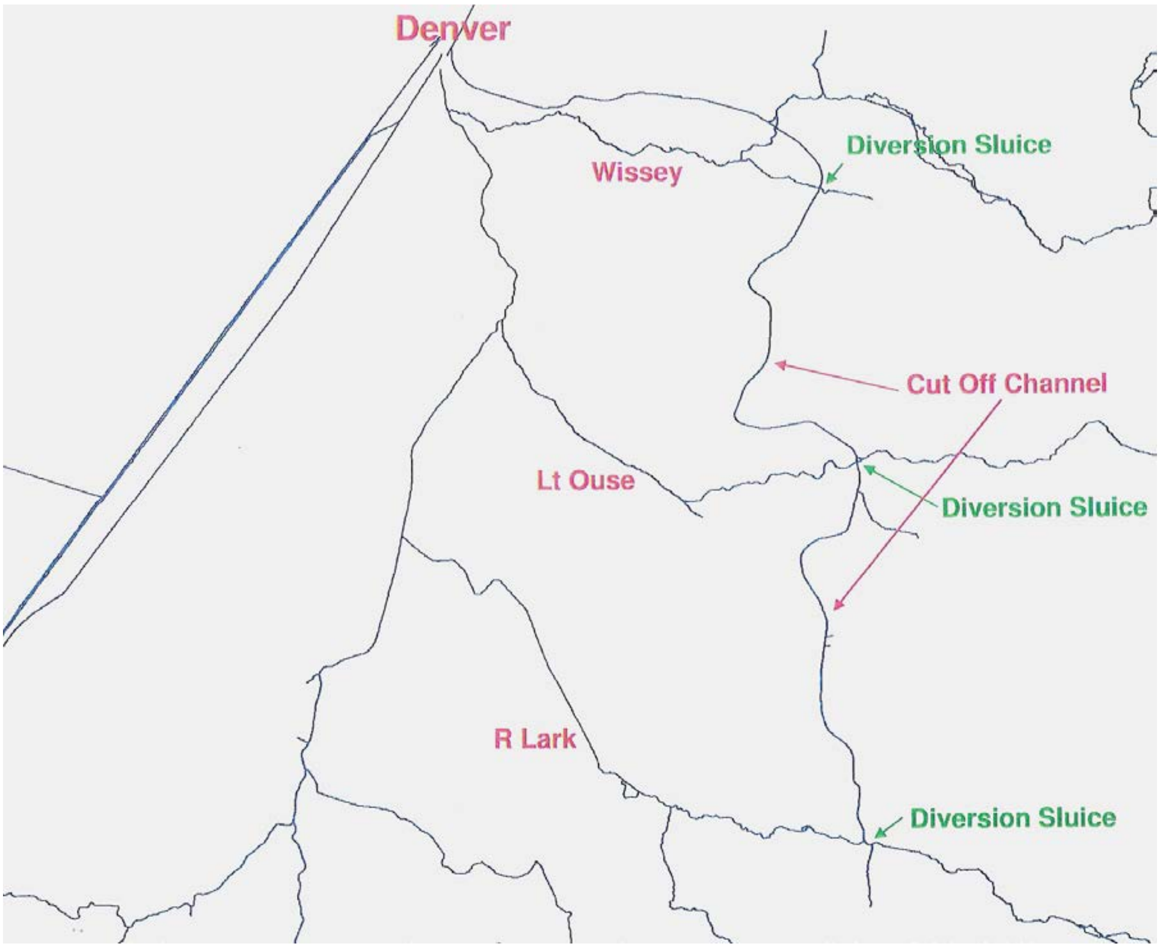
Figure M - A Vision for the expansion of Wicken Fen

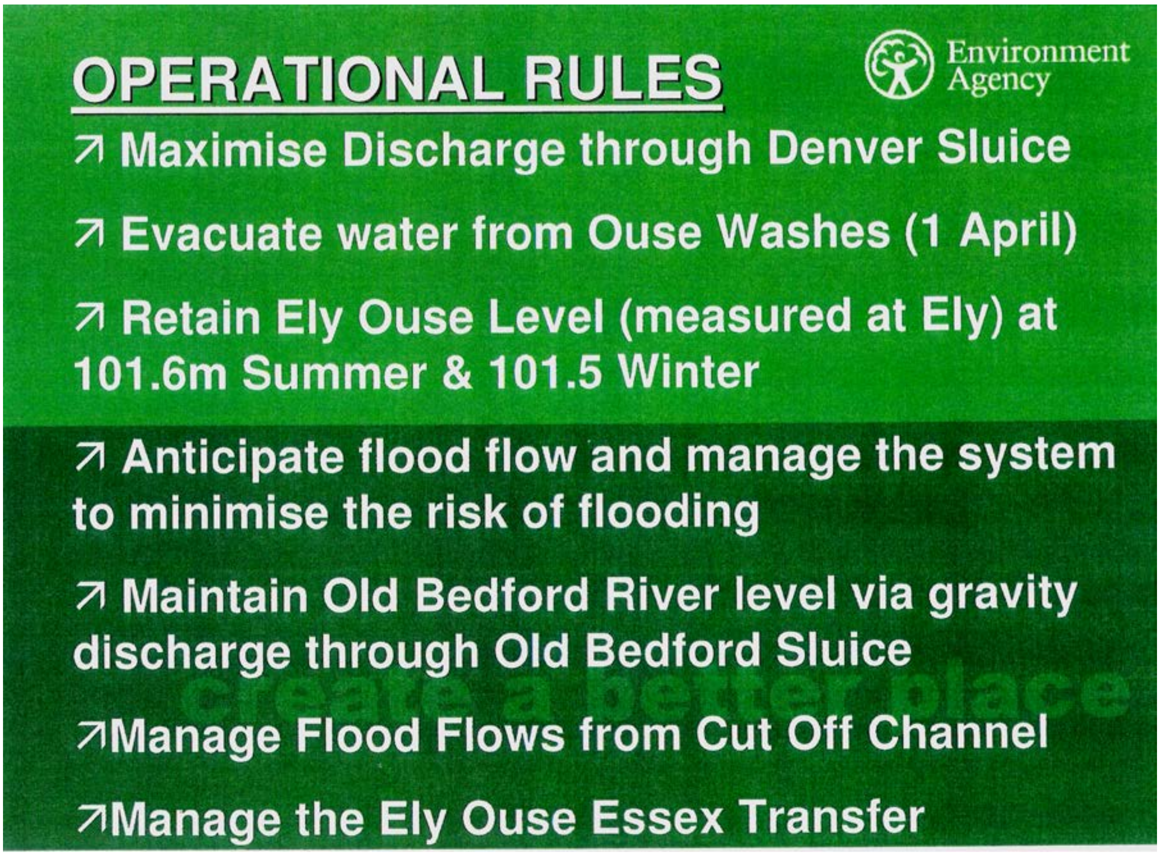
APPENDIX 1 - THE DENVER COMPLEX




Salters Lode
West Fm
Nordelph
Cemy
Birchfield Fm
Nordelph Fm
Denver Sluice
White Hall Fm
Denver
Sluice Common
Mill
Rookery Fm
Silt Fen Fm
Ouse Bridge Fm
Fordham Fen
Sluice
Welmore Sluice
Middle Fm
Willow Fm
Great West Fen
Ouse
Washes
Vennev Fm


Salters Lode
War Meml
Poplar Farm
Lock
Locks
Well Creak
Old Bedford River
Tidal River
Denver Sluice
Sluice
The A G Wright Sluice
Relief Channel
Posts
Jetty
Middle Drove Farm
Cut Off Channel
Ely Ouse
Hundred Foot Drain
Sluice Road
Middle Drove
Drain
Path
DENVER C


Denver
Wissey
Diversion Sluice
Cut Off Channel
Lt Ouse
Diversion Sluice
R Lark
Diversion Sluice


OPERATIONAL RULES
Environment Agency
↗ Maximise Discharge through Denver Sluice
↗ Evacuate water from Ouse Washes (1 April)
↗ Retain Ely Ouse Level (measured at Ely) at 101.6m Summer & 101.5 Winter
↗ Anticipate flood flow and manage the system to minimise the risk of flooding
↗ Maintain Old Bedford River level via gravity discharge through Old Bedford Sluice
create a better place
↗Manage Flood Flows from Cut Off Channel
↗Manage the Ely Ouse Essex Transfer