Lowland agricultural peat characteristics which influence peat hydrology: synthesis report

Chief Scientist's Group research report

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Dr Robert Bradburne
Chief Scientist

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Foreword

The 'LP3+' (Lowland Peat 3 Plus) is a research project comprising a series of linked work packages and reports. Together, these further our knowledge of how peatland characteristics influence peat hydrology and water quality. The project focuses specifically on how the properties of lowland agricultural peat influence peat hydrology and water table management and how raising the water table influences the mobilisation of substances from within the peat, and therefore the likely risks to water quality.

The LP3+ project benefits from the specialist knowledge of the related Lowland Peat 3 (LP3) project and partners including the field data collection infrastructure established by the LP3 project.

LP3+ is funded by the UK Government's Nature for Climate fund through the Environment Agency's Lowland Agricultural Peat Water R&D programme, and is led and managed by UK Centre for Ecology and Hydrology (UKCEH).

The LP3+ project partners are UKCEH, University of Liverpool, Cranfield University and Rigare Ltd.

Acknowledgements

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Executive summary

The LP3+ hydrology project aimed to improve understanding of how differences in the physical and hydrological properties of lowland peats across England influence the expected effectiveness of rewetting to a consistent water table depth. The project comprised multiple studies designed to address this aim, including:

- A literature review of the current understanding of physical and site characteristics of lowland agricultural peat that influence the movement of water (HOLMAN ET AL., 2026)
- Analysis of existing data on peat properties; including analysis of inter- and intra-annual variability in observed water table depths within lowland peat (HOLMAN ET AL., 2026)
- Monitoring of two LP3+ sites in the Manchester Mosses and Somerset Levels to develop conceptual models of their peat hydrology (LOW ET AL., 2026)
- Measurement of saturated hydraulic conductivity (using dipwell and laboratory methods) and soil water release (using laboratory methods) within lowland (current and former) agricultural peats (GRABOWSKI ET AL., 2026)
- Scenario modelling of idealised fields to explore how peat properties, field characteristics, climate conditions and interventions (e.g. subsurface drains; permanent and seasonally raised ditch water levels; irrigation etc) influence simulated water table behaviour (BAIRD ET AL., 2026).

This report synthesises insights from these studies to improve understanding of the factors that make sites more or less suitable for raised water tables and peat rewetting. These studies have demonstrated through literature review, monitoring and modelling that a small number of important factors affect water table depth and dynamics within drained lowland agricultural peats. In particular:

- Climate and climate variability: achieving high stable water tables is expected to be more practicable in wetter parts of the country that have higher hydrologically effective rainfall (rainfall in excess of evapotranspiration).
- Drain spacing: the influence that the surface water level in drains exerts on water table depth is strongly non-linear and declines with distance.
- Drain water levels: although maintaining high drain water levels is often conflated with maintaining high in-field water tables, higher drain levels are still associated with significant variability in water table depth.
- Peat properties: drainage tends to lead to reduced specific yield (reducing storage and increasing water table variability) and reduced saturated hydraulic conductivity (reducing drainage losses, reducing lateral inflows into the peat from the drains and increasing the hydraulic gradient). Degraded drained agricultural peats can support raised water tables, but will tend to have high inter-annual variability due to their lower specific yield and hydraulic conductivity.
- Groundwater seepage: Upward groundwater flow or seepage from an underlying aquifer may be an important (but highly uncertain) contributor to the

water balance of some lowland peats, helping to meet summer evapotranspiration demands and therefore reduce water table lowering.

The project looked at how higher water tables can be supported through a range of interventions, including:

- raising drain water levels,
- reducing drain spacing through additional ditches or pipe/under-drains,
- enhanced surface ponding (whether in natural in-field topographic variation or engineered through surface bunds),
- installation of low permeability sub-surface bunds (as installed at the LP3+ site at Manchester Mosses),
- surface irrigation,
- seasonal drain water level management (lowered in winter; raised in summer)

The interventions generally increased the median simulated water table height, but their effectiveness is influenced by the factors outlined above. However, whilst median simulated water table height generally increased with the interventions, sub-surface bunds and surface ponding were still associated with variable mid-field water table heights. Achieving high and stable water tables is likely to be most effective with either narrow drain (pipe or ditch) spacing in combination with high drain water levels or summer surface irrigation with scheduling based on weather and water table and soil moisture monitoring. There are also trade-offs associated with the interventions such as peat disturbance (e.g. with sub-surface bunds; additional drains) and additional summer water needs (e.g. raised water levels; irrigation).

It is not yet possible to produce a decision tree to inform site selection for rewetting. However, insights from the literature review, data analysis, site monitoring and modelling undertaken within the LP3+ project, supported by expert opinion, have been used to identify the site-to-catchment attributes that influence how challenging it is to achieve stable raised water tables.

1. Introduction

The LP3+ hydrology project included several studies:

- A literature review of the physical and site characteristics of lowland agricultural peat that influence the movement of water required for raising water tables (HOLMAN ET AL., 2026)
- Analysis of existing data on peat properties, including inter- and intra-annual variability in observed water table depths within lowland peat (HOLMAN ET AL., 2026);
- Monitoring of two LP3+ sites in the Manchester Mosses and Somerset Levels to develop conceptual models of their peat hydrology (LOW ET AL., 2026)
- Measurements of the key hydraulic properties within lowland agricultural peat of saturated hydraulic conductivity sites (using dipwell and laboratory methods) and soil water release (using two laboratory methods) (GRABOWSKI ET AL., 2026)
- Scenario modelling using 2D (vertical transect) modelling of idealised fields using DigiBog hydrology to explore how differences in peat properties, field characteristics (e.g. drain spacing, freeboard) and climate conditions are likely to influence water table behaviour and the effectiveness of different interventions (e.g. subsurface drains; permanent and seasonally raised ditch water levels; irrigation etc). (BAIRD ET AL. 2026).

The aim of this synthesis report is to present the understanding gained from these studies of the factors that make sites more or less favourable for raising water tables and peat rewetting.

Agricultural drainage of lowland peats over the past centuries has been achieved by maintaining lowered water levels within a locally-varying combination of drainage channels/ditches and underdrains (also known as pipe drains), with water removed through either pumping or gravity conveyance to a river. Lowland (here defined as land below 200 maOD, as per BURTON AND HODGSON, 1987) agricultural peats occur on the drained remnants of former mires (bogs and fens) that had consistently high, but rarely above-surface, water tables.

The water table elevation within a drained lowland agricultural peat is a consequence of the temporally varying balance between water inputs and water outputs (Figure 1.1) within the constraints set by the drainage controls (e.g. drain water level and drain spacing) and peat properties. Building on insights from HOLMAN ET AL. (2026), LOW ET AL. (2026) and BAIRD ET AL. (2026), conceptual models in Figure 1.2 illustrate the effects of drainage system (ditch or pipe-drains) and drain water level on winter and summer water tables. Inputs of water to the peat can include precipitation, natural sub-irrigation (lateral water movement from the drains into the peat when the elevation of the water table in the peat is lower than the water level in the drain), surface irrigation and groundwater seepage (from an underlying aquifer). Soil water can leave the peat via drainage (water movement from the peat into the drains when the water table in the peat is higher than that in the drain), evapotranspiration, and seepage losses (into an underlying aquifer). When inputs are greater than outputs, as typically occurs in winter, the water table elevation increases above the drain water level which facilitates lateral saturated flow to the drains (Fig. 1.2). Water table height and likelihood of ponding are influenced by the peat properties (hydraulic conductivity and specific yield), drain spacing and drain water level.

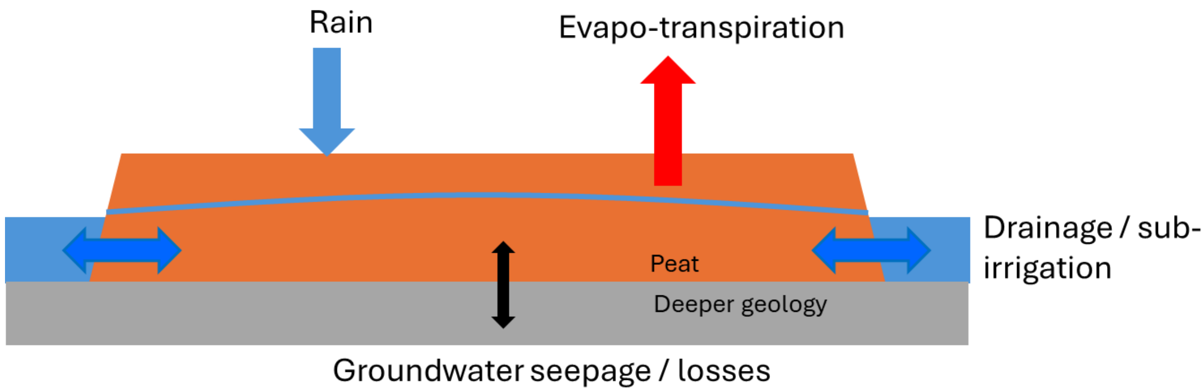

Figure 1.1 Schematic of the water balance components that drive water table behaviour in drained lowland peats.

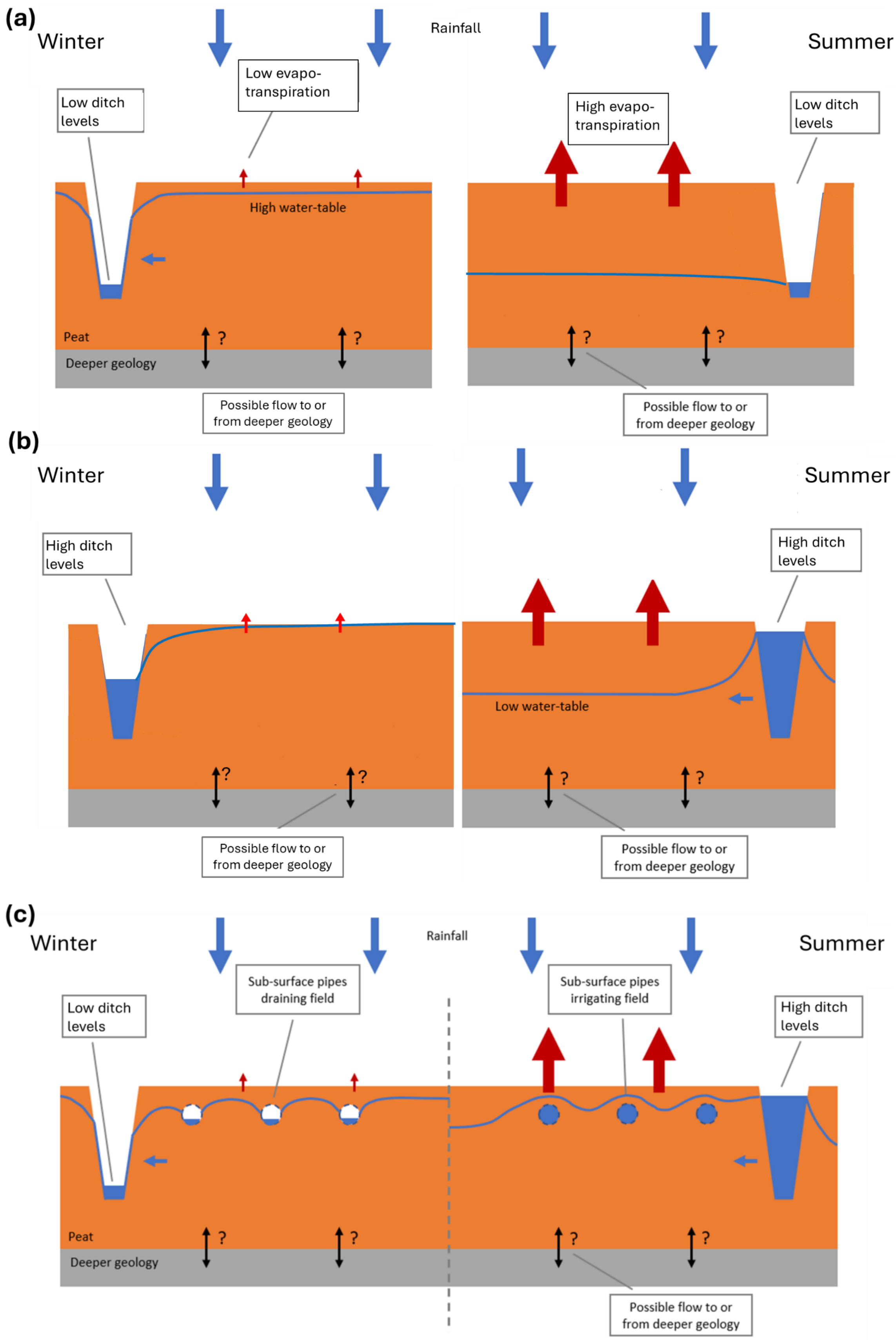

Figure 1.2 Conceptual models of winter and summer water table cross-sectional profiles in ditch drained lowland agricultural peat with (a) low ditch water levels and (b) high ditch water levels and (c) pipe drainage with low and high ditch water levels (adapted from LOW and BAIRD. 2023).

When outputs are greater than inputs, as typically occurs in summer, the water table elevation declines in response to lateral drainflow and evapotranspiration. In circumstances where capillary rise is able to move water upwards into the root zone to sustain evapotranspiration, the water table elevation drops below the height of the drain water level, leading to a reversal in the direction of water flow i.e. the drain provides lateral inflow or sub-irrigation to the peat (HARPENSLAGER ET AL. 2024) (Fig. 1.2). However, under very deeply drained conditions, the water table depth may be greater than the extinction depth for evapotranspiration and the water table tends towards the drain water level.

2. Factors affecting rewetting favourability

The literature review (HOLMAN ET AL., 2026), data analysis (LOW ET AL., 2026) and modelling (BAIRD ET AL., 2026) have demonstrated that a small number of important factors affect water table depth and dynamics within drained lowland agricultural peats, and therefore the relative future ease of maintaining raised stable water tables.

2.1 Climate and climate variability

Climate and climate variability determine the amount and timing of hydrologically effective rainfall (rainfall in excess of evapotranspiration). BAIRD ET AL. (2026) compared simulated water table depths for idealised sites under the current climate in the East Anglian Fens representing a drier, continental-influenced climate, and Somerset representing a wetter, maritime-influenced climate. Because of the lower effective rainfall and greater inter-seasonal variability in the Fens compared to Somerset, median water tables are generally deeper and more variable in the Fens (Figure 2.1). For example, for Scenario 3 in BAIRD ET AL. (2026) (which assumes 100 m ditch spacing, an intermediate ditch water level of 60 cm bgl, and high hydraulic conductivity, K) the median water-table depth is 35 cm for Somerset and 54 cm for the Fens. Similarly, water table is <10cm bgl and deeper than 50cm bgl for 5% and 56% of the time, respectively, in the Fens, compared to 22% and 36% for Somerset. Given this sensitivity of water table depth and dynamics to regional differences in current climate and climate variability, it is likely that a changing climate (in terms of mean and variability) will change the feasibility of maintaining stable high water tables in future.

Insight 1: Achieving high stable water tables is more practicable in wetter parts of the country that have higher hydrologically effective rainfall.

Uncertainty 1: The implications of a changing climate (mean and variability) for lowland agricultural peat water table dynamics.

2.1 Drain spacing

The influence that the surface water level in the drains exerts on the water table depth is strongly non-linear and declines with distance and increasing peat humification, as demonstrated from the data presented in LOW ET AL. (2026). The drain spacing in many existing drainage systems, without pipe or under-drains, will be too wide to maintain and control raised water tables, especially in degraded peats (Figure 2.2). In contrast, narrowly-spaced drains (whether ditches or pipe- or under-drains) that can be used for drainage and provide enhanced sub-irrigation deliver stronger water table control, (Figure 2.2 and Figure 2.3), although modelled water table variability is still significant at 20 m drain spacing (Fig. 2.2). Figure 2.3 shows the high degree of measured water table depth control within intensively pipe-drained fields (10 m pipe spacing), with the high water table fields being associated with drain water levels maintained at approximately 10 cm below ground level.

In the absence of other interventions, narrower effective drain spacings to enhance water ingress into the peat is likely to be necessary, through installation of sub-surface infiltration systems (pipe-drains) or the excavation of shallow foot drains, although foot drains can rapidly be colonised and blocked by soft rush (Andrea Kelly, *pers. comm.*).

Insight 2: Achieving high stable water tables is more effective with narrow drain (pipe or ditch) spacing that provide enhanced sub-surface irrigation.

Uncertainty 2: The extent and current performance of pipe- or under-drainage systems is unknown beyond the farm-level, due to lack of centralised data, pipe age, uncertainty in maintenance regimes and extent of clogging due to sediment, ochre etc.).

Uncertainty 3: There is a lack of data (empirical or modelling) on the relative performance and long-term costs of pipe-drains (sub-surface) and foot drains (surface) in increasing water ingress.

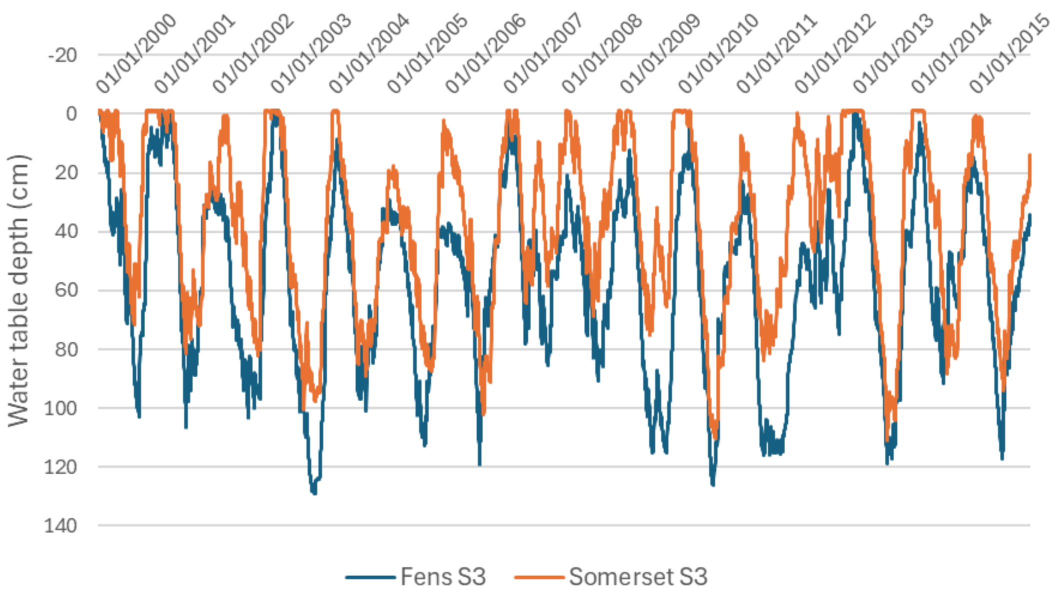

Figure 2.1 Simulated water table depth for Scenario 3 (100 m ditch spacing, intermediate ditch water level of 60 cm bgl, high K) in Somerset and the Fens. Model data from BAIRD ET AL. (2026).

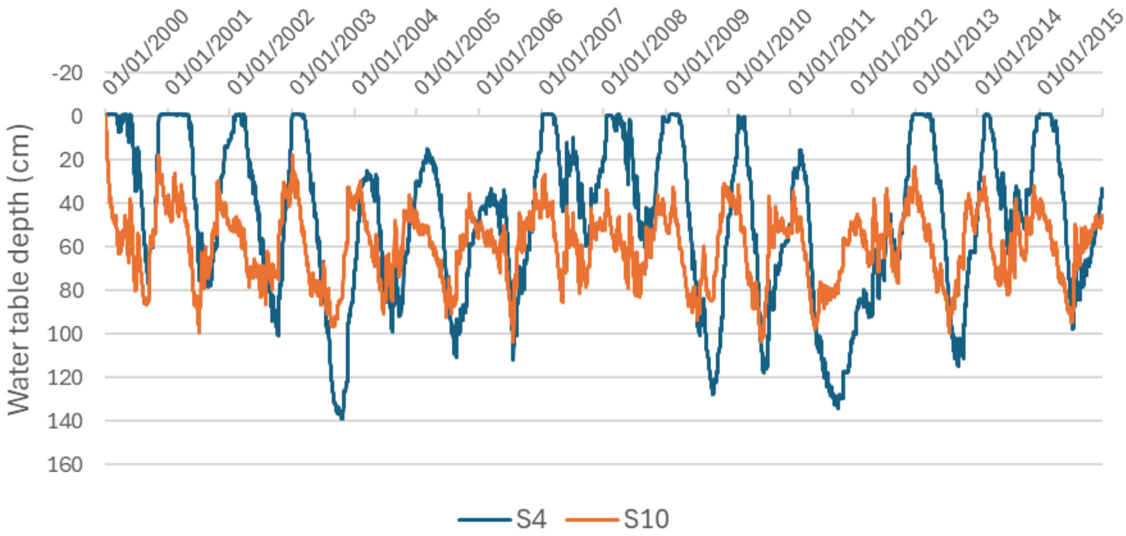

Figure 2.2. Time series of the mid-drain water table depth for (blue) 100-m drain spacing, intermediate ditch water level of 60 cm bgl, low peat K (Fen Scenario 4 from BAIRD ET AL., 2026) and (orange) 20-m drain spacing, intermediate ditch water level of 60 cm bgl, low peat K (Fens Scenario 10 from BAIRD ET AL., 2026).

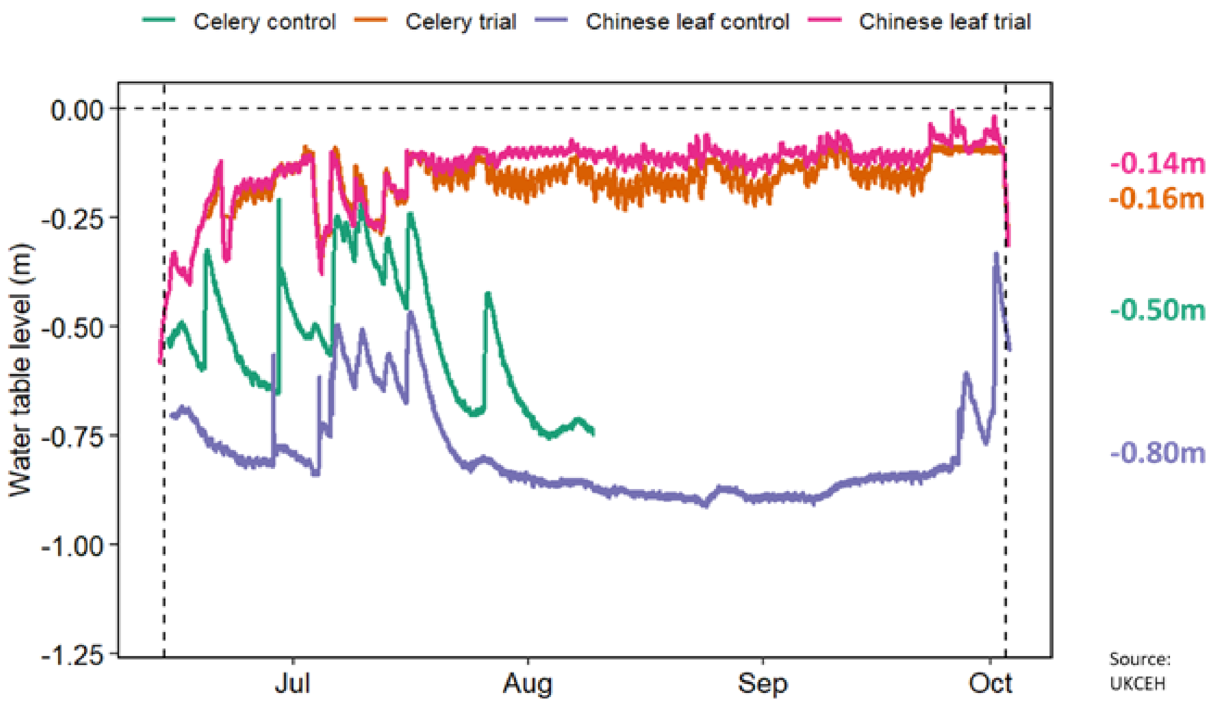

Figure 2.3 Water table depth in 2024 within the high ditch water level Fenland SOIL PEF Paludiculture trials (orange and pink) and in the conventionally managed control (green and purple) at nearby LP3 site, both with 10 m pipe drain spacing in East Anglia in 2024. Average water table depth given by the coloured values on the right of the figure (D'ACUNHA, ET AL. 2024)

2.2 Drain water levels

Maintaining high drain water levels is often conflated with maintaining high in-field water tables. Although high drain levels do support reduced mean water table depth, the interactions of weather, drain spacing and peat properties lead to significant variability in water table depth (Figure 2.4). Despite the importance of drain water levels in influencing peat water table depth as shown in BAIRD ET AL. (2026), there is little data on drain water levels or water level management regimes within Internal Drainage Board (IDB) and non-IDB areas. Although HOLMAN ET AL. (2023) developed a remote-sensing based approach to mapping drain water levels, this only provided a single (winter) snapshot.

An alternative to constant drain water levels are variable regimes in which the drain water level is changed through the year to balance flood risk management, water tables and agricultural production. The seasonally-varying drain water level intervention in BAIRD ET AL. (2026) had low ditch water levels (120 cm bgl) between the autumn to early spring months and then higher water levels for later spring and summer (to 15 cm bgl). Conceptually similar to seasonal drainage regimes operated in parts of the Somerset Levels and Broads, this scenario not surprisingly gave results intermediate between the low ditch water level (120 cm bgl all year) and the high ditch water level (15 cm bgl all year) simulations (Figure 2.4). Although the field-edge water table responds rapidly to changes in the drain water levels (Figure 2.5), the mid-field water table is much less responsive to the seasonal drain management, even with the high-K peat, being substantially higher than the drain water level in winter (drainage) and lower in the summer (sub-irrigation). Although seasonally varying ditch water levels are unlikely to support stable raised water tables in most lowland agricultural peats, the effectiveness of other dynamic drain water level regimes is uncertain.

Insight 3: Higher drain levels support reduced mean water table depth but are still associated with significant variability in water table depth in many lowland agricultural peats due to weather, drain spacing and peat property interactions.

Insight 4: The mid-field water table is much less responsive to the seasonal drain management than near the field edge, with seasonally varying ditch water levels unlikely to support stable raised water tables in most lowland agricultural peats.

Uncertainty 4: Understanding of water table behaviour and agricultural production under a greater range of dynamic drain water level management regimes is needed.

Uncertainty 5: Despite the important influence of drain water levels on current and future water table levels, there is little accessible data on drain water level elevations or water level management regime (e.g. constant; seasonally varying [lower in winter; higher in summer] etc).

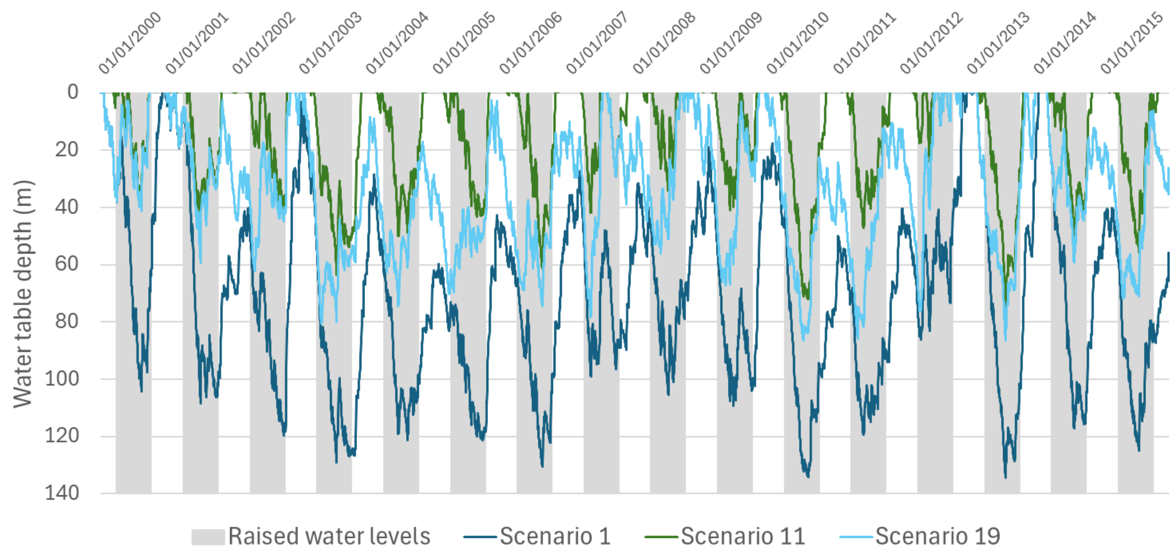

Figure 2.4. Time series of water tables for (dark blue) Somerset Scenario 1 (100-m ditch spacing, low ditch water level of 120 cm bgl, high K), (green) Scenario 11 (as for 1 except with high ditch water levels of 15 cm bgl) and (pale blue) Scenario 19 (as for 1, except with seasonally varying ditch water levels). Grey areas show times of raised ditch water levels (from BAIRD ET AL., 2026).

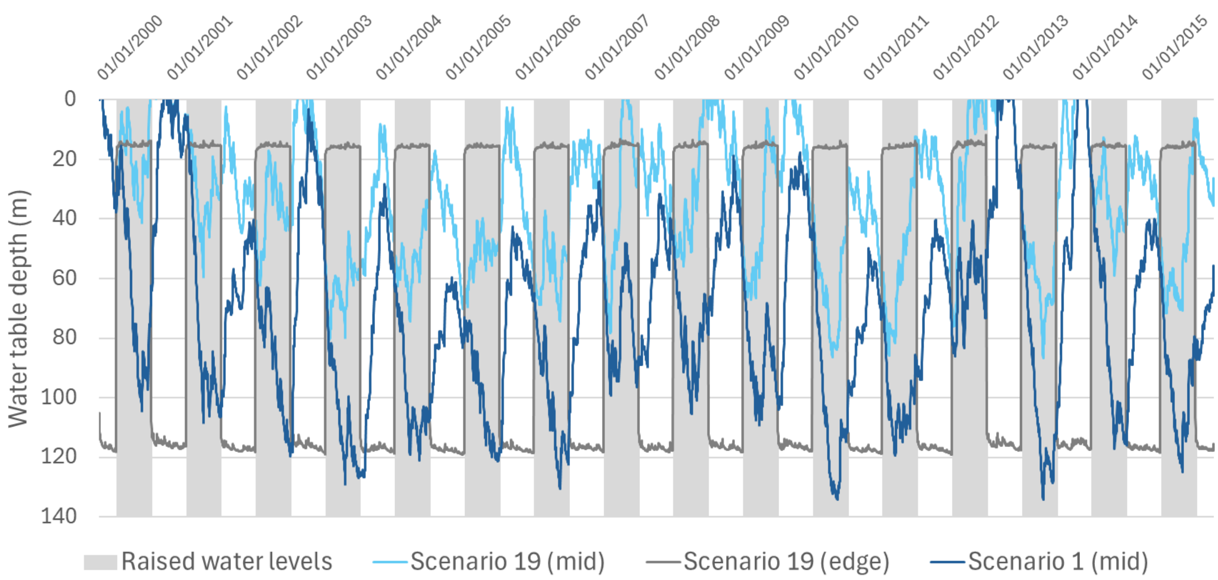

Figure 2.5. Time series of field-edge (grey) and mid-field (pale blue) water tables for Scenario 19 (as for 1, except with varying ditch water levels) and mid-field for Scenario 1 (100-m ditch spacing, low ditch water level of 120 cm bgl, high K) (dark blue). Grey areas show times of raised ditch water levels. Data from BAIRD ET AL. (2026).

2.3 Peat properties

Peat properties - particularly hydraulic conductivity and specific yield - are an important control on water table depth and behaviour, and hence are influential factors in achieving stable raised water tables (BAIRD ET AL., 2026). Drainage to lower the water table in lowland agricultural peatlands causes subsidence, consolidation and increased decomposition of peat (or humification), particularly above the zone of water table fluctuation. This increases the bulk density of the peat and alters its hydrological properties, affecting both the rate at which water can move into and out of the drained peat (hydraulic conductivity) and the responsiveness of the water table to short-term changes in water storage (specific yield) (HOLMAN ET AL. 2026; GRABOWSKI ET AL. 2026). In particular, drainage tends to lead to reduced specific yield (reducing storage and increasing water table variability) and reduced saturated hydraulic conductivity (reducing drainage losses, reducing lateral sub-irrigation inflows into the peat from the drains and increasing the hydraulic gradient). However, significant variability in specific yield and hydraulic conductivity data within and between sites was measured by GRABOWSKI ET AL. (2026) (Figure 2.6), due to differences in peat composition, past land drainage history and agricultural practices and methodology.

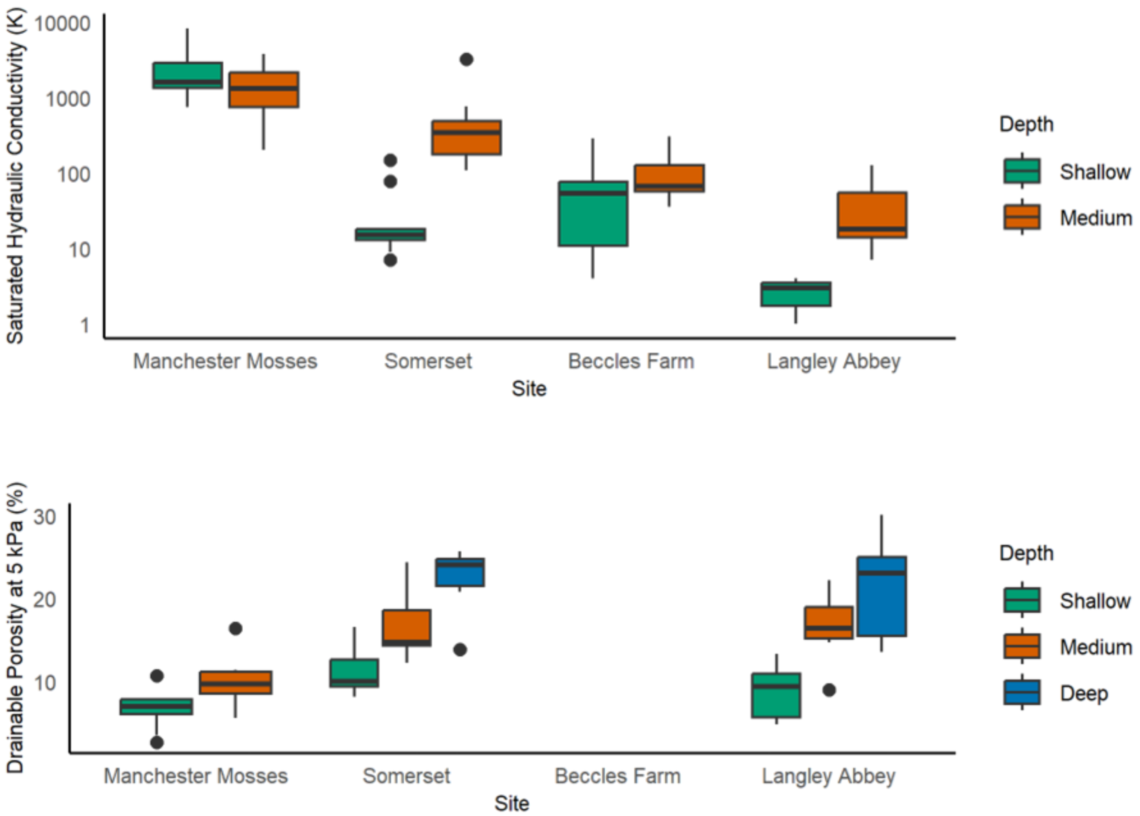

Figure 2.6. Variability in peat properties within and between four sites within LP3+ showing (upper) vertical saturated hydraulic conductivity (K, cm day^{-1}) and (lower) drainable porosity at 5 kPa suction measured in the laboratory from undisturbed samples (Shallow: ~30 cm, Medium: ~70 cm; Deep ~ 100 cm depth).

Saturated hydraulic conductivity was measured at two LP3+ sites both in the field from piezometer tests and in the laboratory using undisturbed peat samples (GRABOWSKI ET AL., 2026). The Ksat measured in the field from the piezometer tests were 2 to 3 orders of magnitude smaller than those measured in the laboratory demonstrating the high methodological uncertainty. However, it is unclear whether the differences are mainly due to scale – because the piezometer test provides a depth-integrated value while the laboratory method measures small samples from specific depths – or due to methodological issues, such as piezometer development failing to remove auger smearing even when following BAIRD's (2023) protocol. In contrast, water content and drainable porosity measurements from the two laboratory methods (Hyprop 2: METER 2024a and sand tables: CRANFIELD UNIVERSITY, 2007) were strongly correlated. The variability of the water content results obtained from triplicate measurements was smaller with the Hyprop 2 method, resulting from the larger sample size which reduces heterogeneity between replicates and because the method does not rely on hydraulic equilibrium (SCHELLE ET AL., 2013).

The degree of drainage-induced modification of these properties is related to the inherent susceptibility of different peat types to degradation, the intensity of drainage management and the loss of peat (e.g. due to wind erosion, crop off-take and peat extraction), with studies suggesting that the adverse effects of drainage on specific yield and saturated hydraulic conductivity persist after raising water tables (KREYLING ET AL., 2021 - fen peatlands across temperate Europe; LAUDON ET AL., 2023 - drained peatland forest in Sweden). Both studies suggest that that water table resilience to dry conditions is not restored with raised water tables, with KREYLING ET AL. (2021) suggesting that there is "no general trend towards natural conditions up to three decades after re-wetting".

The relative elevation of the water table within the middle of the field in winter compared to the drain water level depends on net rainfall and the ability of the peat to transmit excess water laterally to the drain. A steeper hydraulic gradient, and thus higher water table is needed where the peat is degraded, lacks preferential flow paths within the saturated zone (e.g. peat pipes) and thus has lower saturated hydraulic conductivity (Ksat) (Figure 2.7 and 2.8). Consequently, low Ksat is thought to play a central role in maintaining shallow water tables in degraded peatlands by inhibiting lateral drainage (MORRIS ET AL., 2022), but the water table variability is also greater because of the generally low specific yield of degraded peats (PRICE ET AL., 2003). PRICE ET AL. (2003) considered that the effect of lowered specific yield is more important than the effects of reduced hydraulic conductivity on controlling the variability in water table elevation, because more water is typically lost annually from agricultural peatlands by evapotranspiration than lateral drain flow.

However, other properties of peat can also affect the partitioning of effective rainfall between runoff and infiltration and thus modify recharge, and water table depth and variability, in particular hydrophobicity and cracking. Prolonged desiccation of surface peat layers can lead to the development of a hydrophobic layer which reduces infiltration capacity (EVANS ET AL., 1999). Although there has been significant research on water repellency in peat soils associated with burning (e.g. WILKINSON ET AL., 2020), there are very few studies in agricultural peats (e.g. DEKKER AND RITSEMA, 1996; SCHWARZEL

ET AL., 2002) and the relationship between water repellency and the state of peat degradation (KALISZ ET AL., 2015; OBENG ET AL. (2023)). Similarly, although preferential flow paths are well acknowledged in upland peats (e.g. HOLDEN, 2005), there is less information on their prevalence and flow properties in agricultural peat soils, with most studies focussing on implications for solute fluxes (e.g. BAIRD and GAFFNEY, 2000; TIEMEYER ET AL., 2009; SADE ET AL., 2010; LIU ET AL., 2017).

Insight 5: Degraded drained agricultural peats can support raised water tables but will tend to have high water table inter-annual variability due to their lower specific yield and hydraulic conductivity.

Insight 6: Evidence in the literature suggests that raising water tables or re-wetting does not reverse the effects of drainage on the hydrological properties of peat soils.

Uncertainty 6: Despite greater Ksat and specific yield data availability and some identified relationships (e.g. between degree of humification and Ksat), it is not yet possible to accurately predict peat properties from site characteristics (rather than directly measuring the peat properties) in order to inform site selection or design management interventions.

Uncertainty 7: The frequency of occurrence and extent of hydrophobicity and its influence on water table dynamics in lowland agricultural peats is largely unknown.

Uncertainty 8: The prevalence, flow properties and impacts on recharge and saturated flow of preferential flow paths in agricultural peat soils.

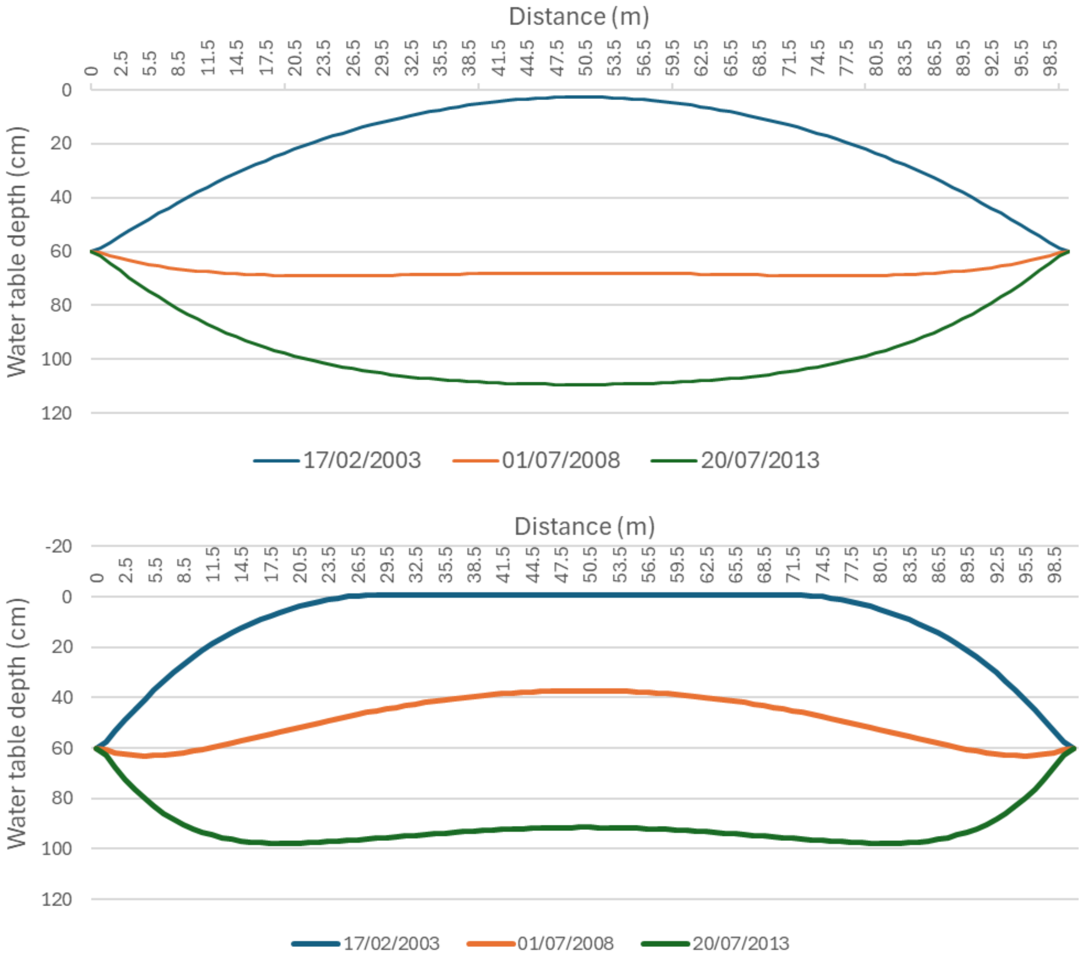

Figure 2.7. Water-table cross-sections between the bounding ditches on three occasions for Somerset (upper) Scenario 3 (100 m ditch spacing, intermediate ditch water level of 60 cm bgl, high K) and (lower) Scenario 4 (100 m ditch spacing, intermediate ditch water level of 60 cm bgl, low K). Data from BAIRD ET AL. (2026).

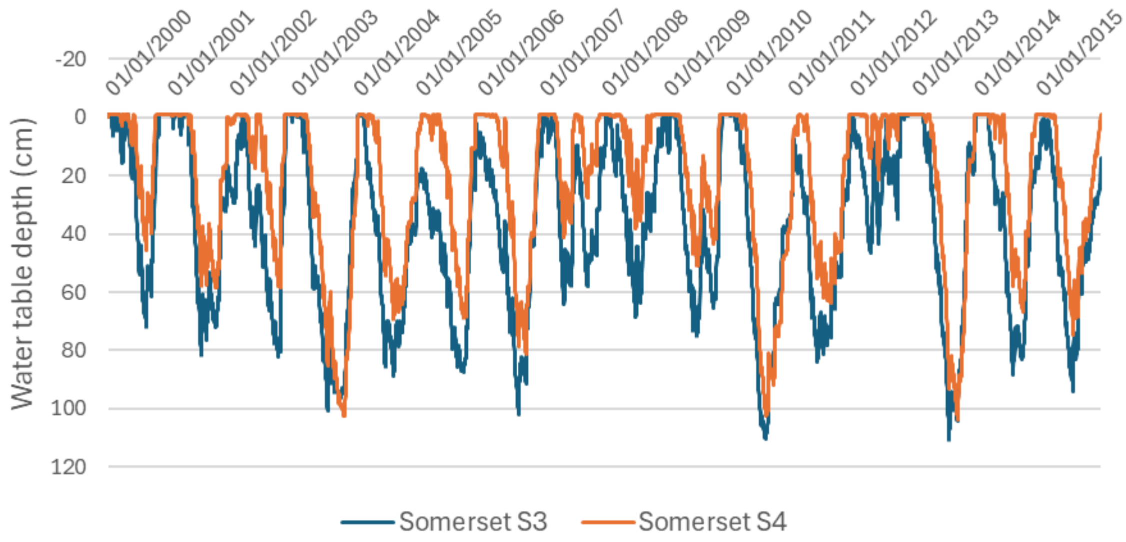

Figure 2.8. Mid-drain water-table cross-sections for Somerset Scenario 3 (100 m ditch spacing, intermediate ditch water level of 60 cm bgl, high K) and Scenario 4 (100 m ditch spacing, intermediate ditch water level of 60 cm bgl, low K). Data from BAIRD ET AL. (2026).

2.4 Groundwater seepage

Although WETMECS (WHEELER ET AL., 2009) describe the water supply mechanisms of semi-natural eco-hydrological systems, the pathways they describe can also be relevant to areas of modified LAP. The potential importance of groundwater seepage into the water balance of lowland peat is recognised within the WETMECS classifications (WHEELER ET AL., 2009) (Appendix 1 of HOLMAN ET AL., 2026) e.g. WETMECS 8 and 9 (groundwater-fed bottom with aquitard and groundwater-fed bottom, respectively) and 7 (groundwater floodplain). Some types of lowland agricultural peats form in the natural groundwater discharge zone (WHEELER ET AL., 2009) where the groundwater head within the underlying aquifer would be expected to be higher than in the peat, potentially facilitating a vertical inflow (e.g. VARMAAT ET AL., 2016; SIMPSON ET AL. 2011a&b) into the peat and/or ditches. Observations consistent with upward groundwater discharge are seen at West Sedgemoor in the Somerset Levels (LOW ET AL., 2026).

Upward groundwater flow or seepage from an underlying aquifer can be a contributor to the water balance of some WETMECS, helping to meet summer evapotranspiration demands and therefore reducing the water table decline. Whilst the contribution is low or minimal in raised bogs and fens underlain by impermeable geological deposits, it may be significant in some fens underlain by permeable geology (Figure 2.9), despite the piezometric evidence for significant upward flows into UK lowland peats being variable (e.g. GILVEAR ET AL., 1997; BAIRD ET AL., 2004; WHEELER ET AL., 2009). However, groundwater discharge into the drains, especially where the drain is in hydraulic continuity with an underlying aquifer (SIMPSON ET AL. 2011a&b), can help maintain summer drain water levels. There is little evidence of downward seepage in LAP in the UK (i.e.

groundwater flow out of the drains towards underlying aquifers), although the catchment-scale modelling study of SIMPSON ET AL. (2011b) suggested less than 0.1% of the groundwater exchange between the aquifer and the drains was downwards; and TORO ET AL. (2022) observed downward groundwater flow out of the coastal peat fen during winter periods of high precipitation and low evapotranspiration.

Insight 7: Achieving high stable water tables is more practicable with fen peats hydrogeologically connected to underlying aquifers.

Uncertainty 9: The volumetric contribution, and therefore importance, of upward groundwater flow into drained peats is poorly understood.

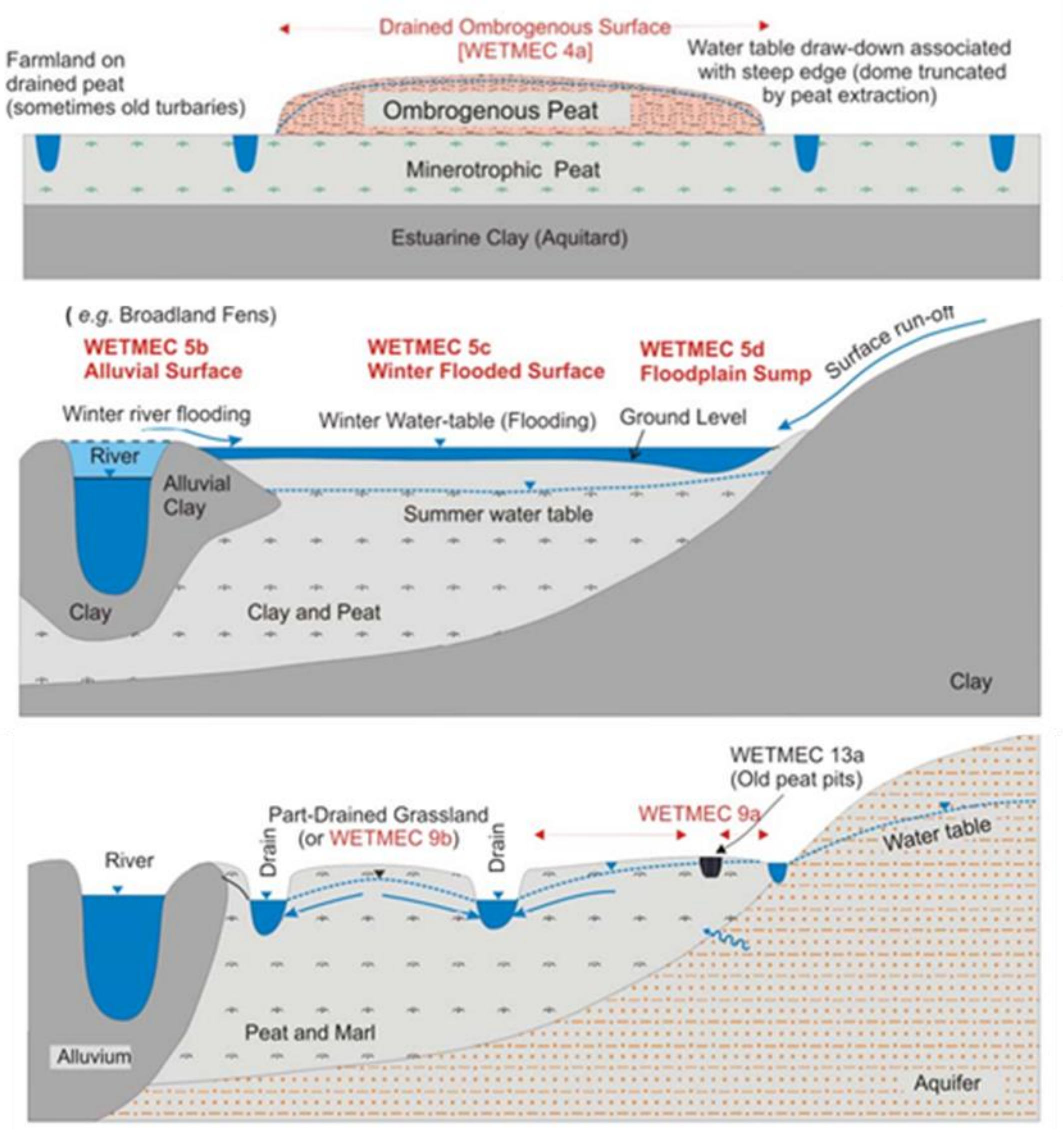

Figure 2.9 WETMECS Illustrating the differing importance of groundwater inflows from (upper) WETMEC 4a (Drained ombrogenous bog e.g. Holme Fen) in which the raised peatland is above the wider water table; (middle) WETMEC 5 (Summer 'dry' floodplains e.g. Wicken Fen; Broadland Fens) in which WETMEC is above impermeable geological layer) and (lower) WETMEC 9 (groundwater-fed bottoms e.g. Thelnetham Fen) in which WETMEC sits within groundwater discharge zone of underlying aquifer (from WHEELER et al., 2009).

2.5 Enhancing water table recharge

2.6.1 Surface Ponding

In-field topographic variation due to subsidence, peat extraction and/or drain management (e.g. drainage) can influence waterlogging, water table depth, soil moisture, vegetation establishment (CROWLEY ET AL., 2021), evapotranspiration and surface runoff. In-field topographic variation can also be reduced by land management e.g. field laser levelling. Concave in-field topographic variation will favour retention of excess water, mostly in the winter, through surface ponding which may help to sustain the water table through subsequent infiltration and recharge. This is in contrast to convex in-field topographic variation which will favour surface runoff of excess water associated with a water table at the surface or intense rainfall. Surface ponding within concave in-field topographic variation may be augmented by flooding if WETMECS 5 (summer 'dry' floodplain) and, to a lesser extent, 7 (groundwater floodplain) hydrological regimes can be re-established with restoration.

A similar effect is seen in the simulation in Figure 2.10 where surface bunds at the field edges in scenario S16 supports winter ponding (shown by the water table being above ground level) that helps to maintain a slightly higher water table in spring and summer, although the effect is limited by insufficient incident excess rainfall to support significant ponding depths, enhanced drainage and evapotranspiration. Significant surface ponding was observed at the LP3+ dipwells at West Sedgemoor (Figure 2.11) in winter 2024-25 (LOW ET AL., 2026) although the effects of this on the water table recession will only become evident with continued monitoring.

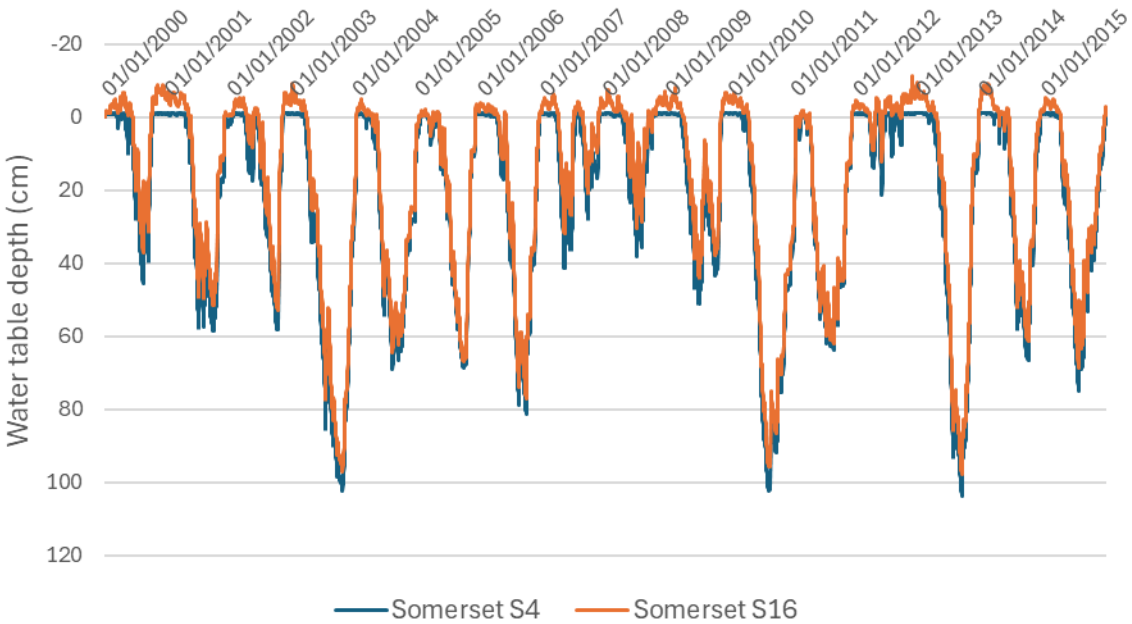

Figure 2.10. Effects of surface ponding as seen in comparison of mid-drain water-table for Scenario 4 (100 m ditch spacing, intermediate ditch water level of 60 cm bgl, low K) and Scenario 16 (100 m ditch spacing, intermediate ditch water level of 60 cm bgl, low K; surface bund) in Somerset. Data from BAIRD ET AL. (2026).

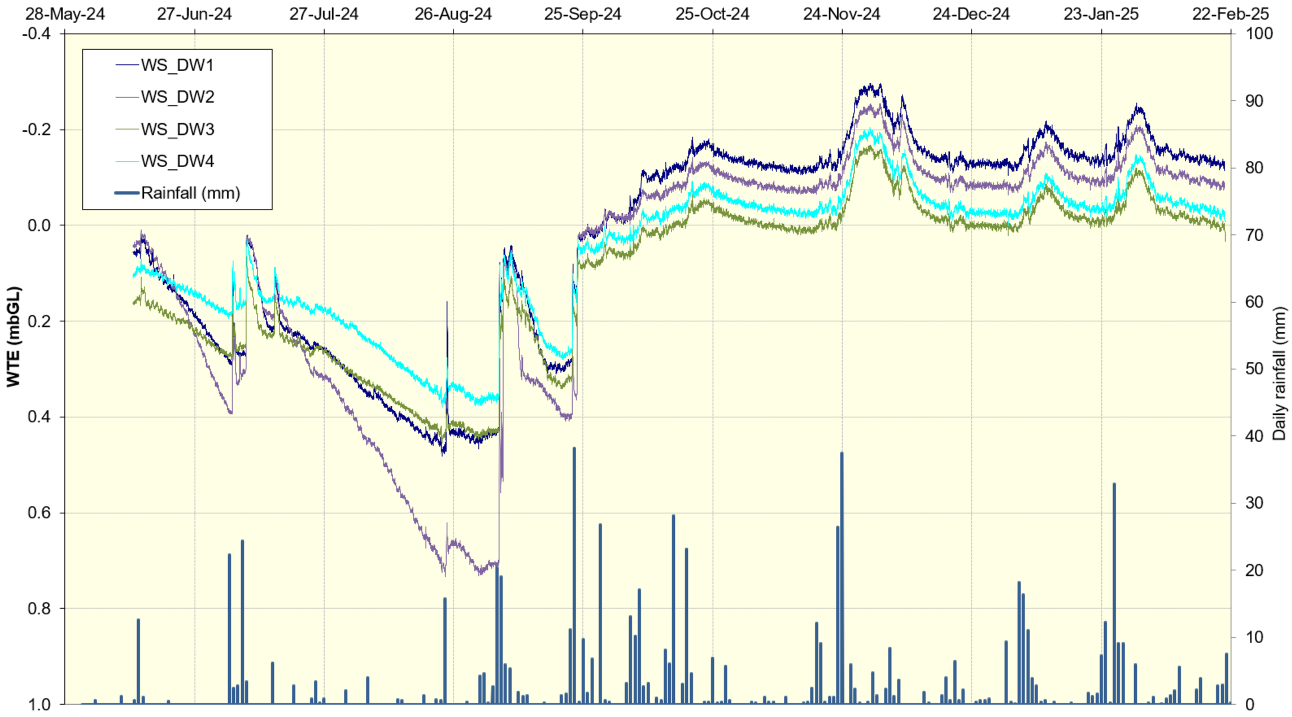

Figure 1. Hydrographs of dipwells (DW) (m below ground level / mbGL) for the LP3+ West Sedgemoor (WS) site (from LOW ET AL., 2026) – dipwells are 5m (DW1 and 3) and 20 m (DW2 and 4) from the boundary ditches.

2.6.2 Subsurface bunds

Subsurface bunds reduce water losses during and after rainfall (which may lead to higher than desired water tables) and reduce subirrigation when in-field water tables are below ditch water levels (which may lead to lower than desired water tables). An increase in the water table elevation (and thus increased hydraulic gradient) was observed across the sub-surface bund at the LP3+ site at Railway View Field (Manchester Mosses)(LOW ET AL., 2026). The water table elevation (Figure 2.12) in the dipwell 1.5m in-field from the trench-bund centre (DW-2) was consistently higher (generally 0.3-0.5 m) than in DW1 that is located 1.5 m downstream or drain side of the trench-bund centre, showing that the trench-bund acts as a poorly permeable curtain in the substrate whilst also blocking the original pipe-drains. However, the water table in the upstream DW2 still falls during dry periods during the colder-month period (i.e. low evapotranspiration period (marked ‘1’ in Figure 2.12), suggesting that there is still flow through the trench-bund in response to the steep hydraulic gradient across it.

Although subsurface bunds led to higher simulated average water table height due to the reduced drainage losses and subirrigation, mid-field water tables remain very variable (BAIRD ET AL., 2026). This variability is maintained even when the hydraulic conductivity of the modelled bund is set at an even lower rate, but this is also associated with longer periods during which the water table reaches the surface.

Figure 2.12. Water level hydrographs (maOD) in Railway View field, Manchester Mosses. S8_SW1: ditch water level (purple); S8_DW1 located between ditch and sub-surface bund (dark blue); S8_DW2 located 1.5m in-field from the bund centre (yellow); NE_Rai3 located 75m in-field from DW_2 (pale blue) (from LOW ET AL., 2026).

2.6.3 Surface irrigation

In contrast to sub-surface irrigation associated with high drain water levels and shallow pipe-drain spacings (e.g. HARPENSLAGER ET AL., 2024; BOONMAN ET AL., 2022; KECHAVARSI ET AL., 2007), there has been little research on the potential benefits of surface irrigation for raised water table management in lowland agricultural peats (e.g. plot-scale experiments in EVANS ET AL., 2023). Modelling suggests that surface irrigation can be effective in maintaining raised summer water tables but leads to higher autumn/winter levels because there is less unsaturated peat available at the end of summer, so rainfall can bring the water table to the surface more easily (BAIRD ET AL., 2026).

Whilst this will be case for any mechanism which maintains high water tables through the summer, the peat above the water table is likely to be wetter with surface irrigation (as this requires all of the peat above the water table to be above field capacity for recharge to occur, in the absence of preferential flow paths) in contrast to, for example, sub-surface irrigation. Surface irrigation might prove effective if strategically deployed during very dry summers, but would require irrigation scheduling based on weather and water table and soil moisture monitoring.

Insight 8: Concave in-field topographic variation, whether natural or created with surface bunds, will favour retention of excess water through surface ponding to support subsequent recharge.

Insight 9: Sub-surface bunds are unlikely to maintain stable raised water tables within lowland peats.

Insight 10: Surface irrigation can be effective in maintaining raised summer water tables but leads to higher autumn/winter levels.

Uncertainty 10: The relative frequency of occurrence of different in-field topographic variation types (convex, flat, concave) in drained lowland agricultural peat fields has not been characterised, although this forms a component of the ongoing LP3 project.

Uncertainty 11: There are no available data on the hydraulic properties of sub-surface bunds influencing drainage and sub-irrigation, leading to uncertainty in their performance in lowland peats.

Uncertainty 12: There is a lack of field-scale studies to evaluate irrigation scheduling regimes to support stable raised water tables.

2.6 Vegetation

Different vegetation types have differing water table preferences which will affect colonisation and succession following raising water tables. Decreasing water table depth promotes changes from conventional crops (including intensive grasses) and woody plants (shrubs and trees), to other graminoids (e.g., sedges, reeds) and Sphagnum mosses, to hydrophyte species (that are better adapted to submergence) (ZHONG ET AL., 2020).

Raising water tables can prolong the root growing season by reducing soil moisture stress (SCHWEIGER ET AL., 2022) and promoting plant functional types such as some graminoids (e.g. sedges) which are adapted to high and prolonged water tables and can grow roots deep into the saturated peat layers (VOESENEK ET AL., 2006). Consequently, raising water tables can lead to significant increased actual evapotranspiration (RENGER ET AL., 2002; MOUNTFORD ET AL., 2002), negative climatic water balances (WESSOLEK ET AL., 2002) and lead to decreased annual discharge (LUNDIN ET AL., 2017). Actual evapotranspiration rates are also likely to be higher where water tables are raised within small spatial extents due to local advection (PEREIRA ET AL., 2024) although there is considerable uncertainty around this. Consequently, raising and maintaining stable water tables in lowland agricultural peat will generally require access to additional water resources in excess of the incident precipitation.

Insight 11: Raising water tables is likely to lead to increased evapotranspiration demand, although the increases is partly dependent on scale and vegetation type/condition.

Uncertainty 13: Crop coefficients (relating potential evapotranspiration to reference evapotranspiration) are lacking or highly uncertain for UK lowland vegetation (paludiculture crops, grass etc) under raised water tables.

3 Implications for achieving raised stable water tables in lowland agricultural peat

3.1 Insights from past experience

Analysis of UKCEH (Figure 3.1) and Environment Agency (Figure 3.2) shallow groundwater monitoring data in areas of lowland peat showed that, across most land uses (including grassland, fen and bog) and sites, water table variability typically exceeds the 20 cm range specified in current Countryside Stewardship grants for raised water tables in lowland agricultural peat (HOLMAN ET AL., 2026). All but one of the fen sites fail to maintain a water table at less than 30 cm depth through all years. This analysis demonstrates the challenges of maintaining consistent high water tables, even within sites relatively unimpacted by agricultural drainage, as high surface water levels in ditches are often unable to support high summer in-field groundwater levels due to evapotranspiration demands and low horizontal conductivity of peat.

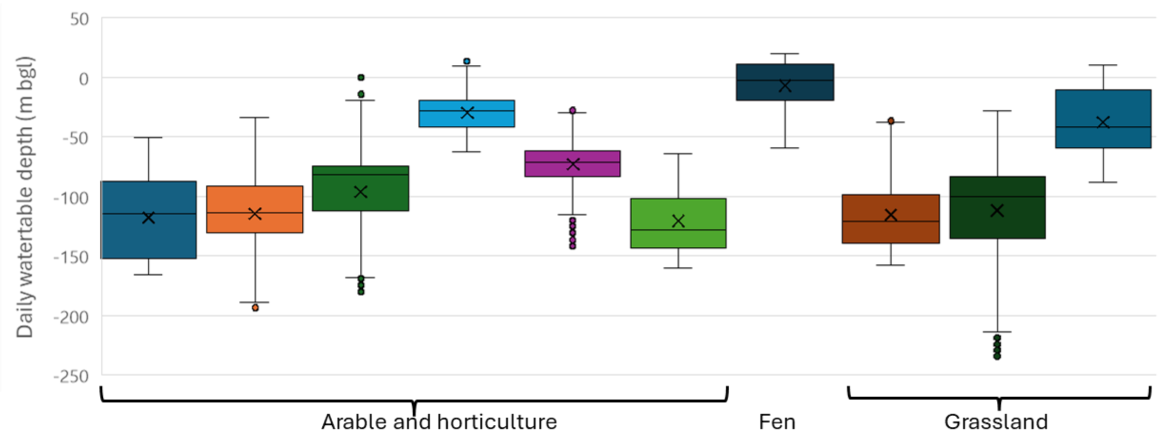

Figure 3.1 Box and whisker plot (lower) of daily average water table depth (metres below ground level) within logged dipwells at UKCEH flux tower sites by land use (from HOLMAN ET AL., 2026).

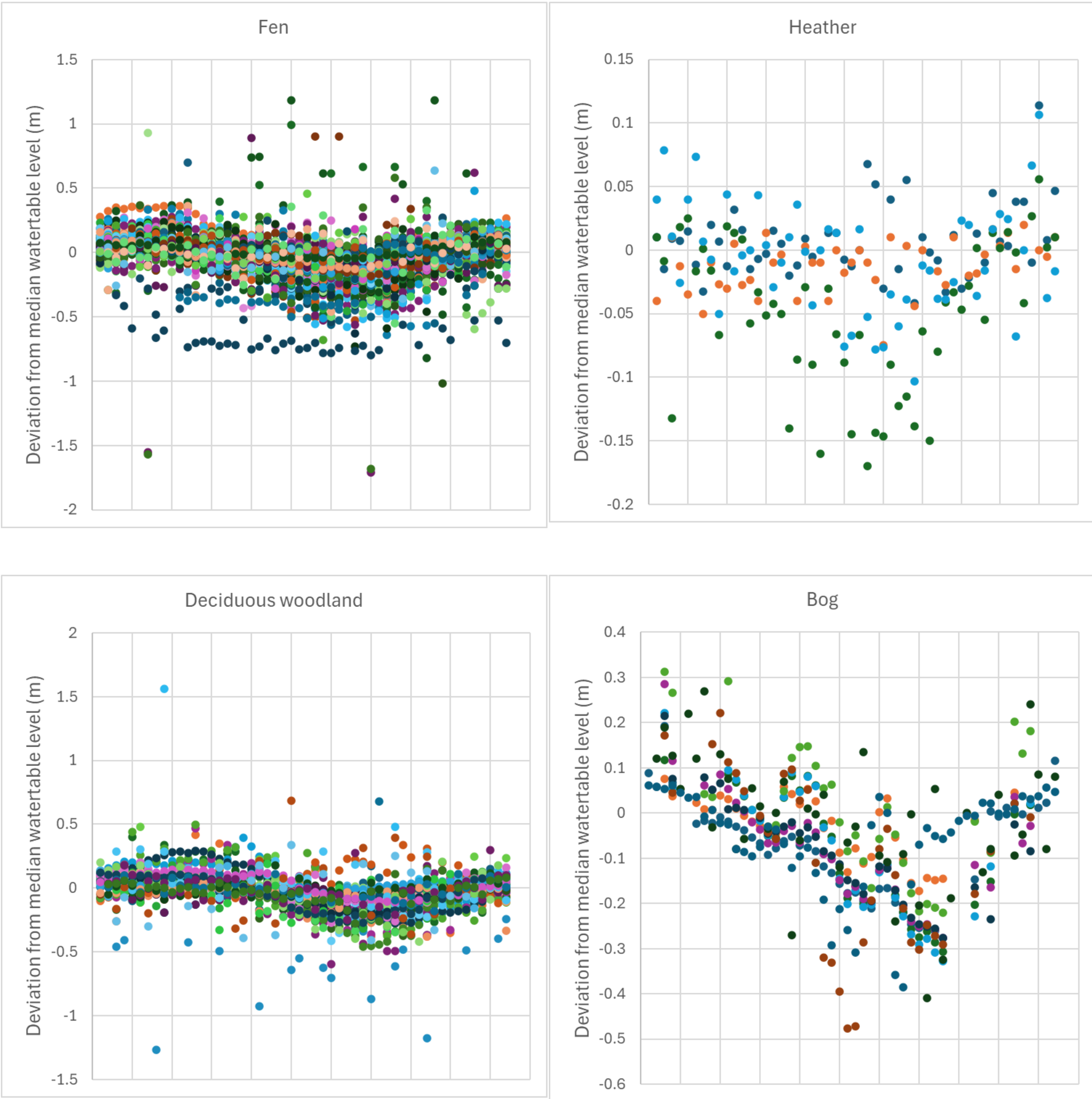

Figure 3.2 Weekly average deviation from median water table level within Environment Agency dipwells (each colour represents a different dipwell) within different landcovers based on UKCEH Land Cover Class within the Land Cover Map 2020 (UKCEH 2022) for the site's given grid reference (note different y-axes). X-axis is week of year. (from HOLMAN ET AL., 2026).

3.2 Insights for future practice

It is not yet possible to develop a decision tree to inform site selection for rewetting, due to remaining uncertainties in understanding the multiple interacting factors that determine water table behaviour. Figure 3.3 synthesises insights from the literature review, data analysis, site monitoring and modelling undertaken within LP3+, supported by expert opinion, to identify the attributes that make achieving stable raised water tables more or less challenging. In particular:

- Climate: wetter and cooler areas of the country that have higher hydrologically effective rainfall (the surplus of precipitation over evapotranspiration), will develop smaller soil moisture deficits during summer and thus smaller evapotranspiration-induced drops in the water table. All other things being equal, raising and maintaining higher water tables will be relatively less challenging in wetter areas (such as the Somerset Levels) than drier areas (such as the Fens) (BAIRD ET AL., 2026), notwithstanding any concerns around flood risk;
- Original trophic type: trophic type is an important predictor in the saturated hydraulic conductivity models of MORRIS ET AL. (2022) due to the effects of the original peat-forming vegetation type on peat properties and susceptibility to degradation;
- Peat properties: saturated hydraulic conductivity and specific yield are important controls on saturated flow within the peat and the response of the water table to water inputs/outputs, respectively. Where drains with high water levels are the primary water table management control, high saturated hydraulic conductivity and specific yield will support stable raised water table elevation;
- Original WEMTECS: because summer evapotranspiration is usually in excess of rainfall in lowland areas, LAP sites that were former WETMECS 1 and 4 (domed and drained ombrogenous surfaces, respectively) that are reliant on precipitation as their water source will have greater future challenges to maintain stable raised water tables than sites that have the potential to receive additional water inputs. These include former WETMECS 5 (summer ‘dry’ floodplains) which potentially receive winter flooding and WETMECS 8 and 9 (groundwater-fed bottom with aquitard and groundwater-fed bottom, respectively) and 7 (groundwater floodplain), the latter of which has the potential to receive occasional floodwaters in addition to groundwater inputs. However, the ability to benefit from future seasonal inundation depends on wider drainage system management;
- Drainage history: The duration and intensity of past and current drainage has important consequence for peat degradation (MA ET AL., 2022), peat bulk density (LIU ET AL., 2020) and physical properties of the peat;
- Drainage type: the wider drainage network aims to maintain drain water levels within target ranges through conveying excess water away for discharge into the river network. Pumped drainage systems tend to provide greater and more active control of water levels and also may afford greater potential of moving water between drainage levels;
- Drain spacing: In the absence of other interventions, it will be more effective to raise and maintain high water tables within sites that currently have efficient water table control (BAIRD ET AL., 2026). These will tend to have smaller under- or pipe-drain spacing, typically at the spacing of the old English unit of a “chain” (22 yards or approximately 20 m) or less, which enables greater sub-irrigation from raised drain water levels;
- CAMS (Catchment Abstraction Management Strategy) status: The scenario modelling assumed that the additional water needed to support higher water tables,

whether for increased sub-irrigation or for surface irrigation, was available (BAIRD ET AL., 2026). However, the extent to which this increased demand can be met from local summer water resources or require increased winter storage (CAULDWELL, 2023) will depend on the Environment Agency's water resource availability and abstraction reliability assessment (ENVIRONMENT AGENCY, 2024) and abstraction licencing strategy (ENVIRONMENT AGENCY, 2023);

- Preferred interventions: as shown in Section 2, different interventions have different simulated effectiveness in achieving raised and stable water tables with (1) raised drain water levels in conjunction with narrow ditch or pipe-drain spacing and (2) irrigation being generally more effective than surface ponding and/or sub-surface bunds. However, all are likely to provide some water table benefits.

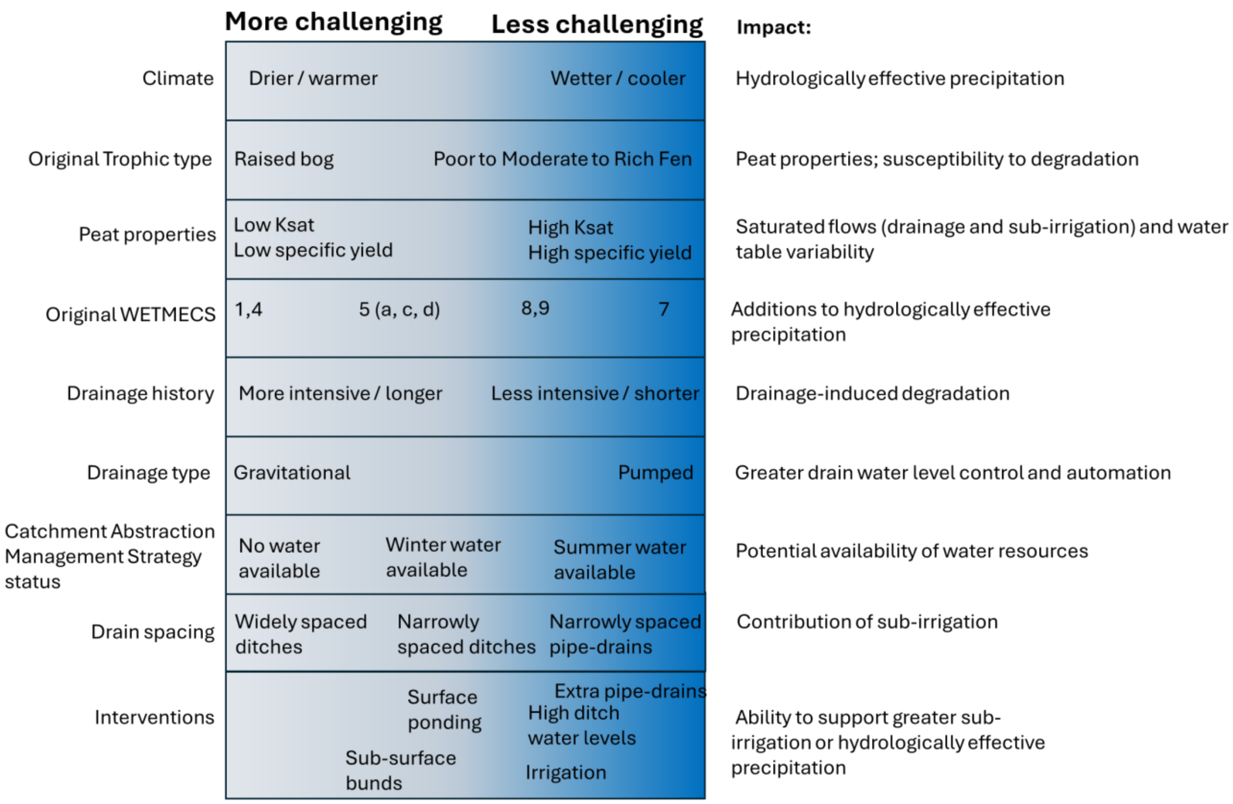

Figure 3.3 Attributes of lowland agricultural peat areas that make achieving stable raised water tables more or less challenging.

4. Conclusion

The LP3+ research has demonstrated the multiple factors, in isolation and in combination, that influence water tables dynamics within lowland agricultural peat.

The research has also demonstrated that water table elevation varies in both time and space (distance from the drains), with greatest variability in water table found at the mid-drain position and lowest close to the drains. This variability in water table elevation will interact with in-field topographical variation and field geometry to determine water table depth. However, uncertainty remains regarding how field shape, variations in peat thickness and vegetation type affect water table depth, and the implications for water table monitoring design.

Achieving a desired low variability in raised water table levels to minimise greenhouse gas emissions, which is not seen in many natural lowland peat environments, will be challenging within many existing drained lowland agricultural peatlands. The results of this study demonstrate the importance of recognising the natural variability in water table levels when seeking to raise water tables in lowland agricultural peat. Otherwise more active and expensive water table management interventions are likely to be required to ensure stable raised water tables in agricultural fields with relatively wide ditch spacings and the absence of under-drains, which may lead to increased peat disturbance.

The limited available literature summarised in HOLMAN ET AL. (2026) on the water table regime requirements of many peatland vegetation communities of conservation relevance (WHEELER ET AL., 2004) and potential paludiculture crops (NATURAL ENGLAND, 2022) also suggests that their required water table depths and fluctuations may be beyond the current specifications of CSW17/18 and CSW19/20, potentially reducing the ability to fully achieve biodiversity and agricultural co-benefits from raised water tables.

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