River Ems – Catchment Appraisal

Photo: Mill Meadows, John Barker

Western Sussex Rivers Trust

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DISCLAIMER:

This report has been prepared by the Western Sussex Rivers Trust (WSRT) working in collaboration with the Friends of the Ems (FotE), local experts, regulators, community members and other stakeholders. The report was funded by Portsmouth Water. This report was prepared with all reasonable care and diligence within the terms of the contract of engagement with Portsmouth Water Limited, and taking into account the resources and information made available at the time.

PHOTOS:

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1. Introduction

The River Ems, in West Sussex is recognised as a chalk stream in the WWF-UK Chalk Streams report, supporting specialist flora and habitats within the catchment. It is also listed on Catchment Based Approach (CaBA) under the Chalk Stream Strategy stating that Chalk streams are one of our rarest and most precious freshwater habitats. With most of the world's chalk streams found in England, restoring and protecting them is a matter of global importance.

It runs from the South Downs National Park in the north skirting the Sussex / Hampshire border and joins the English Channel via Emsworth and Chichester Harbour in the south – an internationally important wildlife site. The wider Ems drainage area (called waterbody area) comprises nearly 30km of streams and relic spring-fed channels, with approximately 9km formally designated as 'main river'.

The River Ems is one of only 224 chalk rivers and streams in England which were described by the Flagship Chalk Stream Restoration Strategy (2021) as our equivalent to the Great Barrier Reef, holding 'a truly special natural heritage with a responsibility'.

The Ems also bears more pressures than most. Small in size and draining into the English Channel, it sits in a shrinking landscape. With decreased river flow due to drinking water abstraction, and future threats of increased drought and sea level rise, taking action to protect and ready the Ems for future changes is now vital. Local people know this and have been instrumental in driving action.

1.1 Chalk Streams

Chalk rivers are globally rare and exceptionally biodiverse, found in a limited range covering parts of England, France and Denmark, with the vast majority of found in England. They support a unique array of wildlife species – some of which are chalk stream specialist species.

Characteristically clear and cool, often with good water quality, chalk streams and rivers are fed by flow from an underground chalk aquifer – where the chalk acts as a sponge to retain water, and emerges from this aquifer through springs, supplying flow to overground rivers and streams. The location and extent of flow can change from year to year, and is influenced by drought, water abstraction and other modifications. As water levels in the aquifer change so does the location of the spring head, and the length of stream that runs. The permanently running sections are called perennial, and those that do not run year-round are called ephemeral.

It is increasingly recognised that these special chalk streams are under threat from multiple impacts, most significantly by demand for water abstraction for drinking water, agriculture and global climate change. These pressures means that the perennial areas of streams are shrinking, reducing water available to feed downstream habitats, and replenish floodplain wetlands.

1.2 Background

In recent years there has been increasing interest and concern for our chalk streams, not just from river experts but also by the communities that are connected with and love these rare and special places. This has built greater recognition of the need for protection and restoration. Local people have been at the heart of driving this movement and prompting action.

1.3 Chalk Stream Strategy

In view of the rare and threatened nature of chalk streams in 2021 the Catchment Based Approach (CaBA) formed a Chalk Stream Restoration Group, who with support from diverse industry partners developed the UK 'Chalk Stream Strategy'.

"The chalk-streams restoration strategy is a comprehensive, up-to-date analysis of the issues threatening chalk streams in England, of the ways in which ecological pressures are assessed and regulated. It includes multiple pragmatic recommendations to bring about the ecological recovery and good health of our chalk streams."

This guidance and direction to DEFRA seeks to drive greater protection for these precious streams. The Strategy was followed by an 'Implementation Plan' – an actions-based guide to help kick start planning and restoration.

The Chalk stream strategy underlined that river health depends on three essential elements – called the Trinity of Ecological Health.

- Water quality (good clean water)
- Water quantity (healthy and consistent flow)
- Physical habitat (healthy and thriving supporting habitats)

Restoring all these elements is critical to the functioning of the other, and overall ecosystem health.

Figure 1 Trinity of Ecological Health (from CaBA Chalk Stream Strategy).

This plan incorporates and utilises the Chalk Stream Strategy and Implementation Strategy and is aligned with the 'Trinity of Ecological Health'.

1.4 Flagship Chalk Stream Project

In answer to the CaBA strategy, the Chalk Stream Restoration Group recommended that a number of chalk streams should be nominated by water companies as test cases for future work to reduce ecological impacts of water abstraction. In acknowledgement of the impacts of their drinking water abstraction and local pressure, Portsmouth Water nominated the Ems to be part of this flagship project. Work on the Ems will continue to contribute to this project.

2. Catchment Appraisal

This document provides an overview of the history, ecology and hydrology of the catchment, identifying key pressures and impacts to inform the development of the River Ems Restoration Plan 2024-2034 (available as a separate document from WSRT).

Developed using the recommendations outlined in the Chalk Stream Strategy, this provides a comprehensive baseline of the Ems as it is today, and incorporates a broad range of data from both quantitative and qualitative sources.

Figure 2: River Ems at River St, Westbourne

3. Catchment Overview

The Ems waterbody covers 60km2 (6000ha) and incorporates over 30km of waterways including main river and streams. This has been recognised by Chichester District Council as a critical link between the South Downs National Park (SDNP) and Chichester Harbour, both of which are Areas of Outstanding Natural Beauty (AONB), by providing a blue and green wildlife corridor for species to move and migrate across our landscape.

At the highest strategic level, the river Ems lies within the Southeast River Basin District (SE RBD), which comprises 12 operational catchments. The river Ems is located within the Arun, Rother & Western Streams Catchment, within the Western Streams sub-catchment (see figure 3).

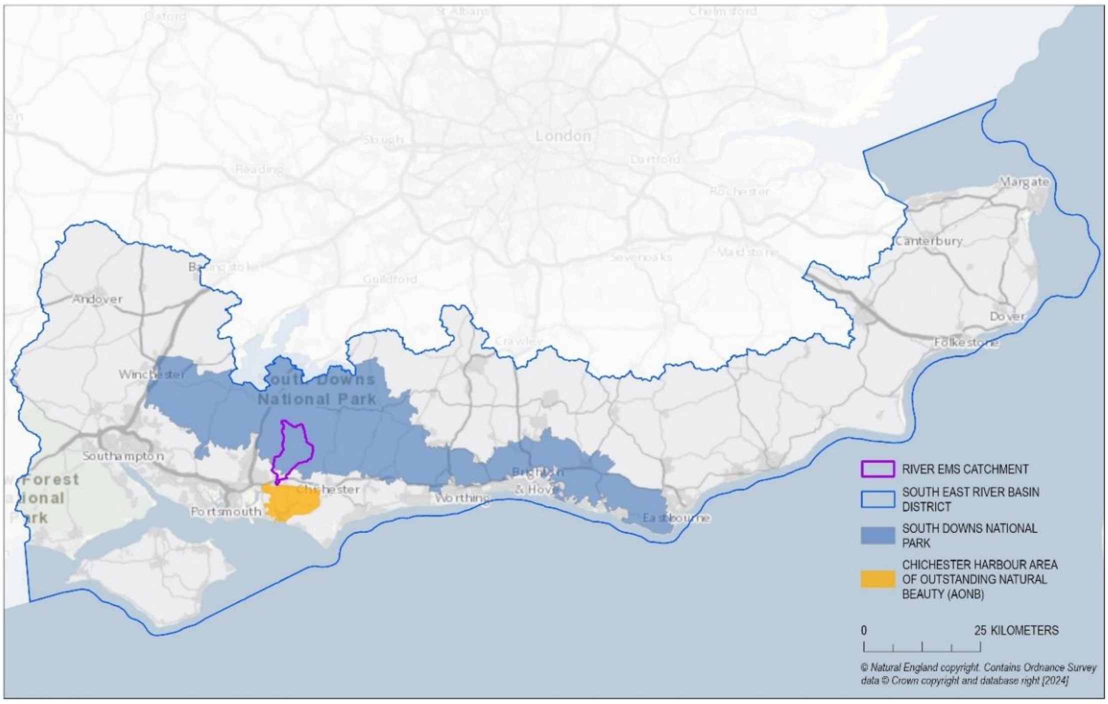


Figure 3. The South East River Basin District shown with the Ems catchment, South Downs National Park and Chichester Harbour AONB.

The Ems waterbody (i.e. catchment drainage area) is currently classified under the Water Framework Directed as ‘poor’, with Reasons for Not Achieving Good (RNAG) attributed to historic modifications to the river channel which impede fish passage and disrupt the river’s ‘natural flow’, along with impacts on water levels due to abstraction for drinking water, and chemical elements. These issues are discussed in more detail in Section 14.

Outside of the catchment boundary at the river mouth, the Ems flows into Chichester Harbour – and Internationally Important RAMSAR site. Freshwater flow into the Harbour is critical to coastal habitats and species, and the industries which rely on these resources, such as fisheries. In 2019/2020 Natural England assessed the condition of Chichester Harbour as ‘Unfavourable – Declining’. The Ems is important for providing supporting habitats for wetland birds, migration routes, and a clean and plentiful supply of water to keep the harbour and habitats healthy.

In terms of hydrology the Ems is complex. Groundwater dominated, the headwater springs are fed from a natural reservoir which sits within the chalk aquifer. As water levels in the aquifer rise spring heads appear extending the flowing part of the river. As water levels fall these springs dry and stop issuing water. Combined with this the Ems flows through the low-lying coastal plain to the sea, travelling over mixed geology including chalk, seams of clay and gravels, some of which support above ground river flow, and others where the river disappears for periods of time into the groundwater below, and only reappearing when groundwater levels are sufficiently high. Whilst the Ems is not subject to tidal rises due to flood protection flaps at the mouth of the river, high tides still influence the ability of the river to flow out into the harbour. It is also unclear how and if the Ems retains its water, with underground flows, seasonal fluctuations and a suggestion of freshwater springs emerging in the harbour, there are many variables.

In common with many chalk streams the Ems is under immense pressure from water abstraction, human modification and pollution, development and climate change.

In recent decades the impact of abstraction for drinking water, exacerbated by historic physical channel modification, has limited the ability of the main river Ems and its tributaries to thrive. The perennial head of the river, below which flow is continuous throughout the year, is gradually being pushed further downstream over time as abstraction rates respond to water demand. The naturally ephemeral (winterbourne) headwater reaches are becoming longer in length and drier for longer periods of time. Only relatively short reaches of the perennial river show glimpses of keystone species of plant, invertebrate and fish species (among others) that the river can support. Habitats and species indicative of regularly flowing winterbourne reaches are becoming harder to find, with the ingress of more terrestrial flora and fauna, indicating these upper reaches are becoming drier for longer.

In recognition of the impact of abstraction on the lowest times of flow in the Ems, an augmentation scheme and associated (EA permitted) license is in place to provide additional water. The location and operation of the augmentation has been problematic, with flow being lost to groundwater, and also on occasion failing to operate, causing devastating impacts for Ems ecology. Portsmouth Water are currently investigating where to place the augmentation point to ensure water stays in the river, and the complexities of underlying geology, groundwater levels and abstraction are still being understood. This subject is covered in greater detail later in this report.

What is clear is that if a ‘Sustainable Abstraction’ level can be achieved then augmentation would not be needed.

Building a science-based approach to better understanding the Ems catchment as a whole, from its source to the sea, is key to its future protection. Recognising how the river has changed, and why, is important if we are to identify a workable Ems Restoration Plan to secure its sustainable, resilient future.

4. Historic Evidence

This report largely focuses on quantitative data, however due to gaps in the historic data record it is important to consider and incorporate other qualitative information such as oral histories, maps and documents, as these may capture a snapshot of the past which may otherwise be missed. In the context of the Ems it may also be possible to get a greater sense of water flow in the past.

As part of this assessment, we used responses from our River Ems Community Questionnaire and other local knowledge and documents.

There are also a range of other tools which can be utilised to give a glimpse of the past, some of which are considered in this section.

4.1 Historic Data – importance and limitations.

Often the main sources of this supporting historic information are local testimonies and historic records and manuscripts. Often this information is difficult to find, not least because it is housed in many locations and often in paper form. Some data are available via digital archives; however coverage can be patchy. Regardless looking into the past is of vital importance.

4.2 Shifting Baseline Syndrome

A great body of evidence shows a decline and degradation in biodiversity and habitats over the last 100 years. This means that each generation starts on at a lower level of biodiversity and ecological health than their parents. This is then accepted as 'normal', lowering expectations and failing to appreciate the full loss, and ultimate potential, of nature.

For example, many people note that numbers of moths gathering around lights at night, or insects squished on windscreens have reduced dramatically in their lifetime – the next generation will start in a diminished state of biodiversity and may not notice this reduction. This is often referred to as 'Shifting Baselines Syndrome' and is recognised as a major issue contributing our biodiversity crisis. It is therefore of utmost importance that we understand past conditions to inform future targets and plans.

4.3 Species Recording

Records of local species are often patchy in coverage, represented by one off surveys, with fewer historic records, and less representative of some species groups. This is partly because some species groups are more difficult to identify (and / or less charismatic) and need in-depth knowledge so are seldom recorded. Also some sites, such as designated wildlife sites, are subject to more focus and recording than others. Whilst the situation is improving through greater recording effort, and better, bigger species databases, it is often difficult to draw conclusions on trends over time without more information. Historic species records can however provide a snapshot of the past, and help us to envisage past species diversity, presence and abundance.

A full assessment of species data can be found in section 8. Looking at these records over time, there is a clear increase in species records from the early 2000s. Conversely, we know that globally species are in decline, and that a number of species have been lost from the Ems landscape. This is difficult to extrapolate from available species data.

There are however a number of sources which provide clues and indications of the water landscape of the past.

4.4 Ems Historic River Flow Data

In terms of the Ems, we know that water levels are greatly affected by seasonal rainfall and drought. However, understanding trends in flow records over time is difficult here. River gauging, which provides regular water level data, was instated in the late 1960's after abstraction for drinking water had commenced. This means there is a lack of information about Ems water levels without abstraction. In addition, there is only one river gauge in constant operation (situated at Westbourne) in the middle section of the waterbody area, which does not account for the upper reaches. This information is looked at in more detail, including abstraction and gauging, in section 10 of this report. There was formerly a gauge further upstream at Walderton, which was installed in 1966 but abandoned in 1984 as there was mostly zero flow.

4.5 Historic Flooding

The Ems has also been subject to a number of large flood events all focused between December and March. Whilst there were some significant events in the first half of the 20th Century (in 1928, 1937, 1960), since the mid-1990s there has been an increase in the number and scale of events with flooding in 1994, 1995, 2000, 2003, 2012, 2014 and 2020. The year 2000 flooding broke records of flooding and river flow across the Ems and wider Sussex.

4.6 Historic Landscape Mapping

A wealth of maps both digital and paper, historic and current, can be utilised to understand historic land use and character. Regarding the Ems these can help to gain insight into historic water use, management and abundance.

4.7 LiDAR

Use of LiDAR (Light Detecting and Ranging) has provided another tool in helping to identify historic land features. Using remote scanning technology LiDAR provides a detailed ground surface map, showing undulations and features that may otherwise be overlooked.

One water focused, historic and local land use where LiDAR can provide insight is 'water meadows'. They are suggested to have been used extensively across chalkland valleys since post medieval times, becoming most popular in the mid to late 1800s. Water meadows utilised stream flow to flood river side land utilising a series of carrier ditches which run through the field and draining back into the river network at the lowest point. Managed through a series of sluices and other small control structures, this approach was called ‘drowning’ or ‘floating’, and allowed an earlier crop of grass, and better quality hay.

With regard to water flow, it was submitted that it should flow ‘on at a trot, off at a gallop’, and belies a landscape with sufficient water to utilise these approaches. Falling out of use in the 1900s, in many places the river network has now been changed or lowered, meaning they are no longer linked to the river. In other locations these wet meadows were later converted to watercress beds, which utilised existing sluices to keep water flowing. The majority of water meadows have been ploughed or developed however.

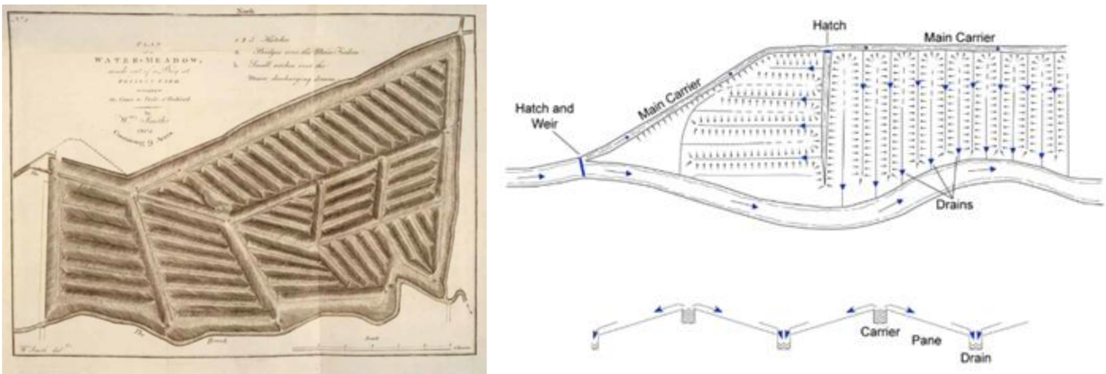
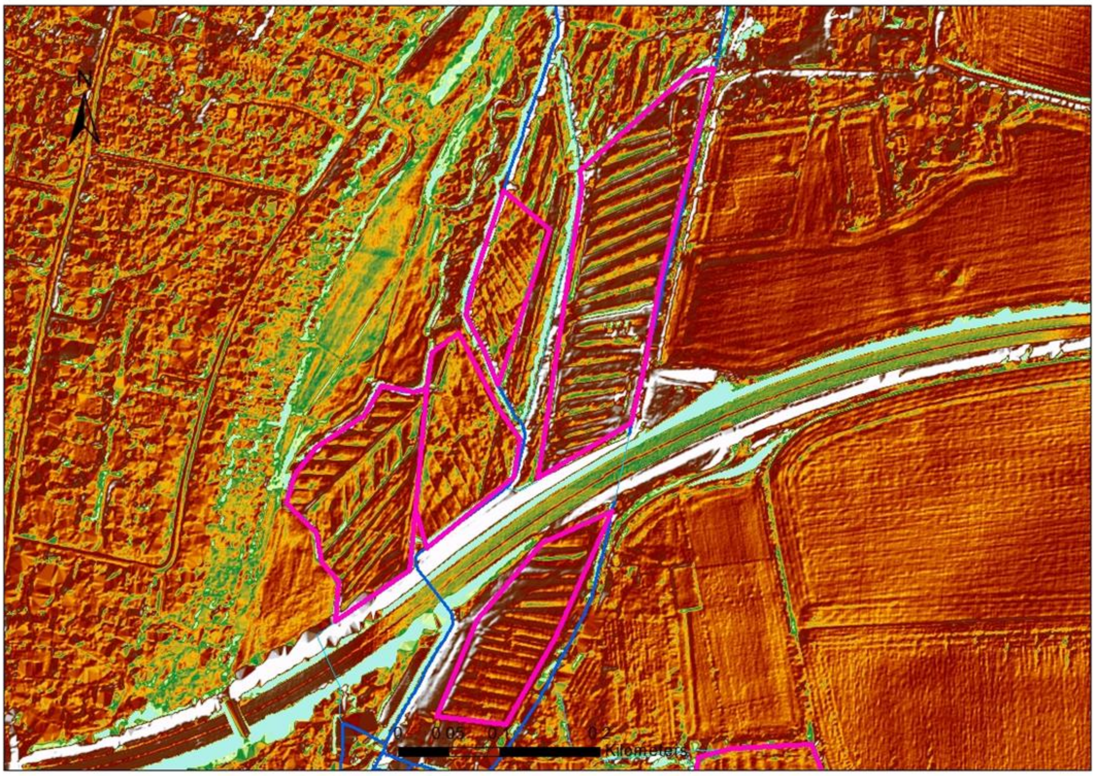


Figure 4. Water meadow designs. (English Heritage / Williamson and Cook ,2007)

LiDAR imagery suggests that there are a number of water meadows and / or watercress beds dispersed along the Ems, up to Westbourne, with further potential for sites as far north as Walderton. These need further verification to ensure they fit with other evidence.

In terms of meadow restoration, if a site was once a meadow it has greater potential than an area under different landuse. With regard to water meadows, management approaches in environmental conservation lean more to using natural processes to drive enhancement, and returning sluices and boards may not align with this and meet the criteria for related permits and license that would be needed. In some places restoration is undertaken to provide an example of historic land use (and using related control structures).

These sites may indicate where wet meadows could be encouraged, with grazing and management for species rich grasslands, and additional wet features such as scrapes or ponds could be located.



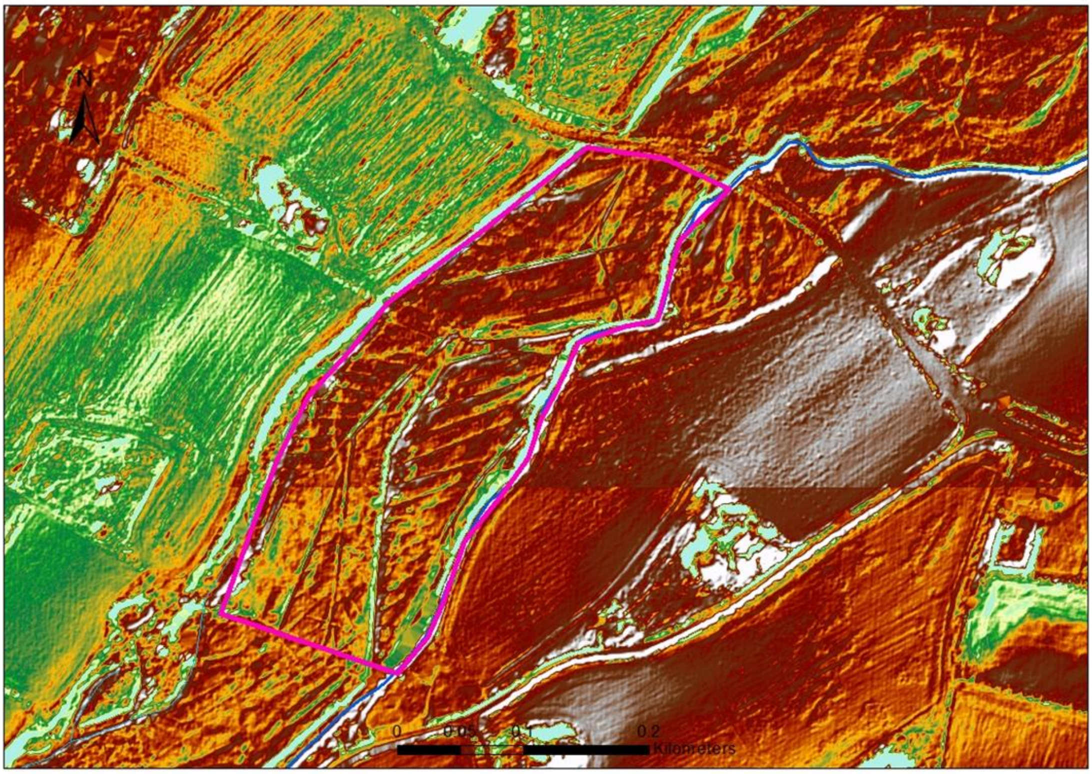


Figure 5. LiDAR highlighting potential wet meadows at Lumley (top) and similar features at Broadwash Bridge (bottom), where watercress beds are also highlighted on historic maps.

4.8 Tithe Maps

In the 1840s there was a concerted mapping effort in UK to fulfil the Tithe Commutation Act of 1836, producing detailed 'Tithe maps'. These maps were also accompanied by apportionment information pertaining to who owned or rented each land parcel, its land use and other relevant information. This provides a wealth of data and provides a snapshot of the past.

An assessment of the tithe maps and data for the parishes of Stoughton and Westbourne highlight a number of areas with references to water. There is a greater number of wet features recorded in the more southerly Westbourne map, with areas of marsh, ponds, and osier beds recorded. One 'wet meadow' is also listed, however characteristic ridge features are no longer distinct on the LiDAR imagery.

Further detailed assessment of these tithe maps could help to identify lost ponds and other features for future restoration targets.

4.9 Written Evidence

Historic accounts and records also hint at a range of species and habitats which may once have been present.

One notable mention is of 'Otter hole' – a pool situated just below Broadwash Bridge. It is unclear whether this was because it was home to otter, or for some other reason lost to history, however other mentions of the presence of otter locally have been noted in historic records. Rudkin (1984) also highlights Ell Bridge, and that this could once have been Eel bridge – an idea which was backed up by locals who noted good eel populations in this area.

A pool on the river above Broadwash bridge, known as Sheepwash was used for annual sheep wash before shearing in June each year – suggesting sufficient flow to achieve this.

Reger (1967) suggests that in the mid-1700s Emsworth was an important centre of flour milling industry. The Ems supported a number of mills over its history, some of which are still intact, while others have been lost, with only remnants of related ponds or in-river structures now present.

Rudkin (1984) states that the most northerly mill on the River Ems was at Lordington Mill (now a private home), and upstream of here is a characteristic mill pond which supports this. This has some significance in terms of water provision – a mill would need plentiful supply of water, and it is unlikely that current flows would support its operation. This reach is currently ephemeral (only flowing when water levels are high) and could support evidence of historic perennial flow further up to at least this point.

There are further remnants of weirs and other structures downstream have different significance – some were likely the sites of historic mills, but also structures relating to fisheries, and for supply of water to other landscape and built features.

A further glimpse of Ems water flow pre-abstraction is provided by a sale notice for Lumley Mill from 1821. This states that Lumley Mill "*A trade of considerable magnitude has been conducted on this site for nearly a century. It is a stream mill of uncommon and almost unceasing power*" (Yoward, 2007).

An increase in access to cheaper corn markets led to a loss of the majority of mills on the Ems, with some being converted to private dwellings and others being destroyed or lost.

Mee (1913) and Rudkin (1984) also talk about the water meadows and watercress beds that were once a key part of the landscape – corroborating the LiDAR data.

Whilst many of these activities and land use types need water to operate, there are also historic reports of low flow events, when the channel has dried out. Rudkin (1984) cites local memories of the channel drying out down to Aldemoor (Lords fishpond), which seemed exceptional at the time, however the channel now frequently runs dry further downstream than this point. Indeed, the current augmentation point is downstream of here. Mee (1913) cites an historic record of the tenant at Westbourne Mill in 1663 as having their rent reduced to account for loss of revenue as the mill was not able to operate for over a month. This is attributed by Rudkin to a lack of flow, however this is not implicit in the record.

Below Deepsprings and before the Ems reaches Westbourne it makes a sharp westerly turn, flowing through a canal before going under River Street, and into Westbourne Mill pond. The angle of flow and straight channel are clearly man made, and it is surmised by Mee, Rudkin and locals that the original course of the Ems may once have continued south, flowing down the course of New Road (formerly Water Lane), and feeding back into the Ems further downstream. The reason for rerouting of the channel could be to provide greater flow for Westbourne Mill, however further investigation is needed.

There is also evidence of other moves and changes to the river channel. The lower section of the Ems between Westbourne and Emsworth is heavily modified, with man-made channels and water control structures for flooding, and remnants of its historic past. In other locations further upstream the channel has been straightened, meanders have moved or been cut off, and in some places the river rerouted.

Accounts highlight that water was part of this working landscape. Watercress beds, wet meadows and ditches all suggest a history of water management and reliance. Locals utilised flow to power and feed farming and food production.

4.10 Local Testimonies (2023)

As part of our development of the Ems plan, we conducted a community questionnaire. This sought local knowledge about the Ems and its landscape, and asked a range of questions to uncover historic views of the Ems. We received over 207 responses from a wide range of local people and stakeholders and including members of 35 different local interest groups.

We asked if respondents had noticed changes in the river Ems over time, with space provided for comments.

A total of 81% respondents (166) noted a decline in the health of the river over time. Of these responses 86% (143) mentioned a reduction in water quantity and flow. Of these 11 mentioned living in the catchment for over 20 years; with 3 having lived there for 60 years or more.

There were also 50 different responses relating to a loss in wildlife, with Water vole and Kingfisher frequently mentioned, along with a greater abundance of fish including Sea trout in the past.

See Appendix 1 for comments from our questionnaire. A related report is available from the WSRT website.

Anecdotal evidence gathered by Holmes (2007) paints a historic picture going back decades of fish abundance and distribution further up the catchment. He mentions local people fishing in Mitchamer pond near Stoughton, and Lordington Pond (which has been listed as fishing ponds), albeit with a possible damming structure in place to hold water back. The lack of flow leading to drying out of the river in the upper catchment is mentioned as having a negative impact for fish and aquatic species. We also talked at length with locals, landowners and others about the history of the Ems as part of this plan, with notable mentions of otter in the 1970s, abundant trout and water vole.

5. Geology and Soils

According to the British Geological Survey, the main underlying geology of the Ems is from the chalk group, and includes a variety of different sub-divisions (see figure 6). Towards the south west of the catchment the chalk is overlayed by clays from the Lambeth Group and London Clay group which comprise silty clay and sand.

Chalk geology (and hydrogeology) is influenced by the presence of Karst features – deep fissures which can increase flow in both directions between surface and groundwater under different conditions.

In terms of superficial deposits (i.e. soils) includes chalk rendzina style shallow soils, with alluvium in the valley bottom and river terrace deposits.

A full table of underlying geology, superficial deposits along with detailed descriptions can be found in the Appendix 2 & 3.

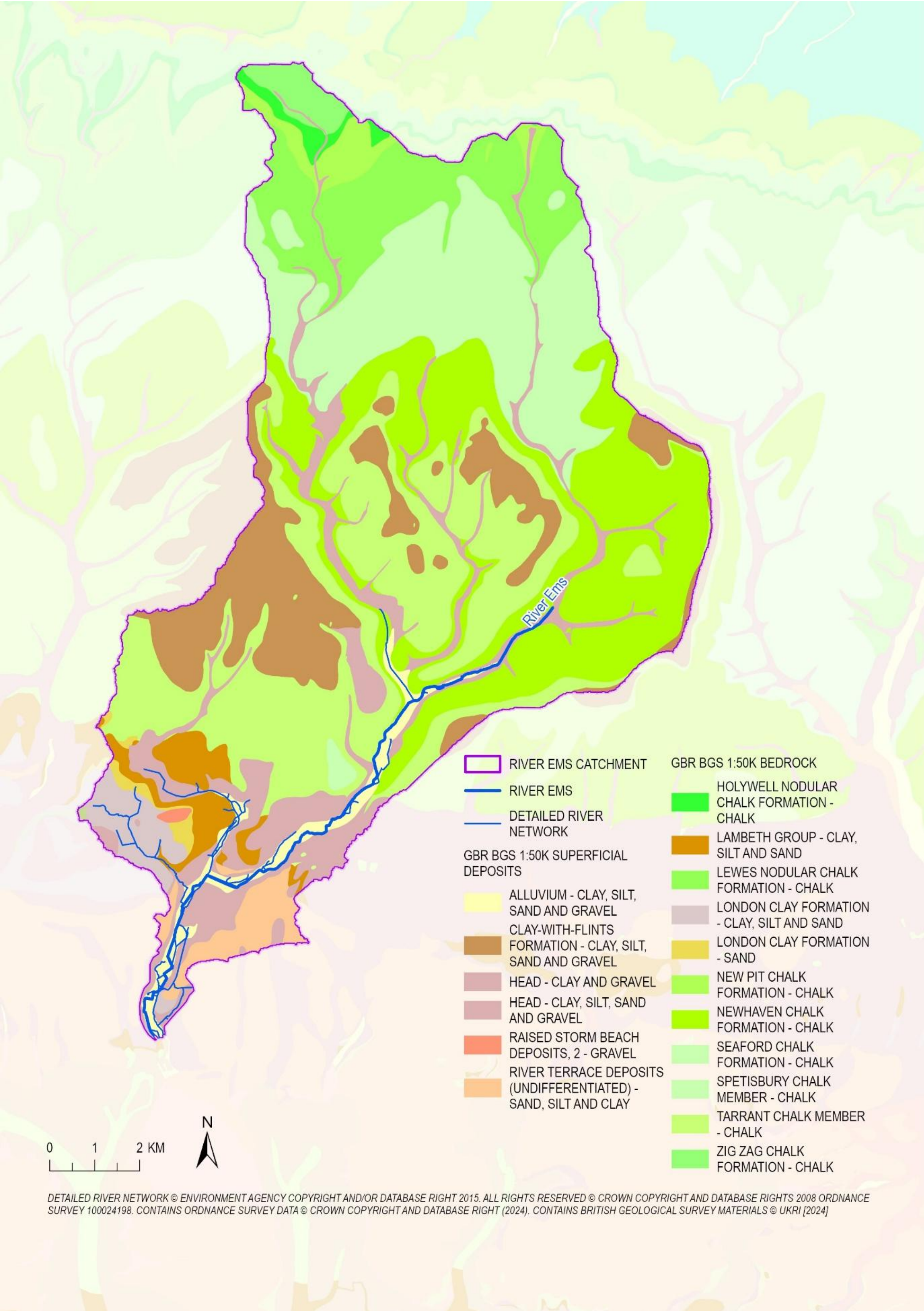


Figure 6. Bedrock and superficial deposits in the Ems catchment (British Geological Survey).

The ground surface soils are representative of their parent geology. In some areas soil distribution and type has been influenced by erosion, deposition and local land use. The coastal plain would once have been frequently inundated by sea water, and shows a long geological history of these processes in the underlying soils.

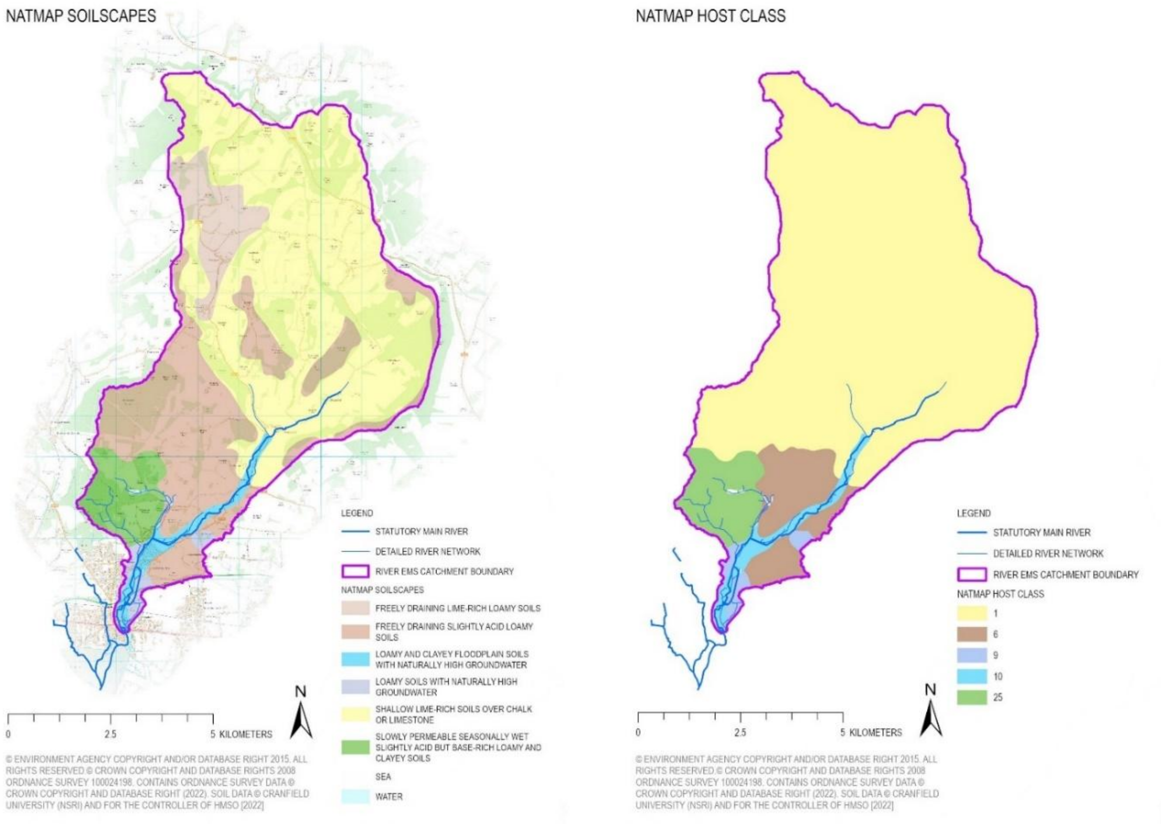


Figure 7. River Ems Map showing soils (left) and Hydrology of Soil Type

6. Land Use

In this section we provide an overview of available data from Natural England, CaBA and others.

This report takes a wider waterbody view of the Ems, however more detailed site survey reports would provide a more detailed picture of plant communities and land management at the site scale.

Some of these datasets are based on modelling and may not be 100% accurate – they do however provide a good overview of landscape character, and highlight opportunities for enhancement or further investigation.

The Ems catchment land cover is predominantly arable, improved grassland, and deciduous woodland. There are small patches of plantation (conifer) woodland and tiny freshwater areas. There is a low level of urbanisation along the river with Emsworth being the main settlement on the coast at the river mouth, and Westbourne on the southern section of the Ems where it divides into two sections.

6.1 Landcover Map 2020 (CEH)

Produced by the Centre for Ecology and Hydrology (CEH), the Land Cover 2020 dataset uses derived data from satellite images and digital cartography to define land use type, and can provide a high-level overview of how land is used and managed in the Ems catchment. This data suggests that there are three main landuse types – arable (37%), followed by grassland pasture (Improved grassland) (30%) and Deciduous woodland (27%).

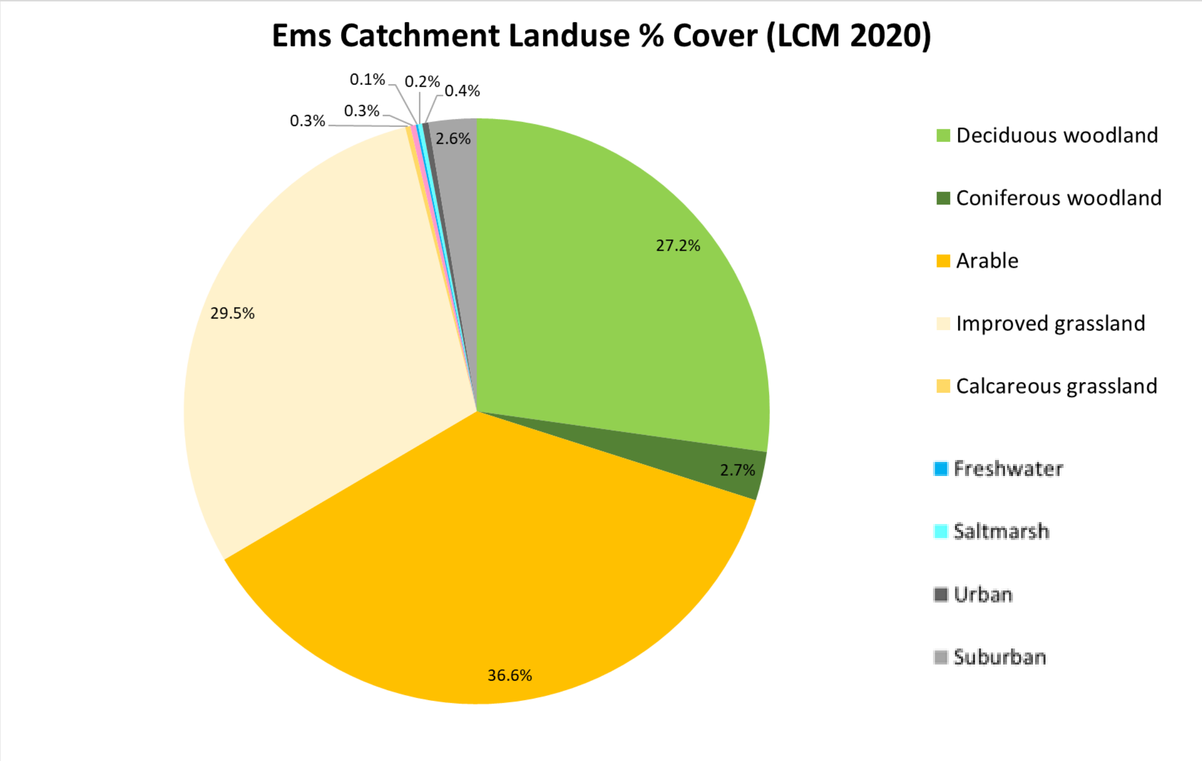


Figure 8. Ems Catchment Land Use % Cover (Land Cover Map 2020, CEH).

The catchment has a significant proportion of Deciduous Woodland (27%), with nearly 1463 hectares made up of large tracts of woodland, smaller copses and dense hedges. This is much higher than the national average of around 11%.

6.2 Environmental Stewardship Schemes

Within the Ems catchment a large amount of the land is under Countryside Stewardship or Environmental Stewardship Schemes which indicates that the land has biodiversity and habitat value, and farm payments are made to ensure the ongoing management protects and promotes this.

There are three areas within the catchment that are at Entry Level Plus Higher-Level stewardship. One falls around the Racton area just northeast of Watersmeet, the second is at Lordington and the third is at Forestside (north of Stansted Park).

There is a large area of land in the centre of the Ems catchment in Higher Tier Countryside Stewardship. There is also a small area in Aldsworth east of Brickkiln ponds.

There are four areas within the Ems catchments made up of Middle Tier Countryside Stewardship and they are around Aldsworth pond, Walderton, North Marden and north of Uppark.

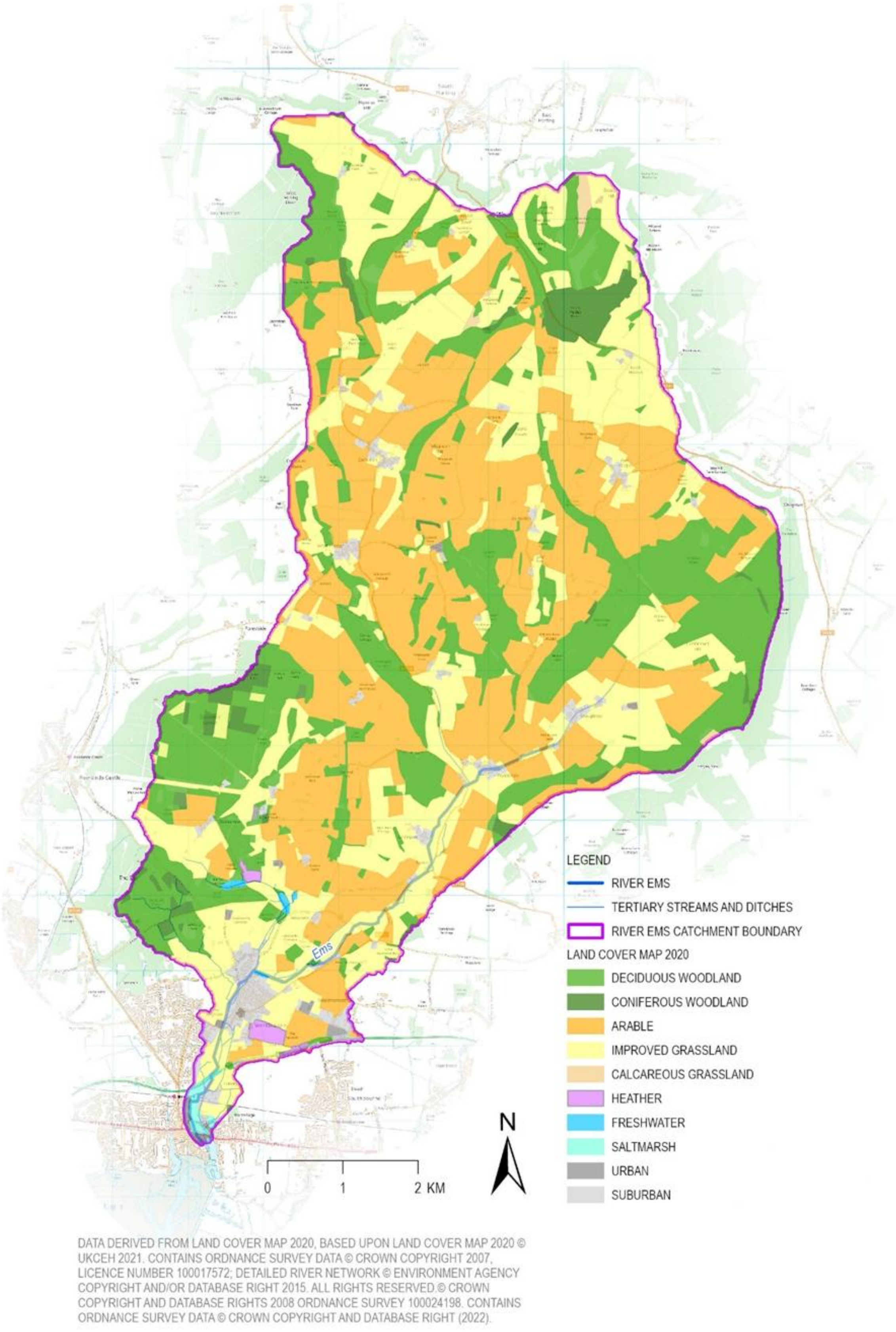


Figure 9. Ems Waterbody Landcover data (CEH 2020).

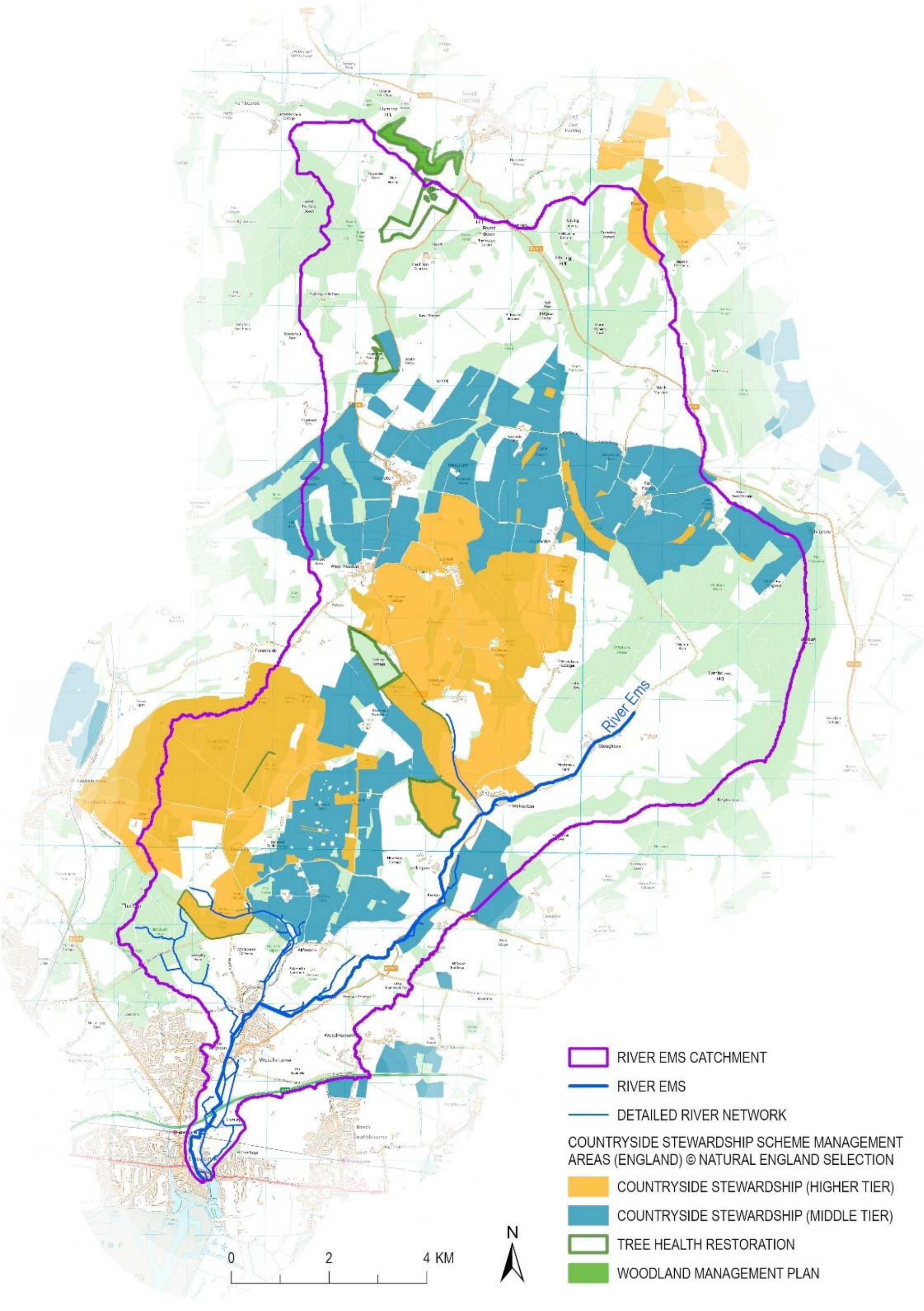


Figure 10. Ems Waterbody Countryside Stewardship Agreements (Natural England).

7. Habitats

Sitting underneath the landcover and stewardship are the habitats themselves. The following section will describe the habitats found, their distribution and size.

An outline of protected sites can be found in Appendix 4.

7.1 Designated Sites

Within the River Ems catchment there are a number of areas of land designated as protected sites, ranging from internationally recognised habitats to locally important sites and areas. The whole of the Ems system, being fed by springs from the chalk, is a Biodiversity Action Plan (BAP) priority habitat; this, most importantly, includes not only the perennial sections, but the intermittently-flowing headwaters too.

7.1.1 Statutory Sites

Statutory sites are areas of nature conservation importance, in recognition of its wildlife or geological significance. These sites are protected under a range of legislation. Some sites have more than one designation.

7.1.2 Internationally Important (SAC, SPA, Ramsar)

There is only one Special Areas of Conservation (SAC) site within the waterbody area which is internationally protected, Kingley Vale, which is also a National Nature Reserve (NNR) and Site of Special Scientific Interest (SSSI), only part of which is within the Ems boundary (43ha).

There are no Special Protection Areas (SPA) or Ramsar sites within the waterbody area, however just below the Ems river mouth lies Chichester Harbour (SPA, RAMSAR, SAC, SSSI), which is influenced by flow from feeder streams such as the Ems.

High nitrates and other inputs from these streams has an impact on the condition of this important site, which has statutory protection via legislation including EC Habitats Directive (SAC), European Birds Directive (1979) (SPA), The Ramsar Convention (1971) (relating to wetland sites) and as such these areas are focus of work to reduce harmful inputs into the harbour related to land and water management.

7.1.3 Nationally Important (NNR, SSSI)

Both NNRs and SSSIs are designated under the Wildlife and Countryside Act (1981). There are three SSSIs in the area, the most significant being Harting Down (177ha), with further remnants at Kingley Vale (43ha) and Pads Wood (22ha). Part of Kingley Vale is also an NNR with a very small area represented in the Ems (5ha).

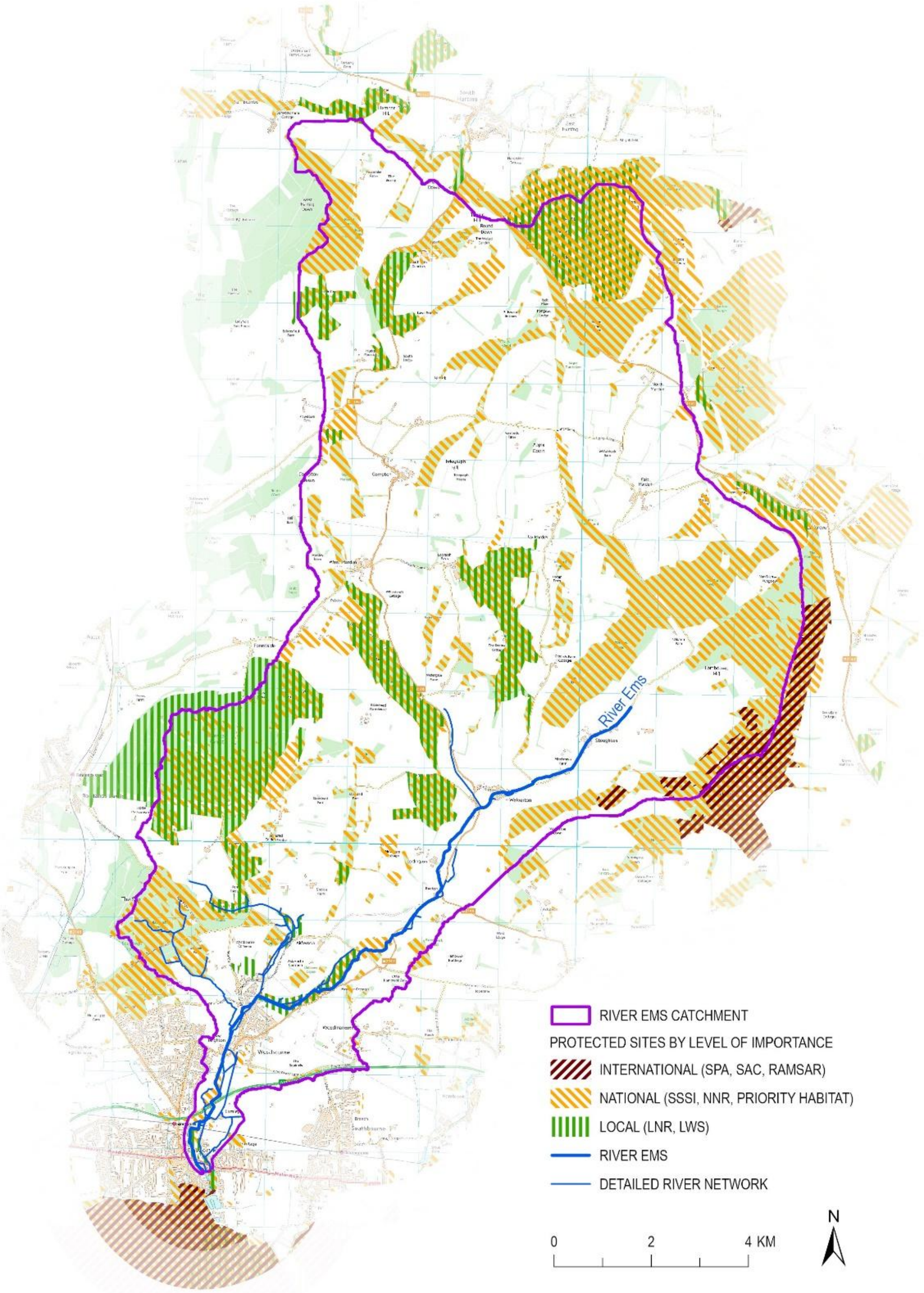


Figure 11. River Ems waterbody map of protected sites, by level of designation.

7.2 Non-Statutory (locally important)

Local Wildlife Sites (formerly Sites of Nature Conservation Importance SNCI) are non-statutory designations which are identified at a county level. These sites represent places which have been identified as having high nature / geological value.

Despite LWS not having statutory protection, they should be taken into consideration by local authorities when they are determining planning and development policies/applications. LWS tend to be selected because of a particular wildlife habitat or if they support a scarce or rare species outside their natural habitats or range. They can be natural sites or man-made.

There are 16 LWS in the Ems waterbody area, including a large number of woodland sites, including ancient and wet woodland, and other sites focused on the river itself, meadows and ponds (including Brickkiln, Aldsworth, Peter's and Slipper Mill ponds).

There are two Local Nature Reserves in the catchment with one in the north, between Harting and North Marden, and the other at Brooks Meadow to the south, where the divided river Ems runs through at this point.

7.3 Priority Habitats Inventory (NERC)

Priority Habitats are those that are identified in the National Environment and Rural Communities Act (NERC Act) section 41 - habitats of principal importance. Produced by Natural England this replaces the previous 'Biodiversity Action Plan' habitat inventories.

There are a number of priority habitats identified within the Ems catchment, including Deciduous woodland, good quality semi-improved grassland, Saline Lagoons, Mudflats, and Intertidal Substrate Foreshore. There is also a significant amount of ancient woodland in the catchment with some parts along the river.

The most prevalent 'Priority Habitat' in the Ems is Deciduous Woodland, which is largely situated on the steeper slopes to the north, and largely positioned on chalk. These woodlands provide a number of special services to the catchment including slowing rainfall to allow greater ingress into the aquifer (and subsequent groundwater recharge), and high biodiversity value – particularly where management is active.

Across the catchment, mainly on the boundary, there are areas ranging in size from small pockets to large fields of good quality Semi-Improved Grassland. There is only one on the river Ems itself and that is at Racton near Deepsprings. The total area of this habitat in the catchments is just over 111.5 hectares.

There are about 25 other sites across the catchment that have 'No Main Habitat but Additional Habitats Present' and which make up a significant area of just under 68 hectares. A significant site thus defined is just north of Broadwash Bridge, adjacent to an area of Coastal and Flood Grazing Marsh and immediately next to the River Ems channel. There are two other such sites near to the Watersmeet canal section of the river, and one in the higher catchment at Mitchmere Farm where the river runs through the grounds.

To the north of the catchment are four areas, and one to the east, that have been classified as Lowland Calcareous Grassland but these are not in close proximity to the river itself.

There are five small areas of Coastal and Floodplain Grazing Marsh adjacent to the river Ems, one at Brook Meadows, one at Mill Meadow Farm, one at the Westbourne watercress beds and the final one from Racton to Broadwash Bridge. There is another marked on the Aldsworth Arm between Commonside and Aldsworth Road. In total these make up approximately 20 hectares.

The remaining habitats make up small areas: two small pockets of nearly 3 hectares of Lowland Meadows at Stanstead House, and two sites of Traditional Orchards, one each at Woodmancote and Stansted House, making up almost 3.5 hectares.

There is one area of Saline Lagoon of almost 0.9 hectares, at Peter's Pond, downstream near to the river mouth just north of the A259. Peter's Pond receives much of the upstream flow from the Ems, and locals suggest is damaged by trash and other pollution from upstream.

The ponds of Brickkiln and Aldsworth are marked on the map but not on the Priority Habitats Index or the Protected sites list. However, they are significant bodies of freshwater making up the Aldsworth arm of the Ems and have many notable species of flora and fauna associated with them.

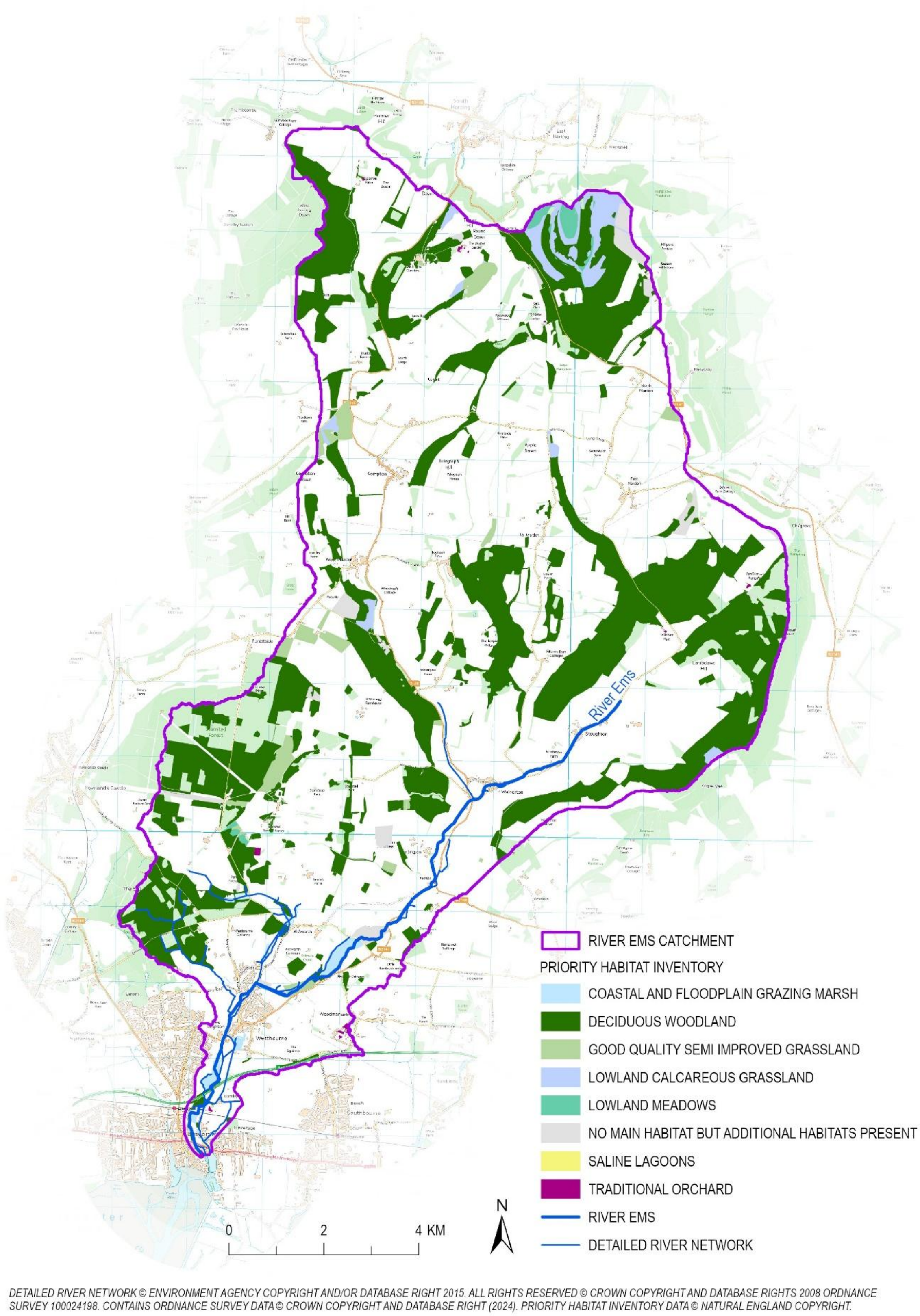


Figure 12. Ems Waterbody Map Priority Habitats Inventory (Natural England).

8. Species

Chalk streams are host to specific riparian and aquatic species as well as a diverse range of species, but water availability is one of the main significant factors influencing their presence or absence.

The Ems has had a history of supporting a rich diversity of flora and fauna with records of large fish numbers presence through both the lower and mid Ems sections (Holmes 2007). While the upper catchment has been prone to periods of prolonged dryness, there is anecdotal evidence that suggests that this area still supported aquatic and riparian species up until the mid-1960's (Holmes 2007)). However this is no longer the case.

A desk study was undertaken to assess species presence and abundance, including rare and protected species. Data were sought from the Sussex Biodiversity Record Centre (SxBRC), local wildlife groups, and both recent and historic reports on the Ems catchment, with additional data from EA surveys, and our recent Ems walkover survey. This resulted in records of more than 2500 different species of all groups in the Ems catchment area, and more than 30,000 individual records. There was however a lack of up to date, comprehensive, consistent and comparable data sets. The species can be listed, the number of protected and notable species summarised but any trends or comparison over time cannot be reliably represented.

All species mentioned in this section are protected or considered rare or locally / nationally notable.

8.1 Fish

The River Ems is designated 'salmonoid' (South East RBMP, Annex D from 2009) as it supports Atlantic Salmon *(Salmo salar)* and Brown/Sea Trout (*Salmo trutta)*, both Economically Significant Species (Freshwater Fish Waters), and species of principal importance for nature conservation in England under the Natural Environment & Rural Communities (NERC) Act 2006. European eels have also been recorded, which are listed as Critically Endangered. All three species have been recorded on the Ems.

The Environment Agency carried out sporadic fish sampling on the Ems with the most recent survey undertaken in 2021, with all monitoring sites located in the bottom 2km of the river, and none in the upstream reaches. Surveys show a total of 7 species - Brown/sea trout, European Eel, Bullhead, 3-spined stickleback, 9-spined stickleback, Roach and Pike. Atkins (2022) noted that Mill Meadows offered good quality habitat for brown trout abundance, condition, and diversity of age groups, comparable with some of the best quality chalk streams elsewhere in the Solent & South Downs Area.

John Barker, local freshwater biologist has reported the following: 9-spined stickleback downstream of Watersmeet and Sea Trout have been recorded as far up as Watersmeet in Westbourne; Sea Trout smolts (young trout 1 to 3 years old) were recorded at Mill Meadows farm, Westbourne in 2014 and it is understood that Roach have disappeared from the river though there is still a viable pike population.

In 2004 as part of the Sussex Chalk Stream Ecological Assessment EA conducted fish and redd (sea / brown trout spawning sites) survey. They recorded four species on the Ems including brown trout, European eel, three-spined stickleback and bullhead. A dead Sea trout and associated redds were also recorded downstream of Lumley. They state further:

"*The Ems supports a resident brown trout population as far upstream as Westbourne but overall diversity of fish is low. Migratory sea trout have been recorded, but only as far as Lumley Mill which may prevent them reaching suitable spawning habitat upstream. Sea trout spawning has only been recorded below the Lumley obstruction. The Ems is important for eel and they can be found as far upstream as Walderton in the winterbourne reach. Eel dominate the fish community at Westbourne and Lumley Mill. The absence of minnow on the Ems is notable, as they are a species usually found in winterbourne and perennial reaches. The absence of all fish above Westbourne except the eel is a probable indication of the detrimental impacts of the upper catchment abstractions and obstructions along the length of the river*"

The fish data provided by the SxBRC were not extensive and there were records of 8 species with 3 having protected or notable status (European Eel (*Anguilla anguilla*), Brown Trout (*Salmo trutta)* and Bullhead (*Cottus gobio*)) at Brook Meadows and the Lumley Stream, both in the lower catchment.

At Deepsprings 9-spined stickleback (*Pungitius pungitius*) were recorded, which are typically found in the vegetated margins of streams.

When examining the fish data from the EA , it would appear that the numbers and species of fish are declining but the low data point numbers make extrapolation of results unreliable. A comprehensive programme of monitoring would be valuable to get an understanding of the fish population, if there is a decline and how that is reflected in the different species. Increasing up and downstream movement, along with an increase in water flow will be critical to supporting these species and giving them space to adapt to climate change.

More frequent recording of all fish species is needed to build a comprehensive picture of trends and abundance.

8.2 Invertebrates

8.2.1 Aquatic Invertebrates

River flies, including mayflies, caddis flies, stoneflies, true flies and alder flies, are all important species that indicate the health of a freshwater river system, and which provide a key food source for fish and other species.

Riverfly surveys started in 2023 at 6 locations; Walderton/Stoughton Road Junction, Broadwash Bridge, Racton Dell, Commonside, Mill Meadows Farm and Brook Meadows LNR. Results can be found on The Riverfly Partnership website.

A Sussex chalk stream ecological assessment undertaken by the EA in 2004 focused on a number of streams around Sussex including the Ems and the nearby Lavant. Results from invertebrate surveys on the Ems showed a very good assemblage of aquatic invertebrates, which suggested aligned the Ems more closely to the Meon in Hampshire – a much larger chalk stream – than others in the Sussex survey.

Also of note in this 2004 report was the presence of Blind cave shrimp (*Niphargus aquilex*), which live in groundwater. Their presence indicates a mix between groundwater and surface water and can therefore be an indicator of a groundwater spring. They have more recently been recorded on the Ems by local freshwater biologist John Barker.

The SxBRC has records for the Sussex rare *Agapetus fuscipes* (caddis fly), the nationally scarce *Paraleptophlebia werneri* (mayfly), the nationally scarce and Sussex rare *Holocentropus stagnalis* (caddis fly), *Allotrichia pallicornis* (caddis fly), and the RedList GB post2001 DD, Nat Scarce species *Potamophylax rotundipennis* (caddis fly).

Atkins 2022 reported that the following notable species were identified:

- *Allotrichia pallicornis* – nationally scarce caddisfly (Eaton, 1873) which was recorded in 2001 (2) and 2003 (1)
- *Amphinemura standfussi* - nationally scarce stonefly (Ris, 1902) which was recorded in 2003 (1), 2007 (1) and 2010 (1)
- *Caenis pusilla* – nationally rare mayfly (Navas, 1913) which was recorded in 2008 (1)
- *Paraleptophlebia werneri* (Ulmer, 1919) - nationally scarce mayfly which was recorded in 2010 (1)
- *Rhyacophila septentrionis* (*fasciata*) (Hagan, 1859) – nationally notable caddis fly recorded in 2009 (1)
- *Oxycera morrisii* (Curtis, 1833) – nationally scarce true fly which was recorded in 2003 (1) and 2004 (1)
- *Oxycera pygmaea* (nigripes) (Fallen, 1817) – nationally scarce true fly which was recorded in 2003 (1)
- *Vanoyia tenuicornis* (Macquart, 1834) – nationally scarce true fly which was recorded in 2003 (1) and 2004 (1)

Further Invertebrate samples have also been collected locally by Friends of the Ems. Atkins (2022) mentions that this includes two stonefly families (*Perlodidae – Isoperla grammatica Nemouridae – Nemoura sp.*) at Broadwash bridge and upstream in ephemeral stretches to Walderton.

Atkins (2022) describes a report on the ecohydrology of the upper and middle River Ems by the Centre for Hydrology and Ecology (CEH) (2013), in which data from the River Habitat Survey (RHS) and macroinvertebrate biomonitoring, built on the work of Holmes (2007). The results showed a clear distinction in ecology between the ephemeral sites in the upper Ems to the perennial sites further downstream. The ephemeral sites tend to fall below the expected biomonitoring values but do present unusual species. The perennial sites, whilst sometimes falling below the expected biomonitoring values, often also exceed them.

Isoperla sp. (stonefly) was also recorded at Walderton and the Aldsworth arm (Brooklyn Cottage) and most recently 2024 at Mill Meadows (single specimen) *Paraleptophlebia werneri* which is important because of its winterbourne characteristics (a specialist insect that relies on the wet-dry habitats of temporary streams, their seasonal predictability enables the chalk winterbournes of south England to host species that need both wet and dry habitats to complete their life cycles – including some of our rarest insects, making Great Britain a global hotspot of temporary stream specialists). This species is still being found in upper winterbourne stretches.

8.2.2 Dragonflies & Damselflies - Odonata

The Ems catchment has good records for dragonflies and damselflies with 21 species identified, 3 of which are notable or protected. The Common Darter (*Sympetrum striolatum*) is a Red Data List species *(Least Concern*), with the Downy Emerald Dragonfly (*Cordulia aenea*) and Small Red-eyed Damselfly (*Erythromma viridulum*) categorised as Sussex Rare species. The other members of this group are the Southern Hawker (*Aeshna cyanea*), Migrant Hawker (*Aeshna mixta*) , Emperor Dragonfly (*Anax imperator*), Hairy Dragonfly (*Brachytron pratense*), Broad-bodied Chaser (*Libellula depressa*), Four-spotted Chaser (*Libellula quadrimaculata*), Black-tailed Skimmer (*Orthetrum cancellatum*), Red-veined Darter (*Sympetrum fonscolombii*), Ruddy Darter (*Sympetrum sanguineum*), Black-tailed Skimmer (*Orthetrum cancellatum*), Banded Demoiselle (*Calopteryx splendens*), Beautiful Demoiselle (*Calopteryx virgo*), Azure Damselfly (*Coenagrion puella*), Common Blue Damselfly (*Enallagma cyathigerum*), Red-eyed Damselfly (*Erythromma najas*), Blue-tailed Damselfly (*Ischnura elegans*), Emerald Damselfly (*Lestes sponsa*), Willow Emerald Damselfly (*Chalcolestes viridis*) and the Large Red Damselfly (*Pyrrhosoma nymphula*). Atkins (2022) lists the Highland Darter, *Sympetrum nigrescens,* (Lucas, 1912) –a red listed dragonfly, which was recorded in 2004, however no additional records of this species were found.

Many of these records are from Aldsworth, and Brickkiln ponds which are significant water bodies that may stay wet the longest when the river flow starts to dwindle. One of the Brickkiln ponds appears to remain wet year-round despite the amount of rainfall and therefore this is an important resource for wildlife.

8.2.3 Other Insects

Of the 1,183 records for insects in the SxBRC data, 175 of these are considered notable as either Sussex Rare, Nationally Rare, or fall under NERC S41, UK BAP priority species, and / or on the Red data list. These insects range from flies, wasps, moths, butterflies, grasshoppers, crickets, bees, beetles, and bugs. Those of particular note are summarised below.

Butterflies – *Lepidoptera*

Chalkhill blue (*Polyommatus coridon)*; Purple emperor (*Apatura iris)*; White-letter Hairstreak (*Satyrium w-album)*; Pearl-bordered fritillary (*Boloria Euphrosyne)*; Duke of Burgundy (*Hamearis Lucina)*; Brown hairstreak (*Thecla betulae)*; Small blue (*Cupido minimus)*; Swallowtail (*Papilio machaon)*; Dingy skipper (*Erynnis tages)*; White admiral (*Limenitis Camilla)*; and Grizzled skipper (*Pyrus malvae)*.

Moths – *Lepidoptera*

Olive crescent (*Trisateles emortualis)*; Clay Fan-foot (*Paracolax tristalis)*; Dark spinach (*Pelurga comitata)*, Knot grass (*Acronicta rumicis*); Beaded chestnut (*Agrochola lychnidis)*, Green-brindled crescent (*Allophyes oxyacanthae)*, Brown-spot pinion (*Agrochola litura*), Dusky brocade (*Apamea remissa)*, Centre-barred sallow (*Atethmia centrago*), Minor shoulder-knot (*Brachylomia viminalis*), Mottled rustic (*Caradrina morpheus)*, Latticed heath (*Chiasmia clathrate)*, The Sallow (*Cirrhia icteritia)*, Striped lychnis (*Shargacucullia lychnitis)*, Small square-spot (*Diarsia rubi)*, Small phoenix (*Ecliptopera silaceata)*, Small emerald (*Hemistola chrysoprasaria)*, Ghost moth (*Hepialus humuli)*, The Rustic (*Hoplodrina blanda)*, Rosy rustic (*Hydraecia micacea)*, Shoulder-striped wainscot (*Leucania comma)*, Rosy minor (*Litoligia literosa)*, Brindled beauty *(Lycia hirtaria)*, The Lackey (*Malacosoma Neustria)*, Dot Moth (*Melanchra persicariae)*, Pretty chalk carpet (*Melanthia procellata)*, Powdered quaker (*Orthosia gracilis)*, Large wainscot *(Rhizedra lutosa)*, Shaded broad-bar (*Scotopteryx chenopodiata)*, Hedge rustic (*Tholera cespitis)*, Blood-vein (*Timandra comae)*, Oak Hook-tip (*Watsonalla binaria)*, Dark-barred Twin-spot carpet (*Xanthorhoe ferrugata)*, and the Shaded fan-foot (*Herminia tarsicrinalis)*.

Beetles - *Coleoptera*

Stag Beetle (*Lucanus cervus)* and Alder leaf beetle (*Agelastica alni)*; *Ceutorhynchus constrictus (*a weevil*)*; Hornet beetle (*Leptura aurulenta); Prionus coriarius (*a longhorn beetle*)*; *Ptenidium turgidum; Microrhagus pygmaeus* (a false click beetle).

Atkins (2022) also found records for:

- *Riolus cupreus* (Muller, 1806) – nationally scarce beetle which was recorded in 2000 (1) and 2009 (1)
- *Riolus subviolaceus* (Muller, 1806) – nationally scarce beetle which was recorded in 2003 (2), 2005 (1), 2006 (1) and 2008 (2)
- *Nebrioporus depressus* (Fabricius, 1775) – near threatened beetle which was recorded in 2008 (1) and 2010 (1)

Bees – *Hymenoptera*

Brown-Banded carder bee (*Bombus humilis)*; Big-headed mining bee (*Andrena bucephala)*; Long-fringed mining bee (*Andrena congruens)*; Small scabious mining bee (*Andrena marginata)*; Plain mini-miner (*Andrena ninutuloides)*; Lobe-spurred furrow bee (*Lasioglossum pauxillum)*; Painted nomad bee (*Nomada fucata)*; Fringe-horned mason bee (*Osmia pilicornis)*; Red-shanked carder bee (*Bombus ruderarius)*; Bryony mining bee (*Andrena florea)*; Grooved sharp-tail bee (*Coelioxys quadridentate)*; Small shiny furrow bee (*Lasioglossum semilucens)*; Long-horned Nomad bee (*Nomada hirtipes)*; and White-footed Furrow bee (*Lasioglossum leucopus)*.

8.2.4 Spiders - *Arachnids*

There are records of 29 different species of spider across the catchment and of these 2 are nationally scarce, the Purseweb spider (*Atypus affinis)* and Triangle Spider (*Hyptiotes* *paradoxus)*, and 2 are nationally scarce and Sussex rare, *Episinus truncates* and *Marpissa muscosa*.

8.2.5 Molluscs – *Malacology*

The SxBRC holds records of 70 different species of Molluscs in the Ems catchment, with 11 notable or falling under a protective status. These range from Sussex Scarce and / or Rare species (6), to Red List, NERCS41, UK BAP Priority species - The Shining Ram's-horn (*Segmentina nitida*) in Aldsworth pond.

Atkins (2022) notes the presence of (*Gyraulus laevis)* – nationally scarce mollusc (Alder, 1838) which was recorded in 2004 (1).

8.2.6 Other invertebrates

At Slipper Mill pond, at the mouth of the Ems, there are 2 notable Estuarine species – the Tentacled Lagoon Worm (*Alkmaria romijni)* and Starlet Sea Anemone (*Nematostella vectensis*).

8.3 Mammals

The river Ems catchment has records for 37 mammal species, 21 of which are protected or notable. This includes 15 species of bats, which as a group are UK BAP Priority species, and which fall under the NERC S41 protections.

Records for bats covered the whole catchment and length of the river itself as the area offers good tree coverage for roosting and foraging, waterways for feeding and good thick hedgerows with margins for travelling. There are bat records from Stoughton to Emsworth and much data has been gathered via surveys at Lumley, Brickkiln ponds, Brook Meadow, Foxbury Lane, Cemetery Lane, and the Hermitage Area to the south.

The SxBRC does not provide Otter data (due to sensitivities with revealing their locations), but Holmes (2007) researched their presence on the Ems and through Graham Roberts of the Otter and Rivers Trust found that all surveys for otters between 1984 – 2002 had proved negative. However, recent anecdotal evidence from 2021 at Old Rectory Close in Westbourne, and footprints found at Watersmeet in 2022 would support the fact that there could be otters passing through the catchment even if not actually resident. As previously described their presence may also have been indicated by the so called ‘Otter hole’ situated near to Broadwash Bridge.

There are records for the Red Data Listed Endangered European Water vole (*Arvicola amphibius*), the fastest declining mammal in England, on the Ems with these mainly in the lower reaches around Brook Meadow and Watersmeet and go back 20 years. The lack of permanent water further up the catchment may limit their range and ability to disperse across the area, isolating colonies and making them vulnerable to environmental change and extinction. There are no records at Racton or Aldsworth Pond and surveys here to gain more data would be valuable.

There are records for the Hazel Dormouse (*Muscardinus avellanarius)*, a NERC S41 and UK BAP Priority species, in the Ems catchment as the high percentage of tree cover, deciduous woodlands and good quality linking hedgerows offers excellent habitat. A comprehensive survey of the catchment would be valuable as they are nationally under recorded and vulnerable to habitat destruction.

The Harvest mouse (*Micromys minutus*), Brown Hare (*Lepus europaeus)*, and European Hedgehog (*Erinaceus europaeus)*, all NERC S41, UK BAP Priority species have records in the Ems catchment.

The Harvest mouse data shows its presence around the Brickkiln and Aldsworth ponds which are relatively undisturbed.

The European rabbit (*Oryctolagus cuniculu*s), on the IUCN Red Data List as Globally Near Threatened, has records throughout the catchment on arable land. Brown Hare (*Lepus europaeus)* throughout the catchment on and around arable land and margins, and the Hedgehog (*Erinaceus europaeus)* records clustered around Westbourne. Badger (*Meles meles)* records are not shared by the SxBRC but the habitat in the catchment is highly suitable with ancient and deciduous woodland, connected hedges, scrub, and pond areas. Anecdotal evidence and site visits have confirmed their presence.

8.4 Amphibians

There are records for 4 amphibian species in the river Ems catchment, all protected by the Wildlife and Countryside Act, Schedule 5, 1981. The most notable is the UK BAP priority species the Great Crested Newt with 2 records at West Marden 2006, and Compton 2015, but not on the Ems itself.

The Common Toad (*Bufo bufo*), also a NERC S41 and UK BAP Priority species, as well as the Common Frog (*Rana temporaria*) and Smooth Newt (*Lissotriton vulgaris*) and Great Crested Newt (*Triturus cristatus*) have been recorded at or near to Brickkiln and Aldsworth ponds, as well as other sites across the catchment. At the junction of Emsworth Common Road and Broad Walk near Brickkiln ponds, there are annual toad crossing patrols when toads are picked up off the road and moved into the safety of the pond. It is reported that the number of toads on these evenings can be in the hundreds.

The high percentage tree cover and flat flood plain meadows make the catchment good amphibian habitat when there is water in the channel, in the ponds and the neighbouring wet meadows. Greater effort to survey for amphibians would help build a better picture, and plan future efforts to increase wet stepping stones for wider dispersal.

8.5 Reptiles

All 4 of the reptile species with records in the catchment are protected NERC S41 and UK BAP Priority species under the Wildlife and Countryside Act 1981. They are Slow-worm (*Anguis fragilis)*, Grass Snake (*Natrix helvetica)* (Sindles Farm), Adder (*Vipera berus)*, and the Common Lizard (*Zootoca vivipara)* (Brickkiln pond). Slow-worm (*Anguis fragilis*), and Common Lizard (*Zootoca vivipara*) were both found on Brook Meadow.

These species forage in meadows, light woodland and around water for prey and are under recorded. More comprehensive recording would benefit habitat management.

8.6 Birds

The river Ems catchment offers a variety of habitats that are reflected in the diversity of bird species that have been recorded. These birds may be resident, annual migrants or passing through and of the 202 species recorded, 131 are notable or protected.

Keys sites for the different birds seen are Brickkiln and Aldsworth ponds and the surrounding meadows and woodland, Peter Pond, Brook Meadow, Mill Meadow Farm, Lumley, and Sindle's Farm. The birds are attracted to the range of habitats from pockets of ancient woodland, freshwater ponds, flowing chalk stream, scrub, reedbeds, unimproved grassland, hedgerows, field margins, brackish lagoon, wet meadows, scrapes, and field margins.

Birds of note in the catchment include Turtle dove *Streptopelia turtur* (Red listed), Curlew *Numenius Arquata* (Red listed), Black tailed godwit *Limosa limosa* (Red listed), Green sandpiper *Tringa ochropus* (Amber listed), Cuckoo *Cuculus canorus* (Red listed), Nightjar *Caprimulgus europaeus* (Not assessed), Nightingale *Luscinia megarhynchos* (Red listed), Hawfinch *Coccothraustes coccothraustes* (Red listed) and Kingfisher *Alcedo atthis* (Green listed, but a good indicator of river health as they only feed on fish and aquatic insects).

8.7 Flora (including plants, mosses, lichens and algae)

The SxBRC data covers 681 species with 107 regarded as notable or of protected status. These range from Sussex rare species like the Green Hellebore (*Helleborus viridis*) to Red Listed in England Critically Endangered, NERC S41, UK BPA Priority, WCA Sch8 species such as the Pennyroyal (*Mentha pulegium*) and Small Fleabane (*Pulicaria vulgaris*).

8.7.1 Aquatic Vegetation

In terms of WFD assessment, the River Ems was classified as 'High' for macrophytes and phytobenthos combined in the 2019 Cycle 2 classification. Environment Agency botanical and macrophyte surveys were limited to one site on the River Ems (sampled a year apart in 2013 and 2014). The site is located on The Canal in the middle Ems, upstream of Watersmeet and the confluence with the Aldsworth tributary.

It should be noted however, the WFD classification is based on only two surveys (2013 and 2014) when usually a minimum of three samples are required to complete a classification.

Holmes (2007) carried out five surveys at seven sites between September 2005 and May 2007, with four additional sites surveyed in 2006 and 2007. Holmes found that the river varies significantly along its reach in terms of flora. Above Broadwash a dryland community, with ‘wetland’ taxa, exists typified by Water-mint *Mentha aquatica* and Fool’s Watercress *Helosciadium nodiflorum* etc. They can grow in wet or dry systems but are more reflective of dry conditions. At Racton Farm Pond, characteristically of wetter conditions, a richer array of classic winterbourne taxa that need wet conditions were found, e.g. *Ranunculus peltatus* (Pond Water Crowfoot).

Holmes (2007) states that the floral community changes at Broadwash to reflect perennial flow conditions, with taxa such as Lesser Water-parsnip *Berula erecta,* Water-crowfoot sp. *Ranunculus penicillatus* subsp. *pseudofluitans* and Blunt-fruited Water-starwort *Callitriche obtusangula* found which are typical of perennial chalk streams. Holmes concludes that the flora recorded within these surveys is “reflective of a classic winterbourne”. It has a downstream progression from largely terrestrial species upstream of Walderton to wetland and aquatic taxa closer to Broadwash.

Of the Aldsworth stream Holmes (2007) notes that much of the stream channel downstream of the Aldsworth pond contains Water-parsnip sp. *Berula* - this suggests historic perennial flow that is again now known to fail regularly.

Bruce Middleton’s (2020 and 2021) botanical survey of 5 sites along the river catchment lists good chalk stream indicator species found.

Common name	***Latin name***
Brook Water Crowfoot	*Ranunculus pencillatus subsp pseudofluitans*
Blue Water Speedwell	*Veronica anagalis aquatica*
Watercress	*Rorippa-nasturtium-aquaticum*
Blunt-fruited Water Starwort	*Callitriche obtusangula*
Floating Sweet grass	*Glyceria fluitans*
Fountain Feather-moss	*Hygroamblystegium tenax*
Long-beaked Water Feathermoss	*Platyhypnidium ripariodes*
Fern-leaved Hook-moss	*Cratoneuron filicinum*
Endive Pelia	*Pellia endiviifolia*

Figure 13. Chalk stream indicator species found in Middleton’s survey (2020 & 2021)

Of further interest were Pepper Saxifrage *(Silaum silaus)*, Corky-fruited Water Dropwort (*Oenanthe pimpinelloides)*, Southern Marsh Orchid *(Dactylorhiza praetermissa),* Common spotted Orchid (*Dactylorhiza fuchsii)*, Adder's-tongue fern (*Ophioglossum vulgatum)* and Spurge Laurel (*Daphne laureola)*.

AMEC and CEH (2013) completed macrophyte surveys in September 2001 and 2012 at six locations along the Ems, using the LEAFPACS methodology. The report summarises that the macrophyte community retains some of the characteristics of a perennial systems, but that restoring a more frequent flow would improve the communities.

Using the taxa and Percentage Cover Value (PCV) recorded in the August 2014 and 2013 surveys the River Macrophyte Nutrient Index (RMNI) was calculated and showed a slight increase from 2013 to 2014 showing the macrophyte assemblages' preferences for enriched nutrient conditions.

The ARRT Ems walkover survey (2022) also mapped presence of macrophytes in each survey reach (see Figure 14 for distribution map).

Furthermore, Divided Sedge (*Carex divisa)* – a nationally scare species (IUCN vulnerable as per JNCC), was recorded on Lumley meadow of Brook Meadow.

8.7.2 Lichens

Of the 167 records for lichens in the SxBRC data, 27 of these are considered notable as either Sussex Rare, Nationally Scarce, or fall under NERC S41, UK BAP priority species, and / or on the Red data list. Those of particular note are: *Caloplaca herbidella.; Cladonia coccifera*; *Lecanora quercicola; Lecanora sublivescens;* Witches' Whiskers Lichen (*Usnea florida*); and *Varicellaria hemisphaerica*.

8.7.3 Lower plants (moss and algae)

There are 161 records for mosses in the SxBRC data for the Ems catchment with 7 being noteworthy. There are 5 Sussex Rare species; Fringed Heartwort (*Ricciocarpos natans)*, Sand Feather-moss (*Brachythecium mildeanum)*, Rusty Beard-moss (*Didymodon ferrugineus)*, Shady Beard-moss (*Didymodon umbrosus)*, Shaw's Bristle-moss *(Orthotrichum striatum)*, 1 Nationally Rare species - Bark Signal-moss (*Sematophyllum substrumulosum)*, and 1 NERC S41, UK BAP Priority, Sussex Rare species – the Curly Beardless-moss (*Weissia condens)*.

Whilst not rare it is worth highlighting the presence of *Hildenbrandia rivularis*, a red algae which favours chalk streams and hard water, and an indicator of good water quality. Fund on boulders and rocks in the stream bed and bright red in colour, Whilst there are only two records held by SxBRC (2021), this species was recorded at a number of sites in 2021 and 2022 in the lower catchment in Mill Farm Meadows, the Aldsworth arm in a wet meadow area, and through Racton Dell in great abundance. This suggests an increase in range and patch size since Rudkin's observational walkover in 1984 (the earliest record we could find), during which he only spotted this species in one location at Racton with coverage of a few yards. This patch persists and appears to have substantially increased.

The 2022 Atkins report notes that as part of a water vole survey undertaken in June 2020, Sarah Hughes and Friends of the Ems recorded *Audouinella pygmaea* to be present in the lower Ems at Mill Meadows. This has been verified by the Natural History Museum and Howard Matcham. The exact location is not known. It is understood that this species was last recorded in England 1980s in West Yorkshire, making the River Ems one of very few sites where it is still extant in England. It will only survive desiccation for very short periods of time.

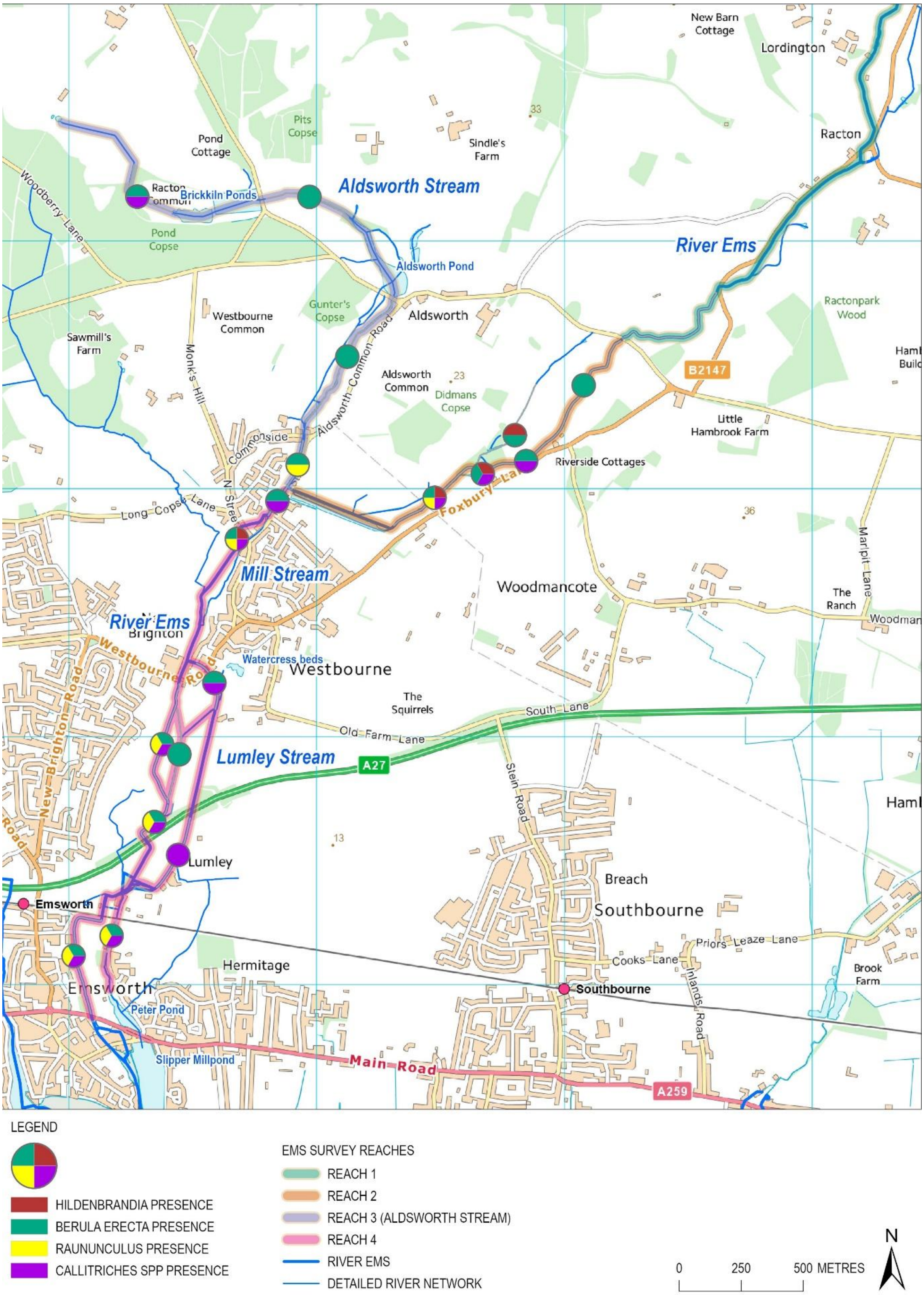


Figure 14. Map showing presence of notable macrophytes and *Hildenbrandia rivularis*. Points show presence but not overall abundance (Ems Walkover Survey 2022).

9. Invasive Species (including native and Invasive Non-Native Species)

Invasive species, especially non-native (INNS), can have a destructive impact on biodiversity. Great care should be made to monitor and record suspected species, and plans created to prevent spread and to action removal. Many are regulated by Schedule 9, Section 2 of the Wildlife and Countryside Act, 1981 (as amended), which lists non-native species that are already established in the wild, but which continue to pose a conservation threat to native biodiversity and habitats, such that species management and further releases should be regulated.

A total of 13 INNS have been recorded, including as part of the 2022 River Ems Condition Assessment survey. This is available as a separate document on request from WSRT.

- Mink (*Neovison vison),* a known contributor to the disappearance of water voles across the UK. There is one record for mink for 2019 and monitoring rafts are now in place in the lower sections of the river. Holmes (2007) cites mink as the main threat to the water vole 'which exists on a knife edge' and the only invasive species of any significance.
- New Zealand Pygmyweed (*Crassula helmsii)*, was found during a walk in October 2022 through Aldsworth pond, matting the base of the dry pond (at that time). This was found dominating some sections of this site and presents a significant risk to the biodiversity in situ as well as the downstream sections of the Ems. It can spread through tiny prions and will require a management strategy and some financial long-term investment to remove.
- Winter heliotrope (*Petasites fragrans)* is a ground covering plant that dominates sites and can reduce floral diversity. There are records across the catchment and management should be considered.
- Japanese knotweed (*Fallopia japonica)*, this invasive plant has records across the catchment and needs swift and careful action to contain its spread.
- Giant Hogweed (*Heracleum mantegazzianum)*, there is just one record for this plant on Harting Down in 1995 so it may well have been successfully removed.
- Hemlock Water Dropwort (*Oenanthe crocata)*, seen throughout the catchment and although it is a native species it can quickly dominate a site and prevent other plants from colonising or persisting. It is also a flood risk as it dies back in late July, early August leaving exposed soil vulnerable to washing away during rainfall events and causing siltation of water courses.
- Hybrid Bluebell *Hyacinthus sp.* has records throughout the catchment and risks spreading and supressing the more delicate native bluebell.

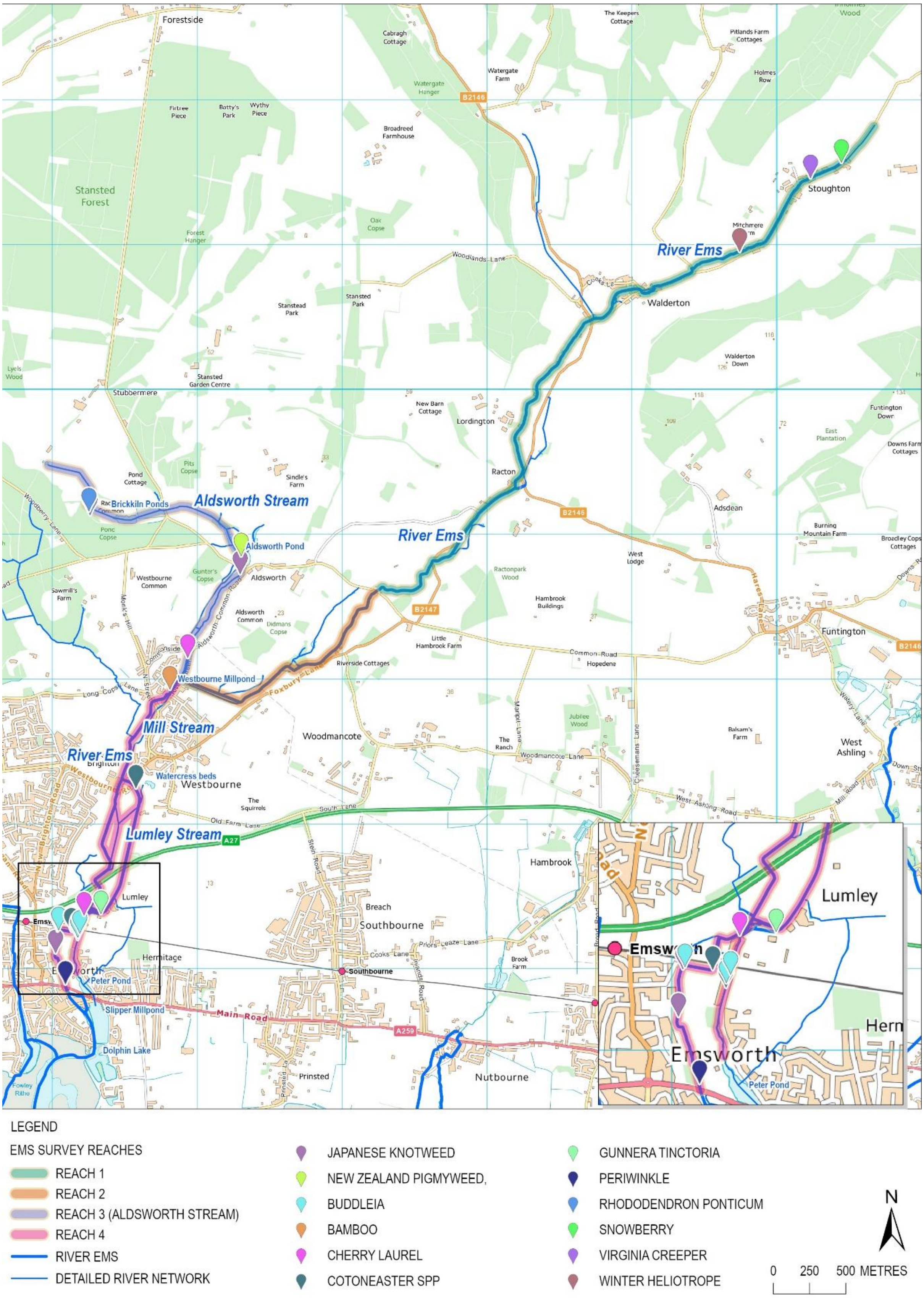


Figure 15. Map showing INNS recorded during walkover survey (2022).

10. Hydrology

Hydrology can be defined as the distribution and movement of water both on the earth's surface and below the ground, as well as the impact of human activity on water availability and environmental conditions.
The Ems is a groundwater dominated waterbody, with the majority of the water being attributed to this source, as opposed to surface water (rainfall and runoff). This means that flow in the river is almost entirely reliant on sufficient groundwater resources within the aquifer. As we have already outlined abstraction for drinking water has an influence on the availability of water in the river. Details of these issues will be discussed later in this section.

There is a growing technical literature resource on the hydrology and hydrogeology of the river Ems, including important reports by Entec (2006), Holmes (2007), AMEC (2013) and Atkins (2022) and wider key texts that date back further, alongside Water Framework Directive assessments by the EA, and local experience and knowledge. This section summarises this information and outlines the hydrological characteristics and status of the river.

A full list of data sources can be found in the Appendices (Section 15).

10.1 Ems River Reaches

To assess river health it is beneficial to break down the river into homogenous sections, or reaches. An assessment of the river was undertaken by Holmes (2007) who identified four distinct river reaches on the Ems – and related to evidence of perennial or ephemeral flow. We reassessed these reaches as part of our River Ems Condition Assessment & Walkover Survey and found that that they still held true, and were subsequently used for the survey, and as the basis for restoration actions (see River Ems Restoration Plan).

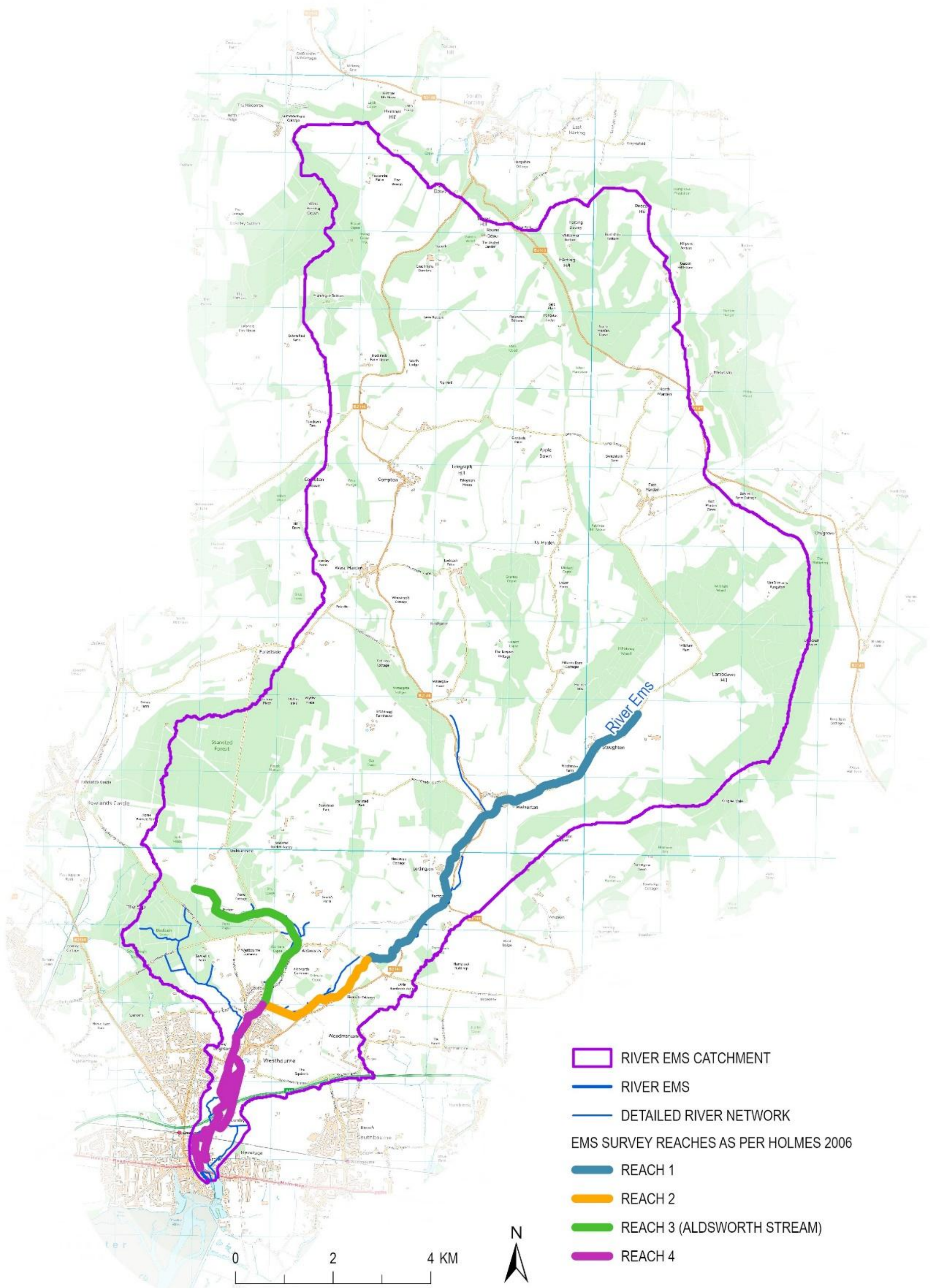


Figure 16. Map showing River Ems River Reaches (after Holmes, 2007).

10.2 Hydrogeology

10.2.1 The Chalk Aquifer

The limestone bedrock underlying the river Ems catchment comprises part of a larger aquifer that stretches across southern and eastern England, known as The Chalk Aquifer. The aquifer is described by the British Geological Survey (BGS) as composed of very finely-grained, microporous white limestone that has a low matrix permeability (*i.e.* does not drain naturally by gravity), forming a natural storage of filtered rainwater that rises to the surface as springs and river baseflow when groundwater levels are high, due to its well-developed interconnected network of fractures and wider pores. Water yields from the aquifer can typically be in the order of 150 litres/second, and are highest where the density and/or size of fractures is greatest. Chalk bedrock is susceptible to contamination because of its natural chemical and structural characteristics and high transmissivity. There are excess nitrate concentrations in parts of the aquifer in Portsmouth Water's resource area, much of which is historic (though some from on-going inputs), and largely linked to agriculture and sewage - the latter being largely from properties not served by mains drainage (see Section 13.2.1).

The river relies on sufficient rainfall, especially during the winter, to top up the level of groundwater in the aquifer to a sufficient extent to keep the river flowing over the summer months until the following winter rains arrive. Autumn and winter rainfall is needed to keep riverbed gravels clean, to flush through natural debris that accumulates over the summer months, removing algae, excess sediment or aquatic vegetation, and preparing the river for optimum fish spawning over the winter months. Fish such as brown trout and sea trout begin spawning once temperatures drop to around/below 10°C and water volumes and velocities increase, enabling fish to navigate up the river to find quieter headwater reaches where younger fish and fry have a greater chance of survival. The gravel riverbed needs to receive a sufficient volume and velocity of water to ensure a clean, constant supply of oxygen to fish eggs that are laid in nests (termed as 'redds') along the riverbed.

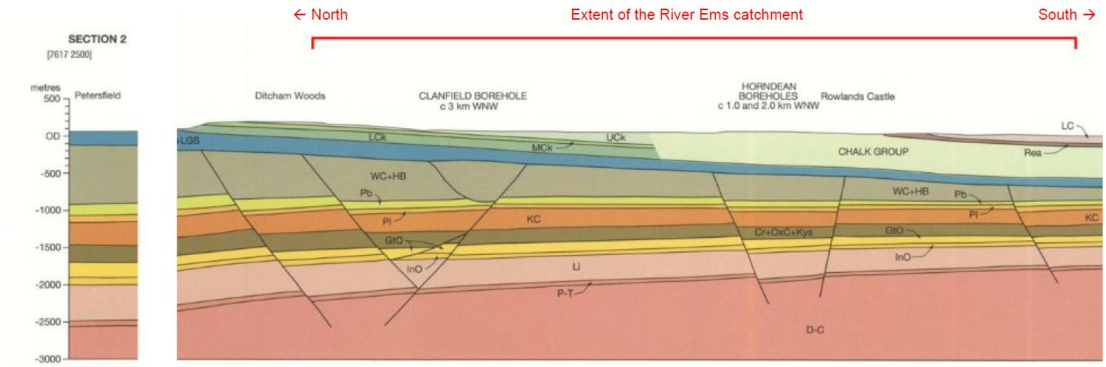


Figure 5-2 - Bedrock geological section

Key to abbreviations: LC = London Clay Group
Rea = Lambeth Group ('Reading Beds')
UCk = Upper Chalk
MCk = Middle Chalk
LCk = Lower Chalk
UGS+G+LGS = Upper Greensand, Gault Clay and Lower Greensand

Figure 17. Ems Underlying Geology diagram (from Atkins, 2022 – Figure 5.2, p57).

The protection of groundwater resource is key to preserving surface flows in the river Ems as well as protecting water reserves that supply vital drinking water for the customers of Portsmouth Water and Southern Water.

10.2.2 Baseflow Index

Baseflow can be described as the amount of river water derived from groundwater sources, and is measured to create a Baseflow Index (BFI).

The BFI for the River Ems is determined to be 0.93. This means that the river Ems relies on groundwater for 93% of its water supply. The remainder is sourced from rainfall and surface runoff. This is as expected given that the bulk of the Ems and associated headwater springs flow entirely over the Chichester Chalk aquifer until shortly before the EA gauging station at Westbourne.

10.2.3 Flow Duration Curve (FDC)

The amount of flow in a river depends on many factors including rainfall, evapotranspiration, surface water and groundwater, artificial abstraction and storage. These variables are assessed through flow duration curves (FDCs).
FDCs are calculated to show the percentage of time over which flow is equal to or exceeds a certain volume (i.e. how much of the year the river is very high or very low). Expressed as a 'Q value', it is used to express the exceedance value (i.e. what % of time the flow rate was equalled or exceeded) at a range of river flow levels. For example Q95 at 0.5 cubic meters of flow per second (cumecs), means that river flow is higher than 0.5 cumecs for 95% of the time.
Q values are delineated into the following flow categories:

- High flows (Q30) (e.g., flow is at this rate or a higher flow for 30% of the time)
- Moderate flows (Q50)
- Low flows (Q70)
- Very low flows (Q95)

National River Flow Archive for 41015 - Ems at Westbourne	
Gauged Daily Flow	
Period of record	1967 - 2020
Percent complete	>99%
Base Flow Index	0.93
Mean Flow (m^3/s)	0.503
95% Exceedance (Q95) (m3/s)	0.016
70 Exceedance (Q70) (m3/s)	0.06
50% Exceedance (Q50) (m3/s)	0.203
10% Exceedance (Q10) (m3/s)	1.35
5% Exceedance (Q5) (m3/s)	1.83

Figure 18. Table showing Daily Gauged flow at Westbourne and related Base Flow and Q values (EA Hydrological Data Explorer: July 2022).

Flow rates can extend further between zero (Q0) and one hundred (Q100); rates between Q0 to Q1 are uncommon and represent very extreme high flooding events. Conversely, Q-values of Q95 demonstrate very low flows of a river. The river Ems daily flow (m3/s) time-series data for the period 1967 to 2020 taken from the EA Westbourne gauge has been used to calculate flow duration curves for the river Ems, with the Q-values as shown in Figure 18 (above).

The low flow index of Q95 over this time period is recorded to be 0.016m3/s, i.e. low flow in the Ems is equivalent to 16l/s at the EA Westbourne gauge.

10.3 Water Quantity

10.3.1 Rainfall

The Met Office states that the South Downs receives some of the highest rainfall in the southeast of England, at around 950mm per year on average.

Examination of the CEH National River Flow Archive presents the total annual rainfall (mm) over the period 1961 to 2017 for the River Ems catchment. These datasets make the best use of all available data, and incorporates all the individual gauges in the catchment. The average annual total rainfall over this period is 930.7mm/year.

The data shows the highest rainfall event over the 57 year period was for the year 2000, when 1355mm of rain fell that led to significant local flooding, closely followed by 1305mm in 2012.

Atkins (2022) reproduced EA rainfall gauge data for the Ems catchment over the period 1999 to 2019 using the rain gauge at Chilgrove House and Walderton, presented in Figure 19. The Chilgrove gauge is strictly just outside of the Ems catchment, however its location within the upper Ems area is closer to the South Downs which is deemed to provide relatively more of the rain that recharges the Ems. Winter rainfall at the Chilgrove gauge is noted as being greater than that at Walderton, whilst summer precipitation is similar at both. The data presented is comparable to that cited above sourced from the CEH national river archive database.

Rainfall Gauge Name	Date Range Available	Data Period Used to Calculate Average Rainfall	Elevation (mAOD)	Average Rainfall (mm/year)
Walderton	Feb 1991 - 2019	Oct 1999 – Oct 2019	33	930
Chilgrove	Oct 1999 - 2019	Oct 1999 – Oct 2019	78	1071

Figure 19. Table showing average rainfall at Walderton and Chilgrove (Atkins 2022).

10.3.2 Effective Rainfall

Effective rainfall is the percentage of precipitation (i.e. rain or snow) that percolates into the aquifer and recharges groundwater levels. Not all rainfall will reach the groundwater, as some will be lost through evaporation. Effective rainfall is also referred to as groundwater or aquifer ‘recharge’. As 93% of baseflow in the river Ems is supplied by groundwater which relies upon

rainfall, understanding relationships between these data is critical to understanding how the river Ems functions.
Winter rainfall is particularly important for aquifer recharge because it is not as depleted by plants (via evapotranspiration) and evaporation to the atmosphere as rainfall during the summer.

Figure 20. (below) illustrates the difference in actual and effective rainfall (mm/year) over the period 2000 to 2021 for the Ems catchment.

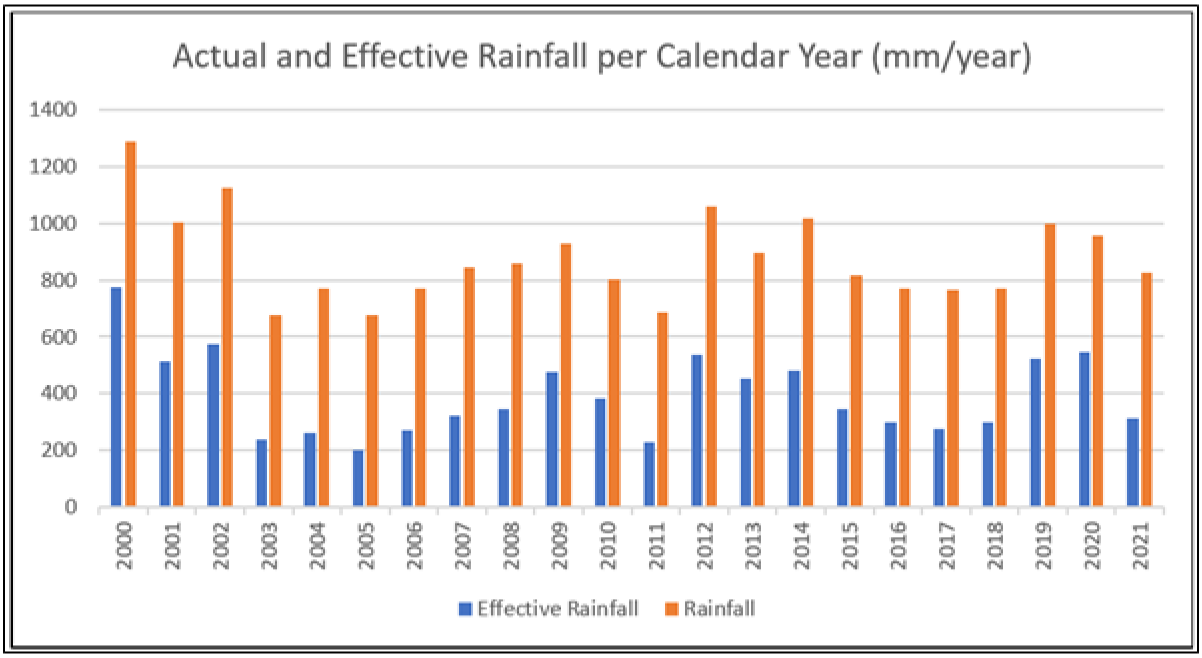


Figure 20. River Ems catchment - actual rainfall vs effective rainfall 2000 - 2021

The Atkins report (April, 2022) also provides rainfall and aquifer recharge data for the Ems catchment based on refinements made to the AMEC (2012) and EHCC model, using hydrological data over the period 1965 to 2010.

Aquifer recharge is recognised as being greatest over the higher ground of the South Downs, which covers the large headwater area of the Ems catchment, with a spatial range across the catchment of 250mm/yr (south) to 575mm/year (north). Greater recharge occurs in wetter years (up to 66%) and vice-versa for drier years (down to 24%), with most of the recharge occurring between November to February.

10.4 Gauge Data

The Environment Agency 'Hydrology Data Explorer' provides open hydrology data, specifically readings for river flow and level, groundwater, and rainfall activity, at stations throughout England. Raw data is uploaded regularly and replaced once plausibility checks have been completed.

10.4.1 Surface Water (River) Gauging

The most consistent source of flow data is provided by the Westbourne Gauge (Grid ref: SU755074), which has been monitoring water levels since 1967. Additional gauges at Walderton and Compton are no longer active, and therefore are less useful for showing long term trends.

Of significance is the fact that formal gauging at Westbourne only started after licensed drinking water abstraction had commenced in the late 1960s. This means that the majority of data pertaining to flow does not show what natural flow conditions were like prior to abstraction, and underlines the need to look at novel evidence before formal gauging.

Average abstraction remains fairly stable over time, deemed to be largely demand-led. Portsmouth Water has relatively little storage capacity within its area and, more recently, has started to export considerable volumes of extracted water to other water-supply regions, including Southern Water's supply grid. Further details about abstraction can be found in Section 11.

Whilst this gives an overview of the data, due to the range in data values it fails to highlight the details of lower flows. In order to better represent the frequency and changes in flow annually a log graph can help to highlight the lower flow periods (see Figure 21).

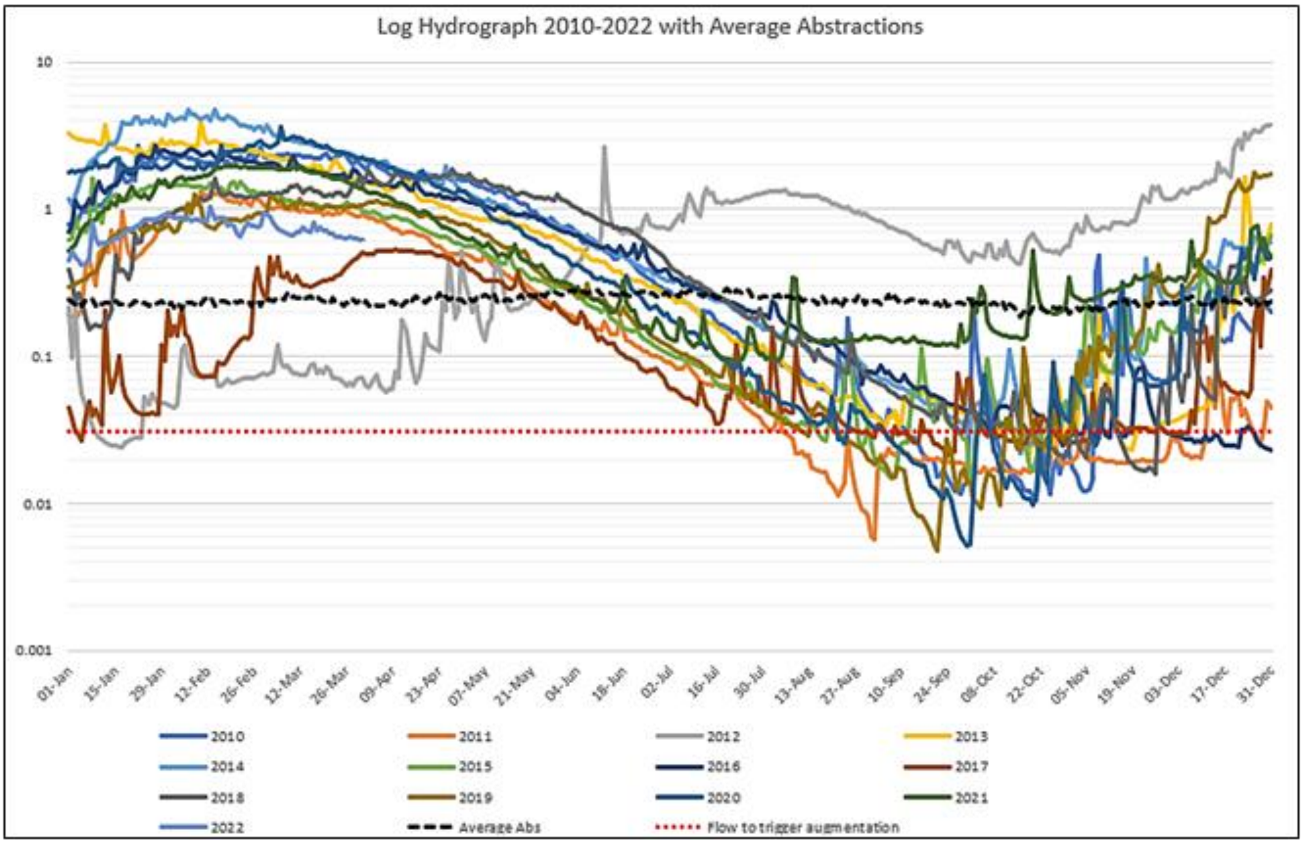


Figure 21. Log hydrograph 2010 – 2021 with average augmentation (and trigger for augmentation).

The flow data is taken from the EA Westbourne flow gauge (m^3/day) and covers years from 2010 to 2021. This effectively reduces the high range in flow regime highlighting the lower flow periods. The average abstraction rate and augmentation trigger level has also been added to show the impact relative to seasonal flow rates in the river Ems over time.

Figure 21. shows that in all years there is flow at the EA Westbourne gauge, and in most years, this follows the natural hydrological cycle, with low flows occurring in the autumn and early winter. The unusually wet years of 2012, 2014 and 2021 stand out as atypical above-average flow regimes, and the drought year of 2011 (into early 2012) can also be seen.

10.4.2 Groundwater Gauging

The Environment Agency, Portsmouth Water and others monitor groundwater levels via a series of boreholes. There are a number of additional boreholes and wells (some active, some not) in the catchment which provide information about groundwater levels, although much of the data is privately held. Friends of the Ems (FotE) have been instrumental in recording and resurrecting these data points, and work is ongoing.

The British Geological Society provides viewable data pertaining to the location and depth of known boreholes and wells (see Figure 22).

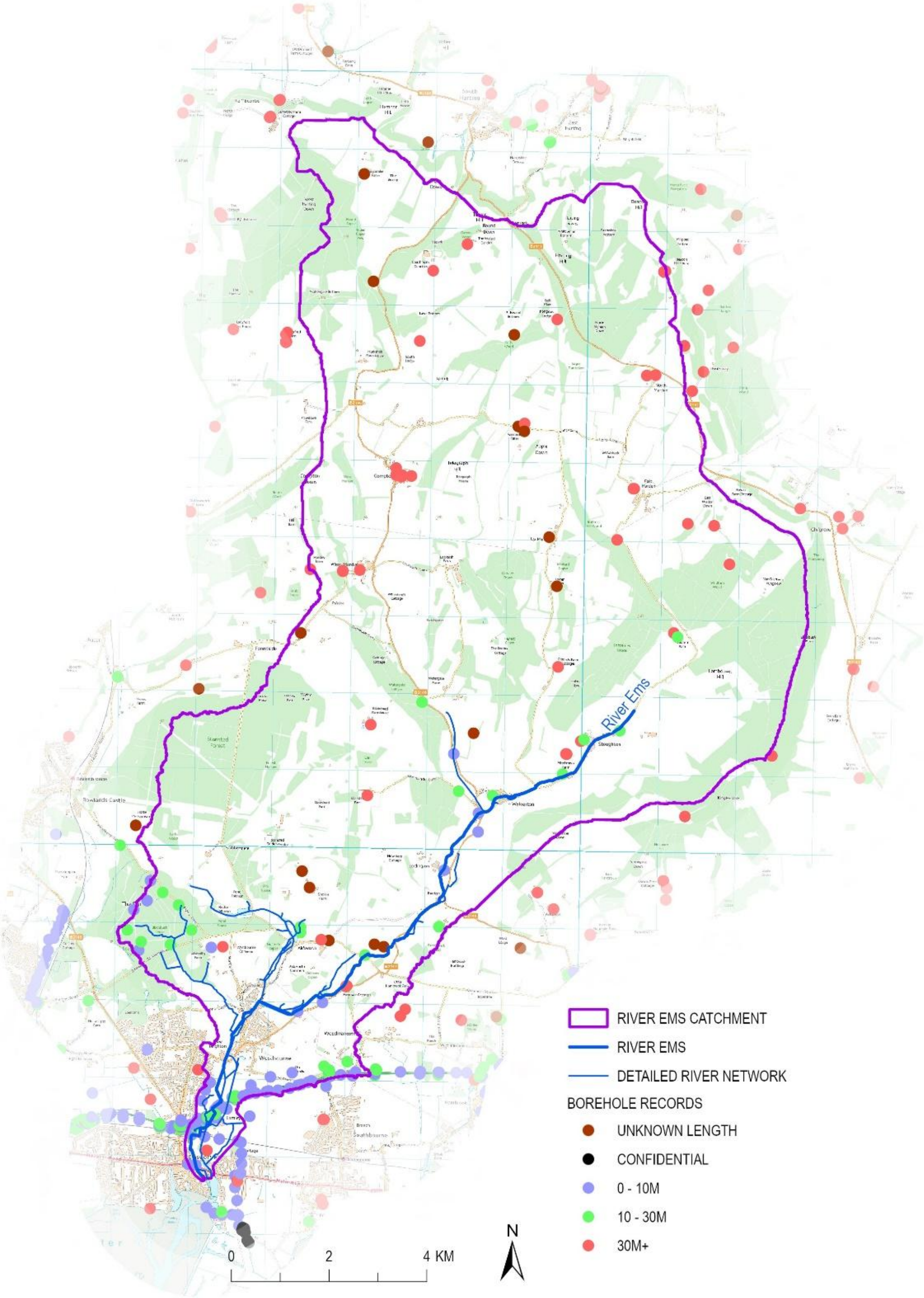


Figure 22. Ems Catchment BGS Single Onshore Borehole Index - delineated by depth. (British Geological Society).

Work by FotE to monitor and map additional groundwater data sources, and with support provided by Portsmouth Water and Atkins, is of the utmost importance, as it will help infill data and provide greater data points in this complex and groundwater dominated catchment.

10.5 Groundwater Operational Catchments

The large chalk aquifer which feeds the Ems, comprises different geo-physical and chemical properties that have been categorised by the EA to aid groundwater planning and management. There are 31 distinct groundwater areas within the South East River Basin District, known as groundwater operational catchments. The river Ems catchment for *surface water* overlaps 4 distinct Groundwater (GW) Bodies: the Chichester Chalk; East Hants Chalk; Sussex Lambeth Group (chalk) and the East Hants Lambeth Group (chalk), as shown in Figure 23. The Chichester Chalk covers the majority of the Ems catchment, in particular the upper headwaters.

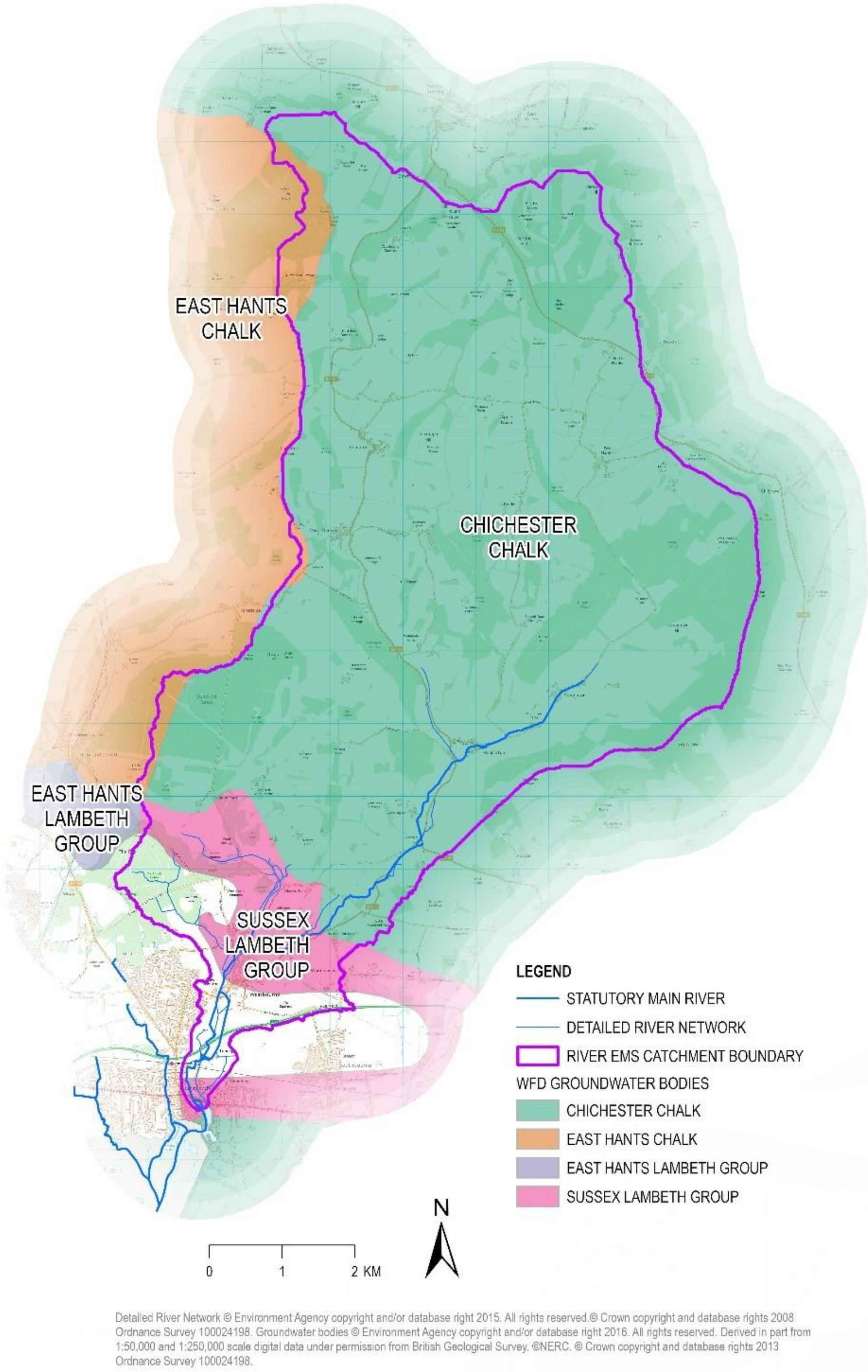


Figure 23. EA Groundwater bodies covering the Ems catchment.

10.6 Water Resource Abstraction Reliability – Cycle 2 (England) (EA)

The Environment Agency monitors water resource availability as part of the Catchment Abstraction Management Strategy. A technical assessment is carried out to determine the water available in each river catchment to support water abstraction. This incorporates the Environmental Flow Indicator (EFI) – the minimum amount of water required to achieve healthy ecological status for the river, in order to identify where resource demands from industry, agriculture or public water supply are compromising water quantity and availability. Water Abstraction resource reliability shows the amount of time that water is available for additional abstraction within the catchment (after all existing licences have been used at full capacity). The higher the impact of abstraction (e.g. the less time that water is available), the more stressed the catchment is due to these pressures. Unreliable water availability can have significant impacts on public drinking water supply, agriculture, industry and businesses. Areas that are identified as water stressed, or at risk of becoming water stressed provide opportunities to target the catchment-based approach to water stewardship and Natural Flood Management/NFM projects (CaBA 2022).

The Water Resource Availability and Abstraction Reliability Cycle 2 dataset indicates whether, and for what percentage of time, additional water may be available for consumptive abstraction (subject to assessment of local risks) for each Water Framework Directive Cycle 2 water body. Each water body is colour coded as follows:

- Green - Water available for licensing
- Yellow - Restricted water available for licensing
- Red - Water not available for licensing
- Grey - Heavily Modified Waterbodies (and /or discharge rich water bodies)

It is worth noting that this data is not raw, factual or measured. It comprises estimated or modelled results showing expected outcomes based on the data available to us. Data for the River Ems Catchment shows that water is available for additional consumptive abstractions less than 30% of the time. It also shows that is highly stressed.

The highly abstracted nature of the groundwater (resource) that underlies the river Ems WFD catchment boundary is illustrated in Figure 24 below. This shows that there is no groundwater available for further licenced abstraction beyond that already granted, except during ‘high flows’ which would typically occur over the winter period after prolonged rainfall. It is important to note that Portsmouth Water does not fully exploit its abstraction licence, utilising ~74% of their maximum annual abstraction licence at Walderton. Also this metric is used to assess (and grant or not) future abstraction licenses.

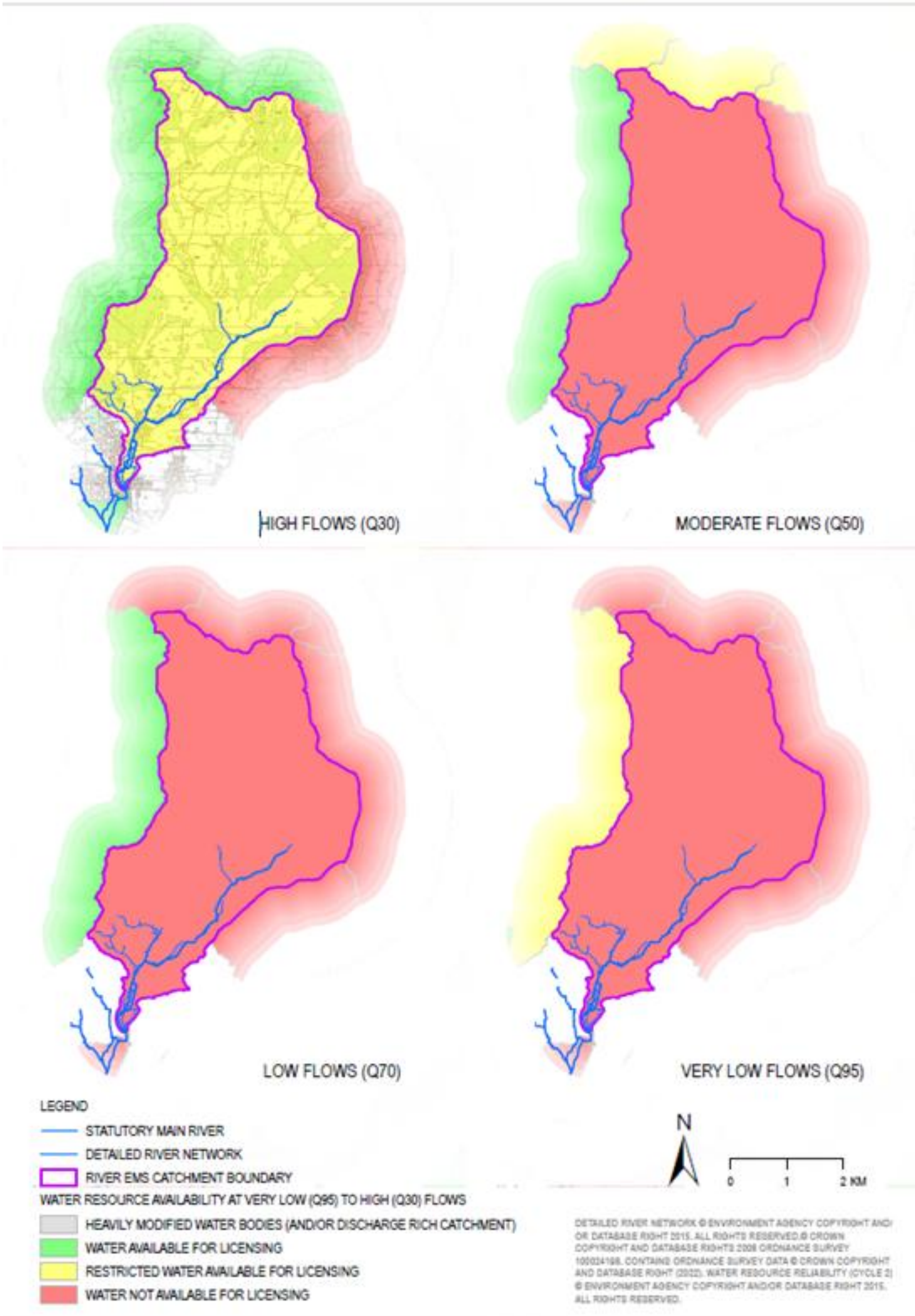


Figure 24. River Ems waterbody - EA Water Resource Availability map (Approval for Access (AfA) product AfA445).

10.7 Water Balance

Water Balance seeks to understand how much water is coming in and going out of the catchment. This is helpful in understanding how recharge (input), alongside abstraction and river flow (outputs) balance against the amount of water available.

In order to assess water balance, quantification of natural losses to the river Ems' water-cycle, including evapotranspiration by plants and evaporation to open water is needed. These processes have been measured in previous studies of the Ems catchment using a range of different approaches.

Atkins (2022) provide a high-level assessment of the inflows and outflows for the Ems catchment (see Figure 25), which fit with previous studies.

	Inflow (mm)	**Outflows (mm)**
Average Annual Rainfall (1965-2010)	**878mm**	-
Evapotranspiration (rainfall minus effective rainfall/recharge)	-	**480mm**
Recharge (effective rainfall)	**398mm**	-
River flow (flow divided by catchment area)	-	**268mm**
Average Annual Abstraction (flow divided by catchment area)*	-	**134mm**

Figure 25. Ems Catchment - Long Term Average aquifer inflows and outflows (Atkins, 2022 p.114)

Whilst not a detailed assessment, Atkins illustrates that the balance between inflows and outflows is close; with effective aquifer recharge at 398mm and outflows (river-flow to sea and abstraction) at 402mm. Using these figures, abstraction accounts for an average of 34% of annual recharge.

As noted earlier, however, these are average values and guides; during dry years less rainfall can bring aquifer recharge down to 24% (Atkins, Apr 22, Pg112). This would almost halve recharge (inflow), and increase abstraction to 60% or more of effective rainfall, leaving less for surface water flow. The determination of abstraction as a percentage of recharge is known as (A%R) and is discussed further in Section 11.

10.8 East Hampshire Chalk Model (EHCC)

In 2013 the EA commissioned AMEC to undertake a detailed computer model, the East Hampshire Chichester Chalk (EHCC), to help predict the status of the underlying aquifer that supports drinking water abstraction and surface river flows of many chalk streams and rivers located across the southern coastal area of England. This investigation, including the river Ems, explored in detail the impact of abstraction on flow using the EHCC model, and was reviewed in the Atkins flow investigation report in 2022. At the time of the AMEC study, the Ems was augmented by flow sourced from Walderton, whereas at present it is sourced from Woodmancote, and the rate of abstraction between 2016 and 2020 from Walderton is 10% higher now (2022) than the rates used in the EHCC model, which were taken for the period 2006 to 2010. Nevertheless, the overall catchment balance defined by the model was agreed (by Atkins, 2022) to remain similar to current observations and so provided reliable predicted impacts of abstraction.

The model used five 'scenarios' to predict the effect of abstraction on groundwater and surface river flows, comprising:

1. a 'naturalised' scenario which simulated the effect on flows if there were no abstractions;
2. a 'recent actual' looking at patterns over the period 2006 to 2010;
3. a 'fully licenced' which assumes all abstractions operate at their permitted maximum levels;
4. a 'max' based on estimated recent actual abstraction rates with Walderton operating at its licenced maximum without Woodmancote; and lastly
5. an 'off' with recent actual abstractions rates only for Woodmancote (i.e., without the larger site at Walderton) operating.

A key output from the model included the prediction that abstraction in the 'recent actual' scenario is shown to deplete Q95 (very low) flows from the naturalised state by about 70%, and Q70 (low) flows by about 61%. These depleted flow rates, as a proportion of total flow, are significantly less than that required by the Environmental Flow Indicator (EFI) rate as set by the EA for the Ems catchment.

A comparison of the EA's recommended guidance for abstraction levels set for very low flow (Q95), and low-flow (Q70) river conditions, that are required to protect the river Ems to enable good ecological functioning, with abstraction rates as taken from the 'recent actual' scenario in the EHCC computer model, are shown in Figure 26.

EA Guidelines: Percentage Reduction (Flow) from Natural Flows recommended to achieve good ecological potential	**River Ems EHCC Flow Model: predicted % reduction in flow (EFI values) based on EHCC 'recent actual' abstraction**
At Q95: Very Low Flows: 15% reduction permissible	**At Q95: 70% reduction in river flow**
At Q70: Low Flows: 20% reduction permissible	**At Q70: 61% reduction in river flow**

Figure 26: Flows at Westbourne EA Gauge at Q95 and Q70 Flows: based on 'recent actual' EHCC model

The data robustly indicates that flow in the river Ems during seasonal periods of low and very low flow are severely depleted from natural levels by abstraction (for potable supply), with resulting flows not compliant with EA EFI Guidelines and therefore preventing attainment of 'Good Ecological Potential' (see WFD section).
The EHCC model also suggests that abstraction is pushing the perennial head of the river downstream by about 1500m, moving from Lordington to Broadwash. The Atkins report (2022, Pg29) acknowledges the 'order of magnitude of the potential length of reach that has changed from perennial to ephemeral' identified via the EHCC model (see section 10.9 for further information on perennial and ephemeral reaches).

This critical situation facing the Ems in the short term underlines the present importance of having an effective augmentation scheme, without which the river faces the increasing risk of becoming ephemeral along its full length, with reaches regularly drying out and fish no longer able to spawn and thrive.

10.8.1 Detailed River Network

Created by the Environment Agency this dataset provides details of each river section and reach including: position above sea level (Above ordnance datum/AOD); width (m); whether the section is part of the main river or a tributary (secondary / tertiary) stream, culverts; and on-line lakes and ponds (i.e. the river flows through the pond). This reveals more than 30km of watercourse, including 9km of 'main river', 20km of tributary streams, 1.7km which flows through and 'online' lake, and 1.4km which is culverted underground.

10.8.2 Gradient

The Detailed River Network data highlight the steeper elevation in the upper reaches, and flatter coastal plain and can help to assess channel gradient. Gradient in chalk streams is critical to keep the river flowing and providing enough energy to flush sediment through the system, providing dynamic conditions with good dissolved oxygen – important for all river species. In-river structures such as weirs also work to reduce channel gradient, leading to upstream sedimentation and large steps in the river network – many of which are not passable by many fish species.

Working on the basis of the river reaches outlined previously (see Figure 16), in terms of the Ems the reach with the lowest gradient drop is Reach 2, where the average drop is 2.6m gradient per kilometre. In comparison Reach 1 shows the greatest drop, at 5.2m drop per kilometre – however it should be noted that Reach 1 is currently ephemeral, with only part ever having been considered perennial.

Although each Reach is a slightly different length, mean values still broadly show the same results – Reach 2 (Westbourne to Broadwash Bridge) shows the least gradient. This is also impacted by the structures and ponds around Westbourne Mill.

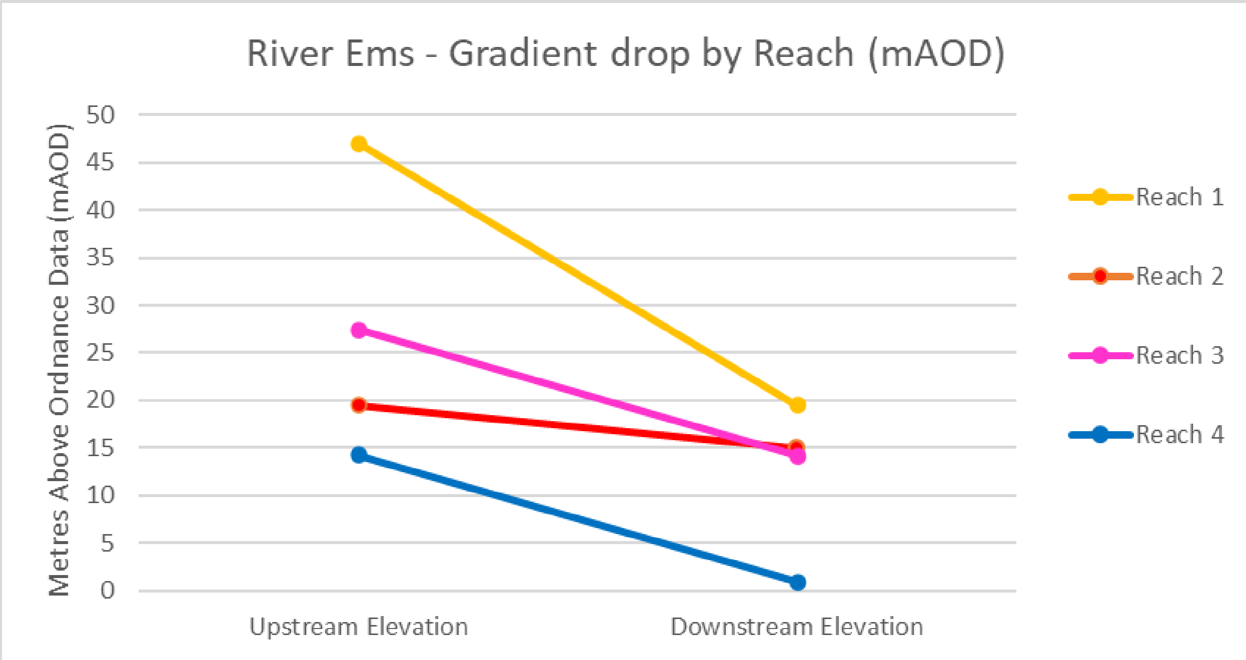


Figure 27. River Ems Gradient by Reach (metres Above Ordnance Datum).

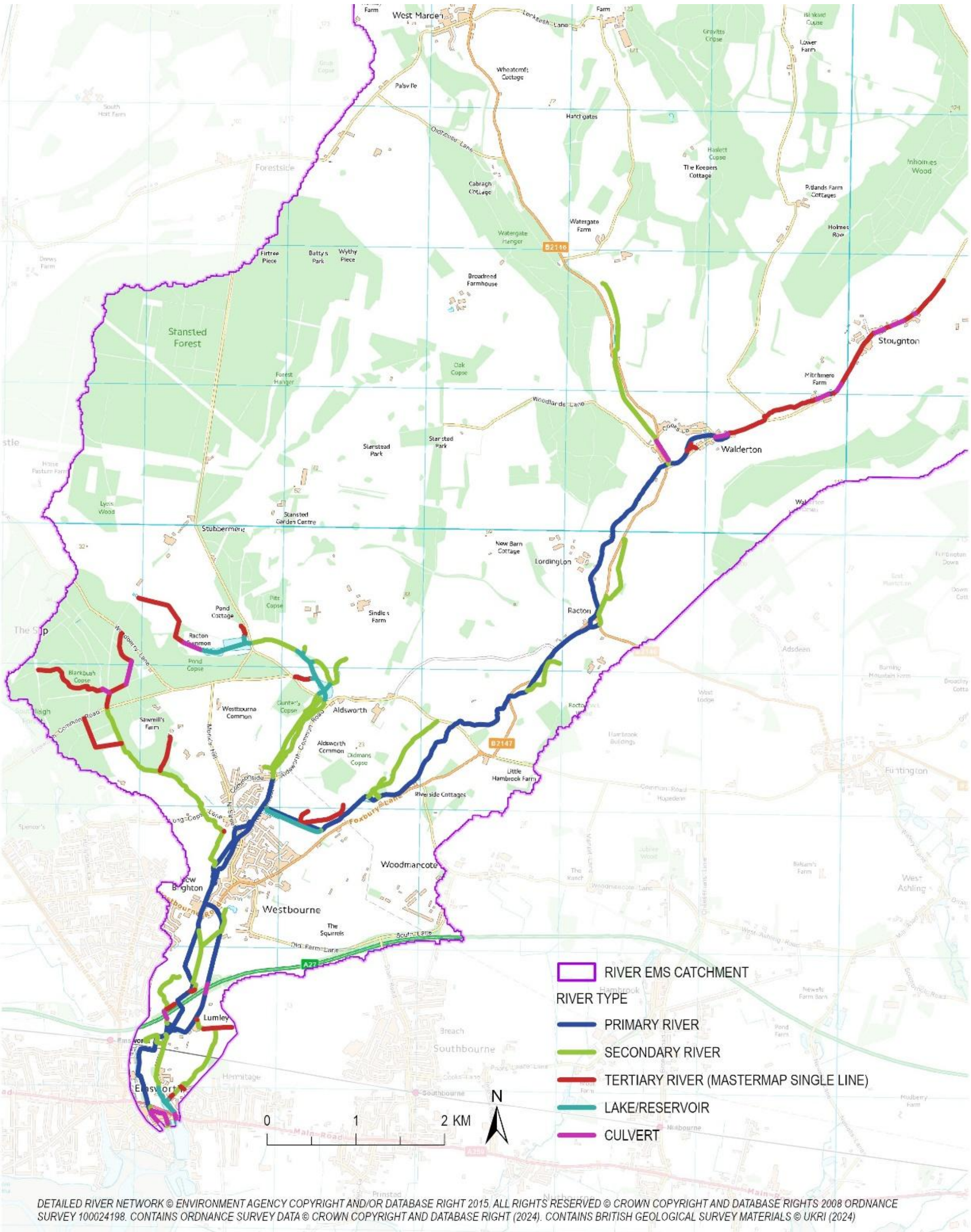


Figure 28. Ems Waterbody Detailed River Network – stream type.

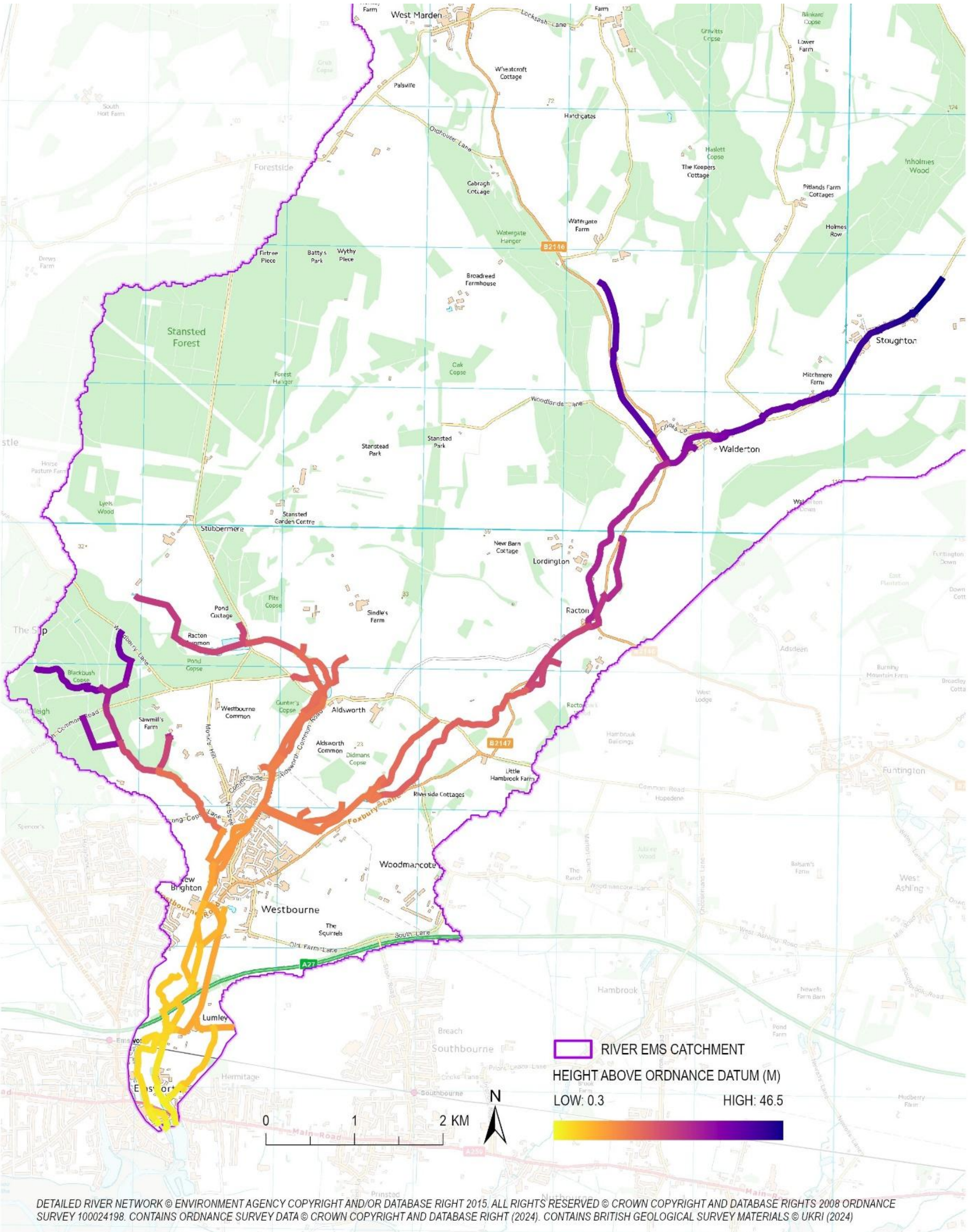


Figure 29. River Ems waterbody Detailed River Network (EA) – height above sea level (Above Ordnance Datum).

10.9 Perennial vs Ephemeral reaches

As previously discussed, the elevated headwater reaches of chalk rivers and streams often naturally dry out over the summer and then wet-up again in the autumn and winter, increasing recharge of groundwater reserves for the following spring and summer. The difficulty with introducing groundwater abstraction into these chalk river catchments is that it can be particularly hard to measure the impact upon ephemeral flow as these reaches typically dry up every year, so a change in perhaps the duration which each river stretch is dry over a year is difficult to confirm. Often, as is the case with the River Ems, there is very little monitoring data (either historic or current) available to assess the impact of abstraction on the upper ephemeral reaches of chalk rivers.

The perennial head of a chalk stream such as the Ems will change depending on annual conditions, however it is still important to understand not just the location, but also the amount of flow needed to support the overall ecology of the stream. Understanding (and agreeing) the location of the perennial head, and the amount of water needed to support ecology is vital in setting objectives to reduce future water abstraction.

As outlined previously Holmes' delineated the four Ems river reaches relative to their homogeneous characteristics (including flow regime). Our subsequent 2022 walkover survey supported earlier findings, and suggesting that Reaches 4, 3 and 2 have the characteristics of constantly flowing perennial streams, but the upper headwater – Reach 1 only in lower stretches. This largely fits with findings from Holmes and more recent studies by Atkins and AMEC.

It should be noted that the Holmes study was undertaken in 2007, and ours in 2022, and given the length of time that water abstraction has been influencing stream flow the channel may have lost features related to flow which it once supported.

Holmes (2007), Entec (2006) and Atkins (2021) agree that the river above Westbourne Mill – both the Aldsworth tributary and the section up to Broadwash Bridge, were once perennial but are no longer.

AMECs 2015 report on the EHCC model suggested that without abstraction the perennial head could be at Lordington, but is pushed down below Broadwash Bridge under abstraction. Model outputs are also supported by historic evidence of a mill at Lordington, and that the presence of (and related cost for building) a structure indicates there was a relatively consistent flow to support operation. The absence of perennial characteristics in Reach 1 - from Broadwash bridge to Lordington - does not necessarily mean that there was not flow here in the Ems history, but it cannot be discounted that these features may have been lost in the nearly 60 years since abstraction began (see Shifting Baseline Syndrome Section 4.2).

Currently the perennial head sits somewhere around Westbourne with stream sections on both the upper Ems and Aldsworth sitting dry for extended periods.

Assessment of maps suggests that assuming Reach 2 should be perennial currently approx. 0.6km of river above the augmentation point at Racton upstream to Broadwash bridge is now ephemeral. Using Lordington as the perennial head would mean a loss (Racton upstream to Lordington) of more than 2km of perennial stream.

10.10 Flooding

There are a number of properties which are impacted by flooding, including in the most frequent duration flood event (e.g. 1/5 year). There are a number of properties which are flooded from river flooding, however a larger number are affected by surface water flooding – water which comes from overground flow and often channelled by road networks and other infrastructure. Flooding impacts and frequency are increased by high groundwater levels, however flash floods due to extreme rainfall can also cause local flooding – particularly in urban areas with swathes of impermeable roads and other hard surfaces.

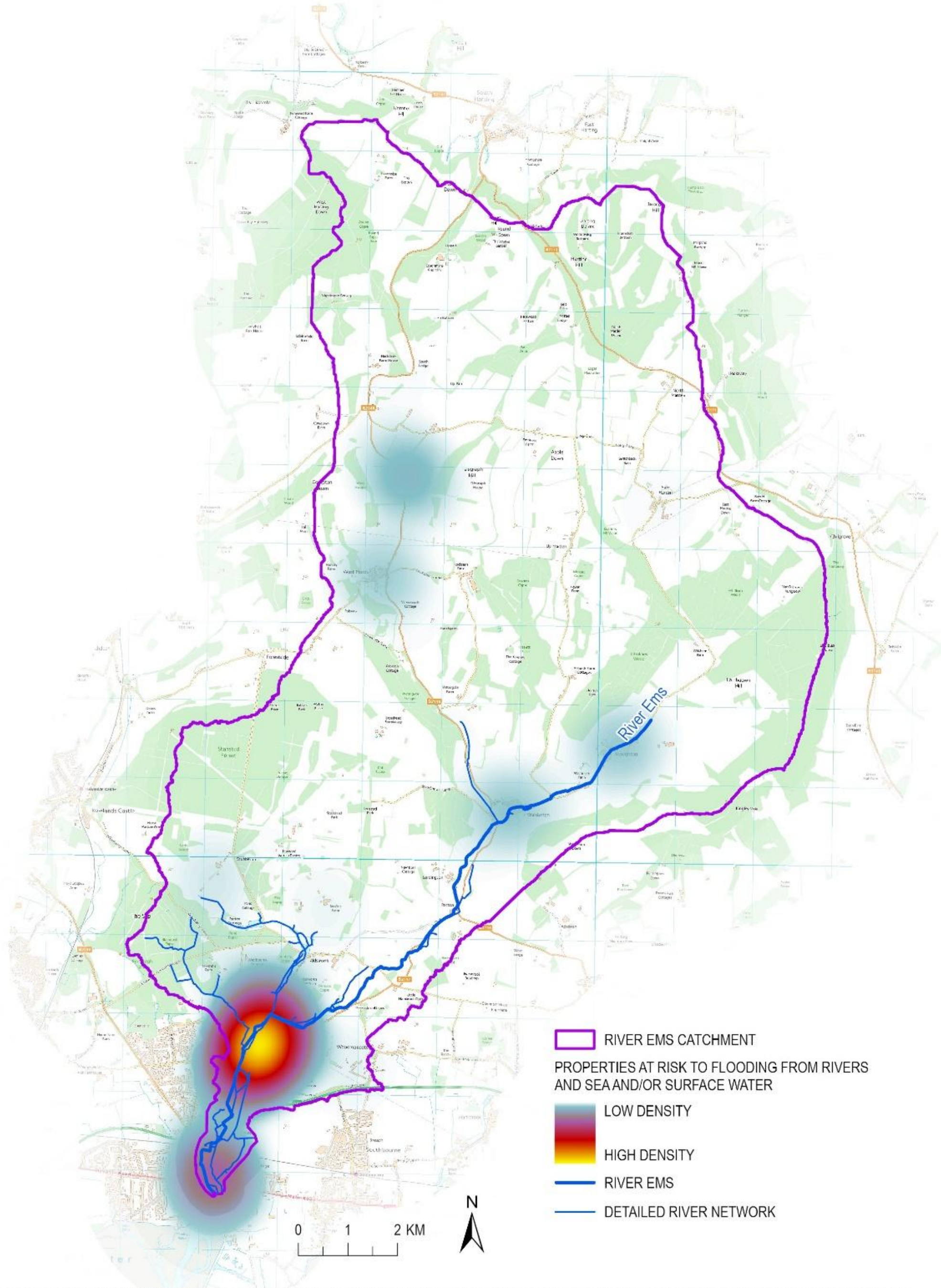


Figure 30. Properties at risk of flooding from river and surface water.

The Ems flooded significantly on a number of occasions in the past 100 years, with a slight increase in flood frequency since the 1990s.

The year 2000 saw extreme flooding across the southeast of England, with over 60mm of rainfall in one hour, and was the largest flood event ever recorded on the River Ems causing a degree of localised flooding in the lower Ems at Brook Meadow and riverside cottages along the Lumley Stream.

This event was caused by wet weather in the preceding months, followed by a large storm event with very high rainfall. The combination of this storm event, high catchment groundwater levels, saturation of the soils and a full aquifer all contributed to the magnitude of this flood. Conditions were further exacerbated by a high tide and on-shore wind at Emsworth which meant discharge of river flow into the sea was slower. Water levels did not return to ‘normal’ for some months after this event.

10.10.1 Flooding and Water Abstraction

There has been some concern about the implications for reduced abstraction on flood frequency, in the belief that abstraction will reduce flood peak. An assessment of the flood hydrograph (e.g. graph showing flood duration and river flow) for the Ems revealed that the amount of water involved in flooding is greatly in excess of the abstraction amount and removal of this would not reduce the likelihood of flooding. More effective would be approaches to slow and store this flood water in the upper catchment before it reaches the properties at risk.

11. Water Abstraction

Abstraction of water from ground or surface water sources (e.g. rivers and reservoirs) is used to support agriculture and industry, and provision of clean drinking water. The Environment Agency act as regulators for licenses for water abstraction. This includes both groundwater and surface water sources.

In the Southeast of England the majority of our drinking water comes from licensed groundwater abstraction (as opposed to surface water). Portsmouth Water rely on groundwater for 88% of its potable water supply, providing water to around 320,000 properties (Portsmouth Water, 2019).

The coastal plain which covers the Western Streams area of our catchment (which incorporates the Ems) is one of this most populated and most water stressed areas of the UK. Increasingly the impacts of growing demand and climate change are having a detrimental effect on the amount of water in the river, particularly groundwater fed chalk streams such as the Ems.

Ensuring that the public have access to a ‘clean and plentiful’ supply of water is part of the statutory remit of both Portsmouth Water and the Environment Agency and is given the utmost priority (currently higher than river ecology). Groundwater is an exceptionally valuable resource because it has the lowest carbon footprint of any sources of drinking water (CaBA). The groundwater resource on the Ems is also one of the most consistent and high-quality drinking water sources in the Portsmouth Water supply area, with their Walderton pumping station supplying water across their operational region. In addition they have a bulk supply agreement with Southern Water, relating to a demand deficit due to a ‘sustainability reduction’ imposed on the amount of water Southern Water could take from the nearby River Itchen chalk stream - a designated SAC (Special Area of Conservation – International level protection). This highlights how protection afforded by the designation increases flow protection for the Itchen, but potentially increases pressure on other local unprotected chalk streams such as the Ems.

In addition to licensed abstraction any riverside landowner can take up to 20 cubic meters of water per day from the river without a license. It is suggested that this unlicensed abstraction represents a small amount of the overall abstraction. Data was not available to assess these impacts however.

River flow can be increased artificially if there is insufficient water in the system for fish to thrive (e.g. low flow periods). The process of adding extra water to a river is known as 'augmentation'.

11.1 Assessing Availability of Water for Abstraction

The Environment Agency utilise a range of methods within their Resource Assessment Management (RAM) programme to assess how much water flow is needed to support ecology, and how abstractions influence river flow. Data pertaining to flow, groundwater levels and ecology are assessed and modelled, some of which span catchment areas, and categorisations made. This information is used to help assess if a waterbody can achieve 'Good Ecological Potential' (GEP) under WFD, and assess how much water is available for further abstraction.

11.1.1 Environmental Flow Indicator (EFI)

Environmental Flow Indicator (EFI) is used to highlight when abstraction pressures may impact on river health and ecology. EFI assesses water resource availability under different flow scenarios and are aligned with the UK water resource good status standards for rivers, and measured at the outfall of the river. Rivers must be compliant with EFI in order to achieve 'Good Ecological Potential' under the Water Framework Directive.

EFI are used to assess further abstraction licenses, but are not applied retrospectively.

During low flow periods (i.e. Q95 – flow exceeds this rate for 95% of the year) should water levels fall below the assigned threshold it is not compliant with EFI, and will trigger a further assessment of the extent of failure (i.e. how far below EFI low flow is), and the scale of risk (i.e. how sensitive the river is to the impacts of low flow) – the latter being the via the Abstraction Sensitivity Bands (outlined below).

Waterbodies which are non-compliant with EFI are given a banding which provides an overview of the extent to which flow is currently depleted from the threshold.

Band 1 - Recent actual flows are up to 25% below the Environmental Flow Indicator at low flows.

Band 2 - Recent actual flows are up to 25 - 50% below the Environmental Flow Indicator at low flows.

Band 3 - Recent actual flows are greater than 50% below the Environmental Flow Indicator at low flows.

The Ems is not compliant with EFI, and is considered to be within Band 3 of this categorisation.

11.1.2 Abstraction Sensitivity Bands

If a waterbody is not compliant with EFI (as seen on the Ems), Abstraction Sensitivity Bands are used to assess the scale of risk posed by low flows. Allocation of a band to a particular waterbody are assessed against the physical/macrophyte typology, the expected macro-invertebrate community and the expected fish community, and separated into three bands which outline the extent to which flow deviates from the EFI.

The Ems is with the ASB2 – Moderate sensitivity band.

RIVER TYPE	FLOW ADEQUATE TO SUPPORT GOOD ECOLOGICAL STATUS	FLOW NOT ADEQUATE TO SUPPORT GOOD ECOLOGICAL STATUS – LOW CONFIDENCE (uncertain)	FLOW NOT ADEQUATE TO SUPPORT GOOD ECOLOGICAL STATUS – MODERATE CONFIDENCE (uncertain)	FLOW NOT ADEQUATE TO SUPPORT GOOD ECOLOGICAL STATUS – HIGH CONFIDENCE (quite certain)
	COMPLIANT WITH EFI	NON-COMPLIANT BAND 1 (upto 25% below EFI Q95)	NON-COMPLIANT BAND 2 (25 – 50% below EFI Q95)	NON-COMPLIANT BAND 3 (greater than 50% below EFI Q95)
ASB3 HIGH SENSITIVITY	<10%	(10% = 25%) <35%	(10% + 50%) <60%	(10% + 50%) >60%
ASB2 MODERATE SENSITIVITY	<15%	(15% + 25%) <40%	(15% + 50%) <65%	(15% + 50%) >65%
ASB1 LOW SENSITIVITY	<20%	(20% + 50%) <70%	(20% + 50%) <70%	(20% + 50%) >70%

Figure 31. Compliance Banding: % Deviation of flows for each compliance band, and related to supporting Good Ecological Status (after CaBA / CSRG, 2021). River Ems banding highlighted in green.

These results highlight that the Ems is not compliant with EFI, and looking at the allocated banding EFI Band 3, ASB2), suggests that flow is depleted by around 65% from Q95 flows, with high certainty that this is the case.

11.2 Ems Catchment History of Abstraction

A number of studies provide detailed accounts of the history surrounding the abstraction of groundwater from the river Ems including Holmes (2007), Entec (2006), Halcrow (1994). AMEC (2013) and Atkins (2022).

The first borehole in the catchment to be developed for public water supply was at the Woodmancote pumping station, which according to Holmes started many decades before the 1960s. Portsmouth Water have been operating since the mid-1850s, which suggests an historic remit for water supply, and there are numerous private wells in the catchment which were historically used for local provision (Mee, 1913).

The larger pumping station at Walderton was granted a licence to abstract up to 2 million gallons per day (9092m^3/day) in 1962, which was then increased three-fold to 6 million gallons per day by 1968 and remains the same today (2022), with an abstraction limit of 9954.55 M litres/year.

The licence issued in the late 60s required Portsmouth Water to augment the river if flow measured at the Westbourne gauge dropped below a specified level, and in recognition that there may be a risk posed to river levels downstream of the Walderton abstraction (Holmes, 2007). The augmentation process is discussed further below.

11.3 Water Abstraction Licenses

The Environment Agency provide data pertaining to each licensed abstraction, including the location of abstraction, maximum amount allowed, and the sector of the license holder. All groundwater abstractions taken from the Ems catchment by sector-type and size are shown in Figure 32 (map) and Figure 33.

License holders include Portsmouth Water (for potable supply), along with local farm enterprises and other businesses.

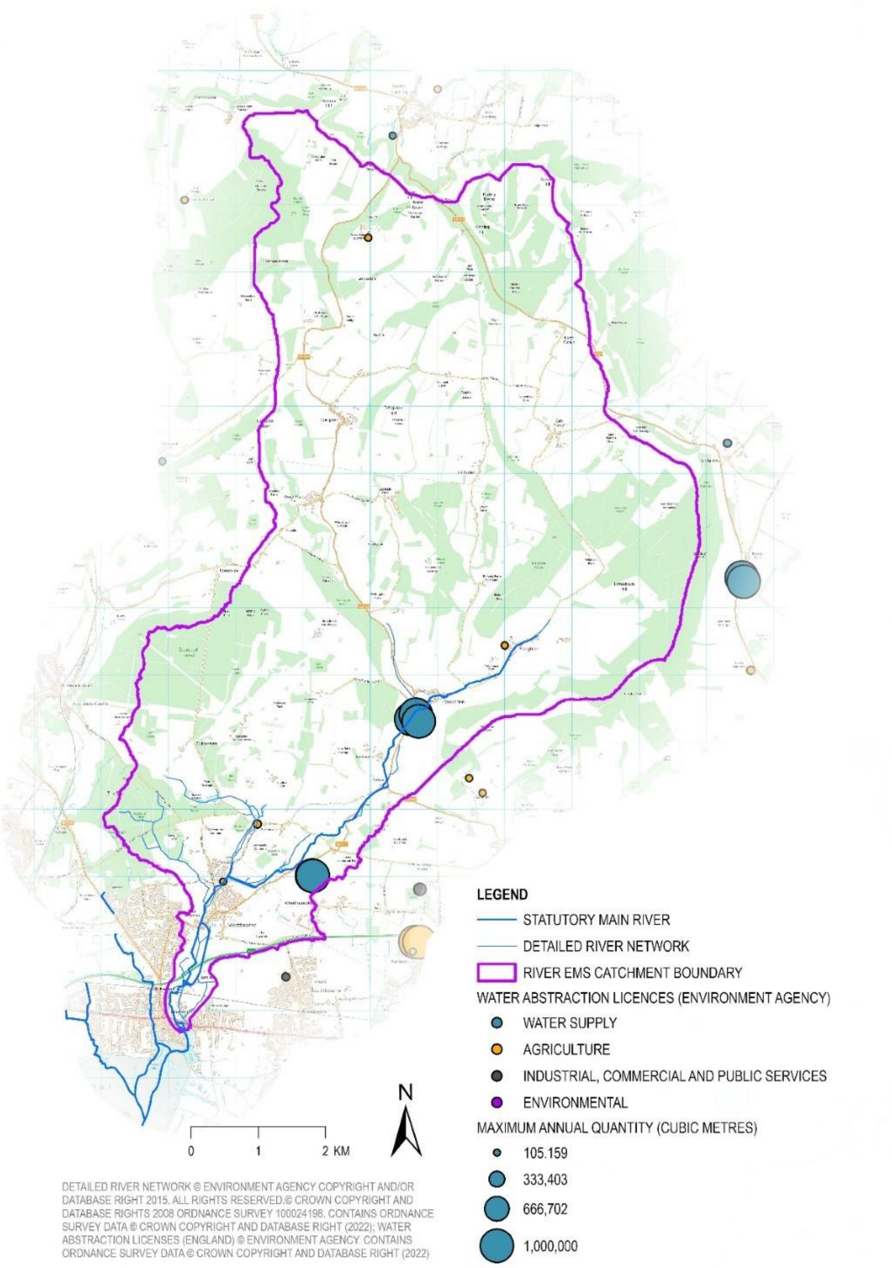


Figure 32. Map of Ems Catchment – Water abstraction licences by volume and sector (EA / CaBA)

The two abstraction points managed by Portsmouth Water comprise the vast majority of abstractions in the catchment. Water is abstracted from the Ems catchment under a group licence held by Portsmouth Water. This extends into the East Hants groundwater body, to the west of the Ems catchment, and across to the neighbouring river Lavant catchment in the east. Of the two abstraction sites the greatest proportion is taken from the Walderton Pumping Water

Station (PWS) which is located relatively close to the source of the Ems. A smaller quantity of groundwater is extracted by Woodmancote PWS, situated lower down the river, approximately 0.5km north of the village of Westbourne, and presently used exclusively for river flow augmentation during low flow periods (to meet requirements of the related abstraction license).

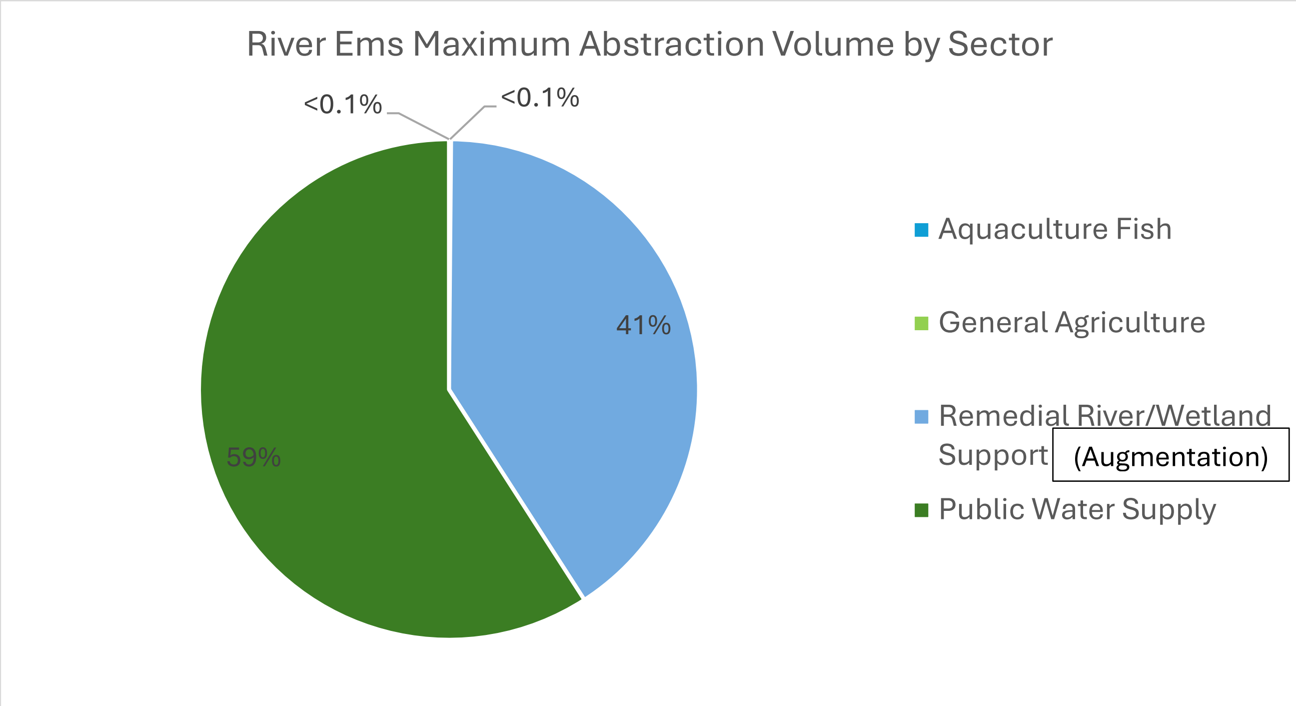


Figure 33. River Ems Maximum Abstraction Volume by Sector (EA / CABA)

It is important to note that the maximum license amount does not necessarily mean that the full license is being utilised. In terms of the Portsmouth Water abstraction licenses, Atkins (2022) provide an overview of maximum permitted amount versus actual use for period 2016 – 2020, shown in Figure 34. This suggests that for this period Portsmouth Water utilised approx. 25% of their licence maximum at Woodmancote, and around 74% of their maximum licensed limit at Walderton.

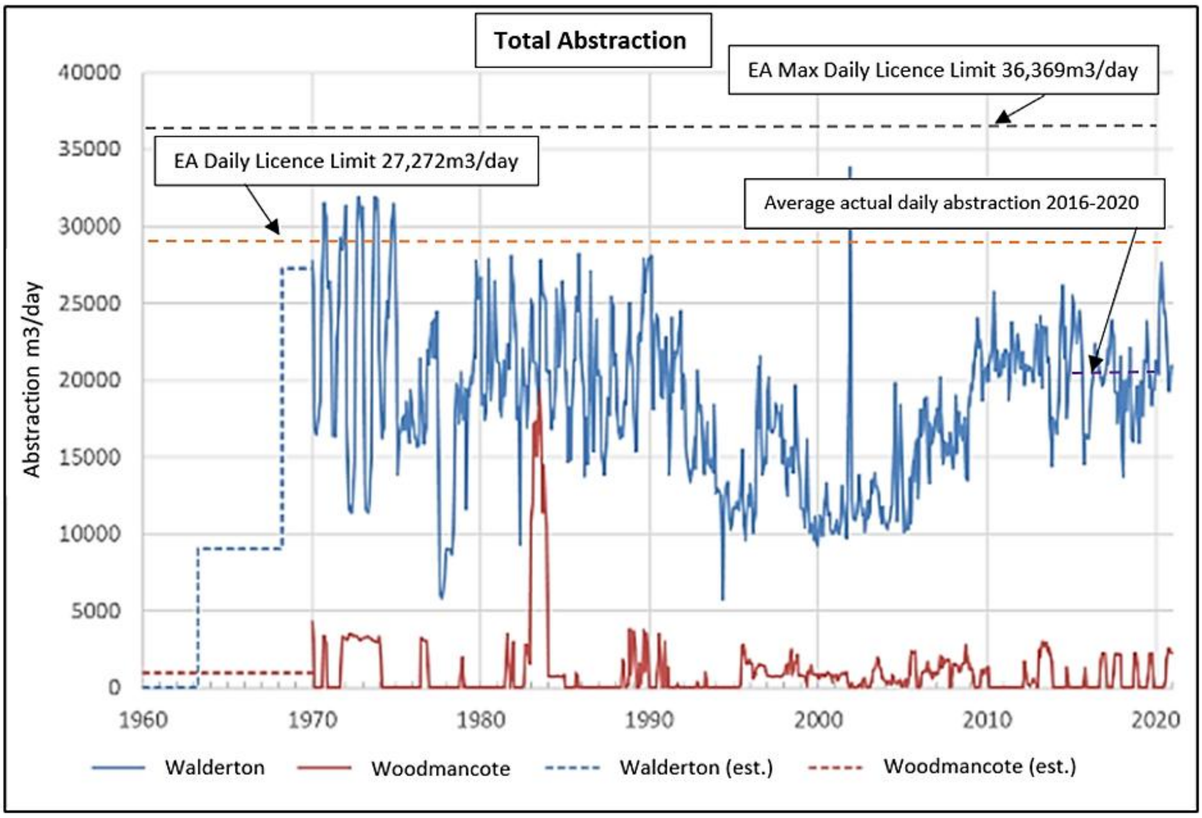


Figure 34. River Ems Catchment Licenced Abstractions (surface and groundwater) & Average Actual Daily Abstraction (from Atkins 2022)

Over the last decade, the UK Government has commenced plans to reduce licenced levels so that they align better with water availability and sustainable abstraction. Abstraction licences are also being changed to abstraction permits which may be time limited as well as having controls (on volume extracted) to protect the environment that relies upon the aquifer. Flow based controls to protect the environment will form part of the revised permits and are likely to reduce the amount of abstraction. This process is ongoing with an end date of 2025.

There is a growing recognition of the disconnect between historic licenced volumes and what river systems can now sustainably afford to supply, with ample evidence to suggest that this level of abstraction has and is reducing the length of perennial reaches, impacting on ecology and river health.

Both Portsmouth Water the Environment Agency acknowledge that current abstraction rates are negatively impacting the Ems and have made commitments to reducing abstraction to meet environmental need. This is currently under investigation with a view to reducing the license to support river ecology. It is yet to be agreed how much water is needed to provide ‘sustainable flow’ for the Ems (this is discussed further in section 11).

In order to meet their statutory obligations to supply clean and plentiful water for people, an alternative and reliable water source must be identified and developed, along with water saving measures. Given investigative timelines and procurement frameworks (including the national Water Industry National Environment Programme (or WINEP), this is likely to take decades to take effect, leaving the Ems vulnerable to the effects of drought and low water levels for the foreseeable future.

12. River Ems Flow Augmentation

As previously outlined the augmentation scheme is triggered when water levels drop below a certain level (currently 31l/s). The location of the augmentation point has changed over time. The first river Ems licenced augmentation system operated from 1968 to 2016. This involved extra water being discharged to the river Ems via a mains water pipe laid on the riverbed, immediately upstream of Watersmeet Canal at Westbourne. Importantly, the augmentation discharge point was located on the clay strata that overlays the Sussex Lambeth aquifer. The source of the augmented water was from Portsmouth Water's Walderton pumping station, drawing water from Chichester Chalk aquifer in the upper catchment, and comprised treated, chlorinated tap water at the point of discharge.

In 2015 a National Environment Programme (NEP) river improvement scheme for the Ems was successfully delivered by ARRT, supported by the Wild Trout Trust, EA and the Arun & Western Streams Catchment Partnership. This river improvement project involved restoring an ecologically poor ~300m section of the mid-Ems at Deepsprings and included relocation of the augmentation discharge point from Westbourne ~500m further upstream above Racton Dell wood, so that it would provide flow to the restored reach.

Figure 35. 'Before' and 'after' the Deepsprings enhancement works 2015 (Ses Wright).

In 2016 Portsmouth Water were subsequently issued a license variation from the EA which switched the source of augmented water from Walderton to Woodmancote pumping station, which was from a raw unchlorinated source. This source is also much closer to the river channel.

The EA variation was supported by the following augmentation rules:

- When non-augmented flow at the EA Westbourne gauge falls below 31 l/s (2678m3/day) there should be augmented flow of at least 25 l/s (2160m3/day) from the 'new' augmentation site upstream of Racton Dell wood, near the riverside cottages, taking abstracted raw water from Woodmancote pumping station.
- If thereafter augmentation river flow falls below 25l/s for 30 consecutive days, or if at any time augmented flow falls below 15l/s (1296m3/day), augmentation from Woodmancote should stop and be replaced by discharge of at least 13l/s (1123m3/day) from Walderton via the old discharge point (NGR SU 76290-07830).
- Augmentation from whichever borehole should continue until 'natural' flow at the EA Westbourne gauge exceeds 38l/s (3283m3/day).

Of note is the requirement in the revised license to replace the augmented supply source from Woodmancote back to the original Walderton (chlorinated) source and discharge point when flow dropped below 15 l/s.

The change in the source of augmented flow from Walderton to Woodmancote also changed the source from treated (chlorinated) water to an unchlorinated source. Chlorinated water can have a negative impact on chalk stream ecology (Salmon & Trout Conservation Trust, 2017) which is increased when dilution is less – as is the case in the low flows which trigger augmented flows. For this reason the Environment Agency were keen to utilise an untreated source.

The change in location of augmentation source and discharge points to the river over time is illustrated in Figure 36.

Once the new augmentation site at Racton commenced in 2016 it became increasingly clear that in some years a high proportion of the augmented flow was not reaching the Westbourne gauge, and in excess of the loss that would generally be expected (i.e. loss to evaporation or groundwater). When compared to pre 2016 data, this also highlighted that at very low flows (i.e. Q95) there is less water in the river after 2016 (Atkins, 2022).

The reasons for this loss are subject of further investigations but are attributed to the highly complex hydrogeology around Racton, which is at the interface of two distinct aquifers and the start of the clay layer that overtops them. When positioned on the clay layer (as was the case at the previous augmentation point at Westbourne) water remains on the surface within the river channel, whereas further upstream at Racton augmented flow drops through into groundwater.

Atkins have been working with Portsmouth Water to investigate the hydrogeology related to the augmentation in order to identify the best location to keep water in the river channel (and ultimately register at the only gauge at Westbourne). Their investigations were expanded via a hydrometric network to provide additional ground and surface water data to help understand the wider abstraction pressures and supported on the ground by Friends of the Ems. This work is currently ongoing.

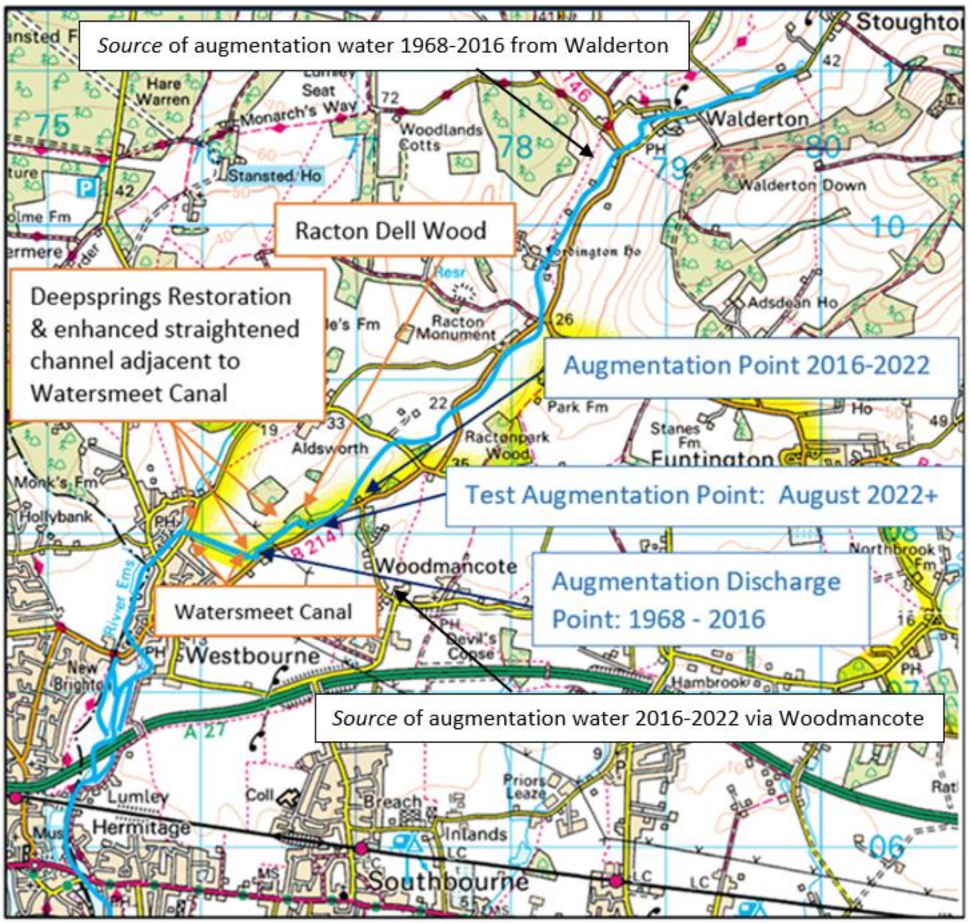


Figure 36. Map showing location of the Ems augmentation discharge points over time.

There does not appear to be a strong pattern of when augmentation commences, varying from July (2017) to August (2019, 2020) and September (2016, 2018) and is likely to reflect seasonal weather and responding hydrological variation and groundwater abstraction.

In years where the ground water levels are suitably recharged to support flow, the augmentation is not triggered. There have also been a couple of occasions in recent years when the augmentation has failed, leading to reports of dead and stranded fish.

The Atkins report neatly summarises the benefits of flow augmentation, and indirectly the impact of abstraction, noting that modelled naturalised flows (i.e. no abstraction) at low-flows (Q95) above the point of discharge at Foxbury Lane, Westbourne, is about 4000m3/day, and in all scenarios with abstraction at Walderton, low flow (at Q95) is zero (Pg 29), and confirms that modelled natural low-flows are depleted by ~70% due to abstraction at Walderton.

It is also worth noting that the augmentation point at Racton sits within Reach 2 which runs from Westbourne to Broadwash Bridge, and which should be perennial, as suggested by various studies and the EHCC model, and supported by findings from our River Ems Condition Assessment (2022). Any future reduction in the Portsmouth Water abstraction license should prioritise return of perennial flow to Reach 2, and lower sections of Reach 1, ensuring that groundwater levels are sufficient to support surface water stream flow, year-round. This would reduce the need for augmentation. The reductions needed to achieve this will be large, and it is still unclear how and when this will be achieved.

The main gauging station on the Ems is situated in Westbourne. This is used to assess if the augmented flow remains in the channel. It should be noted that on occasion, even during the augmentation periods, sections of the river below here are dry. There is ample evidence of how river flow can disappear below ground due to low groundwater levels and complex geology, including the loss of augmented flow from the post 2016 discharge point, and by the loss of flow in the Aldsworth stream below Brickkiln ponds. Further gauging points and investigations around flow and geology downstream of Westbourne would help to understand this complex system and ensure the river had more water.

See Section 11.1 'Assessing Sustainable Abstraction' for further discussion around abstraction and methods to assess the amount of water needed to support and sustain river ecology.

13. Water Quality

Water quality is affected by a range of above ground activities such as how the land is managed or the extent of urban development and driven by natural erosion and weather processes. Clean water is not only vital for river health - but polluted water also demands more treatment, making it more expensive for the consumer.

A range of data are available from the EA via their (Water Framework Directive (2000) assessments), Portsmouth Water and others. Regulatory testing for a range of water quality is regularly undertaken by Portsmouth Water for their Walderton supply area. Relating data (Portsmouth Water, 2021) suggests that currently samples meet the Regulatory Standards for drinking water.

13.1 Consented Discharges

Unlike other river systems, the Ems is not impacted by large Waste Water Treatment Works, the nearest being outside of the catchment boundary, downstream at Thorney Island. There is however a Southern Water pumping station at Lumley (discharging less than 10 times per year), and a number of properties which are not on mains drainage, instead having a Small Sewage Treatment Works or isolated septic tanks. Maintenance of both are the responsibility of the landowner.

In many river catchments across the UK these private sewage treatment systems are a cause of pollution, due to lack of maintenance and regulation. Detailed maps of properties not on main drainage are not widely available, although related discharge permits should be in place. Other supporting water quality data suggests that properties that are not on mains drainage are not having a consistent or disproportionate impact on water quality, however this situation will need continual review.

Under the Environmental Permit Regulation specific discharges into the any river or waterbody must have a permit from the Environment Agency and covering all controlled substances. Information on each permit is held on the Environment Agency's Public Register.

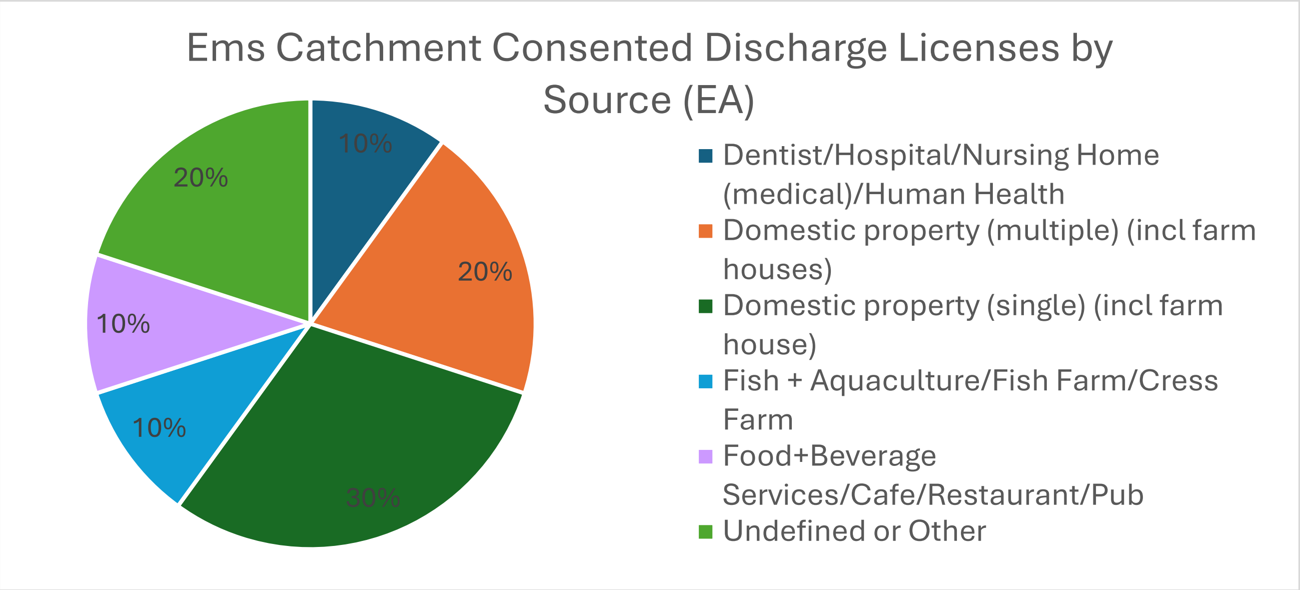


Figure 37. River Ems Consented Discharge Licenses by Source (Environment Agency).

The greatest proportion of discharges into both freshwaters (i.e. surface water), and groundwater is attributed to treated effluent from non-water company sources (i.e. small sewage treatment works, septic tanks etc) which accounts for 59% of freshwater discharges, and 92% of groundwater discharge.

In terms of Freshwater the next most influential discharge is from Trade relating to process effluent (water used in production) accounts for 17% of the total. (See Figure 38 (Freshwater) and Figure 39 (Groundwater) below).

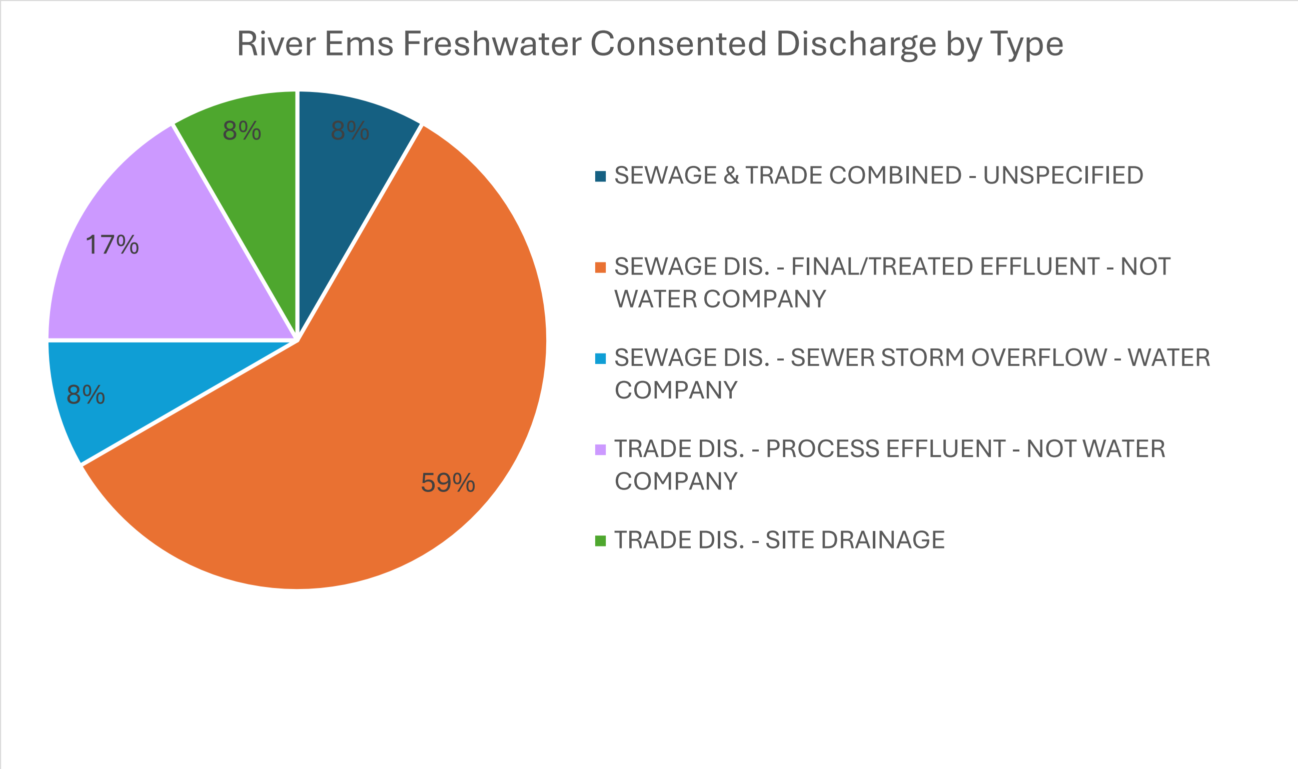


Figure 38. River Ems Consented Freshwater Discharges by Type (EA).

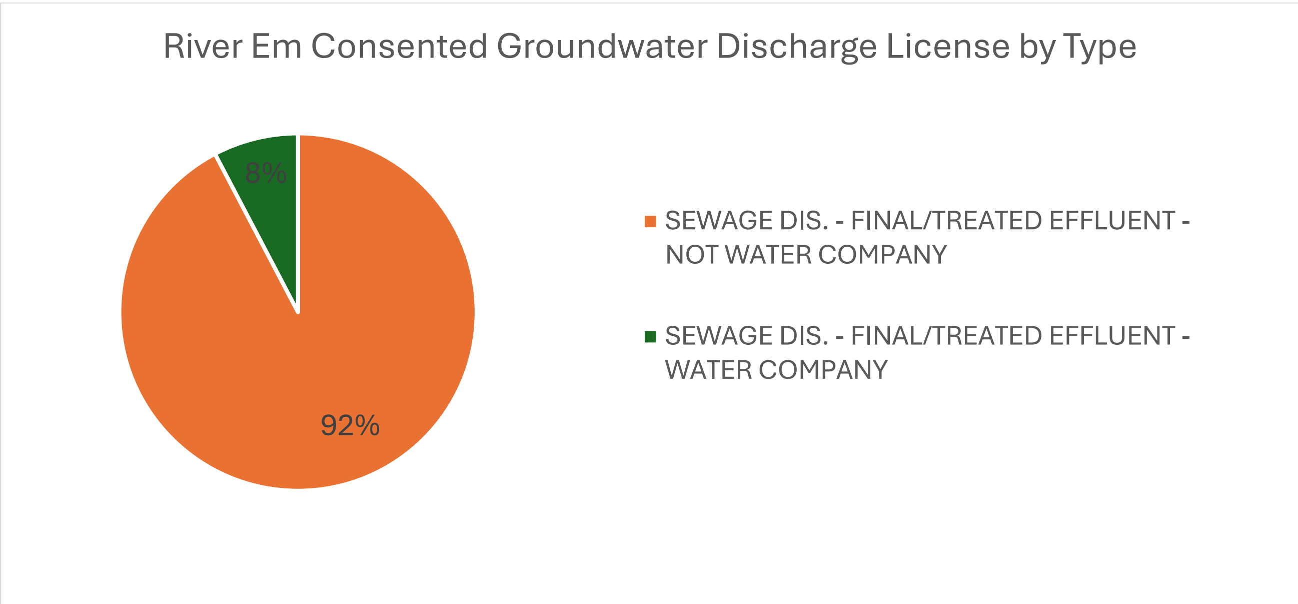


Figure 39. River Ems Consented Groundwater Discharges by Type (EA).

13.2 Environmental Pollution Incidents (Category 1 & 2)

Details of environmental incidents within the remit of the Environment Agency are held on the National Incident Recording System (NIRS2). This dataset only includes substantiated, completed and closed Environment Management incidents (predominantly pollution), where the environment impact level is either category 1 (major) or category 2 (significant) to at least 1 media (i.e. water, land or air). It is updated quarterly and provides a snapshot of data held in NIRS2. There is an inherent lag time in investigating and recording the necessary incident details to complete a record and recent incidents may not appear.

According to available EA data, there are six recorded incidents, all of which were Category 2 (significant) incidents, all at the same location on the lower Ems. The pollutant is recorded as 'Other' and as such further investigation would be needed to understand potential for future occurrence.

It should be noted that where these data indicate an incident occurred on a particular site or property this does not necessarily mean that the property owner was responsible. Equally not all incidents are reported or recorded.

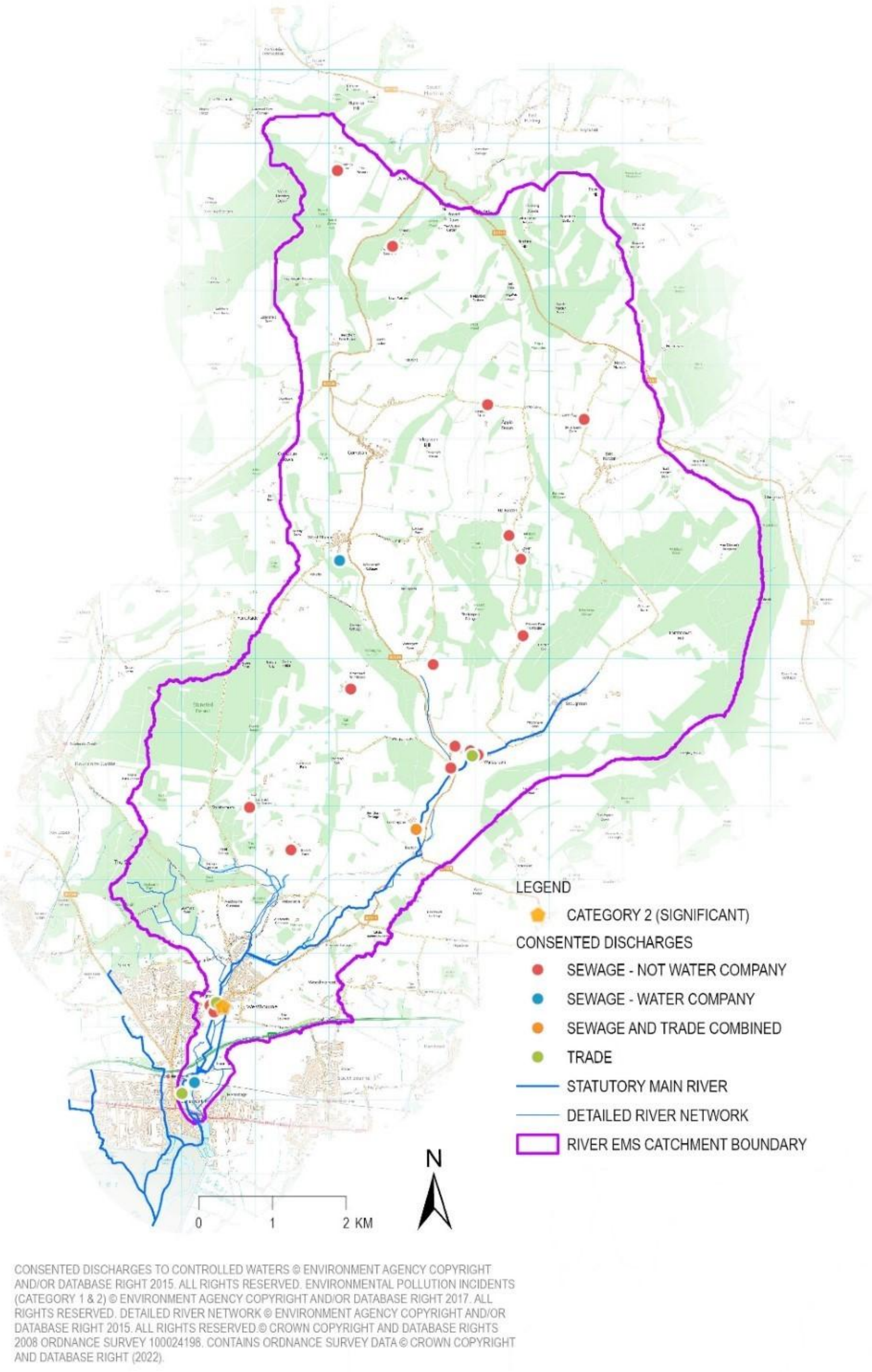


Figure 40. Ems Waterbody – Consented Discharges and Cat 1&2 Pollution Incidents (Environment Agency).

13.2.1 Nitrates & Phosphates

Phosphates and nitrates are useful nutrients for plant growth, but in high concentrations can have a negative impact on water quality.

These inputs are of particular concern in areas of permeable chalk geology, and within estuaries and semi enclosed harbours (e.g. Chichester Harbour). Areas where control of nitrates are critical to water supply have been designated as Nitrate Vulnerable Zones, details of which can be seen in later in this section, along with other water protection areas.

Phosphates and nitrates come from a range of sources including sewage and agricultural waste, and fertilisers. In high concentrations they can increase the rate of oxygen use in water, leading to eutrophic conditions ripe for algal and bacterial growth, and lowering oxygen and light levels vital for fish and other aquatic species.

In terms of the aquifer, above ground farming practices, particularly in the 1970s, increased the amount of nitrate seeping into groundwater. Although regulation has been strengthened to reduce these impacts, it can take decades for water to infiltrate through the chalk in some areas, which means there is a time lag in terms of its effect on water quality.

Portsmouth Water are part of a collaborative partnership project called the Downs and Harbours Clean Water Partnership, which provides advice and grant funding to support for farmers and others to use sensitive practices to reduce nitrate load.

13.2.2 Cryptosporidium

Cryptosporidium is a very small protozoan parasite which is found in many 'hosts' including birds, fish and mammals. In humans it can cause severe sickness and diarrhoea particularly in the young, elderly and immuno-compromised. Even very low-level doses can be sufficient to cause infection. It is transmitted from unwashed fruit and vegetables, swimming pools and water supplies (Portsmouth Water, 2023).

Cryptosporidium has been recorded historically at the Woodmancote borehole. Additionally during the course of the development of this report it was also recorded at PWs Funtington borehole which is outside of the Ems catchment area. The complex hydrogeology across the area does raise concerns that this will spread to other local sources via groundwater or fissures in the underlying geology.

14. Water Designations

14.1 Water Framework Directive 2000 (WFD)

The main assessment of water quality and quantity is undertaken by the EA, to meet regulatory requirements of the European Water Framework Directive (2000). This demands all waterbodies attain 'good' or 'improving' status and is assessed using number of periodic surveys covering ecological, chemical and water quantity elements of the waterbody. We are currently in the third (2021 – 2027) of the 6-year WFD cycle. Under this assessment if the waterbody fails on one element, the whole waterbody is considered to fail.

An overview of the 2019 WFD can be found in Appendix 5.

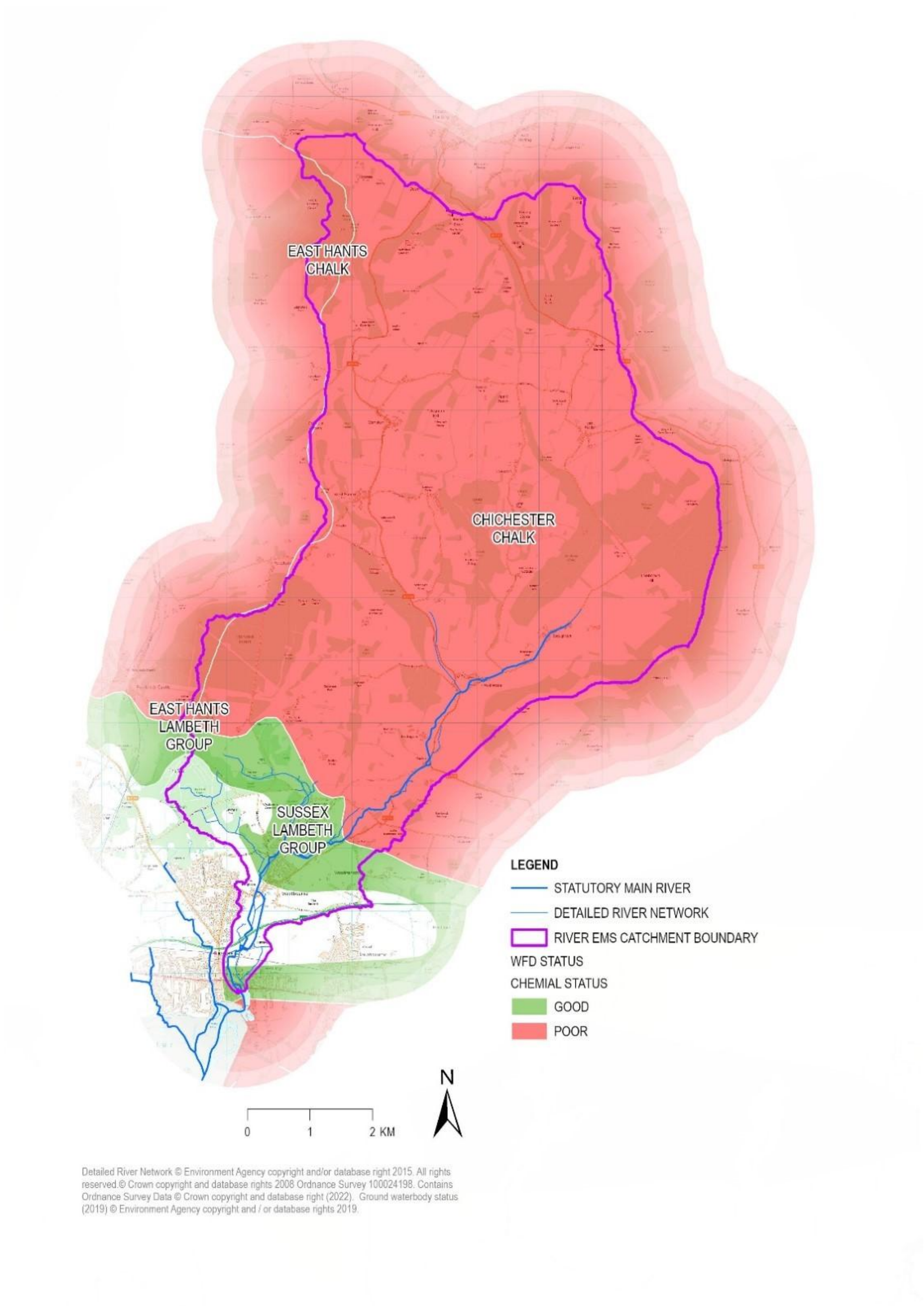


Figure 41. Water Framework Directive – River Ems waterbody status (Environment Agency).

14.1.1 WFD Groundwater status

The most recent WFD assessment (dated 2019, WFD Cycle 2) indicates that the Chichester Chalk and East Hants Chalk groundwater bodies (which together cover 88% of the Ems catchment), are of 'Poor' overall status, with 'Poor' chemical status and 'Poor' quantitative status.

EA's Dependent Surface Water Test dictates 'If the extent of *surface* waterbodies (*i.e.,* rivers) overlying a ground waterbody are of sufficiently poor status, then that groundwater body is also classified as 'Poor'. These two groundwater bodies cover the large areal headwaters of the river Ems, downstream to the mid-reaches around Westbourne.

14.1.2 WFD Ecological Status

The latest survey data from the EA indicates that the river Ems fails to achieve good ecological status and is categorised as 'Poor' as shown in Figure 42.

'Reasons for Not Achieving Good' status (RNAG) are listed as:

Flow. Groundwater abstraction by water company attributed to failure relating to lack of flow and related impacts on fish and invertebrate communities.

Physical Modification. Man-made river and bank structures (mills, dams, flood defences, historic buildings) attributed to failure for fish passage, Dissolved oxygen, and invertebrates.

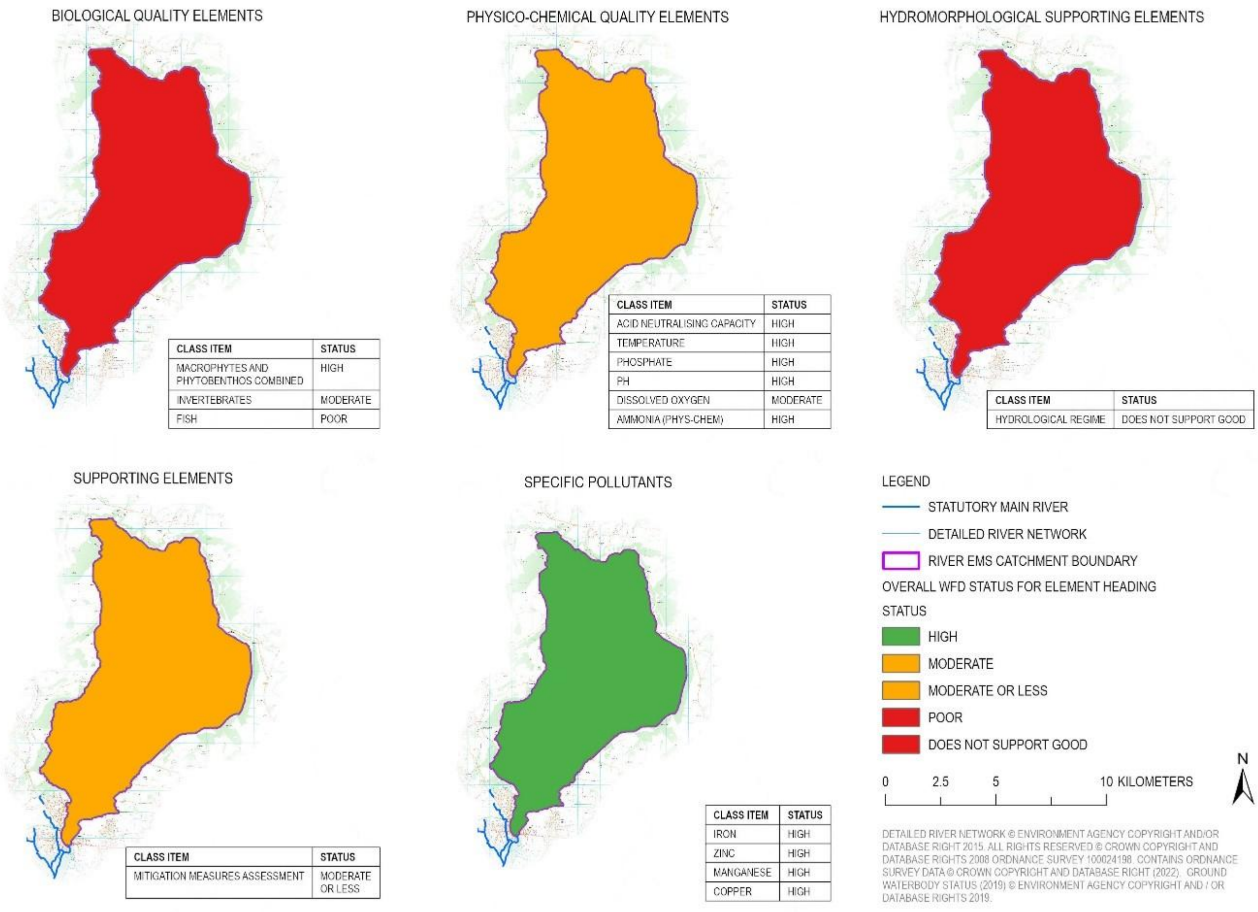


Figure 42. Water Framework Directive – River Ems waterbody status (Environment Agency / CABA)

Currently invertebrates are classified as ‘moderate’ which is of concern as they are an indicator of potential ecological stress.

We are currently within the third WFD cycle, with all three cycles having shown no improvement for the river Ems’ overall ecological status.

14.1.3 Hydrological Regime

As we have outlined in the ‘Water Quantity’ section of this report, the Ems is impacted by lack of flow, and the WFD assessment and EFI recognises this as impacting the ecology of the river.

Until action is taken to resolve the excess abstraction the Ems will continue to fail this element of WFD.

14.1.4 Physical Modifications

Physical structures in the river– many of which are historic man-made structures, can significantly impact upon fish populations and reduce connection to their spawning grounds. They also disrupt natural-flow dynamics, in some places acting as pinch points and increasing local and upstream flooding.

There are a number of in-river structures which are limiting fish passage on the Ems, some (but not all) have been mapped and assessed by the EA and shown in Figure 43. In addition our walkover survey identified a number of other barriers which warrant further investigation.

Two major barriers on the Ems are Lumley Sluice, and Westbourne Mill. Lumley Sluice, an Environment Agency asset, has a function to reduce flooding, with an automatic sluice gate. It has been noted that on occasion that the operation of this sluice has dried the main channel below the structure, a place where Sea Trout are known to spawn. At Westbourne Mill flow pathways are disrupted by the mill pound and related infrastructure, limiting fish passage.

The impact of these in-river structures on river dynamics is increased during lower river flows.

Figure 43. Ems Barriers to fish passage (Environment Agency).

There are significant modifications to the river channel, mostly focused around Emsworth and Westbourne, including channel straightening, sections of river being moved or changed, and bank sides dominated by urban development. In many places there is little than can be done to re-naturalise the river. An assessment of modifications can be seen in the document River Ems Condition Assessment (available from WSRT).

14.1.5 WFD Chemical Status

From 2019 the EA changed their monitoring and evidence to include additional assessment of uPBTs (ubiquitous, persistent, bioaccumulative, toxic) substances. These mainly consist of legacy chemicals used in fire retardants, non-stick and water-repellent commercial products. Although these substances are now largely restricted in the UK, they are almost impossible to remove from water, and barely detectable. They can however bioaccumulate in fish and other aquatic species. It is expected that these pollutants will naturally dissipate in time. As such this element is subject to WFD natural conditions extension, allowing more time (until 2027) to pass this assessment. Prior to the additional 2019 uPBT update, the Ems Chemical Status was recorded 'good' from 2013 to 2016.

14.2 Other Designations

14.2.1 Nitrate Vulnerable Zones/NVZ (set by The Secretary of State)

Nitrate vulnerable zones (NVZ) are areas designated as being at risk from nitrate pollution linked to agriculture. They cover approximately 55% of land in England.

The Ems catchment has two NVZs that are certified for the following reasons:

i. to protect the nationally and internationally designated Chichester Harbour that is suffering from eutrophication due to excess nitrate levels.
ii. to safeguard groundwater aquifers that supply drinking water and are similarly challenged by high nitrate levels in the Ems catchment.

The two NVZ's operating across the Ems catchment are shown in Figure 44. It is important to note that the role of NVZs is to prevent existing and further deterioration caused by excess nitrate levels in groundwater.

The concentration of nitrate in the surface water of the Ems is not currently considered to be a problem from a drinking water viewpoint.

14.2.2 Drinking Water Protected Areas (set by the Water Framework Directive)

Under WFD any waterbody used for drinking water supply are protected. This includes groundwater and surface water supply areas such as reservoirs. Drinking water safeguard zones help to further protect groundwater sources and reduce associated costs associated with water treatment.

In order to protect these areas the EA and water companies have created Safeguard Zones – non-statutory areas where raw water sources are at 'risk' from certain land management practices could pollute the source. These help to highlight and prevent activities that risk polluting and damaging the quality of sources of drinking water, for example, highly turbid groundwater that can arise from agricultural and road runoff can damage water company abstraction pumps and disrupt supply. These Safeguard Zones are further separated into 'groundwater' and 'surface water'.

Much of the river Ems catchment is largely outside of drinking water safeguard zones (see Figure 44). This reflects the absence of a sewage treatment works along the river Ems, the majority of farms being arable-based, and a relatively high percentage (~30%) of woodland cover across the catchment.

14.2.3 Source Protection Zones (set by The Environment Agency)

Source Protection Zones highlight areas where activities which may risk or pollute groundwater is at risk of drinking water contamination, which could arise from potential polluting activities that fall within a certain distance of water-abstraction points.

Areas that source drinking water from the ground are divided into three SPZs as follows:

- SPZ1: Inner groundwater source protection zone (red): defined as the 50-day travel time from any point below the water-table to the drinking water supply source. The zone has a minimum radius of 50 metres from the groundwater source.
- SPZ2: Outer source protection zone (green): defined by a 400-day travel time from a point below the water-table to the source, dependent on the abstraction size.
- SPZ3: Source catchment protection zone (blue): defined as the area around the supply source within which all groundwater is presumed to drain and arrive at the abstraction point.

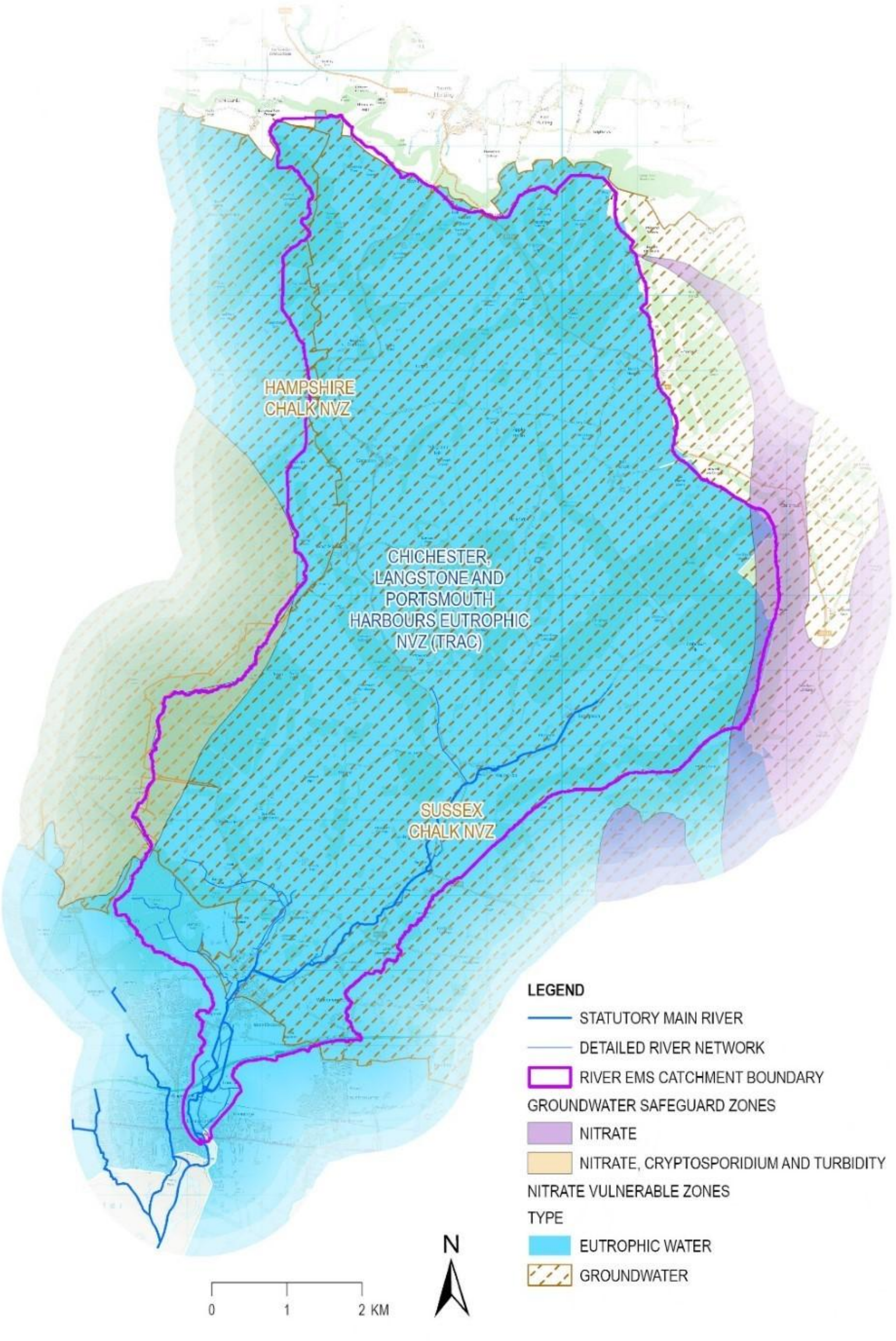


Figure 44. Map showing Ems catchment water protection zones (Environment Agency / CaBA)

15. Further Reading

This document has provided an overview of the history, ecology and hydrology of the catchment, identifying key pressures and impacts. This work, along with the Rivers Ems Condition Assessment (2022) informed the development River Ems Restoration Plan 2024-2034. The documents are designed to be read together for a full appraisal of the catchment and planned work. The Rivers Ems Condition Assessment (2022) and River Ems Restoration Plan 2024-2034 are both available by request from WSRT.

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15. Appendices

Appendix 1 River Ems Community Questionnaire – sample of comments.

- Definitely lower flows 'on average'
- The river bed is dry !!!!!!
- There has been very little water in it this year, due to abstraction. Less water means less habitat for wildlife.
- It now dries up at the northern end of Westbourne in the summer with low flow elsewhere.
- Lack of water has been most noticeable issue
- Variable water flows, incl. complete dry out of sections below Lumley Mill
- Simple, No River
- Longer periods of the year when flow ceases or reduces significantly. 20 years ago the flow was predictably good between Oct and May.
- River is either lower or dry for longer periods of time
- A reduction in the flow of water particularly marked in the last 3-5 years.
- Seriously depleted water levels and flowrate in prolonged periods of dry weather
- Dried out reach at Brook Meadow (summer 2022). Very low shallow flow, very little velocity around Lumley Stream and main channel up & beyond Westbourne
- River drying up further and further downstream year on year
- Water voles have disappeared
- Fewer fish and invertebrates in 2020 & 2021 compared to 2017
- Less wildlife. Dead fish.
- Far less birdlife. I heard a bittern a few years ago, nothing since. Swans have vanished, fish disappearing
- Fish are no longer visible at Lumley mill; very few birds seen long River street
- When we moved to Westbourne 30 years ago the river contained trout, eels and was regularly inhabited by ducks, moorhens and coots and their young. I have not seen any in the last 10 years
- Lack of little fish i.e. spicklebacks
- No water where the local geese can swim or feed, likewise wild moorhen and coots and No fish. Vastly reduced numbers of insects and birdlife
- No fish, no kingfishers, moorhens is a massive reduction in biodiversity.
- No trout
- Very short time of water staying. Not long enough for wildlife to reproduce
- I no longer see Water Voles. I was a regular observer in 2008

Appendix 2. Underlying geology in the Ems catchment, BGS (from Atkins 2022).

Former name	Modern name	Total thickness	Lithological description
-	London Clay Group	90-120 m	Silty clay and sand, including: Bognor Sand Member, a glauconitic fine- to medium-grained sand
-	Lambeth Group	30-40 m	Mottled clay, locally sandy
Upper Chalk	Spetisbury Chalk Member	40 m	White chalk with flints
	Tarrant Chalk Member	30-40 m	White chalk with flints
	Newhaven Chalk Member	50-75 m	White chalk with flints and many thin marl bands
	Seaford Chalk Member	55-80 m	White chalk with flints
	Lewes Nodular Chalk Member	35-75 m	Hard, nodular chalk with flints.
Middle Chalk	New Pit Chalk Member	25-35 m	White chalk with many thin marl bands
	Holywell Nodular Chalk Member	15-35 m	Hard, nodular chalk, some shelly. The Melbourn Rock is at the base, comprising dense flint bands and hardgrounds.
Lower Chalk	Zig Zag Chalk Member	40-60 m	Grey chalk
	West Melbury Marly Chalk Member	10-35 m	Marly chalk and thin limestone
-	Upper Greensand Formation	28-30 m	Fine-grained glauconitic clayey sands and sandstone
-	Gault Formation	80-95 m	Calcareous and silty mudstones

Appendix 3. Superficial deposits in the River Ems Catchment (from Atkins, 2022)

Formation	Lithological description, and distribution
Head	Variable deposits of sandy silty clay, locally gravelly; chalky and flinty in dry valleys. Present on sides of the valleys when on Chalk outcrop, across the lower part of the catchment when on clayey bedrock.
Clay-with-flints	Clay with numerous nodular and well-rounded flints; derived from in-situ weathering of the Lambeth Group overlying the Chalk. Present mostly on the hilltops between dry valleys.
Alluvium	Clay, silt and sands, locally organic, with gravel. In the valley bottoms where there are (or were) watercourses.
Alluvial fan deposits	Clayey gravel. Not present in the catchment area, but downstream of Funtington in the south east of Figure 5-3.
River terrace deposits	Sand and gravel, typically thin. Overlying clayey bedrock in the south of the catchment.
Beach & tidal flat deposits	Silty and sandy clay with sand and gravel. Overlying clayey bedrock in the south of the catchment.
Raised marine deposits	Silt and silty sand, Overlying clayey bedrock in the south of the catchment.
Raised storm beach deposits	Gravel and gravelly sand, Overlying clayey bedrock north west of Westbourne.

APPENDIX 4. RIVER EMS UK PROTECTED SITES AND AREA OF COVERAGE (HA) (NATURAL ENGLAND).

Site Name	**Category**	**Level of Importance**	**Total Area (ha)**	**Total Coverage within Ems Catchment**
Kingley Vale	SAC	International	204.37	43.9
Pads Wood	SSSI	National	22.24	22.24
Harting Downs	SSSI	National	336.34	177.5
Kingley Vale	SSSI	National	204.37	43.6
Kingley Vale	NNR	National	147.9	5.85
Brook Meadow (Emsworth)	LNR	Local	3.944	3.94
Harting Down	LNR	Local	206.59	150.88

Appendix 5. Cycle 2, 2019 Water Framework Directive Assessment – River Ems Waterbody

Classification Item	2019
Ecological	Poor
Biological quality elements	Poor
Fish	Poor
Invertebrates	Moderate
Macrophytes and Phytobenthos Combined	High
Macrophytes Sub Element	High
Physico-chemical quality elements	Moderate
Acid Neutralising Capacity	High
Ammonia (Phys-Chem)	High
Dissolved oxygen	Moderate
Phosphate	High
Temperature	High
pH	High
Hydromorphological Supporting Elements	Supports good
Hydrological Regime	Does not support good
Supporting elements (Surface Water)	Moderate
Mitigation Measures Assessment	Moderate or less
Specific pollutants	High
Copper	High
Iron	High
Manganese	High
Zinc	High
Chemical	Fail
Priority hazardous substances	Fail
Benzo(a)pyrene	Good
Cadmium and Its Compounds	Good
Dioxins and dioxin-like compounds	Good
Heptachlor and cis-Heptachlor epoxide	Good
Hexabromocyclododecane (HBCDD)	Good
Hexachlorobenzene	Good
Hexachlorobutadiene	Good
Mercury and Its Compounds	Fail
Perfluorooctane sulphonate (PFOS)	Good
Polybrominated diphenyl ethers (PBDE)	Fail
Priority substances	Good
Cypermethrin (Priority)	Good
Fluoranthene	Good
Lead and Its Compounds	Good
Nickel and Its Compounds	Good
Other Pollutants	Does not require assessment