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The North West Norfolk Catchment Abstraction Management Strategy

March 2005



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Introduction

The vision for the North West Norfolk Catchment Abstraction Management Strategy (CAMS) is to ensure that the water resources of the area are managed sustainably for the future, with due regard for the needs of the environment, abstractors and other water users.

Catchment Abstraction Management Strategies (CAMS) are strategies for management of water resources at a local level. They will make more information on water resources and licensing practice publicly available and allow the balance between the needs of abstractors, other water users and the aquatic environment to be considered in consultation with the local community and interested parties.

CAMS are also the mechanism for managing time-limited licences by contributing to the determination process which decides whether they should be renewed and, if so, on what terms.

Managing Water Abstraction: The Catchment Abstraction Management Strategy Process is the national document that supports the development of CAMS at a local level. It sets out the national policy and the regulatory framework within which CAMS operate, describes the process of developing CAMS and provides information on the structure and content of CAMS documents. This Catchment Abstraction Management Strategy should be read in conjunction with *Managing Water Abstraction*.

The North West Norfolk CAMS sets out the catchment level abstraction licensing strategy for North West Norfolk over the next six years. The strategy will then be reviewed following a reassessment of water resource availability.

A technical document for the North West Norfolk CAMS has been produced which provides the detailed technical information on which the development of the strategy has been based. If you wish to receive this document on CD-ROM, please contact us at:

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A hard-copy version of the document is also available for viewing at the same office. This may be viewed between the hours of 9.00 am to 5.00 pm.

Consultation on the North West Norfolk CAMS

Consultation is an integral part of the CAMS process. It is important because it ensures that the CAMS process is as transparent as possible and gives everyone the opportunity to get involved. For the Environment Agency to manage water resources in the catchment effectively and sustainably, it is important that as much information as possible is collated on water needs and uses. Comments and suggestions have been gathered during the early stages of development of this strategy through pre-consultation activities. These were:

- Awareness-raising leaflet;
- A CAMS Stakeholder Group;
- An internal project group; and
- Targeted information requests.

The leaflet was distributed in September 2002. Its aim was to raise awareness of the development of the CAMS in the local area and it also invited anyone with an interest to send in written comments, providing information, views and suggestions.

A stakeholder group was set up for the North West Norfolk CAMS. The role of the stakeholder group was to represent the key interests in the catchment and to help identify issues of local significance, provide views on proposals and to consider the likely implications of different strategy options. The members of the North West Norfolk CAMS Stakeholder Group and the interests they represented are as follows:

Name	Interest represented
Barrie Rickards	Independent Chair
Derek Bradley	Navigation
Jeff Clarke	Development and planning
Richard Leishman	Conservation
Peter Lemon	Industry
Terry Mansbridge	Angling
Lou Mayer	Internal Drainage Boards
Jayne Owen	Public water supply
Philip Raiswell	Recreation
Nic Velzeboer	Agriculture

A total of six meetings were held with the Stakeholder Group during the CAMS process. During these meetings, group members learned about the methods used to carry out the resource assessment and the sustainability appraisal. They also took part in discussing the results and ensured that the interests of the areas which they represented were taken into account.

In addition, several groups were targeted for specific information that contributed to the development of the strategy:

- Presentations to a number of agricultural groups, with opportunity for discussion;
- The East of Ouse Polver and Nar Internal Drainage Board;
- King's Lynn Consortium of Internal Drainage Boards;
- Norfolk Wildlife Trust;
- Norfolk Biological Records Centre;
- Sport England;
- English Nature;
- Anglian Water; and
- The Sandringham Estate.

There was also a formal consultation on the North West Norfolk CAMS through a consultation document, distributed in November 2004. The responses received were analysed and taken into account as the strategy was finalised. Comments included:

- Support for the proposal that we should not licence any more water at low flows;
- Support for time limiting and cessation conditions to protect flows;
- Support for the proposal that we should allow licensing of water at high flows;
- Concerns were raised about the status of the River Nar;
- Concerns were raised about the potential impact of planned housing developments both in North West Norfolk and the surrounding area and the pressures these might have on water resources; and
- Proposals were received that water should be reserved for creation of wetland dependent wildlife sites.

This CAMS document now sets out the final strategy that has been determined for the North West Norfolk CAMS area.

The CAMS area

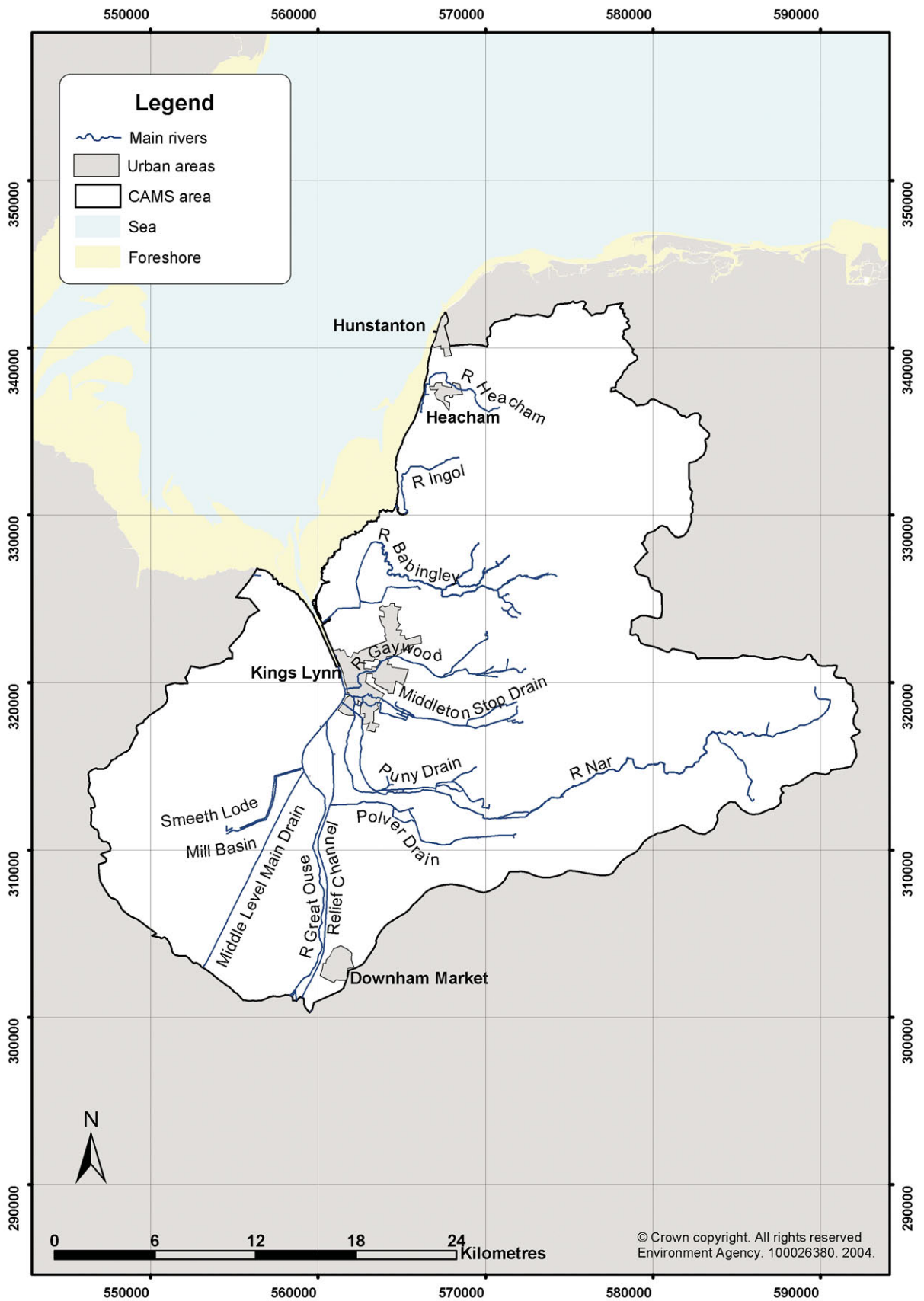
3.1 Catchment overview

The North West Norfolk CAMS area covers an area of approximately 970 km². The catchment covers both

Chalk uplands to the east, and fen to the west. The area is predominately rural and agricultural, but includes the towns of King's Lynn, Wisbech, and (parts of) Hunstanton and Downham Market.



River Nar



3.2 Hydrogeology

The catchment can be divided into two distinct areas. To the west of the Great Ouse, and on the coastal fringes the land is low lying, in some places below sea level. These areas were formed from extensive deposits of unconsolidated clays and sand derived from old river beds and flood plains, beaches and estuarine saltmarsh, all of which overly Kimmeridge and Ampthill clays.

In contrast, to east of the Great Ouse, away from the coastal fringes, the catchment is made up of a layered sequence of rocks and clays. The first outcrop is a distinctive low scarp of Sandringham Sands which rises from the drained coastal marshes, dipping gently from west to east. The assessment of the Sandringham Sands includes the Carstone. Further east the Sandringham Sands outcrop is overlain by Chalk, which also dips from west to east.

The Sandringham Sands and Chalk both act as *aquifers*, that is, rocks that are able to store and transmit significant quantities of water. Within this CAMS, the status of water resources in both these

aquifers has been assessed. In the North West Norfolk CAMS, the Chalk and the Sandringham Sands aquifers are used for significant public water supply. The Chalk also forms an important source of water for irrigation.

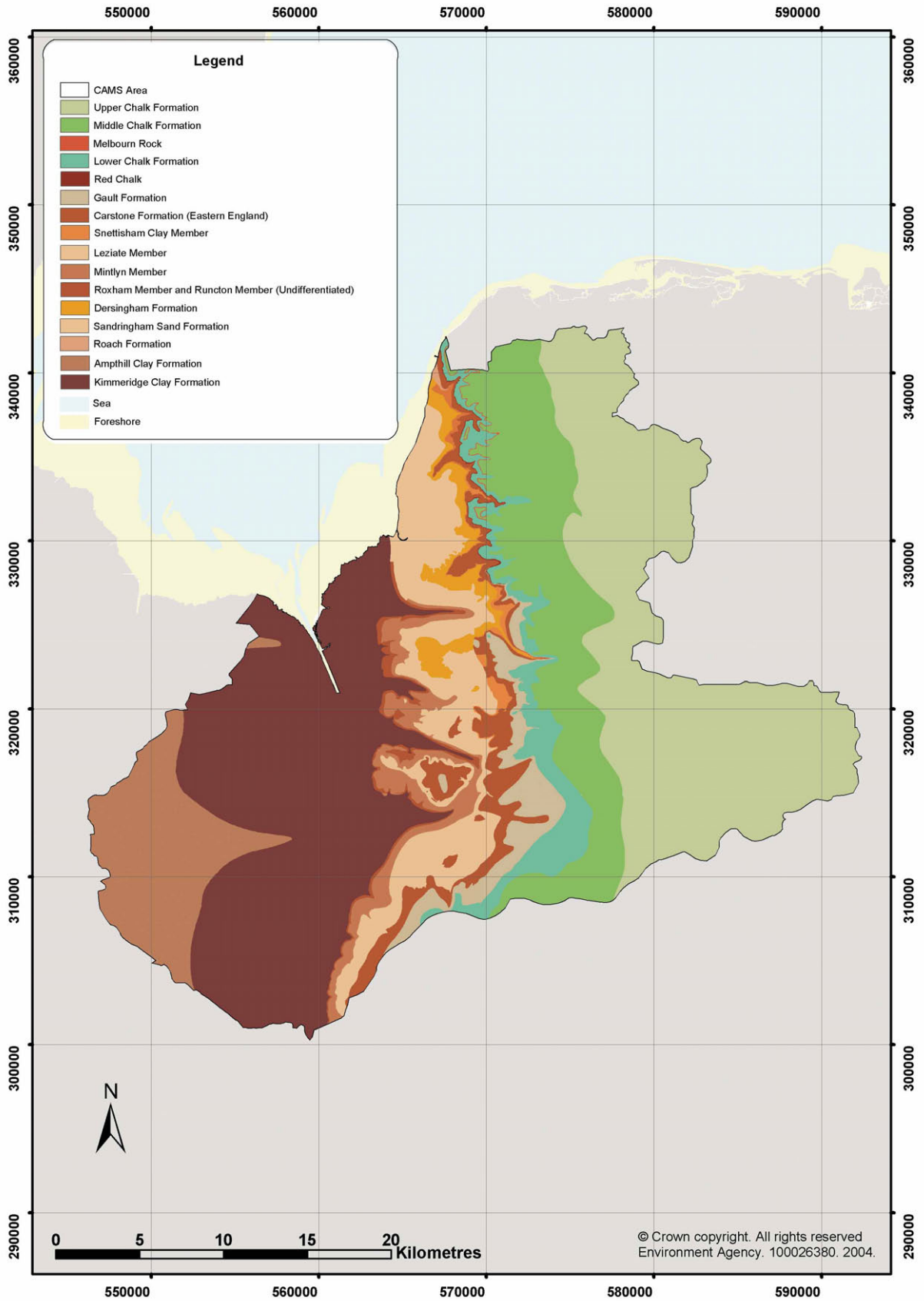
In the north of the North West Norfolk CAMS area it is thought that the Chalk aquifer directly overlies the Sandringham Sands. However the way in which water moves between the two types of rock is poorly understood. Because of this, during the assessment of water resources, an assumption was made that water moved between the two rock types. The two aquifers were therefore treated as a single formation.

Further south a Gault Clay layer is found sandwiched between the Chalk and the Sandringham Sands. This acts as a barrier between the Chalk and the Sandringham Sands preventing the movement of water between the two. In this area of the CAMS the Chalk and Sandringham Sands were considered individually during the assessment of water resources.

Springs from both the Chalk and, to a lesser extent, the Sandringham Sands provide significant contribution to flows in rivers.



Fishing Lake in the Nar Valley



3.3 Hydrology

The major water course in the North West Norfolk CAMS is the tidal reach of the River Great Ouse (also known as the Tidal River), which flows north from Denver Sluice. It discharges into the Wash just north of Kings Lynn. The river is tidal upstream as far as Earith. This is the downstream limit of the Upper Ouse and Bedford Ouse CAMS. The Tidal River does not, however, provide much of a water resource.

The Relief Channel flows parallel to the Great Ouse from Denver, rejoining the main river just south of King's Lynn. The Channel carries water from the Ely Ouse system during periods of medium to high flow, when Denver Sluice is running at capacity. Discharge of water from the Relief Channel to the Tidal River is controlled by the Tail Sluice and occurs at low tide. Although a small amount of abstraction does take place from the Relief Channel, its primary function is flood storage.

To the west of the Great Ouse lies an area of fenland. This area is drained, but has little in the way of water resources. That which is present tends to be of poor quality and unsuitable for irrigation or drinking water. Two main drains, Smeeth Lode and Mill Basin, pump the water from the fen to the Ouse at Wiggshall St Germans. Additional water drains to the Great Ouse via tidal flaps. The Middle Level Main Drain also crosses the fen as a high level carrier, discharging at St Germans pumping station. This drain is owned by the Middle Level Commissioners who manage land drainage in the Middle Level (Old Bedford including Middle Level CAMS). Water from the Middle Level Main Drain is therefore not available for abstraction in this CAMS.

To the east of the Great Ouse, the Sandringham Sands and Chalk outcrops are cut by east-west flowing rivers and drains. There are five main river catchments. All are dominated by baseflow from the underlying aquifer. During drought, as the groundwater level lowers, the upper reaches of the rivers may dry up



The River Nar

as the spring line moves downstream. In this CAMS area, annual rainfall is low compared to the long term average for the UK of 1082 mm. For example, average annual rainfall at Marham is only 627 mm per annum. During long, dry summers, evaporation rate can exceed rainfall. This means that during those periods, recharge to aquifers is not taking place. Aquifer recharge generally occurs during wet winters. Following recharge, when groundwater levels are high, baseflow and therefore flow in the rivers is sustained.

The two most northerly rivers in this CAMS are the River Heacham and River Ingol. Both are less than 20km in length, rising as springs, and flowing west to the sea. They discharge via tidal flaps and so the lowest reaches of both are ponded during periods of high tide. Because the water resource assessment method used only applies to flowing water, it was not possible to assess these lowest reaches.

To the south of the Ingol, the River Babingley rises as Chalk springs above the villages of Flitcham, Hillington and Congham. Tributaries merge a short distance downstream where the underlying geology changes to sandstone. The lower river also receives tributary runoff from springs that rise on the Sandringham Sands. Below this, the river character changes to that of a meandering lowland river. The lower most reaches are channelised, discharging to the tidal River Great Ouse via a tidal sluice. Again these lowest reaches are ponded and therefore not assessed.

The River Gaywood follows similar geological origins to the Babingley, arising from Chalk and flowing west over the Sandringham Sands. The lower reaches are elevated above the flood plain of the Gaywood Valley. Again the final reaches are heavily modified, flowing through Kings Lynn to a tide-locked confluence with the tidal Ouse.

The longest river of the five is the River Nar. This is notable as a Chalk river although the upper most headwaters flow from Clay and are therefore derived from surface runoff. However, springs to the east of Litcham contribute to form a rapidly flowing shallow Chalk river. Below Narborough the river is modified to the tidal sluice which marks the confluence of the Nar with the Great Ouse at Kings Lynn.

In addition to natural rivers, the area east of the Great Ouse also incorporates a number of drainage channels managed by Internal Drainage Boards. Most notable are the Middleton Stop Drain, south of the Gaywood, which flows east-west to Kings Lynn, the Punny Drain which runs parallel to the latter reaches of the River

Nar and in parts contributes water to it, and the Polver Drain to the south of the Nar, which is pumped into the Relief Channel. The Nar can contribute water to the Polver Drain via slackers in its lower reaches. Of these drains, Middleton Stop Drain and the Polver Drain were assessed as a water resource. This was possible because, although they are pumped, there is sufficient flow in them for the resource assessment method to apply.

An additional factor influencing the amount of water entering the NW Norfolk CAMS is the presence of the Ely-Ouse Essex Transfer Scheme. Freshwater which would enter the CAMS area from the Ely Ouse system at the Denver Complex, is diverted into the Cut Off Channel to support public water supply in Essex. A Hands Off Flow exists to ensure that sufficient freshwater reaches the tidal Ouse during periods of low flow. It is worth noting that this water would be destined for the Tidal River, and would not necessarily be counted as an available resource for this CAMS area.

3.4 Hydrometry

The Environment Agency operates an extensive network in the catchment to measure rainfall, river flows and levels and groundwater levels.

Rainfall

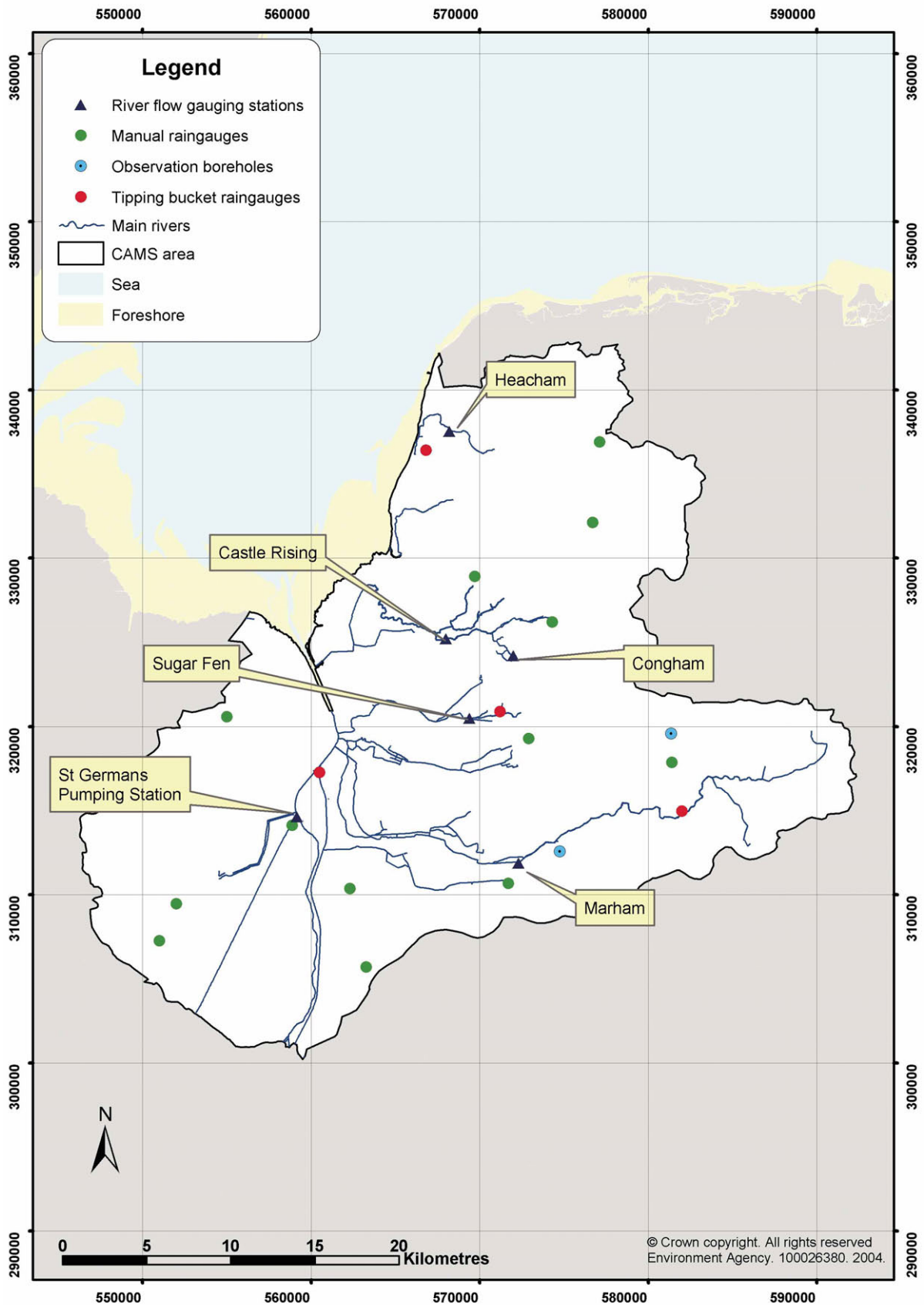
There are eleven daily raingauges in the North West Norfolk CAMS area. These are part of a country wide network, often read by private individuals, who provide data to the Agency and to the Meteorological Office. In this CAMS the oldest gauge is at Sandringham. This has been recording data since 1892. Most are more recent, with six added to the network since the early nineties.

Stream flows and groundwater

There are five primary river gauging stations in the North West Norfolk CAMS area. These are on the Rivers Heacham, Gaywood, Babingley (two sites) and Nar. The River Ingol is not gauged.

The key monitoring point for groundwater levels in the Chalk is at Washpit Farm.

Map 3 | Hydrometric network in the North West Norfolk CAMS area



3.5 Abstractions

There are currently 213 surface and groundwater abstraction licences in the North West Norfolk CAMS. At the time of writing, following the Water Act 2003, a number of these licences (deminimus at 20m³/day) were undergoing deregulation and were to gain exempt status. This is in addition to a number of other abstractions which were already exempt under the Water Resources Act 1991, including domestic licences that do not exceed 20m³/day.

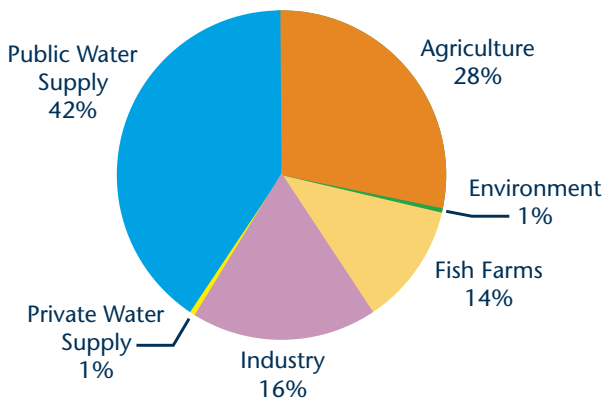


Figure 1 | Licensed abstractions in the North West Norfolk CAMS

Public water supply accounts for 42% of water licensed for abstraction from the CAMS area. The majority is taken from groundwater, but there is also a surface water abstraction. Historically the Chalk aquifer has been the source for groundwater abstraction, but rising nitrate levels in the Chalk water mean that increasingly water is sourced from the Sandringham Sands. Much of the water abstracted is used directly within the CAMS area, but some is exported for use elsewhere.

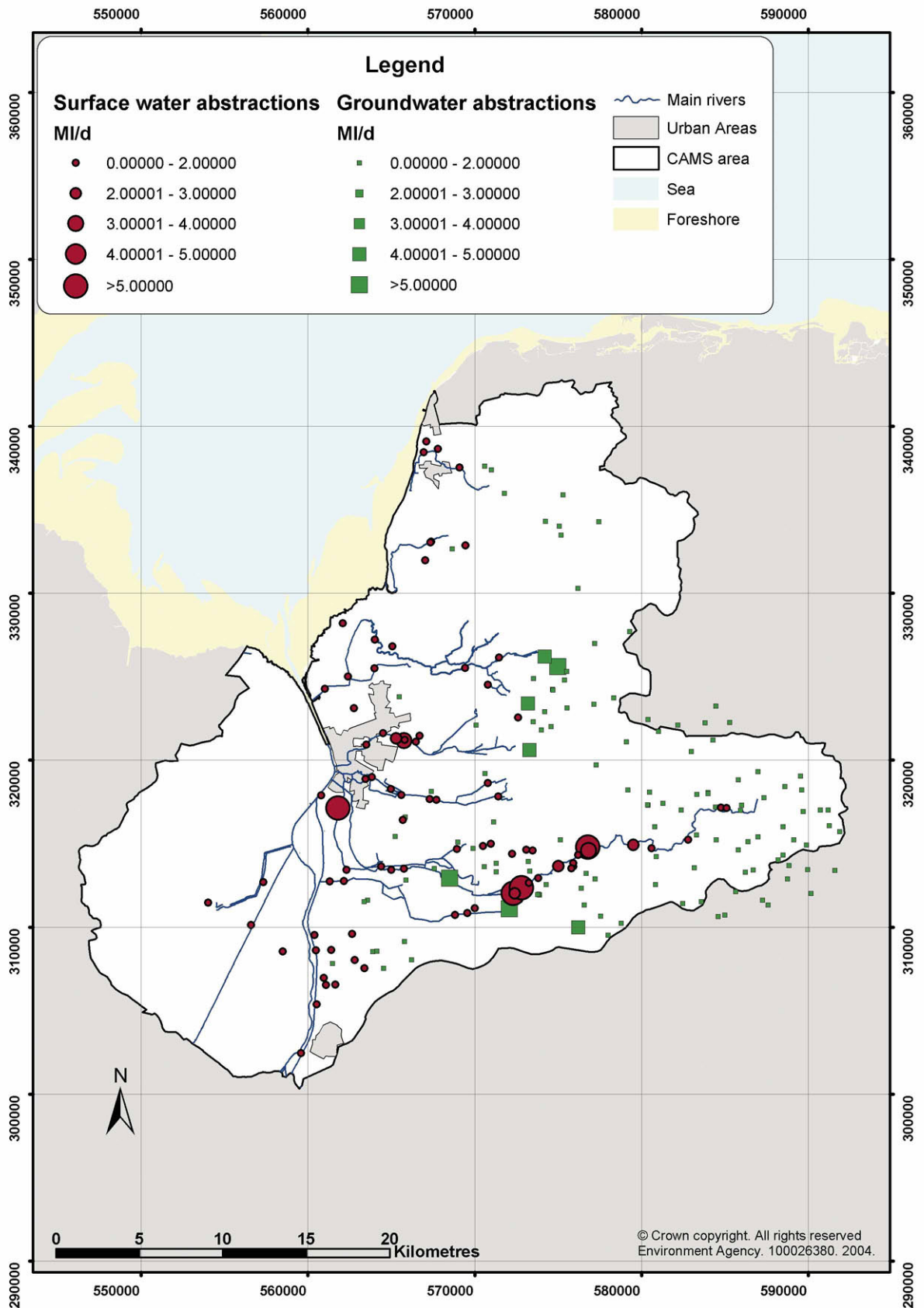
Abstraction from the Chalk also forms an important source for a small number of rural households that are not connected to mains supply.

In addition, 28% of licences are held for agriculture. Of these, 67 licences are held for, or include a component for, agricultural purposes which are classed as ‘general agriculture’. This excludes spray irrigation. Data suggests that a moderate number of these licences are no longer in use.

A further 62 abstraction licences are held for, or include a component for, spray irrigation. This, coupled with the number of general agricultural licences, indicates the importance of agriculture in the area. Spray irrigation licences in particular have the potential to conflict with environmental needs as peak

demand for irrigation usually coincides with periods of low flow in rivers. In addition, spray irrigation is highly consumptive and virtually none of the water is returned to the catchment. As water resources have become increasingly committed, use of winter water has been increasingly encouraged. An additional 17 licences within the CAMS allow abstraction from surface water sources in winter, for storage in reservoirs. This water is subsequently used for spray irrigation during the summer months. Because water is taken in winter when flows are high, these licences do not compete with ecological needs for water in the same way. They have the added bonus of ensuring a secure supply of water during the summer months.

Finally, there are a number of industrial abstraction licences in the CAMS area. Industrial use is variable and includes spray irrigation of golf courses, mineral washing for the aggregates industry, and a number of other purposes. The degree of consumptiveness of these licences therefore varies considerably.



3.6 Water quality and discharges

All main rivers and main drains in the North West Norfolk CAMS area are assessed for compliance with River Quality Objectives (RQOs). RQOs are targets which reflect the needs of riverine plants and animals and are used when planning control of activities that may affect water quality. Recent data shows that only one water course failed to meet its RQO. Mill Basin, west of the Great Ouse, failed due to low oxygen levels.

Although there are high numbers of consents to discharge (over 350) within the CAMS, most are very small and almost a third are consents to discharge to land. Many others discharge to tidal waters or to drains. Few are for discharges greater than 20m³/day. The most significant consents are for public sewage treatment work.

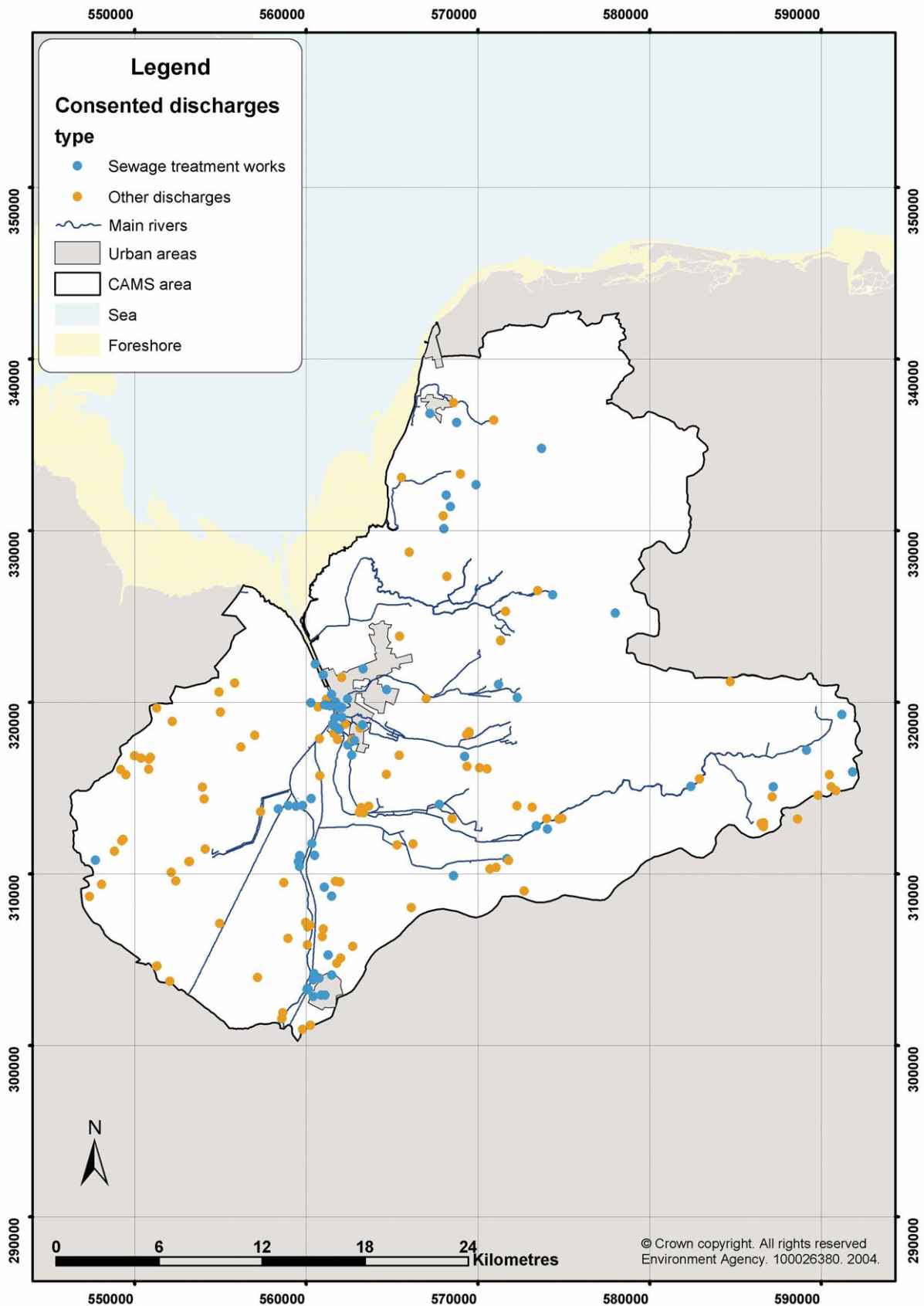
3.7 Ecology

The Agency collects and analyses a large amount of ecological data, including data on macroinvertebrates (aquatic insects), macrophytes (aquatic plants) and fish. Because these are sensitive to changes in conditions, the data can be used to determine the ecological status of a river reach. For example, macroinvertebrate communities are indicators of both water quality and flow regime, the structure of the community present, or abundance of a particular species correlating closely with either parameter. The data collected is used within the biological component of the General Quality Assessment (GQA) scheme, an assessment of water quality. Biological GQA scores range from 'a' (highest quality, where the biology is similar to or better than that expected for an unpolluted river of that size, type and location) to 'f' (lowest quality, where the biology is limited to a small number of very tolerant families, often only worms, midge larvae, leeches and the water hoglouse).

3.8 Fisheries

Fisheries data also demonstrates the variable nature of the rivers in the CAMS area. Native brown trout populations are found in the upper reaches of the Rivers Heacham, Babingley and Nar. More recently, following restoration of meanders to the river channel, these have also been observed in the upper Gaywood. Populations are sufficiently large to support angling on the upper Babingley and Nar. The Nar also supports migratory salmonids and these occasionally also use the Polver Drain to access the Nar. Maintenance of sufficiently high flows is important for the continued success of these populations. Flushing flows are needed to ensure that gravel beds, used for spawning by species such as trout, are kept clear of silts. Maintenance of sufficient depth is also important, particularly during the winter months.

In the lower reaches of the rivers, coarse fish such as roach and bream are a feature. These are also found in Middleton Stop Drain and the Polver Drain, the latter of which supports an angling club. Other coarse fish, such as pike and eel, are found on the Heacham, Gaywood and Middleton Stop Drain. The latter species is protected under the Salmon and Freshwater Fisheries Act (1975), as are all fish, but is also afforded additional recognition under the Wildlife and Countryside Act (1981), European Habitats Directive (1992), is the subject of a UK Biodiversity Action Plan (1995) and an Environment Agency National Eel Management Strategy.



3.9 Conservation

The North West Norfolk CAMS area contains a diverse range of habitats from remnant fen and valley mire to Chalk river. Three water-dependent sites within the area form part of the Natura 2000 network of conservation areas, designated under the European Habitats Directive. These are Roydon Common, Dersingham Bog and East Walton and Adcocks Common. Roydon Common and Dersingham Bog together form a candidate Special Area of Conservation (cSAC). Individually each site is designated as a Site of Special Scientific Interest (SSSI) under the 1981 Wildlife and Countryside Act. East Walton and Adcocks Common are part of the Norfolk Valley Fens cSAC. These sites support a variety of complex plant communities dependent on a supply of water from the underlying aquifers. Again, each is also a SSSI.

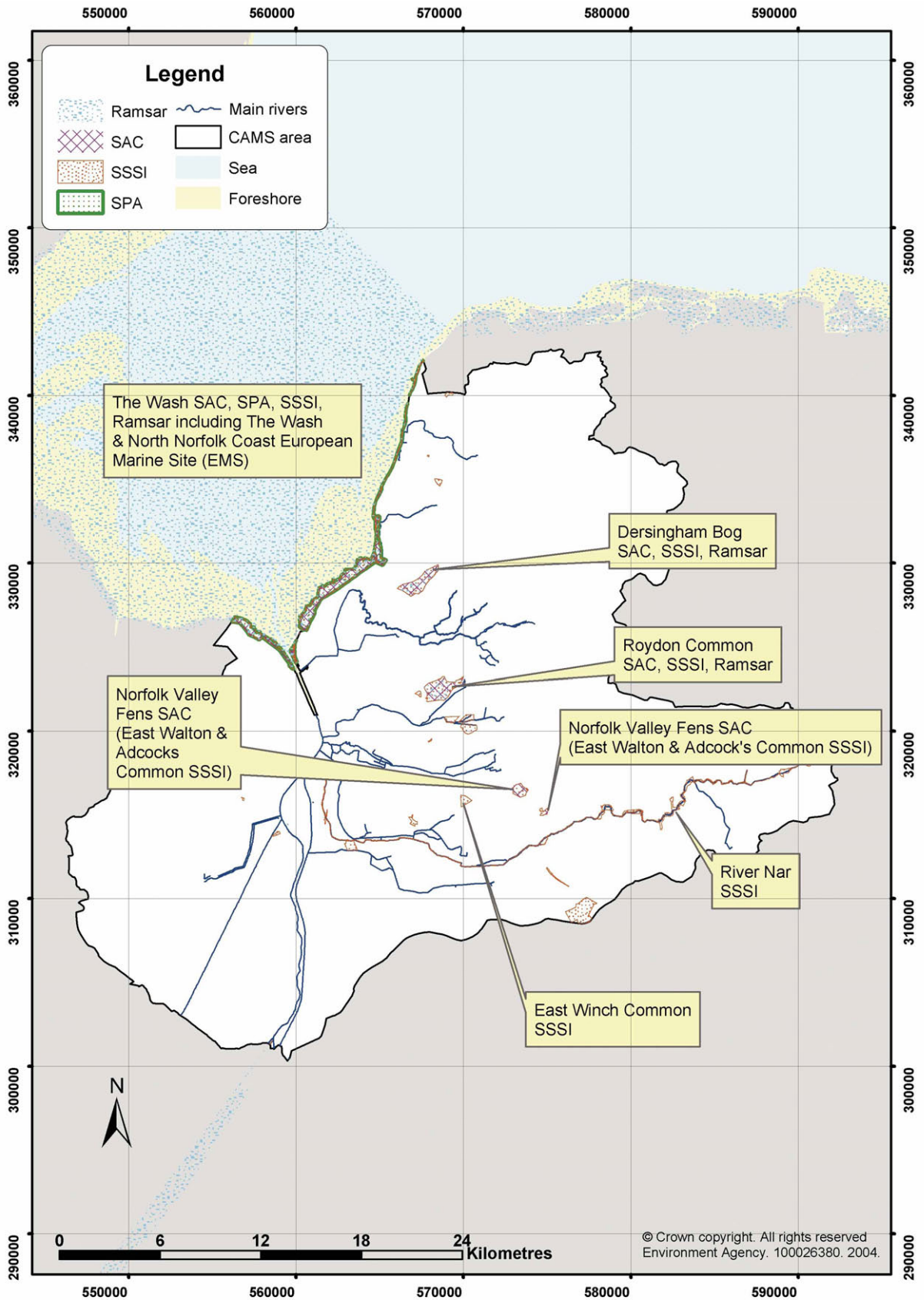
A supply of freshwater from the CAMS area also has the potential to influence a fourth Natura 2000 site, the Wash. This European Marine Site is designated both a cSAC for its shingle communities and diverse habitats of intertidal mudflats and saltmarshes, and a Special Protected Area (SPA) because it supports very large populations of both breeding and overwintering waders and wildfowl. The Wash is also a Ramsar site. At present the relationship between freshwater inputs and the Wash is under investigation. Around the North Norfolk coast, groundwater flow to The Wash has been found to be of local importance, but it is not clear at present whether this is the case elsewhere.

Under the European Habitats Directive, the Agency is currently required to review all consents that may affect the integrity of Natura 2000 sites. This means that by 2010, the impact of all abstraction licences on those sites must have been investigated. Any application for a new licence which has the potential to impact on these sites must also be investigated in the light of the Habitats Directive legislation.

The North West Norfolk CAMS area also supports additional dependent sites designated as SSSI's under the 1981 Wildlife and Countryside Act. Leziate, Sugar and Derby Fen in the Gaywood catchment is the remnants of a valley fen system supporting a range of habitats from dry calcareous to damp acidic grassland and heath. It is thought to be influenced by groundwater. East Winch Common is also potentially influenced by springs from the Chalk aquifer as well as perched water tables and springs from sand and gravel deposits. It supports fen and mire communities. Finally the River Nar, although not typical, (having headwaters which are fed by surface run off, and heavily modified lower reaches) is designated as a

Chalk river SSSI. Baseflow from the Chalk aquifer is therefore important. Rainwater is purified as it percolates through the Chalk, to emerge as alkaline, crystal clear water at a fairly constant cool temperature. This supports characteristic plant communities, a great diversity of aquatic insects, fish, including trout, salmon and lamprey, and frequently larger animals such as water vole and otter. Worldwide, Chalk rivers are rare. Of the 161 Chalk streams and rivers in the UK, only 10 are designated as SSSIs. Few such rivers are in an entirely natural state due to a long history of human intervention dating back to prehistoric times. The Nar is no exception - the lower reaches are embanked and abstraction was a feature of the catchment long before it was designated.

Other, non-designated wildlife sites are also found across the CAMS area with varying degrees of dependency on water resources. These sites form an important part of the natural heritage of North West Norfolk. Examples are given in future sections 4.5.11 to 5.5.11 of this document. At present, information about the relationship between abstraction and such sites is limited. However, as these sites form an important part of the natural heritage of North West Norfolk it is important that consideration is given to their water needs.



3.10 Recreation and navigation

Although North West Norfolk attracts a significant number of tourists annually, for many the key attraction is the coast. Populations in seaside towns such as Hunstanton soar during the summer months, placing increasing demands on public water supply.

Other recreational activities are directly related to the rivers in the area. For example, a number of angling syndicates fish rivers such as the Nar, Babingley and Polver Drain, while wildlife sites such as that at the head of the Babingley attract visitors throughout the year. In addition, old gravel workings in the Gaywood and Nar valleys have been developed into leisure parks, and walkers make use of pathways such as the Nar Valley Way. Navigation, however, is at present constrained to the Tidal River and Relief Channel while Salters Lode and Well Creek provide a link to the River Nene. Nonetheless there are currently plans to expand navigational accessibility within the CAMS area through the regeneration of an area of King's Lynn, the development of a marine complex, and the establishment of a link from the Nar to the Relief Channel.

3.11 Links with other plans

In March 2001 the Agency issued Water Resources for the Future, our national water resources strategy. This provides a strategic framework for decisions and actions that are needed to manage water resources (including abstraction licensing) over the planning period to 2025. The framework is based on the following key principles:

- Sustainable development: the idea of ensuring a better quality of life for everyone, now and for future generations to come;
- The 'twin-track' approach, which takes a balanced view, seeking the efficient use of water whilst recognising additional abstraction may be necessary;
- Robustness to uncertainty and change: we must consider all the options and adopt a flexible approach; and
- The precautionary principle: where there is uncertainty about the consequences, decisions should be cautious, and we should seek to clarify the source of uncertainty. If there is a serious risk of environmental damage because of a proposed abstraction, the decision about that abstraction should ensure that the environment is protected.

The complementary regional water resources strategy for Anglian Region, 'Water Resources for the Future – A Strategy for Anglian Region' was also launched in March 2001. This reflects the 30 actions developed nationally, but provides a more specific strategy for the region, identifying the preferred approach for meeting demand for water over the next 25 years while at the same time protecting the environment. The strategy considers the needs of the environment and society for water for present and future generations, and adopts a flexible approach to reflect uncertainties about future water demand and availability. In so doing, it highlights points that are relevant to North West Norfolk:

- protection and enhancement of the natural environment of the region;
- continued emphasis on co-operation with others in relation to demand management and efficient use of water in the home, commercial premises, by industry and by agriculture should reduce the need for additional abstraction. This could be linked with reduction of authorised quantities where appropriate;
- efficient management of existing sources of supply and integrated networks to maximise reliability and flexibility;
- development of winter storage reservoirs on farms encouraged where feasible, i.e. abstraction of water into storage in the winter when flows are greater, for use during the summer where there is a shortfall of low flow irrigation water;
- encouraged shared farm schemes;
- identification of opportunities to make water available for agricultural use from existing and new developments; and
- promotion of greater public understanding of the value of the water environment.

The Anglian Regional Strategy and the North West Norfolk CAMS exhibit differences because the Regional Strategy examined major aquifers on a large scale using a broader and simpler method of assessment based on an Annual Water Balance Method. In contrast, the RAM Framework used in the CAMS process operates on a smaller scale. However, the CAMS process adds to the Regional Strategy by helping to refine estimates of demands on water resources and environmental water needs.

CAMS also contributes to the Agency's corporate strategy for 2002 to 2007, *Making it Happen*, which aims to protect and improve the environment and to deliver sustainable development. This includes a target to improve and protect inland coastal waters and

ensure that abstraction (among other things) does not cause damage to the environment. The current target is to ensure that 50% of Catchment Abstraction Management Strategies are in place by 2005.

Further links are found to Environment Agency Water Level Management Plans, Catchment Flood Management Plans, Water Quality Improvement Plans and Fisheries Action Plans in order to ensure that all groups consider water resource issues. The CAMS also has links to Biodiversity Action Plans, and external projects such as the Nar Conservation Strategy as well as other management plans relating to sites such as The Wash which aim to conserve or enhance the environment.

As a statutory consultee for the planning process, the Environment Agency also plays a role in planning for the provision of water for new development. Over recent years the Government has proposed plans for increasing the amount of growth within certain areas

of the country. A key issue related to the CAMS strategy, therefore, is the increase in demand for water supply that results from such developments. The Environment Agency expect Public Water Supply companies to assess and allow for this increased demand within their water resource plans. Where development is proposed in a catchment closed to further abstraction, those plans must include proposals for alternative supplies.



Flood Relief Channel

Resource assessment and resource availability status

4.1 Introduction

To manage water resources effectively we need to understand how much water is available and where it is located. This is achieved by undertaking a resource assessment covering both surface water and groundwater.

Water is used for a number of different purposes, the principal categories being general agriculture, spray irrigation, industrial use, power generation and water supply. For each different use, the amount of water that is returned to the water environment close to where the water was abstracted may vary considerably. Where this loss is high, the Agency considers the abstraction to be consumptive. This may restrict the availability of water for these purposes, unless a significant proportion of the water abstracted is returned to the water source close to the point of abstraction.

To easily provide information on the availability of water resources within a catchment that may be used for consumptive purposes, a classification system has been developed. This 'resource availability status'

indicates the relative balance between committed and available resources, showing whether licences are likely to be available and highlighting areas where abstraction needs to be reduced. This does not replace the need for the licence determination process, which is applied to licence applications. More information on the determination process is given in Annexe Two of *Managing Water Abstraction*.

There are four categories of resource availability status, as shown in **Table 1**.

So that water resources are assessed consistently in similar situations, a framework for resource assessment and management, to be applied in all CAMS areas, has been developed.

This framework involves the development of an understanding of the water resources of the CAMS area and assessment of the surface water and groundwater resource. These results are integrated to define the final resource availability status of different units within the CAMS area.

Table 1 | Resource availability status categories

Indicative resource availability status	Definition	Colour coding for illustration on maps
Water available	Water likely to be available at all flows including low flows. Restrictions may apply.	Blue
No water available	No water available for further licensing at low flows although water may be available at higher flows with appropriate restrictions.	Yellow
Over-licensed	Current actual abstraction is resulting in no water available at low flows. If existing licences were used to their full allocation they would have the potential to cause unacceptable environmental impact at low flows.	Orange
Over-abstracted	Existing abstraction is causing unacceptable environmental impact at low flows. Water may still be available at high flows with appropriate restrictions.	Red

Within and between catchments there are variations in characteristics. In order to measure, manage and regulate effectively, we need to break catchments down into smaller areas, recognising similarities in characteristics. In the resource assessment for CAMS, in areas where groundwater resources are significant, groundwater management units (GWMUs) are defined. For surface water, 'assessment points' (APs) are located on the river network. These river APs and GWMUs are the focus of resource assessment and abstraction licensing. (Note that CAMS does not assess the impact of abstraction at a site specific level. This is undertaken during the normal licence determination process).

Map 7 shows the GWMUs and river APs that have been defined for the North West Norfolk CAMS. Further details on how these were defined are provided in the Technical Document for the North West Norfolk CAMS.

NB Note that the map (over) gives the boundaries of the outcrop. Sandringham Sands groundwater management units extend eastward, and thin out beneath the Chalk. This has implications for groundwater abstraction. A borehole may be geographically located in a Chalk unit, but be drilled through to the Sandringham Sands unit beneath (see sections 4.5.1 to 4.5.10).

4.2 Resource assessment of groundwater management units

For the groundwater resource assessment, various tests are applied to each unit to determine the resource availability status. These tests include examining the balance between recharge to the unit and abstraction from it, and the impact of abstraction on summer outflows from the unit.

4.3 Resource assessment of river assessment points

The surface water resource assessment requires us to first determine the sensitivity of the in-river ecology/other flow needs of each river reach to variations in flow (i.e. vulnerability to abstraction impacts). River reaches are banded according to their sensitivity as either Very High (VH), High (H), Medium (M), Low (L) or Very Low (VL). These categories are referred to as 'environmental weighting' scores.

Environmental weighting scores are then used to determine ecological river flow objectives. For each river reach, the ecological river flow objective is represented by the flow which is required for the ecology and other in-river needs. The extent of that flow is dependent on the sensitivity of the ecology/other flow needs to variations in flow as represented by the 'environmental weighting' scores. The ecological river flow objective therefore represents the minimum flow that we are aiming to protect.

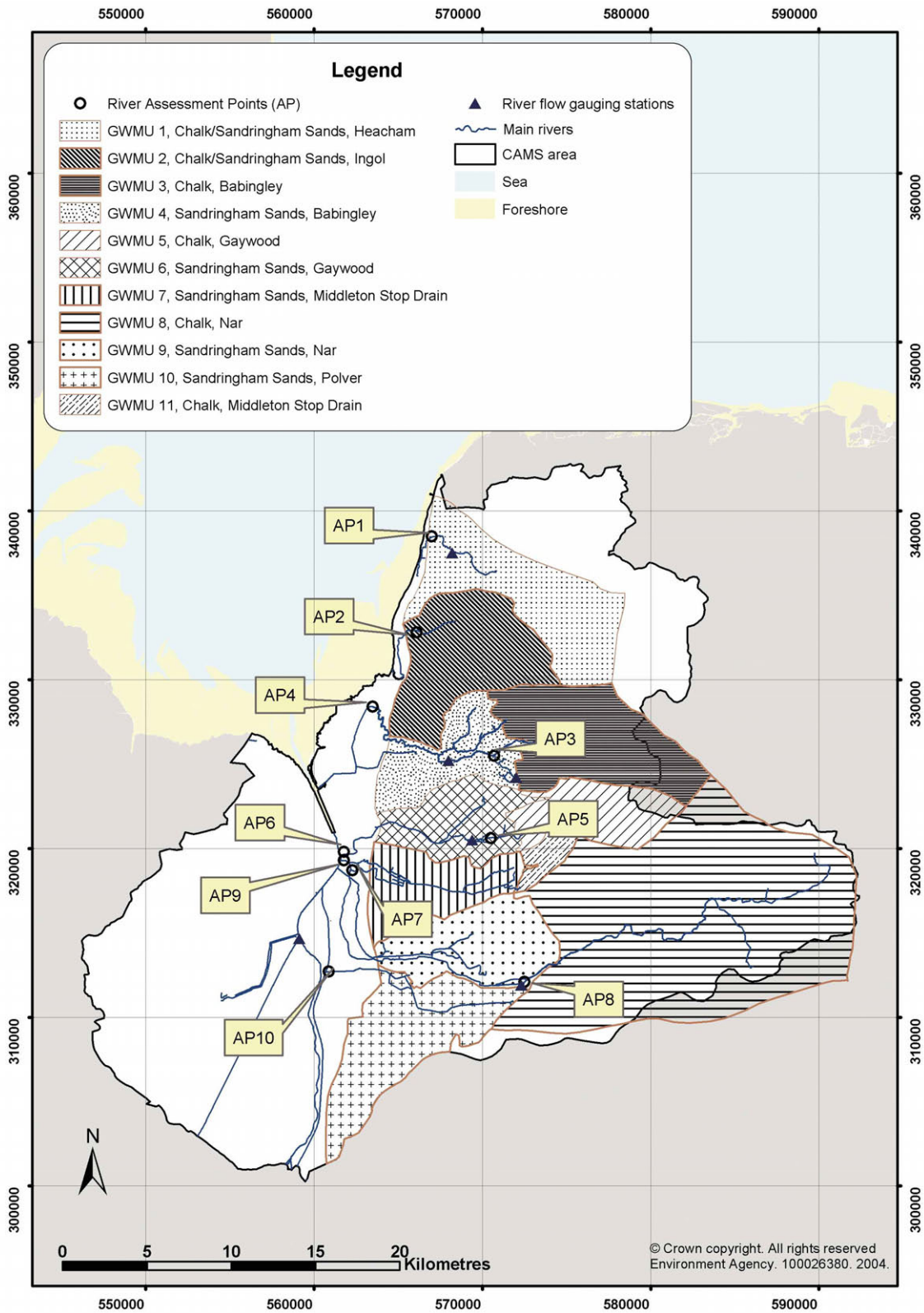
These river flow objectives are then compared with a scenario flow for each river reach which assumes that all licences are being fully utilised (i.e. the full licensed quantity is being abstracted). This comparison reveals either a surplus, balance or deficit. The size of the surplus or deficit corresponds to a resource availability status for the unit.

Map 8 and **Table 2** show the environmental weightings for each assessment point in the North West Norfolk CAMS area.

The surface water resource availability classification gives an indication of whether new licences will be available from the river or whether some recovery of resources is required. However, there are significant variations in flow throughout the year. A classification of 'over-licensed' or 'over-abstracted' generally indicates that no new licences will be granted. However, this applies only at times of low flow. During periods when flows are higher, there may be some water available for abstraction. The classification is therefore really a classification of resource availability at low flow.

Map 7

Groundwater management units (GWMU) and river assessment points (APs) in the North West Norfolk CAMS



Abstraction licences are sometimes managed in order to ensure this flow variability is maintained by the use of 'hands-off flow' conditions. These are conditions on licences that require abstraction to cease (or reduce) when the flow in the river falls below that specified. Therefore, when river flows are above this hands-off flow, abstraction can take place but when flows are below this, no abstraction (or reduced abstraction) can occur. Low flows will occur more frequently during the summer months.

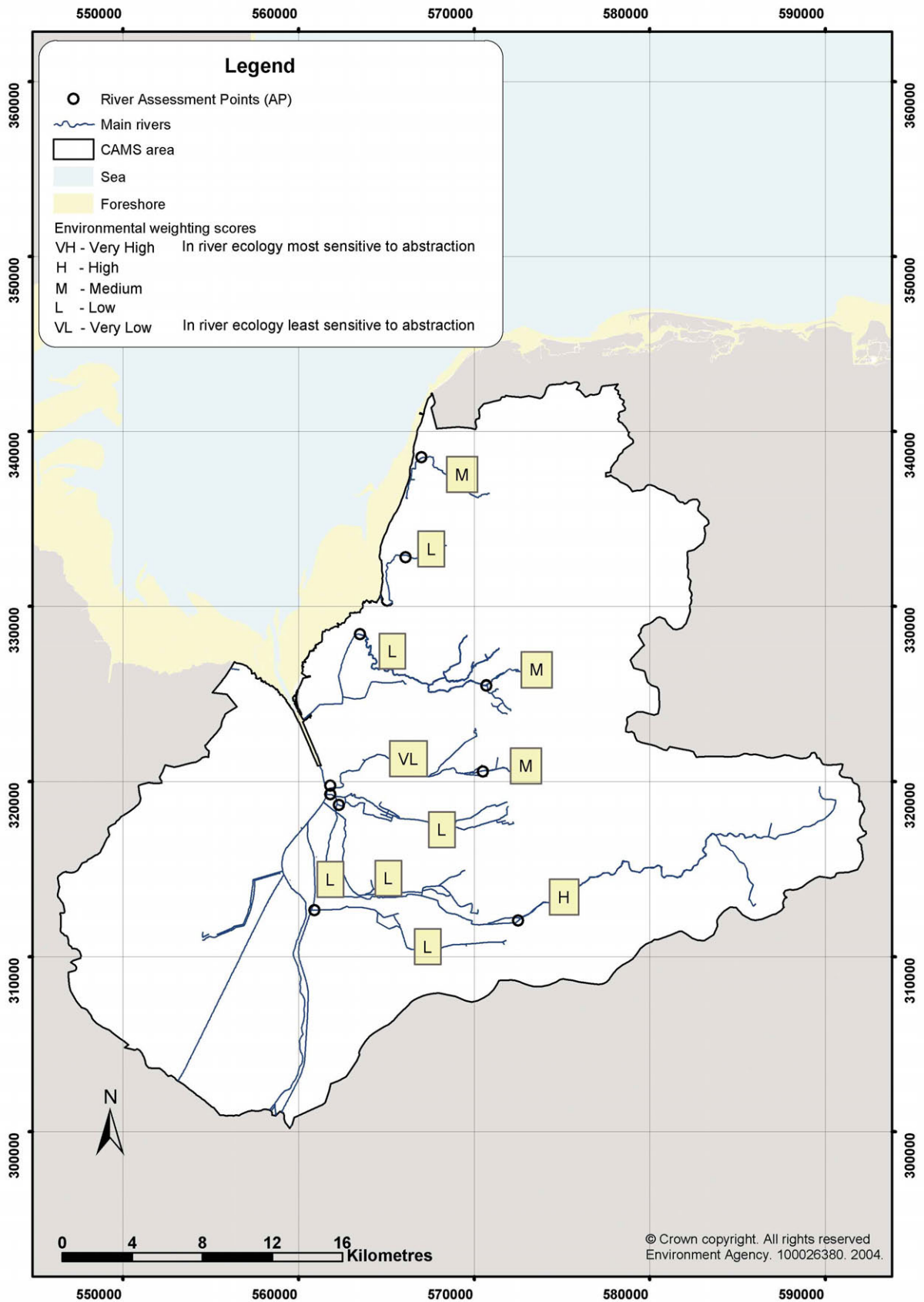
In order to maximise abstraction while maintaining the variability of flow (required for many aquatic species) a tiered system of hands-off flows is applied. Licences are generally granted with the lowest hands-off flow possible on a first-come-first-served basis. As more licences are granted, the hands-off flow must be increased to maintain sustainable flows in the river.

For potential applicants for new abstraction licences, it is therefore important to know not only the likelihood of obtaining a licence, but also the reliability of a licence if granted with a hands-off flow condition. Within the CAMS resource assessment, reliability is expressed as a percentage. This percentage indicates the minimum amount of time over the long term that the scenario flow exceeds the river flow objective, therefore allowing abstraction to take place.

The resource assessments for both surface water and groundwater use a scenario which assumes that all licences are being fully utilised; that is, the full authorised volume is being abstracted. However, many licences are not used fully and therefore in reality the resource availability can be different. If the result of a resource assessment is 'over-licensed', data of actual abstraction is then used to establish whether the status is 'over-abstracted' (actual flows are lower than river flow objectives). 'Over-abstracted' represents abstraction that is already unsustainable whereas 'over-licensed' represents the potential for damage should the full licensed amount be abstracted.

Table 2 | Environmental weightings for each assessment point in the North West Norfolk CAMS area

Assessment Point	Assessment Point Name	Environmental Weighting Bands
1	River Heacham and GWMU	M
2	River Ingol and GWMU	L
3	River Babingley U/S and GWMU	M
4	River Babingley D/S and GWMU	L
5	River Gaywood U/S and GWMU	M
6	River Gaywood D/S and GWMU	VL
7	Middleton Stop Drain D/S and GMWU	L
8	River Nar U/S and GWMU	H
9	River Nar D/S and GWMU	L
10	Polver Drain and GWMU	L
11	Middleton Stop Drain U/S GWMU only	N/A



4.4 Integration of the surface water and groundwater resource assessments

The resource availability results for river reach and groundwater management unit assessments are integrated and iterations made.

The preliminary results for a river reach or a groundwater management unit may be overridden in order to protect a downstream river reach or underlying groundwater management unit that has a worse low flow resource availability status than its own (here the downstream reach or underlying unit is known as the critical reach or unit).

In earlier CAMS these overridden river reaches or groundwater management units would have been assigned the same low flow resource availability status as that of the critical reach or unit. This has caused confusion in some cases about where the actual effects of over-abstraction are seen within the catchment. As a result, we have changed the way in which we override the low flow resource availability status of a river reach or groundwater management unit above a critical reach or unit.

Where the preliminary low flow resource availability status of the river reach or groundwater management unit is 'water available' it is overridden to 'no water available' in order to indicate that additional abstraction will only be allowed where it does not make the position within the critical unit any worse. Where the river reach or groundwater management unit is 'no water available', 'over-licensed' or 'over-abstracted' it maintains its own status. The strategy that is developed still takes into account the impact that any additional abstraction from these river reaches or groundwater management units has on the critical reach or unit.

In this CAMS, the preliminary results for the following river reaches and/or units were overridden:

WRMU 3 (River Babingley U/S) – groundwater status was overridden from 'water available' to 'no water available' to protect flows in the river

WRMU 4 (River Babingley D/S) – groundwater status was overridden from 'water available' to 'no water available' to protect flows in the river

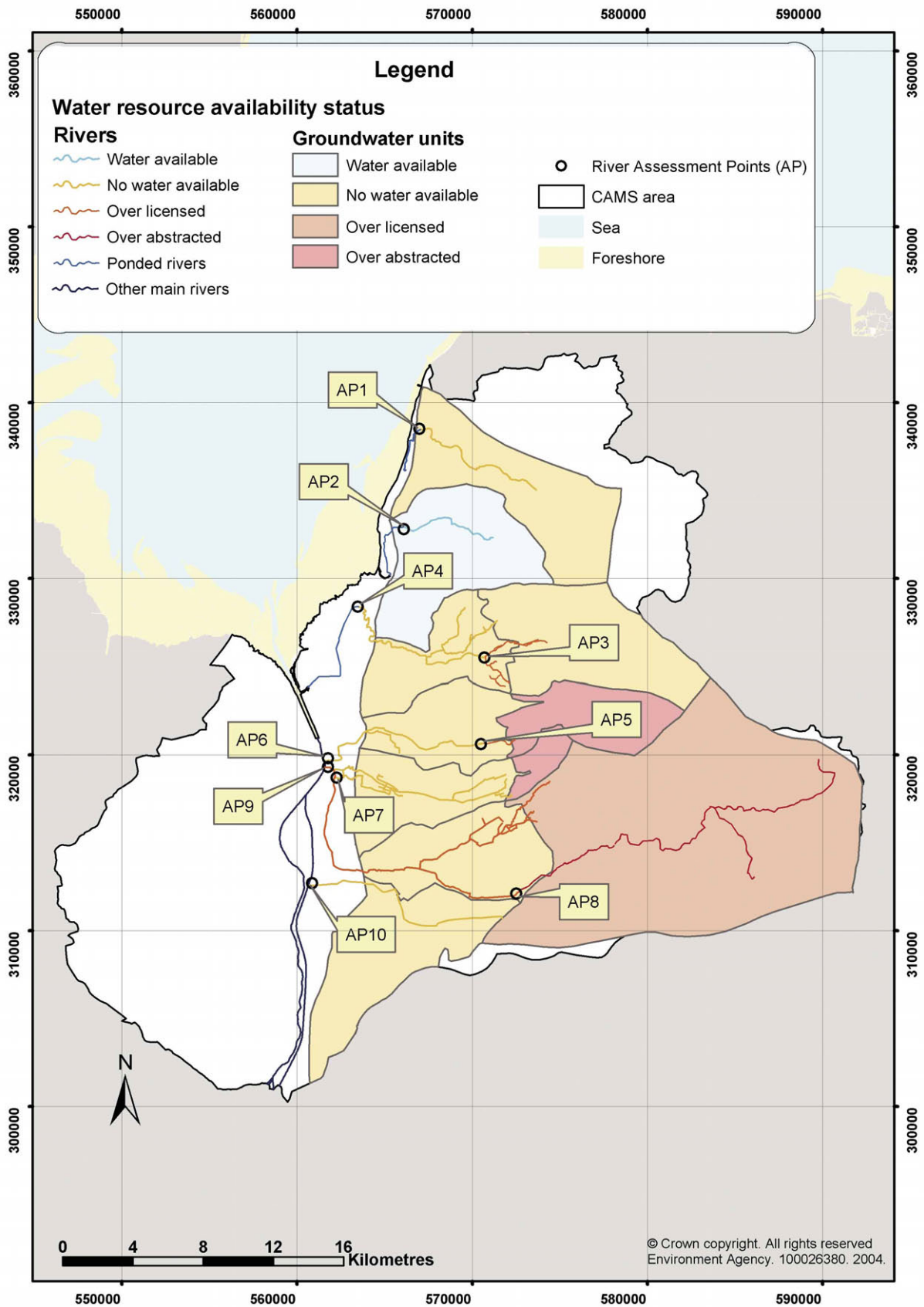
WRMU 6 (River Gaywood D/S) – groundwater status was overridden from 'water available' to 'no water available' to protect flows in the river

WRMU 7 (Middleton Stop Drain D/S) – groundwater status was overridden from 'water available' to 'no water available' to protect flows in the drain

WRMU 9 (River Nar D/S) – groundwater status was overridden from 'water available' to 'no water available' to protect flows in the river

WRMU 10 (Polver Drain D/S) – groundwater status was overridden from 'water available' to 'no water available' to protect flows in the drain

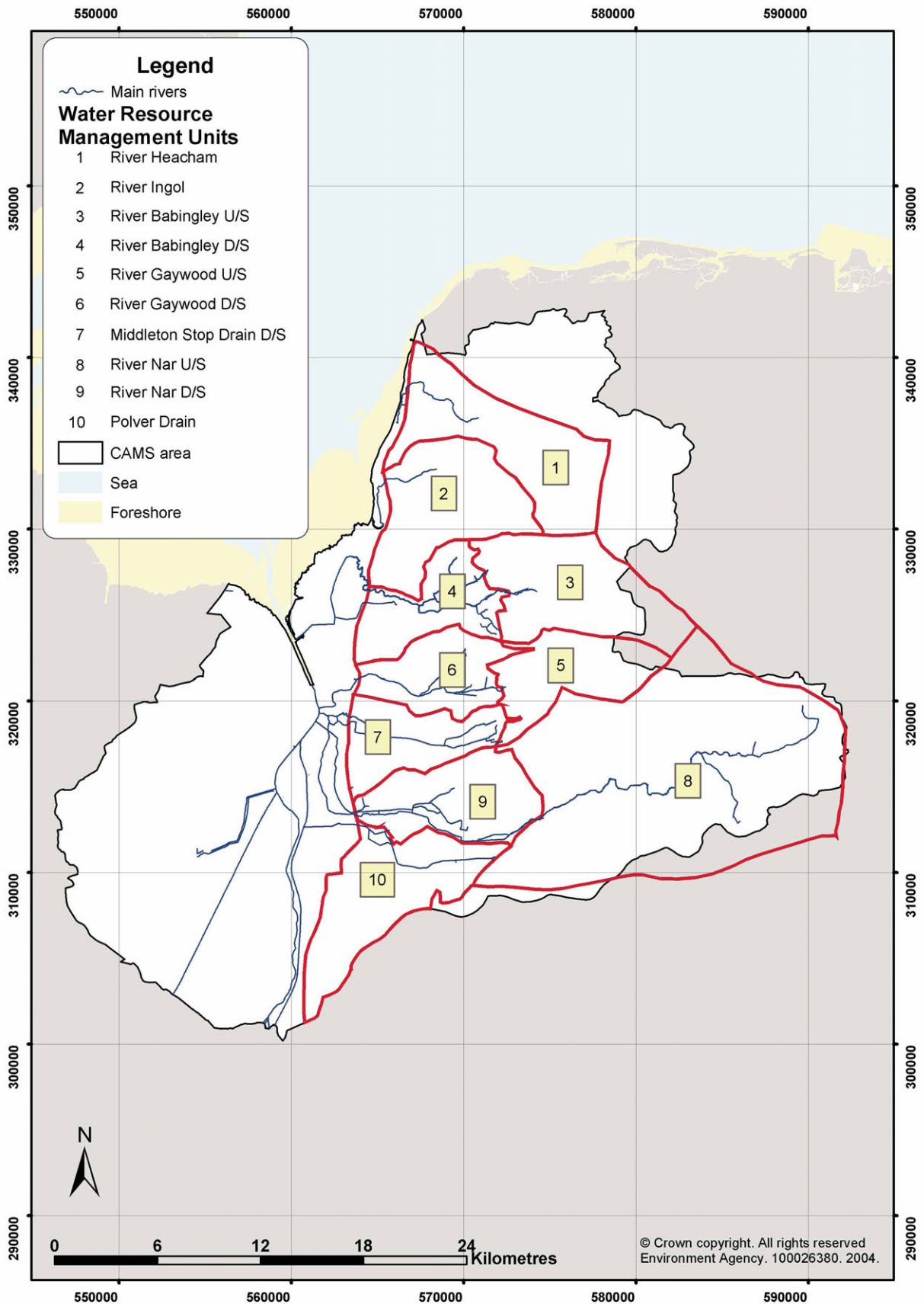
Map 9 shows the resource availability status of groundwater management units and river reaches in the North West Norfolk CAMS area. This is the classification following integration of the groundwater and surface water assessment results and subsequent iterations. The results of the separate surface water and groundwater assessments are available in the North West Norfolk CAMS Technical Document.

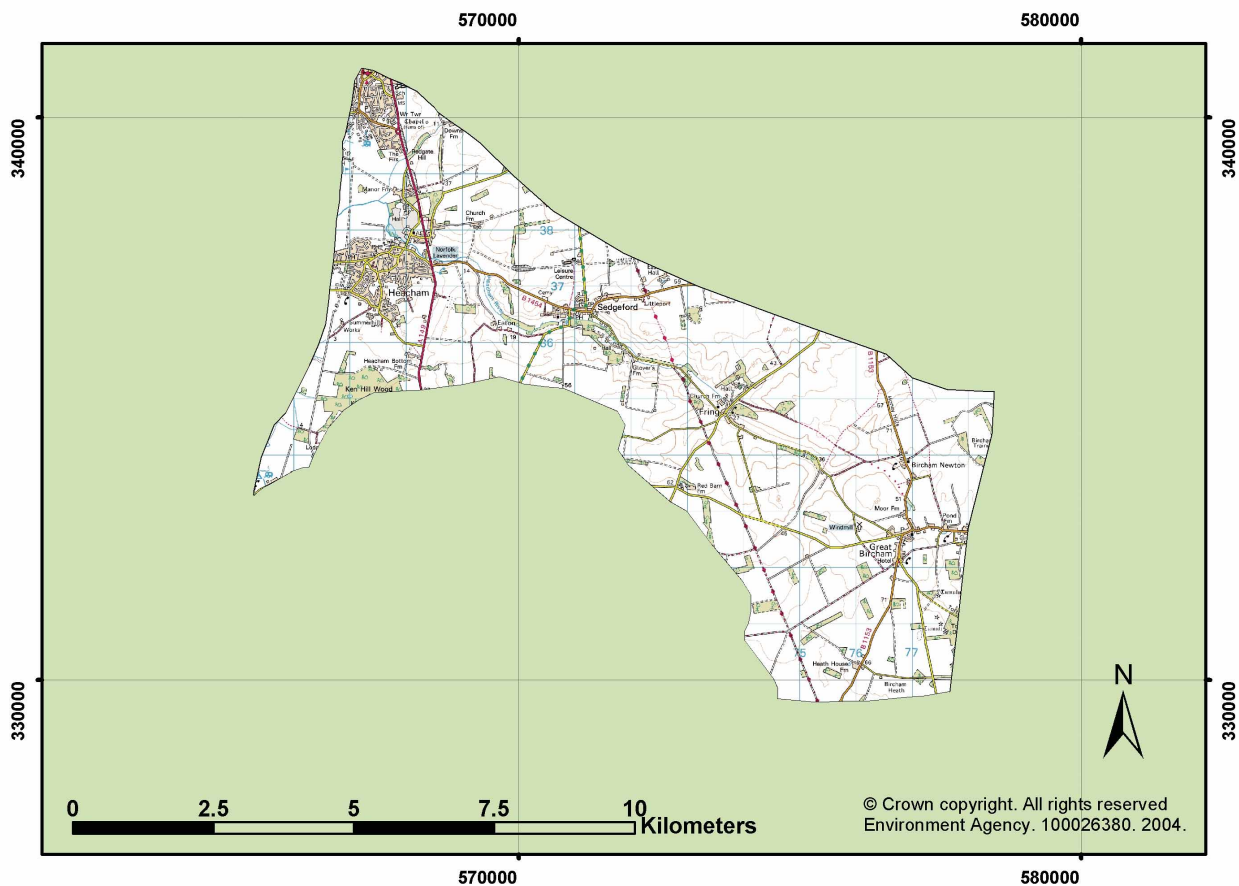


4.5 Water Resource Management Units

Water Resource Management Units (WRMUs) were created following integration of surface and groundwater resource assessment results as illustrated in **Map 10**. WRMU 5 was created by combining Chalk groundwater unit 5 and its associated river reach, the upper Gaywood, with Chalk groundwater unit 11. Although groundwater unit 11 drains to Middleton Stop Drain rather than the Gaywood, it was appropriate to combine it here, because it exhibited the same resource status as groundwater unit 5, and because the resource status of both was attributable to the same abstraction. They would therefore be expected to have the same proposed licensing strategy. All other WRMUs were created by combining a surface water reach with its underlying groundwater unit

Map 10 | Water Resource Management Units in the North West Norfolk CAMS





WRMU 1 | River Heacham and associated groundwater unit

4.5.1 Water Resource Management Unit 1 (River Heacham)

This unit covers a reach of the River Heacham from its source at Fring to AP 1 at Heacham. The river flows across agricultural land, is heavily modified, but not embanked and without significant flood defence structures. The lower most reaches below the AP, which run parallel to the coast, were not included in the resource assessment. In these reaches the river backs up against tidal flaps, discharging to the sea at low tide. These ponded sections are not assessable using the prescribed methodology as they do not flow.

The WRMU also includes the underlying aquifers. The boundaries are those of Chalk and Sandringham Sands groundwater unit 1 (see **Map 7**, page 24). In this location, because the Sandringham Sands is thought to lie directly under the Chalk with no intervening strata, they may be hydrologically linked. Because of this they were treated as a single mixed aquifer.

There are no water-related designated sites within this unit, but the River Heacham is incorporated into the Norfolk Biodiversity Action Plan because it is a Chalk river supporting Chalk habitats. The river supports

water vole, a BAP species, as well as a small breeding trout population in the upper reaches, while the lower reaches are dominated by coarse fish populations, in particular eel. A freshwater supply is important to coastal grazing marshes, e.g. Snettisham Grazing Marshes, that fall outside the WRMU. Other water dependent wildlife sites include Eaton Meadows.

There are 11 licences to abstract within this WRMU. The majority of water licensed for abstraction in this unit is for public water supply. Note that a number of additional licences allow abstraction from the ponded reaches of the river which were not assessed. Sufficient flow must be maintained to protect the rights of these licences.

The resource status of both the groundwater and surface water is 'no water available'.

4.5.2 Water Resource Management Unit 2 (River Ingol)

This unit covers a reach of the River Ingol from its source near Sherborne to AP 2, west of the A149 at Snettisham. The river flows across agricultural land. The river reach is modified in parts but not embanked and there are no significant flood defence structures. Below the AP, the lower most reaches run parallel to the coast and back up against tidal flaps, discharging to the sea at low tide. These ponded sections were not assessable using the prescribed methodology as they do not flow.

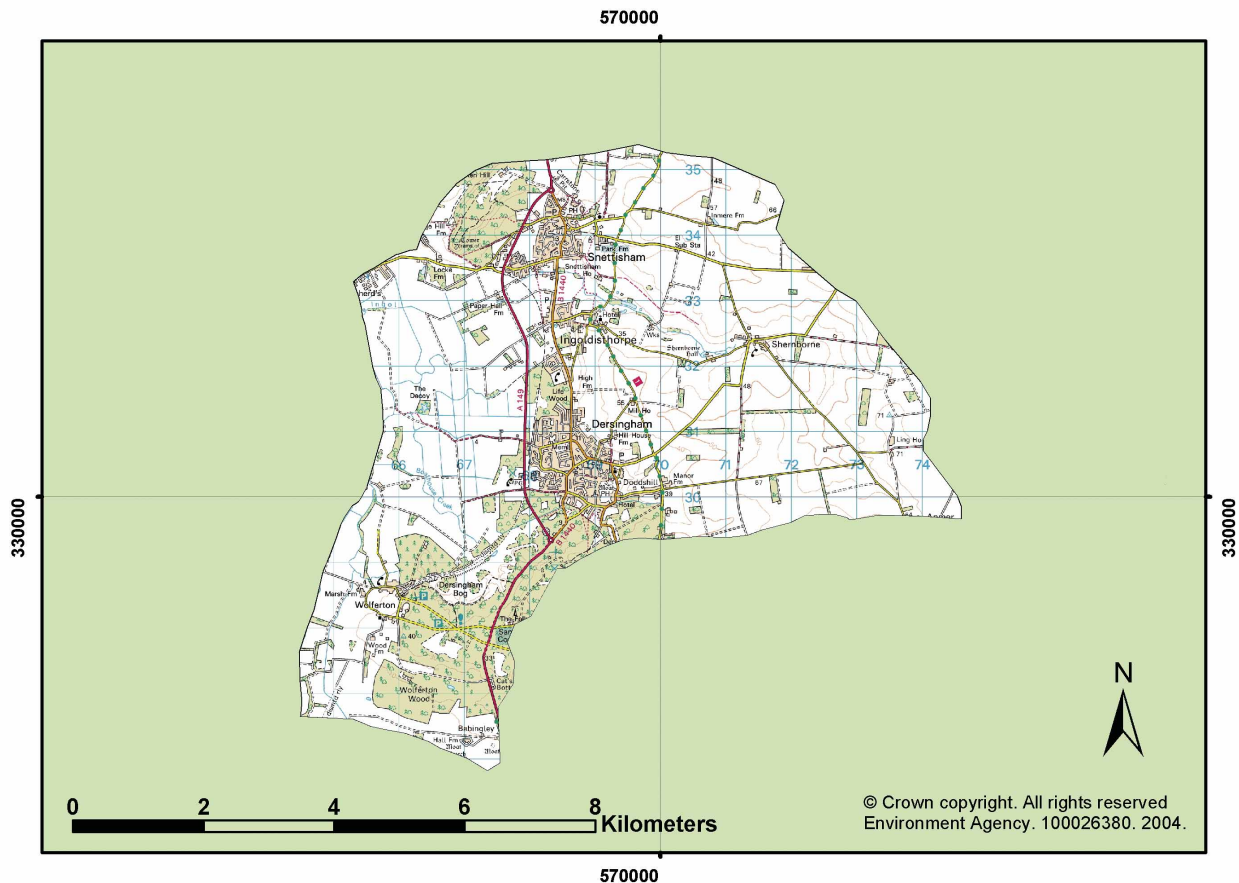
The WRMU also includes the underlying aquifers. The boundaries are those of the Chalk and Sandringham Sands groundwater unit 2 (see **Map 7**, page 24). In this location, because the Sandringham Sands is thought to lie directly under the Chalk with no intervening strata, they may be hydrologically linked. Because of this they were treated as a single mixed aquifer.

There is little information available about the ecology of the River Ingol although it is worth noting that a BAP species, water vole, has been recorded as present. However, Dersingham Bog falls within this WRMU. This site is designated under the Habitats Directive as a candidate Special Area of Conservation. It is also a

Ramsar site. The bog supports acid habitats that are dependent on the Sandringham Sands aquifer. In addition the WRMU incorporates a number of wildlife sites such as Goggs Whins and Dersingham Closed Common which demonstrate varying dependency on water resources.

There are 4 licences to abstract within this WRMU. The majority of licensed abstraction is for spray irrigation. Note that additional licences allow abstraction from the ponded reaches of the river which was not assessed. Sufficient flow must be maintained to protect the rights of these licences.

The resource status of both the groundwater and surface water is 'water available'.



WRMU 2 | River Ingol and associated groundwater unit

4.5.3 Water Resource Management Unit 3 (River Babingley U/S)

This unit covers the upper reach of the River Babingley from its headwater springs near Flitcham and Manor Farm to AP 3 at the confluence of the source tributaries. The headwaters are not modified and do not contain any significant flood defence structures.

The WRMU also includes part of the underlying Chalk aquifer (see **Map 7**, page 24). The Chalk overlies the edge of the Sandringham Sands groundwater unit 4 (WRMU 4) to the west. However, the Chalk and Sandringham Sands are not in hydrological continuity, being separated from each other by a layer of Gault Clay. The Sandringham Sands therefore does not form a component of this WRMU but instead, is part of WRMU 4. Boreholes that fall geographically into WRMU 3, but are drilled through the Chalk to take water from the Sandringham Sands beneath, are therefore considered to fall in WRMU 4.

There are no water-related designated sites within this unit, but the River Babingley is incorporated into the Norfolk Biodiversity Action Plan because it is a Chalk river supporting Chalk habitats. The wetland areas form a wildlife site around the headwaters, supporting a diverse range of species including a small native trout population.

There are 13 licences to abstract within this WRMU. The majority of licensed abstraction is for public water supply.

The resource status of the groundwater is overridden to 'no water available'.

The resource status of the surface water is 'over-licensed'.

The surface and groundwater will be managed in the same way because there is a strong connection between groundwater abstraction and the status of the river.



WRMU 3 | River Babingley U/S and associated groundwater unit

4.5.4 Water Resource Management Unit 4 (River Babingley D/S)

This unit covers the lower reach of the River Babingley from AP 3, downstream to AP 4. The ponded reaches (which follow the coastline) are not included in the assessment because they do not flow and so were not assessable using the prescribed methodology.

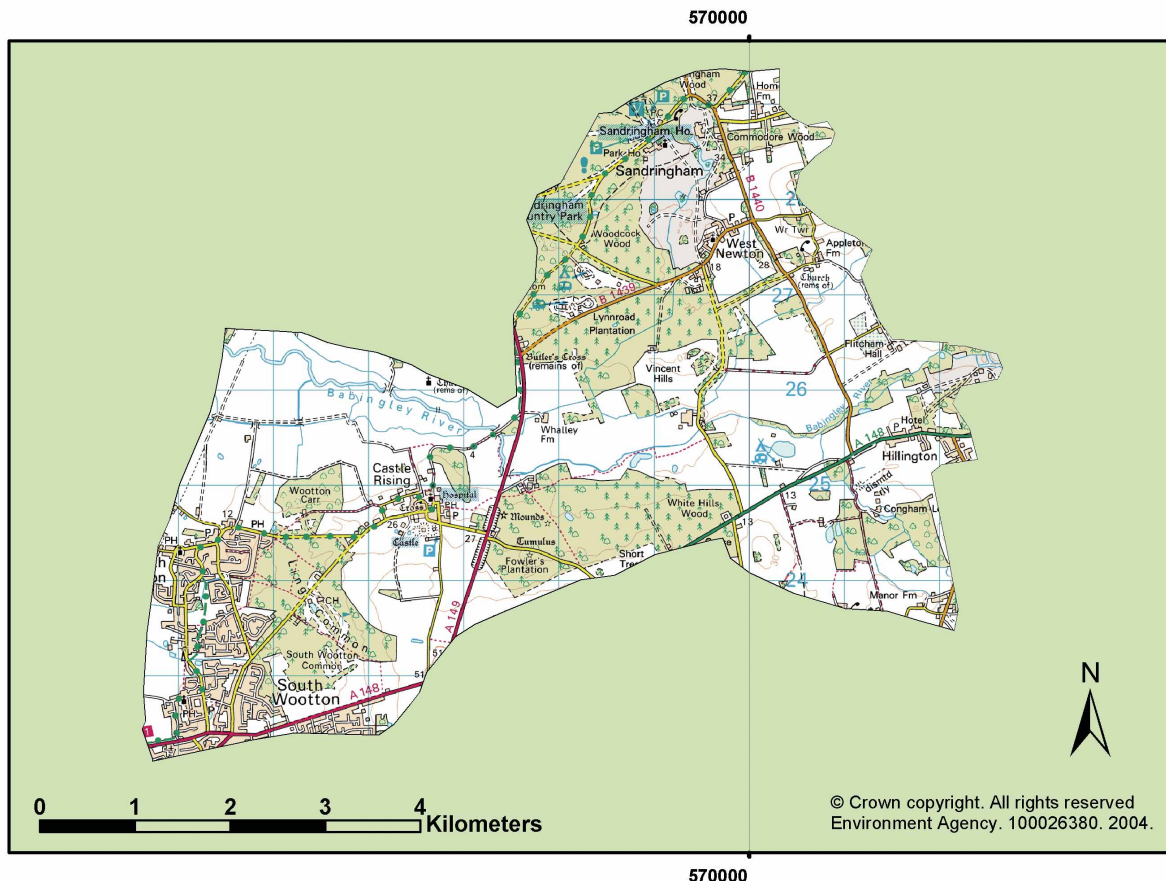
The WRMU also includes the underlying aquifer. The boundaries are those of the underlying Sandringham Sands groundwater unit. The groundwater unit extends, beneath Chalk groundwater unit 3 (WRMU 3) to the east (see **Map 7**, page 24). However, the Chalk and the Sandstone are not in hydrological continuity, being separated from each other by a layer of Gault Clay. Boreholes that fall geographically into WRMU 3, but are drilled through the Chalk to take water from the Sandstone are therefore included in WRMU 4.

There are no water-related designated sites within this unit, but the upper most 2km of this reach of the River Babingley is incorporated into the Norfolk Biodiversity Action Plan because it is a Chalk river supporting Chalk habitats. It also supports a BAP species, the water vole. These lower reaches are more typical of a meandering lowland river.

Wildlife sites include an area of Sandringham Park which supports meostrophic communities, and Wood Cottages Meadows.

There are 4 licences to abstract within this WRMU. The majority of licensed abstraction is for public water supply. In addition there are number of licences which allow abstraction from the lowest ponded reaches. Sufficient supply to the lowest reaches must therefore be maintained to assure the rights of these licences are not derogated.

The resource availability of the groundwater and surface water is 'no water available'.



WRMU 4 | River Babingley D/S and associated groundwater unit

4.5.5 Water Resource Management Unit 5 (River Gaywood U/S)

This unit covers the upper reaches of the River Gaywood from its headwater springs north of Gayton to AP 5 at Derby Fen.

The WRMU also includes the underlying aquifer. The boundaries are those of the Chalk groundwater unit, which feeds the River Gaywood (groundwater unit 5), and that of the Chalk groundwater unit that feeds to the top of Middleton Stop Drain (groundwater unit 11 – see **Map 7**, page 24).

These Chalk units overlie the edge of Sandringham Sands groundwater units 6 and 7 (WRMUs 6 and 7) to the west. However, the Chalk and the Sandringham Sands are not in hydrological continuity, (water does not pass between them), being separated from each other by a layer of Gault Clay. The Sandringham Sands is therefore not a component of this WRMU. Boreholes which fall geographically into WRMU 5, but are drilled through the Chalk to take water from the Sandstone are therefore included in WRMUs 6 or 7.

Note that the springs that supply Middleton Stop Drain fall just inside this WRMU (in groundwater unit 11), but the watercourse flowing from them

(Middleton Stop Drain) is of insufficient length for assessment here. Middleton Stop Drain is assessed and forms a part of WRMU 7. Management of groundwater in this WRMU must therefore take account of flow needs in WRMU 7.

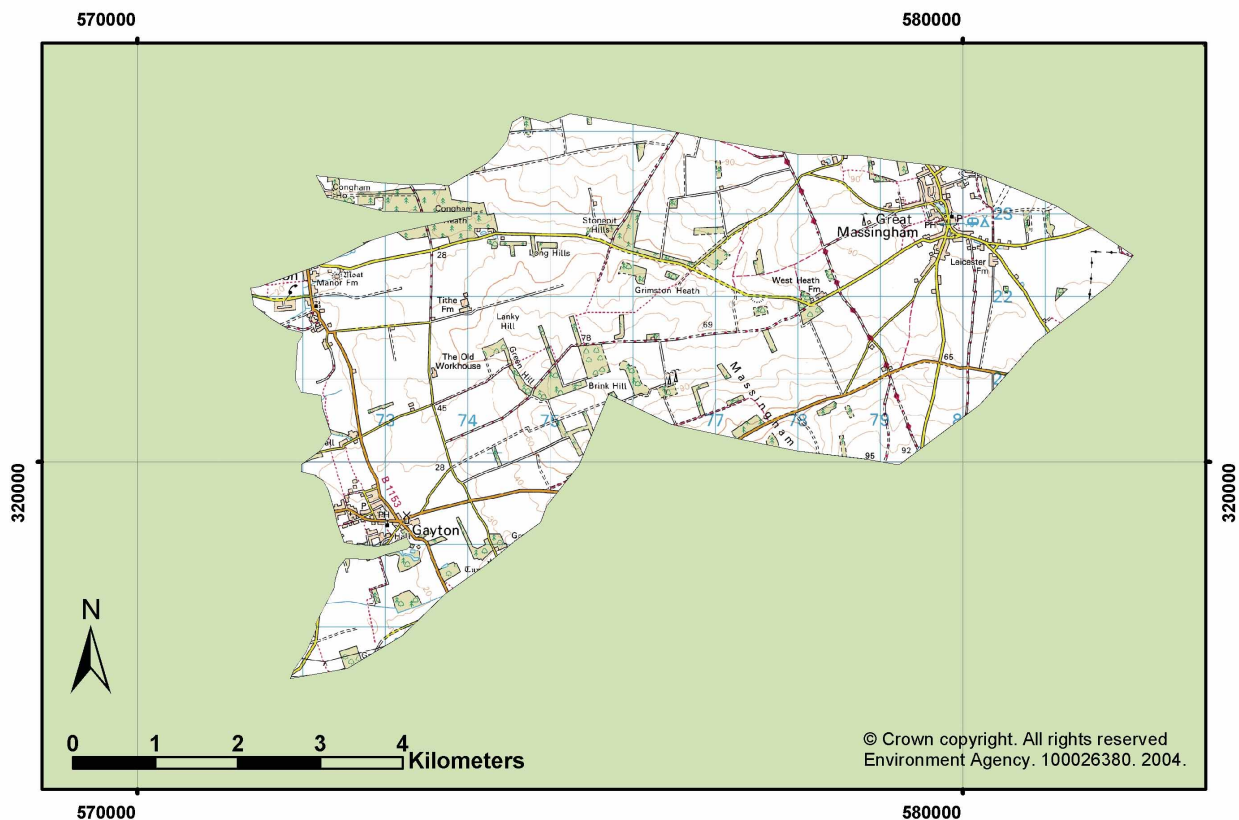
There are no water-related designated sites within this unit although there are a number of non-designated sites which demonstrate at least some dependency on water resources. These include Congham Heath Wood and Gayton Thrope Common. In addition, the River Gaywood supports a small native trout population. There are also records of both otter and water vole within the catchment.

There are 15 licences to abstract within this WRMU. The majority of licensed abstraction is for public water supply.

The resource availability of the groundwater is 'over-abstracted'.

The resource status of the surface water is 'over-licensed'.

The surface and groundwater will be managed in the same way because there is a strong connection between groundwater abstraction and the status of the river.



4.5.6 Water Resource Management Unit 6 (River Gaywood D/S)

This unit covers a reach of the River Gaywood from the AP 5 at Derby Fen to AP 6 at the outfall to the River Great Ouse. In the upper part of the reach, between Pott Row and Ashwicken, the river has recently been restored to follow original meanders. Further downstream, the river flows as a high level carrier across agricultural land. The lower most reaches pass through King's Lynn, and include a number of flood defence structures. The river discharges to the tidal Great Ouse.

The WRMU also includes the underlying aquifer. The boundaries are those of the underlying Sandringham Sands groundwater unit (unit 6, see **Map 7**, page 24). This unit extends eastwards under the edge of the Chalk (WRMU 5). In this location, the Sandringham Sands and Chalk are not in hydrological continuity, being separated by a layer of Gault Clay. Boreholes which fall geographically into WRMU 5, but are drilled through the Chalk to take water from the Sandstone are therefore included in this WRMU or WRMU 7.

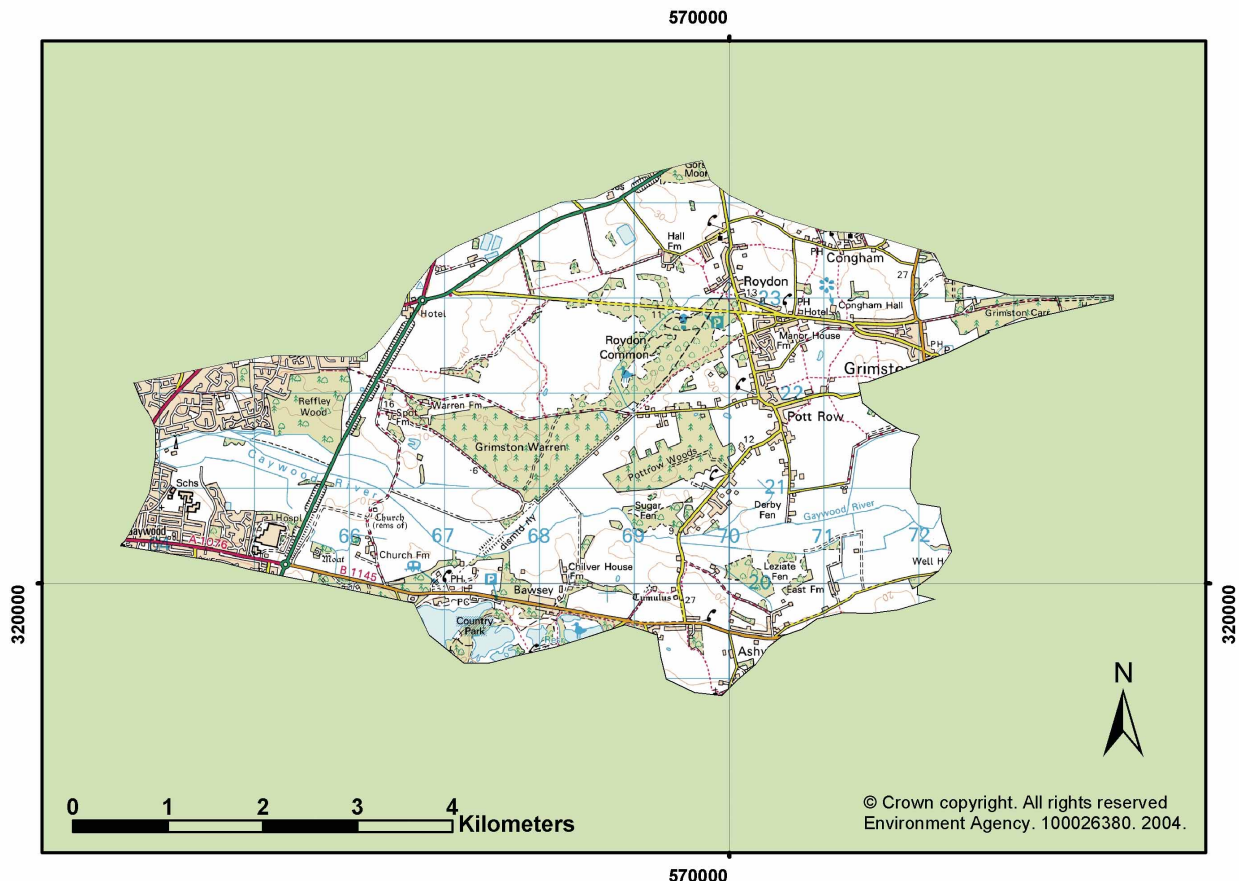
Roydon Common falls within this unit. The Common is a candidate Special Area of Conservation as well as a Site of Special Scientific Interest and Ramsar site. The

site supports acid habitats that are dependent on the underlying Sandringham Sands aquifer. Leziate, Sugar and Derby Fen SSSI also falls within this WRMU and is also dependent on the aquifer. Non-designated water dependent sites include Grimston Warren Pit, Roydon Meadow and Brook Water Meadow.

The lower reaches of the river support coarse fish.

There are 11 licences to abstract within this WRMU. The majority of licensed abstraction is for public water supply.

The resource availability of the groundwater and surface water is 'no water available'.



WRMU 6 | River Gaywood D/S and associated groundwater unit

4.5.7 Water Resource Management Unit 7 (Middleton Stop Drain D/S)

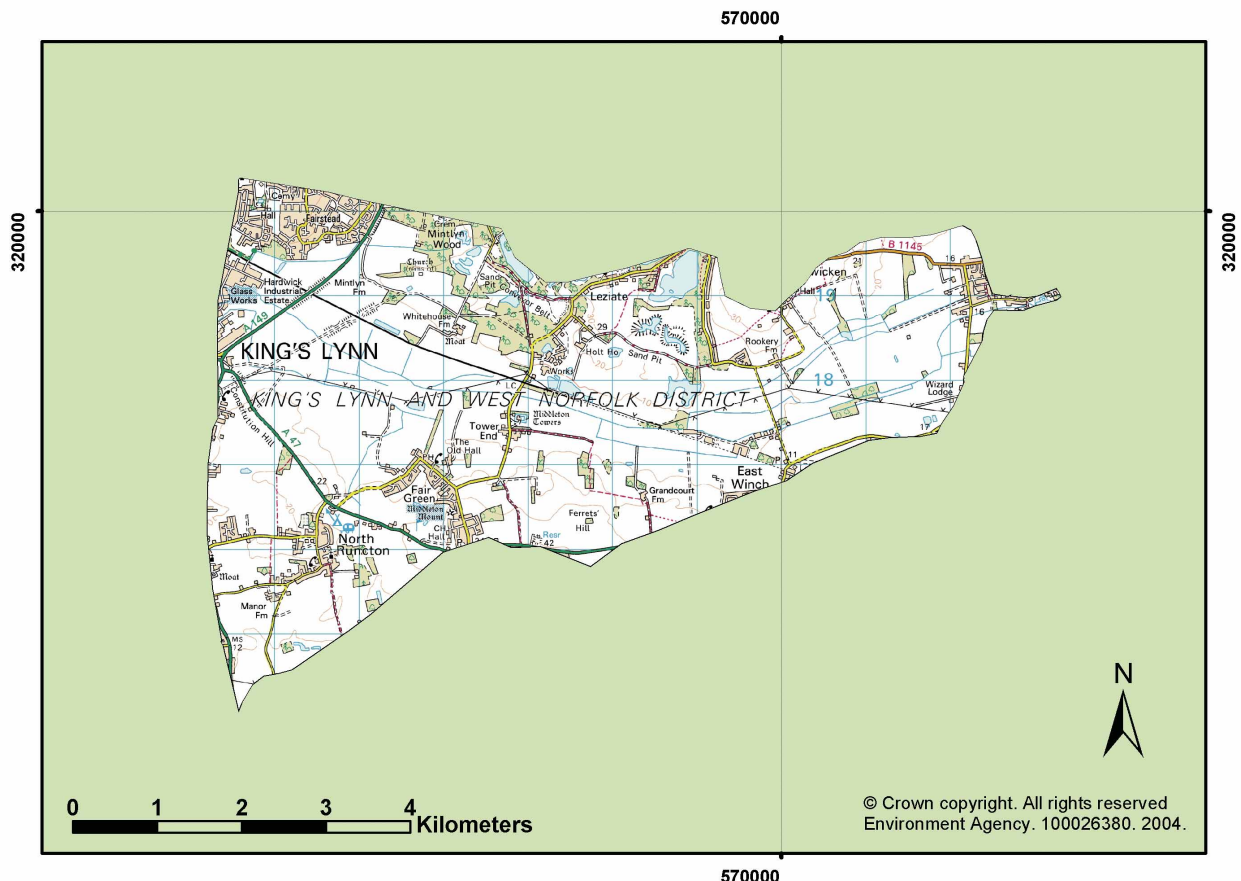
This unit covers the entire length of Middleton Stop Drain to AP 7 at the outfall to the River Nar. The drain is man-made, and is pumped at the lower end. Two further pumps also move water from surrounding tributaries to the main drain. Although artificial, it was considered that there is sufficient flow in the drain for a standard resource assessment to be carried out as if it were a natural river.

The WRMU also includes the underlying aquifer. The boundaries are those of the underlying Sandringham Sands groundwater unit (unit 7, see **Map 7**, page 24). This unit extends eastwards under the Chalk (WRMU 5). In this location, the Sandringham Sands and Chalk are not in hydrological continuity, being separated by a layer of Gault Clay. Boreholes which fall geographically into WRMU 5, but are drilled through the Chalk to take water from the Sandstone are therefore included in this WRMU or WRMU 6.

There are no designated sites within this unit. The drain supports coarse fish.

There are 16 licences to abstract within this WRMU. Over half of licensed abstraction is for industrial purposes, the rest for spray irrigation.

The resource availability of the groundwater and surface water is 'no water available'.



WRMU 7 | Middleton Stop Drain D/S and associated groundwater unit

4.5.8 Water Resource Management Unit 8 (River Nar U/S)

This unit covers a reach of the River Nar from its source above Litcham to AP 8 at Marham gauging station. In the upper reaches, the river is mostly fed from surface run-off due to a layer of Boulder Clay. However this Clay is absent from around Castle Acre, and so from this point to Marham gauging station the river is fed by water from the underlying Chalk aquifer.

The WRMU also includes the underlying aquifer. The boundaries are those of the Chalk groundwater unit (unit 8, see **Map 7** page 24). The Chalk unit overlies the edge of two Sandringham Sands groundwater units, 9 and 10 (WRMUs 9 or 10) to the west. However, the Chalk and the Sandringham Sands units are not in hydrological continuity, being separated from each other by a layer of Gault Clay. Boreholes which fall geographically into WRMU 8, but are drilled through the Chalk to take water from the Sandstone are therefore included in WRMU 9 or 10.

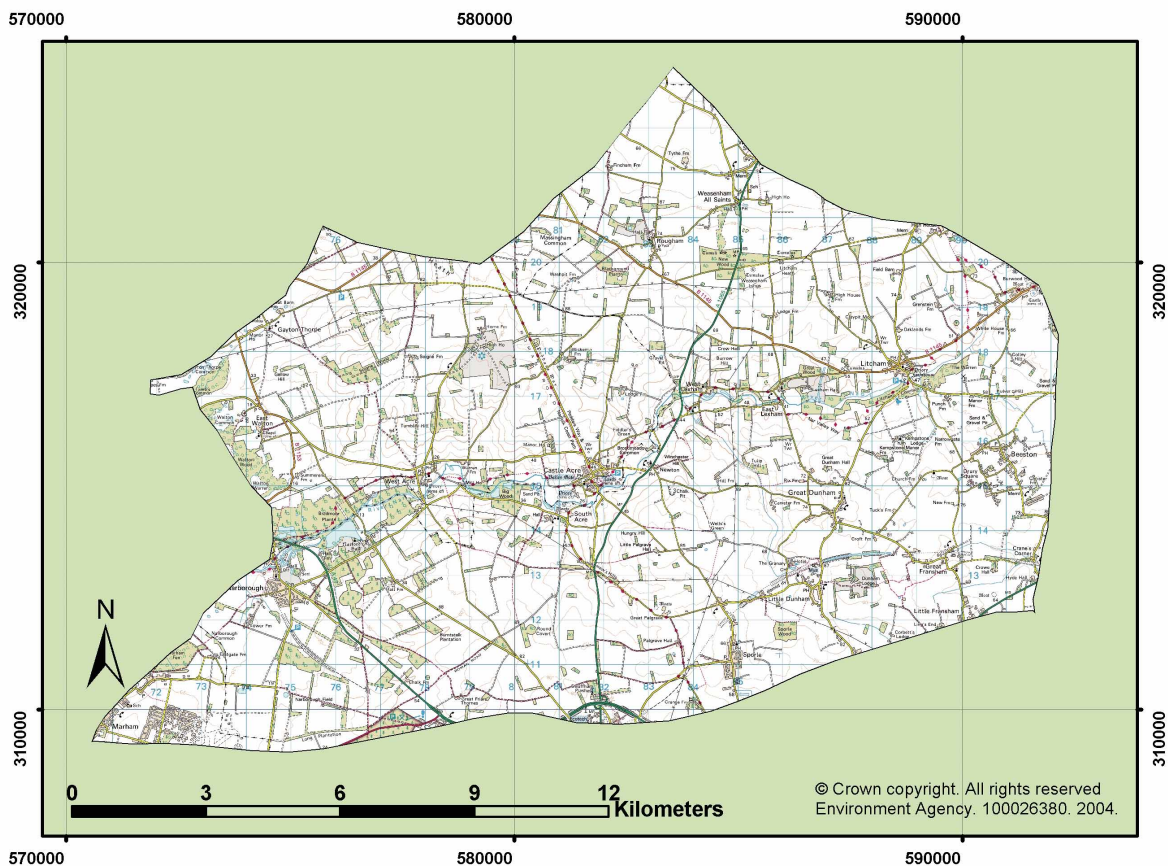
The River Nar is designated a Site of Special Scientific Interest because it is a Chalk river. The underlying geology means that the reach from Castle Acre to Marham gauging station is most typical of a Chalk river. The river supports a diverse range of flora and fauna, including native trout and migratory salmonids, as well as otter and water vole. The riparian strip bordering the river supports wildlife sites of interest.

There are 90 licences to abstract within this WRMU. Licensed abstraction is split fairly evenly between public water supply, fish farming and spray irrigation.

The resource availability of the groundwater is 'over-licensed'.

The resource status of the surface water is 'over-abstracted'.

The surface and groundwater will be managed in the same way because there is a strong connection between groundwater abstraction and the status of the river.



WRMU 8 | River Nar U/S and associated groundwater unit

4.5.9 Water Resource Management Unit 9 (River Nar D/S)

This unit covers a reach of the River Nar from AP 8 to its confluence with the tidal Great Ouse at AP 9. The lower reaches of the river are heavily modified and embanked. The river demonstrates characteristics more typical of a lowland river. Nonetheless these lower reaches are also part of the SSSI designation. Wildlife sites in the catchment include Pentney Gravel Pits.

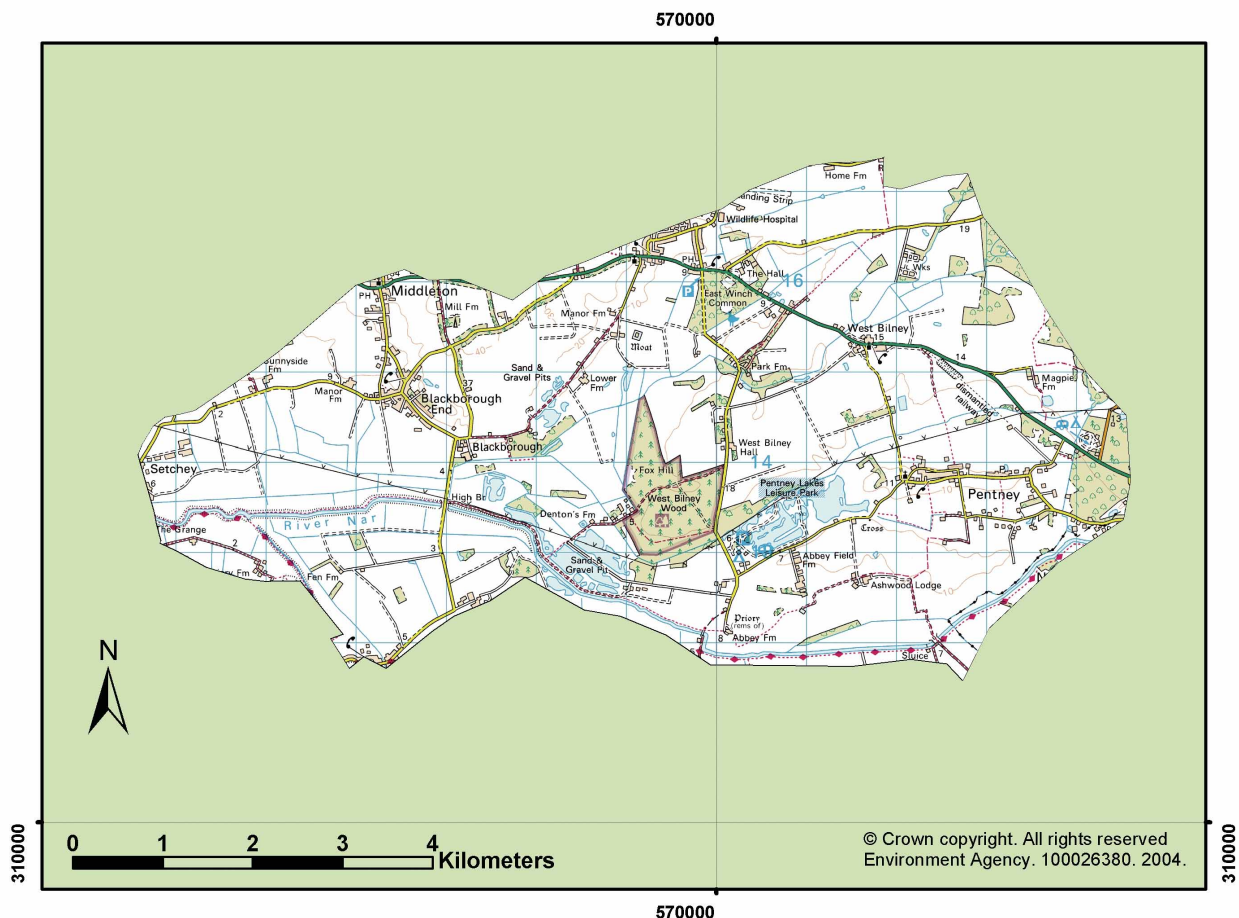
The WRMU also includes the underlying aquifer. The boundaries are those of the Sandringham Sands groundwater unit (unit 9, see **Map 7**, page 24). This unit extends eastwards under the Chalk (WRMU 8). However, the two units are not in hydrological continuity, being separated from each other by a layer of Gault Clay. Boreholes which fall geographically into WRMU 8, but are drilled through the Chalk to take water from the Sandstone are therefore included in this WRMU or WRMU 10.

There are 28 licences to abstract within this WRMU. Licensed abstraction is for public water supply, industrial purposes and spray irrigation.

The resource availability of the groundwater is over ridden to 'no water available'.

The resource status of the surface water is 'over-licensed'.

The surface and groundwater will be managed in the same way because there is a strong connection between groundwater abstraction and the status of the river.



4.5.10 Water Resource Management Unit 10 (Polver Drain)

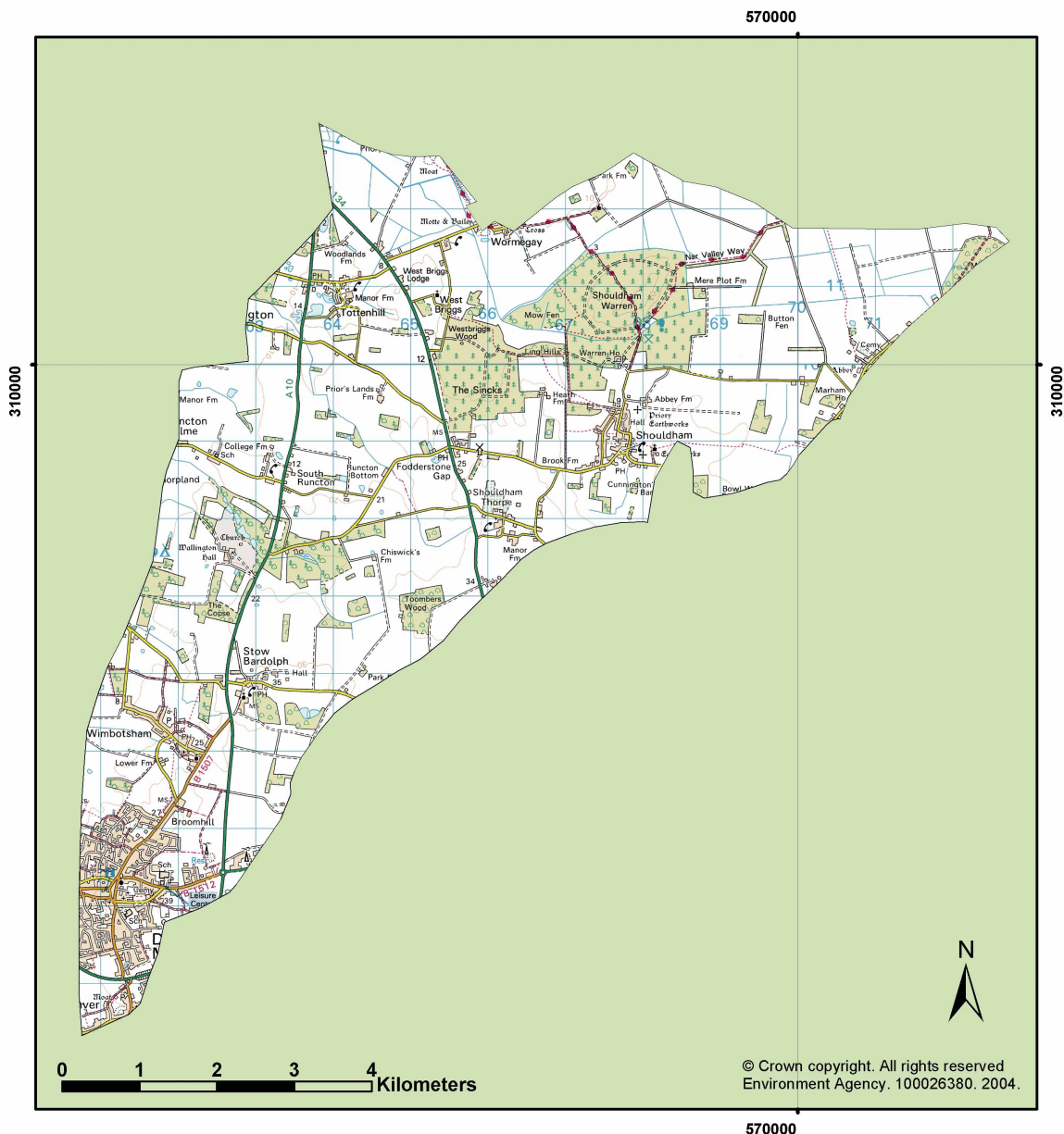
This unit covers the entire of the Polver Drain to its outfall into the Relief Channel (AP 10). The lower reaches of the drain are most heavily modified engineered and embanked. The drain demonstrates some characteristics typical of a lowland river. Wildlife sites include Marham Fen, a predominately dry fen but with some damp areas and pingos, and three seasonally dry ponds at Tottenhill Village Green.

The WRMU also includes the underlying aquifer. The boundaries are those of the Sandringham Sands groundwater unit (unit 10, see **Map 7**, page 24). This unit extends eastwards under the edge of the Chalk

(WRMU 8). However, the two units are not in hydrological continuity, (water does not pass between them), being separated from each other by a layer of Gault Clay. Boreholes which fall geographically into WRMU 8, but are drilled through the Chalk to take water from the Sandstone are therefore included in this WRMU or WRMU 9.

There are 18 licences to abstract within this WRMU; 60% is licensed for industrial purposes, 37% for spray irrigation and 3% for general agricultural purposes.

The resource availability of the groundwater and surface water is 'no water available'.



WRMU 10 | Polver Drain and associated groundwater unit

4.5.11 Areas not covered by a Water Resource Management Unit

A significant proportion of the North West Norfolk CAMS area could not be included in the Resource Assessment and Management (RAM) Framework because there was no underlying aquifer and because the method for assessing surface waters was only suitable for flowing reaches. A method for assessing ponded/level managed reaches is currently under development and should be available when this CAMS is reviewed.

Areas which were not assessed were:

- Areas east of the River Great Ouse incorporating the coastal margins, an area of fenland which is primarily drained, but which includes the ponded reaches of the Rivers Heacham, Ingol and Babingley. The fen also extends south to take in much of King's Lynn and the land bordering the Relief Channel to Downham Market as well as land between the tidal River Great Ouse and the Relief Channel (a flood storage channel); and

- Land to the west of the Great Ouse. Much of this land is reclaimed, with Marine Alluvium overlying Jurassic Kimmeridge Clay. The land is drained but much of the drainage water is not suitable for abstraction as it is of poor quality, frequently being saline. However, it is worth noting that a system for extracting water from depths of only a few metres via a series of well points is currently being trialled on one farm within this area. Water will be abstracted throughout the year, stored in a reservoir, and, if it proves to be of suitable quality, subsequently used for spray irrigation. This water is from 'minor' aquifers – localised and discontinuous deposits, probably of sands and silts, which may contain sufficient water to meet some abstraction needs, but are of insufficient significance for assessment under the RAM Framework. The Middle Level Main Drain also crosses this area of the CAMS, but this water is not available for abstraction.

Our strategy for management of water resources in these areas is given in section 5.9.



River Babingley, Hillington

Licensing strategy

5.1 Sustainability appraisal

5.1.1 Introduction

A sustainability appraisal process has been developed to enable the Agency to take account of costs and benefits in the production of CAMS. The process considers the government's four objectives of sustainable development, relating to environment, economics, society and resource use. It uses a largely qualitative, proforma-based approach to consider what the resource availability status for each water resource management unit should or could be after each six-year cycle (Tier 1). This is undertaken for all units in all CAMS areas. It also allows the appraisal of options for recovering water resources, by taking into account the implications of different options on all aspects of sustainability (Tier 2). This is undertaken to determine the most sustainable options for the future management of the catchment including, where necessary, options for recovery of resources. More information on the sustainability appraisal process is provided in *Managing Water Abstraction: The Catchment Abstraction Management Strategy Process*.

The preferred strategy was described in the consultation document. Responses received were discussed with the North West Norfolk stakeholder group. Reference was also made to the project group. The strategy was finalised and is presented in sections 5.2 to 5.10.

5.2 Catchment overview of licensing strategy

The following sections set out the Agency's strategy for the management of abstraction licences in the North West Norfolk CAMS area over the next 6 years. The strategy includes an indication of whether new or varied licence applications are likely to be considered favourably, dependent on the sustainability of current licensed abstractions. The strategy also provides an

indication of the conditions that are likely to be included on new or varied licences to ensure sustainability. It forms a framework for guidance but it is not prescriptive. It also sets out measures for the reduction of abstraction in parts of the CAMS area where abstraction has been assessed as being unsustainable.

The information contained in this licensing strategy will not negate the need for a normal licence determination to ensure local rights to abstract and nearby water environments (rivers and wetlands) are not subject to derogation. Neither does the strategy prevent anyone from making an application for a licence in any WRMU. The granting of a licence will always be dependent on a thorough licence determination by the Environment Agency.

The results of the resource assessment and the proposed licensing strategy are intended to give an indication at a catchment scale, of the availability of water resources for abstraction during low flow periods. This is often a period when demand can outstrip the supply of natural resources, and when the most detrimental impact to the environment is most likely to occur.

Sections 5.2.1 to 5.2.9 sets out elements of the licensing strategy that apply to the whole CAMS area. Details of the licensing strategy for individual WRMUs are laid out in section 5.3 through 5.8. Details of the licensing strategy for areas that fall outside a WRMU are laid out in section 5.9.

5.2.1 Licence determination

This strategy gives an indication of whether abstraction licences are likely to be available dependent on the sustainability of current licensed abstractions. However, a licence application can still be considered irrespective of the strategy suggesting whether there may be new water available for abstraction or not. *Managing Water Abstraction: The Catchment Abstraction Management Strategy Annex 2* (last updated July 2002) explains the Agency's licence determination process.

All licence applications must be considered under the requirements of the Water Resources Act (1991) as modified by the Water Act (2003).

5.2.2 Non-consumptive licences

CAMS is primarily concerned with licensed abstractions that have a net impact on water resources, i.e. those that are wholly or partly consumptive. Licences that are effectively non-consumptive, (i.e. they are low loss as water is returned to the catchment), and have a minimal impact on flow are likely to be considered irrespective of the resource availability status. Examples include fish farming or some environmental uses. They will, however, be considered on a case-by-case basis and will still be subject to assessment of local circumstances such as derogation and/or local impacts which may override other considerations.

5.2.3 Resource recovery options

The resource assessment and sustainability appraisal has shown that water resources in the North West Norfolk CAMS are generally fully committed at low flows. In some places the results also indicate possible areas of stress. The following resource recovery strategies are particularly applicable to those areas:

- The development of this CAMS has shown that there a number of unused licences within the CAMS area. We will seek voluntary revocation of these licences if they are no longer required;
- For some licences, a significant proportion of the licensed quantity is not abstracted. Where appropriate, the Environment Agency may negotiate an overall voluntary reduction in licensed quantity so that the licensed quantity reflects actual needs while at the same time maintaining adequate headroom;
- Because of the moderately high proportion of Licences of Right in the North West Norfolk CAMS area, a number of licences do not include a Hands Off Flow or cessation clause. We will investigate the option of voluntary acceptance of Hands Off Flow or Hands Off Level conditions to those licences. Where appropriate Hands Off Flows will also be issued on all new licences; and
- It is standard Environment Agency practice to support and encourage licensing for storage reservoirs which are filled by winter high flows when water is available. This option is of particular value where such a move would result in revocation of a summer licence.



River Ingol, near Snettisham

5.2.4 Time limiting

All new and varied licences will be issued with a time limit. The normal duration of a time limited licence granted through the CAMS process will be 12 years. Licences granted between now and 2018 will have a common end date of 31st March 2018 to fit with CAMS common end dates.

For all licences, if there is local uncertainty or need for further investigation a shorter time limit may be appropriate. An example is where there are uncertainties about the impact of the abstraction on the environment. This will depend not only on the result of the CAMS, but also on an assessment of local circumstances.

Exceptions to the common end date will be considered where significant investment has been made, e.g. for winter storage schemes. These will be tied to a winter common end date of 31st March 2030.

All time limited licences will be issued with a presumption of renewal, subject to the applicant satisfying the following three tests:

- The licence is environmentally sustainable;
- There is a continued justification of need; and
- Use of water is efficient.

Licence holders will be notified that their licence will expire. They will be expected to re-apply for their licence. The Environment Agency will endeavour to give six years notice if a licence will not be renewed or if it is likely to be varied significantly.

Further details on time limits and the three tests of renewal can be found in Section 5 of *Managing Water Abstraction*.

5.2.5 Water efficiency

In 2003, the Deputy Prime Minister announced that the Government would be looking for 20–30% water efficiency savings, with specific reference to per capita consumption. He believed that these are both feasible and crucial for the effective management of our water resources, and we agree with this opinion.

The Environment Agency will continue to encourage abstractors to employ water efficiency measures to reduce demands for water. The Environment Agency will seek to reduce demand for water through the active promotion of water efficiency initiatives and through opportunities to work in partnership with other organisations to promote efficiency. A useful source of information covering a wide range of water efficiency ideas and examples is available from the

Environment Agency's Water Demand Management Team at:

Environment Agency
Water Demand Management Team
Guildbourne House
Chatsworth Road
Worthing
BN11 1LD

Tel: 08708 506506

www.environment-agency.gov.uk/savewater

5.2.6 Exemptions

Until recently, some abstractions (for example, abstraction for trickle irrigation) did not require a licence. The Water Act 2003 removed many of these exemptions. These abstractions will therefore be brought into the licensing system over the course of the next few years. Where exemptions remain, the Environment Agency would encourage these to operate within the spirit and principles of abstraction licensing policy.

5.2.7 Designated sites

Within the North West Norfolk CAMS area there are a number of water dependent sites designated under the Habitats Directive (see **Map 6**). Through the Review of Consents, the Environment Agency is currently investigating the impact of abstraction (and other consented activities) on each site. Until these studies are complete, the Environment Agency will take a precautionary approach in dealing with applications to abstract which may influence these sites.

5.2.8 Management of licences

The Environment Agency has the responsibility to enforce abstraction licence conditions. This is carried out through a programme of routine inspections.

5.2.9 Impoundments

Applications for impoundment licences will be dealt with on a case-by-case basis.

The sections which follow set out the specific licensing strategy for each Water Resource Management Unit. Where units exhibit the same final resource status, these have been grouped together as they also share the same licensing strategy.

5.3 Water Resource Management Unit 2 (River Ingol)

5.3.1 Resource availability status and results of sustainability appraisal

The resource assessment showed that this unit has a surface water low flow resource availability status of **'water available'**. Through the sustainability appraisal process it was decided that this was an appropriate status for the unit and that the licensing strategy should not licence away further water at low flows. Water will be available at higher flows.

The resource assessment showed that the groundwater has a resource availability status of **'water available'**. However, as a broad policy, groundwater in these units will be closed to further abstraction. This is because there are uncertainties in the resource balance because the unit is of mixed geology and the hydrological relationship between the Chalk and the Sandringham Sands is not well understood. It was felt that the economic gains from the relatively small quantities of water which might be available, are outweighed by the environmental risks to a small river which is highly dependent on the underlying Chalk strata.

5.3.2 Guidance on the assessment of new applications

Consumptive abstractions

- Surface water in these WRMUs will remain closed to further abstraction during the lowest flows Q95. Flows at Q95 are exceeded 95% of the time. Water will also not be licensed to Q92 as these flows are identical to that at Q95. Flows at Q92 are exceeded 92% of the time.
- The Environment Agency will retain the pre-CAMS presumption that at high flows water will be available for new consumptive licences. The surplus available upstream of the assessment point will be determined by transposing flows to the proposed point of abstraction.
- All applications will be considered on a case-by-case basis. Applications will be subject to a local determination. Licences will be subject to Hands Off Flow conditions. The RAM Framework Tool (a nationally consistent spreadsheet based software that assesses water availability in the catchment) will be used for the determination of Hands Off Flow conditions.
- As a broad policy, groundwater in these units will be closed to further abstraction. However, groundwater applications which can demonstrate that they do

not have a significant impact on the river may still be considered. A detailed groundwater model of the area is currently in preparation and once complete this will contribute additional information which will greatly assist in the assessment of any such applications.

- All new and varied licences will normally be time limited to a common end date of 31st March 2018, with a normal renewal period of 12 years. Where significant investment has occurred (e.g. winter storage reservoirs) a longer renewal period may be applied (see section 5.2.4). Where there may be an environmental impact, licences may be time limited for a shorter period.

Non-consumptive abstractions

- Proposals for non-consumptive abstractions will be considered on a case-by-case basis.

5.3.3 Renewals and management of existing licences

Licences in these units that are time limited to expire prior to 31st March 2018 will be treated with a presumption of renewal subject to the renewal tests outlined in section 5.2.4. They will be time limited into the CAMS cycle. Where there is the possibility of an environmental impact, licences may be time limited for a shorter period (see section 5.2.4). Licence conditions may also be subject to minor changes including the addition of water-efficiency and metering good practice conditions.

5.4 Water Resource Management Units 1, 4, 6, 7 and 10 (River Heacham, River Babingley D/S, River Gaywood D/S, Middleton Stop Drain D/S and Polver Drain)

5.4.1 Resource availability status and results of sustainability appraisal

The resource assessment showed that all the units have a surface water low flow resource availability status of **'no water available'**. Through the sustainability appraisal process it was decided that this was an acceptable status for these units and that the licensing strategy should not seek to actively licence away further surface water at low flows. This is a conservative approach which minimises the risk of further impacting the environment during low flows.

The resource assessments showed that the groundwater in each unit has a resource availability status of 'water available'. Following standard CAMS practice, these were over-ridden to '**no water available**' in order to protect flows to the rivers from groundwater. This was necessary because the resource status of the rivers was more critical than that of the underlying aquifers. The exception was WRMU 1 (River Heacham) where no over-ride was necessary as the groundwater resource status was already 'no water available'. As a broad policy, groundwater in these units will be closed to further abstraction.

5.4.2 Guidance on the assessment of new applications

Consumptive abstractions

- Surface water in these WRMUs will remain closed to further abstraction during low flows to Q70. Flows at Q70 are exceeded 70% of the time.
- The Environment Agency will retain the existing presumption that at high flows water will be available for new consumptive licences. The surplus available upstream of the assessment point will be determined by transposing flows to the proposed point of abstraction.
- All applications will be considered on a case-by-case basis. Applications will be subject to a local determination. Licences will be subject to Hands Off Flow conditions. The RAM Framework Tool (a nationally consistent spreadsheet based software that assesses water availability in the catchment) will be used for the determination of Hands Off Flow conditions.
- As a broad policy, groundwater in these units will be closed to further abstraction. However, groundwater applications which can demonstrate that they do not have a significant impact on the river may still be considered. A detailed groundwater model of the area is currently in preparation and once complete this will contribute additional information which will greatly assist in the assessment of any such applications.
- All new and varied licences will normally be time limited to a common end date of 31st March 2018, with a normal renewal period of 12 years. Where significant investment has occurred (e.g. winter storage reservoirs) a longer renewal period may be applied (see section 5.2.4). Where there may be an environmental impact, licences may be time limited for a shorter period.

Non-consumptive abstractions

- Proposals for non-consumptive abstractions will be considered on a case-by-case basis.

5.4.3 Renewals and management of existing licences

Licences in these units that are time limited to expire prior to 31st March 2018 will be treated with a presumption of renewal subject to the renewal tests outlined in section 5.2.4. They will be time limited into the CAMS cycle. Where there is the possibility of an environmental impact, licences may be time limited for a shorter period (see section 5.2.4). Licence conditions may also be subject to minor changes including the addition of water-efficiency and metering good practice conditions.

5.5 Water Resource Management Unit 3 (River Babingley U/S)

5.5.1 Resource availability status and results of sustainability appraisal

The resource assessment showed that this unit has a surface water low flow resource availability status of '**over-licensed**'. Through the sustainability appraisal process it was decided that this was an acceptable status for the unit at this time because the unit is not '**over abstracted**', and the current risk of this occurring was considered to be low. Future plans for key current abstractions meant that the risk may also decrease with time. In order to ensure that the status does not become more critical, no new water will be licensed away at low flows

The resource assessment showed that the groundwater has a resource availability status of 'water available'. However, following standard CAMS practice, this was over-ridden to '**no water available**' in order to protect flows to the river from groundwater. This was necessary because the resource status of the river was more critical than that of the underlying aquifer.

5.5.2 Guidance on the assessment of new applications

Consumptive abstractions

- Surface water in this WRMUs will remain closed to further abstraction during the lowest flows to Q69. Flows at Q69 are exceeded 69% of the time.

- The Environment Agency will retain the existing presumption that at high flows water will be available for new consumptive licences. The surplus available upstream of the assessment point will be determined by transposing flows to the proposed point of abstraction.
- All applications will be considered on a case-by-case basis. Applications will be subject to a local determination. Licences will be subject to Hands Off Flow conditions. The RAM Framework Tool (a nationally consistent spreadsheet based software that assesses water availability in the catchment) will be used for the determination of Hands Off Flow conditions.
- Groundwater in this unit will remain closed to further abstraction.
- All new and varied licences will normally be time limited to a common end date of 31st March 2018, with a normal renewal period of 12 years. Where significant investment has occurred (e.g. winter storage reservoirs) a longer renewal period may be applied (see section 5.2.4). Where there may be an environmental impact, licences may be time limited for a shorter period.

Non-consumptive abstractions

- Proposals for non-consumptive abstractions will be considered on a case-by-case basis.

5.5.3 Renewals and management of existing licences

Licences in these units that are time limited to expire prior to 31st March 2018 will be treated with a presumption of renewal subject to the renewal tests outlined in section 5.2.4. They will be time limited into the CAMS cycle. Where there is the possibility of an environmental impact, licences may be time limited for a shorter period (see section 5.2.4). Licence conditions may also be subject to minor changes including the addition of water-efficiency and metering good practice conditions.



River Babingley

5.5.4 Resource recovery strategy and other changes to existing licences

Current licence holders should be aware that the current 'over-licensed' status of the river must be maintained (or improved) and that a move to an 'over-abstracted' status would be unacceptable. Section 5.2 describes a generic licensing strategy for the whole catchment which will be a particular focus in this unit in order to preserve the resource status and where possible, to recover resources on a voluntary basis. This strategy aims to reduce the potential for the resource status to become over-abstracted and for the environment to be derogated.

The resource assessment showed that, although the surface water resource status was 'over-licensed' the river reach was not over abstracted. The sustainability appraisal indicated that a programme of resource recovery, except for that described in section 5.2.4, was inappropriate at this stage. Proposed plans for use of abstraction points indicate actual abstraction from the Chalk aquifer in this unit may decrease over time, further reducing the risk of the river becoming over-abstracted.

A groundwater model for the North West Norfolk area is currently under development. This will serve to increase our understanding of the impact of abstraction in the CAMS area. Once complete this will provide information that should be considered alongside this licensing framework in order to enlighten future management decisions.

5.6 Water Resource Management Unit 5 (River Gaywood U/S)

5.6.1 Resource availability status and results of sustainability appraisal

The resource assessment showed that this unit has a surface water low flow resource availability status of 'over-licensed'. Through the sustainability appraisal process it was decided that this was an acceptable status for the river because it is **not** 'over-abstracted' and the risk of this occurring was considered to be low. Future plans for key current abstractions meant that the risk may also decrease with time. In order to ensure that the status does not become more critical, no new water will be licensed away at low flows.

The resource assessment showed that the groundwater has a resource availability status of 'over-abstracted'. Through the sustainability appraisal process it was

decided that a programme of resource recovery except for that given in section 5.2.3 was inappropriate at this stage. This is because:

- Uncertainties occur in the resource assessment due to the small size of the units. A groundwater model for the North West Norfolk area is currently under development. This will serve to increase our understanding of the impact of abstraction in the CAMS area. This best available information should be considered alongside this licensing framework in order to enlighten future management decisions; and
- The resource status is strongly influenced by a public water supply abstraction. Future plans for the use of abstraction points indicate that actual abstraction from the Chalk aquifer may reduce over time.

5.6.2 Guidance on the assessment of new applications

Consumptive abstractions

- Surface water in this WRMU will remain closed to further abstraction during the lowest flows to Q67. These are exceeded 67% of the time.
- The Environment Agency will retain the existing presumption that at high flows water will be available for new consumptive licences. The surplus available upstream of the assessment point will be determined by transposing flows to the proposed point of abstraction.
- All applications will be considered on a case-by-case basis. Applications will be subject to a local determination. Licences will be subject to Hands Off Flow conditions. The RAM Framework Tool (a nationally consistent spreadsheet based software that assesses water availability in the catchment) will be used for the determination of Hands Off Flow conditions.
- Groundwater in this unit will remain closed to further abstraction.
- All new and varied licences will normally be time limited to a common end date of 31st March 2018, with a normal renewal period of 12 years. Where significant investment has occurred (e.g. winter storage reservoirs) a longer renewal period may be applied (see section 5.2.4). Where there may be an environmental impact, licences may be time limited for a shorter period.

Non-consumptive abstractions

- Proposals for non-consumptive abstractions will be considered on a case-by-case basis.

5.6.3 Renewals and management of existing licences

Licences in these units that are time limited to expire prior to 31st March 2018 will be treated with a presumption of renewal subject to the renewal tests outlined in section 5.2.4. They will be time limited into the CAMS cycle. Where there is the possibility of an environmental impact, licences may be time limited for a shorter period (see section 5.2.4). Licence conditions may also be subject to minor changes including the addition of water-efficiency and metering good practice conditions.

5.6.4 Resource recovery strategy and other changes to existing licences

Current licence holders should be aware that further deterioration of the 'over-abstracted' status of the aquifer would be unacceptable. Deterioration of the 'over-licensed' status of the river to 'over-abstracted' would also be unacceptable. Section 5.2 describes a generic licensing strategy for the whole catchment which will be a particular focus in this unit in order to preserve the resource status and where possible, to recover resources on a voluntary basis. This strategy aims to reduce the potential for the resource status to become more critical and for the environment to be derogated.

It is worth noting that a number of abstractions are currently the subject of investigation under the Habitats Directive Review of Consents (see section 5.2.7). These have been identified as being likely to have a significant effect, hydrologically, on East Walton and Adcocks Common SSSI and cSAC. The process will examine, in more detail that the CAMS methodology, the local impacts of those licences. If any are shown to have an adverse affect, modification (or revocation) of those licences is possible under legislation. Such an action would have implications for the resource status of this WRMU.

5.7 Water Resource Management Unit 8 (River Nar U/S)

5.7.1 Resource availability status and results of sustainability appraisal

The resource assessment showed that this unit has a surface water low flow resource availability status of 'over-abstracted'. However through the sustainability appraisal process it was decided that it was inappropriate to undertake a programme of resource recovery at this time. A number of factors contributed to this decision including:

- The over-abstracted status of the river reach appears to be strongly related to a public water supply (PWS) abstraction from groundwater within the unit. The geology of the Nar Valley is extremely complex and we currently do not fully understand the interaction between the river and the abstraction. It was therefore considered inappropriate to look for an immediate alteration to the licence in question. In addition, the social and economic costs of retrieving water from public water supply at this time was considered too high. However, because the River Nar is a SSSI, further investigation was considered necessary as an appropriate first step to resolving these issues;
- The PWS abstraction is located at the western boundary of the unit near to the assessment point. Although it may influence flows reaching the assessment point, it is considered unlikely to influence the entire river reach. The risk to the river is therefore, to an extent, likely to be localised. In contrast, the resource status is applied to the entire reach, even though it is based on flows at the assessment point at the bottom of the reach; and
- The sustainability appraisal process recognised that the river is designated a Site of Special Scientific Interest. There is a statutory obligation to protect these sites. In order to ensure that the status of river does not deteriorate further, no new surface water will be licensed away at low flows and to flows to Q32. This value is derived from the fully licensed scenario. Water may be available at flows above Q32, i.e the highest flows that are exceeded 32% of the time. The reliability of new licences, subject to flow restrictions, could therefore be reduced when compared to pre-CAMS winter licences. Note, that this approach may be reconsidered in the light of additional information following production of the North West Norfolk groundwater model and other investigations relating to the status of the Nar (see section 5.7.4).

The resource assessment showed that the groundwater has a resource availability status of 'over-licensed'. Groundwater will also remain closed to new abstractions to protect flows to the river from groundwater.

5.7.2 Guidance on the assessment of new applications

Consumptive abstractions

- Surface water in this WRMU will be closed to further abstraction to Q32. These flows are exceeded 32% of the time.
- The surplus available upstream of the assessment point will be determined by transposing flows to the proposed point of abstraction.
- All applications will be considered on a case-by-case basis. Applications will be subject to a local determination. Licences will be subject to Hands Off Flow conditions. The RAM Framework Tool (a nationally consistent spreadsheet based software that assesses water availability in the catchment) will be used for the determination of Hands Off Flow conditions.
- Groundwater in this unit will remain closed to further abstraction.
- All new and varied licences will normally be time limited to a common end date of 31st March 2018, with a normal renewal period of 12 years. Where significant investment has occurred (e.g. winter storage reservoirs) a longer renewal period may be applied (see section 5.2.4). Where there may be an environmental impact, licences may be time limited for a shorter period.

Non-consumptive abstractions

- Proposals for non-consumptive abstractions will be considered on a case-by-case basis.

5.7.3 Renewals and management of existing licences

Licences in these units that are time limited to expire prior to 31st March 2018 will be treated with a presumption of renewal subject to the renewal tests outlined in Section 5.2.4. They will be time limited into the CAMS cycle. However, where there is the possibility of an environmental impact, licences may be time limited for a shorter period (see Section 5.2.4). Licence conditions may also be subject to minor changes including the addition of water-efficiency and metering good practice conditions.

5.7.4 Resource recovery strategy and other changes to existing licences

Current licence holders should be aware that an increase in the 'over-abstracted' status of the river would be unacceptable. Section 5.2 describes a generic licensing strategy for the whole catchment. This will be a particular focus in this unit as it aims to reduce the potential for the resource status to become over abstracted any further, and for the environment to be detrimentally affected. Where possible, resources will be recovered on a voluntary basis.

The status of flows in the River Nar was initially raised as a possible issue by English Nature through the Nar Conservation Strategy. That strategy awaited the results of this CAMS. The resource assessment and the sustainability appraisal process have shown that there is a potential impact on the Nar by public water supply abstraction. However, a more detailed understanding of the interaction between abstraction and the river is considered necessary. Further investigation will take place within the Restoring Sustainable Abstraction programme. A fluvial audit, and the groundwater model which is currently being prepared for North West Norfolk, will contribute greatly to this. Any resource recovery, if needed, can then be scaled appropriately.

It is worth noting that there is on-going discussion about the appropriate level of flows for Chalk rivers and SSSI's. English Nature are currently preparing generic guidance on conservation objectives for riverine SSSI's and this will contribute to the debate. However, until that debate is resolved, flow targets for Chalk rivers and SSSI's will comply with those set through CAMS.

It is worth noting that a number of abstractions are currently the subject of investigation under the Habitats Directive Review of Consents (see section 5.2.7). These have been identified as being likely to have a significant effect, hydrologically, on East Walton and Adcocks Common SSSI and cSAC. The process will examine, in more detail that the CAMS methodology, the local impacts of those licences. If any are shown to have an adverse affect, modification (or revocation) of those licences is possible under legislation. Such an action would have implications for the resource status of this WRMU.

5.8 Water Resource Management Unit 9 (River Nar D/S)

5.8.1 Resource availability status and results of sustainability appraisal

The resource assessment showed that this unit has a surface water low flow resource availability status of 'over-licensed'.

However through the sustainability appraisal process it was decided that it was inappropriate to undertake a programme of resource recovery at this time. A number of factors contributed to this decision.

The over-licensed status of the river reach appears to result from a complex interaction between abstractions in this WRMU and abstractions in WRMU 8 upstream, which affect flows received by WRMU 9. These include

public water supply abstraction. Because we currently do not fully understand the interaction between the river and the abstraction in question and because the social and economic costs of retrieving water were high, it was considered inappropriate to modify or revoke the licence at this time. However, the sustainability appraisal process also recognised that the River Nar is designated a Site of Special Scientific Interest. There is a statutory obligation to protect these sites. A more detailed understanding of the interaction between abstraction and the river is therefore required. Any resource recovery, if shown to be necessary, can then be scaled appropriately. The issue will therefore be passed to the Restoring Sustainable Abstraction programme. The groundwater model which is currently being prepared for North West Norfolk will contribute greatly to this.

The resource assessment showed that the groundwater has a resource availability status of 'water available'. Following standard CAMS practice, this was over-



River Nar at West Lexham

ridden to 'no water available' in order to protect flows to the river from groundwater. This was necessary because the resource status of the river was more critical than that of the underlying aquifer. As a broad policy, groundwater in these units will be closed to further abstraction.

5.8.2 Guidance on the assessment of new applications

Consumptive abstractions

- Surface water in these WRMUs will be closed to further abstraction up to an inclusive of flows to Q59. These flows are exceeded 59% of the time.
- The Environment Agency will retain the existing presumption that at high flows water will be available for new consumptive licences. The surplus available upstream of the assessment point will be determined by transposing flows to the proposed point of abstraction.
- All applications will be considered on a case-by-case basis. Applications will be subject to a local determination. Licences will be subject to Hands Off Flow conditions. The RAM Framework Tool (a nationally consistent spreadsheet based software that assesses water availability in the catchment) will be used for the determination of Hands Off Flow conditions.
- Groundwater in these units will remain closed to further abstraction.
- All new and varied licences will normally be time limited to a common end date of 31st March 2018, with a normal renewal period of 12 years. Where significant investment has occurred (e.g. winter storage reservoirs) a longer renewal period may be applied (see section 5.2.4). Where there may be an environmental impact, licences may be time limited for a shorter period.

Non-consumptive abstractions

- Proposals for non-consumptive abstractions will be considered on a case-by-case basis.

5.8.3 Renewals and management of existing licences

Licences in these units that are time limited to expire prior to 31st March 2018 will be treated with a presumption of renewal subject to the renewal tests outlined in Section 5.3.3. They will be time limited into the CAMS cycle. Where there is the possibility of an environmental impact, licences may be time limited

for a shorter period (see Section 5.2.4). Licence conditions may also be subject to minor changes including the addition of water-efficiency and metering good practice conditions.

5.8.4 Resource recovery strategy and other changes to existing licences

Current licence holders should be aware that a move from an 'over-licensed' status to an 'over-abstracted' status would be unacceptable. Section 5.2 describes a generic licensing strategy for the whole catchment. This will be a particular focus in this unit as it aims to reduce the potential for the resource status to become over abstracted, and for the environment to be detrimentally affected. Where possible, resources will be recovered on a voluntary basis.

The outcome of investigations on the River Nar under the Restoring Sustainable Abstraction programme may dictate future resource recovery strategies if appropriate.

5.9 Areas not covered by a Water Resource Management Unit

The current licensing policy for the Relief Channel will be maintained:

- Summer water in the Relief Channel and tributaries are fully committed to existing abstractors and the water environment in order that sufficient flow is maintained to tide;
- Water is generally available during periods of high winter flow and abstractors are encouraged to store water in reservoirs for summer use. Hands Off Flow clauses may apply; and
- Applications will be considered on a case-by-case basis.

Applications to abstract from the coastal fen margin (drains, and downstream of assessment points on the Rivers Heacham, Ingol and Babingley), drains to the west of the Great Ouse, and any other area not covered by a Water Resource Management Unit will be determined on a case by case basis. In these areas:

- It is unlikely that summer water will be available;
- Water may be available during periods of high winter flow and abstractors are encouraged to store water in reservoirs for summer use. Hands Off Flow clauses may apply; and
- Applications will be considered on a case-by-case basis.

Abstractions from minor aquifers (Sands and Gravels) will be considered on a case by case basis.

Potential applicants are encouraged to contact the Environment Agency at an early stage to discuss proposals.

5.10 Opportunities for licence trading in the North West Norfolk CAMS area

One of the objectives of the CAMS process is to facilitate water rights trading. The term water rights trading refers to the transferring of licensable water

rights from one party to another, for benefit. It involves a voluntarily movement of a right to abstract water between abstractors, using the abstraction licensing process. More detailed information is available in *Managing Water Abstraction*.

A guidance leaflet (Water Rights Trading) was published and sent to Licence Holders towards the end of 2002 explaining the scope for water rights trading within current legislation. Consultation on more detailed proposals followed in 2003. After considering the responses to this consultation exercise, further information will be made available to update Licence Holders on the Environment Agency's conclusions for a detailed framework within which water rights trading will take place. This information and guidance will be timed to coincide with the expected implementation



River Heacham at Heacham Mill

of the sections of the Water Act 2003 that are most relevant to trading. Further information on Water Rights Trading is available on the Environment Agency web-site (www.environment-agency.gov.uk/subjects/waterres).

5.11 The Water Act 2003

Following the first major review of the abstraction licensing system since its inception in 1963, the Government set out, in 1999, a new framework for managing water resources. The CAMS process and the move to time limited licences are key elements of the new framework, which is completed by revisions to the statutory framework introduced by the Water Act 2003. The Act updates the Water Resources Act 1991 in several key areas:

- Deregulation of small abstractions;
- New controls on previously exempt abstractions for mine and quarry dewatering, trickle and other forms of irrigation, transfers into canals and internal drainage districts;
- Stronger powers for water resources planning and management;
- Changes to the legal status of abstraction licences;
- More flexibility to the licensing regulations to improve its efficiency and to encourage trading; and
- Stronger powers on water conservation.

For more details on the Act and its implementation, see the Environment Agency's web-site, www.environment-agency.gov.uk.

The Environment Agency web site will be updated to provide information as the Water Act is implemented.

Future developments in the CAMS area

6.1 Regional groundwater model

The Regional Groundwater Modelling Strategy will deliver the North West Norfolk groundwater model, incorporating the Chalk and Sandringham Sands. Delivery of the Strategy, scheduled for the winter of 2006, will enhance the Environment Agency's ability to make groundwater resource decisions based on sound science and good technical practice to re-evaluate water resource availability. The Regional Groundwater Modelling Strategy will also technically underpin future Catchment Abstraction Management Strategies (CAMS) and will contribute to the assessment of the impact of abstraction on wetlands and other sites designated under the Habitats Directive Review of Consents process. The Strategy will also contribute to the implementation of the Water Framework Directive.

Work on the North West Norfolk model began in 2004 and will be available to provide a more accurate resource assessment for the Chalk and Sandringham Sands groundwater units that fall within the North West Norfolk CAMS boundary, when the CAMS is due for review in 2009. It will also have an important role to play in licence determinations during this round of CAMS.

6.2 Restoring Sustainable Abstraction Programme

The national Restoring Sustainable Abstraction (RSA) programme catalogues sites that are affected or could be affected by abstraction. The catalogue includes National Environment Programme (NEP) sites, water company Asset Management Plan (AMP) schemes and Habitats Directive sites, where consents need to be reviewed. Abstraction licences which are likely to have a significant effect on these sites have been identified acting either alone or in combination.

The RSA Programme will be the means by which further investigations are carried out to establish the interaction between abstraction and the River Nar SSSI. The groundwater model should contribute substantially to this, and other North West Norfolk sites that are currently catalogued.

6.3 Climate change

In *Water Resources for the Future: A Strategy for Anglian Region*, the possible effects of climate change on water resources are examined and set out in context with other predicted changes for the areas, such as demand for water for household use and agriculture. There is evidence that climate change may increase the annual variability of rainfall, making the climate less predictable, with both more dry years (with hot and dry summers) and wet years (with warmer and wetter winters), and it is likely that the occurrence of low flows will increase. This could potentially lead to an increase in demand for water, coupled with a reduction in resources, or a changed pattern of resource availability. As our understanding of climate change improves, we will be able to refine existing scenario predictions and reduce uncertainty for the future. This will help to produce a measured response that allows society to adapt and accommodate the new climate as it evolves.

Post CAMS appraisal

Catchment Abstraction Management Strategies for each catchment across England and Wales will be produced on a cyclical basis with each Strategy being reviewed on a 6 yearly basis. The North West Norfolk CAMS will be reviewed in 2009 and a new North West Norfolk CAMS document will be published in 2011.

In order to determine whether this first CAMS has been successful, a number of indicators will be monitored. These will contribute to the assessment of whether the aims and objectives of CAMS, as described by the Vision Statement on page 4 have been met. Indicators are listed in **Table 3**.

Table 3 | North West Norfolk CAMS success indicators

Indicator	Measure
1 The resource status of WRMUs 1, 2, 4, 6, 7 and 10 will remain at, or drop no lower than, the 'no water available' banding	Long term flow duration curves for each site will remain within the 'no water available' resource band, dropping no lower than the Q70, i.e. the ecological river flow objective will be compromised for no more than 30% of the time under the fully licensed scenario
2 Routine monitoring for fisheries, macrophytes and macroinvertebrates will continue at strategic points related to assessment points used within the CAMS process. These will monitor any changes to the river environment when compared with baseline data.	Routine monitoring will allow us to monitor any change in the environment compared to the baseline which has been established by this CAMS. A review of this CAMS on a six yearly cycle will highlight any changes from the baseline situation.
3 Our understanding of the relationship between abstraction and the River Nar (WRMUs 8 and 9) will increase.	The North West Norfolk groundwater model and output from the Restoring Sustainable Abstraction programme will provide information on the affect of abstraction on the River Nar, and will indicate the source of any unsustainable abstraction(s). Subsequent adjustment to licences will be made where appropriate. A full review will take place in the next round of CAMS.
4 Encourage winter storage reservoirs	We will see appropriate use of winter storage as a means of acquiring new water and/or will see replacement of summer water licences.
5 A decrease in the number of unused licences	A review of this CAMS on a six yearly cycle should highlight a decrease in the number of unused licences
6 A decrease in the number of licences in which a significant proportion of the licence is not used	A review of this CAMS on a six yearly cycle should highlight a decrease in the number of these licences
7 A decrease in the number of licences without cessation conditions to protect low flows	A review of this CAMS on a six yearly cycle should highlight an increase in the number of licences with Hands Off Flow conditions
8 The resource status of WRMUs 3 and 5 will remain at, or drop no lower than their present positions within current resource bandings (Q69 and Q67 respectively)	Long term flow duration curves will indicate no further decline in resource status. The next round of CAMS will hope to see changes to public water supply abstraction reflected in improvements in resource status

Appendix 1

Glossary

Abstraction

Removal of water from a source of supply (surface or groundwater).

Abstraction – Actual

The volume of water actually abstracted as opposed to the volume of water that may be abstracted under the terms of an abstraction licence. Individual abstraction records are reported to the Environment Agency each year.

Abstraction licence

The authorisation granted by the Environment Agency to allow the removal of water from a source.

Alluvial deposit

Layers of sediment resulting from the activity of rivers. Usually fine material eroded, carried, and eventually deposited by rivers in flatter areas such as flood plains or lake beds.

Aquifer

A geological formation, group of formations or part of a formation that can store and transmit water in significant quantities.

Aquifer transmissivity

A measure of the ease at which water moves through a porous media.

Assessment Point

Critical point in catchment at which an assessment of available resources should be made. APs are located at the extremities of identified reaches and water resource management units.

Baseflow

That part of the river flow that is derived from groundwater sources rather than surface run-off.

Borehole

Well sunk into a water bearing rock from which water will be pumped.

Catchment

The area from which precipitation and groundwater will collect and contribute to the flow of a specific river.

Cessation condition

A condition on a licence that requires the licence-holder to immediately cease abstracting when a pre-determined flow or water level is reached, to prevent environmental damage.

Confluence

The point where two or more streams or rivers meet.

Consumptiveness

Proportion of the water not returned either directly or indirectly to the source of supply after use e.g. water evaporated, transpired or transferred elsewhere.

Demand

The requirements for water for human use.

De-naturalisation

Process of converting a natural flow to an estimated existing or scenario flow by adding consumptive abstraction and discharge impacts.

Derogation

In legal terms, the taking away of protected rights under the Water Resources Act due to the granting of a new licence.

Designated water dependent sites

Legally defined nationally and internationally important sites potentially affected by water management or water quality issues.

Discharge

The release of substances (i.e. water, sewage etc.) into surface waters.

Discharge Consent

A statutory document issued by the Environment Agency, which defines the legal limits and conditions on the discharge of an effluent into controlled waters.

Drift

A loose, deposit of sand, gravel, clay etc.

Drought

A general term covering prolonged periods of below average rainfall resulting in low river flows and/or low recharge to groundwater, imposing significant strain on water resources and potentially the environment.

EU Wild Birds Directive (1979)

Implemented through the Conservation (Natural Habitats, & c) Regulations along with the Habitats Directive 1992 – collectively known as the Habitats Directive. A network of sites has been established to protect important and threatened species.

EU Water Framework Directive

First major review of European water policy. Seeks to improve water quality in rivers and groundwater in an integrated way (see Integrated River Basin Management). This will be transposed into UK law in 2003.

Ecosystem or Ecological River Flow Objectives/level requirements

The minimum river flows (or water levels) required to protect ecological objectives.

Effective rainfall

That rainfall available for recharge of aquifers or to support river flows after 'losses' due to evaporation and take-up by plants.

Environmental impact

The total effect of any operation on the environment.

Environmental River Flow Objectives

The minimum river flows from the area required to protect ecological and other environmental objectives

Environmental Weighting

An assessment of a river's sensitivity to abstraction based on physical characteristics, fisheries, macrophyte and macro-invertebrates for a catchment/sub-catchment.

Existing abstraction and discharge impacts

The amount by which all abstractions reduced natural flows in the scenario year, taking into account the consumptiveness of the use, the location of any effluent return and any lags or smoothing effects between abstraction and outflow impact. Based on estimated abstraction returns from the scenario year.

Flow duration curve

Plot of flow vs percentage of time a flow is exceeded. Thus QN95 (the natural flow that is exceeded 95% of the time) will be a low rate of flow, and QN5 (natural flow exceeded 5% of the time) will be a high rate of flow.

Flow regime

The statistical pattern of a river's constantly varying (mean daily) flow rates.

Fluvial

Associated with river processes such as flow and erosion.

Gauged flow records

Records of flow in river as conventionally measured. They reflect not only natural runoff from the catchment, but also artificial influences (abstraction, discharge etc) that occur upstream of the measurement point.

Gauging station

A site where the flow of a river is measured.

GQA

Method for assessing the general quality of inland and coastal waters.

Groundwater

Water occurring below ground in natural formations (typically rocks, gravels and sands).

Groundwater baseflow

That part of the river flow that is derived from groundwater sources rather than surface run-off e.g. soil water, reservoir releases, effluents etc.

Groundwater catchment

The area from which recharge to the aquifer would naturally discharge to a defined point of a river, or over a defined discharge boundary.

Groundwater Management Units

Administrative sub-divisions of aquifers, defined on geological and hydrogeological criteria, which form the basis for groundwater resource management and licensing policy decisions.

Hands-Off Flow

A condition attached to the abstraction licence so that if the flow in the river falls below the flow specified on the licence then the abstractor may be required to stop or reduce the abstraction.

Hydrogeology

Branch of geology concerned with water within the Earth's crust.

Hydrology

The study of water on and below the earth's surface.

Hydrometric network

Networks of sites monitoring rainfall; river flow; river, lake, tidal and groundwater levels and some climate parameters. The data is used extensively for water resources management and planning, water quality and ecological protection and improvement, flood defence design, flood forecasting and flood warning.

Internal Drainage Board

Internal Drainage Board. A local land drainage authority with powers to raise finance and do works.

Irrigation

Supply (land) with water by means of artificial canals, ditches etc, especially to promote the growth of food crops.

Licence

Formal permit allowing the holder to engage in an activity (in the context of this report, usually abstraction), subject to conditions specified in the licence itself and the legislation under which it was issued.

Licence determination

A decision by the competent authority on whether and on what terms to grant or refuse a licence application, by reference to the authority's regulatory powers and duties.

Licence of Right

Licence granted under section 23 of the Water Resources Act 1963 in respect of an abstraction that was already in operation when that Act was implemented in 1965.

Licensed abstraction and discharge Impacts

The impacts of abstractions and discharges calculated for current abstraction licences and discharges based on full uptake of licensed abstraction rates and consumptiveness assumptions.

Low flow

The flow that is exceeded for a given percentage of the time. For example Q95 is the flow that is exceeded 95% of the time, this means that flow will only fall this low 5% of the time.

Main river

The watercourse shown on the statutory "Main River Maps" held by the Environment Agency and MAFF. The Environment Agency has permissive powers to carry out works of maintenance and improvements on these rivers.

Managing water abstraction

Document produced in May 2001 on the CAMS Process.

Mean flow

A long term average of the daily flow.

Minimum residual flow

The flow set at a river gauging station to protect downstream uses and below which controlled abstractions are required to cease.

MORECS

Meteorological office rainfall and evaporation calculation system. The calculations are of areal values at an average height above sea level for each of 188 40 x 40 km grid squares covering Great Britain.

Natural flow regime

The river flow pattern experienced prior to the influence of man, with no abstraction from or discharge to the catchment.

Natural flows

The flows, which would naturally leave an Assessment Area or assessment point in the absence of any artificial impacts.

Naturalisation

Process of converting gauged flows to natural flows by removing consumptive abstraction and discharge impacts (as detailed in 'Good Practice for Flow Naturalisation by Decomposition'). Note: there are other techniques of estimating natural flows.

Naturalised flow records

River flow records from which a best estimate of the effects of upstream artificial influences has been removed. These represent the runoff from the catchment that would occur if there were no artificial influences upstream.

Non-consumptive

This is where all abstracted water is returned to source a relatively short distance downstream of the abstraction point.

OFWAT

Office of Water Services.

Percolation

The descent of water through soil pores and rock crevices.

Permeability

The characteristic of a rock or soil that determines the rate at which fluids pass through the rock or soil under the influence of differential pressure.

Potential yield

The volume of water which can be withdrawn from a reservoir or aquifer in specified conditions, without depleting the storage so that withdrawal is no longer possible.

Precautionary principle

Where significant environmental damage may occur, but knowledge on the matter is incomplete, decisions made should err on the side of caution.

Precipitation

Deposition of moisture including dew, hail, rain sleet and snow.

Prescribed flow

A generic term for any flow 'prescribed' under statute or regulation.

Protected right

Protected rights include all existing licensed abstractions, and certain exempt abstractions for domestic and agricultural purposes (excluding spray irrigation) not exceeding 20m³/d.

Public water supply

Term used to describe the supply of water provided by a water undertaker.

Q50

The flow of a river which is exceeded on average for 50% of the time.

Q95

The flow of a river which is exceeded on average for 95% of the time.

RAM framework

Resource Assessment and Management Framework – a technical framework for resource assessment (for the definition and reporting of CAMS) and subsequent resource management (including abstraction licensing).

Ramsar site

A site of international conservation importance classified at the 'Convention on Wetlands of International Importance' 1971, ratified by the UK Government in 1976.

Reach

A length of river.

Recent actual abstraction and discharge impacts

The impacts of abstractions and discharges calculated for current abstraction licences and discharges based on recent abstraction returns or estimated from uptake and consumptiveness assumptions.

Recharge

Water which percolates downward from the surface into groundwater.

Restoring Sustainable Abstraction Programme (RSA Programme)

The programme for resolving environmental problems caused by over abstraction in certain catchments.

Revocation

Cancellation of licence and associated rights and benefits.

River flow objectives (RFOs)

The minimum river outflows from the area required to protect ecological objectives, effluent dilution requirements, navigation and amenity in-river needs.

River quality objective (RQOs)

A River Quality Objective is an agreed strategic target, expressed in terms of River Ecosystem standards, which is used as the planning base for all activities affecting the water quality of a stretch of watercourse.

River reach

Unit of a river between two assessment points, delineated for the purposes of abstraction licensing and resource management.

Salmonids

Members of the family salmonidae, includes Salmon, Trout and Char.

Scenario abstraction and discharge impacts

The amount by which all the abstractions in the area reduce natural outflows from it, taking into account the consumptiveness of the use, the location of any effluent return and any lags or smoothing between abstraction and outflow impact. Based on an assumed abstraction and discharge scenario (e.g. full Licensed rate, 'Existing', 'Recent Actual' etc).

Scenario flows

The flows, which would leave the assessment point in the specified year, based on the assumed scenario abstractions and discharges.

Source of supply

Either an inland water (river, stream, canal, lake, etc.) or underground strata. See Section 221 WRA91.

Special area of conservation (SAC)

A Special Area of Conservation is one classified under the EC Habitats Directive and agreed with the EC to contribute to biodiversity by maintaining and restoring habitats and species.

Special Protection Area (SPA)

A Special Protection Area is one classified as such under the EC Birds Directive to provide protection to birds, their nests, eggs and habitats.

Spray irrigation

Abstracted water sprayed onto grassland, fruit, vegetables etc. Can have a high impact on water resources.

Springs

These occur where the water table intersects the ground surface.

Site of Special Scientific Interest

A Site of Special Scientific Interest is an area given a statutory designation by English Nature or the Countryside Council for Wales because of its nature conservation value.

Strata

Layers of rock, including unconsolidated materials such as sands and gravels.

Surface water

This is a general term used to describe all the water features such as rivers, streams, springs, ponds and lakes.

Surface water catchment

The area from which runoff would naturally discharge to a defined point of a river, or over a defined boundary.

Surplus or deficit

How much more or how much less abstraction impact is acceptable: = Scenario flows – RFOs.

Sustainable development

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This involves meeting four objectives simultaneously:

- social progress which recognises the needs of everyone;
- effective protection of the environment;
- prudent use of natural resources; and
- maintenance of high and stable levels of economic growth and employment.

Telemetry

Telemetry is a means of collecting information that has been collected by unmanned monitoring stations (often for river flows or rainfall) using a computer that is connected via the public telephone system.

Threshold

A Hands Off Flow (HOF) value within a sequence of HOFs, each INT MI/d higher than the previous.

Tidal limit

The most upstream point within an estuary or river where water levels are subject to tidal variation.

Time limited licence

Licence with specified end date

Topography

Physical features of a geographical area.

Total licensable resource

Is equivalent to the 'acceptable abstraction impacts' i.e. The abstraction impacts which are considered acceptable given target outflows in the specified year. e.g. = Benchmark (Natural) river flows – RFOs, or = (Surplus or Deficit) + Scenario Abstraction Impacts below.

Will vary with reference to assessment point and time frame (e.g. season).

Total rainfall

Precipitation as measured by a raingauge.

Unconstrained abstraction impact

Abstraction impacts not related to hydrological or water quality constraints.

Water resource

The naturally replenished flow or recharge of water in rivers or aquifers.

Water Resource Management Unit

An area that has similar groundwater and or surface water characteristics and is managed in a similar way.

Water resources strategies (The)

Strategy for Water Resource planning in England and Wales over the next 25 years to ensure sustainable use and sufficient water for all human uses with an improved water environment. The strategies predict demand using different social and economic scenarios.

Water Rights Trading

The transfer of licensable water rights from one party to another for benefit.

Watercourse

A stream, river canal or channel along which water flows.

Yield

The reliable rate at which water can be drawn from a water resource.

Appendix 2

List of abbreviations

AMP	Asset Management Plan produced by the Water Companies for OFWAT. It sets out the water industry investment programme. These plans are drawn up through consultation with the Environment Agency and other bodies to cover a five year period. AMPs have to be agreed by Defra and OFWAT	Q50 / Q95	Flow exceeded during 50% / 95% of period over which flow data are being considered
AP	Assessment Point	RFO	River Flow Objectives
BAP	Biodiversity Action Plan	RQO	River Quality Objective
CAMS	Catchment Abstraction Management Strategy	SAC	Special Area of Conservation (cSAC = candidate Special Area of Conservation)
Defra	Department of the Environment, Food and Rural Affairs	SPA	Special Protection Area
EU	European Union	SSSI	Site of Special Scientific Interest i.e. an area given a UK statutory designation because of its conservation value
FDC	Flow Duration Curve	STW	Sewage Treatment Works
GQA	General Quality Assessment		
HOF	Hands Off Flow		
IDB	Internal Drainage Board		
mAOD	metres Above Ordnance Datum (mean sea level at Newlyn Cornwall 1915-1921)		
MI, MI/d, MI/day	MI = megalitres = 1,000,000 litres = 1,000 cubic metres = 1,000m ³ = 220,000 gallons MI/d = MI/day = MI per day = tcmd = thousand cubic metres per day		
PWS	Public Water Supply		

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