Peatlands of Cheshire West and Chester

An Assessment of Greenhouse Gas Emissions and Biodiversity

September 2023

Acknowledgements

This report was commissioned by Cheshire West and Chester Council (CW&C) as a baseline report in support of the Council's Climate Emergency Response Plan, which recognises that changes in land-use can provide reductions in carbon.

The Peatlands of Cheshire West and Chester (CW) was produced by Rachel Giles (Evidence and Planning Manager), Amelia Airey (Conservation Officer at Cheshire Wildlife Trust), Ross Harding (Nature Based Solutions Programme Manager at Cheshire Wildlife Trust), and Joe Phillips (Senior Planning & Advocacy Officer) with valuable input from the following individuals:

Jo Kennedy (Lancashire Wildlife Trust), Linda Edwards (Natural England), Hannah Cliverd (UK Centre for Ecology and Hydrology) and Paul Henshall (Forest Research).

Cover Image: Sphagnum moss at Delamere Forest © Claire Huxley (Cheshire Wildlife Trust)

For more information contact:

Cheshire Wildlife Trust,
Bickley Hall Farm,
Bickley,
Malpas,
SY14 8EF
01948 820728
info@cheshirewt.org.uk

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Executive Summary

This study provides a desk-based collation of the best available evidence of the extent, condition, greenhouse gas (GHG) emissions and biodiversity value of Cheshire West and Chester (CW) peatlands and should be read with reference to the accompanying GIS dataset: "*Cheshire West Peatlands - CWT_region.shp*".

There are approximately 3,033 ha of deep peat across CW, representing around 0.5% of the national extent. The vast majority (95%) of CW's peatlands are in a drained condition and therefore emit 52,472 tCO2e yr^{-1}. Around 73% of total CW peatland emissions (equivalent to nearly 40,000 tCO2e yr^{-1}) occur as a result of agriculture, yet this only accounts for 47% of the peatland extent. Rewetted fens make up the largest area of the semi-natural condition categories (110 ha or 4% of the peat extent), however these habitats still emit a very small amount of GHGs (366 tCO2e yr^{-1} or less than 1% of total annual emissions). Only 11 ha (0.4%) of CW's peatlands currently sequester carbon, providing a saving of 3.82 tCO2e yr^{-1}, equivalent to 0.01% of the total CW peatland emissions. Over half of the borough's deep peats are designated for nature conservation (1,714ha or 57%), with the vast majority being non-statutory designations.

The agricultural use of lowland deep peats is the largest source of peatland emissions across the borough, with nearly half of the peatland extent contributing three quarters of the total emissions. These areas represent the most significant opportunities for emissions avoidance through the implementation of sensitive management regimes and restoration. This confirms the statement in the Climate Emergency Response Plan which states that agriculture is to be an area to target emission reductions (CW&C 2019). Restoration of all intensive grasslands on deep peat across CW back to rewetted fen would result in an emissions' saving of 17, 192 tCO2e yr^{-1}, equivalent to a 32% reduction in total CW peatland emissions. To avoid potentially permanent emissions the extraction and development of peatlands should be stopped immediately across CW.

Targeted restoration of drained deep peat in close proximity to existing semi-natural peatland habitat, or sites designated for nature conservation, can have significant benefits in terms of reducing emissions and improving biodiversity value. Moreover, protecting existing semi-natural peatland would again benefit biodiversity and limit carbon emissions. Tree planting on areas of deep peat or in areas that have the potential to affect the hydrology of a peatland is inappropriate and should be stopped immediately.

Achieving the targets set out in the Climate Emergency Response Plan (CW&C 2019), Carbon Management Plan (CW&C 2023), Sixth Carbon Budget (CCC 2020), or setting further specific targets for the borough, would result in a significant reduction in peatland GHG emissions and substantial benefits to biodiversity, flood management, and water quality across the borough. Peatland restoration provides very high value for money green infrastructure improvement. However, there are likely to be significant barriers to restoration at the scale required. The formation of effective and inclusive stakeholder partnerships to access new funding, alongside the development of strong local policy, will be vital to influence and support landowners to adopt a more sustainable approach to peatland management, while protecting the cultural identity and heritage of these land-use sectors.

Background

Peatlands are a wetland ecosystem where a net accumulation of organic matter, known as peat, occurs as a result of waterlogging (Gregg *et al.* 2021). However, the term 'peatland' is also used to describe the physiographic, geomorphological, ecological, and biogeographical setting of peat (Bonnett *et al.* 2009). Peatlands can be classified into two major types; bogs (generally rain fed and nutrient poor) and fens (generally fed by surface or ground water and more nutrient rich) (Parish *et al*. 2008). Peat itself is formed of the remains of a range of wetland plants and mosses that build up under almost permanently waterlogged conditions (Natural England 2010). The rate of primary production exceeds the rate of organic matter decomposition, which is limited as the result of a high water table, leading to an accumulation of peat (Kivimäki *et al*. 2008). This process gradually locks carbon into the soil, with peat typically accumulating at a rate of around 0.3 – 2 mm per year depending on conditions (Gregg *et al.* 2021). Peatlands are therefore areas of land characterised by an organically accumulated layer of peat, although the term peatland also encompasses the whole ecosystem including the soil layer and the habitat it supports (IUCN 2018).

Peatlands can be naturally forested, or more open and vegetated with a diverse range of mosses and sedges. The term applies both to areas where peat is actively forming, known as mires, and areas where peat formation has stopped due to human intervention or changes in the climate (Parish *et al*. 2008). Expanding international consensus defines peat soils as "a wetland soil composed largely of semi-decomposed organic matter deposited in-situ, having a minimum organic content of 30% and a thickness greater than 30 cm." (Finlayson & Milton 2016). In the UK national peat depth definitions differ slightly; expanding to a thickness greater than 40 cm in England and Wales (which has been used for the purposes of this report) and 50 cm in Scotland and Northern Ireland (Evans *et al.* 2017).

Peatlands are present on every continent, ranging from tropical swamps in Southeast Asia through to tundra permafrost across Canada and Russia; they cover approximately 3% of global land surface (IUCN 2017). Peatlands represent the largest natural terrestrial store of carbon on Earth (IUCN 2017). Near natural peatlands store more than 550 gigatonnes (550,000,000,000 tonnes) of carbon and sequester an additional 0.37 gigatonnes of carbon dioxide (CO_2) per year - more than all other vegetation types in the world combined (IUCN 2017). Due to their ability to sequester and store atmospheric carbon over thousands of years, peatlands are considered to be the most important long-term carbon store in the terrestrial biosphere (Parish *et al*. 2008) and the most carbon dense terrestrial ecosystem on Earth (IUCN 2018).

UK Peatland Biodiversity and Carbon

In the UK, peatland is categorised into three broad types: blanket bog, raised bog, and fen. All these habitats are recognised as being a priority for conservation under UK law, and in many instances, they are designated as Sites of Special Scientific Interest (SSSI) or under the Conservation of Habitats and Species Regulations 2017 (as amended). They cover approximately 10% of the UK's land area; equivalent to over 2.5 million hectares (IUCN 2018) and have been estimated to contain between 500 (Natural England 2010) to 3,000 million tonnes of carbon (Stafford *et al.* 2021). Upland peatlands are dominated by blanket bog with peat depths ranging from circa 0.5 m to 10 m (IUCN 2018). In the lowlands, all three types of peatlands exist (with examples of blanket bog occurring at sea level in Scotland) although, most commonly, raised bog is associated with lower altitudes (also referred to as lowland raised bog). The UK's peatlands are of international importance; blanket bog forms the largest expanse of any semi-natural habitat in the UK and this area represents 13% of the global distribution (Littlewood *et al.* 2010). In addition to the mapped 2.5 million ha, there is thought to be an equivalent area of shallow peaty soils distributed across the UK which support Annex 1 priority habitats whilst also providing ecosystem services and natural capital benefits in the form of carbon storage (IUCN 2018).

Peatlands are crucial in the context of national biodiversity conservation; they support an extensive range of specialised species and provide shelter to others displaced as a result of habitat degradation and climate change. In the UK, *Sphagnum sp.* mosses are the main contributors to peat formation in bogs, whereas fen peats are mainly formed of sedges, graminoids, and brown mosses (Gregg *et al.* 2021). Numerous species are exclusively found in peatlands, and many have adapted to the specific acidic, nutrient-poor, and water-logged conditions of bogs (Parish *et al*. 2008). These include species with distinctive features, such as the carnivorous round-leaved sundew (*Drosera rotundifolia)*, or seasonally associated species such as the golden plover (*Pluvialis apricaria)* (IUCN 2018). Peatlands have been found to help maintain the micro-climatic and hydrological features of areas outside their boundaries, underpinning their value as an ecosystem at the landscape scale (Parish *et al*. 2008). A study by Lindsay & Clough (2017), found 444 designated sites in the UK with at least one peatland habitat present, demonstrating their importance to nature conservation. However, there are also large areas of peatland habitat that remain undesignated, many of which are subject to unsustainable management practices.

Despite the inherent importance of peatlands to both biodiversity and carbon on a global scale, the national picture is concerning. There is very little remaining peat cover across central and southern England, excluding Cornwall, and the majority is restricted to more remote areas in Scotland, Wales, Northern England, and Northern Ireland. Only 20% of UK peatlands remain in a near-natural state, with the remaining 80% modified as a result of unsustainable historical, and ongoing, management practices (IUCN 2018). In England near-natural state peatlands drop to less than 1.3% of the total extent (Gregg *et al.* 2021). In the lowlands, attempts to drain peatlands for use as agricultural land, plus the encroachment of infrastructure and extraction for horticulture, have led to severe losses and declines in the condition of remaining peatland (IUCN 2018). In the uplands, blanket bog has historically been drained to facilitate commercial forestry and large swathes are regularly burned on rotation by land managers to facilitate driven shooting of red grouse (*Lagopus lagopus scotica)* (Thompson *et al.* 2016). Due to their dependence on a high water table and vegetation cover, bare or drained peatlands are subject to continual drying, leading to deterioration and erosion (Gregg *et al.* 2021). The status of a peatland as either a carbon sink or a carbon source is dependent on the balance between biomass decomposition and production (Joosten *et al.* 2016). The combined effect of widespread anthropogenic impacts has profoundly impacted that balance and transformed the UK's peatlands from natural greenhouse gas (GHG) sinks to modified GHG sources. Research undertaken by Evans *et al.* (2017) to develop specific 'tier 2' emissions factors for UK peatlands, estimate they have transitioned from a pre-anthropogenic influence net-sink of -0.25 $MtCO_2e$ per year to a net-source, with an estimated emissions range of between 21 $MtCO_2e$ per year (CCC 2020) and 16 $MtCO_2e$ per year (BEIS 2021a), equivalent to 3.5 - 4.5% of national emissions. This emissions contribution has resulted in the entire UK 'land use, land use change and forestry' sector transitioning from a net GHG sink to a net GHG source (Gregg *et al.* 2021).

Climate Change, Natural Capital, and Ecosystem Services

There is however a growing recognition of the economic value of peatlands, particularly in terms of the range of stacked ecosystem services they provide and natural capital value they hold.
The IPCC's AR6 Synthesis Report on Climate Change (IPCC 2023) highlighted that the conservation of peatlands can provide immediate benefits as a climate change adaptation option and other societal goals, compared to other land-based options (such as afforestation) which take more time to deliver measurable results. Peatlands in good condition also intercept and store greater volumes of water, mitigating flood risk and providing a sustainable supply of high-quality drinking water (DEFRA

2021a). The Office for National Statistics (ONS) estimate the annual value of water supply from UK peatlands to be £208 - £888 million (DEFRA 2021a). However, over the past 30 years, dissolved organic carbon (DOC) being released into water has increased as a result of ongoing peatland degradation. This process causes discolouration and a reduction in water quality which can cost millions of pounds per year to remove during treatment (DEFRA 2021a).

Highlighting the importance of the natural capital value of semi-natural habitats, a recent publication from the RSPB investigating the economic consequences of conserving or restoring sites for nature found that conservation or restoration benefits (e.g., greenhouse gas regulation and flood protection) tended to outweigh private benefits (e.g., profits from agriculture or logging) (Bradbury *et al.* 2021). More significantly, the HM Treasury-funded Dasgupta Review concluded that our relationship with nature to supply us with the goods and services we need is highly unsustainable. It went on to suggest that our economies, livelihoods, and well-being all depend on nature and that we must increase nature's supply to ensure our demands do not exceed its supply (Dasgupta 2021).

The importance of peatlands across the UK is being recognised at a political level. Peatlands were included in the HM Treasury's 2020 Budget, in which the Nature for Climate Fund was announced to invest £640 million in tree planting and peatland restoration across England (HM Treasury 2020). December 2020 also saw the publication of the Sixth Carbon Budget (CCC 2020). Required under the Climate Change Act 2008, this budget provides the UK government with advice on the volume of greenhouse gases the UK can emit during the period 2033-2037. Within it were significant recommendations for how peatlands can contribute to a balanced net-zero pathway for the UK, including:

- Increasing the UK peatland area restored from 25% (current level) to 58% in 2035 and 79% by 2050, with a further 35% of lowland cropland sustainably managed.
- All upland peat restored by 2045 (or stabilised if degradation is too severe to restore, to halt carbon losses).
- 25% of the area of lowland grassland is rewetted by 2035, rising to half by 2050.
- 75% of lowland cropland is either rewetted or sustainably managed by 2050:

A quarter of the area is rewetted to near natural condition (and crop production ceases), and a further 15% is rewetted but conventional crop production switches to paludiculture crops.

- Water-table management options are deployed to 35% of the lowland cropland area.
- All low-productive trees of less than Yield Class 8 (YC8)[1] are removed off peatland by 2030 and all peat extraction sites are restored by 2035.

The government's 25 Year Environment Plan included a goal to restore vulnerable peatlands and end the use of peat in horticultural products by 2030 (DEFRA 2018). These goals were carried forward and set out in more detail in the England Peat Action Plan (DEFRA 2021a). This action plan sets out goals for England's peatlands to meet the needs of wildlife, people, and the planet, stating that all uses of peatland should keep the peat wet and in the ground. In the action plan, DEFRA have committed to:

- Work to ensure all peatlands, not just deep or protected peat, are responsibly managed, in good hydrological condition, or under restoration management.
- Set a target for peatland restoration as part of the forthcoming Net Zero Strategy which, as indicated by the Secretary of State, will be in line with the action required to meet the Sixth Carbon Budget (summarised above).
- Develop a more up-to-date and detailed England peat map by 2024.
- Immediately fund at least 35,000 ha of peatland restoration by 2025, through the Nature for Climate Fund and other sources (the government's new Sustainable Farming Incentive, Local

[1] Yield class is an index used in Britain of the potential productivity of even-aged stands of trees.

Nature Recovery, and Landscape Recovery Schemes will provide the main delivery mechanism for peatland restoration after 2024-25).

- Publish recommendations for a more sustainable future for our lowland agricultural peatlands by 2022, developed by the Lowland Agricultural Peat Task Force.
- Consult on banning the sale of peat and peat-containing products in the amateur sector by the end of this parliament (2021).
- Continue to protect peat from fire by both phasing out managed burning and reducing the risk of wildfire.

Since the publication of the action plan, the government has set out its Net Zero Strategy, committing to the restoration at least 35,000 hectares of peatlands in England by 2025 (through the Nature for Climate Fund). This will expand to approximately 280,000 hectares of peat in England by 2050, including via funding from the new environmental land management schemes. The strategy also boosted the existing £640 million Nature for Climate Fund with a further £124 million of new money, ensuring total spend of more than £750 million by 2025 on peat restoration, woodland creation and management. On those peatlands where full restoration may not be desirable or possible, due to the lowlands' agricultural value and interactions with landscape scale water level management regimes, the strategy sets out a commitment to support new responsible management measures for lowland peatlands. This will be informed by recommendations from The Lowland Agriculture Peat Taskforce on how to improve the condition of lowland farmed peatlands, both to reduce emissions and support continued profitable agriculture (BEIS 2021b).

The Environmental Improvement Plan (EIP) 2023, the first revision of the 25 Year Environment Plan, sets out a plan to deliver the Environment Plan's framework in respect of peatlands. The plan states that from 2025, the main delivery vehicles for peat will be incentives through the government's new farming schemes including Countryside Stewardship, Landscape Recovery, and through the Farming Innovation Programme. The government also committed to continue to work with partners to develop the Peatland Restoration Roadmap, to set out a detailed trajectory for restoration to 2050, capturing detailed actions required to achieve the restoration target which will be informed by data from the England Peat Map and findings of the Lowland Agricultural Peat Task Force. The EIP also highlighted that, in order to protect peatlands from further harm, the government has already introduced regulations that ban the burning of vegetation on deep peat on SSSI sites in England, unless licensed (DEFRA 2023a). Since the EIP was published, DEFRA has also confirmed a phased reduction in the horticultural use of peat with a date of 2026, allowing for certain technical exemptions, with a complete ban from 2030 (DEFRA 2023b).

Alongside the publication of Version 2.0 of the Peatland Code (IUCN 2023) - the UK's first regulated scheme that provides businesses with a means to invest in peatland restoration projects through carbon offsetting - the government's commitment to bringing forward strategy, legislation, and regulations shows that recognition of the importance of peatlands is translating into action, albeit less urgently and radically than is currently required. It is clear however, that the economic benefits of peatland restoration exceed the costs. The ONS estimate that the cost of restoring all UK peatlands to near-natural condition would range from £8.4 - £21.3 billion, while delivering carbon benefits of £109 billion alone, outweighing the costs of doing so by 5 to 10 times (DEFRA 2021a). When considered alongside the provision of additional ecosystem services, such as flood management and water quality, peatland restoration provides very high value-for-money green infrastructure improvement.

Introduction

Peatlands of Cheshire West and Chester

Cheshire West and Chester (CW) has a rich and diverse landscape of which peatlands form a distinctive component. The mosaic of meres and relict mosses across Cheshire developed approximately 15,000 years ago as a result of glacial drift (Davies 2018). The glacial meres and mosses comprise a series of wetlands that illustrate all stages of the process of natural succession developed over thousands of years, from open water through swamp, fen, and moss habitats, to wet woodland, with vegetation types at each site varying according to the prevailing nutrient status and water level. This diversity is reflected in an extensive range of plants and animals, including many species specially adapted to the unusual wet and sometimes acid conditions. As a result, a variety of peatland types are present, ranging from un-named basin mires to the larger, recognisable meres, mosses, and marshes such as Hatchmere, Abbots Moss, and Frodsham Marshes. As well as variety in type, the borough's peatlands also show extensive variety in condition and preservation. A number of the meres and the associated mosses are protected by national and European designations including Sites of Special Scientific Interest (SSSI), for example: Black Lake, Oak Mere (also a Special Area of Conservation - SAC), Petty Pool, Hatchmere, and Bar Mere near Bickley. Oak Mere, Black Lake, Hatchmere, Flaxmere, and Abbots Moss (also a SAC) are also designated as Ramsar sites and include schwingmoor characteristics (Brown & Bradford 2016).

In general, over time, many of Cheshire's peatlands have been drained for agricultural use, extracted, used as landfill, or colonised by woodland. Many now only survive as small peat blocks or fragmented remnants of larger peat bodies (Davies 2018). Disregarding those extracted or converted for agriculture, the remaining peatlands of CW can be generalised into four landscape character types (LCT) - typically recognisable landscape features identifiable across the borough (Brown & Bradford 2016):

- LCT 1: Woodlands, Heaths, Meres and Mosses
  - "This character type is defined by extensive blocks of woodland (mainly planted coniferous but with some broadleaves), interspersed with relict heath, and meres and mosses formed in glacial hollows. More recent water bodies have been created through the extraction of sand and gravel or the quarrying of sandstone. The complex of meres, mosses, and relict heathland is of internationally importance for nature conservation supporting species such as nightjar, common lizard, cross leaved heath, and round leaved sundew."
- LCT 4: Drained Marsh
  - "This landscape character type is located on former saltmarsh or mudflats adjacent to the Dee and Mersey estuaries. It is drained by inter-connecting networks of drainage channels arranged in a regular, often linear pattern, and this gives the impression of an open, unenclosed landscape. This character type is significantly reduced in size; it formerly covered a much greater area. Today, the reclaimed land is mainly used as grazing land, with some arable crops. Small patches of scrub are common, with few trees. Where there are hedgerows, they are mostly grown out and in poor condition. Reeds and other aquatic or emergent plants are mainly restricted to ditches. The drained marsh has ornithological interest as a wintering ground for wading birds and wildfowl, as well as birds of prey.
- LCT 12: Mere Basin
  - "The LCT comprises part of a distinctive basin landform containing meres formed by natural salt subsidence, coinciding with a geological fault line on the eastern boundary of the borough. The character type extends into the neighbouring Cheshire East borough. Meres support a wide range of habitats

including open water, reedbeds, and willow/alder woodland. Alluvial soils in the basin typically support pasture, woodland, and some unimproved species rich grassland. Fields of arable and pasture typically occur on the basin slopes bounded by hedgerows."

- LCT 13: Lowland Farmland and Mosses
    - "This character type is found in two localities within CW: at its north-eastern tip to the east of Antrobus, and to the far eastern fringe of the borough between Peover and Allostock. Both areas extend beyond the CW boundary into Cheshire East. The Lowland Farmland and Mosses landscape type is a flat or gently undulating farmland landscape, of intermediate to low elevation. This landscape type is characterised by its strong field patterns, seasonally waterlogged soils, presence of peat mosses, and wetland habitats."

A number of these surviving peatlands form a network of internationally important sites for the conservation of nature, including: the Midland Meres and Mosses Ramsar (Natural England 2020a), West Midlands Mosses SAC, and Oak Mere SAC (Natural England 2020b). Several more are designated as nationally important SSSIs and Local Wildlife Sites (LWS) of regional importance.
In October 2021, a natural capital audit and investment plan for Cheshire and Warrington Local Enterprise Partnership was published (Roquette *et al.* 2021). It highlighted that peatland across Cheshire and Warrington are likely to be a carbon source given the degraded nature of the peat itself. It also identified that peatland restoration is particularly important to arrest carbon loss in degraded peat soils and, like woodlands, can provide a range of benefits for water resources, biodiversity, and people accessing nature. As a result, the report recommends the restoration of bog (mire) habitats, stating they are a significant asset and an important carbon store that is important to protect. It continues, stating that agricultural activity and planting woodland on peat soils should be avoided as the GHG emissions associated with these are very high. A focus on bog restoration is also important for slowing the flow of water and increasing water quality.

Local Political Context

The Council unanimously declared, on 21 May 2019, that the borough is in a Climate Emergency. The Council agreed that:

- Climate Change presents a threat to our way of life.
- The Council recognised the need to act in-line with worldwide agreements on Climate Change and the best available evidence, which states that, to limit emissions to 1.5°C, there is a requirement to reach 'net zero' by 2045.
- The Council must play its part by evidencing leadership on this issue.

The following year the Council published its Climate Emergency Response Plan, setting out the scale of the challenge to achieve carbon neutrality by 2045 (CW&C 2019). The plan is guided by evidence on the current state of emissions in west Cheshire and the engagement and intervention planning undertaken since the Climate Emergency was declared. The plan acknowledges that a flourishing natural environment is needed to support economic growth and development and that the depletion of the borough's natural capital must be reversed to achieve climate change mitigation and adaptation and support long-term natural and economic prosperity. The plan identified numerous actions including a review of the Council's land holdings to explore the case for this land to contribute to becoming carbon neutral by 2030. This included reviewing opportunities to support low-carbon agricultural practices which reduce emissions and increase carbon sequestration, alongside promoting solutions such as tree planting, wetland management, and creation. It also included an action for the Council to work with partners and government to assess how to increase carbon capture and storage across the whole landscape including wetlands, peatlands, woodland, and farmland.

In making the climate emergency declaration, the Council also set a target date of 2030 to achieve carbon neutrality for the Council's own emissions, to be delivered through a Carbon Management Plan (CW&C 2022). Set out in the plan is a recognition that by 2030 there will be carbon emissions from the Council's services even after following extensive planned actions to reduce them throughout the life of the plan. Subsequently, the Council has committed to purchasing offsets to the residual emissions, including through the restoration of lowland peat.
This report was commissioned by CW&C as a baseline report in support of the Council's Climate Emergency Response Plan, which recognises that changes in land-use can provide reductions in carbon. It is intended to form part of an evidence base for the Council regarding the feasibility and desirability of peatland restoration in the borough. This is presented in the form of a Geographic Information System (GIS) dataset (*Peatland Condition - GHG - Cheshire West .shp*) with an accompanying appraisal of the borough's peatland resource, including its extent, condition, greenhouse gas emissions, and biodiversity.

Approach

This study provides a desk-based collation of the best available evidence of the extent and condition of peatland across CW, presented alongside an assessment of greenhouse gas emissions and biodiversity value.

Extent

The extent of peatland across CW was primarily derived from the national dataset reported in the Natural England NE257 'England's Peatlands' report (Natural England 2010). Following a review of relevant literature, this dataset was considered to be the best currently available to determine the extent of peatland across the borough, in the absence of detailed or recent data at the local scale. However, it should be noted that this dataset will likely be updated by 2024, as set out in the England Peat Action Plan (DEFRA 2021a). The NE257 dataset includes a range of peatland soil types: deep peaty soils, shallow peaty soils, and soils with peaty pockets. For the purposes of this assessment, only deep peaty soils (i.e., areas covered with a majority of peat >40cm deep) were retained in the dataset. As described by Evans *et al.* (2017), despite being extensive across the UK, shallow peaty soils, and soils with peaty pockets, do not meet the national definitions of peat (i.e., they are shallower than true peat or have a lower carbon density). They differ from wasted deep peat (peat lost through agricultural drainage, leading to loss of peat through erosion and decomposition), which are included in this assessment. The NE257 dataset was then compared against the Cranfield University NATMAP[2] national soils dataset to check for any discrepancies or any additional deposits of deep peat.

Condition and Greenhouse Gas Emissions

Deep peat condition category and emission factors were assigned across the peatland extent as described in 'Aligning the Peatland Code with The UK Peatland Inventory' (Evans *et al.* 2022)[3]. These categories and emission factors are the latest update to the 2021 review[4] (National Inventory Report, Brown *et al*. 2021) of the 'Implementation of an Emissions Inventory for UK Peatlands' (Evans *et al.* 2017).

The original report by the Centre for Ecology and Hydrology (CEH) provides estimates of GHG emission factors (EF), expressed as tonnes of carbon dioxide equivalent per hectare per year (tCO2e ha^{-1} yr^{-1}), of numerous peat condition categories that are informed by land cover types on UK peatlands. Evans *et al.* (2023) presents the most recent and encompassing overview of GHG emissions from UK peatlands that is currently available, as shown below in

[2] Soil data © Cranfield University (NSRI) and for the Controller of HMSO [2023]
[3] Excluding the emission factors for the 'Forest' and 'Settlement' condition categories which were not updated in Evans *et al.* 2022. These emission factors are based on Gregg *et al.* 2021.
[4] https://unfccc.int/ghg-inventories-annex-i-parties/2021

Table 1. For the condition categories not covered in Evans' report – 'forest' and 'settlement' – the EF are taken from Natural England Research Report NERR094: 'Carbon Storage and Sequestration by Habitat: A Review of the Evidence (Second Edition)' (Gregg *et al.* 2021).

Table 1. Emissions factors for peat condition categories taken from Gregg et al. 2021 and updated from Evans et al 2022.

Peat Condition Category	Drainage Status	Emissions Factor ($tCO2e\ ha^{-1}\ yr^{-1}$) Gregg et al. 2021	Emissions Factor ($tCO2e\ ha^{-1}\ yr^{-1}$) Evans et al. 2022
Forest	Drained	5.46 to 1.15	[redacted]
Cropland	Drained	[redacted]	37.17
Eroding Modified Bog (bare peat)	Drained	[redacted]	18.86
	Undrained	[redacted]	17.72
Modified (semi-natural heather & grass dominated)	Drained	[redacted]	3.32
	Undrained	[redacted]	2.51
Extensive Grassland (combined bog/fen)	Drained	[redacted]	15.88
Intensive Grassland	Drained	[redacted]	22.00
Rewetted Bog	Rewetted	[redacted]	3.42
Rewetted Fen	Rewetted	[redacted]	3.31
Rewetted Modified (semi-natural bog)	Rewetted	[redacted]	0.32
Near Natural Bog	Undrained	[redacted]	0.32
Near Natural Fen	Undrained	[redacted]	-0.36
Extracted Domestic	Drained	[redacted]	15.18
Extracted Industrial	Drained	[redacted]	18.86
Settlement	Drained	1.61	[redacted]

The NE257 dataset contains additional attribute data including land cover and management. Despite being based on a number of robust sources (including phase 1 habitat survey data, aerial imagery, the National Inventory of Woodland and Trees, and a range of other dataset sources) this dataset is now over 10 years old and as discussed by Evans *et al.* (2017), contains a number of instances of incompatible attributes within the same location (e.g., peatland parcels with afforested and improved grassland land cover). Therefore, to update and resolve errors in the NE257 additional attribute data, an updated land cover assessment was undertaken as described below.

As described above, land cover influences peatland emissions, as it relates directly to the condition of the peat body. Therefore, the more accurate the land cover assessment, the more accurate the GHG emissions assessment. The updated land cover assessment of peatland across CW was derived in a hierarchical manner using a combination of historic survey data held by Cheshire Wildlife Trust (CWT), in addition to licensed and open-source data. Land cover over deep peat deposits was derived from the following datasets:

1. Phase 1 habitat survey data held by CWT for nature reserves and LWS was used where available. This is primary survey data historically collected and stored by the Trust and, despite its age[5], is therefore considered to be the most accurate dataset used to determine land cover.
2. In locations where no CWT phase 1 habitat data was available, the UK Government Priority Habitats Inventory dataset (Natural England 2020c) was used to determine land cover.
3. In locations where no CWT phase 1 habitat survey or Priority Habitat Inventory data was available, the Land Cover Map 2019 (LCM2019) vector dataset (Morton *et al.* 2020) provided by CEH was used. This is a parcel-based land cover map covering the entirety of the UK, created by classifying satellite data into 21 land cover classes based on the UK Biodiversity Action Plan Broad Habitat definitions.

Following the updated land cover assessment, the land cover for each peatland parcel was compared to the additional attribute data within the NE257 dataset. Any discrepancies between the

[5] Only data from phase 1 habitat surveys undertaken in the last 10 years was used.

NE257 land cover and the updated land cover assessment were reviewed against open-source aerial imagery (© Microsoft Bing[6]) and resolved where possible.

Determination of the drainage status of peatlands was primarily derived from the NE257 dataset unless otherwise identified during the updated land cover assessment as described above. Any discrepancies between the NE257 data and the updated land cover assessment that could not be resolved using aerial imagery were assigned a condition category, as per Evans *et al.* (2017), in the following way:

Pristine < rewetted < burned < drained < bare (eroded) < extracted < extensive grassland < improved grassland < cropland.

Biodiversity

The biodiversity value of peatlands across CW was derived by determining the extent of peatland that lies within areas designated as sites of importance for nature conservation. A combination of LWS data held by CWT and open-source data was used to determine the boundaries of statutory and non-statutory designated sites:

- LWS boundary data held by CWT on behalf of the Cheshire LWS Partnership.
- Ramsar boundary open data (Natural England 2020a).
- SAC boundary open data (Natural England 2020b).
- SPA boundary open data (Natural England 2021a).
- SSSI boundary open data (Natural England 2021b).
- Local nature reserve (LNR) boundary open data (Natural England 2021c).

[6] ©Microsoft Corporation © 2023 Maxar ©CNES (2023) Distribution Airbus DS

Limitations

There are a number of limitations associated with the assessment of the peatlands of CW, particularly in regard to the extent, establishing land cover, and the associated emissions factors. Limitations encountered while undertaking the assessment are reported here for transparency. As highlighted within Evans *et al.* (2017), there are limitations associated with the NE257 Natural England dataset:

"For England, the digital data derived for the Natural England (2010) report on peatland carbon storage and greenhouse gases in England, subdivides the peat resource into blanket bog, lowland raised bog and fen peats (deep and wasted). However, these area figures when combined do not make up the total of the deep peat soils (blanket bog, inclusive of upland Valley Mire = 355,300 ha; raised bog = 35,700 ha; lowland fen (deep) = 95,800 ha; lowland fen (wasted) = 1,922 ha; no data = 900 ha). All of the above bog/fen types combine to 489,622 ha not the 679, 900 ha total deep peat soils). It may be that Natural England have access to complete maps of blanket and lowland raised bog peat and can therefore assess all land cover on these classes but lack an equivalent map of fen peat. Hence there may only be mapped areas of 'fen habitat' but no other land-use on fen peat or wasted fen peat. Since the unmapped area potentially includes very large areas of deep and wasted peat under cropland and grassland, it is likely to be of high significance for overall UK peat emissions."

As this study utilised the same dataset, some of these unmapped areas of fen may be located within CW and therefore, may be significant in the overall peatland extent and total GHG emissions across the borough.

In line with national peat definitions, this study did not take any shallow peats or soils with peaty pockets into consideration when establishing the peatland extent across the borough. As highlighted in Evans *et al.* (2017):

"Soils with a peaty organic horizon over mineral soil (often confusingly referred to as 'shallow peats' or 'peaty soils') were not included. These organo-mineral soils are very extensive in the UK, covering a large part of the uplands, but do not meet national definitions of peat as they are either shallower than true peat or have a lower carbon density, and in most cases are not thought to have ever been peat (i.e., they are not wasted former deep peat). They differ from true peat in important respects with regard to their hydrology and carbon cycle and are subject to different land-use pressures."

As a result, as well as influencing the extent of peatland across CW this will also affect the total peatland GHG emissions across the borough.

The approach taken in this assessment to establish peatland condition was based on assigning an accurate land use type (e.g., cropland) for each peatland land parcel, which was undertaken in a hierarchical manner as discussed above. While primary ground-truthed phase 1 habitat survey data was prioritised, the coverage of this data across Cheshire is not extensive and is limited to some LWS and CWT managed nature reserves only. Therefore, land use across a significant proportion of the peatland extent was informed by either the UK Government Priority Habitats Inventory dataset (Natural England 2020c), land cover data (LCM2019) (Morton *et al.* 2020), or aerial imagery. Due to potential inaccuracies in all these datasets, and on occasions where aerial imagery was not useful in resolving a land use, the peatland condition category assigned to a land parcel may be inaccurate. It is also important to note that although the NE257 dataset provided some information on land use (e.g., extracted) - which was used to infer peat condition - and management (e.g., gripped) - which was used to identify whether the peat had been drained - not all peat land parcels contained this information. Additionally, the age of the NE257 dataset may also limit the accuracy of identifying the peatland condition category when considering land use and management. However, this assessment provides a desk-based estimate of extent, emissions, and biodiversity, and is based on the most current and reliable datasets available at the time of writing. There are likely to be some discrepancies between the peatland condition categories assigned to land parcels in this study and their 'real-life' condition, but this is to be expected when undertaking a large-scale desk-based assessment and is not thought to be a significant limitation to this assessment.

In the 2021 review (Brown *et al*. 2021) of the 'Implementation of an Emissions Inventory for UK Peatlands' (Evans *et al.* 2017), as reported in 'Carbon storage and sequestration by habitat: a review of the evidence (second edition)' Natural England Research Report NERR094 (Gregg *et al.* 2021), the 'forest' condition category is given an emissions factor range of 5.64 to 1.15 tCO2e ha^{-1} yr^{-1}. This range of implied emission factors for forested organic soils are derived from the Forest Research CARBINE model[7], which implies that inputs to the soil from litter, deadwood, and exudates will become greater than the losses from the existing soil, given the increasing number of years since afforestation of UK forests on deep peats. CWT does not have the resources to model carbon flow through woodlands using the CARBINE model as undertaken in the 2021 National Inventory Report (Brown *et al*. 2021). Therefore, a worst-case scenario approach has been taken to inform emissions across forested peatlands by applying the upper limit of the emissions factor range (5.64 tCO2e ha^{-1} yr^{-1}) to all woodland on deep peat across the borough, which affects the calculation of the total peatland GHG emissions across the borough.

The 'settlement' peat condition category also encompassed any road verges and drainage ditches adjacent to development, as per the methodology set out in (Brown *et al*. 2021). It is important to bear in mind that although they are included in the same peat condition category, these linear features are valuable as ecological corridors, and some may also have lower GHG emissions factor than that of the actual developed area.

As this project was undertaken at a local level, as opposed to a national level, an additional peat condition category for open water/freshwater was created. This included all areas of standing and running water including canals, rivers, ponds, and ditches (those not adjacent to development included in the settlement category) that are located on peat. This included small stretches of The River Dee SSSI and areas of open water/freshwater particularly peaty meres within Delamere and the surrounding area. Due to a lack of published research, there are no accepted GHG emission factors associated with open water/freshwater on deep peat therefore, this area is included in the total extent for completeness, but it is presented without an accompanying emissions factor.

It is also important to understand that the NE257 dataset and the research behind the implied emissions factors across each condition category represent reporting at a national level. Therefore, some caution is needed when applying these figures at a local scale as has been done in this assessment. However, this is a typical limitation when applying a national methodology at a local scale and the implied emissions factors are considered to be the most current and reliable available to estimate peatland GHG emissions. As it is likely any subsequent local level study of peatland GHG emissions would also use the implied national emissions factors, this is not considered to be a significant limitation to this assessment.

Although not used to inform GHG emissions in this assessment, estimating peat depth can be subject to a considerable amount of error depending on the methodology used (Parry *et al.* 2014). This limitation extends to the estimates of carbon stocks in peat across the UK and England, as reported

[7] https://www.forestresearch.gov.uk/research/forestry-and-climate-change-mitigation/carbon-accounting/forest-carbon-dynamics-the-carbine-carbon-accounting-model/

by Gregg *et al.* (2021); estimates are highly uncertain due to the considerable variation in the depth of peat soils. Peat depth is not uniform and varies over short distances due to the underlying topography. This, along with nationally mandated reporting standards, is why peatland GHG emissions are routinely presented at the national level rather than peatland carbon stocks.

Results

This report should be read with reference to the accompanying GIS dataset: "*Peatland Condition - GHG - Cheshire West.shp*" and excel spreadsheet "*Cheshire West Peatland*".

Extent

The extent and type of deep peat across CW is shown below in Figure 1 and summarised in **Table** 2. There is approximately 3,033 ha of deep peat across CW, representing nearly 0.5% of the England's national extent, and 3.2% of the total local authority area. CW's deep peat resource originates from rich fens only, accounting for 100% of the borough's peatland. The majority of this rich fen is wasted 60% (1816 ha) rather than deep 40% (1217 ha). Raised bog and blanket bog do not feature within CW.

Table** 2: **extent and habitat of origin of CW's peatlands.

Deep Peat Habitat of Origin	Area (ha)	Area (%)
Rich fens/reedbeds (deep)	1217	40
Rich fens/reedbeds (wasted)	1816	60
Total	3033	100

The majority of CW's lowland peatland is located at Frodsham Marshes, in the River Gowy Catchment, Appleton, Willey Moor, and a cluster of peat within and around Delamere. There are also smaller areas around the City of Chester.

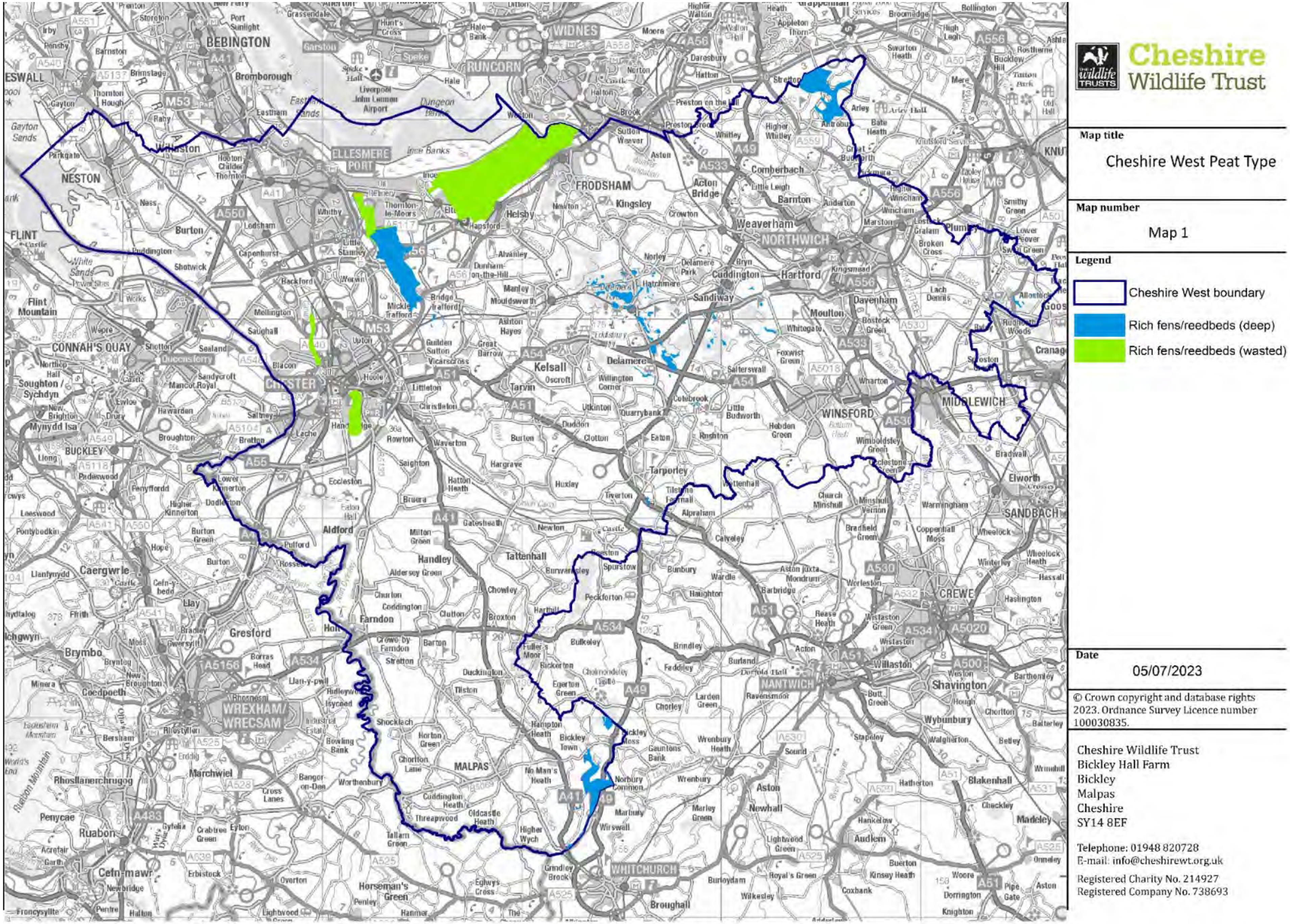


Figure 1: a map to show the extent and habitat of origin of CW's peatland.

Condition and Greenhouse Gas Emissions

The area, condition, and associated greenhouse gas emissions of deep peat across CW are shown below in Table 3 and Figures 2 and 3.

Table 3: area, condition, emissions factors, and annual emissions of CW peatlands. Positive annual emissions indicate net GHG emission and negative annual emissions indicate net GHG removal.

Peat Condition Category	Drainage Status	Emissions Factor ($tCO_2e\ ha^{-1}\ yr^{-1}$)	Area (ha)	Area (%)	Annual Emissions ($tCO_2e\ yr^{-1}$)	Annual Emissions (%)
Forest[8]	Drained	5.46	306	10	1,671	3
Cropland	Drained	37.17	498	16	18,513	35
Eroding Modified Bog (bare peat)	Drained	18.86	0	0	0	0
	Undrained	17.72	0	0	0	0
Modified (semi-natural heather & grass dominated)	Drained	3.32	6	0.2	22	0.04
	Undrained	2.51	11	0.4	28	0.05
Extensive Grassland (combined bog/fen)	Drained	15.88	687	23	10,913	21
Intensive Grassland	Drained	22.00	920	30	20,236	38
Rewetted Bog	Rewetted	3.42	0	0	0	0
Rewetted Fen	Rewetted	3.31	110	4	366	0.7
Rewetted Modified (semi-natural bog)	Rewetted	0.32	0	0	0	0
Near Natural Bog	Undrained	0.32	0	0	0	0
Near Natural Fen	Undrained	-0.36	11	0.4	-4	-0.01
Extracted Domestic	Drained	15.18	46	2	692	1
Extracted Industrial	Drained	18.86	0	0	0	0
Settlement	Drained	1.61	264	9	425	0.8
Open water/freshwater[9]	-	-	173	6	-	-
Total	**-**		**3,033**	100	**52,862**	100

[8] In the absence of detailed forestry modelling, the upper value of the forest peat condition category EF range (5.46 $tCO_2e\ ha^{-1}\ yr^{-1}$) was used as a worst-case scenario estimate as discussed in the limitations section.

[9] There is a lack of published research on emissions arising from open water/freshwater on peatland. Therefore, the area of this condition category has been provided without a GHG emission factor.

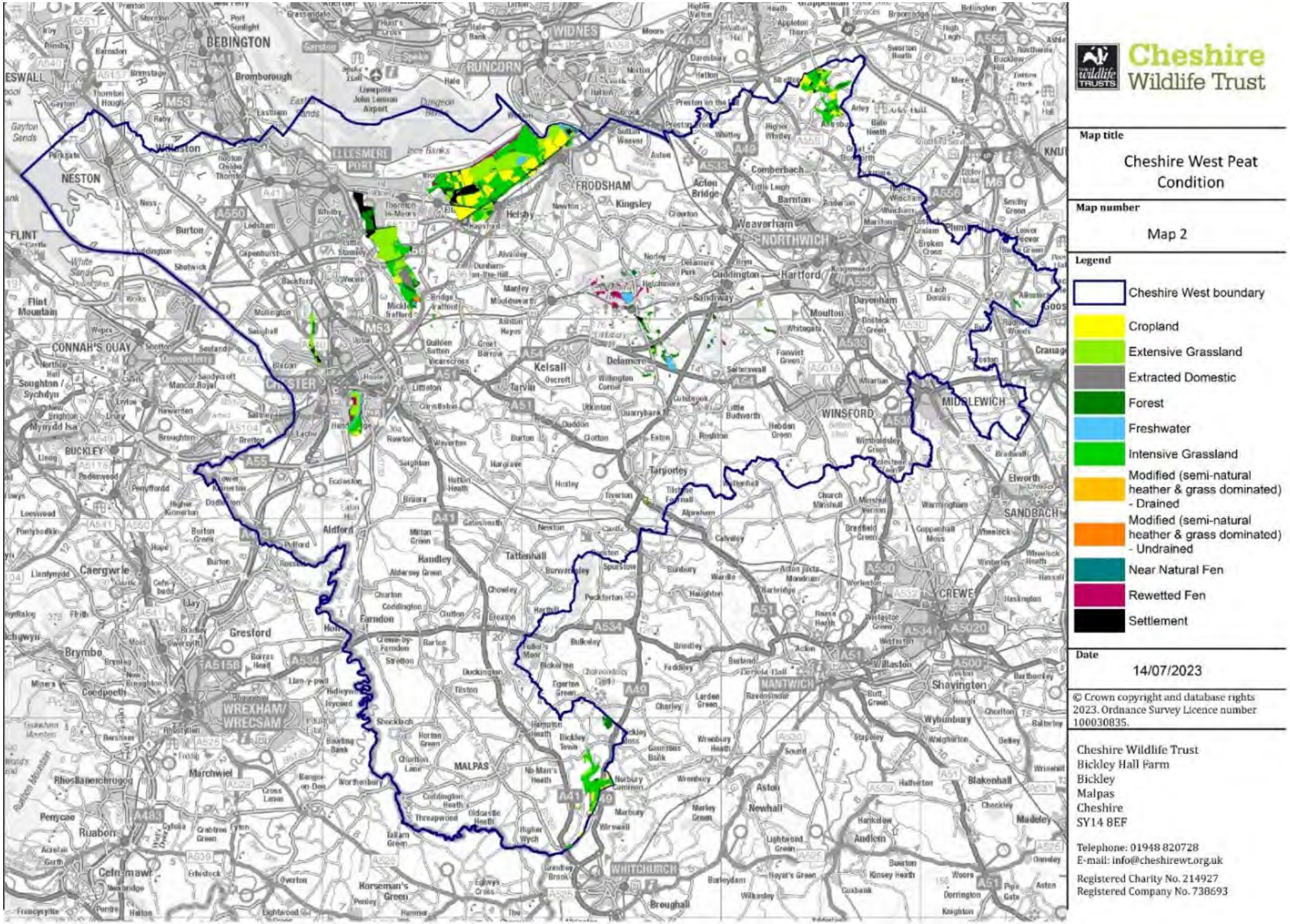


Figure 2: a map showing the condition categories of peatlands in CW.

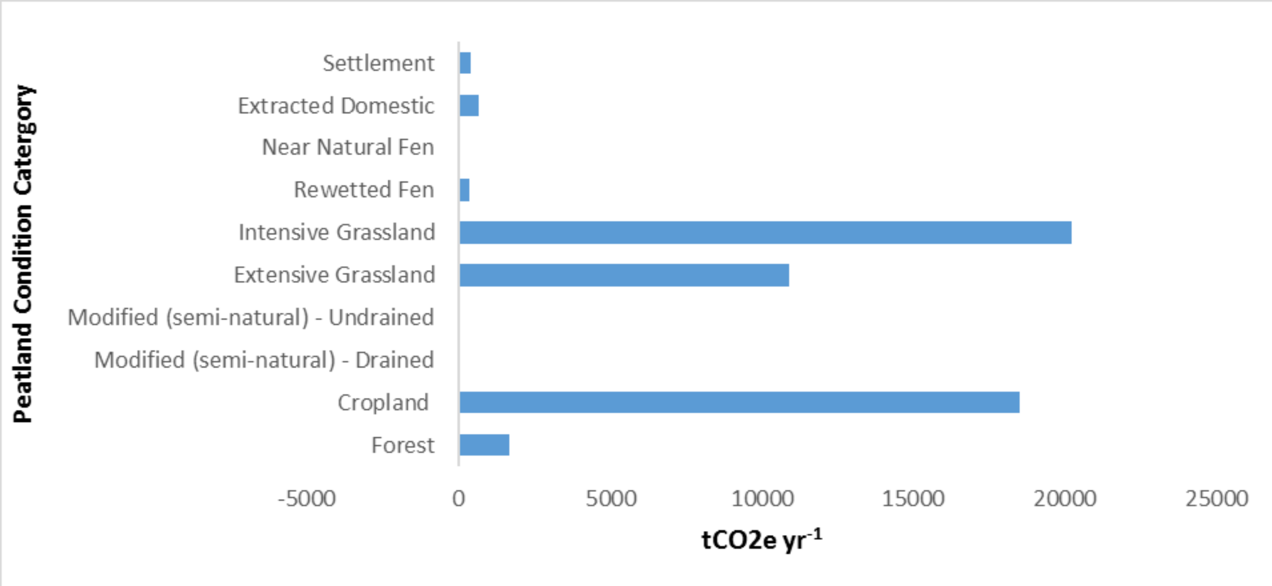


Figure 3: annual GHG emissions (tCO2e yr^{-1}) of CW peatlands. Positive annual emissions indicate net GHG emission and negative annual emissions indicate net GHG removal.

The vast majority of the borough's deep peat is in a drained state (95%) ; only 4% has been rewetted, and less than 1% is currently undrained (Table 4). The most expansive land-use associated with deep peat across Cheshire West is agricultural, with intensive grassland accounting for 920 ha (30% of the total extent) and cropland accounting for an additional 498ha (16%). Rewetted fen accounts for the largest extent of the semi-natural categories (110ha or 4%), with only 0.3% (11ha) of the entire peatland resource in Cheshire West in a near natural condition, which is considerably lower than the national extent of 1.3% (Gregg *et al.* 2021) (Table 3).

Table 4: comparing the area, and annual emissions, of CW's drained, undrained, and rewetted peatland.

Drainage Status	Area (ha)	Area (%)	**Annual Emissions (tCO2e yr^{-1})**	**Annual Emissions (%)**
Drained	2,728	95	52,472	99
Rewetted	110	4	366	0.7
Undrained	22	0.8	24	0.05
Total	**3,033**	100	**52,862**	100

CWs peatlands emit 52,862 tCO2e yr^{-1}. 99% of CW's peatland emissions result from drained peatland (Table 4). Of this drained peatland, agricultural use is the biggest emitter: around 73% of the total CW peatland emissions (nearly 40,000 tCO2e yr^{-1}) occur as a result of the agricultural use of peatlands, yet this only accounts for less than half of the peat extent across CW. Intensive grasslands are the greatest emitter, generating 20,236 tCO2e yr^{-1}, equivalent to 38% of the total CW peatland emissions. This is followed by croplands which release 18,513 tCO2e yr^{-1}, equivalent to 35% of emissions but only accounting for 16% of the total extent. Another condition category that generates a large number of emissions are extensive grasslands (10,913 tCO2e yr^{-1} or 21%) (Table 3). Peatland rewetted or undrained are emitting less than 1% (390 tCO2e yr^{-1}) of the total emissions (Table 4). Only 11ha peatland, in near natural fen condition, are currently acting as a net sink, sequestering 4 tCO2e yr^{-1} (Table 3).

Depth

Available peat depth data for eight Meres and Mosses sites across CW are included in Figure 4 and summarised in Table 5 below. As discussed, this data is for reference only and does not represent a definitive list of all peatlands across CW. Historic data shows that the deepest peat reserves in CW are located within Delamere Forest and the surrounding area with deep peat deposits at Hatchmere, Black Lake, Oak Mere, Abbots Moss, and Beech Moss. All these sites, apart from Whitley Reed and Willey Moor, are under some form of designation.

Table 5: peat depth of eight peatland sites in CW

Peatland	O.S Grid Reference	Soil Type	Land use	Peat Depth	Reference
Whitley Reed	SJ 645 819	Organic soils with surrounding mineral soils	Grassland	1.5m	Burton & Hodgson 1987
Hatchmere, Delamere Forest	SJ 549 730	Scattered basin meres throughout Delamere Forest	Woodland, rewetted fen and *Schwingmoor* characteristics	6m	Leah et al. 1997
Black Lake, Delamere Forest	SJ 546 707			5.5m	Leah et al. 1997
Oak Mere	SJ 574 679	The shorelines of the lake consist of sand and gravel with peat in the northern portion of the site	Open water with surround mere vegetation and woodland	4m	Savage, Bradburne and Macpherson, 1992
Nunsmere, Abbotts Moss	SJ 595 689	A basin mere including a number of peaty hollows and numerous mosses	Woodland / Undisturbed active *Sphagnum* Mire	4m 3.5m – 4m	Leah et al. 1997 Burton & Hodgson 1987
Breech Moss Norley	SJ 566 722	Small deposit of till, within a deep hollow	Woodland	5m	Tallis, 1973
Moss Wood Cholmondeley	SJ 543 497	Historical widespread peat with small patches of organic soil within Moss Wood	Woodland surrounding areas of pasture	1m – 2m	Burton & Hodgson 1987
Willey Moor (Bar Mere)	SJ 538 466	Extensive area of shallow peat and deeper organic soils	Group of grassland fields and narrow stretches along road	1m	Burton & Hodgson 1987

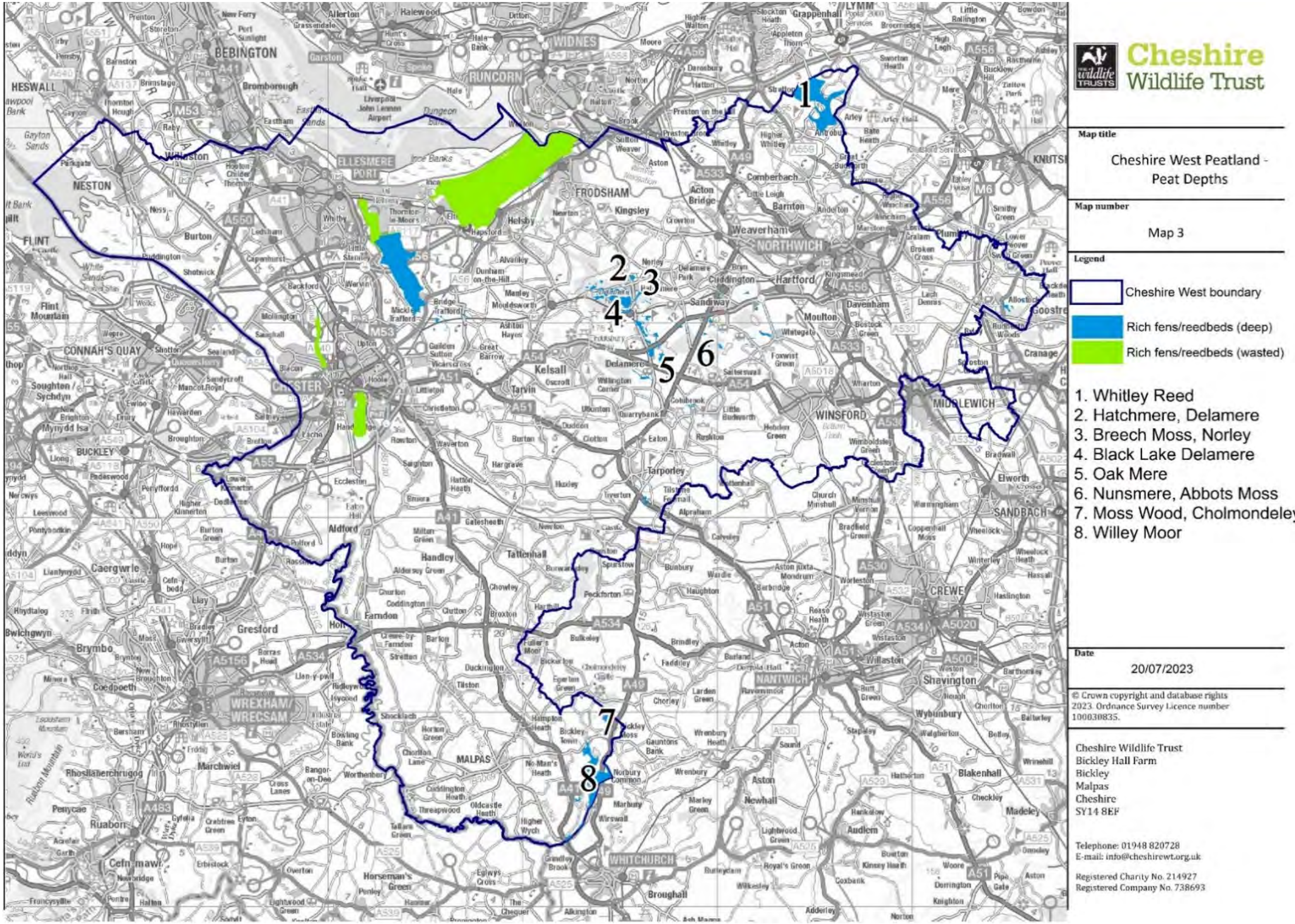


Figure 4: a map showing the eight Meres and Mosses sites

Biodiversity

The area of deep peat within sites designated for nature conservation across CW is shown below in Table 6. Lists of both statutory and non-statutory sites that contain deep peat deposits are included in Appendix 1 – Statutory and Non-Statutory Designated Sites for Nature Conservation on Deep Peat within Cheshire .

Table 6: extent of CW's peatlands designated for nature conservation.

Designation	Number of Sites	Area of Deep Peat (ha)	Area of Deep Peat (% of CW Extent)
Statutory designated sites (SSSI, SPA, SAC, Ramsar)	10	109	4
Non-statutory designated sites (LWS)	41	1, 605	53
Total	51	1,714	57

As shown in Table 6, over half of CW's deep peatlands are designated for nature conservation (1,714ha or 57%), with the bulk of designated peatland (53%) being identified as LWS. The number of LWS (41) greatly outnumber the number of statutory designated sites (10), although this is to be expected due to the nature of the non-statutory designated site system. The LWS 'Frodsham, Helsby and Ince Marshes' accounts for 36% of all CW's peatlands (Figure 5). Whitley Reed[10] and Willey Moor[11] are two sites containing a notable amount of deep peat – 1.5m and 1m respectively – and yet these are undesignated.

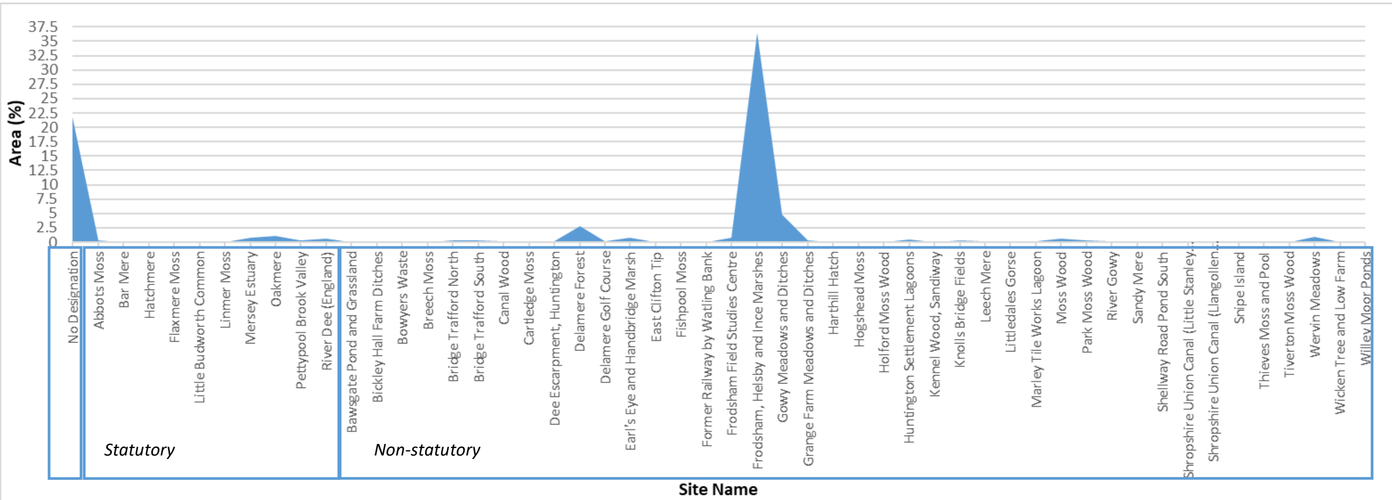


Figure 5: proportion of land covered by non-designated, statutory designated, and non-statutory designated sites.

[10] The woodland south of Whitley Reed is under a LWS designation 'Park Moss Wood'.
[11] 'Willey moor ponds' are designated as a LWS but the wider area of peatland is not.

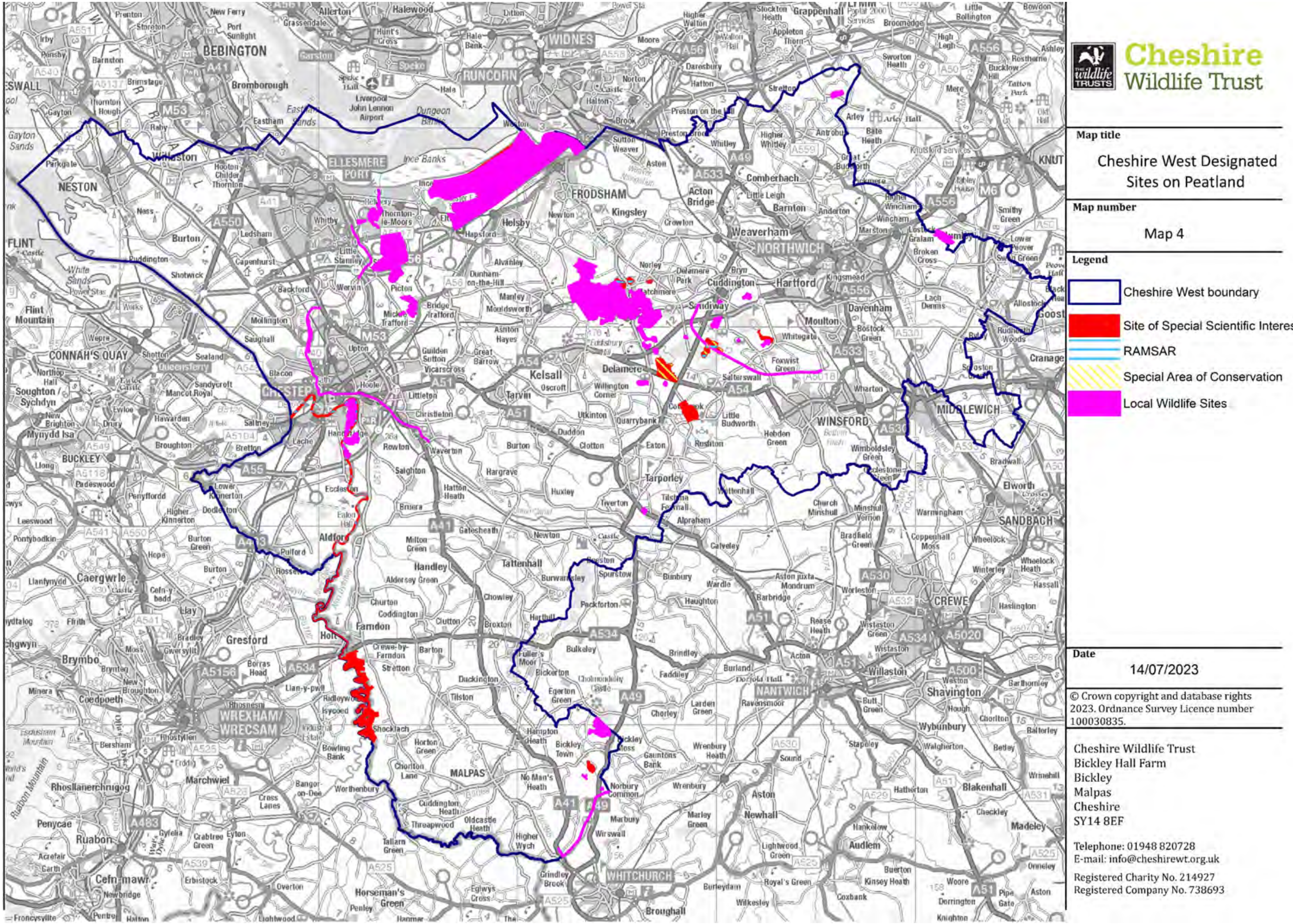


Figure 6: a map showing the location of peatland under statutory and non-statutory designation.

All of the peat in more favourable condition categories is located within designated sites. All the borough's rewetted, and near natural, fens are designated as either a statutory (65% near natural and 11% rewetted) or non-statutory site (35% near natural and 89% rewetted). 'Modified – undrained' are all under non-statutory designation in comparison to 'modified – drained' peatlands which are not protected. The forest habitats are mostly under designation (81%), with most of these peatland woodlands under non-statutory designation (70%) (Figure 7). This highlights that some of the woodland on deep peat in CW may be of semi-natural origin.

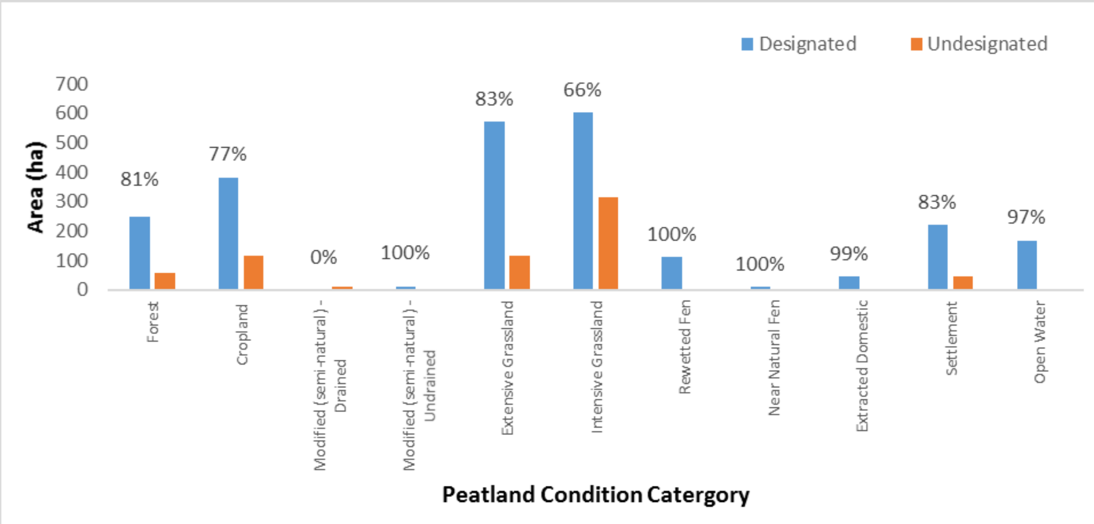


Figure 7: distribution (%) of peatland condition categories under designation (statutory and non-statutory) for nature conservation versus undesignated.

Rich Versus Wasted Fen

As shown in Figure 8, the majority of the borough's peatland under agricultural management are wasted fen peats (intensive grassland 53% and cropland 77%). In contrast, 56% of the semi-natural peatlands are rich fens. CW's rich fen equates to 40% (1,217ha) of the total peatland extent, and much of this is in a drained condition. The use of land situated on rich fen for agriculture has resulted in significant losses of semi-natural peatland habitats, with 115ha (9% of all rich fens) now used for cropland and 437ha (36% of all rich fens) now used for intensive grassland.

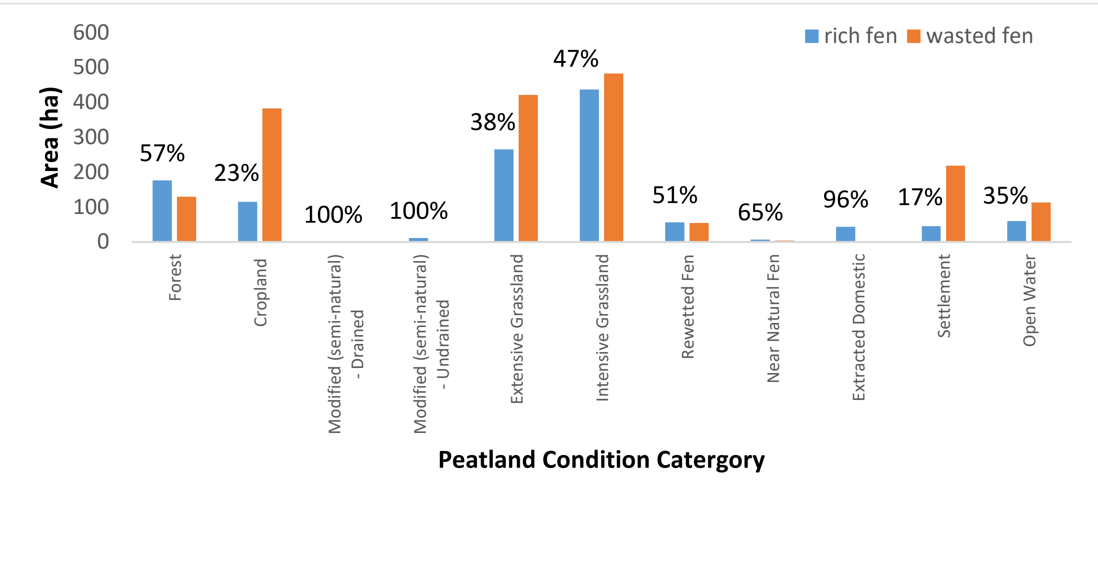


Figure 8: the distribution (%) of rich versus wasted fen in different peatland condition categories.

The borough's total extent of rich fen emits 20,003tCO2e yr-1, and 70% (13,873 tCO2e yr-1) of this arise from unsustainable land use (cropland and intensive grassland) covering less than half its extent (551ha). An additional 15% of rich fen peats are covered by woodland, emitting 964 tCO2e yr-1 (6%). Only 7ha of lowland rich fens are in a near natural condition. These areas are acting as natural carbon sinks and sequestering 2.5 tCO2e yr-1. The lowland rich fen (deep) peat within rewetted fen (56ha) are, despite being rewetted, acting as a GHG source, emitting 186 tCO2e yr-1 (less than 1% of the emissions from rich fen peatland) (Figure 9).

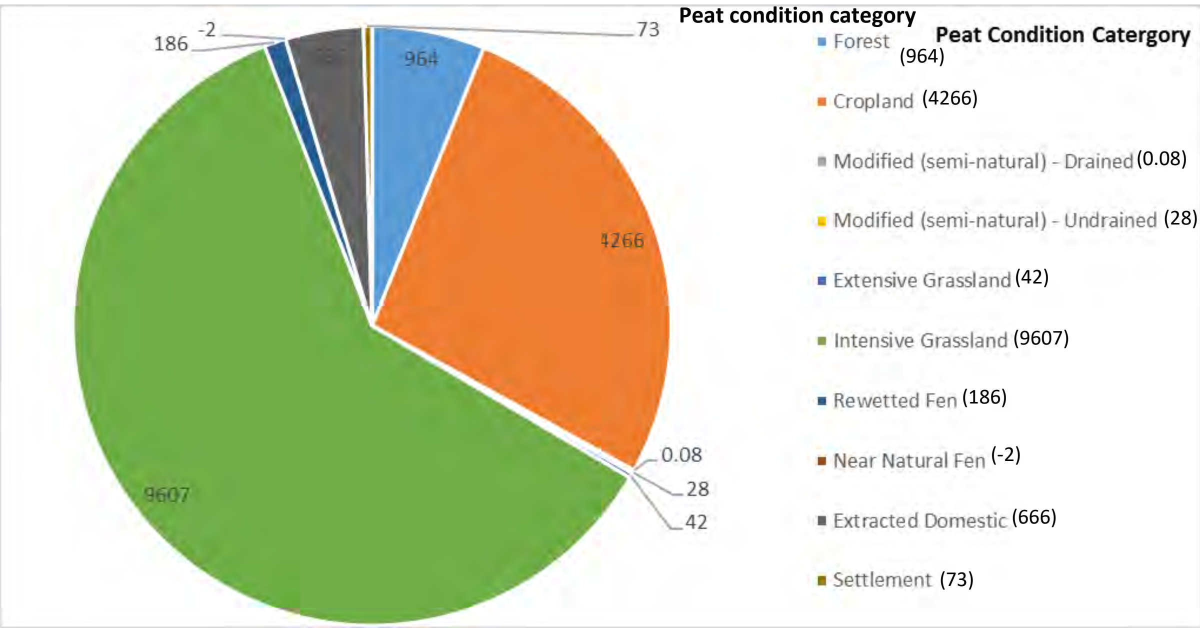


Figure 9: annual GHG emissions (tCO2e yr-1) of CW peatlands originating from lowland rich fen, deep peat. Positive annual emissions indicate net GHG emission and negative annual emissions indicate net GHG removal.

The majority (60% or 1,816ha) of peatland within CW is of wasted fen peatland type, with much of it under agricultural land use: 21% (383ha) under cropland management and 26% (483ha) under intensive grassland. The other extensive peatland condition type on wasted fen is extensive grassland (23% or 422ha).

The borough's total extent of wasted fen emits 32,859 tCO2e yr-1. Despite only accounting for one fifth of the extent, wasted peatlands under cropland management account for 44% of GHG emissions (14, 126 tCO2e yr-1). Intensive grasslands account for a third of GHG emissions (32% or 10,629 tCO2e yr-1), whilst extensive grassland emit 6,698 tCO2e yr-1 or 20%. There is still approximately 4ha (only 0.2%) is in a near natural condition. In addition to 54 ha of rewetted fen (only 3%) of wasted fen extent. Rewetted fen accounts for 179 tCO2e yr-1 (less than 1% of total wasted peat emissions) (Figure 10).

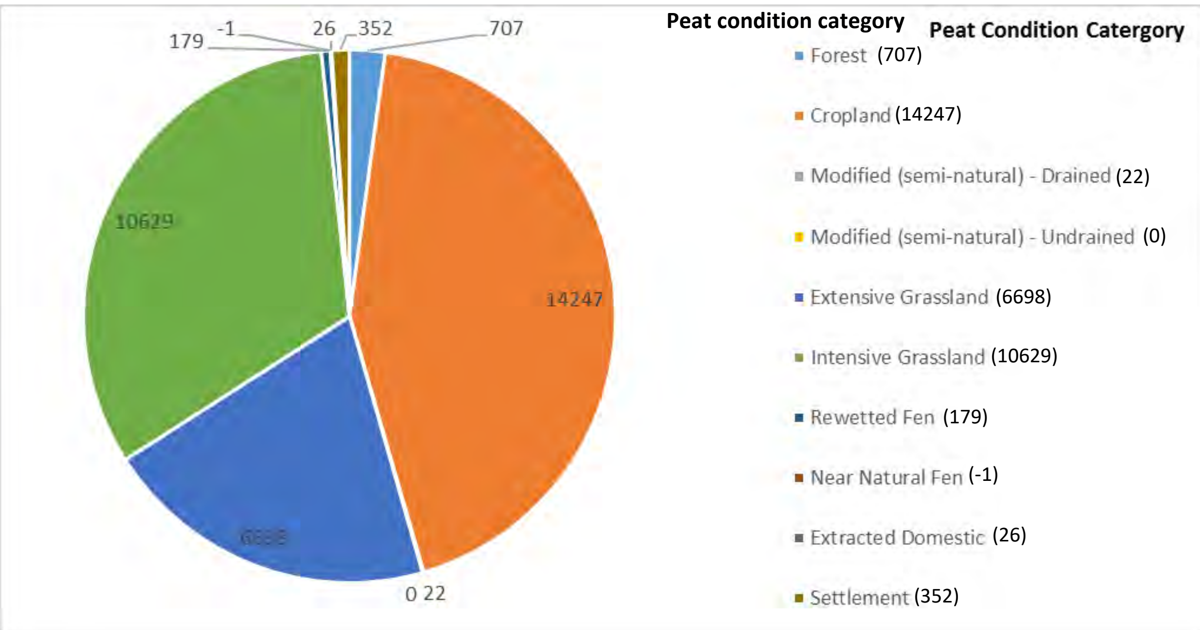


Figure 10: annual GHG emissions (tCO2e yr-1) of CW wasted fem peatlands. Positive annual emissions indicate net GHG emission and negative annual emissions indicate net GHG removal.

Domestic extraction of rich fen results in emissions of 666 tCO2e yr^{-1}, equivalent to 3% of total emissions, but 96% of total extraction emissions across both rich and wasted fen. Development impacts rich fen significantly less than wasted fen, with less than 4% of rich fen classified as settlement, emitting 73 tCO2e yr^{-1}. A much higher proportion of wasted fen peatlands are categorised as settlement (12% or 219 ha), emitting 352 tCO2e yr^{-1}.

Discussion

Carbon Savings through Reduced Emissions

CW's peatlands are a net-source of GHGs, emitting 52,862 $tCO_2e\ yr^{-1}$, equivalent to 0.01% of the UK's total annual emissions, or 0.29% of the UK's Land Use, Land Use Change and Forestry Sector (LULUCF) as reported in the UK National Inventory Report 2021 (Brown *et al.* 2021). As a result, there are substantial opportunities for emissions reductions across the borough through the implementation of sensitive management regimes and restoration. The greatest GHG reductions, and therefore the largest carbon savings, can be made by facilitating the transition of drained deep peats to modified or rewetted habitats. There are a number of ways that this could be achieved, depending on the appetite of the Council and the willingness of landowners to engage.

Agricultural Lowlands

As highlighted, the agricultural use of lowland deep peats is the largest source of peatland emissions across the borough, with just under half of the peatland extent contributing nearly three quarters of the total emissions. Therefore, these areas represent the most significant opportunities for emissions savings. This sentiment is reflected in CWAC's Climate Emergency Response Plan, which states that agricultural land is a target area for emissions reduction.

Whilst recognising that agriculture is an essential provisioning sector across Cheshire West, and that deep peats can be associated with higher Agricultural Land Classification (ALC) grades, the use of deep peats for intensive farming is highly unsustainable. Intensive grasslands on deep peats are the greatest GHG emitter: with an emissions factor of 22.00 $tCO_2e\ ha^{-1}\ yr^{-1}$, they generate 20,236 $tCO_2e\ yr^{-1}$, equivalent to 38% of the total CW peatland emissions. However, croplands are not emitting much less despite occupying roughly half the land area of intensive grasslands: with an emissions factor of 37.17 $tCO_2e\ ha^{-1}\ yr^{-1}$, croplands generate 18,513 $tCO_2e\ yr^{-1}$, equivalent to 35% of all CW peatland emissions. In comparison, the emissions factors of agricultural land not located on deep peats are significantly lower, highlighting the unsustainability of using peatlands in an intensive way.

Arable land (equivalent to cropland in this assessment) that is not located on deep peat is thought to have an emissions factor in the range of 0.29 to 0.7 $tCO_2e\ ha^{-1}\ yr^{-1}$ (Gregg *et al.* 2021), resulting in approximately 36.91 $tCO_2e\ ha^{-1}\ yr^{-1}$ less emissions from croplands located on deep peats. Emissions factors of intensive grasslands not located on deep peat are less well understood, although they are thought to have the potential to sequester carbon. Some examples of grazed intensive grasslands in Central Europe have been estimated to sequester -0.24 to -4.9 $tC\ ha^{-1}\ yr^{-1}$ (Gregg *et al.* 2021).

If the intensive management of grasslands on deep peat in CW was stopped, and appropriate management plans were put in place to transition these areas to extensive grassland i.e., unfertilised permanent grassland, lower-density grazed or hay-cropped, this could translate to an emission saving of 5,629 $tCO_2e\ yr^{-1}$, more than a 10% reduction in overall peatland emissions. If areas currently utilised as croplands were also converted to this condition category, the emissions could be reduced further by over 10,000$tCO_2e\ yr^{-1}$, or an additional 20% reduction in total peatland emissions. Greater savings still could be made by transitioning to semi-natural peatland condition categories; if all intensive grasslands on deep peat across CW were restored and managed back to rewetted fen or modified 'grass-dominated' (with a high cover of semi-natural species such as graminoids, including *Molinia caerulea*), this could result in an emissions saving of 17, 192 $tCO_2e\ yr^{-1}$ or 17,183 $tCO_2e\ yr^{-1}$ respectively (or approximately a 32% reduction each in overall peatland emissions). Undertaking the same process with cropland would result in a similar reduction of one third of emissions (approximately 16,000 $tCO_2e\ yr^{-1}$).

These figures demonstrate that peatland under agriculture offers 'low-hanging fruit' opportunities for carbon emission savings; managing grassland more strictly and sympathetically and taking cropland out of production and into extensive grassland, will together save almost one third of the total carbon emissions. However, ultimately, taking peatland out of agriculture and restoring it to semi-natural states will result in the highest emission savings of at least 65% of total emissions. Naturally, a balance could be struck between restoration and productivity, by prioritising restoration on land of ALC grade 3 or lower value. There is very high potential for restoration of peatland on agricultural land, whilst maintaining productivity, in CW, because only 2.5% is identified as high value (grade 2) agricultural land, and 16% is identified as low value (grade 4). To envision this, see Case Study 3 'River Gowy Catchment' and Case Study 4 'Whitley Reed'.

Due to the significant emissions arising as a result of drainage-based agriculture on deep peat reserves, yet the need to maintain productivity, research in this field is ongoing and a recently published study from Evans *et al.* (2021) offers an alternative approach to that discussed above. The team found that the mean annual effective water-table depth (the average depth of the aerated peat layer) overrides all other ecosystem and management related controls on greenhouse gas fluxes of agricultural land. The research team estimate that reducing the mean annual effective water depth could reduce emissions by at least 3 $tCO_2e\ ha^{-1}\ yr^{-1}$ for every 10 cm. In other words, raising the water table to reduce the amount of aerated peat results in significant emissions savings. The team conclude that by using this approach, GHG emissions from peatlands drained for agriculture would be greatly reduced without necessarily halting their productive use. Additional research into how this approach could be applied across CW and how it could reduce the borough's peatland emissions as a result is required.

Extraction and Development

Where deep peat is extracted domestically (i.e., manual extraction), extracted to facilitate development, or developed over, it is essentially lost forever. Currently, around 310 ha or 2% of CW's total peatland extent has been lost to extraction and settlement. The loss of peat to extraction and settlement, whilst not accounting for a particularly large area across the borough, still results in significant emissions (1,117 $tCO_2e\ ha^{-1}\ yr^{-1}$). Settlement is defined in accordance with the 2006 IPCC Agriculture, Forestry and Other Land Use Guidance[12], including all developed land i.e., residential, transportation, commercial and production (commercial manufacturing) infrastructure of any size. Importantly, the emissions factor for settlements does not account for any potential emissions or loss of stored carbon in vegetation or soil associated with the construction of new infrastructure (i.e., the emissions associated with the land use change from undeveloped to developed land). Therefore, development on peatland is even more damaging to the climate as, in reality, it emits an initial burst of carbon before then emitting a further 1.61 $tCO_2e\ ha^{-1}\ yr^{-1}$.

Extraction of peat has a high emissions factor compared with emissions arising as a result of settlement however, both are equally damaging when consideration is given to time as a limiting factor. The time an area of deep peat is extracted over is finite (e.g., 50 years) whereas the lifetime of a development such as a housing estate can be much longer or even permanent. Emissions associated with extraction can potentially, eventually, be reversed with restoration (assuming not all peat has been extracted), whereas those associated with development cannot. If domestic extraction of peat (currently the source of 692 $tCO_2e\ yr^{-1}$) across the borough was banned and

[12] https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

halted immediately, and the extraction areas and any remaining deep peat was rewetted (to create rewetted fen), there would be a substantial emission saving of 540 tCO2e yr^{-1}.

When compared to deep peat located beneath settlement (currently the source of 425 tCO2e yr^{-1}), despite being a smaller GHG source, these emissions are essentially permanent and cannot be reversed. When considering both over a 50-year time period, the difference becomes significant: the peat under settlement will have emitted 21,250 tCO2e, whereas extracted peat would have the potential to emit a fraction (less than 1%) of these emissions if it was restored to rewetted fen. To avoid additional, potentially permanent, emissions, the extraction and development of peatlands should be stopped immediately across CW (see case Study 2 'Frodsham, Helsby, and Ince Marshes' and Case Study 3 'River Gowy Catchment'). This should also extend to the inclusion of deep peats within future strategic development allocations (e.g., local plan allocations such as 'New Bridge Road, Stanlow' – employment land provision in Ellesmere Port; or the Ellesmere Port settlement area). Where strategic development allocations have already been approved, the loss of stored carbon and any GHG emissions associated with the development of deep peat should be considered as part of the planning decision process, with consideration to how offsetting increased emissions can be demonstrated.

Restoration and Management

In addition to transitioning CW's drained to modified or rewetted habitats, the ongoing restoration and appropriate management of semi-natural peatland habitats is essential, not only to protect and maintain these important habitats, but to also ensure emissions arising from them do not increase. Modified, rewetted, and near natural peatland habitats account for 5% of the peat extent in CW. Only 0.3% (11ha) is in a near natural condition, which is considerably lower than the national extent of 1.3% (Gregg *et al.* 2021). These semi-natural peatlands emit 412 tCO2e yr^{-1} or less than 13% of the total emissions. This demonstrates the importance of the ongoing management of semi-natural habitats to keep them in such a state in terms of limiting emissions. The alternative state - inappropriate land use – is demonstrated by the fact that just over half of the borough's deep peat is the source of 75% of its GHG emissions.

Targeted restoration of drained areas of deep peat can also have significant benefits in terms of improving, buffering, expanding, and linking existing semi-natural peatland habitats. Many semi-natural peatland sites across the borough are isolated, and the underlying deep peat is surrounded by and encroached on by unsustainable land uses, such as intensive and extensive grasslands or croplands, as demonstrated in the examples below (see Case Study 1 'Frodsham Field Centre', Case Study 3 'River Gowy Catchment', and Case Study 4 'Whitley Reed'). This can lead to complications that reduce the effectiveness of management efforts at a semi-natural site, in particular where nutrient rich habitats, such as intensive grasslands, border nutrient poor habitats, such as lowland fen. Ditches that drain water off intensively farmed peatland surrounding semi-natural peatland are nutrient rich and therefore cannot be utilised to rewet semi-natural peatlands further. If the surrounding areas of drained peatland were subject to a suitable restoration programme, the nutrient inputs surrounding the semi-natural peatland would reduce and the existing drainage ditches could be used to redirect additional water on to the core site, thereby further repairing the hydrology. The targeted restoration of drained peatlands adjacent to existing semi-natural peatland habitats has the potential to result in significant benefits to both the restoration areas and any existing hydrologically linked restored or semi-natural peatlands in close proximity.

Tree planting on areas of deep peat or in areas that have the potential to affect the hydrology of a peatland is also highly inappropriate and should be stopped immediately throughout CW. Tree roots draw moisture out of the ground, lowering the water table, which results in accelerated degradation of the underlying peat body. This is particularly important in light of the significant national and local targets and incentives for tree planting to offset emissions. A suitably qualified ecologist, and the datasets presented in this report, should be consulted prior to any tree planting taking place across CW. Additionally, as highlighted in the following biodiversity section, a proportion of the forested peatland condition category within CW is likely to be of semi-natural origin. Therefore, due to the inherent biodiversity associated with this semi-natural habitat type, further assessment of peatland areas in this condition is required to establish if there are opportunities for deforestation of plantations to facilitate the restoration of fen habitats across the borough (see Case Study 5 'Delamere').

Biodiversity

Over half (1,714 ha or 57 %) of CW's peatlands are designated as statutory or non-statutory sites for nature conservation. Overall, 109 ha or 4% of the borough's semi-natural peatlands[13] are designated as statutory designated sites for nature conservation, and 1,605 or 53% are designated as non-statutory LWS. However, only a small proportion of the borough's semi-natural peatland habitats fall within statutory designated sites for nature conservation including 12 ha (11%) rewetted fen, 5 ha (4%) near natural fens, and zero undrained, and zero drained, modified fen, equivalent to an area of 17 ha. The remaining rewetted fen (98 ha), the remaining near natural fen (6 ha), and the vast majority of the remaining undrained modified fen (9ha) falls under LWS designation (see Case Study 1 'Frodsham Field Centre'). Some undrained modified fens (2ha – see Case Study 4 'Whitley Reed') and drained modified fen (7 ha) are not under any designation.

There are 40 non-statutory sites identified as LWS. Of the LWS, 35% (14 of the 40 sites) are designated because of the woodland. 55% (22 of the 40) of the LWS are designated because of the presence of wetland habitat. All these sites were surveyed in 2010 or more recently against the Cheshire LWS Selection Criteria (Giles 2012).

Additional Sites Suitable for Designation

The assessment has revealed that there are potentially some areas of semi-natural peatland across the borough that could potentially already meet the criteria to be designated as either statutory or non-statutory designated sites for nature conservation: 9 ha of drained and undrained modified semi-natural peatlands, some of which is within one of CW's deepest peat sites (Whitley Reed), are undesignated (see Case Study 4 'Whitley Reed'). These areas should be surveyed against the Cheshire LWS Selection Criteria (Giles 2012) as a priority to ascertain whether they meet the criteria to be designated as LWS. The added protections afforded from LWS status will help to ensure these sites are managed appropriately for their biodiversity value. If, as previously discussed, any of these drained areas were rewetted and transitioned to the rewetted modified (semi-natural bogs) condition category, then they may also be suitable for designation under the fens, swamps, bogs and reedbeds LWS habitat criteria.

Expansion and Connection of Designated Sites

In line with the Lawton Principles (Lawton *et al.* 2010) a step change in the approach to wildlife conservation is required if ongoing national declines in biodiversity are to be halted and reversed. Large-scale habitat restoration and recreation, underpinned by the re-establishment of ecological processes and ecosystem services, for the benefits of both people and wildlife should be the ambition for nature's recovery across CW. The borough's wildlife and semi-natural habitats,

[13] Semi-natural peatland condition categories include undrained modified bogs (semi-natural heather & grass dominated), drained and undrained eroding modified bogs (bare peat), rewetted bogs, rewetted fens, rewetted modified (semi-natural bogs), near natural bogs, near natural fens and freshwater.

including peatlands, have become increasingly fragmented and isolated, leading to declines in the provision of ecosystem services and declines in semi-natural habitat extent and species populations. Ecological networks, or the Nature Recovery Network (NRN), have become widely recognised as an effective way to conserve wildlife in environments that have been fragmented by human activities. Peatlands are a finite natural capital asset that provide both ecosystem services and benefits to biodiversity and should form a core component of any ecological network, or the NRN, across CW. As previously discussed, the targeted restoration of drained areas of deep peat can have significant benefits in terms of improving, buffering, expanding, and linking existing semi-natural peatland habitats. Targeting areas of drained deep peats surrounding sites designated for nature conservation can also bring about additional benefits to biodiversity due to the principles behind landscape scale habitat connectivity. This could potentially result in both emissions savings and significant improvements to the connectivity of semi-natural habitats in and around the designated sites, thereby providing additional benefits to the biodiversity within and throughout the wider area (see Case Study 1 'Frodsham Field Centre', Case Study 3 'River Gowy Catchment', and Case Study 4 'Whitley Reed').

Wasted Versus Rich Fen

CW's lowland peatlands are split relatively equally between rich fen (40% or 1,217ha) and wasted fen (60% or 1,816ha). However, total emissions from wasted fen (32,859 $tCO_2e\ yr^{-1}$) are significantly higher than those from rich fen (20,003 $tCO_2e\ yr^{-1}$). Both fen peatland types are under a very similar proportion of agricultural use (47% on wasted fen; 45% on rich fen). Emissions arising from this land use are much higher from wasted than rich fen, although the proportions are similar: agricultural land use on wasted fen emits 24,755 $tCO_2e\ yr^{-1}$ (76%) compared to 13,873 $tCO_2e\ yr^{-1}$ (70%).

Subsequently this data suggests, in terms of emission savings, transitioning agricultural land use to a better peatland condition category would be equally beneficial on wasted compared to rich fen. There have been limited studies to date to measure GHG emissions from wasted peatlands in the UK, except one which suggests that GHG emissions are less from wasted peatlands (Newman, 2021). This is because carbon has historically been lost from wasted peatlands causing a decreased depth of peat, and a reduced soil carbon stock. This means there is less stored carbon to lose and emit than in non-wasted (rich) peatland. More studies would need to be done to better assess whether wasted fen is emitting any different than rich fens.

Wasted fen is classified as formerly deep peat that is less than 40 cm deep (Newman, 2021) that has been degraded by erosion or oxidation (Page et al, 2020). Wasted peatland have typically been ignored in restoration projects as they have lost peat forming vegetation and typically peat is not present at the surface level (Worrall, 2010), which renders them more difficult to restore. The comparative difficulty of restoring wasted compared to rich fen indicates the prudence of protecting and restoring rich fen in poor condition (i.e., under agricultural or extraction land use) to prevent it degrading to wasted fen. CW accounts for 0.5% of all England's peatlands, but its proportion of national wasted peat is more significant at 1% of England's wasted peatlands. Thus, wasted fen restoration in CW may be a priority when considering CW's impact on the national landscape.

Case Studies

Case Study 1: Frodsham Field Centre

Frodsham Field Centre is an example of the importance of LWS designations for peatlands across CW. As identified in the 'Biodiversity' discussion section, over three quarters of CW's peatlands are under some form of designation, yet the vast majority of these designated sites are non-statutory LWS, like Frodsham Field Centre. This suggests LWS are just as, if not even more important for CW's peatlands than statutory sites and this must be reflected in policy and their protection.

Designated sites have accrued this classification often because they contain habitat in its best condition. Frodsham Field Centre contains 3.7 ha of near natural fen, i.e., peatland in its best condition, or 35% of this peatland condition in CW. Protection of this habitat is of course vital, not only because it is pristine, but also because it is sequestering carbon at 3.8 $tCO_2e\ yr^{-1}$. Nevertheless, in line with the Lawton Principles (Lawton *et al.* 2010), the condition of protected sites like Frodsham Field Centre should be targeted for improvement. As shown in Figure 11, much of the peatland within the red line boundary of this site is in an undesirable condition, contributing to the site as a whole emitting around 300 $tCO_2e\ yr^{-1}$. Targeted restoration of the areas under extraction and extensive grassland would improve the condition of this peat body as a whole, whilst also reducing carbon emissions from it.

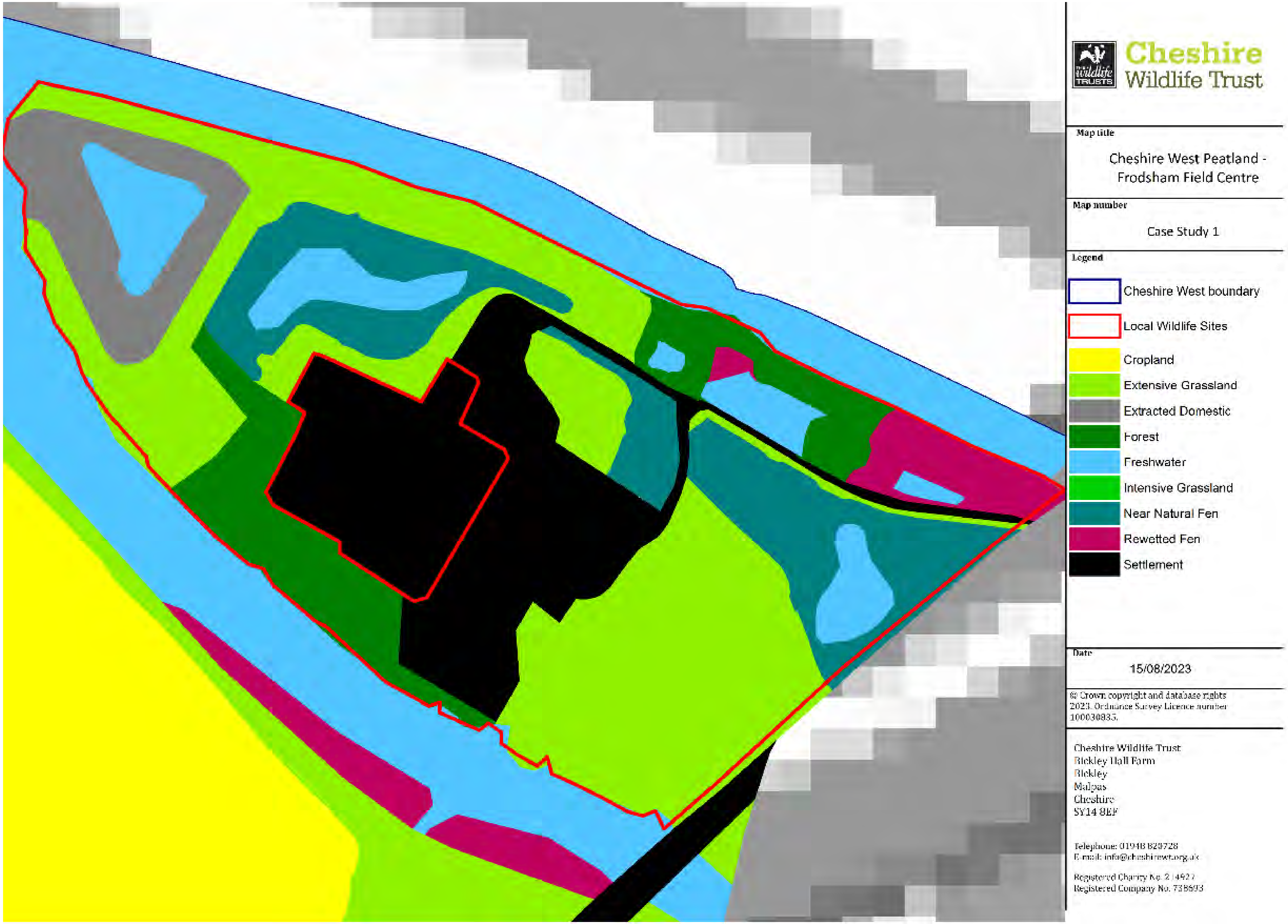


Figure 11: Case Study 1 – Frodsham Fields Centre LWS – showing peatland condition categories, including areas of near natural fen.

Case Study 2: Frodsham, Helsby and Ince Marshes

Frodsham, Helsby, and Ince Marshes is identified as a LWS for its mosaic of habitats, including priority habitat ‘floodplain grazing marsh’ (Figure 12b) which is an important habitat for numerous species of wetland birds. As mentioned in the ‘Biodiversity’ discussion section, consideration should be given to biodiversity requirements before peatland restoration takes place, as there are sometimes conflicting management needs. The floodplain grazing marsh is classified as peatland under extensive grassland and thus, the condition of the peat could be improved by rewetting and blocking ditches. Nevertheless, the complex ditch system on site is an important component maintaining the floodplain grazing marsh on site, which is not only an important habitat in itself, but is also crucial for the sustenance of important bird populations. This site is an example of where peatland restoration potential should be limited because of the existing needs of biodiversity.

Frodsham, Helsby, and Ince Marshes account for over half of CW’s peatland under LWS designation and 42% of CW’s entire peatlands, meaning it is a very important peatland in CW. Despite this, this LWS is of high development interest; a wind farm has already been developed, whilst a section has been identified for the development of a solar farm, and the site may also be affected by the HyNet pipeline infrastructure. Development on peatland not only results in the permanent loss of peat, but also reduces the amount of peat available for restoration, reducing the potential for carbon emission savings. This site exemplifies why all development on peatland across CW must cease.

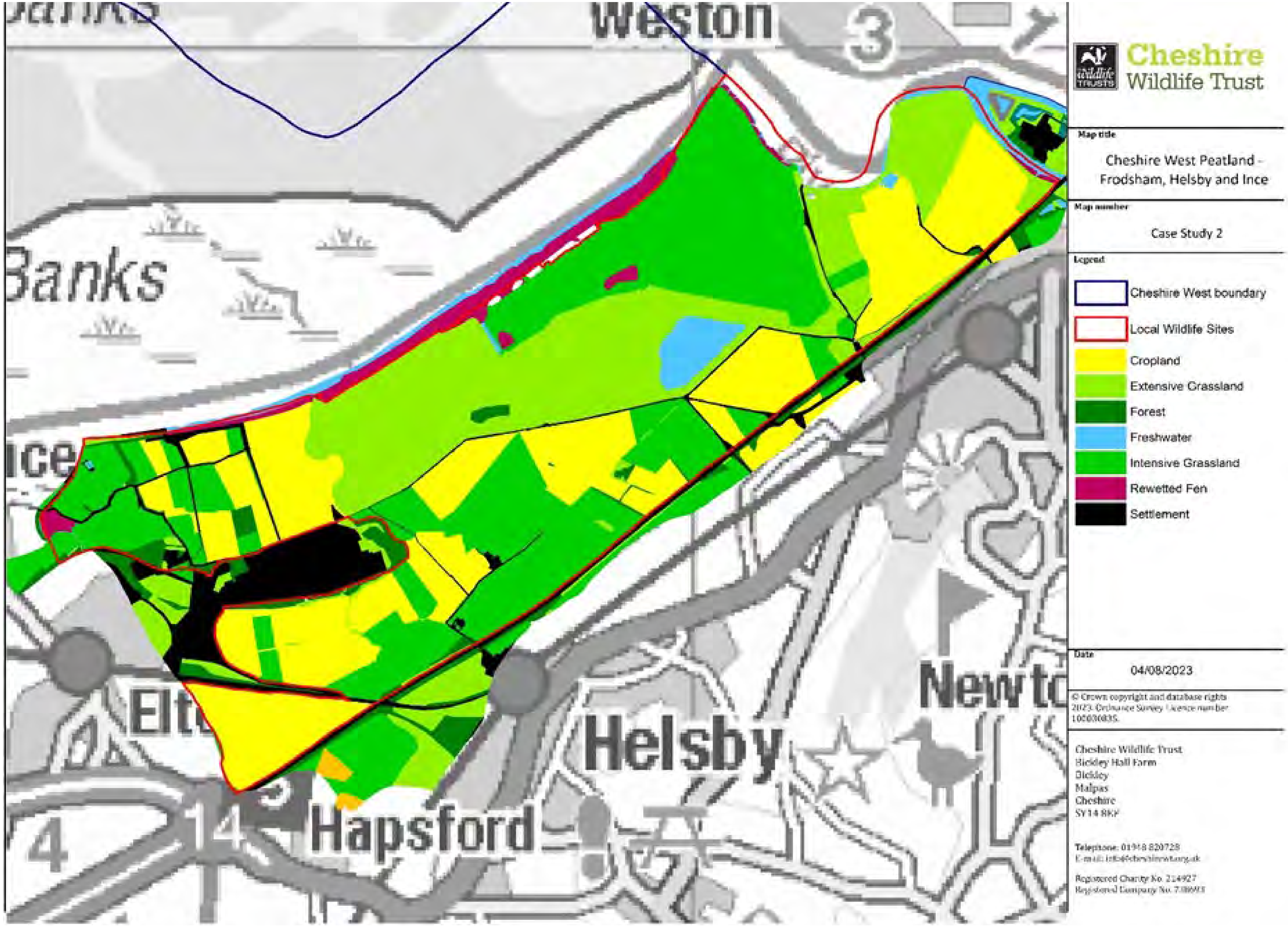


Figure 12a: Case Study 2 – Frodsham, Helsby, and Ince Marshes LWS – showing peatland condition categories.

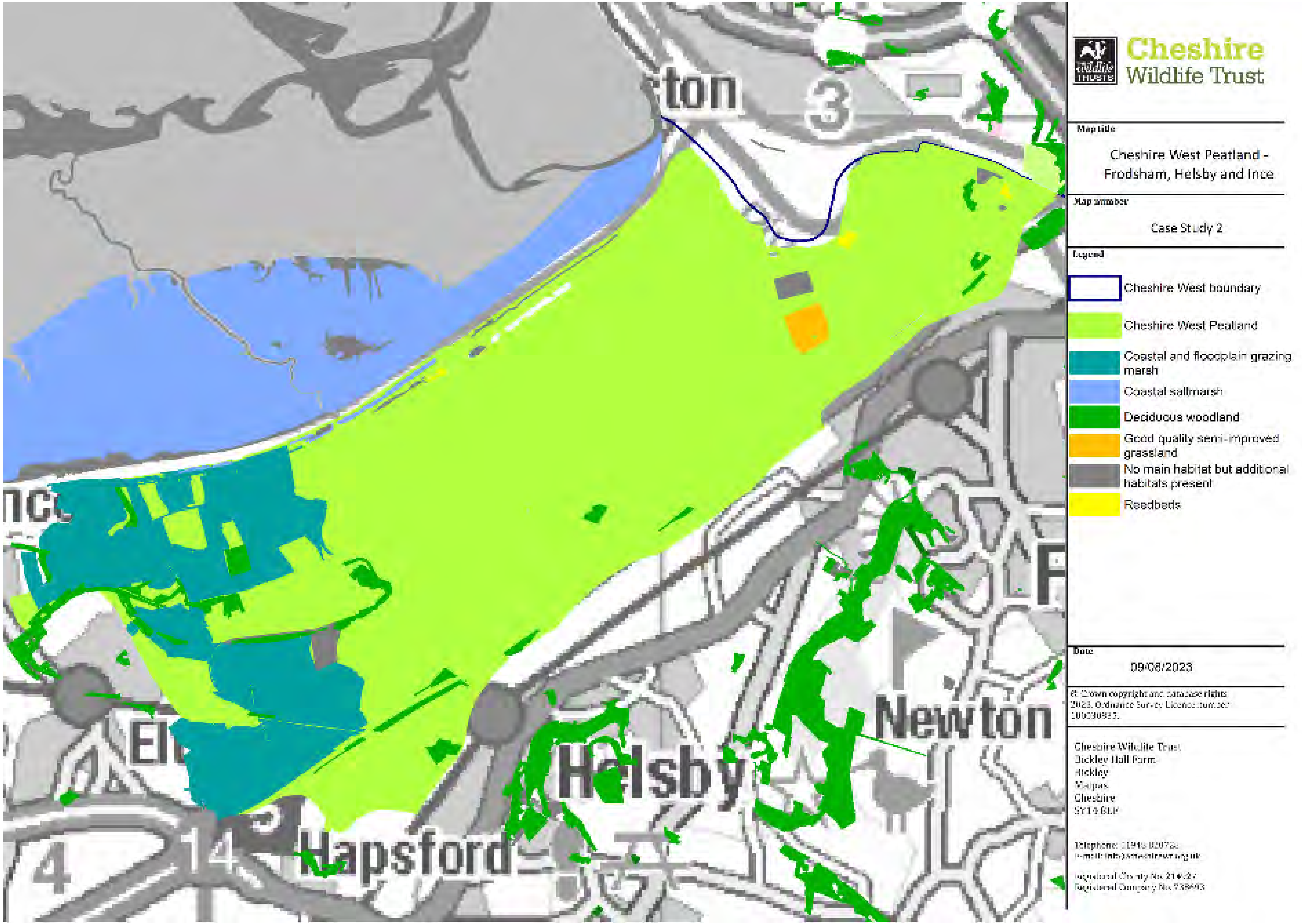


Figure 12b: Case Study 2 - Frodsham, Helsby, and Ince Marshes – showing priority habitats on site including 'coastal and floodplain grazing marsh'.

Case Study 3: River Gowy Catchment

The River Gowy Catchment area includes several Local Wildlife Sites including Gowy Meadows and Ditches and Wervin Meadows. Gowy Meadows and Ditches, and Wervin Meadows, LWSs contain the priority habitat ‘floodplain grazing marsh’ which is an important habitat for numerous species of wetland birds (Figure 13b). As explained in ‘Case Study 2’, this is another example of a site where peatland restoration potential should be limited because of the existing needs of biodiversity.

An active landfill site and agricultural land on the opposite side of the river disconnect Gowy Meadows and Ditches, and Wervin Meadows, from several other LWS: Bridge Trafford North, Bridge Trafford South, and Grange Farm Meadows and Ditches. As seen from Figure 13a, all this land is on one continuous peat body. Following Lawton principles (Lawton *et al.* 2010), this area is an example of where expanding and connecting designated sites in CW could happen. Stopping any further extraction, and targeting restoration of any peat not yet extracted by the active landfill, and under agriculture, would connect the LWSs, benefitting the biodiversity and habitats on site, and improve the condition of the entire peat body, reducing the amount of carbon it currently emits because of these land uses (2,634 tCO_2e yr^{-1}).

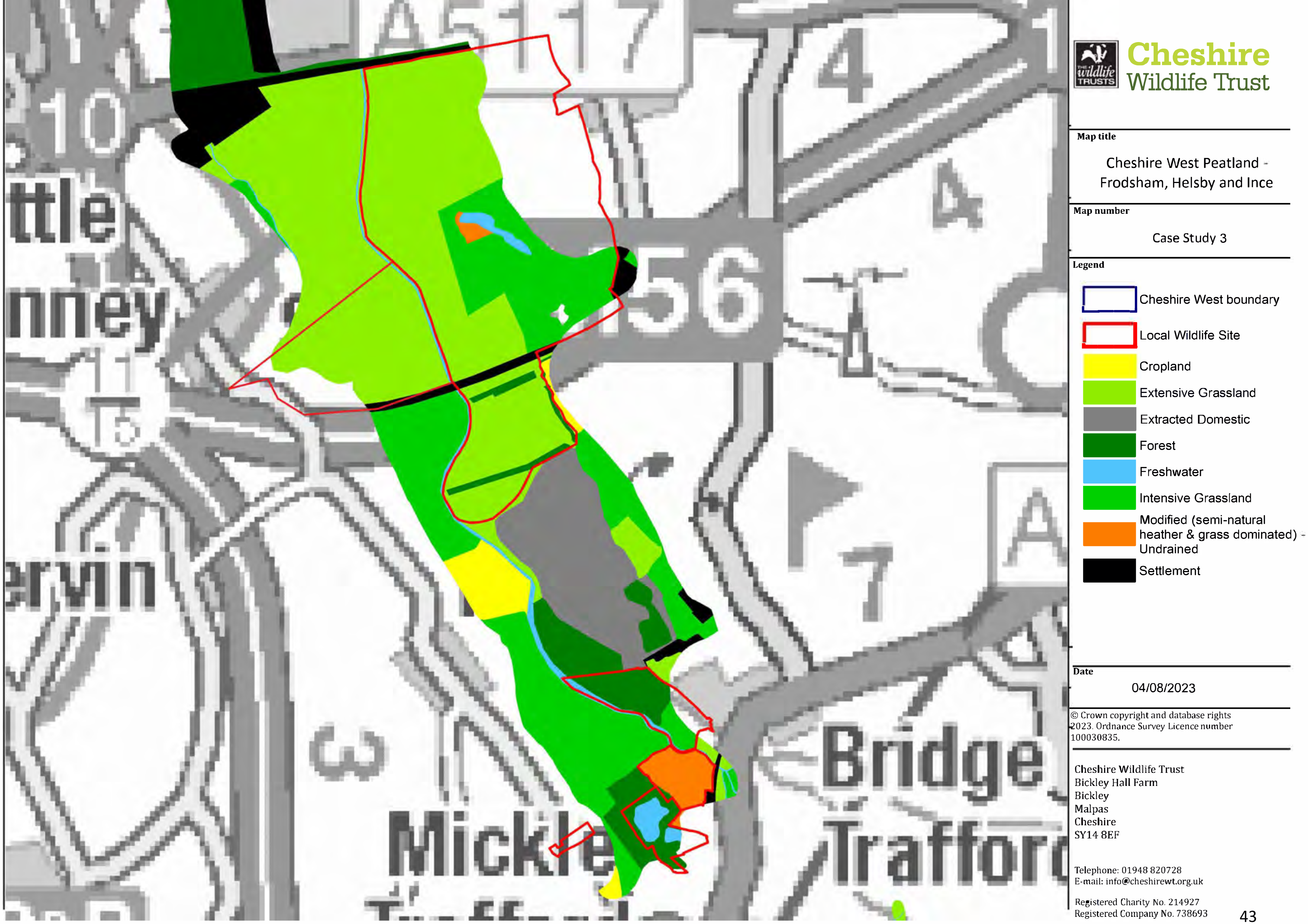
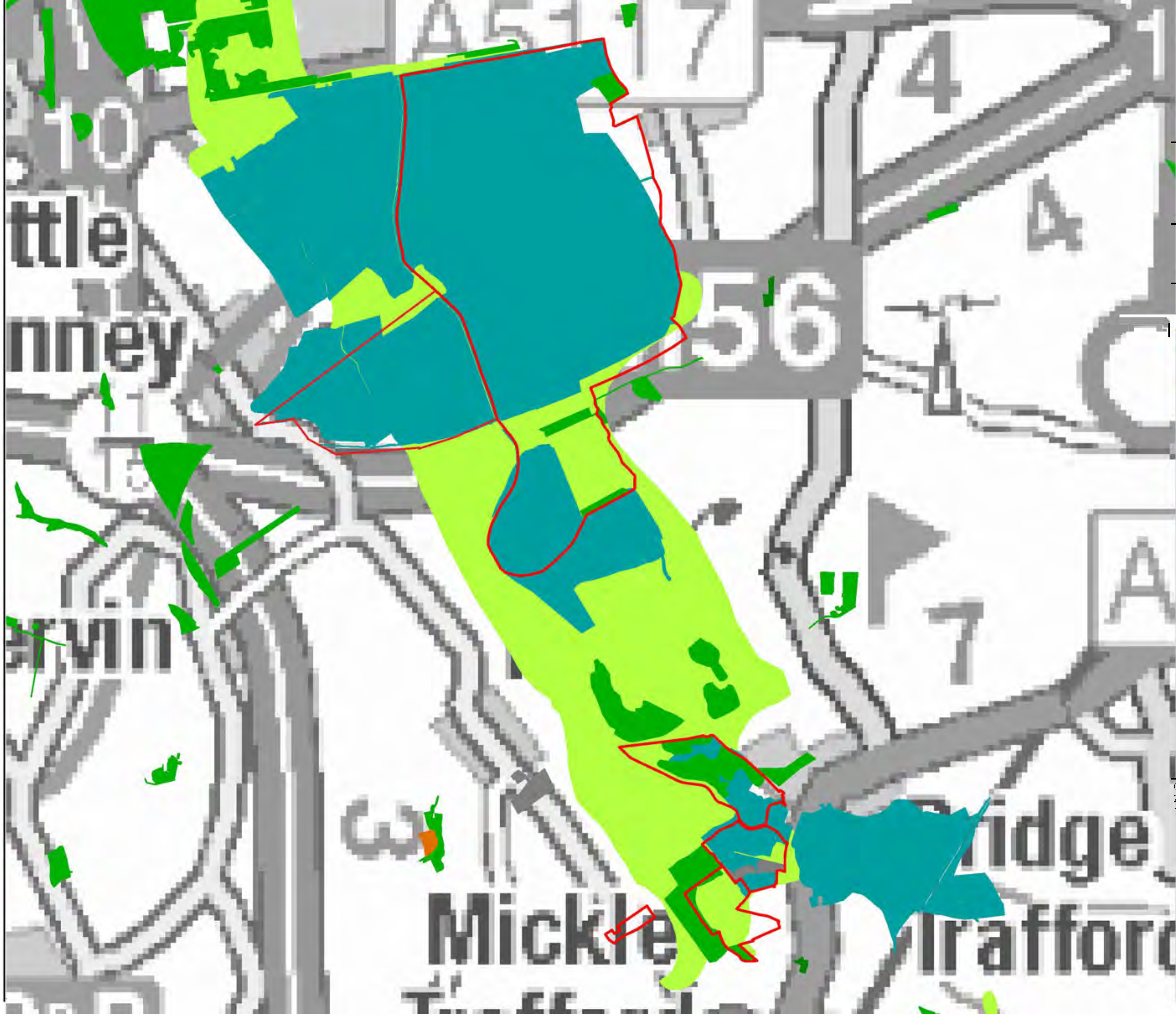


Figure 13a: Case Study 3 – River Gowy Catchment – showing peatland condition category.



Cheshire Wildlife Trust

Map title

Cheshire West Peatland - Frodsham, Helsby and Ince

Map number

Case Study 3

Legend

- Cheshire West boundary
- Local Wildlife Site
- Cheshire West Peatland
- Coastal and floodplain grazing marsh
- Deciduous woodland
- No main habitat but additional habitats present

Date

04/08/2023

Cheshire Wildlife Trust
Bickley Hall Farm
Bickley
Malpas
Cheshire
SY14 8EF

Telephone: 01948 820728
E-mail: info@cheshirewt.org.uk

Registered Charity No. 214927
Registered Company No. 738693

Figure 13b: Case Study 3 – River Gowy Catchment – showing priority habitats including 'coastal and floodplain grazing marsh'.

Case Study 4: Whitley Reed

Whitley Reed is one of CW's deepest peat sites, with peat historically recorded to depths of 1.5m. It is an undesignated site connected to Appleton and Stretton Moss's (with the latter being a designated site) forming a large, continuous peat body which is mostly under agriculture (Figure 14a). Some of this peat body falls outside of CW's boundary however, within CW this peat body accounts for 9% of total peatland area yet is responsible for 12% (6,516 $tCO_2e\ ha^{-1}\ yr^{-1}$) of CW's peatland emissions. This area demonstrates the vast potential of peatland restoration on agricultural land. As identified in Figure 14b, the vast majority of the agricultural land is of poorer quality (ALC grade 3) suggesting restoring this land to semi-natural peatland would not impact heavily on food production. Restoring this peatland to a semi-natural state (modified drained) would not only connect the designated sites, benefiting biodiversity and ecosystem function, but it would also significantly reduce CW's carbon emissions by 2,502 $tCO_2e\ yr^{-1}$, or 5% of CW's emissions.

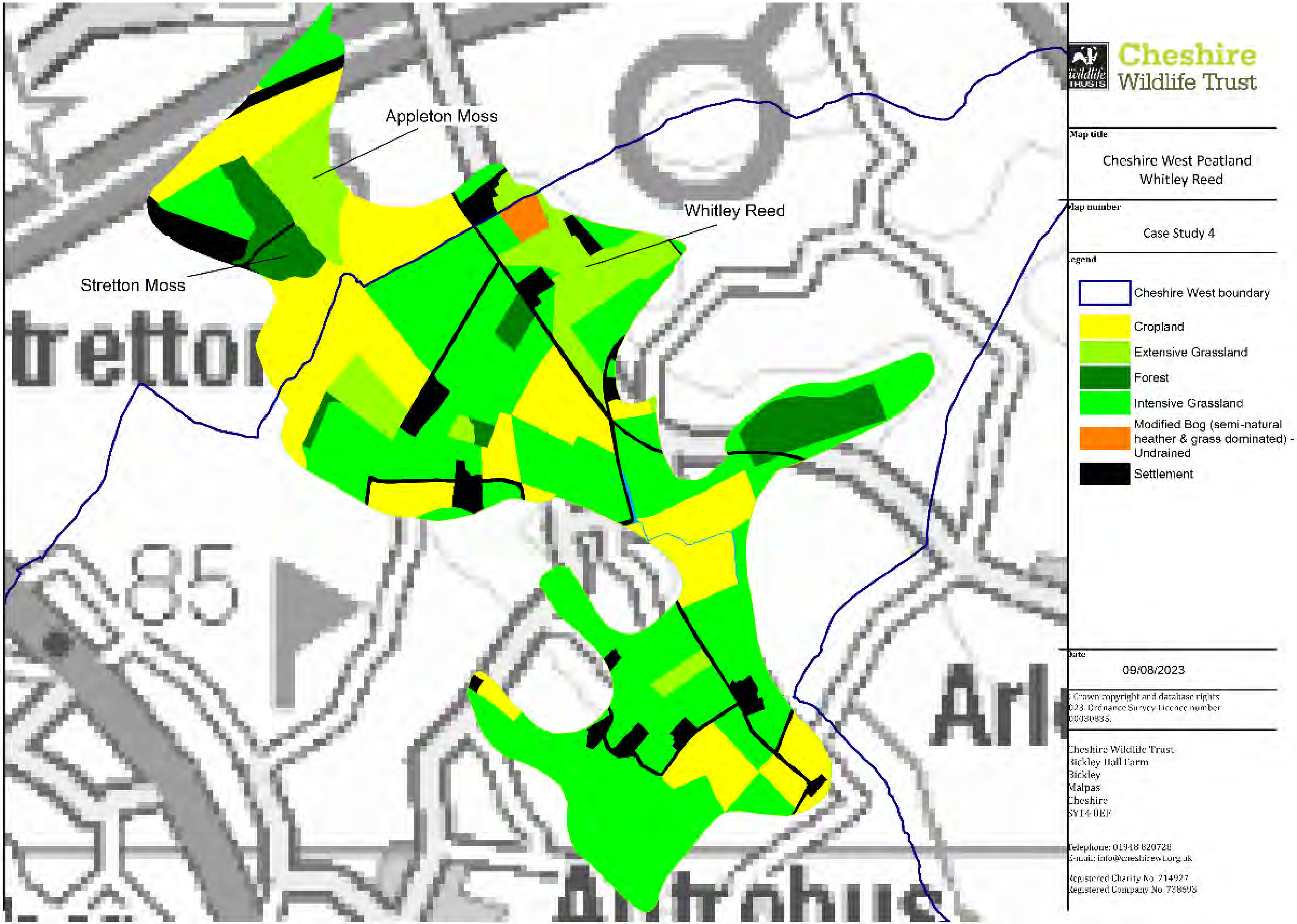


Figure 14a: Case Study 4 – Whitley Reed – showing peatland condition category.

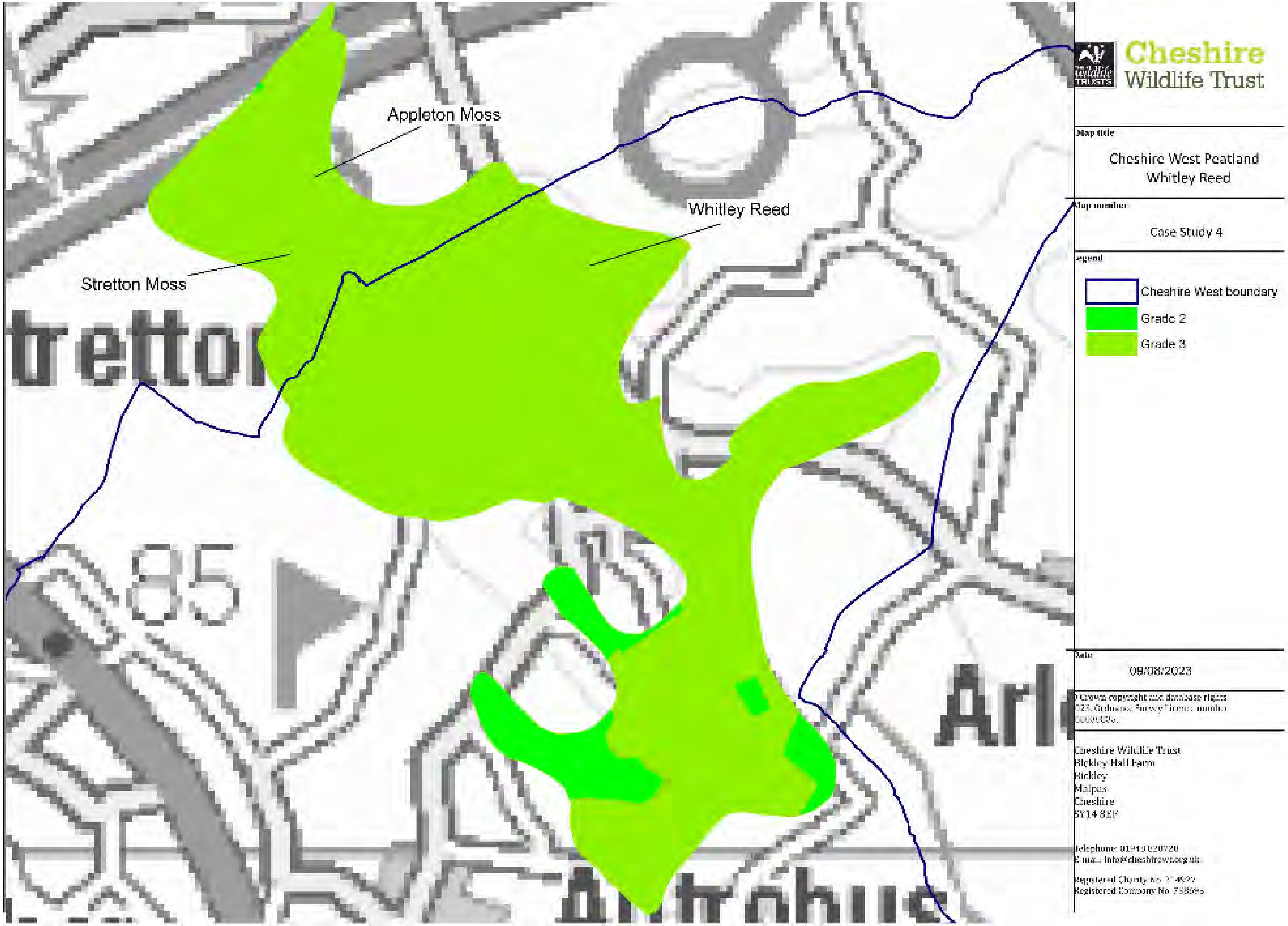


Figure 14b: Case Study 4 – Whitley Reed – showing agricultural grade of peatland.

Case Study 5: Delamere Forest

Delamere Forest is an example of a successful peatland restoration in CW. Much of this peatland is afforested with coniferous plantation (Figure 15) which is deteriorating the condition of the peat (as discussed earlier). Widespread restoration began in 1994 through actions such as tree removal, implementation of appropriate management plans and rewetting through bunding. The peatland is now in a much better condition with large areas classified as rewetted fen, leading to emission savings of 91.5 tCO_2e yr^{-1} compared to its previously afforested state.

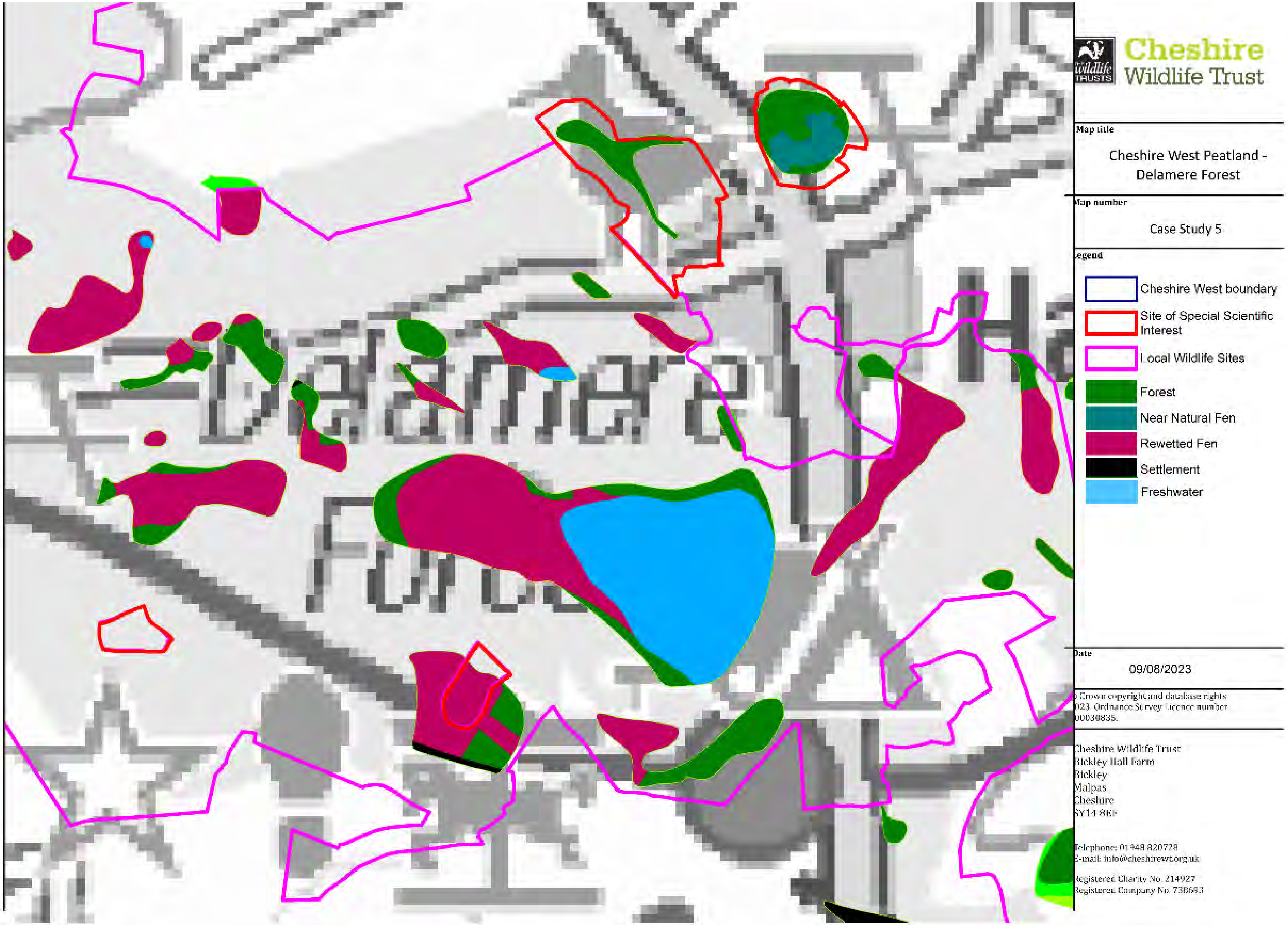


Figure 15: Case Study 5 – Delamere Forest – showing peatland condition category.

Management and Restoration Targets

CW&C's Climate Emergency Response Plan states that the borough aims to achieve carbon neutrality by 2040 (CW&C 2019). Within this plan is a particular section on the Land Use Sector, with a target of a 10% reduction (3850 tCO_2e) in emissions (38.5 $ktCO_2e$/annum) by 2025. This report has demonstrated that this target is more than achievable by transitioning peatland under certain land uses to others, particularly away from agricultural, extraction, and settlement use.

CW&C's Carbon Management Plan reports the Council are targeting reducing their own carbon emissions to a residual of 445 $tCO_2e\ yr^{-1}\ ha^{-1}$ by 2030 (CW&C 2023). The strategy states the council will purchase offsets to account for residual emissions including, amongst other examples, lowland peat restoration. Offsetting the entirety of CWAC's residual emissions would be easily achievable through peatland restoration and resulting emissions savings, given the residual emissions are less than 1% of the total emissions from peatland. This could be achieved by purchasing offsets to restore peatland on third party land, as stated in the plan, or instead, this could be achieved through insetting instead, i.e., restoring peatland on CWAC-owned land. Reviewing Council land for this reason is stated as an action in the Climate Emergency Response Plan (CW&C 2019).

CW&C's Climate Emergency Response Plan references the restoration of peatland as a priority for the UK government (CW&C 2019). Despite this, there is no mention within this plan of any peatland emission saving or restoration targets within the borough. This report demonstrated that peatland restoration could not only make CWAC a net zero council, but also has the potential to reduce the borough's carbon emissions significantly. It could be used as a starting point to setting carbon emission and peatland restoration targets, and subsequently identifying priority sites for restoration.

The peatland management and restoration targets as set out in the Sixth Carbon Budget (CCC 2020), which could be formally adopted by government as part of commitments within the England Peat Strategy (DEFRA 2021a), are also highly ambitious. In the context of Cheshire West, these targets would equate to the equivalent areas shown in Table 7 below.

Table 7: Peatland management and restoration targets as set out in the Sixth Carbon Budget (CCC 2020) and the equivalent areas in CW.

Sixth Carbon Budget Peatland Target	Equivalent area in Cheshire West
Increasing the UK peatland area restored from 25% (current level) to 58% in 2035 and 79% by 2050, with a further 35% of lowland cropland sustainably managed.	Existing area restored in CW is 128 ha (4%) increasing to 1,759 ha (58%) by 2035 and 2,396 ha (79%) in 2050, with an additional 174 ha (35%) of lowland cropland sustainably managed.
25% of the area of lowland grassland is rewetted by 2035, rising to half by 2050.	172 ha (25%) of lowland grassland is rewetted by 2035, rising to 344 ha (50%) by 2050.
75% of lowland cropland is either rewetted or sustainably managed by 2050.	374 ha (75%) of lowland cropland is either rewetted or sustainably managed by 2050.
A quarter of the area is rewetted to near natural condition (and crop production ceases), and a further 15% is rewetted but conventional crop production switches to paludiculture crops.	93 ha (25%) of the area is rewetted to near natural condition (and crop production ceases), and a further 56 ha (15%) is rewetted but conventional crop production switches to paludiculture crops.
Water-table management options are deployed to 35% of the lowland cropland area.	Water-table management options are deployed to 174 ha (35%) of the lowland cropland area.
All low-productive trees of less than YC8 are removed off peatland by 2030[14] and all peat extraction sites are restored by 2035.	All peat extraction sites (46 ha) are restored by 2035.

Achieving the targets set out in the Climate Emergency Response Plan (CW&C 2019), Carbon Management Plan (CW&C 2023), Sixth Carbon Budget (CCC 2020), or setting further specific targets for the borough, would result in a significant reduction in peatland GHG emissions and substantial benefits to biodiversity across the borough. However, there are likely to be barriers to restoration at the scale set out above.

Difficulties associated with peatland restoration can range from: a lack of land ownership or a lack of influence over peatland landowners; a lack of incentives for landowners to implement land-use change; ongoing funding to mitigate the economic consequences of a loss of productive land; and the loss of the cultural identity and heritage associated with lowland management for agriculture. However, with new funding sources such as the UK Government's Nature for Climate fund, carbon credits through The Peatland Carbon Code[15], and the Environmental Land Management or Biodiversity Net-gain schemes, opportunities for mitigating the economic consequences of a loss of productive land are available. The formation of effective and inclusive stakeholder partnerships to access this funding, alongside the development of strong local policy, will be vital in order to influence and support landowners to adopt a more sustainable approach to peatland management, whilst protecting the cultural identity and heritage of these land-use sectors.

[14] This target could not be calculated based on the findings of this report and will require more detailed woodland modelling to estimate.
[15] https://www.iucn-uk-peatlandprogramme.org/funding-finance/introduction-peatland-code

Conclusion

The vast majority of peatlands in CW are in a drained state. They cover an area of 3,033 ha and are the source of 52,862 $tCO_2e\ yr^{-1}$. The majority of peatland emissions are the result of unsustainable land use and management across the borough. As a result of agriculture, nearly half of the total deep peat extent contributes three quarters of all CW peatland emissions. When compared to the GHG emissions of agricultural habitats away from deep peats, the unsustainability of using peatlands for agriculture is evident. Arable land that is not located on deep peat is thought to have an emissions factor in the range of 0.29 to 0.7 $tCO_2e\ ha^{-1}\ yr^{-1}$ (Gregg *et al.* 2021), compared to an emissions factor of 37.17 $tCO_2e\ ha^{-1}\ yr^{-1}$ when croplands are located on deep peat. The emissions factor of intensive grasslands located away from deep peats is less well understood, although they are thought to have the potential to sequester carbon (Gregg *et al.* 2021) as opposed to emitting 22.00 $tCO_2e\ ha^{-1}\ yr^{-1}$ when located on deep peats. Consequently, restoring peatland under agriculture will result in significant emission reduction. This confirms the statement in the Climate Emergency Response Plan which states that agriculture is to be an area to target emission reductions (CW&C 2019). Raising the water table to reduce the amount of aerated peat beneath agricultural land can also result in significant emissions savings without necessarily halting its productive use (Evans *et al.* 2021). Over half (1,714ha or 57%), of the borough's peatlands fall within 51 sites designated for nature conservation, with the vast majority of these being non-statutory designations. As a result of the drained nature of CW's peatlands there are significant opportunities for emissions reductions and improved biodiversity, flood management, and water quality through the implementation of a combination of the following measures:

- Implementing and managing the transition of drained agricultural peatlands to modified or rewetted semi-natural habitats in the lowlands.
- Stopping the domestic extraction of peat.
- Stopping development and tree planting on peatlands.
- Targeting additional peatland habitat restoration efforts and continuing with ongoing semi-natural peatland habitat management.
- Raising the water table of agricultural land on peat.
- Designating additional peatlands for nature conservation.

In order to achieve the management and restoration targets as set out in the Achieving the targets set out in the Carbon Emergency Response Plan (CW&C 2019), Carbon Management Plan (CW&C 2023), Sixth Carbon Budget (CCC 2020), or in any further specific targets for the borough, significant changes to land use will be required across a large extent of the borough's peatland. However, as a result of the range of ecosystem services peatlands provide, restoration on the scale required will deliver very high value for money green infrastructure improvement, including reduced GHG emissions, increased carbon storage, and benefits to biodiversity, flood management, and water quality. Nevertheless, the formation of effective and inclusive stakeholder partnerships to access new funding, alongside the development of strong local policy, is vital to influence and support landowners to adopt a more sustainable approach to peatland restoration and management, while protecting their cultural identity and heritage.

The next steps for peatland recovery across CW will involve identifying carbon emission reduction and peatland restoration targets as well as identifying specific peatland opportunity areas that may potentially be suitable for implementing the range of recovery measures identified in this assessment. This could be done as part of, or to inform a Climate Emergency Response Plan for the borough but will also need to be included in the Cheshire's Local Nature Recovery Strategy.

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Appendices

Appendix 1 – Statutory and Non-Statutory Designated Sites for Nature Conservation on Deep Peat within Cheshire West

		Statutory Sites
Site Name	**Area (ha)**	**Designation**
Abbots Moss	9.35	SSSI/Ramsar
Bar Mere	1.75	SSSI
Hatchmere	2.26	SSSI/Ramsar
Flaxmere Moss	4.94	SSSI/Ramsar
Little Budworth Common	3.39	SSSI
Linmer Moss	1.79	SSSI/Ramsar
Mersey Estuary	25.03	SSSI
Oakmere	33.69	SSSI/Ramsar
Pettypool Brook Valley	6.91	SSSI
River Dee (England)	19.48	SSSI
		Non-Statutory Sites
Site Name	**Area (ha)**	**Designation**
Bawsgate Pond and Grassland	0.03	LWS
Bickley Hall Farm Ditches	0.12	LWS
Bowyers Waste	1.51	LWS
Breech Moss	0.97	LWS
Bridge Trafford North	9.88	LWS
Bridge Trafford South	7.08	LWS
Canal Wood	2.39	LWS
Cartledge Moss	0.93	LWS
Dee Escarpment, Huntington	5.50	LWS
Delamere Forest	83.04	LWS
Delamere Golf Course	4.25	LWS
Earl's Eye and Handbridge Marsh	21.73	LWS
East Clifton Tip	0.08	LWS
Fishpool Moss	5.37	LWS
Former Railway by Watling Bank	0.25	LWS
Frodsham Field Studies Centre	22.44	LWS
Frodsham, Helsby and Ince Marshes	1104.45	LWS
Gowy Meadows and Ditches	146.37	LWS
Grange Farm Meadows and Ditches	8.87	LWS
Harthill Hatch	0.25	LWS
Hogshead Moss	0.69	LWS
Holford Moss Wood	1.45	LWS
Huntington Settlement Lagoons	12.92	LWS
Kennel Wood, Sandiway	0.11	LWS

Knolls Bridge Fields	11.49	LWS
Leech Mere	3.19	LWS
Littledales Gorse	2.33	LWS
Marley Tile Works Lagoon	2.42	LWS
Moss Wood	20.22	LWS
Park Moss Wood	10.37	LWS
River Gowy	3.31	LWS
Sandy Mere	1.11	LWS
Shellway Road Pond South	2.53	LWS
Shropshire Union Canal (Little Stanley to Waverton)	0.41	LWS
Shropshire Union Canal (Llangollen Branch) At Marbury	2.42	LWS
Snipe Island	0.36	LWS
Thieves Moss and Pool	3.06	LWS
Tiverton Moss Wood	2.06	LWS
Wervin Meadows	29.71	LWS
Wicken Tree and Low Farm	0.53	LWS
Willey Moor Ponds	0.60	LWS