

## 2. Study Area

### 2.1 Overview of the Study Area (Borough of King's Lynn and West Norfolk)

The Borough of King's Lynn and West Norfolk covers an area of 1,471km<sup>2</sup> located in the west of Norfolk and borders the eastern shoreline of the Wash (Figure 2.1). The area is primarily rural in nature, dominated by arable farming. The largest town is King's Lynn which has an urban area of approximately 28km<sup>2</sup>, followed by Downham Market in the south, Hunstanton to the north on the coast, as well as a large number of smaller settlements. The Borough is largely low lying and includes a large area of fenland where the landscape is dominated by drainage channels managed by Internal Drainage Boards. King's Lynn was an important fishing and trade port in the past and although these industries continue the economy of the town is now based on manufacturing and service industries whilst tourism provides an important component of the local economy in Hunstanton and the North Norfolk Coast. The Royal Sandringham Estate is located in the north east of the Borough.

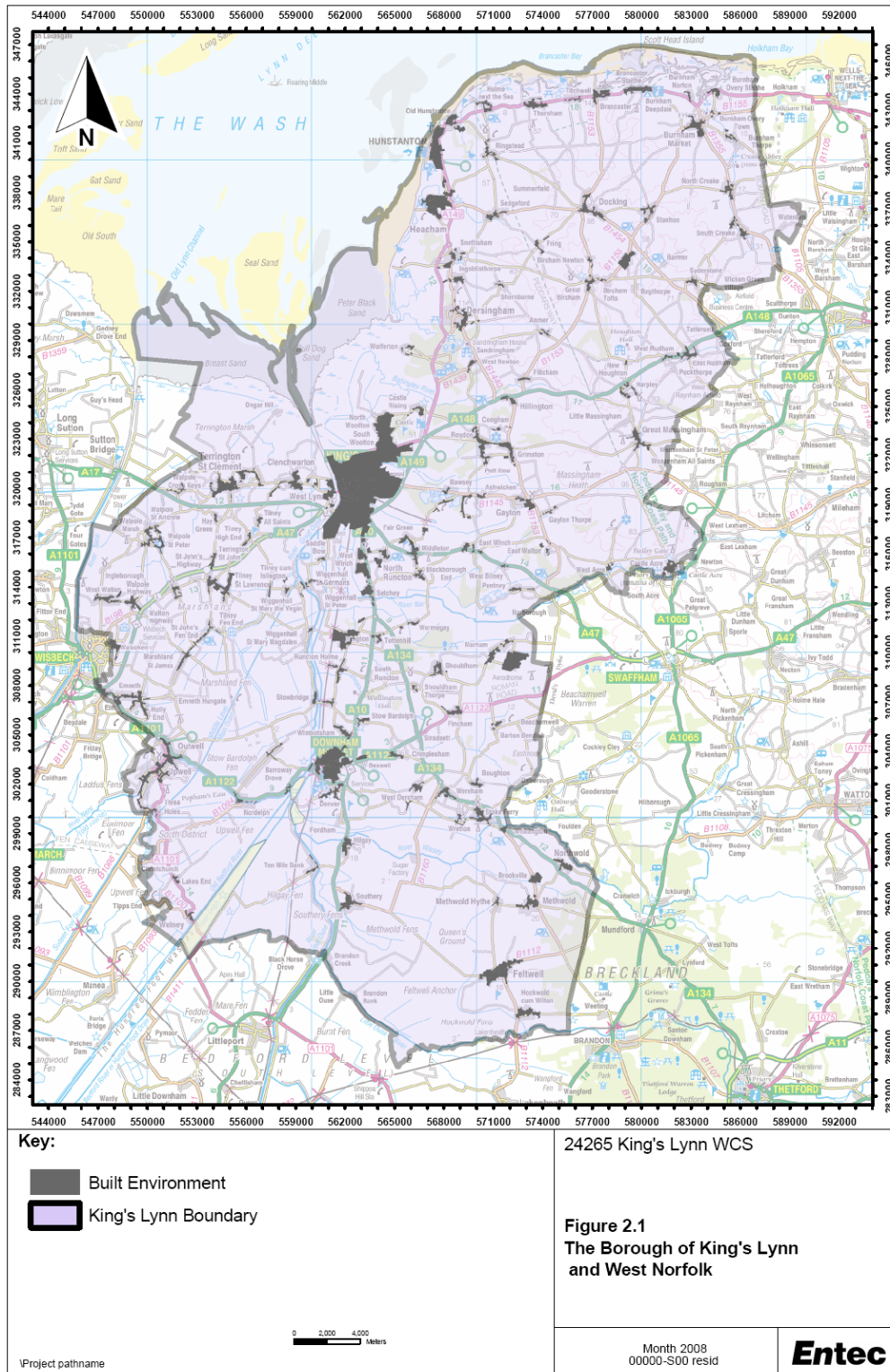
The Borough of King's Lynn and West Norfolk has approximately 53km of coastline stretching from Breast Sand in the Wash to Holkham Bay in the north-eastern edge of the study. Much of the coastline is characterised by sand dunes and wetlands and designated as an Area of Outstanding Natural Beauty (AONB).

### 2.2 Hydrology

The Borough of King's Lynn and West Norfolk is located at the downstream end of the Great Ouse catchment that drains an area of approximately 690km<sup>2</sup> excluding the Fenland area. Water from the Bedford Ouse to the south flows into the Borough via the tidal Hundred Foot River and Ouse Washes where flood water is stored during the winter before release at low tide into the tidal Great Ouse before it flows into the Wash. Water from the Ely Ouse (tributaries include the Cam, Lark, Little Ouse and Wissey) flows into the tidal river via Denver sluice or can be diverted into the Flood Relief Channel that runs parallel to the tidal river down to Tail End Sluice in King's Lynn. The Cut Off Channel also receives flood flows from the Little Ouse, Lark and Wissey that can also be diverted into the Flood Relief Channel. The Cut Off Channel and River Wissey run through the south eastern corner of the Borough and extend into neighbouring districts to the south and west. The Cut Off Channel also diverts water from the Ely Ouse to the Blackdyke Pumping station where it is pumped to the River Stour to support flows in this river and provide water to Abberton Reservoir (operated by Essex and Suffolk Water).



**Figure 2.1 The Borough of King's Lynn and West Norfolk**



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River flow patterns across the rest of the catchment are predominantly east to west, rising from springs in the chalk uplands, and to a lesser extent the Sandringham Sands, in the east to fens in the west. The River Nar drains an area to the south east of King's Lynn, the River Heacham enters the Wash south of Hunstanton; the River Babingley flows through the smaller villages just north of King's Lynn, flowing into the marsh lands of the Old Lynn Channel; and King's Lynn itself is drained by parts of the Rivers Gaywood, Nar, and the Great Ouse.

The southern and western area of the Borough is low lying where drainage is actively managed by the Internal Drainage Boards (Figure 2.2). Water from the low lying drains is pumped into the rivers by IDB pumps during the winter and in some cases water is released from the rivers via slackers to provide irrigation water during the summer. The Middle Level Main Drain crosses the fen as a high level carrier, discharging at St Germans pumping station. This drain is owned by the Middle Level Commissioners. There are several other artificial channels draining this area, principally the Middleton Stop Drain, the Puny Drain and Polver Drain.

The geology of the low lying fenland areas of the Borough is dominated by estuarine clays. In contrast, the higher western side of the Borough includes significant outcrops of Greensand and Chalk which support water supply boreholes (Figure 2.3).

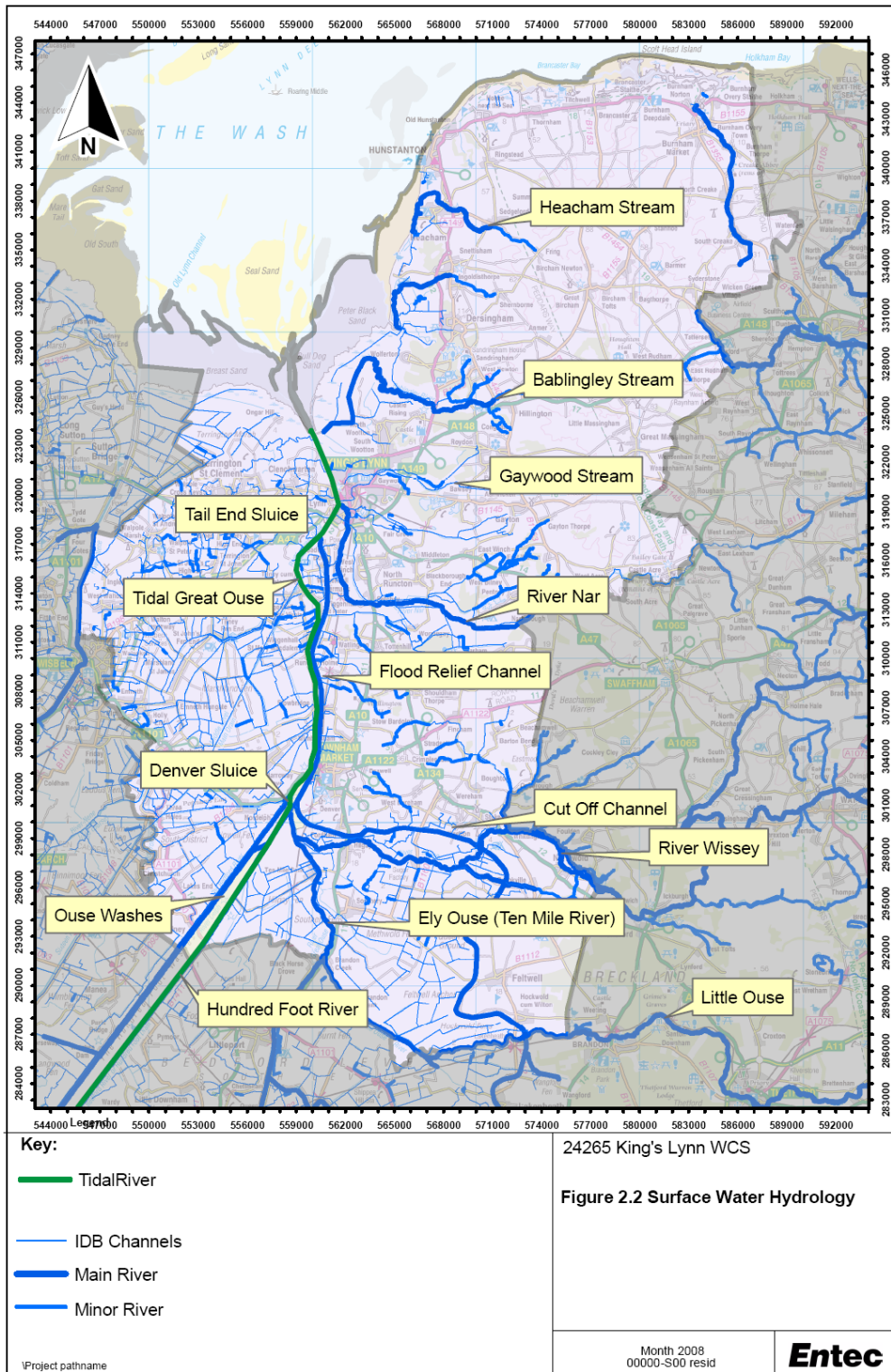
## 2.3 Climate Change

The changes in global climate patterns are predicted to lead to increased global temperatures, cause sea levels to rise and increase the frequency and intensity of rainfall and extreme weather. At a regional scale the nature of these impacts will vary, and will depend on the levels of greenhouse gas in the atmosphere. Alternative forecasts have been calculated based on varying greenhouse gas emissions scenarios by the UK Climate Change Impacts Programme (UKCIP).





**Figure 2.2 Surface Water Hydrology**

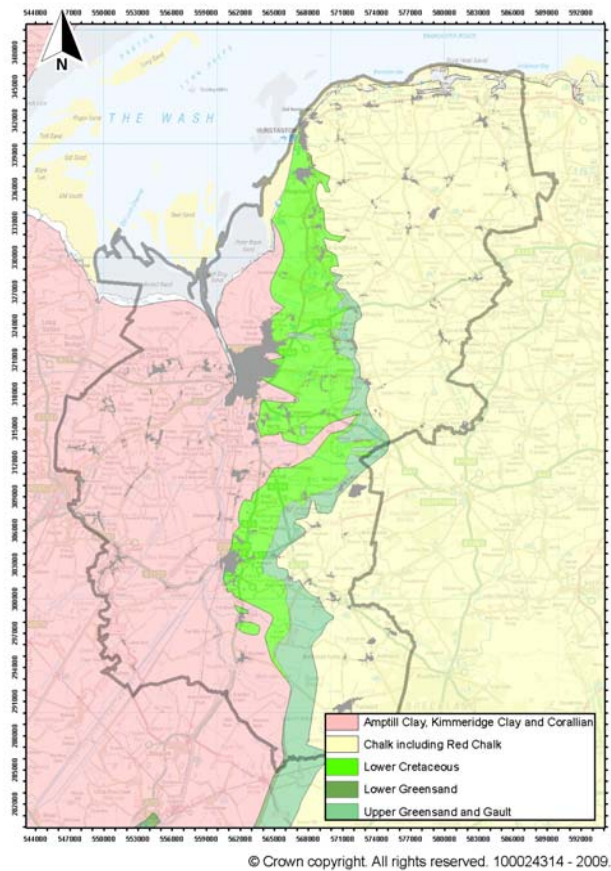


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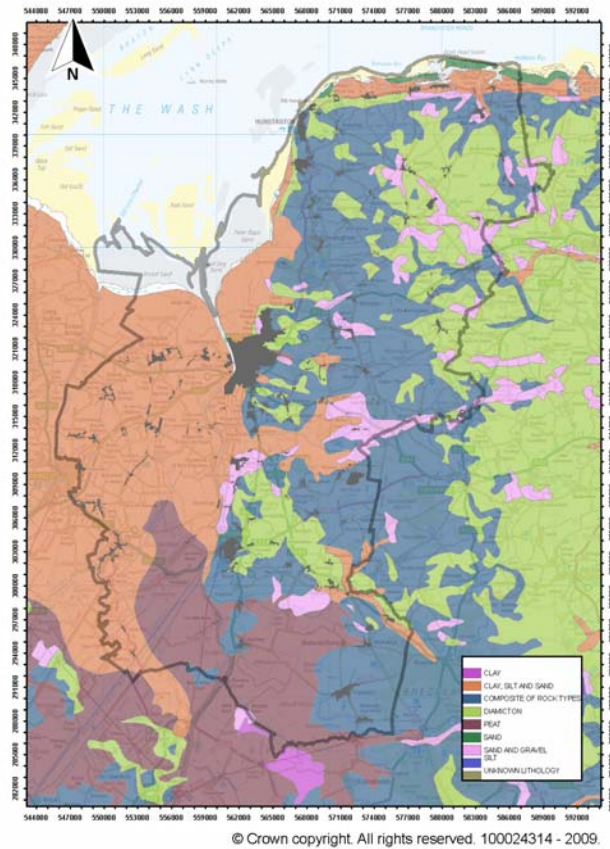


**Figure 2.3 Geology in the Borough of King's Lynn and West Norfolk**

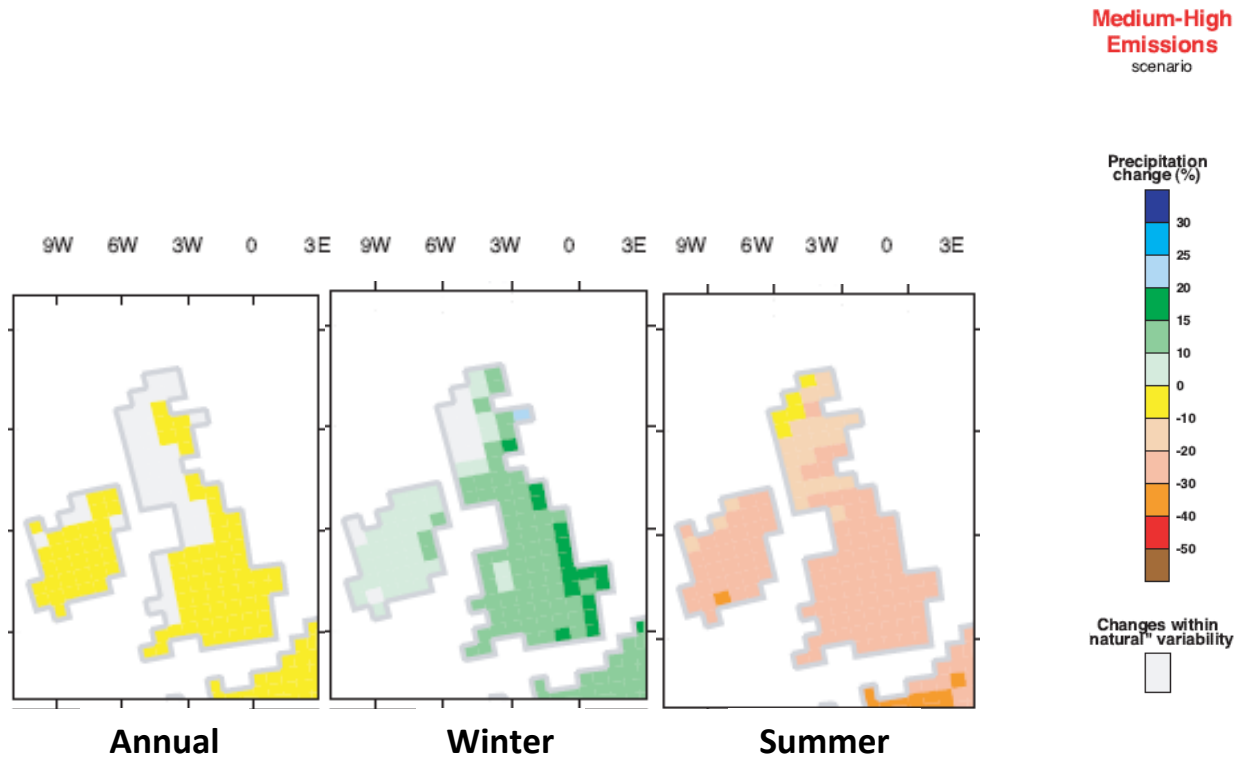
## Solid Geology



## Drift Geology



**Figure 2.4 Climate Change Impacts on Precipitation in the 2050's Under the Medium-High Emissions Scenario**



For Norfolk, under a Medium-High emissions scenario in the 2050s, the 2002 UKCIP predictions<sup>1</sup> forecast a reduction in annual average rainfall of between 0 and 10%, while winter rainfall is forecast to increase by 15 to 20%.. Summer rainfall is indicated to fall by between 20 and 30% on average.

Regional projections for sea level rise in South East England indicate that under the Low Emissions Scenario net sea level change in the 2080s relative to 1960-1990 baseline will be 0.22m, and for the High Emissions Scenario 0.82m. These figures are net of vertical land movement rates due to isostatic adjustment.

Revisions to the UKCIP predictions were due to be released in 2008, although this has been delayed until Spring 2009, and these should be taken into consideration in future phases of the WCS once they are released as they will provide a more localised understanding of climate change impacts (including pluvial flood risk) across the East of England.

<sup>1</sup> Climate Change Scenarios for the United Kingdom, The UKCIP Scientific Report, UKCIP, April 2002



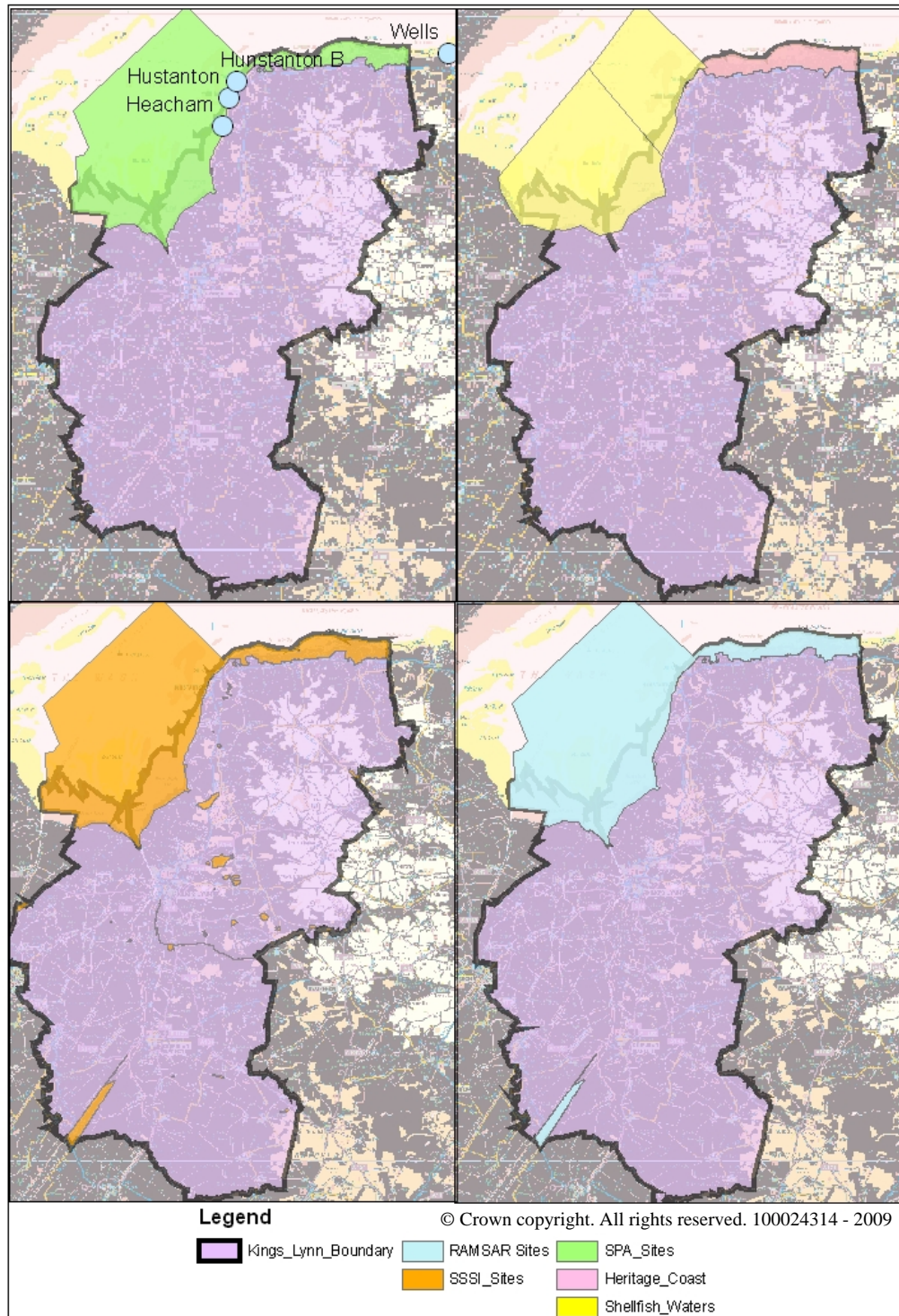
## 2.4 Built Environment

The towns of King's Lynn (17,500 houses), Downham Market (4,700 houses) and Hunstanton (2,800 houses) comprise most of the built environment within the Borough (Figure 2.1). Major roads include the A47 and A17 which run from east to west across the centre of the Borough, the A10 which connects King's Lynn to Cambridge to the south and the A149 which connects King's Lynn to the North Norfolk Coast. A railway line runs south from King's Lynn towards Cambridge.





**Figure 2.5 Protected Habitats and Sites**





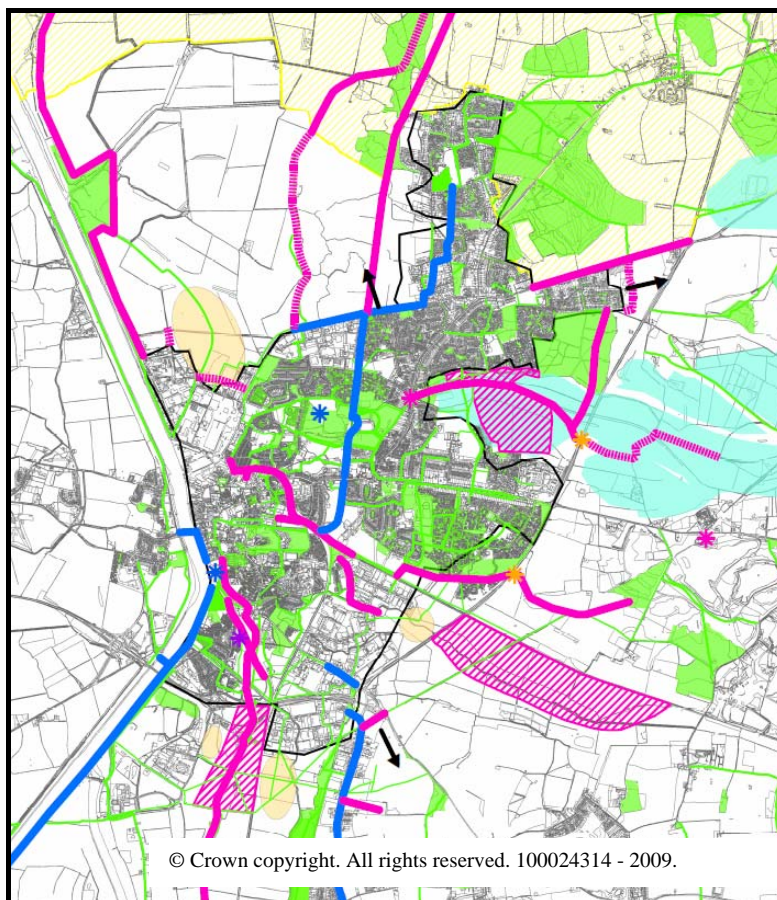
## 2.5 Ecology and Green Infrastructure

Figure 2.5 shows the location of protected habitats in the study area including Sites of Special Scientific Interest (SSSIs), Special Protection Areas (SPAs) and Special Areas of Conservation (SACs). Table 2.1 provides a list of the key sites and indicates the nature of the habitat and water related features (a complete list of sites is provided in Appendix G).

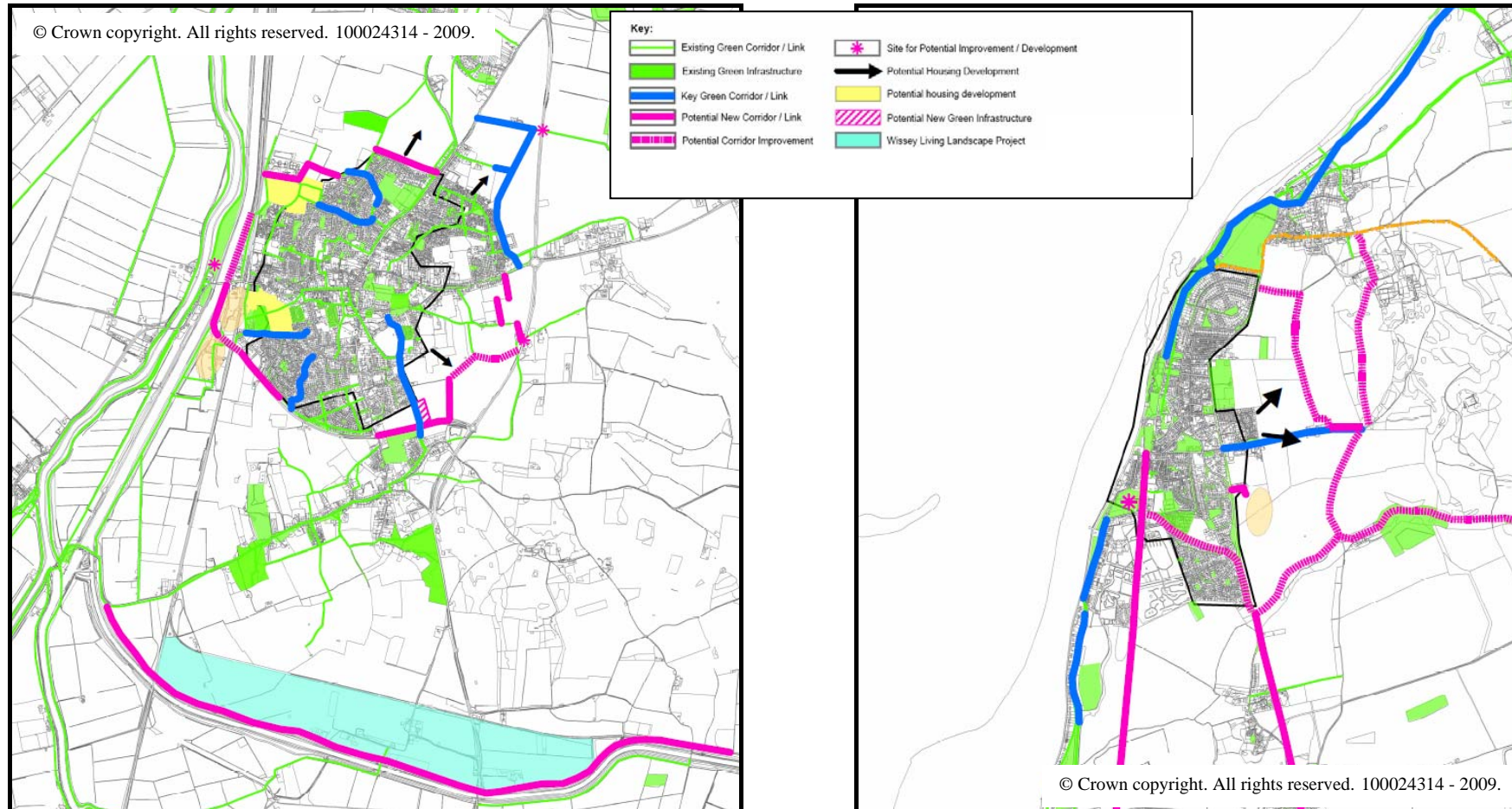
Key sites of European significance (designated under the Habitats and Birds Directives) within the Borough are Ouse Washes SAC/SPA, The Wash SAC/SPA, the North Norfolk Coast and the Norfolk Valley Fens. Only parts of these sites are located within the study area. The Rivers Nar, Babingley, Heacham and Wissey are chalk rivers, which are a priority UK BAP habitat.

Existing and future green infrastructure within the Borough of King's Lynn and West Norfolk is identified by a Green Infrastructure Strategy that has been carried out by Entec in parallel with the WCS. Key green infrastructure in the King's Lynn, Downham Market and Hunstanton areas are shown in Figure 2.6 and 2.7.

**Figure 2.6 Key Green Infrastructure in the King's Lynn Area (Draft; see Figure 2.7 for key)**



**Figure 2.7 Key Green Infrastructure in the Downham Market and Hunstanton Areas (Draft)**



**Table 2.1 Protected habitats in the Borough of King's Lynn and West Norfolk**

| Site                    | Description of habitats  | Potential water related issues  | Designations                            |
|-------------------------|--|---|---|
| The Wash                | The Wash estuary is the largest estuarine system in the UK, measuring 15 miles long by 12 miles wide, fed by the rivers Witham, Welland, Nene and Great Ouse. The Wash comprises very extensive saltmarshes, major inter-tidal banks of sand and mud, shallow waters and deep channels. The inter-tidal flats have a rich invertebrate fauna and important food sources for the large numbers of waterbirds dependent on the site. The Wash is also of outstanding importance for a large number of geese, ducks and waders, both in spring and autumn migration periods, as well as through the winter months. The sheltered nature of The Wash creates suitable breeding conditions for shellfish, principally mussel, cockle and shrimps, which are important food sources for water birds. | Water quality issues related to pollution loads from the inland rivers and direct coastal discharges.   | SPA, SAC, Ramsar, SSSI                  |
| The Ouse Washes         | The Ouse Washes, comprising a 32 km long, 2403 ha area of washland are of international importance in terms of their conservation interest. Within the Washes are internationally important areas of wet grassland. The area is of great ornithological interest with nationally and internationally important breeding colonies of several species. In addition to this, the two rivers to the north-west of the washes [Counter (Old Bedford) Drain & River Delph] are designated as a cSAC on the basis of their spined loach <i>Cobitis taenia</i> populations.  | Water quality issues related to pollution inputs from the upstream catchment and IDB pumps. Hydrological impacts from the upstream catchment related to the frequency of flooding | SPA, SAC, Ramsar, SSSI                  |
| The North Norfolk Coast | The North Norfolk marshland Coast extends for some 40kms between Hunstanton and Weybourne. The area consists primarily of inter-tidal sands and muds, saltmarshes, shingle banks and sand dunes. There are extensive areas of brackish lagoons, reedbeds and grazing marshes. A wide range of coastal plant communities is represented and many rare or local species occur. The whole coast is of great ornithological interest with nationally and internationally important breeding colonies of several species. The area, much of which remains in its natural state, now constitutes one of the largest expanses of undeveloped coastal habitat of its type in Europe.   | Water quality issues related to pollution inputs from the upstream catchment. Hydrological impacts related to impacts of abstractions on freshwater flows into the marshes.       | SPA, SAC, Ramsar, SSSI                  |
| Roydon Common           | Roydon Common is considered to be one of the best examples in Britain of a lowland mixed valley mire, a complex series of plant communities grading from wet acid heath through valley mire to calcareous fen. The mire is extremely diverse and supports many rare and locally uncommon plants. Large areas of nationally important dry <i>Calluna</i> heath on acidic sands are also present. There is, in addition, considerable ornithological and entomological interest in the site.   | Impacts of abstraction on water levels  | SSSI, SAC (part of Norfolk Valley Fens) |
| Dersingham Bog          | Dersingham Bog is the largest, and most intact example of an acid valley mire in East Anglia. The mire itself lies on shallow peat and has extensive areas dominated by bog mosses with several locally rare species of plant. The mire is bordered on one side by an escarpment, which marks the edge of an ancient coastline, which has large areas of heathland on its slopes. Self-regenerating pine woodland has developed on the top of the escarpment. The site also  | Impacts of abstraction on water levels  | SSSI                                    |





| Site                            | Description of habitats  | Potential water related issues   | Designations                            |
|---------------------------------|--|--|---|
|                                 | has considerable ornithological and entomological interest.  |  |   |
| East Walton and Adcock's Common | These two commons though lying about one kilometre apart are notable for a complex set of basin-shaped depressions separated by chalky ridges which were formed under periglacial conditions. Active springs are also a feature. This varied topography has resulted in a mosaic of habitats ranging from fen or occasionally open water in the depressions to chalk grassland or scrub on the intervening ridges.   | Impacts of abstraction on water levels   | SSSI, SAC (part of Norfolk Valley Fens) |
| River Wensum                    | The Wensum has been selected as one of a national series of rivers of special interest as an example of an enriched, calcareous lowland river. With a total of over 100 species of plants, a rich invertebrate fauna and a relatively natural corridor, it is probably the best whole river of its type in nature conservation terms, although short stretches of other similar rivers may show a slightly greater diversity of species.   | Water quality impacts from diffuse and source point pollution. Impact of abstractions on flow. | SSSI, SAC                               |
| River Nar                       | The River Nar combines the characteristics of a southern chalk stream and an East Anglian fen river. Together with the adjacent terrestrial habitats, the Nar is an outstanding river system of its type.  | Water quality impacts from diffuse and source point pollution. Impact of abstractions on flow. | SSSI                                    |
| Boughton Fen                    | Boughton Fen is situated on shallow fen peats in the valley of a tributary of the River Wissey. A tall fen community covers much of the site and several interesting plants are present. Scrub is well represented and is used by breeding birds. The site is of entomological interest.   | Impacts of abstraction on water levels   | SSSI                                    |
| Islington heronry               | Islington Heronry is a small, isolated stand of mature oaks surrounded by fenland which supports the largest colony of Grey Herons <i>Ardea cinerea</i> in Norfolk.  | Diffuse and point source pollution on water quality.   | SSSI                                    |
| East Winch Common               | An area of predominantly wet acid heathland on shallow peat of a type that has become rare in west Norfolk. Many wet hollows are present containing diverse fen and mire communities.  | Impacts of abstraction on water levels   | SSSI                                    |
| Leziate, Sugar and Derby Fens   | These three fens are the remnants of a once extensive valley fen system along the Gaywood River. The site has dried out considerably in recent years due to the drainage of surrounding agricultural land but a wide range of habitats, from dry calcareous grassland to wet boggy heath, is still present. These diverse plant communities reflect variations in the underlying soils. Much of the site is on the greensand belt and here, extensive areas of damp acidic grassland and heath have developed. The Gaywood River is fed by chalk springs and locally there is species-rich calcareous grassland on chalky soils. | Impacts of abstraction on water levels   | SSSI                                    |



| Site               | Description of habitats  | Potential water related issues         | Designations |
|--------------------|--|--|--------------|
| Synderstone Common | Syderstone Common consists of a series of heath and grassland communities occupying a shallow valley in the headwaters of the River Tat, a tributary of the River Wensum. These communities grade from dry heath dominated by gorse scrub, but with areas of bracken <i>Pteridium aquilinum</i> , heather <i>Calluna vulgaris</i> and acid grassland dominated by wavy hair grass <i>Deschampsia flexuosa</i> , to marshy, acid grassland dominated by purple moor grass <i>Molinia caerulea</i> and rushes <i>Juncus spp.</i> In the lowest areas there are a series of seasonally wet pools. | Impacts of abstraction on water levels | SSSI         |



## 2.6 Neighbouring Council Areas

The Borough of King's Lynn and West Norfolk is bordered by North Norfolk, Breckland, Forest Heath, East Cambridgeshire, Fenland and South Holland council areas. Table 2.2 summarises the position of these councils with regard to the completion of Water Cycle Strategies. Water infrastructure issues in the Borough of King's Lynn and West Norfolk may also be affected in water management in upstream catchments which form part of the Bedford Ouse and Ely Ouse areas. Interactions with neighbouring and upstream areas are considered in detail in the technical sections of this report

**Table 2.2 Progress with Water Cycle Studies in Neighbouring Areas**

| Council Area        | Progress with water cycle studies                    |
|---------------------|--|
| North Norfolk       | No WCS work carried out to date.                     |
| Breckland           | Phase 1 Complete, Phase 2 shortly to be commissioned |
| Forest Heath        | Phase 1 Complete, Phase 2 shortly to be commissioned |
| East Cambridgeshire | Scoping study recently commissioned                  |
| Fenland             | Scoping study recently commissioned                  |
| South Holland       | No WCS work carried out to date.                     |

