Land North of Brackenway, Formby

Palaeoenvironmental Assessment and Updated Geoarchaeology Report

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Land North of Brackenway, Formby

Palaeoenvironmental Assessment and Updated Geoarchaeological Report

by Mairead Rutherford

With contributions from Enid Allison, Nigel Cameron, Denise Druce, Harlie Mason, and John Whittaker, with illustrations by Mark Tidmarsh

Contents

List of Figures 5
Plates 5
Summary 7
Acknowledgements 8
1 INTRODUCTION 1
1.1 Background 1
1.2 Methodology 1
2 RESULTS 4
2.1 Lithology 4
2.2 Palaeoenvironmental assessment 7
3 DISCUSSION 9
3.1 Deposit model 9
3.2 Palaeoenvironmental data 10
4 CONCLUSIONS 12
5 BIBLIOGRAPHY 13
APPENDIX A LITHOSTRATIGRAPHIC RECORDS 16
APPENDIX B POLLEN 21
APPENDIX C DIATOMS 36
APPENDIX D PLANT REMAINS 40
APPENDIX E INSECTS 42
APPENDIX F FORAMINIFERAL AND OSTRACODA 44
APPENDIX G RADIOCARBON DATING CERTIFICATES 46
APPENDIX H SITE SUMMARY DETAILS 47

List of Figures

Figure 1 Site location
Figure 2 Location of additional boreholes superimposed on an extract from the British Geological Survey
Figure 3 West to East borehole transects for OABH01-CP03 (North) and OABH03-CP05 (South)

Plates

Plate 1 OABH01 (2–4m) – upper peat underlying blown sand and underlain by silts of the Downholland Silt
Plate 2 OABH04 (3–5m) – upper peat underlying blown sand and underlain by silts of the Downholland Silt
Plate 3 OABH01 (15–17m) – lower peat underlying the Downholland Silt and overlying Shirdley Hill Sand
Plate 4 OABH03 (15–17m) – lower peat and organic sand underlying the Downholland Silt and overlying Shirdley Hill Sand
Plate 5 A schematic section showing the sequence of superficial deposits at Downholland Moss and Formby (reproduced from Cowell and Innes 1994, fig 19)

Summary

Oxford Archaeology North was commissioned by Taylor Wimpey NW to complete a palaeoenvironmental study within an area of land north of Brackenway, Formby, Merseyside (centred on NGR: SD 30285 08943), in line with a planning condition implemented by Sefton Council (DC/2018/00093, Planning Condition 22). This study entailed: the drilling of two deep and three shallow boreholes; assessing the stratigraphic results derived from these interventions; completing palaeoenvironmental assessment and radiocarbon dating; and using the resulting data to update a previous deposit model for the site developed by Oxford Archaeology North in 2021.

The new stratigraphic data derived from the study largely support the results of the previous deposit model. However, the data also allows for some slight modification to this model, in that deep peat, originally assumed to seal glacial till, and lie beneath deposits of the Shirdley Hill Sand, is now known to occur at the top of the Shirdley Hill Sand deposits, directly beneath deposits of marine clays and silts, classified as the Downholland Silt. The dating evidence now available from this peat also provides a valuable *terminus post quem* for the deposition of the Downholland Silt, which is slightly earlier than previously estimated.

The organic deposits within the sediment sequence were also discovered to contain some palaeoenvironmental data relevant to landscape evolution during the prehistoric period and into the historic period. This data, comprises pollen, plant remains, diatoms, foraminifera/ostracoda, and insects, and it relates to a complex mosaic of intertidal, saltmarsh, fen/mire, heather-heath and (probably regionally developed) woodland habitats. Radiocarbon dating places the age of a lower peat deposit within the middle part of the Mesolithic period, whereas dates obtained from an upper peat deposit suggest an age ranging from early/middle Neolithic, at the base of the deposit, to medieval, at its top. The pollen, and other palaeoenvironmental proxies, exhibited variable preservation, and although grass and heather charcoal in the lower peat might indicate fire setting of heathlands by humans, there were no clear signals for anthropogenic activity. Indeed, this charcoal could relate to natural burning, or relate to a more generalised and widespread pattern of burning across the Formby area by human groups, which was not necessarily focused at this particular site. Given these factors, a the depth of the deposits, no further work is recommended.

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Oxford Archaeology would like to thank Taylor Wimpey NW for commissioning this project, and Emily Mercer and Karl Taylor of Lanpro Services Ltd for managing the project on their behalf. The project was managed for Oxford Archaeology by Fraser Brown. The geoarchaeological work, sediment description, and palaeoenvironmental sub-sampling was undertaken by Harlie Mason and Mairead Rutherford. Mairead Rutherford also assessed the pollen, whilst Denise Druce assessed plant macrofossils, Nigel Cameron assessed diatoms, John Whittaker assessed the foraminiferal/ostracod remains, and Enid Allison assessed the insects. The report was compiled by Mairead Rutherford, with illustrations by Mark Tidmarsh, and was edited by Richard Gregory.

1 INTRODUCTION

1.1 Background

1.1.1 This study represents a geoarchaeological and palaeoenvironmental investigation across an area of land north of Brackenway, Formby (centred on NGR: SD 30285 08943; Fig 1), undertaken in line with a planning condition imposed by Sefton Council (DC/2018/00093, Planning Condition 22). Previously, Oxford Archaeology (OA) North had been commissioned, by Taylor Wimpey NW, to undertake a baseline geoarchaeological desk-based review of this area, in accordance with the methodology set out in a Written Scheme of Investigation (WSI; Lanpro 2021), and to compile and interpret a deposit model using stratigraphical log data derived from historical interventions, and from more recent borehole data (CP01-10; Fig 2), completed during geotechnical investigations at the site (OA North 2021). This study was successfully completed, and the accompanying report contains full details relevant to the location, topography, and geology of the site (*ibid*). It also contains a review of the regional landscape, including sea-level changes, geomorphology, and palaeoecology (*ibid*). This report therefore forms an essential companion piece to the current study, and should be read in conjunction with this updated report.

1.1.2 With the completion of the baseline study, and following consultation with the Merseyside Environmental Advisory Service (MEAS) and Historic England Science Advisor (North West), it was agreed that a supplementary programme of geoarchaeological and palaeoenvironmental investigation should be undertaken. The aims of this, set out in an addendum to the WSI (Lanpro 2022), were to:

- collect new lithostratigraphic data from the site, via a borehole survey, which could be used to test the accuracy of the previously developed deposit model;
- incorporate the borehole data within an updated deposit model;
- collect core samples and undertake palaeoenvironmental assessment and radiocarbon dating,
- to use the palaeoenvironmental proxies to understanding landscape development, and identify any anthropogenic impacts on this coastal landscape across the prehistoric and historic periods;
- and evaluate if the assessed palaeoenvironmental data is worthy of additional analysis.

1.2 Methodology

1.2.1 ***Borehole survey:*** this survey was primarily designed to acquire detailed lithological data and also sample two buried peat units, referred to as the upper peat deposit and lower peat deposit, that had been identified during the baseline study (OA North 2021). During this study, stratigraphically, the lower peat deposit had been assumed (based on information contained in stratigraphical logs) to occur beneath deposits of Shirdley Hill Sand, and directly above glacial till, and hence relate to a very early terrestrial environment.

1.2.2 Borehole location and the sampling methodology was developed following discussions with Sam Rowe, Historic England's Science Advisor for North-West England, and set out in the addendum to the WSI (Lanpro 2022). A specialist company (Socotec) was commissioned to undertake the coring, utilising cable percussive boreholes, which was overseen by a geoarchaeologist from OA North.

1.2.3 In total, five cores were extracted for lithological and palaeoenvironmental study (OABH01-05; Fig 2). Of these, three (OABH01-03) comprised deep boreholes that penetrated sediments to a depth of 17m below ground level (bgl). Two of these boreholes (OABH01 and OABH02) were positioned close to a borehole (CP10), examined as part of the earlier study (OA North 2021), whilst the third was located adjacent to another previous borehole (CP06). Two further shallower boreholes, OABH04 and OABH05, targeted the upper peat deposit. Table 1 lists the samples targeted and collected for each of the boreholes.

BH	Depth (m) bgl	Upper peat deposit (m)	Top DHS (m)	Lower peat deposit (m)	Cores to collect (m)
Deep OABH01	18m	2.9–4.4	4.4–9.5	15.6–15.8	2–10m 15–17m (10m)
Deep OABH02	18m	2.9–4.4	4.4–9.5	15.6–15.8	2–10m 15–17m (10m)
Deep OABH03	18m	4.6–6.3	6.3–15.8	15.8–15.9	4–16m (12m)
Shallow OABH04	7m	2.95–4.4	4.4–6.6		2–7m (5m)
Shallow OABH05	9m	3.3–5.3	5.3–8.45		3–9m (6m)

Table 1: Borehole samples. DHS=Downholland Silt

1.2.4 Following extraction, the borehole cores were taken to the Socotec laboratory at Deeside, where they were opened, photographed, and the sediments logged (*Appendix A*), following Historic England guidelines (Historic England 2015; 2020). This data was then incorporated into the pre-existing deposit model for the site.

1.2.5 ***Palaeoenvironmental assessment:*** the first element of the palaeoenvironmental assessment entailed sub-sampling the collected cores, following Historic England guidelines (Campbell *et al* 2011; Historic England 2021). However, given the extent of previous palaeoenvironmental work along the Lancashire coast, in particular further north, at and around Lytham, and further west, at Downholland Moss (*cf* OA North 2021), a targeted approach to sub-sampling was implemented. Sub-sampling of the upper and lower peat deposits was considered a priority, to obtain palaeoenvironmental data and samples for radiocarbon dating. Sub-sampling either side of the peats was also undertaken to understand the depositional environments of the sedimentary sequence. The methodologies employed to assess the various paleoenvironmental proxies are included in *Appendices B–F*. Specifically, *Appendix B* details the pollen; *Appendix C* the diatoms; *Appendix D* the plant remains; *Appendix E* the insects; and *Appendix F* the foraminiferal and ostracoda.

1.2.6 ***Radiocarbon dating:*** ten radiocarbon dates were acquired form two of the sub-sampled cores (OABH01 and OABH04). These assays were made on two short-lived plant macrofossils and four sediment samples, with the humin and humic fractions from these being dated, in order to mitigate against possible contamination from older, dissolved, carbon (especially in calcareous conditions) and more recent, deep rooted, plant remains (Bayliss and Marshall 2022, 52). All of these samples were submitted to the radiocarbon laboratory at Queen's University Belfast (QUB) where they were assayed using the accelerator mass spectrometry (AMS) and given a UBA laboratory code. Details of the laboratory procedures employed are available from QUB and the radiocarbon certificates are presented in *Appendix G*.

1.2.7 The resulting dates were then calibrated using IntCal20 and OxCal v4.4 (Reimer *et al* 2020; *cf* Bronk Ramsey 2001; 2009), and the date ranges have been calculated using the maximum intercept method (Stuiver and Reimer 1986), and are quoted at the 95% probability level. The dates have also been rounded outwards to five years where the error measurement is less than ±25 BP and to ten years when it is greater than this (Mook 1986). The paired humin/humic dates from the sediment samples were also subjected to statistical testing in order to establish their consistency. The statistical technique employed for this analysis was the non-Bayesian chi-square (χ^2) test of Ward and Wilson (1978), which can be used to determine whether duplicate dates are actually of the same age. As the dates from the humic and humin fractions are from a different radiocarbon reservoir, the Combine function in OxCal v4.4 was used to undertake this test, which merges the radiocarbon dates following calibration and provides an agreement index (A_{comb}). Within this index, good agreement between the combined dates is indicated by an A_{comb} value that is greater than the An value (*ie* the individual critical value).

2 RESULTS

2.1 Lithology

2.1.1 The lithologies of the five boreholes (OABH01-05) extracted for the study are described in *Appendix A*, and this lithostratigraphic data has been used to update the deposit model (Fig 3). It is worth stressing that boreholes OABH02 and OABH05 contained poor lithological data, whilst the deposits from OABH02 were also contaminated by seepage of oil from the Triassic bedrock reservoirs of the Formby oil field (The Geological Society 2016). Given these factors, the data from these boreholes were omitted from the assessment.

2.1.2 ***Upper peat deposit:*** this upper deposit of peat was captured in all boreholes (Fig 3), occurring at approximately 2.5–3.5m bgl, though it was particularly well-preserved in OABH01 and OABH04, where it was overlain by blown sand and underlain by silt (Plates 1 and 2). The underlying silt is a thick unit, with organic lenses or streaking, and equates with the Downholland Silt.

2.1.3 In both cores, the upper and lower contacts of this peat unit were radiocarbon dated, with assays made on four sediment samples (with paired assays from their humin and humic fractions) and a short-lived plant macrofossil (Table 2). Although the resultant dates broadly correlate, and indicate that this peat formed across an extended period dating between the early Neolithic and early medieval periods, the dates from OABH01 may be the more reliable, as each of the paired sediment dates are statistically consistent; this is in contrast to the humin/humic dates from OABH05, which are statistically inconsistent. It also seems possible based on the relative shallow thickness of this peat (less than 1m), that accumulation was not constant, and there was either a hiatus in peat deposition, or the peat was truncated at some stage (*Appendix B*).

Plate 1: OABH01 (2–4m) – upper peat underlying blown sand and underlain by silts of the Downholland Silt

Plate 2: OABH04 (3–5m) – upper peat underlying blown sand and underlain by silts of the Downholland Silt

BH	Depth (m) bgl	Depth (m OD)	Laboratory code	Material	Radiocarbon age (BP)	Calibrated date range (95% confidence)	χ^2 test
OABH01	2.56–2.57	3.92–3.91	UBA-49167	Humic	1376±23	cal AD 605–675	Passed: (T'=3.2; T(5%)=3.8; *v*=1; A_{comb}=65.6% (An=50.0%))
			UBA-49168	Humin	1314±21	cal AD 655–775	
	3.12–3.13	3.36–3.35	UBA-49169	Humic	4920±28	3770–3640 cal BC	Passed: (T'=1.6; T(5%)=3.8; *v*=1; A_{comb}=76.8% (An=50.0%))
			UBA-49170	Humin	4973±24	3890–3650 cal BC	
OABH04	3.31–3.32	2.90–2.89	UBA-49173	Humic	1117±21	cal AD 890–990	Failed: (T'=4.1; T(5%)=3.8; *v*=1; A_{comb}=33.0% (An=50.0%))
			UBA-49174	Humin	1051±21	cal AD 900–1030	
	3.95–3.96	2.26–2.25	UBA-49166	*Calluna/Erica* roundwood	4885±27	3720–3540 cal BC	

Table 2: Radiocarbon dates from the upper peat deposit

2.1.4 ***Lower peat deposit:*** this deposit was at approximately 15.5m bgl and was sampled in OABH01 and OABH03 (Fig 3). In OABH01 it lay below silt deposits (the Downholland Silt) and overlay wind-derived redeposited sands (the Shirdley Hill Sand; Plate 3). The recorded lithology is significant, as it clearly indicates that this peat unit occurs above the Shirdley Hill Sand, and not below this deposit, as was originally assumed from data examined as part of the earlier baseline study (OA North 2021; *Section 1.2.1*). Lithological data from OABH03 (Plate 4) also support this interpretation.

Plate 3: OABH01 (15–17m) – lower peat underlying the Downholland Silt and overlying Shirdley Hill Sand

Plate 4: OABH03 (15–17m) – lower peat and organic sand underlying the Downholland Silt and overlying Shirdley Hill Sand

2.1.5 Radiocarbon dates were obtained from both of the deep peats in OABH01 and OABH03, at the upper peat to silt boundary; however, no dates were possible for the lower part of the peat across the lower peat to sand boundary, as the sediments were too sandy and the contact insecure (Plates 3 and 4). The assays from the lower peat were made on a plant macrofossil and the humin/humic fractions in a single sediment sample (Table 3). These latter dates are not, however, statistically consistent, providing different age ranges, with one falling in the late tenth/early ninth millennium cal BC and the other in the mid-ninth millennium cal BC. This difference is probably down to the composition of the fractions, as the humin fraction is composed of organic detritus that can be a heterogeneous mix of organic matter, which, in this instance, might contain contaminated material (*cf* Brock et al. 2011). In contrast, the humic acids reflect the *in-situ* products of plant decay and, although these can be mobile in groundwater in weakly acidic and slightly alkaline peatlands, they are usually homogenous and therefore may provide a more secure radiocarbon date for the respective sediment sample (*cf* Hamilton and Kinnaird 2022).

BH	Depth (m) bgl	Depth (m OD)	Laboratory code	Material	Radiocarbon age (BP)	Calibrated date range (95% confidence)	χ^2 test
OABH03	15.64–15.65	-8.53 to -8.52	UBA-49165	*Calluna vulgaris* roundwood	8274±36	7480–7170 cal BC	
OABH01	15.43–15.44	-8.95 to -8.94	UBA-49171	Humic	9162±36	8540–8280 cal BC	Failed: (T'=53.1; T(5%)=3.8; *v*=1; A_{comb}=0.0% (An=50.0%))
OABH01	15.43–15.44	-8.95 to -8.94	UBA-49172	Humin	9624±41	9230–8820 cal BC	

Table 3: Radiocarbon dates from the lower peat deposit

2.1.6 Therefore, if the humic date and the date from the plant macrofossil are considered as being the more reliable, together these indicate that the peat had formed by, and was potentially forming across, the mid-ninth and late eighth millennia cal BC. In terms of recent discussions of Mesolithic chronologies relevant to the British Isles, this period largely equates with the 'Middle Mesolithic', which is viewed as dating to the eighty-second to seventieth centuries cal BC, and that is typified in northern Britain and North Wales by distinctive lithic assemblages, associated with narrow scalene triangle microliths, accompanied by other distinctive narrow-blade lithic types (Conneller 2022, 23-5).

2.2 Palaeoenvironmental assessment

2.2.1 Palaeoenvironmental assessment has focused on the upper and lower peat deposits and the sediments above and below each of these peat units. In terms of the upper peat deposit, its lower contact with the Downholland Silt was sub-sampled for pollen, plant macrofossils, insects, diatoms, and foraminifera/ostracoda, to evaluate if this contact represents a transition from marine, or brackish marine silt deposits to an overlying terrestrial peat deposit.

2.2.2 The upper contact of the lower peat deposit with the overlying Downholland Silt was well preserved in the boreholes. Samples were therefore taken across this boundary, again for pollen, plant macrofossils, diatoms and foraminifera/ostracoda, to evaluate the transition from terrestrial peat deposits to probable marine/brackish marine sediments. In contrast, the lower contact of the lower peat deposit, with the Shirdley Hill Sand was not well preserved, as the peat was 'smeared out' and therefore insecure. A few sub-samples (for pollen, plant macrofossil, and foraminifera/ostracoda) were taken from the underlying sand, to explore any palaeoenvironmental data that may be preserved within the sand deposit.

2.2.3 Detailed assessments for each proxy, including pollen, diatoms, plant remains, insects, and foraminifera/ostracoda are respectively presented in *Appendices B–F*. It is evident from these that the most productive of the data relates to the upper peat deposit and its lower contact with the Downholland Silt, and the lower peat deposit and its upper contact with this same deposit of silt. The following, therefore, represents an integrated summary of these results.

2.2.4 ***Upper peat deposit and its lower contact with the Downholland Silt, sampled from OABH01 and OABH04***: this peat is bracketed by dates for the upper and lower parts, suggesting an age range from the medieval to the Neolithic periods (Table 2). The pollen data suggest a scrubby environment dominated by heather and either hazel-type or sweet gale (bog myrtle), as well as wetland areas, overlying probable saltmarsh environments and overlain by blown sand. Plant macrofossils from the upper peat, from OABH01 and OABH04, suggest heath and wet fen/mire environments, which are also inferred from the insect data. Changes in the pollen data from freshwater peats to underlying probable saltmarsh and marine deposits are coincident with the lithological change from peaty sediments to deposits of the Downholland Silt. Diatoms from the Downholland Silt, from OABH01 and OABH04, are all indicative of high salinity, tidal environments. No ostracods or foraminifera were recovered from the Downholland Silt in this upper sequence.

2.2.5 ***Lower peat deposit and its upper contact with the Downholland Silt, sampled from OABH01 and OABH03***: this upper part of the lower peat, close to the contact of the peat with the overlying Downholland Silt, is dated in both boreholes, suggesting an age range within the middle part of the Mesolithic period (Table 3; *Section 2.1.6*). Pollen assessed data from the lower peat deposits may be interpreted to suggest regionally developed mixed woodlands and local communities including hazel-type/bog myrtle scrub, with heather heath and wetland mire. Plant macrofossils also identified heather and charred grasses from the peats in OABH03, raising the possibility of natural or possibly anthropogenic firing. Sediments overlying the lower peat (*ie* the Downholland Silt) contained a pollen assemblage with evidence of saltmarsh taxa. This interpretation is supported by the diatom data from OABH01, which, at 15.28m, contained evidence of marine and brackish water diatoms, suggesting a tidal environment with high salinity. These data are also reinforced by the microfossil data, which are indicative of mid-high saltmarsh communities at 15.60m, overlain by brackish-intertidal deposits between 15.40 and 15.50m. There was no recovery of foraminifera from the clastic, sandy deposits underlying the peat unit. However, the absence of marine microfossils, in conjunction with the identification of aquatic mosses (16.25m and 16.62m, *Appendix D*) from these deposits suggests a probable freshwater origin for the sands. These data are consistent with marine transgression and show a transition from freshwater to saltmarsh, to intertidal deposition.

3 DISCUSSION

3.1 Deposit model

3.1.1 The results from this study illustrate the importance of ground-truthing deposit models that have been created from data based on previous, historic ground interventions. Specifically, prior to the present study, deep peat sequences (the lower peat deposit) were interpreted as occurring below the Shirdley Hill Sand and directly above glacial till deposits (OA North 2021); however, targeted borehole intervention and lithological assessment has shown this is not actually the case. Whilst deep peats were found, and at the correct altitudes identified by previous interventions, conversely, the stratigraphical data suggest these occur *above* the Shirdley Hill Sand and directly *below* the Downholland Silt. Radiocarbon assay indicates that the lower peat dates to the middle Mesolithic period, which is also significant, in that it confirms the stratigraphic position of the lower peat, as a much earlier (Late Glacial) date would be expected if the peat lay beneath the Shirdley Hill Sand.

3.1.2 The original deposit model has therefore been altered to reflect the new lithological data obtained from the five new interventions, three of which penetrated the deeper deposits of peat (Fig 3). The data show a much thicker sequence of the Downholland Silt series in the west, thinning eastwards. At the type site for the Downholland Silt, east of Formby, at Downholland Moss, theses sediments are characterised by estuarine silts and interbedded peats, some of which have been radiocarbon dated (Tooley 1978; Cowell and Innes 1994; Plate 5). These include an assay on a lower peat deposit (from core DM-11A), lying above Shirdley Hill Sand, which returned a date of 5590-5730 cal BC (6980±55 BP; Hv-3936; Tooley 1978, 39; Plate 5), which was also seen to date the onset of marine conditions in the area (*cf* Middleton *et al* 2013, 51). The dating evidence from the lower peat obtained during the present study is therefore significant. Specifically, it indicates that peat closer to the present-day coastline, in an identical stratigraphic position to that recorded at Downholland Moss (*ie* directly above the Shirdley Hill Sand) dates to a much earlier period, potentially spanning the mid-ninth to late eighth millennia cal BC. Indeed, the lower peat deposit close to the present study area had previously been estimated to date to *c* 6000 BC (*c* 8000 BP; Tooley 1978, 99; Cowell and Inness 1994, 75; Plate 5), which is clearly not the case, based on the radiocarbon dates that are now available.

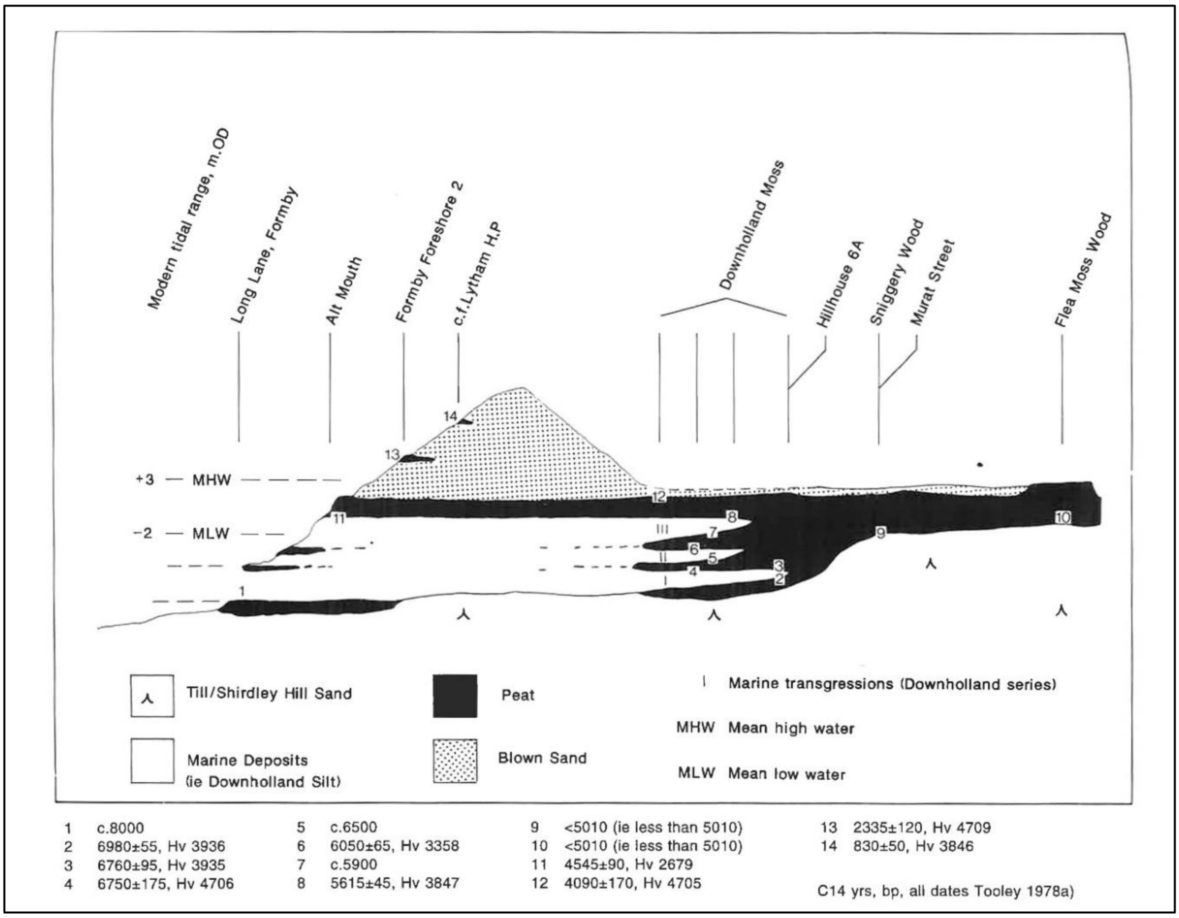

Plate 5: A schematic section showing the sequence of superficial deposits at Downholland Moss and Formby (reproduced from Cowell and Innes 1994, fig 19)

3.2 Palaeoenvironmental data

3.2.1 The assessment data illustrate the importance of utilising a multi-proxy approach to palaeoenvironmental assessment. The transition from freshwater peats to saltmarsh to intertidal deposits is clearly demonstrated across the sediment packages in the deeper borehole sequences, as shown by the pollen, plant macrofossil, diatom, and foraminifera/ostracod assessment data. Within the upper peat deposit, the transition from marine/estuarine silts to peats is demonstrated following diatom, pollen, plant macrofossil and insect assessment data.

3.2.2 Following reinterpretation of the sediment sequence, aided by radiocarbon dating, it is now evident that the organic data (from the lower peat deposits) do not represent a transition from the Late Glacial to the early Holocene, as originally anticipated. The palaeoenvironmental data extracted from these deep peats do, however, provide evidence of changing landscapes during the middle Mesolithic period, where places that may once have provided source areas for food and other resources, became inundated by rising relative sea levels. The pollen evidence suggests that initially when the lower peat deposit began to form the surrounding landscape was terrestrial, with a local hazel-type woodland (possibly sweet gale/bog myrtle) and heather scrub, along with evidence of freshwater, mossy wetlands, being present. Marine conditions then began to prevail, as the sea levels started to rise, which witnessed the development of salt-mash conditions at Formby, probably during the late ninth or eighth millennium cal BC. This was then followed by a major transgression event, when sea levels rose, which resulted in the deposition of marine clays, silts, and sands, forming elements of the Downholland Silt (*cf* Tooley 1978; Middleton *et al* 2013), which in some areas, such as Downholland Moss, were interlaced with peat deposits. Moreover, these organic deposits have been dated (*Section 3.1.2*) and interpreted as evidence for separate phases of marine transgressions, and subsequent regressions, designated DM-1 to DM-3 (Tooley 1978, 102). The initial formation of the Downholland Silt (and in turn the onset of transgression DM-1) can now be placed at some point after the Mesolithic date obtained from the top of the peat sequence in OABH03, 7480–7170 cal BC (8274±36 BP; UBA-49165), which provides a *terminus post quem* for this sedimentary/transgressive event.

3.2.3 The reverse is observed with the deposition of the upper peat deposit, dated from the Neolithic to the medieval periods, and demonstrates that terrestrial areas developed following falling relative sea levels. The earliest age for renewed peat formation is based on the dates obtained from the bottom of the upper peat from OABH01, an early/middle Neolithic age of 3770–3640 cal BC (4920±28 BP; UBA-49169), and the bottom of the upper peat from OABH04, also of early/middle Neolithic age (3720–3540 cal BC; 4885±27 BP; UBA-49166). These dates also broadly correspond with that described by Michael Tooley (1978) and illustrated by Ron Cowell and Jim Innes (1994, 75; Plate 5), for the bottom of the laterally extensive peat layer at the top of the Downholland series, dated to 3520-2930 cal BC (4545±90 BP; Hv-4705; Plate 5). The palaeoenvironmental assessment data record a complex of mudflat, fringing wetland/fen mire, heathland, and woodland habitats.

3.2.4 Recovery of palaeoenvironmental indicators from the sediments assessed, is variable. Pollen is generally well preserved within the peats, but sparse in sandy peats or organic silts. Plant macrofossils and insects occur in the peat deposits, but are generally both poorly diverse and abundant, although this may in part reflect small sample sizes. Diatoms are poorly preserved, but proved very useful as marine indicators within the upper part of the Downholland Silt within which no foraminifera or ostracoda were present. These microfossils were present, however, within the lower part of the Downholland Silt where, at assessment, their ecology proved useful in determining the salinity of the deposit overlying the deeper peat.

3.2.5 Whilst all these proxies have provided information on environmental changes within the buried landscape, there is also some possible evidence for local human interaction with the landscape, in the form of charred grasses and heather associated with the lower peat deposit. This may have been a product of intentional burning, though it may reflect burning across a wide area, which was necessarily focused at this site. Alternatively, it could also relate to a natural event. In contrast, there were low counts of microcharcoal particles in this peat. Aside from these charred elements, there is an absence of evidence for anthropogenic activity in the upper peat.

3.2.6 The radiocarbon dates obtained at the transition from peat to silt reflect the transition from terrestrial to marine environments or *vice versa*. This could be related to sea-level index points and utilised in further studies to enhance the sea-level curve for this part of the coast of north-west England.

4 CONCLUSIONS

4.1.1 The lithological data provided by the new interventions have been interpreted stratigraphically to update and reinterpret the deposit model, which was originally based on stratigraphy from historical borehole interventions. The data support a reinterpretation of sediments previously considered to represent a thin peat deposit underlying the Shirdley Hill Sand as actually overlying the Shirdley Hill Sand. Elsewhere the original stratigraphic interpretation is upheld.

4.1.2 The lithological data have been carefully considered to maximise recovery of various palaeoenvironmental indicators, including pollen, diatom, plant macrofossils, insects and foraminifera/ostracoda. Assessments of these palaeoenvironmental proxies were targeted to capture as much information as possible regarding the palaeoenvironmental history of the buried deposits. This programme of sampling and investigation has contributed towards landscape characterisation during the prehistoric period, in particular the Mesolithic and Neolithic periods, as well as the historic, medieval periods, in this coastal setting.

4.1.3 This assessment has led to the interpretation of a variety of former palaeoenvironments, including marine environments exposed to tidal regimes, for example, mudflats, as well as saltmarshes, fen mire wetlands, heather/heath habitats, and (probably regionally developed) woodlands. No clear signals for anthropogenic activity were present in the data, although grass and heather charcoal in the lower peat could indicate fire setting of heathlands by humans, or may be naturally occurring.

4.1.4 AMS radiocarbon dating from two locations for both the upper and lower peats has revealed relative correlation of dating of the peat deposits across the site. The dating evidence therefore provides greater accuracy to the interpreted deposit model.

4.1.5 No further detailed analytical palaeoenvironmental work is recommended. This is based on the sandy nature of the peats, which impacts pollen recovery, together with the generally poor preservation of diatoms, the sparse microfossil, insect, and plant remains assemblages, and the lack of definitive evidence of anthropogenic impact.

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APPENDIX A LITHOSTRATIGRAPHIC RECORDS

OXFORD ARCHAEOLOGY

BOREHOLE RECORDING SHEET

SUMMARY DETAILS

Site code	OLF21	**Old Lane, Formby**	
Borehole No.	OABH01	**Cable Percussion Cores**	
Easting	330040	**MAIN REFERENCE SECTION – adjacent to original CP10**	
Northing	408994	**Target: Deep peat at >15m**	
GL ELEV (m aOD)	6.5	**Logged by**	Mairead Rutherford, based on original logged data by Harlie Mason and lab-based work (MMR).
Total depth (m)	17	**Date**	August 2022

COMPOSITE LITHOLOGICAL LOG

Depth (m)		Keyword	Upper contact	Description
From	To			
0	0.30	Topsoil		
0.3	2.5/2.53	Blown Sand	Diagonal	
2.5/2.53	3.19	Peat		Sandy fibrous clayey silty peat (sand lens at 3.12–3.13m, increasing clay content 3.17–3.18m. Peat overlying Downholland Silt.
3.19	4.81	Silt	Sharp	Sandy silt, yellow/brown to plastic grey/blue, streaked with organics
4.81	6.4	Silt	Gradual	Generally silt; some voids in core collection
6.4	7.55	Sand	Gradual	Clayey sand and silty sand, shell debris.
7.55	8	Void		
8	10	Sandy silt	-	Dominantly sandy silt with voids; waterlogged sandy silt (HM notes).
10	14.80	Not collected		Note: these depths not collected/recorded as original Deposit Model based on Tier borehole logs identified the Shirdley Hill Sand from 9.50m from CP10. The object of this core was to target peat underneath the SHS as indicated from CP10 borehole records, at >15m bgl.
14.80	15.43	Silt	-	Drillers' logs indicated grey silty clay and sandy silt at 14.80m. Core lithology assessment indicates grey silt from 15–15.43m.
15.43	15.55	Peat	Sharp	Intact peat
15.55	15.80	Peat	Smeared out	Poorly recovered; smeared out peat
15.80	16.84	Sand	-	Light grey-brown slightly silty sand
16.84	17.00	Sand	-	Grey silty sand (Drillers' log)

OXFORD ARCHAEOLOGY			
BOREHOLE RECORDING SHEET			
SUMMARY DETAILS			
Site code	OLF21	Old Lane, Formby	
Borehole No.	OABH02	Cable Percussion Cores	
Easting	330045	Adjacent to original CP10	
Northing	408989	Target: Deep peat at >15m (correlation with OABH01)	
GL ELEV (m aOD)	6.41	Logged by	Harlie Mason Input by Mairead Rutherford
Total depth (m)	17	Date	July 2022/August 2022

COMPOSITE LITHOLOGICAL LOG

Depth (m)		Keyword	Upper contact	Description
From	To			
1.2	2	Blown Sand		Grey silty sand (Drillers' logs)
2	2.40	Blown Sand	Gradual	Brown/light yellow silty sand. Clear but irregular boundary.
2.40	2.82	Peat		Dark black/brown, fibrous, slightly silty Peat.
2.82	3.00	VOID		
3.00	3.57	Peat		Peaty sand / sandy peat
3.57	4.00	VOID		
4.00	4.78	Silty clay		With charcoal and organics: DOWNHOLLAND SILT
4.78	5.16	VOID		
5.16	5.96	Silt	-	DOWNHOLLAND SILT
5.96	6.00	VOID		
6.00	6.53	Silt	-	DOWNHOLLAND SILT
6.53	7	VOID		
7	7.67	Sand	-	Grey-brown silty sand
7.67	7.74	Silt		Blue grey sandy silt
7.74	8.00	VOID		
8.00	8.93	Silt		Mid yellow/brown silt
9	15.00	Not collected		Note: these depths not collected/recorded as original Deposit Model based on Tier borehole logs identified the Shirdley Hill Sand from 9.50m from CP10. The object of this core was to target peat underneath the SHS as indicated from CP10 borehole records.
15.00	15.24	Silt	-	Pale grey/brown/blue sandy silt; shelly debris
15.24	15.46	Peat	Diffuse	Sandy peat – the on-site geoarchaeologist reported hydrocarbon contamination from the Formby Oil Field.
15.46	16.00	VOID		
16.00	16.07	Peat	-	Apparently quite well preserved, layered but very thin.
16.07	16.11	Clay	-	Dark grey-brown silty clay
16.11	16.64	Sand	-	Yellow/brown sand – SHIRDLEY HILL SAND - contaminated with hydrocarbons from the Formby Oil Field.
16.64	17.00	VOID		

OXFORD ARCHAEOLOGY			
BOREHOLE RECORDING SHEET			
SUMMARY DETAILS			
Site code	OLF21	**Old Lane, Formby**	
Borehole No.	OABH03	**Cable Percussion Cores**	
Easting	330002	**Located adjacent to original CP6**	
Northing	408809	**Target: Deep peat at >15m**	
GL ELEV (m aOD)	7.11	**Logged by**	Mairead Rutherford, based on original logged data from Harlie Mason and lab-based work (MMR).
Total depth (m)	17	**Date**	August 2022

COMPOSITE LITHOLOGICAL LOG

Depth (m)		Keyword	Upper contact	Description
From	To			
0	0.20	Topsoil		
0.20	3.50	Blown Sand	Sharp	Brown / grey sand; slightly silty
3.50	4.41	Peat	Sharp	Brown slightly silty, sandy peat and peaty sand. Peat overlying Downholland Silt.
4.41	6.53	Silt	Sharp	Soft grey sandy silt, grey sandy clay, charcoal.
6.53	7	VOID		
7	14.86	Silt	-	Grey-brown sandy silt, shelly debris. Voids in core collection throughout.
14.86	15	VOID		
15	15.58	Silt	-	Slightly sandy
15.58	15.64	Silt	Gradual	Mottled silt/clay with organics
15.64	15.72	Peat	Sharp	Sandy peat (lower peat at base of Downholland Silt)
15.72	16.08	VOID		
16.08	16.10	Silt	-	Light grey silt (*in situ*?)
16.10	16.12	Sand	-	Dark brown-grey silty organic sand (? top SHS)
16.12	16.23	Sand		Inorganic
16.23	16.34	Sand		Organic
16.34	16.59	Sand		Inorganic pale grey silty sand [SHS]?
16.59	16.69	Peaty sand		
16.69	16.84	Sand		
16.84	17.00	VOID		

OXFORD ARCHAEOLOGY			
BOREHOLE RECORDING SHEET			
SUMMARY DETAILS			
Site code	OLF21	Old Lane, Formby	
Borehole No.	OABH04	Cable Percussion Cores	
Easting	330203	Located north of original CP8	
Northing	408955	Target: Top Peat at 3-4m MAIN TOP PEAT REF SECTION	
GL ELEV (m aOD)	6.21	Logged by	Mairead Rutherford, based on original logged data by Harlie Mason and lab-based work (MMR).
Total depth (m)	17	Date	August 2022

COMPOSITE LITHOLOGICAL LOG

Depth (m)		Keyword	Upper contact	Description
From	To			
0	2			Not recorded
2	2.75	Sandy silt		Light brown slightly sandy silt (? Plough soil)
2.75	3.00	VOID		
3.00	3.31	Sand	-	Blown sand
3.31	4.00	Peat	Sharp	Dark brown, very well-preserved peat, occ. wood, occ. fibrous
4.00	4.20	*Limus*	-	Very soft, grey probable *Limus* plus organics. Probably the top of the DOWNHOLLAND SILT.
4.20	4.28	Peat		Suspicious 'lump', probably contamination
4.28	4.58	Clay		Lt grey stiff clay and organic mix
4.58	4.66	Silty clay		Grey stiff silty clay
4.66	5.00	VOID		

OXFORD ARCHAEOLOGY			
BOREHOLE RECORDING SHEET			
SUMMARY DETAILS			
Site code	OLF21	**Old Lane, Formby**	
Borehole No.	OABH05	**Cable Percussion Cores**	
Easting	330238	**Located north of original CP4**	
Northing	408822	**Target: Top Peat at 3-4m; begun coring at 3m**	
GL ELEV (m aOD)	6.39	**Logged by**	Harlie Mason Input by Mairead Rutherford
Total depth (m)	17	**Date**	August 2022

COMPOSITE LITHOLOGICAL LOG

Depth (m)		Keyword	Upper contact	Description
From	To			
0	0.30	Topsoil		Drillers' log
0.30	1.00	Sand		Yellow/grey/brown silty sand (Blown Sand) Drillers' Log
1.00	3.00	-		No record – presumed sand
3.00	3.17	VOID		
3.17	3.55	Sand	-	Brown sand, some charcoal flecks
3.55	3.92	Peat	Sharp	Brown clayey peat
3.92	4.10	VOID		
4.10	4.33	Clay	-	Blue/grey clay
4.33	4.49	Peat	Gradual	Dark brown clayey peat
4.49	4.72	Clay	Gradual	Grey silty clay
4.72	4.84	Sand	Sharp	Pale grey-brown
4.84	5.1	VOID		
5.1	5.25	Sand	-	Yellow/brown, clayey sand
5.25	5.82	Silt	Gradual	Silty
5.82	6.10	VOID		
6.10	6.59	Silt	-	Grey/yellow/brown sandy
6.59	8.10	VOID		
8.10	8.70	Silt		Sandy
8.70	8.90	VOID		

APPENDIX B POLLEN

By Mairead Rutherford

B.1.1 A total of 52 sub-samples was assessed for pollen content and preservation. The collected cores (from cable-percussion coring) were cleaned and logged prior to sub-sampling (see *Appendix A* for lithological descriptions). Sub-sampling focused on two main peat units, an upper peat and a lower peat and, where possible, the contacts between the peats and overlying / underlying sediments. The upper peat unit and the transition from the peat into the underlying silts of the Downholland Silt was sub-sampled from OABH01 and OABH04, where the sediments were well retained in the cores. No sub-samples were taken from the overlying Blown Sand deposit, as this is an inorganic deposit. The lower peat and transitions to the overlying Downholland Silt and the underlying Shirdley Hill Sand were sub-sampled from OABH01 and OABH03.

B.1.2 ***Methodology:*** the sub-samples were prepared using a standard chemical procedure (method B of Berglund and Ralska-Jasiewiczowa 1986), using HCl, NaOH, sieving, HF, and Erdtman's acetolysis to remove carbonates, humic acids, particles >170 microns, silicates, and cellulose, respectively. The samples were then stained with safranin, dehydrated in tertiary butyl alcohol, and the residues mounted in 2000cs silicone oil. Pollen tablets containing an exotic (*Lycopodium*) were added to the preparation, to permit pollen concentration to be estimated, following Stockmarr (1972). The sub-samples were processed at the pollen laboratory in the Geosciences Department of the University of Aberdeen.

B.1.3 Pollen identification was made following the keys of Moore *et al* (1991), Faegri and Iversen (1989), and a small modern reference collection. Plant nomenclature follows Stace (2010). Identification of non-pollen palynomorphs (NPP) follows van Geel (1978) and van Geel and Aptroot (2006).

B.1.4 ***Results:*** the pollen data are described and then interpreted below. The pollen counts are presented in Tables B.1–A.5 at the end of this appendix.

B.1.5 ***Upper peat deposit – OABH01 and OABH04***: the upper organic deposit is dominantly peat with sandy and clay-rich intervals. The preservation of pollen reflects this variability, in that some sub-samples are very rich in pollen, whereas within more minerogenic layers within the deposit, pollen is relatively poorly preserved or absent.

B.1.6 In general, the pollen sequences from the upper peat deposits from both boreholes, (OABH01 and OABH04), contain abundant tree and shrub pollen. Assessment indicates that the most abundant pollen types are those of hazel-type (*Corylus avellana*-type or possibly sweet gale (*Myrica gala*)) and heather (*Calluna*). Arboreal pollen types include commonly occurring oak (*Quercus*) and alder (*Alnus*) with lower frequencies of elm (*Ulmus*), pine (*Pinus*), and lime (*Tilia*). Rare occurrences of ash (*Fraxinus*), ivy (*Hedera*), and elder (*Sambucus*) are also recorded.

B.1.7 Pollen of herbs is generally poorly diverse, including mostly grasses (Poaceae), with some sedges (Cyperaceae), ribwort plantain (*Plantago lanceolata*), docks/sorrels (*Rumex*-type), and mugworts (*Artemisia*). Of interest is the occurrence of pollen of mallows (*Malva*-type), daisy-family (Asteraceae), and the goosefoot family

(Amaranthaceae/Chenopodiaceae), all of which occur close to or within the clastic (silt, clay) deposits.

B.1.8 There are relatively few fern spores present in these sub-samples, but those that occur include common polypody (*Polypodium vulgare*), bracken (*Pteridium aquilinum*), and monolete ferns (Pteropsida). *Sphagnum* moss spores occur in low frequency throughout the sub-samples but are particularly abundant within the upper sub-samples (for example, 3.32m OABH04 and 2.56–2.64m OABH01).

B.1.9 A variety of non-pollen palynomorphs (NPP), including fungal spores and freshwater algae, occur throughout the deposits. These include fungal spores of *Glomus* (HdV-207, *Gelasinospora* (HdV-1), *Sordaria* (HdV-55A/B), and *Podospora* (HdV-368), as well as the fresh/brackish water algal types *Botryococcus* (HdV-766) and *Pediastrum* (HdV-760), and freshwater indicators *Copepoda* (HdV-28). Fungal spores associated with peat bogs (HdV-18) are particularly abundant in the peat recovered from OABH01 at 2.64m. Low frequency of microscopic charcoal is recorded throughout.

B.1.10 The clay/silt deposits underlying the peat sequences in OABH01 and OABH04 clearly represent saltmarsh deposits, based on the presence of saltmarsh taxa, including mallows (such as marsh-mallows, *Althaea officinalis*, locally common around coasts), daisy family (for example, sea daisy, *A. tripolium*), and pollen of the goosefoot family (which is a large group and includes saltmarsh taxa such as glassworts (*Salicornia*) and sea-blites (*Suaeda*)). Saltmarsh taxa are present in sub-samples from OABH01, between 3.16m and 4.32m, and in OABH04 at 4.40m.

B.1.11 The peat itself shows increasing expansion of heather moorland and hazel-type scrub (although the hazel-type pollen could also represent sweet-gale/bog myrtle (*Myrica gale*), as the pollen grains are very similar). Evidence of wetness may be inferred from records of freshwater algae and pollen of sedges. Drier episodes on the boglands may be inferred from fungal spores associated with dry, heather mosses (*eg* HdV-10). Regionally, there is evidence of mixed deciduous woodlands on better drained soils (including for example, oak, elm, ash, and lime). There are no clear indicators of anthropogenic influence, although variations in oak pollen could represent selective clearance of oaks. Although occurrences of fungal spores associated with charred-plant debris are sporadically recorded, the frequency of microscopic charcoal is low, suggesting low incidence of firing (either accidental or deliberate).

B.1.12 These peats are well dated at the upper contact (where the peat is overlain by windblown sand) to the medieval period (for example, from OABH01 at 2.56–2.57m, a date (humic acid fraction) of cal AD 605–675 (1376±23 BP; UBA-49167) was obtained). The lower contact of the peat with the clay/silt deposit (Downholland Silt) is also well dated to the Neolithic period (for example, from OABH04, at 3.95–3.96m, a macrofossil of *Calluna*/*Erica* roundwood was dated to 3720–3540 cal BC (4885±27 BP; UBA-49166). The thickness of the peat deposit is less than 1m and it is probably unlikely that this represents the whole of archaeological time between the Neolithic and the medieval period, although this is possible. This may suggest that a hiatus or truncation could exist within the peat deposit.

B.1.13 ***Lower peat deposit – OABH01 and OABH03***: as with the upper peat deposits, recovery of pollen from the deeper peat units proved to be variable. This is again attributed to minerogenic sands and clays within the peats. The best pollen recovery, however, is from the deeper peat from OABH03, between 15.56m and 15.72m. Although spot sub-samples from the deeper peat from OABH01 are productive, the most continuously productive interval assessed is from OABH03. The description and interpretation from the pollen assessment is therefore based primarily on the better recovery obtained from OABH03. A fragment of heather (*Calluna vulgaris*) roundwood was dated at 15.64–15.65m bgl from OABH03 to 7480–7170 cal BC (8274±36 BP; UBA-49165).

B.1.14 The pollen spectra in the deepest productive sub-sample (OABH03, 15.72m) are dominated by hazel-type (which could include pollen of sweet gale (bog myrtle) (*Myrica gale*), birch and heather. In the overlying sub-sample (OABH03, 15.68m), there is little birch pollen but a significant increase in pine pollen. Oak and elm pollen are present in low quantities and fluctuations in heather occur. There are no records of alder pollen. Between 15.64m and 15.56m pollen of the goosefoot family increases, and foraminiferal test linings are recorded at 15.56m and 15.60m. *Sphagnum* moss spores are present throughout. Generally low frequency of microcharcoal is recorded; however, some levels record slightly increased incidence. Spermatophores of *Copepoda* (HdV-28) are present in low numbers.

B.1.15 The data may be interpreted to suggest a dominantly local hazel-type (possibly sweet gale/bog myrtle) and heather scrub, along with evidence of freshwater, mossy wetlands, with pollen evidence also suggesting saltmarsh conditions were in place at 15.56m (based on increasing quantities of pollen of the goosefoot family and incidence of foraminiferal test linings). Regional vegetation suggests a largely forested environment, with pine, oak, and elm. Small quantities of microcharcoal testify to the incidence of fires and may represent a regional signal. However, the counts are very low, and so it seems unlikely that local firing was taking place.

B.1.16 ***Potential and recommendations***: although full counts are available at assessment for both the upper peat and the lower peat, the presence of more minerogenic sand and clays lenses within the peats suggests that obtaining continuous detailed pollen sequences might be difficult. The upper peat, in particular, is characterised by abundant plant debris and amorphous organics, which conceal many of the palynomorphs and could result in skewing of the pollen data. This preservation issue, coupled with little change in the pollen assemblages (*ie* dominance of heather/hazel-type/sweet gale) and the lack of anthropogenic indicators, suggests that little new data could be obtained through detailed analysis. Furthermore, although the depth of peat (less than 1m thick) is dated as ranging from the Neolithic to the medieval period, it is possible that a hiatus may exist within the peat. Therefore, no further work on pollen from the upper peat is therefore recommended.

B.1.17 Pollen from the lower peat, dated to the Mesolithic, is best preserved from OABH03. The sub-samples suggest a local wetland which transitions to a saltmarsh, following tidal inundation. There is little evidence of anthropogenic impact, for example, counts of microcharcoal particles are very low. It is unlikely that further detailed palynological work would result in significant new interpretations and therefore no further work is recommended on pollen from the lower peats.

Formby – upper peat		**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**
Preservation		**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**-**	**-**	**Mixed**
Potential		**YES**	**YES**	**YES**	**YES**	**Possible**	**NO**	**Possible**	**Possible**	**NO**	**NO**	**NO**	**NO**
Depth (m)		**2.56**	**2.64**	**2.72**	**2.80**	**2.88**	**2.96**	**3.04**	**3.12**	**3.16**	**3.20**	**3.28**	**3.36**
Trees/shrubs													
Alnus	Alder	8	4	7	11	5	2	2	5	4			1
Betula	Birch		3	1	2	1		2	3	1			
Calluna	Heather	31	37	32	20	24	2	18	38				
Corylus avellana-type	Hazel-type	32	33	41	38	33	6	15	19	1			2
Hedera	Ivy				1								
Pinus	Pine									1			2
Quercus	Oak	3	5	13	9	17	2	6	9	12			
Salix	Willow				1								
Ulmus	Elm			1	1	1	1	1					
Herbs													
Amaranthaceae/Chenopodiaceae	Goosefoot family		1							4			3
Apiaceae	Carrot family									3			
Artemisia	Mugworts	5											
Cyperaceae	Sedges	1		1	1								
Fabaceae	Pea family			1									
Hippocrepis-type	Horseshoe vetch		1										
Malva-type	Mallows									4			
Plantago lanceolata	Ribwort plantain				1								
Poaceae	Grasses	24	19	10	15			7	9	7			1
Ranunculaceae	Buttercups		1										
Rubiaceae	Bedstraws							2		1			
Taraxacum-type	Dandelion-type									1			
	Total land pollen	**104**	**104**	**107**	**100**	**81**	**13**	**53**	**83**	**39**	**0**	**0**	**9**

Formby – upper peat		OABH01	OABH01	OABH01	OABH01	OABH01	OABH01	OABH01	OABH01	OABH01	OABH01	OABH01	OABH01
Preservation		**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**-**	**-**	**Mixed**
Potential		**YES**	**YES**	**YES**	**YES**	**Possible**	**NO**	**Possible**	**Possible**	**NO**	**NO**	**NO**	**NO**
Depth (m)		**2.56**	**2.64**	**2.72**	**2.80**	**2.88**	**2.96**	**3.04**	**3.12**	**3.16**	**3.20**	**3.28**	**3.36**
	Number of traverses	6	9	5	7	10	10	10	10	10	10	10	10
Lycopodium spp.	Exotic	13	22	2	9	15	3	13	20	17			95
Fern spores													
Polypodium vulgare	Polypodies				1								
Pteridium aquilinum	Bracken				1								
Pteropsida	Monolete ferns												2
Mosses													
Sphagnum	Moss spores	15	22	6	7	2	1	5	9				1
Microscopic charcoal		2	2	6	8	3		5	6	13			
Non-pollen palynomorphs													
Botryococcus HdV-766				2	2					1			
Copepoda HdV-28		2	2	1	1	1		1	2	1			
Gelasinospora HdV-1		1		1				1					
Glomus HdV-207		1	1										8
Pediastrum HdV-760		1											
Podospora HdV-368					1				1				
Sordaria HdV-55A/B		2	2										3
HdV-16C			1	1	1								
HdV-18		1	57					1					

Formby – upper peat		**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**
Preservation		**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**-**	**-**	**Mixed**
Potential		**YES**	**YES**	**YES**	**YES**	**Possible**	**NO**	**Possible**	**Possible**	**NO**	**NO**	**NO**	**NO**
Depth (m)		**2.56**	**2.64**	**2.72**	**2.80**	**2.88**	**2.96**	**3.04**	**3.12**	**3.16**	**3.20**	**3.28**	**3.36**
HdV-121													1
HdV-128					2				1				
HdV-324						1		1	1				
Fungal spores (undifferentiated)						1		2	2				
Foram test linings													1
Reworked													4
Broken grains			1	1									1
Concealed grains		11	5	8	10		1	2	3	7			1
Crumpled grains			2	2	2			1	2	4			1

Table B.1: Raw pollen counts, OABH01 – upper peat

Formby – upper peat		**OABH01**	**OABH01**	**OABH01**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**
Preservation		**Mixed**	**Mixed**	**-**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**
Potential		**NO**	**NO**	**NO**	**NO**	**YES**	**YES**	**Possible**	**YES**	**YES**	**Possible**	**YES**	**Possible**
Depth (m)		**4.28**	**4.32**	**4.36**	**3.32**	**3.40**	**3.48**	**3.56**	**3.64**	**3.72**	**3.80**	**3.88**	**3.92**
Trees/shrubs													
Alnus	Alder				2	20	22	5	19	7	4	10	1
Betula	Birch					4	5	5	5	2		4	2
Calluna	Heather				1	21	19	5	39	70	34	52	19
Corylus avellana-type	Hazel-type		4		9	33	40	38	27	24	30	26	21
Fraxinus	Ash					3							
Hedera	Ivy								1				
Pinus	Pine		3							1	1		
Quercus	Oak		2		2	14	17	7	18	6	11	11	5
Salix	Willow												1
Sambucus	Elder				1								
Tilia	Lime						1	4				3	
Ulmus	Elm		1			3					2	1	
Herbs													
Amaranthaceae/ Chenopodiaceae	Goosefoots		9										
Artemisia	Mugworts											1	1
Asteraceae	Daisy family				1								
Cyperaceae	Sedges		1		3								
Fabaceae	Pea family		1										
Malva-type	Mallows		9										
Plantago lanceolata	Ribwort plantain				2	1	1						
Plantago spp.	Plantains						1						
Poaceae	Grasses		3		10	7	1		1		1	6	7
	Total land pollen	**0**	**31**	**0**	**31**	**105**	**107**	**64**	**110**	**110**	**83**	**114**	**57**
	Number of traverses	10	10	10	10	10	9	10	10	6	10	7	10

Formby – upper peat		**OABH01**	**OABH01**	**OABH01**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**
Preservation		**Mixed**	**Mixed**	**-**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**
Potential		**NO**	**NO**	**NO**	**NO**	**YES**	**YES**	**Possible**	**YES**	**YES**	**Possible**	**YES**	**Possible**
Depth (m)		**4.28**	**4.32**	**4.36**	**3.32**	**3.40**	**3.48**	**3.56**	**3.64**	**3.72**	**3.80**	**3.88**	**3.92**
Lycopodium spp.	Exotic		6		23	19	5	6	4	5	6	13	4
Fern spores													
Polypodium vulgare	Polypodies					1		1	2		1		
Pteridium aquilinum	Bracken						2		1				
Pteropsida	Monolete ferns				1			2		1	2		
Mosses													
Sphagnum	Moss spores				17	5	2				1	2	
Microscopic charcoal			1		1		1		2	1		2	1
Non-pollen palynomorphs													
Botryococcus HdV-766					2								
Copepoda HdV-28							1				1	1	
Glomus HdV-207			1										
Podospora HdV-368					1								
HdV-121			2				1		1				
HdV- 128			1						1			1	
HdV-10							2	35				4	2
HdV-16												1	
HdV-20									6			9	
HdV-324								6			2		
Sordaria HdV-55A/B			3										
Fungal spores undifferentiated						3	4	25			1	2	

Formby – upper peat		**OABH01**	**OABH01**	**OABH01**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**	**OABH04**
Preservation		**Mixed**	**Mixed**	**-**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**
Potential		**NO**	**NO**	**NO**	**NO**	**YES**	**YES**	**Possible**	**YES**	**YES**	**Possible**	**YES**	**Possible**
Depth (m)		**4.28**	**4.32**	**4.36**	**3.32**	**3.40**	**3.48**	**3.56**	**3.64**	**3.72**	**3.80**	**3.88**	**3.92**
Diatoms					+								
Testate amoebae undifferentiated									1				
Broken grains					2	5							
Concealed grains					10	7	5	9	2	4	12		13
Crumpled grains						1	3		1		1		

Table B.2: Raw pollen counts, OABH01 and OABH04 – upper peat

Formby – upper peat		OABH04	OABH04	OABH04	OABH04
Preservation		Mixed	Mixed	-	Mixed
Potential		YES	Possible	NO	Possible
Depth (m)		3.96	4.08	4.24	4.40
Trees/Shrubs					
Alnus	Alder	15	4		3
Betula	Birch	5	4		1
Calluna	Heather	42	6		2
Corylus avellana-type	Hazel-type	24	8		5
Pinus	Pine		6		4
Quercus	Oak	9	8	1	18
Tilia	Lime	2	1		
Ulmus	Elm		1	1	1
Herbs					
Amaranthaceae/ Chenopodiaceae	Goosefoot family		2	1	15
Artemisia	Mugworts		1		
Cyperaceae	Sedges		3		1
Poaceae	Grasses	4	8		4
Rumex spp.	Docks/Sorrels		1		
	Total land pollen	**101**	**53**	**3**	**54**
	Number of traverses	8	10	10	10
Lycopodium spp.	Exotic	11	44	10	155
Fern spores					
Polypodium vulgare	Polypodies	1			2
Pteridium aquilinum	Bracken				1
Pteropsida	Monolete ferns		2		6
Aquatics					

Formby – upper peat		**OABH04**	**OABH04**	**OABH04**	**OABH04**
Preservation		**Mixed**	**Mixed**	**-**	**Mixed**
Potential		**YES**	**Possible**	**NO**	**Possible**
Depth (m)		**3.96**	**4.08**	**4.24**	**4.40**
Typha angustifolia	Lesser bulrush				2
Mosses					
Sphagnum	Moss spores		1		2
Microscopic charcoal		6			
Non-pollen palynomorphs					
Copepoda HdV-28		1			
Botryococcus HdV-766			2		
HdV-4		1			
HdV-10		1	1		
HdV-20		1			
HdV-55		1	1		
Fungal spores undifferentiated		1	3		3
Foraminiferal test linings			1		
Broken grains		1	5		1
Concealed grains					
Crumpled grains			5		4
Reworked pollen			7		9

Table B.3: Raw pollen counts, OABH04 – upper peat

Formby – lower peat		**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**
Preservation		**Mixed**	**Mixed**	**-**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**-**	**-**	**Mixed**	**-**	**-**
Potential		**NO**	**YES**	**NO**	**YES**	**NO**	**NO**	**NO**	**NO**	**NO**	**YES**	**NO**	**NO**
Depth (m)		**15.24**	**15.32**	**15.36**	**15.40**	**15.44**	**15.48**	**15.52**	**15.56**	**15.64**	**15.68**	**15.72**	**15.76**
Trees/shrubs													
Alnus	Alder				1			1			1		
Betula	Birch		10		3	4	1	2			18		
Calluna	Heather		13		14	3					13		
Corylus avellana-type	Hazel-type	2	42		70	13	6	3			57		
Hedera	Ivy										1		
Pinus	Pine	10	25		11	9					12		
Quercus	Oak	6	4			1					1		
Salix	Willow	1			1	1							
Ulmus	Elm		1								2		
Herbs													
Amaranthaceae/ Chenopodiaceae	Goosefoot family		10		1						2		
Artemisia	Mugworts										2		
Asteraceae	Daisy family						1						
Cyperaceae	Sedges	1	1			5	3	1			2		
Poaceae	Grasses	2	1			2	1				2		
	Total land pollen	**22**	**107**	**0**	**101**	**38**	**12**	**7**	**0**	**0**	**113**	**0**	**0**
	Number of traverses	10	4	10	7	10	10	10	10	10	10	10	10
Lycopodium spp.	Exotic	100	24		3		25	66			70		
Fern spores													
Pteridium aquilinum	Bracken		1		1								
Pteropsida	Monolete ferns		1		5			1			2		
Mosses													

Formby – lower peat		**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**	**OABH01**
Preservation		**Mixed**	**Mixed**	**-**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**-**	**-**	**Mixed**	**-**	**-**
Potential		**NO**	**YES**	**NO**	**YES**	**NO**	**NO**	**NO**	**NO**	**NO**	**YES**	**NO**	**NO**
Depth (m)		**15.24**	**15.32**	**15.36**	**15.40**	**15.44**	**15.48**	**15.52**	**15.56**	**15.64**	**15.68**	**15.72**	**15.76**
Sphagnum	Moss spores	79	74		85	13		2			51		
Microscopic charcoal			8		16								
Non-pollen palynomorphs													
Botryococcus HdV-766						1							
Copepoda HdV-28			1		6								
Glomus (HdV-207)											1		
Pediastrum HdV-760						2		1					
HdV-18			1		5		7						
Diatoms							2						
Foram test linings		5											
Broken grains		1				1					3		
Concealed grains		1			8	4	2	1			4		
Crumpled grains		1	7		5	1					3		
Reworked		5			1	2		1					

Table B.4: Raw pollen counts, OABH01 – lower peat

Formby – lower peat		**OABH01**	**OABH03**	**OABH03**	**OABH03**	**OABH03**	**OABH03**	**OABH03**	**OABH03**	**OABH03**	**OABH03**	**OABH03**	**OABH03**
Preservation		**-**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**-**	**-**	**-**	**-**	**-**	**-**
Potential		**NO**	**YES**	**Possible**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Depth (m)		**15.80**	**15.56**	**15.60**	**15.64**	**15.68**	**15.72**	**16.24**	**16.28**	**16.32**	**16.60**	**16.64**	**16.68**
Trees/shrubs													
Alnus	Alder												
Betula	Birch		4	5	8	6	25						
Calluna	Heather		7		28	9	43						
Corylus avellana-type	Hazel-type		35	10	50	62	36						
Pinus	Pine		35	19	16	26	1						
Quercus	Oak		7	8	8	1							
Salix	Willow		1				1						
Ulmus	Elm		2	1	3	2							
Herbs													
Amaranthaceae/ Chenopodiaceae	Goosefoot family		11	6	5								
Asteraceae	Daisy family			1									
Artemisia	Mugworts		1										
Cyperaceae	Sedges		2				1						
Poaceae	Grasses		5	1	2								
	Total land pollen	**0**	**110**	**51**	**120**	**106**	**107**	**0**	**0**	**0**	**0**	**0**	**0**
	Number of traverses	10	5	10	6	3	7	10	10	10	10	10	10
Lycopodium spp.	Exotic		34	15	6	0	0						
Fern spores													
Pteropsida	Monolete ferns		2	1		1	7						
Mosses													
Sphagnum	Moss spores		26	7	8	27	24						
Aquatics													
Myriophyllum alterniflorum	Alternate water-milfoil				1								

Formby – lower peat		**OABH01**	**OABH03**	**OABH03**	**OABH03**	**OABH03**	**OABH03**	**OABH03**	**OABH03**	**OABH03**	**OABH03**	**OABH03**	**OABH03**
Preservation		**-**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**Mixed**	**-**	**-**	**-**	**-**	**-**	**-**
Potential		**NO**	**YES**	**Possible**	**YES**	**YES**	**YES**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
Depth (m)		**15.80**	**15.56**	**15.60**	**15.64**	**15.68**	**15.72**	**16.24**	**16.28**	**16.32**	**16.60**	**16.64**	**16.68**
Myriophyllum spicatum	Spiked water-milfoil		1										
Microscopic charcoal				9	7								
Non-pollen palynomorphs													
Copepoda HdV-XXX			1			1	1						
Glomus HdV-207				1									
Sordaria hdV-55A/B				2									
HdV-18						3							
Fungal spores undifferentiated			6										
Foram test linings			1	2									
Diatoms				+									
Broken grains				1									
Concealed grains			1	2	7		13						
Crumpled grains			5	5	4		1						
Reworked			5	1									

Table B.5: Raw pollen counts, OABH01 and OABH03 – lower peat

APPENDIX C DIATOMS

by Nigel Cameron

C.1.1 ***Introduction***: a total of 12 sub-samples were submitted for diatom assessment. The diatom assessment considers the numbers of diatoms, the state of preservation of the diatom assemblages, species diversity, diatom species environmental preferences, and the potential of the sediments for further diatom analysis.

C.1.2 ***Methodology***: diatom preparation followed standard techniques (Battarbee *et al* 2001). Two coverslips were made from each sample and fixed in Naphrax for diatom microscopy. A large area of the coverslips on each slide was scanned for diatoms at magnifications of x400 and x1000 under phase contrast illumination.

C.1.3 Diatom floras and taxonomic publications were consulted to assist with diatom identification; these include Hendey (1964), van der Werff and Huls (1957-1974), Hartley *et al* (1996), Krammer and Lange-Bertalot (1986-1991), and Witkowski *et al* (2000). Diatom species' salinity preferences are indicated using the halobian groups of Hustedt (1953; 1957, 199). These salinity groups are summarised as follows:

- Polyhalobian: >30 g l-1;
- Mesohalobian: 0.2–30 g l-1;
- Oligohalobian – Halophilous: optimum in slightly brackish water;
- Oligohalobian – Indifferent: optimum in freshwater but tolerant of slightly brackish water;
- Halophobous: exclusively freshwater;
- Unknown: taxa of unknown salinity preference.

C.1.4 The following sub-samples were assessed for diatoms (Table C.1). Table C.2 presents the results of the assessment.

Sample no.	Sample depth (m)	Borehole
1	15.28	OABH01
2	3.36	OABH01
3	3.60	OABH01
4	4.20	OABH01
5	4.40	OABH01
6	4.60	OABH01
7	4.08	OABH04
8	4.16	OABH04
9	4.32	OABH04
10	4.40	OABH04
11	4.56	OABH04
12	4.62	OABH04

Table C.1: Sub-samples submitted for diatom assessment

Core and diatom sample no.	Diatoms	Diatom nos	Quality of preservation	Diversity	Assemblage type	Potential for % count
OABH01						
1	present	low	v poor	mod	mar bk (fw)	low
2	present	ex low	ex poor	1 sp.	mar	none
3	absent	-	-	-	-	none
4	present	v low	v poor	low	bk mar	low
5	present	v low	v poor	low	bk mar	low
6	present	ex low	ex poor	1 sp.	mar	none
OABH04						
7	present	low	v poor	mod	mar bk	low
8	present	low	v poor	mod	mar bk	low
9	present	v low	v poor	mod	mar bk	low
10	present	low	v poor	mod	mar bk	low/some
11	present	v low	v poor	mod	mar bk	low/some
12	present	v low	v poor	low/mod	mar bk	low

Table C.2: results of diatom assessment; (fw – freshwater; bk – brackish; mar – marine; mod – moderate; ex – extremely)

C.1.5 ***OABH01 (samples 1–6, Table B.1)***: diatoms are present in five of the six samples from OABH01. Diatoms are absent from sample 3. However, only fragments of a single planktonic marine species, *Podosira stelligera*, are present in samples 2 and 6. There is therefore no further potential for diatom analysis of samples 2, 3, and 6.

C.1.6 Samples 1, 4, and 5 contain low or very low numbers of diatoms and the quality of diatom preservation is very poor. Diatom diversity is moderate in sample 1, and low in samples 4 and 5. There is low potential for further diatom analysis of these samples, although low sum percentage diatom counts might be possible if this is relevant for further analysis of the sequence.

C.1.7 The poor preservation or absence of diatom assemblages in these samples indicates that conditions were unfavourable for diatom silica preservation (Flower 1993; Ryves *et al* 2001). Taphonomic processes cause the absence or poor preservation of diatom valves from some samples. This may be the result of diatom silica dissolution and diatom valve breakage caused by factors such as high sediment alkalinity, acidity, the under-saturation of sediment pore water with dissolved silica, cycles of prolonged drying and rehydration, or physical damage to diatom valves from abrasion.

C.1.8 Nevertheless, the diatom assemblages of samples 1, 4, and 5 show the dominance of marine and brackish-marine diatoms. Marine diatoms are most common in sample 1 (this is the only sample, at 15.28m, from the silt/clay overlying the lower peat) and these Polyhalobous taxa include *Paralia sulcata, Rhaphoneis amphiceros, Rhaphoneis surirella*, and *Podosira stelligera*. Marine-brackish diatoms in sample 1 include *Actinoptychus undulatus* and *Diploneis smithii*. *Diploneis smithii* is also present in sample 5.

C.1.9 A range of benthic brackish-marine diatoms are present in samples 1, 4, and 5. These mesohalobous taxa include *Diploneis didyma, Diploneis interrupta, Nitzschia granulata, Nitzschia navicularis, Nitzschia punctata*, and *Scoliopleura tumida*. A single valve of the oligotrophic freshwater diatom *Eunotia tenella* was recorded. This probably represents washed in material from a peaty, fen habitat and does not represent the autochthonous diatom flora.

C.1.10 The diatom assemblages of samples 1, 4, and 5 reflect tidal environments with high salinity shown by the mixtures of predominantly shallow-water, benthic, brackish-marine diatoms and allochthonous, open-water, marine plankton. The presence of single marine planktonic diatom fragments in samples 2 and 6 also suggests that these samples represent tidal sedimentary environments.

C.1.11 ***OABH04 (samples 7–12, Table B.1)***: diatoms are present in all six samples from OABH04; however, diatom numbers are low or very low in each sample and the quality of valve preservation is very poor. Diatom diversity is moderate. There is only low or some potential for further percentage diatom analysis. The six samples assessed from OABH04 all have marine-brackish diatom assemblages.

C.1.12 Marine diatoms in OABH04 include *Paralia sulcata, Podosira stelligera, Rhaphoneis amphiceros*, and *Rhaphoneis surirella*. Marine-brackish diatoms in the OABH04 sequence are the benthic diatoms *Diploneis smithii, Ardissonia crystallina*, and *Navicula marina*. Polyhalobous to mesohalobous plankton includes *Actinoptychus undulatus* and *Thalassiosira decipiens*.

C.1.13 The mesohalobous diatoms are dominated by shallow-water, benthic diatoms, with no open-water, planktonic, brackish-marine diatoms recorded. The benthic mesohalobous diatoms include *Caloneis westii, Diploneis didyma, Diploneis interrupta, Navicula digitoradiata* fo. *minor, Navicula digitoradiata, Navicula peregrina, Nitzschia granulata, Nitzschia navicularis, Nitzschia punctata, Nitzschia sigma*, and *Scoliopleura tumida*. Other attached, non-planktonic mesohalobous diatoms include *Rhopalodia gibberula* and *Synedra tabulata*.

C.1.14 Freshwater, oligohalobous indifferent, taxa are rare. *Fragilaria pinnata*, a species with a freshwater optimum for growth, but having a wide salinity tolerance, was recorded in sample 11. The freshwater, aerophilous diatom *Pinnularia borealis* is present in sample 7.

C.1.15 Like OABH01 there is a mixture of benthic brackish-marine diatoms and allochthonous marine plankton in the samples from OABH04. This reflects tidal habitats with high salinity.

C.1.16 ***Conclusions***: diatoms are present in five of the six samples from OABH01. The diatoms are poorly preserved and there is low potential for further diatom analysis of three samples from the sequence and no potential for analysis of the other three samples. However, low sum percentage diatom counts might be possible for the former three samples if this is relevant in the further analysis of the sequence.

C.1.17 The mixtures of predominantly shallow-water, benthic, brackish-marine diatoms, and allochthonous open-water marine plankton in the OABH01 samples represent tidal environments with high salinity. Freshwater diatoms are almost absent from the diatom assemblages.

C.1.18 Diatoms are present in all six samples from OABH04, although diatom numbers are very low, and the quality of preservation is very poor. However, moderate diatom diversity indicates that there is some potential for further percentage diatom analysis should other geoarchaeological analyses suggest that further diatom investigation of the sequence would be useful.

C.1.19 In the OABH04 sequence the mixture of benthic brackish-marine diatoms and allochthonous marine plankton consistently show that the environments were shallow, tidal habitats with high salinity. Freshwater diatoms are present only as trace components of the assemblages.

APPENDIX DPLANT REMAINS

By Denise Druce

D.1.1 ***Introduction***: ten sub-samples, collected from two peat layers (an upper and lower) recovered in boreholes OABH01, OABH03, and OABH04, were processed and assessed for the presence of plant remains and material suitable for radiocarbon dating. The contents of the sub-samples were also described as an aid to assess the type of vegetation growing at the site during the accumulation of the peat deposits.

D.1.2 ***Methodology***: the ten samples, no larger than 0.10 litres in size, were wet sieved by hand through a 250µm mesh and scanned using a binocular microscope for the presence of plant material, including fruits, seeds, and leaves, and charcoal and wood fragments. Any surviving plant remains were identified with the aid of specialist texts (*eg* Mauquoy and van Geel 2007). The remains were quantified on a scale of 1–4 where 1 is rare (one to five items); 2 is frequent (6–50 items); 3 is common (51–100 items); and 4 is abundant (greater than 100 items). Plant nomenclature follows Stace (2010). The results were recorded on a proforma, which will be kept with the site archive.

D.1.3 Any wood and charcoal fragments considered suitable for radiocarbon dating were extracted and carefully broken to observe them in transverse section using a binocular microscope at x40 magnification. Given their small size no further sectioning was possible, therefore only an 'approximate' level of identification was possible. Identification and classification of the wood and charcoal was made with reference to Hather (2000).

D.1.4 ***Results***: the results of the archaeobotanical analyses are presented in Table D.1 below. The limited data suggests that all the peat layers recorded in the three boreholes comprise primarily herbaceous peat, which have undergone various levels of humification, and which contain rare to abundant identifiable macrofossils. The presence of heather (*Calluna vulgaris*) at 3.95–3.96m depth in OABH04, together with *Sphagnum* moss, rush (*Juncus* sp.) seeds at 3.31–3.32m depth, and *Sphagnum* moss, cottongrass (*Eriophorum*) spindles, and gypsywort (*Lycopus europaeus*) and sedge (*Carex* sp.) seeds in the uppermost peat layer in OABH01 indicate a heath or wet fen/mire environment.

Borehole no.	Depth (m)	Stratigraphic description (where applicable)	Sediment description	Macrofossils	C14 dating potential of macrofossils
OABH01	2.56–2.56	Top peat	Humified herbaceous peat	*Shagnum* leaves (1), *Eriophorum* spindles (1), wood fragments (1) possible root wood, insects (2)	No

Borehole no.	Depth (m)	Stratigraphic description (where applicable)	Sediment description	Macrofossils	C14 dating potential of macrofossils
OABH01	2.80–2.81	Top peat	Herbaceous peat	Wood fragments (1) possible root wood	No
OABH01	3.12–3.13	Base of top peat	Humified herbaceous peat. Medium sand content	*Sphagnum* leaves (2), *Lycopus europaeus* (1), *Carex* (1), insects (2)	No
OABH01	4.32–4.33		Herbaceous peat	*Juncus* (1), insects (2)	No
OABH01	15.43–15.44		Highly humified herbaceous peat. High sand content	-	No
OABH04	3.31–3.32	Top peat	Herbaceous peat	*Sphagnum* leaves (1), *Juncus* (1), insects (2)	No
OABH04	3.95–3.96	Base of top peat	Herbaceous peat with abundant small round wood fragments	*Calluna vulgaris* leaves/stems (2), *cf Calluna vulgaris* round wood fragments (4)	Yes – *Calluna vulgaris* round wood
OABH03	15.64–15.65		Humified herbaceous peat	Small charred Poaceae culm fragments (1), small charred round wood fragments (2), *cf Calluna/Erica* (2)	Yes – charred *Calluna/Erica* round wood
OABH03	16.25–16.26		Highly humified peat with stem/root fragments. High sand content	Moss stems (1) *cf Drepanocladus*	No
OABH03	16.62–16.63		Highly humified moss peat. High sand content	Moss stems (4) *cf Drepanocladus*	No – possible reservoir effect

Table D.1: Results of the archaeobotanical analyses. 1 = <5 items, 2 = 6–25, 3 = 26–100 and 4 = >100 items

D.1.5 Although the lowermost peat in OABH03 was highly humified and therefore less likely to contain preserved waterlogged macrofossils, the sample at 15.64–15.65m did contain rare to frequent charred remains, including small grass (Poaceae) culm fragments and small round wood tentatively identified as heather/heath (*Calluna vulgaris/Erica* sp). This low scrub may have succumbed to the effects of a natural fire strike; however, it is also possible these remains are anthropogenically derived, perhaps from clearance, accidental fires, and/or hearths.

D.1.6 The lowest samples from OABH03, collected at 16.25m and 16.62m, were similar and comprised highly humified peat with a high sand content. Although very few macrofossils had survived at 16.25m depth, this and the sample collected at 16.62m depth contained moss stems and leaves provisionally identified as *Drepanocladus* sp. *Drepanocladus* are aquatic mosses, which occur in fens and pools in blanket bogs, and also in small lakes, ponds, or streams (Mauquoy and van Geel 2007).

D.1.7 ***Retention and disposal***: the assessment sheets will be kept with the site archive. All remaining samples, not required for future work, will be discarded.

APPENDIX E INSECTS

By Enid Allison

E.1.1 ***Introduction***: a total of 12 small samples from boreholes OABH01 (NGR 330040 408994) at 6.5m OD and OABH04 (NGR 330203 408955) at 6.21m OD were submitted for assessment of their insect content and potential to produce environmental data. The date range of the deposits is from the Neolithic to the medieval periods.

E.1.2 ***Methodology***: the peat samples taken from the borehole cores were very small (representing 10mm depth within each core). Initial wet-sieving to 0.25mm was carried out by OA North staff and the volume of the retents received ranged from 25ml to 60ml. Each retent was washed onto 0.3mm mesh to remove the finest plant material and was then scanned in its entirety for insect and other invertebrate remains using a stereoscopic microscope (x10). The minimum number (MNI) of identifiable beetles (Coleoptera) and true bugs (Hemiptera) and the state of preservation of remains were recorded, and the potential to provide environmental data was assessed. Nomenclature for Coleoptera follows Duff (2018). The material is currently stored in water in plastic bags.

E.1.3 ***Results*: General observations**: the results of the scanning are presented in Table E.1 below. Depths of the samples are in metres below ground level. Small numbers of identifiable beetle and bug remains were present in nine of the 12 samples (MNI 1–7). The lower four samples from OABH01 (2.77–3.08m), representing the lower part of the top peat, produced only a single identifiable sclerite. In the samples where insect remains are present, preservation is generally good, and the remains are not significantly affected by chemical erosion. Sclerites of larger beetles are highly fragmented as is commonly the case in archaeological deposits.

Borehole	Depth (m)	Insects and other invertebrate taxa noted during scanning
OABH01	2.59–2.60m	Earthworm egg capsule; Delphacidae sp. forewing; *Agabus* or *Ilybius* elytral fragments; Hydrophilidae sp. elytral fragment; *Acidota* sp. elytral fragment; ?*Oxytelus* sp. elytron; *Stenus* sp. elytron; indeterminate Coleoptera abdominal segments [MNI = 7]
OABHO1	2.69–2.70m	*Donacia* or *Plateumaris* elytral fragments; Curculionidae sp. head fragment [MNI = 2]
OABH01	2.77–2.78m	Earthworm egg capsule; trace Coleoptera cuticle
OABH01	2.85–2.86m	*Erichsonius* sp. elytron [MNI = 1]
OABH01	2.94–2.95m	Tiny trace insect cuticle
OABH01	3.07–3.08m	No invertebrate taxa
OABH04	3.37–3.38m	Earthworm egg capsule; *Tachyporus* elytron; *Lathrobium* pronotum; Staphylinidae underside; *Acarina* sp. (mite) [MNI = 3]
OABH04	3.45–3.46m	Hydroporinae spp. elytra [MNI = 2]
OABH04	3.57–3.58m	*Graptodytes granularis* elytra; *Pterostichus nigrita/rhaeticus* pronotum fragments; *Lesteva* sp. elytron; indeterminate Curculionidae sp. underside; Diptera (fly) puparium fragment; Formicidae sp. (ant) head [MNI = 5]
OABH04	3.69–3.70m	?*Lesteva* sp. elytron; indeterminate Coleoptera abdominal segments [MNI = 2]
OABH04	3.77–3.78m	Indeterminate Carabidae sp. elytral fragment; *Donacia* or *Plateumaris* elytral fragments; Curculionidae elytron [MNI = 3]

Borehole	Depth (m)	Insects and other invertebrate taxa noted during scanning
OABH04	3.85–3.86m	Indeterminate Carabidae sp. fragment; *Donacia* or *Plateumaris* elytral fragments; indeterminate Coleoptera cuticle [MNI = 3]

Table E.1: Details of insect assessment. The estimated minimum number of individuals (MNI) refers to beetles and bugs only

E.1.4 The range of aquatic and terrestrial taxa noted throughout the sequence in OABH04 and the upper parts of the top peat in OABH01 are consistent with a well-vegetated wetland habitat with shallow, still to slowly flowing water. Plant-associated insects could not be identified closely enough to provide detailed information on species of wetland vegetation.

E.1.5 **OABH01**: no invertebrates were recorded from the lowermost sample examined from 3.07–3.08m, which is probably of Neolithic date (date obtained from 3.12m), and traces of indeterminate insect cuticle were the only remains noted from 2.94–2.95m. *Erichsonius,* a genus usually associated with damp litter in wetland or riparian habitats (Lott and Anderson 2011, 160–2), was identified at a depth of 2.85–2.86m. Beetle remains were somewhat better represented in the upper part of the sequence (2.59–2.70m). Distinctive elytral fragments of a donaciine leaf beetle (*Donacia* or *Plateumaris*) were identified from 2.69–2.70m suggesting wetland vegetation: most species of these genera are associated with taller types of emergent or waterside vegetation. The upper sample from 2.59–2.60m appears to be of medieval date. It produced mostly fragmentary remains of at least six beetle and bug taxa, including an *Agabus* or *Ilybius* species (a predatory diving beetle, Dytiscidae), and an *Acidota* species associated with moss and decaying plant litter.

E.1.6 **OABH04**: identifiable beetle remains in the lowest sample from OABH04 (3.85–3.86m), dated to the Neolithic period, and the sample from 3.77–3.78m, both contained elytral fragments of a donaciine leaf beetle (*Donacia* or *Plateumaris*) that would have been associated with emergent and waterside vegetation. At least two individuals of *Graptodytes granularis*, a small predatory diving beetle, were recovered from the sample at 3.57–3.58m. It typically occurs in well-vegetated shallow water in lowland fen or similar situations, often where the water is shaded in beds of tall vegetation or has fluctuating margins (Foster and Friday 2009, 72; Foster *et al* 2016, 292). *Pterostichus nigrita* or *rhaeticus* (probably the former but the two species are not distinguishable without genitalia) and a *Lesteva* species occur in damp terrestrial habitats. Two species of aquatic beetle (Hydroporinae spp.) were recorded from 3.45-3.46m, while the uppermost sample from 3.37–3.38m produced remains of *Tachyporus* and *Lathrobium*, species of which are well-represented in marshy places, albeit not confined to them.

E.1.7 ***Conclusions***: the insect remains provide indications for wetland conditions on the site between the Neolithic and medieval periods. Numbers of beetles and true bugs recovered were considerably restricted by the very small sample size. Further work is not required on the insect material as it currently stands. The peat deposits would have a considerably greater potential for insect work if larger samples (2–5 litres) from different parts of the sequence are available.

APPENDIX F FORAMINIFERAL AND OSTRACODA

By John Whittaker

F.1.1 ***Introduction***: a total of 12 samples, six each from boreholes OABH01 and OABH03, were assessed for environmental interpretation using foraminifera and ostracods. The sediments from OABH01 exhibit Downholland Silts beneath an upper peat, dated as Lower Neolithic. The sediments of OABH03 are lower in the Formby sequence and comprise Downholland Silts above the lower peat, dated as early Mesolithic, with sands below. It is anticipated the micropalaeontological analysis will provide some useful ecological information about these sediments.

F.1.2 ***Methodology***: the sediment from each sample was broken up further by hand if needs be and placed in a ceramic bowl and dried in an oven. After drying, a small quantity of sodium carbonate was added to facilitate the breakdown. The sediment mix was immersed in hot water and left to soak overnight. It was then washed through a 75µ sieve with hand-hot water, the resulting residue being returned to the bowl for drying. Once thoroughly dry the residues were transferred to labelled plastic bags for storage and picking. For examination, the residue was first sieved through a nest of >500µ, >250µ and >150µ small sieves. Sediment from each grade was then examined under the binocular microscope and notes taken of the contained material. Because much of the residue was in the <150µ fraction great care was made in the examination of this. Details of the selected sub-samples are presented in Table F.1.

Borehole	Depth (m)	Weight (g)
OABH01	3.24–3.25	45
OABH01	3.31–3.32	50
OABH01	3.41–3.42	55
OABH01	3.47–3.48	65
OABH01	3.55–3.56	70
OABH01	3.65–3.66	80
OABH03	15.39–15.40	85
OABH03	15.49–15.50	80
OABH03	15.59–15.60	50
OABH03	16.15–16.16	120
OABH03	16.45–16.46	155
OABH03	16.79–16.80	90

Table F.1: Weights of submitted sub-samples

F.1.3 ***Results***: **OABH01**: Table F.2 shows the material in the short section from OABH01 contained only plant debris. This comprises entirely silts, coated in fine organic material above and plain white silt (of <150 micron fraction) below. It is totally otherwise unfossiliferous. A palynological analysis may provide some information of its ecology. In the absence of information, at present it would seem to be freshwater in origin.

Borehole	Depth (m)	Foraminifera	Ostracoda	Mollusca	Plant debris
OABH01	3.24–3.25				x
OABHO1	3.31–3.32				x
OABH01	3.41–3.42				x
OABH01	3.47–3.48				x
OABH01	3.55–3.56				x
OABH01	3.65–3.66				x
OABH03	15.39–15.40	x	x	x	x
OABH03	15.49–15.50	x	x	x	x
OABH03	15.59–15.60	x			x
OABH03	16.15–16.16				x
OABH03	16.45–16.46				
OABH03	16.79–16.80				x

Table F.2: Micropalaeontology of samples from OABH01 and OABH03. x = presence/ absence

F.1.4 **OABH03**: OABH03 is much more informative (Tables F.2 and F.3). The two uppermost samples, covering the interval 15.40–15.50m, are brackish and contain a typical assemblage of intertidal mudflats and saltmarsh foraminifera and include an important intertidal ostracod species. There are also some molluscs—probably hydeobids—but are partially decalcified; they still might warrant further attention, nevertheless. The sample below (15.60m depth) marks the actual onset of tidal access, evidenced by mid-high saltmarsh foraminifera, which is invariably the case when freshwater conditions switch to brackish with the coming of tidal conditions. The three basal samples, apart from variable vegetation, are freshwater sandy silts and others entirely unfossiliferous.

Microfossils	Habitat	OABH03 (m)					
Foraminifera		15.40	15.50	15.60	16.16	16.46	16.80
Elphidium williamsoni	Brackish/ intertidal	xx	xxx				
Hynesina germania	Brackish/ intertidal	xx	x				
Ammonia sp.	Brackish/ intertidal	xx	x				
Jadammima macrescens	Mid-high saltmarsh	xxx	xx	xx			
Trochammina inflata	Mid-high saltmarsh		x				
Ostracoda							
Leptocythere lacertosa	Intertidal	x	x				

Table F.3: Micropalaeontology of samples from OABH03. x = several, xx= common, xxx = abundant

APPENDIX G RADIOCARBON DATING CERTIFICATES

APPENDIX HSITE SUMMARY DETAILS

Site name:	Land North of Brackenway, Formby, Merseyside
Site code:	OLF21
Grid Reference	SD 30285 08943
Type:	Palaeoenvironmental and updated geoarchaeology
Date and duration:	April–August 2022
Area of Site	13.68ha
Location of archive:	The archive is currently held at OA, Mill 3, Moor Lane Mills, Moor Lane, Lancaster, LA1 1QD.

Summary of Results:

Oxford Archaeology North was commissioned by Taylor Wimpey NW to complete a palaeoenvironmental study within an area of land north of Brackenway, Formby, Merseyside (centred on NGR: SD 30285 08943), in line with a planning condition implemented by Sefton Council (DC/2018/00093, Planning Condition 22). This study entailed: the drilling of two deep and three shallow boreholes; assessing the stratigraphic results derived from these interventions; completing palaeoenvironmental assessment and radiocarbon dating; and using the resulting data to update a previous deposit model for the site developed by Oxford Archaeology North in 2021.

The new stratigraphic data derived from the study largely support the results of the previous deposit model. However, the data also allows for some slight modification to this model, in that deep peat, originally assumed to seal glacial till, and lie beneath deposits of the Shirdley Hill Sand, is now known to occur at the top of the Shirdley Hill Sand deposits, directly beneath deposits of marine clays and silts, classified as the Downholland Silt. The dating evidence now available from this peat also provides a valuable *terminus post quem* for the deposition of the Downholland Silt, which is slightly earlier than previously estimated.

The organic deposits within the sediment sequence were also discovered to contain some palaeoenvironmental data relevant to landscape evolution during the prehistoric period and into the historic period. This data, comprises pollen, plant remains, diatoms, foraminifera/ostracoda, and insects, and it relates to a complex mosaic of intertidal, saltmarsh, fen/mire, heather-heath and (probably regionally developed) woodland habitats. Radiocarbon dating places the age of a lower peat deposit within the middle part of the Mesolithic period, whereas dates obtained from an upper peat deposit suggest an age ranging from early/middle Neolithic, at the base of the deposit, to medieval, at its top. The pollen, and other palaeoenvironmental proxies, exhibited variable preservation, and although grass and heather charcoal in the lower peat might indicate fire setting of heathlands by humans, there were no clear signals for anthropogenic activity. Indeed, this charcoal could relate to natural burning, or relate to a more generalised and widespread pattern of burning across the Formby area by human groups, which was not necessarily focused at this particular site. Given these factors, no further work is recommended.

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