

Bioregional, RSK

# Central Lincolnshire Local Plan: Climate Change Evidence Base

Task L – Peat Soil Mapping

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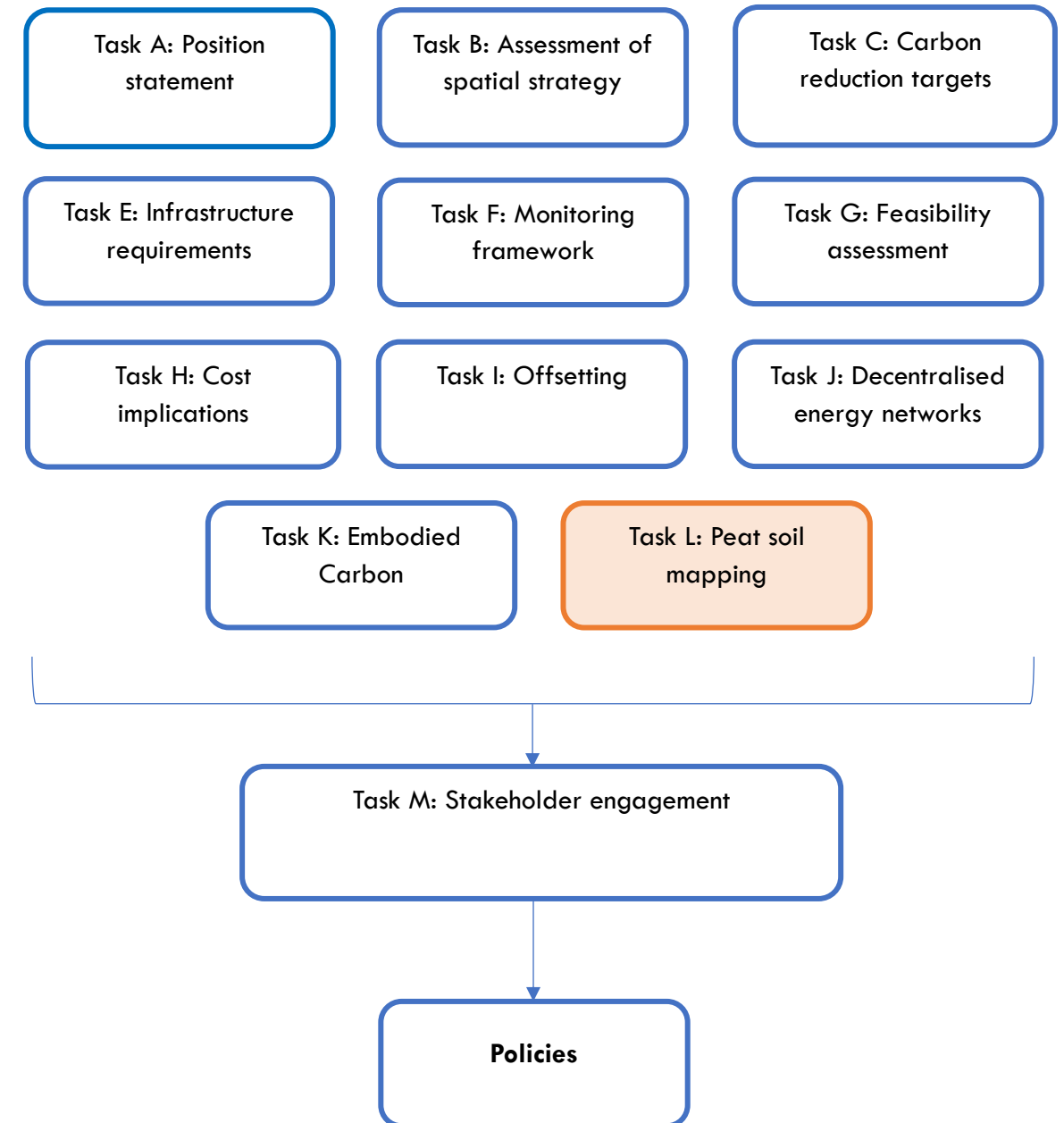
## Peat Soil Mapping

Peat and peat soils are important carbon stores when maintained in good condition. They also support a wide range of internationally important habitats and are recognised as playing a valuable role in flood management through water storage and filtration.

Recognised peat and peat soils have been identified from published geology and soils mapping from the British Geological Survey and Cranfield Soil and Agrifood Institute. Areas identified as peat, blanket peat, fen peat, raised bog peat or as having a peaty character or peaty surface have been considered to constitute peat and peat soil. Areas have been assessed against detailed descriptions as available, to determine their current peatland status.

Identification of the extent, current land use and, where available, quality of remaining peatland and peaty soils have been used to underpin advice to the Client regarding the advisability of including a peat soil-related policy in the Local Plan.

This is part of a wider set of analyses (shown in diagram to the right) to support the relevant local authorities in their stated commitments to combat climate emergency by transitioning their entire areas to net zero carbon by 2030 (Lincoln and North Kesteven) or no later than 2050 along with the national legislated goal (West Lindsey, and Lincolnshire County Council). It is also relevant to Lincolnshire County Council's Green Masterplan<sup>i</sup>.



# 1. Introduction

## Peat and Peat Soil

- 1.1. In recent years, the importance of peat and peat soil as long-term carbon stores has been increasingly recognised internationally. The International Union for Conservation of Nature (IUCN) identifies that peatlands are the largest natural terrestrial carbon store, sequestering 0.37 gigatonnes of carbon dioxide per year, and that damaged peatlands are a major source of greenhouse gas emissions (IUCN, 2017). As a result, countries are being encouraged to include peatland restoration as part of their commitments to global international agreements such as the Paris Agreement on climate change.
- 1.2. Within the UK, peatland is present within all four of the home nations although the distribution is heterogeneous as a result of the conditions required for peat formation and the natural variation in geography. There are three main types of peat: blanket bog, raised bog and fen peat. These occur in different natural settings and have different characteristics, but all are recognised as important habitats for biodiversity, carbon sequestration and storage, and increasingly as forming a key part of natural flood management processes. In England, all three peatland types are present in different geographical settings.
- 1.3. Natural England estimates that peatlands cover approximately 11% of England’s land area (NE, 2010), much of which has been modified or converted for use in agriculture or forestry. Less than 1% of England’s deep peat has been identified as undamaged, with almost a quarter being under cultivation. This includes approximately 40% of England’s lowland fen peatland areas (NE, 2010).

## Peat in the Lincolnshire Combined Authority Area

- 1.4. Existing peatland in the Lincolnshire Combined Authority Area is all classed as fen peat. Fen peatlands tend to develop in low-lying settings, where the groundwater table naturally meets the ground surface leading to naturally wet areas (NE, 2010). These can be along the margins of open water bodies, in natural hollows that form ephemeral ponds, or along spring and seepage lines. Fen vegetation is highly varied as a result and can be very biodiverse, providing a home to a wide range of plant and animal life.
- 1.5. Unlike blanket bog and raised bog peats, fen peat is usually alkaline in character as a result of the significance of groundwater to the formation of the fen habitat, and fenlands have often been drained to provide agricultural land. Former fens such as those in the Fens of East Anglia, Cambridgeshire and Lincolnshire became some of the most productive agricultural land in England and have been under cultivation for around 400 years (NE, 2010).

Peatland area	Coverage (ha)	Data source
Gainsborough	323.9	CSAI
Gainsborough (main area)	345.0	BGS
Gainsborough (minor areas)	135.7	BGS
North Kelsey (main area)	423.4	BGS
North Kelsey (minor areas)	16.7	BGS
Lincoln	2,829.7	CSAI
Sleaford (main area)	137.8	BGS
Sleaford (minor areas)	9.6	BGS
Total (all areas)	3,897.9	
Total (main peatland areas only)	3,735.9	

Table 1: Summary details of the identified peatland areas in the Lincolnshire Combined Authority area.

CSAI: Cranfield Soil and Agrifood Institute  
BGS: British Geological Survey

## 2. Peat Mapping

- 2.1. Areas of existing peatland have been identified from current soil and superficial geology mapping. Both datasets can be viewed online.
- 2.2. Soil mapping for England and Wales is available to view on the LandIS Soilscales viewer (Cranfield Soil and Agrifood Institute, [landis.org.uk/soilscales/](http://landis.org.uk/soilscales/)). This identifies the three main peatland classes as well as two soil types with peaty surfaces. Two areas of mapped fen peat have been identified within the Lincolnshire Combined Authority area: one near Lincoln and one near Gainsborough.
- 2.3. Superficial geology mapping for Great Britain is available to view on the British Geological Survey's GeoIndex Onshore viewer (British Geological Survey, [mapapps2.bgs.ac.uk/geoindex/home.html](http://mapapps2.bgs.ac.uk/geoindex/home.html)). This identifies areas of significant peat cover as part of the surface geology, but does not discriminate between the different peat classes. Three main areas of mapped peat have been identified within the Lincolnshire Combined Authority area: one near North Kelsey, one near Gainsborough and one near Sleaford.
- 2.4. The soil and superficial geology mapping both identify the same main area near Gainsborough.
- 2.5. The total peatland coverage is nearly 3,900 ha, equivalent to 1.84% of the Lincolnshire Combined Authority land area. The four main areas of peatland cover an area just over 3,700 ha, or 1.77% of the Lincolnshire Combined Authority land area. Areas of peatland within the Lincolnshire Combined Authority boundary are shown in Figure PM-1.

### Area 1: Gainsborough

#### Peat distribution

- 2.6. The mapped peat and peaty soils in the Gainsborough area are all located north of Gainsborough and extend beyond the Lincolnshire Combined Authority boundary (Figure 1). The largest area is identified by both the CSAI soil mapping and the BGS superficial geology mapping. This area is located between Blyton and Morton, to the north side of the A159, and is aligned with two main watercourses.
- 2.7. The other areas of mapped peat are all derived from the BGS superficial mapping and are small, discontinuous and well-scattered.

#### Landuse and drainage

- 2.8. Aerial photography of this area shows a history of agricultural use, with the peatland areas shown mainly as under cultivation. Some areas of woodland are noted, including some areas labelled as plantation, although these are mostly adjacent to rather than on the areas of mapped peatland. Historical mapping indicates that the area has been under cultivation since the 1880s.
- 2.9. Drainage infrastructure is apparent on available historical mapping from the 1880s, indicating that it predates this time period.

#### Peatland quality

- 2.10. Recent aerial photography and satellite imagery indicate that the mapped areas of peatland show no remaining peatland character, although the soils may remain peaty in nature. The long history of cultivation and drainage for agriculture would support a significant loss of

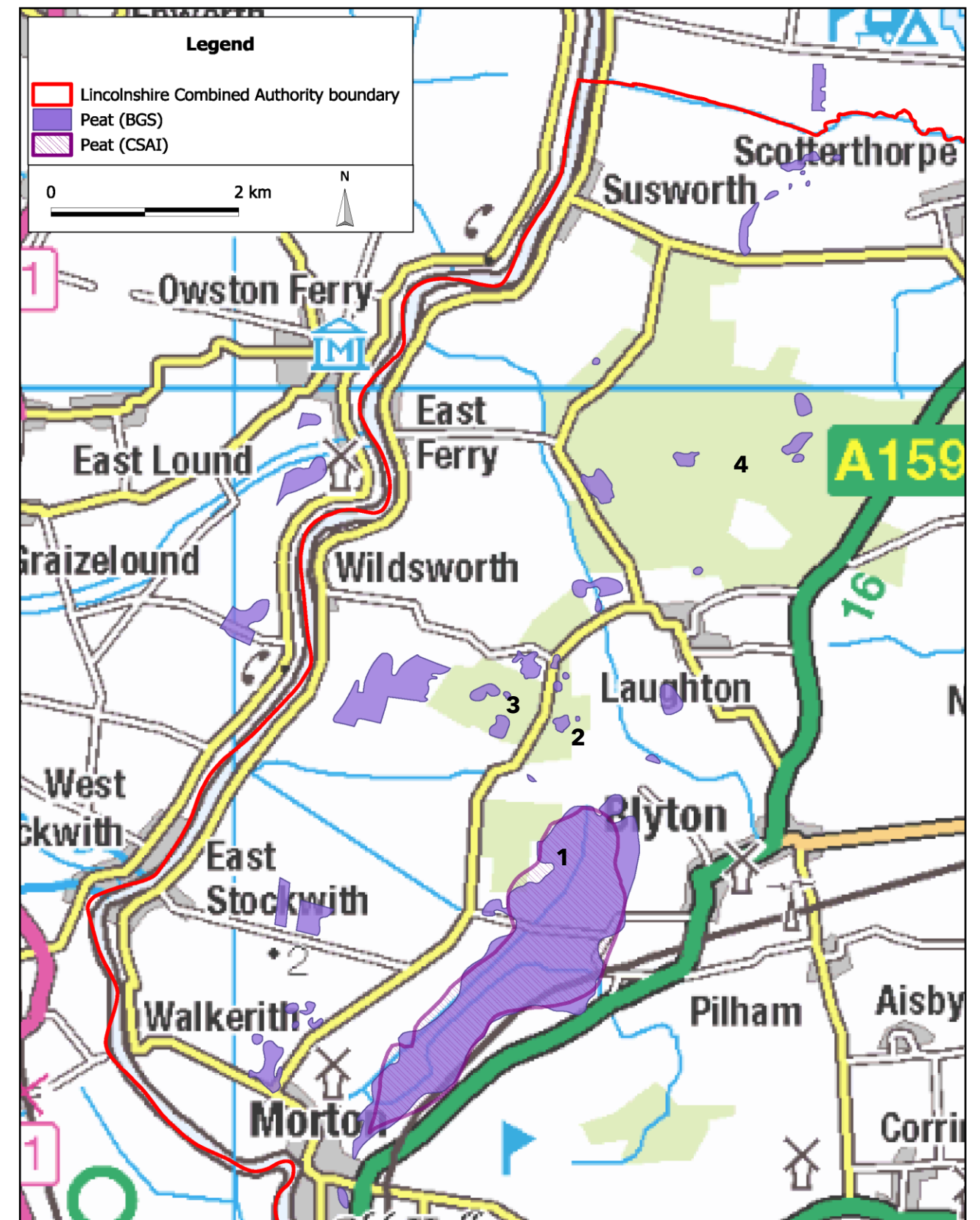


Figure 1: Peat areas near Gainsborough. Location numbers: 1 – peatland near Blyton; 2 – Carmer Wood; 3 – Peacock Wood; 4 – Laughton Wood.

Soils data © Cranfield University (NSRI) and for the Controller of HMSO (2020). Superficial geology data reproduced under Licence no. 2011/3PDL/630704, British Geological Survey © NERC. Contains public sector information licensed under the Open Government Licence v3.0.



peatland habitat and peat character. The peatland near Gainsborough is determined to be in a degraded condition.

- 2.11. Parts of the area may be suitable for rewetting, including the northern part of the main peatland area near Blyton (Location 1 on Figure 1), where some areas apparently remain boggy and there may also be possibility to convert plantation woodland to more natural vegetation. In addition, some of the scattered peatland areas in Carmer Wood (Loc. 2), Peacock Wood (Loc. 3) and Laughton Wood (Loc. 4) may be suitable for rewetting and natural habitat restoration, which may also allow reconnection of the peatland habitats in these areas.

## Area 2: North Kelsey

### Peat distribution

- 2.12. The mapped peat and peaty soils in the area near North Kelsey are mainly associated with the Old River Ancholme and the North Kelsey Beck, located approximately 2-4 km west of North and South Kelsey and extending south to Snitterby Carr (Figure 2). Parts of the mapped peat body extend beyond the Lincolnshire Combined Authority boundary. Peat in this area is only identified by the BGS superficial geology mapping and consists of one main peatland area and a number of small outlying areas mainly located west of the main body. All the mapped peat in this area is east of the A15.

### Landuse and drainage

- 2.13. Aerial photography of this area shows a history of agricultural use, with the peatland areas shown mainly as under cultivation. Some areas of woodland are visible, although it is not clear whether these are shelter belts or are remnant areas of larger woodland blocks. Historical mapping indicates that the area has been under cultivation since at least the 1880s.
- 2.14. Drainage infrastructure is apparent on available historical mapping from the 1880s, indicating that it predates this time period.

### Peatland quality

- 2.15. Recent aerial photography and satellite imagery indicate that the mapped areas of peatland show no remaining peatland character, although the soils may remain peaty in nature. The long history of cultivation and drainage for agriculture would support a significant loss of peatland habitat and peat character. The peatland near North Kelsey is determined to be in a degraded condition.
- 2.16. Options for restoration or rewetting in the North Kelsey peatland area are limited as there appears to be very little non-agricultural land within the identified area of peatland. Some areas that appear to be persistently boggy or wet are apparent in the northern part along the North Kelsey Beck, and rewetting may be a possibility in this area.

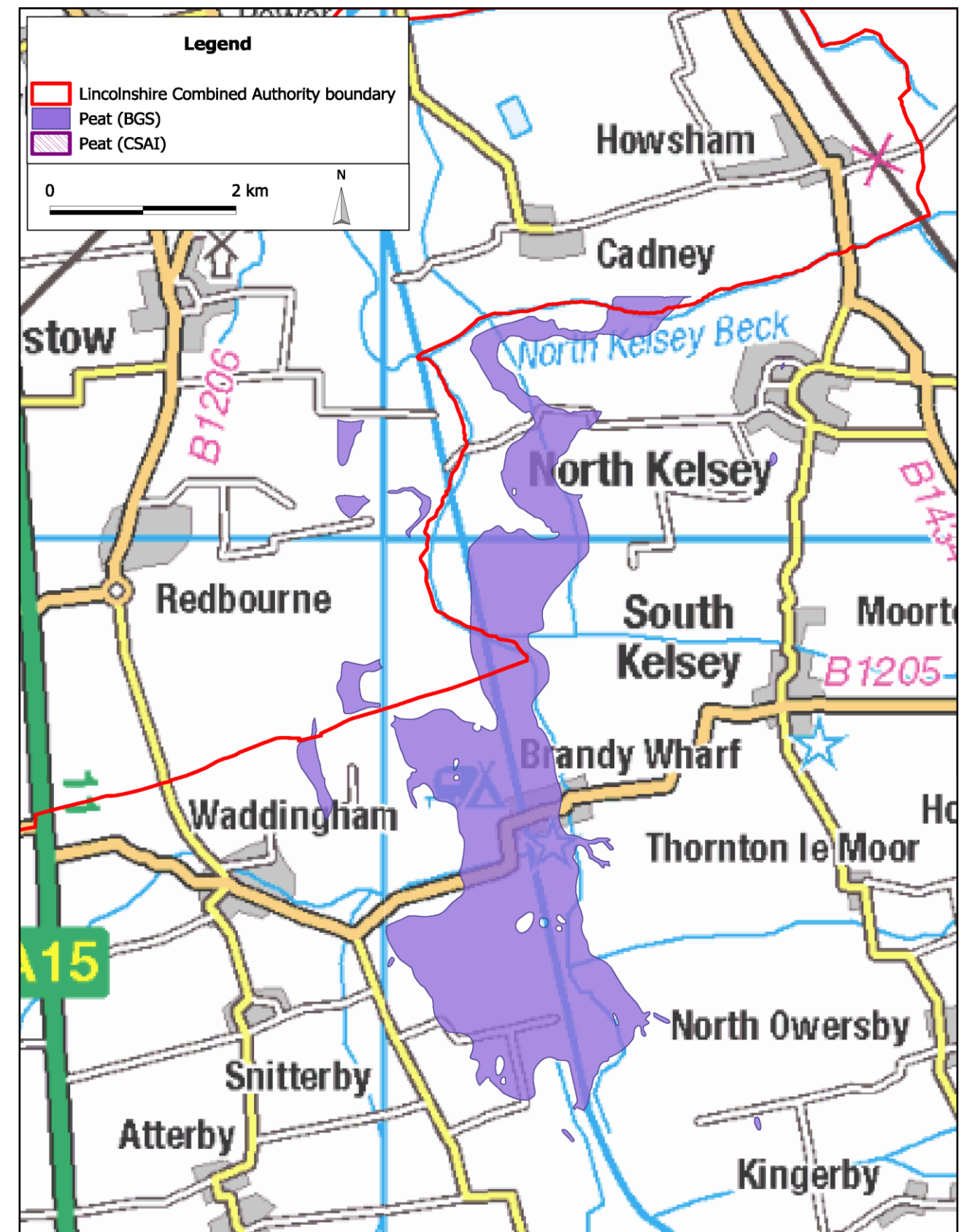


Figure 2: Peat areas near North Kelsey.

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Area 3: Lincoln

Peat distribution

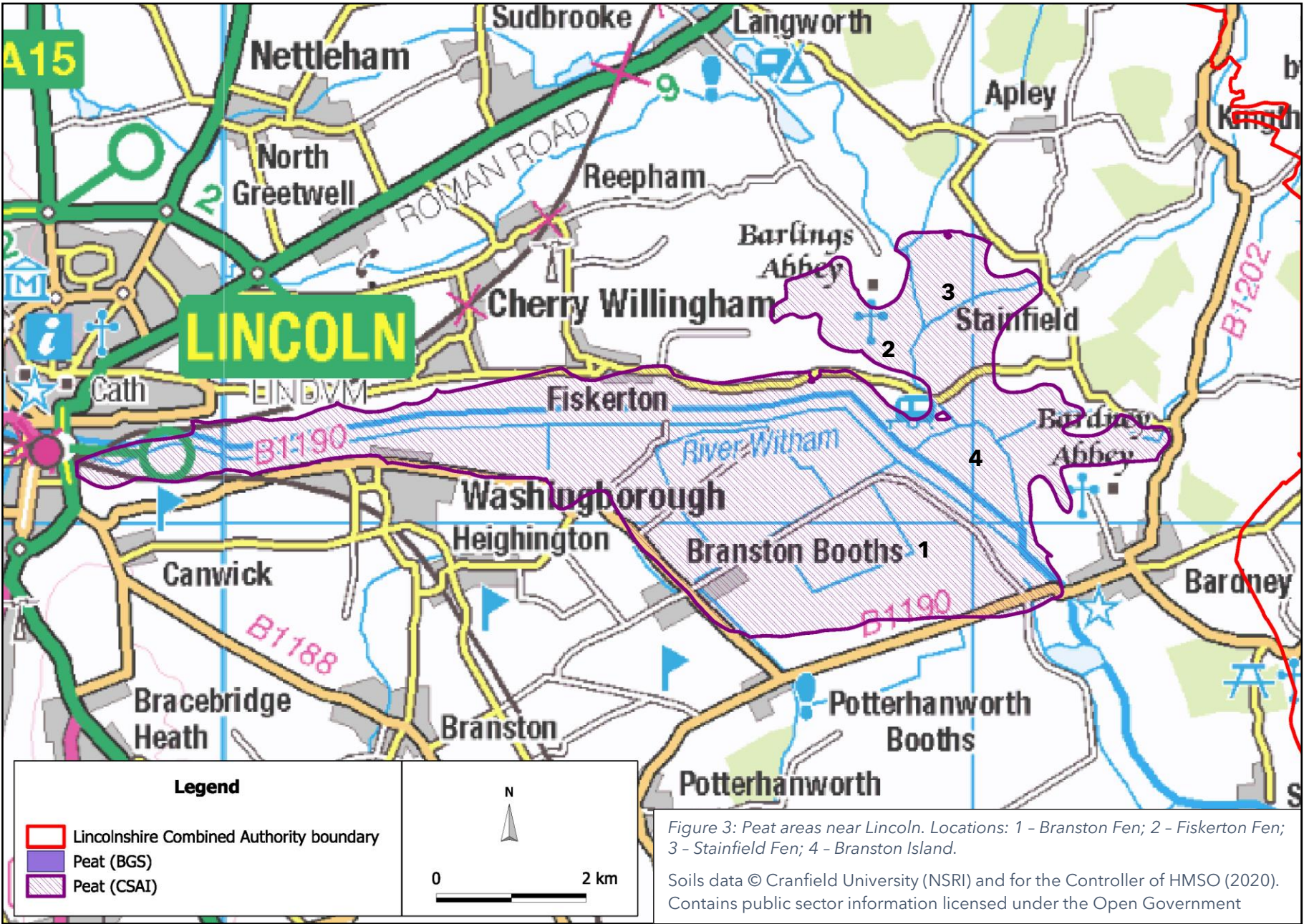
2.17. The mapped peat and peaty soils near Lincoln are mainly associated with the River Witham, the Old River Witham and various tributaries to these rivers. The peatland is indicated to begin immediately east of Lincoln and to extend east to Bardney Abbey (Figure 3). Peat in this area is identified only by the CSAI soil mapping and consists of one large area located north of the B1190, west of the B1202 and south of the A158.

Landuse and drainage

- 2.18. Aerial photography of this area shows a history of agricultural use, with the peatland areas mainly shown as under cultivation. A small nature reserve is indicated near Short Ferry, which includes a number of small ponds, and appears to be relatively recent. Historical mapping indicates that the area has been principally under cultivation since at least the 1880s.
- 2.19. Drainage infrastructure is apparent on available historical mapping from the 1880s, indicating that it predates this time period.

Peatland quality

- 2.20. Recent aerial photography and satellite imagery indicate that the mapped areas of peatland show no remaining peatland character, although the soils may remain peaty in nature. The long history of cultivation and drainage for agriculture would support a significant loss of peatland habitat. The peatland near Lincoln is determined to be in a degraded condition.
- 2.21. Some parts of the area, notably around Branston (Loc. 1 on Figure 3), Fiskerton (Loc. 2) and Stainfield Fens (Loc. 3) and Branston Island (Loc. 4), show intermittent periods of waterlogging and standing surface water. It may be possible to re-wet some parcels of land in this area as part of flood mitigation, which would have potential to lead to re-development of fen habitat and peaty soils.





#### Area 4: Sleaford

##### Peat distribution

- 2.21. The mapped peat and peaty soils near Sleaford are mainly associated with the River Slea and the Old River Slea. Peat in this area is identified only by the BGS superficial geology mapping. The main area of peatland is north-east of Sleaford, immediately south of the A153 in the area around Anwick (Figure 4). A small subsidiary area is located immediately west of Sleaford and east of the A15 (Figure 4).

##### Landuse and drainage

- 2.22. Aerial photography of this area shows a history of agricultural use, with the peatland areas shown mainly as under cultivation. There are some areas of woodland, scrub and rough grassland, notably in the area south-east of Anwick and the subsidiary area of peatland immediately west of Sleaford. Historical mapping indicates that the area has been under cultivation since at least the 1880s.
- 2.23. Drainage infrastructure is apparent on available historical mapping from the 1880s, indicating that it predates this time period.

##### Peatland quality

- 2.24. Recent aerial photography and satellite imagery indicate that the mapped areas of peatland show no remaining peatland character, although the soils may remain peaty in nature. The long history of cultivation and drainage for agriculture would support a significant loss of peatland habitat.
- 2.25. The peatland near Sleaford is determined to be in a degraded condition. It is unlikely to be practical to restore this area to active peatland, owing to the long history of drainage and cultivation which have caused irreversible damage to the peatland area.
- 2.26. Some parts of the area, notably between Haverholme Wood (Loc. 1 on Figure 4) and Cobbler's Lock (Loc. 2) and the area around Sleaford Fen, Guildhall Springs and Cobbler's Hole (Loc. 3), show less evidence of long-term cultivation and drainage and include areas of woodland and rough grassland. The continued presence of springs around Sleaford Fen, Guildhall Springs and Cobbler's Hole, immediately west of Sleaford, suggests this area may have potential for rewetting and redevelopment of fen in this area.

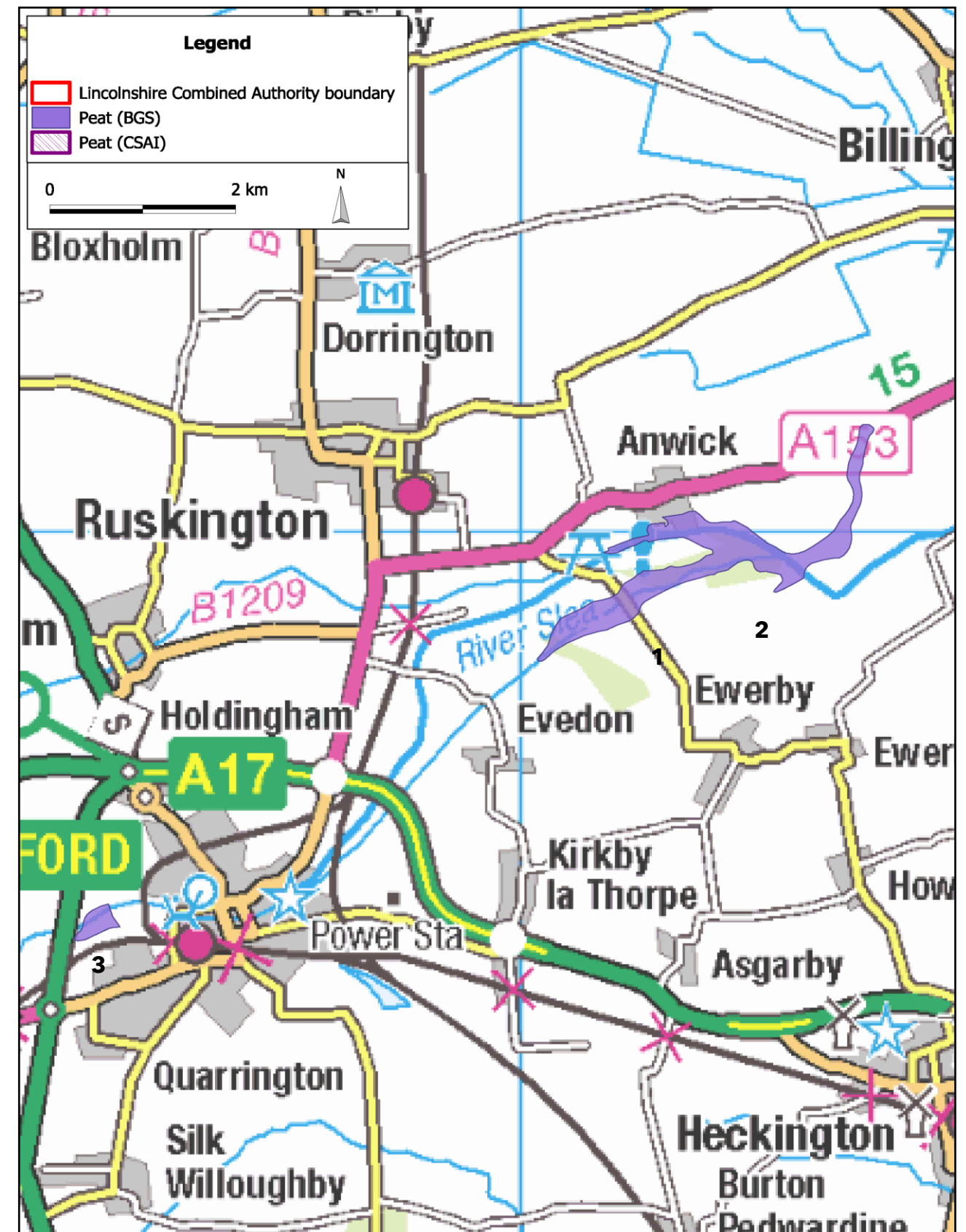


Figure 4: Peat areas near Sleaford. Location numbers: 1 – Haverholme Wood; 2 – Cobbler's Lock; 3 – Sleaford Fen, Guildhall Springs and Cobbler's Hole.

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3. Peatland Carbon

- 3.1. Some initial calculations relating to peatland carbon and greenhouse gas emissions have been undertaken to provide a context for potential rewetting and restoration plans. These make use of the Tier 2 emission factors provided within the CEH report to BEIS in 2017 (Evans *et al.*, 2017) and are provided in Table 2.
- 3.2. Calculations assume that all the land area is either under cropland or under woodland. There are some areas of rough grassland and scrubland, but the datasets to separate these areas are not readily available. Land under woodland has been derived from the OS VectorMap District vector dataset (OS, 2020). All land not under woodland has been assumed to be cropland, as this is considered to provide a worst-case estimate for emissions data purposes. More detailed mapping at a local level would be able to provide a more accurate discrimination between different landuse categories and a more reliable estimate of carbon and carbon-equivalent emissions for the peatland areas.

Rewetting fens

- 3.3. A comparison is provided in Table 3 to show the CO<sub>2</sub> reduction that could be achieved through conversion of 10% of Central Lincolnshire’s mapped peatland from its current cropland landuse to rewetted fen. This shows a central estimated reduction of 9.6 kt CO<sub>2</sub>/yr.
- 3.4. There would be a concomitant increase in methane emissions, as these are higher in fenland than cropland. Estimated methane emissions from the same area of rewetted fen amount to 1.5 kt CO<sub>2</sub>/yr, giving a net benefit of 8.1 kt CO<sub>2</sub>/yr
- 3.5. There is no emission factor available for N<sub>2</sub>O emissions from rewetted fens so it is not possible to estimate the change in emissions arising from N<sub>2</sub>O. It is likely to be an improvement over their cropland status.

Tier 2 EF		Peatland Area (ha)	GHG Emissions	Tonnes CO <sub>2</sub> -equivalent
Direct CO <sub>2</sub> (t CO <sub>2</sub> -C/ha/yr)				
Woodland	2	131	263 t CO <sub>2</sub> -C/yr	964 t CO <sub>2</sub> /yr
Cropland	7.2	3,766	27,119 t CO <sub>2</sub> -C/yr	99,444 t CO <sub>2</sub> /yr
Total			27,382 t CO <sub>2</sub> -C/yr	100,408 t CO <sub>2</sub> /yr
Direct CH <sub>4</sub> (kg CH <sub>4</sub> /ha/yr)				
Woodland	5	131	657 kg CH <sub>4</sub> /yr	16 t CO <sub>2</sub> /yr
Cropland	1	3,766	3,766 kg CH <sub>4</sub> /yr	94 t CO <sub>2</sub> /yr
Total			4,424 kg CH <sub>4</sub> /yr	111 t CO <sub>2e</sub> /yr
Direct N <sub>2</sub> O (kg N <sub>2</sub> O-N/ha/yr)				
Woodland	1.4	131	184 kg N <sub>2</sub> O-N/yr	86 t CO <sub>2</sub> /yr
Cropland	19.1	3,766	71,940 kg N <sub>2</sub> O-N/yr	33,658 t CO <sub>2</sub> /yr
Total			72,124 kg N <sub>2</sub> O-N/yr	33,744 t CO <sub>2e</sub> /yr

Table 2: Greenhouse gas emissions estimates for the peatland areas in Central Lincolnshire. Areas are the combined total mapped peatland areas from both sources. Woodland areas are the peatland areas coinciding with OS VectorMap District woodland polygons. Greenhouse gas emissions have been calculated using the Tier 2 emission factors provided in Evans *et al* (2017) and have been converted to CO<sub>2</sub> equivalent for ease of comparison.

Tier 2 EF		10% of Peat (ha)	GHG Emissions	Tonnes CO <sub>2</sub> -equivalent	Change to Emissions
Direct CO <sub>2</sub> (t CO <sub>2</sub> -C/ha/yr)					
Cropland	7.2	377	2,712 t CO <sub>2</sub> -C/yr	9,944 t CO <sub>2</sub> /yr	-9,667 t CO <sub>2</sub> /yr
Rewetted fen	0.2	377	75 t CO <sub>2</sub> -C/yr	276 t CO <sub>2</sub> /yr	

Table 3: Potential reduction in CO<sub>2</sub> emissions achievable through rewetting 377 ha (10%) of the mapped peatland area currently under cropland. Greenhouse gas emissions have been calculated using the Tier 2 emission factors provided in Evans *et al.* (2017) and have been converted to CO<sub>2</sub> equivalent for ease of comparison.



#### 4. Carbon in Topsoil and Vegetation

- 4.1. In parallel with the peatland mapping, there are datasets available which provide estimates of carbon density in topsoils (0-15 cm depth from ground surface) and carbon storage in above-ground vegetation (Henrys *et al.*, 2012, 2016).

##### **Carbon density in topsoil**

- 4.2. Organic matter is an important component of soil and influences its physical, chemical and biological properties. Soil organic matter improves soil quality through improving water retention, nutrient retention and soil structure, and reducing soil erosion. It can help to improve water quality in both surface water and groundwater, and leads to increased productivity of plants and better food security. Disturbance of soil through agriculture, construction, mining, tree felling or other activities lead to increased erosion and nutrient-leaching from soils, increased rainfall-runoff and a parallel decrease in infiltration to ground, and increased flood risk.
- 4.3. Most organic matter is present within the topsoil, with levels typically decreasing with depth. As a result, measures of carbon in topsoil can give a key insight into soil health. Soils with very low organic carbon content are typically restricted to desert environments, whereas soils with higher natural organic carbon content tend to be found in wetlands and forest regions.
- 4.4. Carbon density in topsoil for the Lincolnshire Combined Authority area is shown in Figure PM-2. The figure demonstrates that carbon density in topsoil within this region is typically low, with much of the area having a mean topsoil carbon density of around or below 50 t/ha. The dataset includes estimates of carbon density in topsoil for 1998 and 1978, and the figures show a sustained reduction in topsoil carbon density across much of the Lincolnshire Combined Authority area over this time period, although some small areas show an improvement. Figure PM-2 shows the 1978 and 2007 data together for comparison purposes.

##### **Carbon density in above-ground vegetation**

- 4.5. Carbon in vegetation can be a more complex aspect to determine as it includes seasonal vegetation including agricultural crops and natural grassland as well as long-lived vegetation in woodland areas. The method used to determine the carbon density of vegetation takes into account the increase in carbon storage as woodland ages, to provide a better reflection of their value as carbon stores. Larger forest areas such as Sherwood Forest and Kielder Forest are clearly visible in the dataset.
- 4.6. Carbon density in above-ground vegetation for the Lincolnshire Combined Authority area is shown in Figure PM-3. As would be expected for an arable farming-dominated region, carbon density in vegetation is low across most of the area, typically at or below 10 t/ha. Some areas show a higher carbon density in vegetation, correlating with the areas of woodland, notably Laughton Woods north of Gainsborough, Willingham Woods and Willingham Forest near Market Rasen, and the smaller scattered areas of woodland east and west of Lincoln.

## 5. Conclusions

- 5.1. Historically, much of Lincolnshire was fenland but was drained for cultivation around 400 years ago (NE, 2010). Today, mapped peatland areas are a small remnant of the former fens and cover less than 2% of the Lincolnshire Combined Authority's land area and all appear to be in a degraded condition.
- 5.2. Despite their long history of agriculture, these areas of peatland provide a contribution to greenhouse gas emissions that needs to be taken into account. Restoration of even fairly small areas to rewetted fen would help to control and reduce the Lincolnshire Combined Authority area's carbon emissions over time.
- 5.3. As peatland forms such a small land area, consideration also needs to be given to the wider soils and vegetation, as the carbon contribution and storage in topsoil and above-ground vegetation are also important. The widespread arable farming in the authority area would suggest that targeting improved soil husbandry to improve the topsoil's longterm carbon storage would be worthwhile and has potential to bring additional benefits including improved soil productivity and reducing flood risk.

## 6. Recommendations

- 6.1. The small footprint area of mapped peatland and their long history of drainage and cultivation indicate that new development is unlikely to significantly impact on the current situation, however the emissions from these are significant, so it may be appropriate to have some policies in place to mitigate any further loss of current or future carbon sequestration from peatland, ideally also considering the wider potential of topsoils and vegetation for this.
- 6.2. Topsoils and carbon-rich soils including peatland have a very important role within the authority area and could form a key area for consideration within natural flood management policy or as part of a wider plan for soil improvement as a means to increase productivity and environmental enhancement.
- 6.3. Where possible and cost-effective, rewetting of suitable land areas should be considered as part of the overall response to greenhouse gas emissions. If undertaken sensitively, there would be a parallel benefit in terms of environmental enhancement and accessibility for members of the public.

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Appendix A

Estimated greenhouse gas emissions by peatland area. Tier 2 Emission Factors are from Evans *et al.* (2017). Conversion to CO<sub>2</sub>-equivalent uses conversion factors in NE (2010).

Tier 2		Gainsborough		North Kelsey		Lincoln		Sleaford		Combined		CO <sub>2</sub> -equivalent	
	EF	Area (ha)		Area (ha)		Area (ha)		Area (ha)					
Direct CO <sub>2</sub> (t CO <sub>2</sub> -C/ha/yr)													
Woodland	2	54.5	109	4.8	10	35.5	71	36.6	73	263	t CO <sub>2</sub> -C/yr	964	t CO <sub>2</sub> /yr
Cropland	7.2	426.2	3069	435.3	3134	2794.2	20118	110.8	798	27,119	t CO <sub>2</sub> -C/yr	99,444	t CO <sub>2</sub> /yr
										27,382	t CO <sub>2</sub> -C/yr	100,408	t CO <sub>2</sub> /yr
Direct CH <sub>4</sub> (kg CH <sub>4</sub> /ha/yr)													
Woodland	5	54.5	273	4.8	24	35.5	177	36.6	183	657	kg CH <sub>4</sub> /yr	16	t CO <sub>2</sub> -e/yr
Cropland	1	426.2	426	435.3	435	2794.2	2794	110.8	111	3,766	kg CH <sub>4</sub> /yr	94	t CO <sub>2</sub> -e/yr
										4,424	kg CH <sub>4</sub> /yr	111	t CO <sub>2</sub> -e/yr
Direct N <sub>2</sub> O (kg N <sub>2</sub> O-N/ha/yr)													
Woodland	1.4	54.5	76	4.8	7	35.5	50	36.6	51	184	kg N <sub>2</sub> O-N/yr	86	t CO <sub>2</sub> -e/yr
Cropland	19.1	426.2	8140	435.3	8314	2794.2	53369	110.8	2116	71,940	kg N <sub>2</sub> O-N/yr	33,658	t CO <sub>2</sub> -e/yr
										72,124	kg N <sub>2</sub> O-N/yr	33,744	t CO <sub>2</sub> -e/yr

<sup>i</sup> Lincolnshire County Council (2020), *Environment and Planning: Green Masterplan*. <https://www.lincolnshire.gov.uk/green-masterplan>