MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

Outline Hydrogeological Risk Assessment of Lytham St Annes Dunes SSSI

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Glossary

Term	Meaning
Cable percussion drilling	Drilling technique used through superficial deposits and very weak rocks.
Cone penetration testing	Method used to determine the geotechnical engineering properties of soils and delineating soil stratigraphy.
D_{10} particle size	The point on the distribution curve below which 10% of the particles fall.
Dewatering	The removal of water from a location.
Direct Pipe drilling method	A cable installation technique which involves the use of a mini (or micro) tunnel boring machine and a hydraulic (or other) thruster rig to directly install a steel pipe between two points. Simultaneous excavation of the borehole and installation of the pipeline at the same time. A pipe is simultaneously installed along with the borehole excavation, eliminating the need for borehole wall support
Drawdown	A change in groundwater level due to an applied stress, caused by events such as pumping from a well.
Dynamic sampling	Drilling technique used for the construction of relatively shallow boreholes within superficial deposits.
Permeability (hydraulic conductivity)	A measure of the ability of a material (such as rocks) to transmit fluids.
Principal aquifer	A geological unit that yields significant groundwater that support regionally or nationally important supplies and support rivers, lakes and wetlands at a strategic scale.
Rortary core drilling	Drilling technique used to obtain core samples of rock.
Secondary A aquifer	A geological unit that provides modest groundwater that can support local water supplies and may form an important source of water to rivers.
Secondary B aquifer	A geological unit that is dominated by low permeability layers that may store and yield limited amounts of groundwater.
Secondary undifferentiated aquifer	Where it is not possible to apply either a Secondary A or B definition because of the variable characteristics of the rock type, but generally have only a minor resource value.
Zone of Influence	A region where the water level decreases due to well discharge.

Acronyms

Acronym	Meaning
BGS	British Geological Survey
BHS	Biological Heritage Site
PSD	Particle Size Distribution
LNR	Local Nature Reserve
MHWS	Mean High Water Springs

Acronym	Meaning
SSSI	Site of Special Scientific Interest
TJB	Transition Joint Bay

Units

Unit	Description
%	Percentage
m	Metre
D_{10}	Particle size value at which 10% of the sample's particles are smaller
m/s	Metres per second
mAOD	Metres above Ordnance Datum
mgl	Metres below ground level
K	Hydraulic conductivity
s	Drawdown
n	Effective porosity
t	Elapsed time

1 Introduction

1.1 Overview

1.1.1.1 This document forms the Outline Hydrogeological Risk Assessment (oHyRA) prepared for the Morgan and Morecambe Offshore Wind Farms: Transmission Assets (referred to hereafter as 'the Transmission Assets').

1.1.1.2 The oHyRA has been prepared in response to Relevant Representations (RRs) from Natural England (RR-1601; PDA-021), the Environment Agency (RR-0677; PDA-010) and The Wildlife Trust for Lancashire, Manchester and North Merseyside (RR-2180; PDA-007) regarding the potential impact that the Transmission Assets landfall (shown in Work Nos. 6A/B, 8A/B, 9A/B and 10/A/B on **Figure 1.1**) could have on the Lytham St Annes Dunes Site of Special Scientific Interest (SSSI), Lytham St Annes Local Nature Reserve (LNR) and St Annes Old Links Golf Course & Blackpool South Rail Line Biological Heritage Site (BHS) (see **Figure 1.2**).

1.2 Implementation

1.2.1.1 The oHyRA forms an appendix to the Outline Code of Construction Practice (CoCP) (document reference J1). Following the granting of consent for the Transmission Assets, detailed HyRA(s) will be prepared as part of the detailed Code of Construction Practice(s) on behalf of Morgan OWL and/or Morecambe OWL, prior to commencement of the relevant stage of works and will follow the principles established in this oHyRA. The detailed HyRA(s) will require approval by the relevant planning authority following consultation with relevant stakeholders.

1.2.1.2 This is an outline document based on the design set out in Volume 1, Chapter 3: Project Description of the Environmental Statement (document reference F1.3) and includes measures that have been identified as part of the EIA process.

1.2.1.3 The Applicants have committed to implementation of detailed HyRA(s) via commitment CoT128 (see Volume 1, Annex 5.3: Commitments Register (REP2-010)), which is secured through Requirement 8 of the draft Development Consent Order (DCO) (document reference C1) Schedules 2A for Morgan OWL & 2B for Morecambe OWL. The requirement wording for Project A (Morgan) is set out below (Project B's (Morecambe) requirement mirrors that of Project A's for this requirement and is, therefore, not repeated):

8.—(1) No stage of the Project A onshore works or Project A intertidal works may commence until for that stage a code of construction practice has been submitted to and approved by the relevant planning authority following consultation as appropriate with –

(a) Lancashire County Council;

(b) Natural England;

(c) the Environment Agency;

(d) in relation to the Project A intertidal works or, if applicable to the Project A offshore works, the MMO; and

(e) in relation to the Project A Blackpool Airport works, BAOL to the extent specified in the outline code of construction practice.

(2) Each code of construction practice must accord with the outline code of construction practice and include, as appropriate to the relevant stage-…

(o) hydrogeological risk assessment for trenchless installation beneath Lytham St Annes SSSI (in accordance with the outline hydrogeological risk assessment).

(3) The code of construction practice approved in relation to the relevant stage of the Project A onshore works must be followed in relation to that stage of the Project A onshore works and Project A intertidal works.

1.2.1.4 The Transmission Assets may adopt a staged approach to the approval of DCO requirements. This will enable requirements to be approved in part or in whole, prior to the commencement of the relevant stage of works in accordance with whether staged approach is to be taken to the delivery of the each of the offshore wind farms.

1.2.1.5 For onshore and intertidal works (landward of Mean Low Water Springs), this approach will be governed by the inclusion of Requirement 3 within the draft DCO, which requires notification to be submitted to the relevant planning authority/authorities detailing whether Project A or Project B relevant works will be constructed in a single stage; or in two or more stages to be approved prior to the commencement of the authorised development.

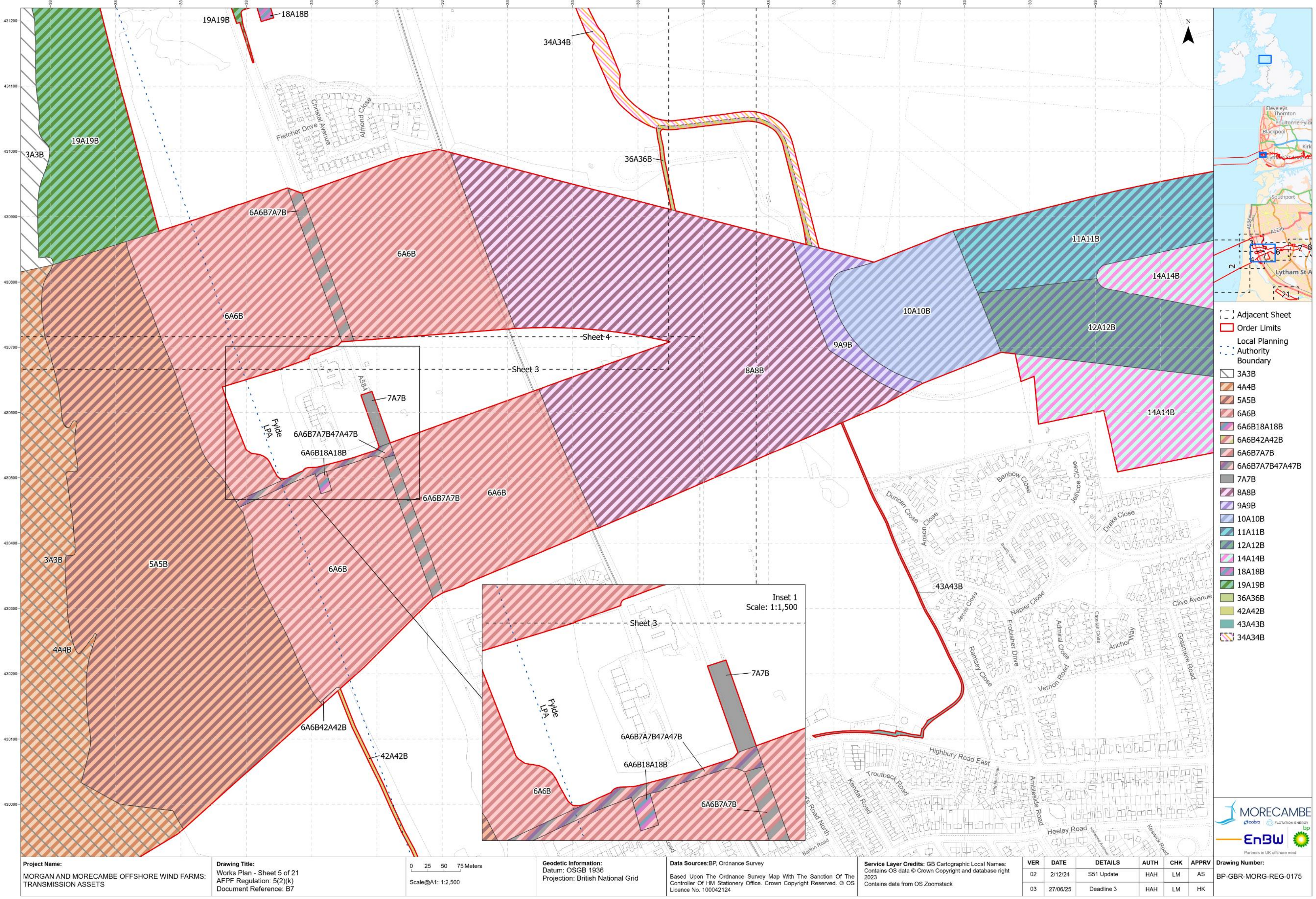

Figure 1.1: Onshore Order Limits and Work No. at Landfall [1]

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[1] The proposed works are set out in Schedule 1 (Authorised Project) of the draft DCO, and shown in Sheet 3 of the Works Plans - Onshore and Intertidal (AS-016)

1.3 Objective and methodology

1.3.1 Objective

1.3.1.1 The objective of the oHyRA is to determine the potential risk that construction activities associated with the installation of the offshore export cables beneath the Lytham St Annes Dunes SSSI, Lytham St Annes LNR and St Annes Old Links Golf Course & Blackpool South Rail Line Biological Heritage Site (BHS) may pose to the sand dune features of these sites.

1.3.1.2 Stakeholders have raised comments during the DCO Examination (see paragraph 1.1.1.2) relating to the potential presence of a shallow water table and the impact on the SSSI, LNR and BHS from the following activities:

- dewatering activities during construction excavations potentially in hydraulic continuity with the SSSI/LNR/BHS;
- construction activities relating to the trenchless installation; and
- the permanent location of the cables beneath the SSSI/LNR/BHS.

1.3.1.3 The oHyRA considers the potential groundwater pathway or pathways that may exist between the landfall and the key groundwater dependant features of the SSSI, LNR and BHS. It considers the risks that the construction and operational activities may have on those pathways should they be identified, and the potential consequences on those features.

1.3.1.4 The oHyRA comprises the initial stage of the risk assessment process. It sets out the hydrogeological and ecological assumptions and preliminary hydrogeological conceptual model that will inform the scope of the detailed HyRA(s) and the detailed crossing design of the offshore export cables beneath Lytham St Annes Dunes SSSI/LNR and the St Annes Old Links Golf Course & Blackpool South Rail Line BHS.

1.3.2 Methodology

1.3.2.1 The oHyRA has involved the following specific tasks:

- evaluation of existing Ground Investigation (GI) data undertaken to date by the Transmission Assets (see Section 2.3);
- development of a preliminary Hydrogeological Conceptual Model (HCM) for the local area (see Section 2.5);
- assessment of risk to water dependent features in the SSSI/LNR/BHS and the golf club abstractions based on potential linkages identified in the HCM utilising empirically derived estimates of zones of influence of required dewatering associated with construction of the Transition Joint Bays (TJBs) (see Section 3.4.1); and

- identification of measures required to manage or mitigate those risks given their magnitude (see Section 3.5).

1.3.2.2 The key aspects of the SSSI/LNR/BHS hydrogeological regime that must be considered as part of the assessment include:

- the geological units/aquifers that underlie the SSSI/LNR/BHS; and
- the interaction between groundwater and the dune slacks.

1.3.2.3 Consideration of the level of certainty to each aspect of the hydrogeology is key, given the limited amount of site-specific data available.

1.3.2.4 The following construction activities are considered:

- construction of Transition Joint Bays (TJB) at Blackpool Airport for trenchless installation; and
- trenchless installation of cables crossing beneath the SSSI/LNR/BHS.

1.3.2.5 The trenchless installation technique will drill underground from the landfall compound (located in or around Blackpool Airport) under the SSSI/LNR/BHS and exit on the North Beach at Lytham St. Annes 100 m from the sand dunes. The TJB site is within Blackpool Airport.

1.3.3 Sources of information

1.3.3.1 The following information sources have been utilised for this oHyRA:

- Environmental data disclosure report:
  - Groundsure Insight Report: Morgan, Report Ref. GSIP-2023-13424- 13080 (1-16). 10 March 2023
- Historical ground investigation data including borehole logs:
  - Fugro, Intertidal Survey - Morgan, Ground investigation Report (GIR) Factual Account, F216874-Morgan 02, 20 December 2023 (Fugro, 2023)
  - Central Alliance - Morgan St Annes Ground Investigation, 2372506-FAC-01,May 24 (Central Alliance, 2024)
- Literature values of hydrogeological properties
- Historical ecological survey reports:
  - Fylde Sand Dunes Management Plan (Skelcher, 2008)
- British Geological Survey mapping data
- Lytham St Annes Dunes SSSI citation
- Outline cable engineering design parameters (set out in Volume 1, Chapter 3: Project Description (REP2-008)).

1.3.4 Limitations

1.3.4.1 This outline assessment is based on existing ground investigation data with no direct data pertaining to the ground conditions of the SSSI/LNR/BHS, including the groundwater regime and its likely seasonal variability.

1.3.4.2 The potential Zone of Influence distance is estimated using empirically derived relationships utilising hydraulic conductivity and dewatering drawdown requirements. These calculations are not used for strictly predictive purposes of likely impacts but to provide reasonably worse case screening criteria to inform relative potential of impacts given the sites hydrogeological setting and expected characteristics.

1.4 Report Structure

1.4.1.1 The structure of this oHyRA is as follows:

- Section 2: Site Setting – Description of key aspects of the site setting including most notably the SSSI designated features and the geology and hydrogeological characteristics that are required to develop the Conceptual Hydrogeological Model for the HyRA.
- Section 3: oHyRA – Describes the approach to be used for the oHyRA and activities under consideration to determine the potential impact on the SSSI/LNR/BHS given the pathway/hydraulic links identified in the Conceptual Hydrogeological Model.
- Section 4: Risk Management and Reduction Measures – Presents the recommended risk management measures, commensurate with the level of risk identified through the risk assessment.
- Section 5: Next Steps.
- Section 6: Conclusion

1.4.1.2 The detailed HyRA for the Lytham St. Annes Dunes SSSI will follow the structure of the oHyRA.

1.4.1.3 This structure will also be used for the HyRA of the trenchless installation below the River Ribble (as specified in CoT41 of the Commitments Register (REP2-010)).

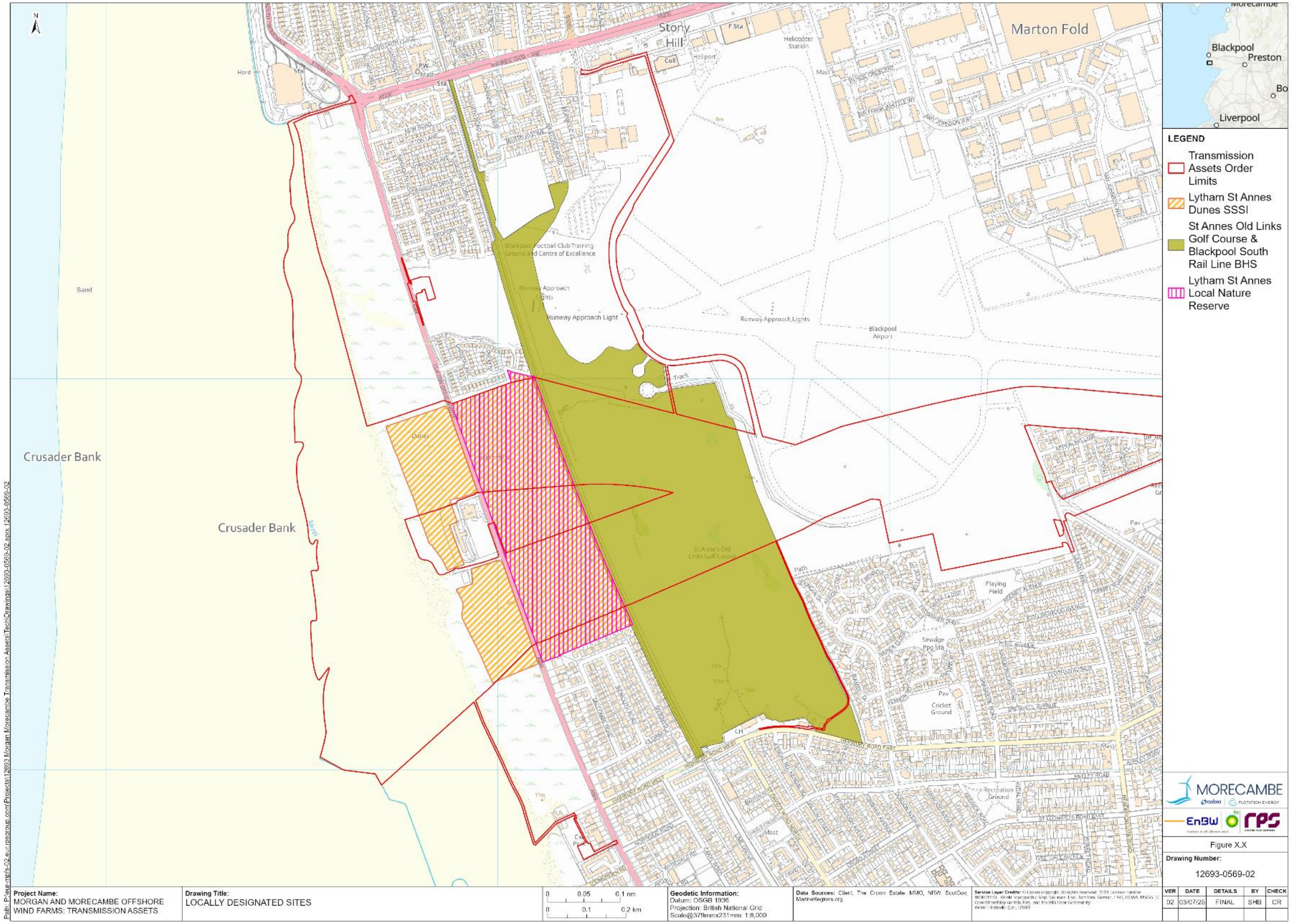

Figure 1.2: National statutory and local designated sites at Lytham St Annes

2 Site Setting

2.1 Introduction

2.1.1.1 This section provides an overview of the local ecological, geological and hydrogeological setting. For the purposes of this report, the term, ‘study area’, refers to the Transmission Assets Order Limits in which the offshore export cables are routed from the exit pits on the beach (100 m from the western boundary of the Lytham St Annes Dunes SSSI) through the direct pipe ducts beneath the Lytham St Annes Dunes SSSI, Lytham St Annes LNR and the St Annes Old Links Golf Course & Blackpool South Rail Line BHS to entry pits at Blackpool Airport as shown in **Figure 1.2**.

2.2 Ecology

2.2.1.1 The coastal dunes at the landfall site occur on either side of Clifton Drive North; the dunes to the west between the beach and the road are designated as the Lytham St Annes Dunes SSSI and the dunes on the eastern side (between the road and the rail line) are designated as the Lytham St Annes Dunes LNR. Further east, the remnant dunes occurring within the golf course are designated as the St Annes Old Links Golf Course & Blackpool South Rail Line BHS.

2.2.1.2 The Lytham St Annes Dunes SSSI citation states that the dunes support a wide range of species, particularly associated with dune slacks, which vary according to the depth of water and degree of moisture retention of overlying strata in relation to the water table.

2.2.1.3 Curelli et al (2013) provide a description of dune slack formation and interdependence on hydrogeological conditions:

“*Dune slacks form when bare sand is disconnected from seawater influence by the establishment of a new dune front, or inland, where wind erosion scours bare sand down to the water table or to the capillary wetted layer. Thus their formation and subsequent plant and soil development are intimately connected to the dune groundwater hydrological regimes. Large water table fluctuations are a feature of most slacks, and control slack vegetation development. Variation of water levels occurs both within the year, typically around 70 cm with a rapid rise in autumn and a gradual decrease from spring to summer and between years, depending on precipitation and evapotranspiration balances*.”

2.2.1.4 The baseline environment at the Lytham St Annes Dunes SSSI and Lytham St Annes LNR may be considered non-static due to the natural state of dune succession and ecological colonisation and the changes in land management practice.

2.2.1.5 An extract from the National Vegetation Classification (NVC) survey for the SSSI/LNR is shown in **Figure 2.1** (after 2016 Map drawn by Graeme Skelcher Ecological Consultant, November 2016, based on survey work carried out in summer 2016).

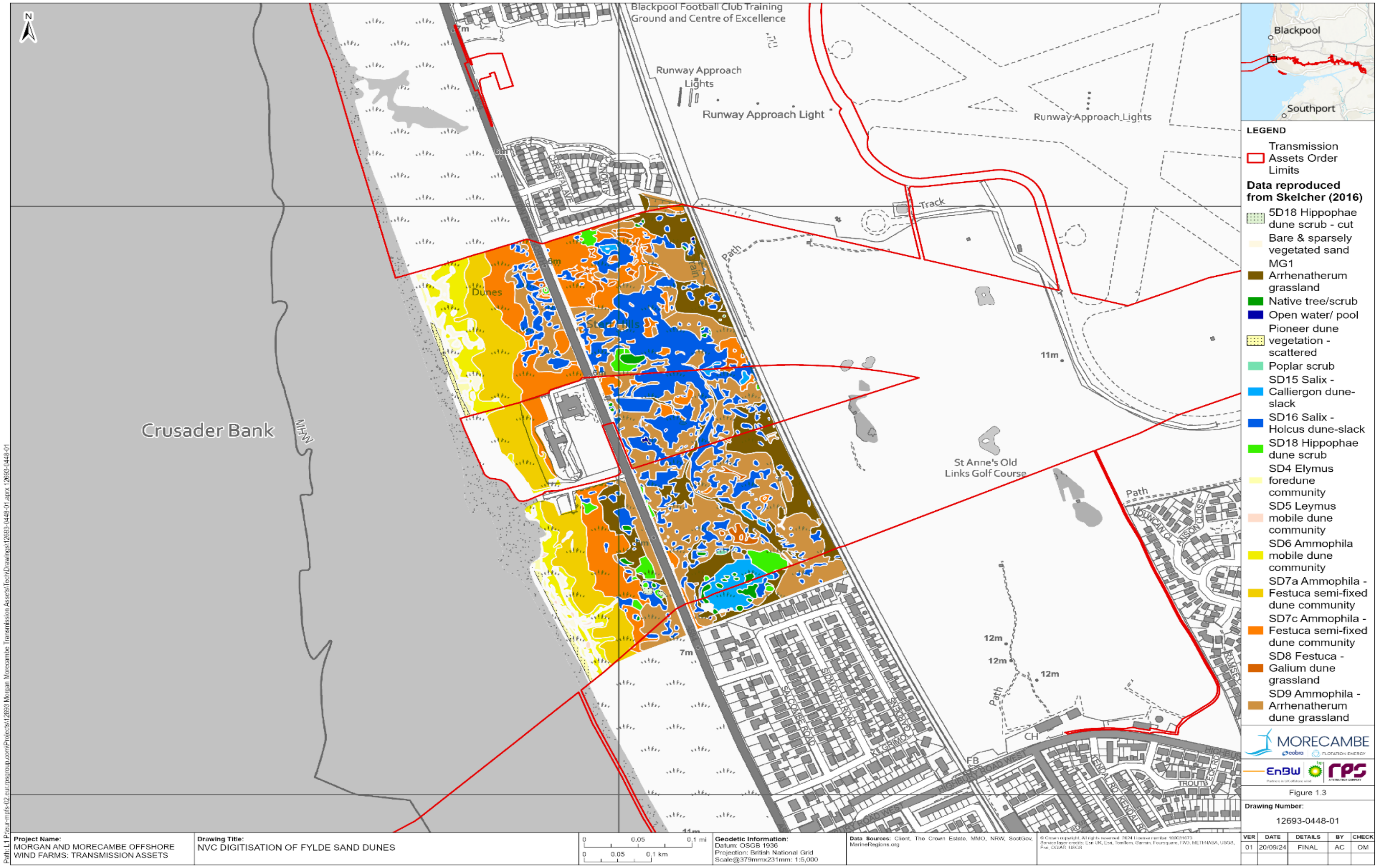

Figure 2.1: Location of dune slack and swamp vegetation communities at Lytham St Annes Dunes SSSI/LNR (2016)

2.2.1.6 The Fylde Sand Dunes Management Plan (Skelcher, 2008) describes the following relating to dune slacks within Lytham St Annes - being the part of the Lytham St Annes Dunes SSSI to the east of Clifton Drive North and indicate that the permanently wet dune slack ecosystems are more prevalent in this eastern portion of the SSSI:

"*Separated from the coastal dunes of Starr Hills by the hard barrier of Clifton Drive North, the Lytham St Annes Local Nature Reserve nevertheless supports an impressive range of dune wildlife and habitats. This is the only area on the coast where substantial wet dune slacks can be found, and the associated helleborines, orchids and other dune-slack species are generally much more numerous here than elsewhere in the Fylde Dunes*."

2.2.1.7 The existing groundwater abstraction associated with the adjacent St Annes Old Links Golf Course (see Section 2.4.4) is not considered to be impacting the hydrogeology of the SSSI/LNR to an extent where effects on groundwater dependent terrestrial ecosystems are visible. The nearest SSSI unit to the golf course (unit 3) was assessed by Natural England in 2024 as being in 'unfavourable - recovering' condition, which was attributed to the positive management strategies implemented by the Fylde Sand Dunes Project in recent years.

2.2.1.8 Ground truthing of the NVC surveys at the Lytham St Annes Dunes SSSI/LNR were undertaken in August 2024. These surveys sought to reconcile the data from the Skelcher (2016) report with direct observation in the field, with a focus on the hydrologically sensitive dune slack communities present.

2.2.1.9 A Geomorphological Study (JBA consulting, 2016) provides the following information with regard to the dune slack species:

"*The series of exceptionally large and extensive dune slacks on either side of Clifton Drive North support a wide range of species, which vary according to the depth of water and degree of moisture retention in relation to the water table.*

The largest slack in the south-west corner of the site is permanently wet. Its central zone of standing water is dominated by water horsetail Equisetum fluviatile and water crowfoot Ranunculus aquatilis with fringing marsh pennywort, marsh bedstraw Galium palustre, water mint Mentha aquatica, water forget-me-not Myosotis scorpioides, lesser spearwort R. flammula and branched bur-reed Sparganium erectum. A large clump of the rare hybrid rush J. balticus inflexus is a notable feature as is common cottongrass Eriophorum angustifolium."

2.2.1.10 The St Annes Old Links Golf Course & Blackpool South Rail Line BHS citation states that the following habitats are present:

"A *mosaic of relict dune grassland, dune heath and sand dune within the wider golf course. The site is a fragment of the much larger Fylde dune system prior to the 19th and 20th century resort development. The site supports several plant species of local interest. The site is designated for its coastal sand dune, yellow bartsia and chaffweed Anagallis minima (both classed as endangered in Lancashire). It is also designated for Grass-of-Parnassus Parnassia palustris (classed as* *vulnerable in Lancashire) and trailing St. John's-wort Hypericum humifusum (classed as sensitive in Lancashire) with a significant county population of both species within the site."*

2.2.1.11 The golf course has been present since 1886, and therefore it is reasonable to conclude that it has been subject to significant anthropogenic modification over the past c. 140 years. The Phase 1 Habitat survey undertaken by RPS in 2023 did not identify any dune slack wetland habitats, and the habitats were found to be dominated by the short-mown grassland fairways and greens, with areas of rough semi-improved grassland to the fairway margins. The survey identified a small area of dry dune heath grassland in the north-west corner of the BHS, which is indicative of its previous, less modified history when it was part of the mobile dune system on this stretch of the coastline. Given that the golf course does not support any groundwater dependent terrestrial ecosystems, it is reasonable to assume that the habitats are less sensitive to the effects of hydrological changes than the SSSI/LNR.

2.2.1.12 The results of the NVC ground truthing survey and the Phase 1 habitat survey are reported Volume 3, Annex 3.3: Phase 1 habitat, national vegetation classification and hedgerow survey technical report (APP-077) and are shown on **Figure 2.2**.

Figure 2.2: NVC and Phase 1 habitat survey results

2.3 Geology

2.3.1 Introduction

2.3.1.1 Geological conditions have been delineated based on BGS mapping data shown in **Figure 2.3** and **Figure 2.4**, and the strata revealed within the two locally drilled boreholes CP+RC and MORGAN_A2_CP01B, with total depths of 39.0 metres (m) and 20.45 m respectively. The location of these boreholes is shown on **Figure 2.5**.

2.3.1.2 The local stratigraphy is described as follows and summarised isometrically in **Figure 2.5** and as a conceptual cross section in **Figure 2.7**. The line of the cross section and topography between the two local boreholes is shown on **Figure 2.6**.

2.3.2 Made Ground

2.3.2.1 A thin horizon of Made Ground (0.2 m thickness) is observed in borehole CP+RC, representative of the drilling location within the maintenance yard of the golf course site.

2.3.3 Superficial deposits

Blown sand deposits

2.3.3.1 Surface superficial deposits in this area are dominated by blown sand. These unconsolidated, granular, deposits form naturally unstable dunes at the coast. These dunes become progressively stabilised by vegetation inland until they ultimately thin out upon peat, alluvium or glacial till (Wray et al., 1948).

2.3.3.2 As shown on the geological cross section shown on Sheet 74 for Southport (BGS, 1989), the blown sand deposits are only 2.5 m and 4 m thick (Wilson and Evans, 1990) and overlie thin peat deposits, tidal saltmarsh deposit or glacial till.

2.3.3.3 Offshore boring undertaken in the Ribble Estuary indicate a sand cover of 10 to 20 m (the surface deposits of blown sand overlie alluvium and glacial deposits along the Blackpool coastline) (Skelcher, G., 2008).

2.3.3.4 Based on exploratory hole locations, blown sands and possibly middle sands of the glacial till were encountered to depths of 14.0 m and 14.5 m. These comprised medium dense (sometimes loose, dense and very dense) fine to coarse sand with variable gravel and cobble content of mixed lithologies.

Intermediate clay and peat

2.3.3.5 A single layer of peat (thickness 1.7 m) overlying clay (thickness 2.8 m) is identified in borehole CP+RC to the east of the study area at a depth of between 3.5 m and 8.0 m. No corresponding peat/clay layer was observed in borehole MORGAN_A2_CP01B. The peat was described as comprising two layers - amorphous peat (thickness 0.60 m) overlying pseudo fibrous peat (thickness 1.1 m).

Tidal flat deposits

2.3.3.6 British Geological Survey (BGS) mapping shows a significant extent of comparatively thick tidal flat deposits where they outcrop along the coast and extend inland becoming concealed beneath blown sand deposits.

2.3.3.7 The tidal flat deposits are typically dominated by muds and sand of a marine or estuarine origin. These deposits are commonly overlain by thinner layers of saltmarsh deposits or tidal river/creek deposits.

2.3.3.8 Tidal flat deposits are present to the west of the study area associated with the marine tidal zones.

Glacial clays/till

2.3.3.9 These unconsolidated strata, mapped as glacial till, predominately comprises cohesive clays with some interspersed sands and gravels horizons. The geological cross section provided on BGS Sheet 74 for Southport (BGS, 1989) and BGS Sheet 75 for Preston (BGS, 2012) shows that the glacial till can be thick, typically being 20 m to 30 m in the Lytham St. Annes area.

2.3.3.10 The glacial till in the local area has been divided into a cohesive ‘upper boulder clay’ and ‘lower boulder clay’. These boulder clay horizons are separated by the granular ‘middle sand’ horizon. Boulder clay is the historical term for glacial till, reflecting the fact this clay-rich unit commonly contains large pebbles and boulders.

2.3.3.11 Around Preston the upper boulder clay is between approximately 5 m to 15 m thick. It is generally a reddish or reddish brown slightly sandy clay with many boulders. The middle sand is typically thin. The thickness of the lower boulder clay is not reported in BGS geological memoirs for Sheet 74 or Sheet 75.

2.3.3.12 Borehole CP+RC recorded these clays from a depth of 14.4 m to 32.7 m. Borehole MORGAN_A2_CP01B did not prove the full depth extent of these strata encountered at a depth of 14.5 m. These strata are described as brown clay with increasing gravel and cobble content with depth with gravel and cobbles of mudstone and siltstone.

Other deposits

2.3.3.13 Saltmarsh deposits and ‘tidal river or creek deposits’ are associated with the tidal areas of the River Ribble and Ribble Estuary. Freshwater alluvium is found inland from the coast. Alluvium is a mixed deposit that is constrained to narrow strips along certain watercourses.

2.3.3.14 These strata are not encountered in this study area.

2.3.4 Bedrock

2.3.4.1 The bedrock comprises red mudstones (Singleton Mudstone Member) of the Sidmouth Mudstone Formation of the Mercia Mudstone Group (see **Figure 2.4**).

Within the deeper site borehole that proved bedrock, the strata are described as weak and very weak reddish brown and greenish grey mudstone including a weathered upper horizon (1.9 m thickness) of very stiff reddish brown clay.

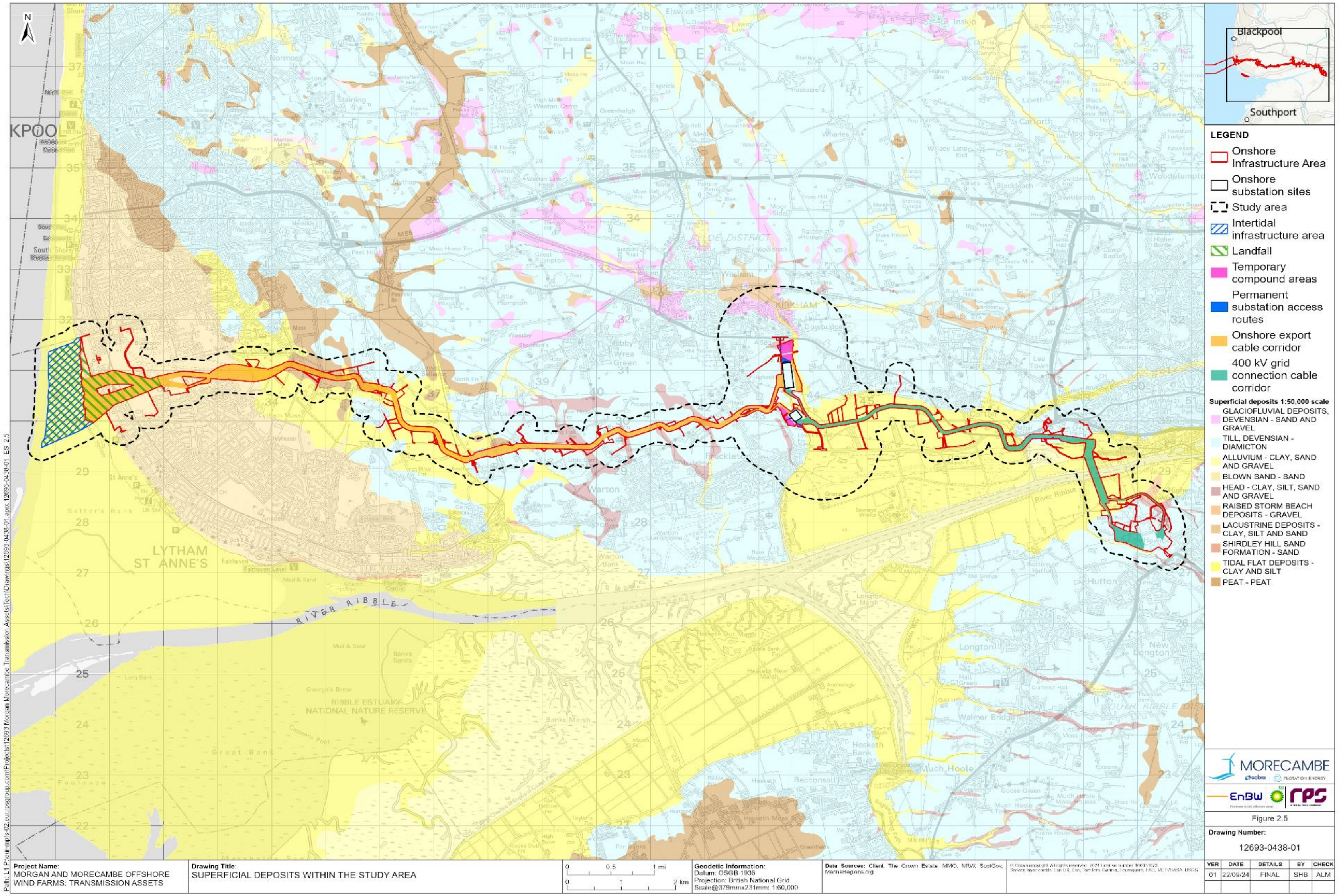

Figure 2.3: Superficial deposits within the region

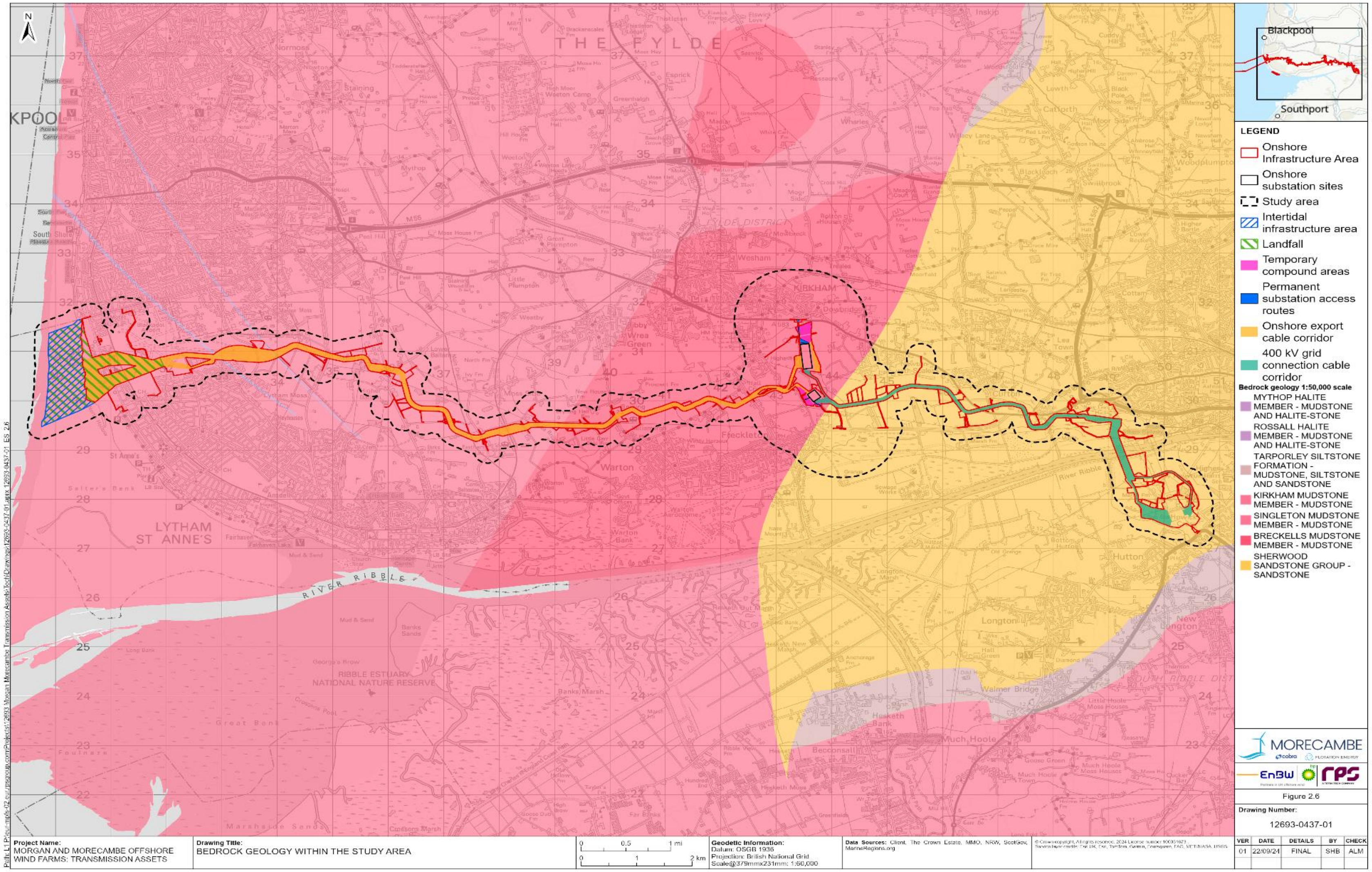

Figure 2.4: Bedrock geology within the region

2.4 Hydrogeology

Blown sands

2.4.1.1 The blown sand deposits are designated as a Secondary A aquifer. These are granular surface deposits commonly underlain by sand and gravel deposits that may be attributed to the middle sand of the glacial till. Together, these deposits form a locally important groundwater resource from which modest abstractions are made, typically for spray irrigation. Groundwater discharge from these shallow deposits is likely to contribute to flow in surface watercourses and other groundwater dependent features.

Peat and clay

2.4.1.2 Peat and associate clay bands within the blown sands may be associated with perched shallow water tables where present, or depending on the hydrogeological properties of the peat, comprise relatively saturated strata. Based on the borehole evidence it is not understood to what extent peat and clay layers persist within the blown sands.

2.4.1.3 The clay-rich glacial till is classified as a Secondary (undifferentiated) aquifer unit. The presence of groundwater in this clay-rich, low permeability material is restricted to localised granular lenses or layers. These granular deposits do not typically form significant groundwater bodies and the glacial till is not considered to be of significant resource value in the study area.

2.4.1.4 The tidal flat deposits and peat are designated as unproductive strata and are not important from a groundwater perspective.

Bedrock

2.4.1.5 The red mudstones of the Mercia Mudstone Group are designated as a Secondary B aquifer and are of little groundwater resource value given that:

- groundwater is uncommon within these mudstone units; and
- the bedrock concealed beneath a thick sequence of low permeability glacial till.

2.4.2 Particle Size Distribution tests

2.4.2.1 Samples of blown sands were collected during the site investigations for particle size distribution analysis. This provides useful hydrogeological information to assist in the estimation of hydraulic conductivity of the strata using literature empirical relationships. **Table 2-1** and **Table 2-2** present results for samples obtained within the sand deposits.

Table 2-1: Particle Size Distribution – borehole CP+RC

Borehole and Sample Depth (m)	Strata	Clay/Silt (%)	Sand (%)	Gravel (%)	Cobbles (%)
CP+RC 2.00 – 2.45	Blown sands	1	99 Fine – 45 Medium – 54 Coarse - 0	0	1
CP+RC 11.00 – 11.50	Blown sands	10	89 Fine – 41 Medium – 47 Coarse - 1	1 Fine – 1 Medium – 0 Coarse - 0	0
CP+RC 13.00 – 13.50	Blown sands	10	88 Fine – 51 Medium – 35 Coarse - 2	2 Fine – 2 Medium – 0 Coarse - 0	0

Table 2-2: Particle Size Distribution – boreholes A2_CP01 / A2_CP01B

Borehole and Sample Depth (m)	Strata	Clay/Silt (%)	Sand (%)	Gravel (%)	Cobbles (%)
A2_CP01 8.00 – 8.20	Blown sands	2.9	54.9	42.2	0.0
A2_CP01B 1.20 – 1.65	Blown sands	0.4	99.3	0.3	0.0
A2_CP01B 2.50 – 2.80	Blown sands	0.2	99.8	0	0.0
A2_CP01B 4.50 – 4.80	Blown sands	0.3	58.8	28.4	12.5
A2_CP01B 6.00 – 6.45	Blown sands	9.3	56.9	33.8	0.0
A2_CP01B 9.00 – 9.45	Sand and gravel	1.0	54.0	45.0	0.0
A2_CP01B 11.00 – 11.30	Blown sands	0.9	95.3	3.8	0.0
A2_CP01B 13.00 – 13.30	Blown sands	0.9	86.6	12.5	0.0

2.4.3 Groundwater observations

2.4.3.1 A groundwater strike was recorded within the blown sands during drilling of borehole CP+RC at 1.0 m bgl rising to 0.73 m bgl after 20 minutes. This borehole is installed with a groundwater monitoring well placed at a depth of between 21.0 m and 30.0 m, within the glacial till. It is therefore not expected to provide useful information on the shallow groundwater conditions of the site.

2.4.3.2 Groundwater elevations were observed weekly in this borehole on four occasions between 30/11/2023 and 21/12/2023. Surprisingly, given the monitoring well depth, this showed groundwater levels at 0.53 m below ground level (9.40 mAOD) on the first round rising to ground level (9.93 mAOD) by the final two rounds. This either suggests a sub artesian piezometric pressure within the low permeability glacial till or, more likely, that the borehole has become flooded by surface water given the high rainfall experienced during this period.

2.4.3.3 Table 2-4 presents the groundwater monitoring results from borehole CP+RC.

Table 2-3: Groundwater monitoring – borehole CP+RC

Date	Borehole Level (mAOD)	Water Depth (m bgl)	Water Level (mAOD)
30/11/2023	9.93	0.53	9.40
07/12/2023	9.93	0.21	9.72
14/12/2023	9.93	0.00	9.93
21/12/2023	9.93	0.00	9.93

2.4.4 Groundwater abstractions

2.4.4.1 An active licensed groundwater abstraction (GWA_01) is located in close proximity to the SSSI/LNR. Details of this abstraction are provided in **Table 2-4**. Given the provided NGR is only accurate to 500 m, this approximate location is shown in **Figure 2.5**. Following discussions with the Environment Agency, it is understood this abstraction point is representative of a number of abstraction points within the golf course grounds.

Table 2-4: Active licenced groundwater abstraction

Location	Licence No.	Purpose of abstraction	Abstraction volume (m^3)
St Annes Old Links Golf Club NGR 331500, 430500	2671353002	Spray irrigation	Annual volume 11,365 Maximum daily volume: 454.60

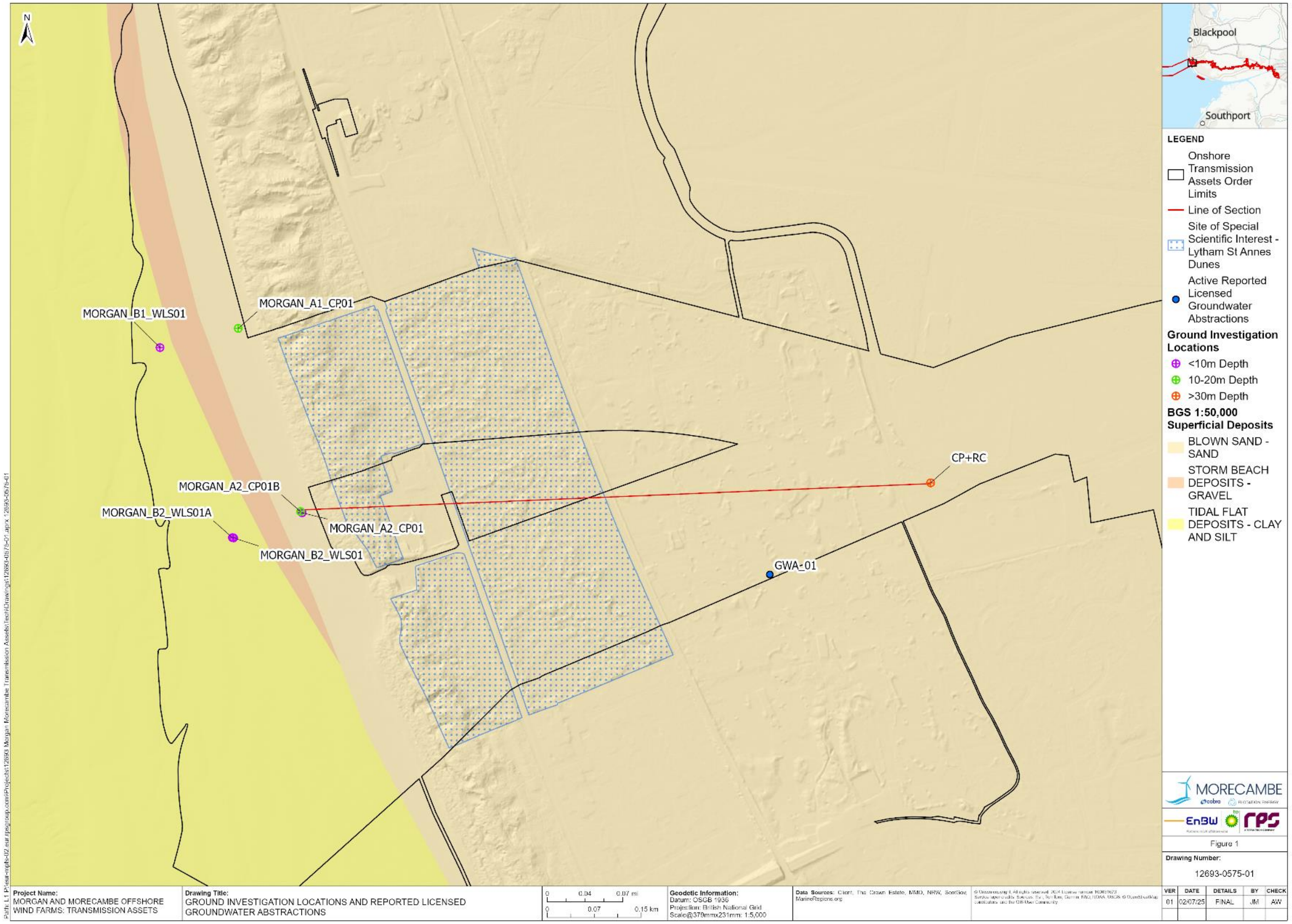

Figure 2.5: Ground investigation locations and reported licensed groundwater abstraction GWA_01

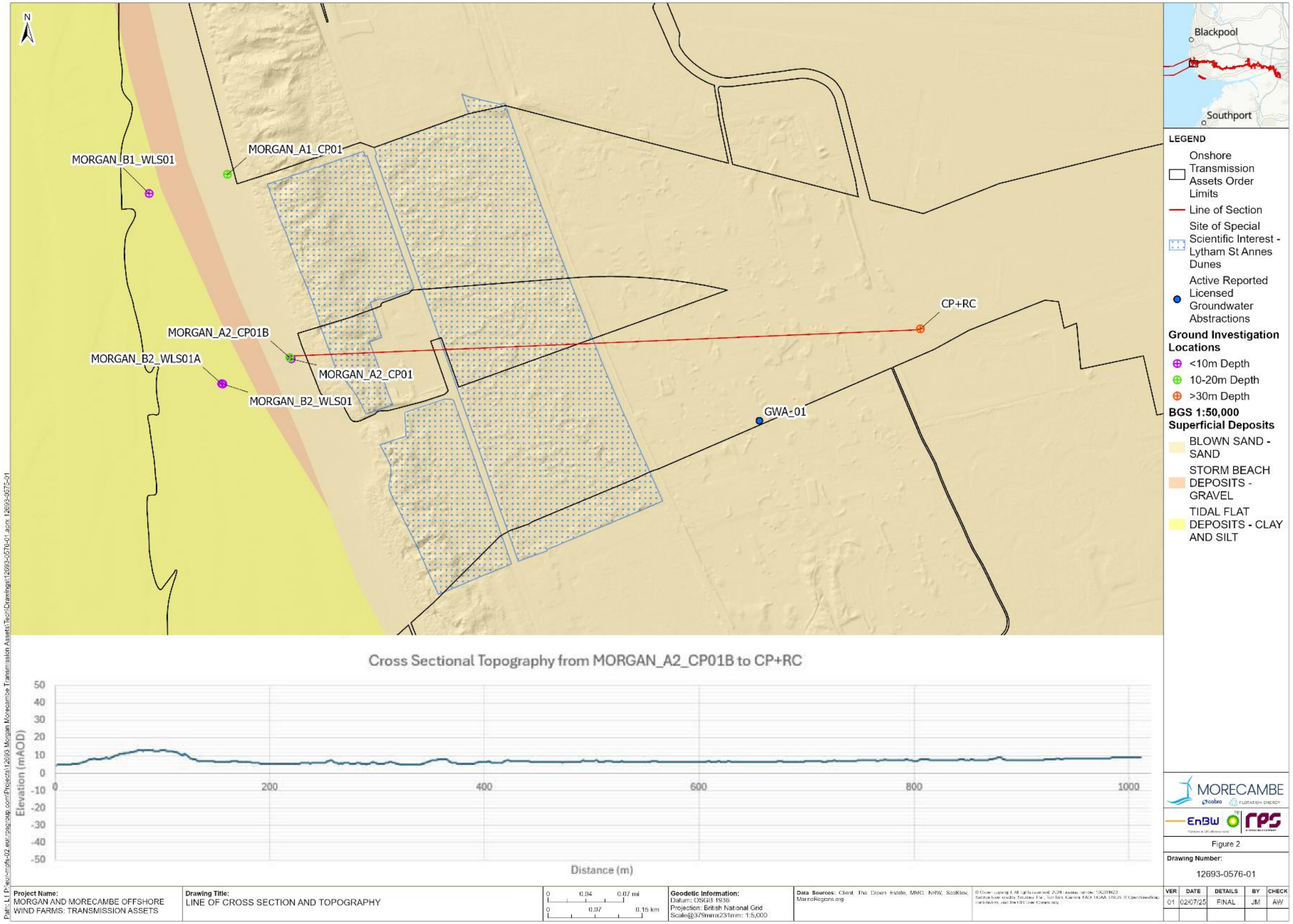

Figure 2.6: Line of cross section and topography

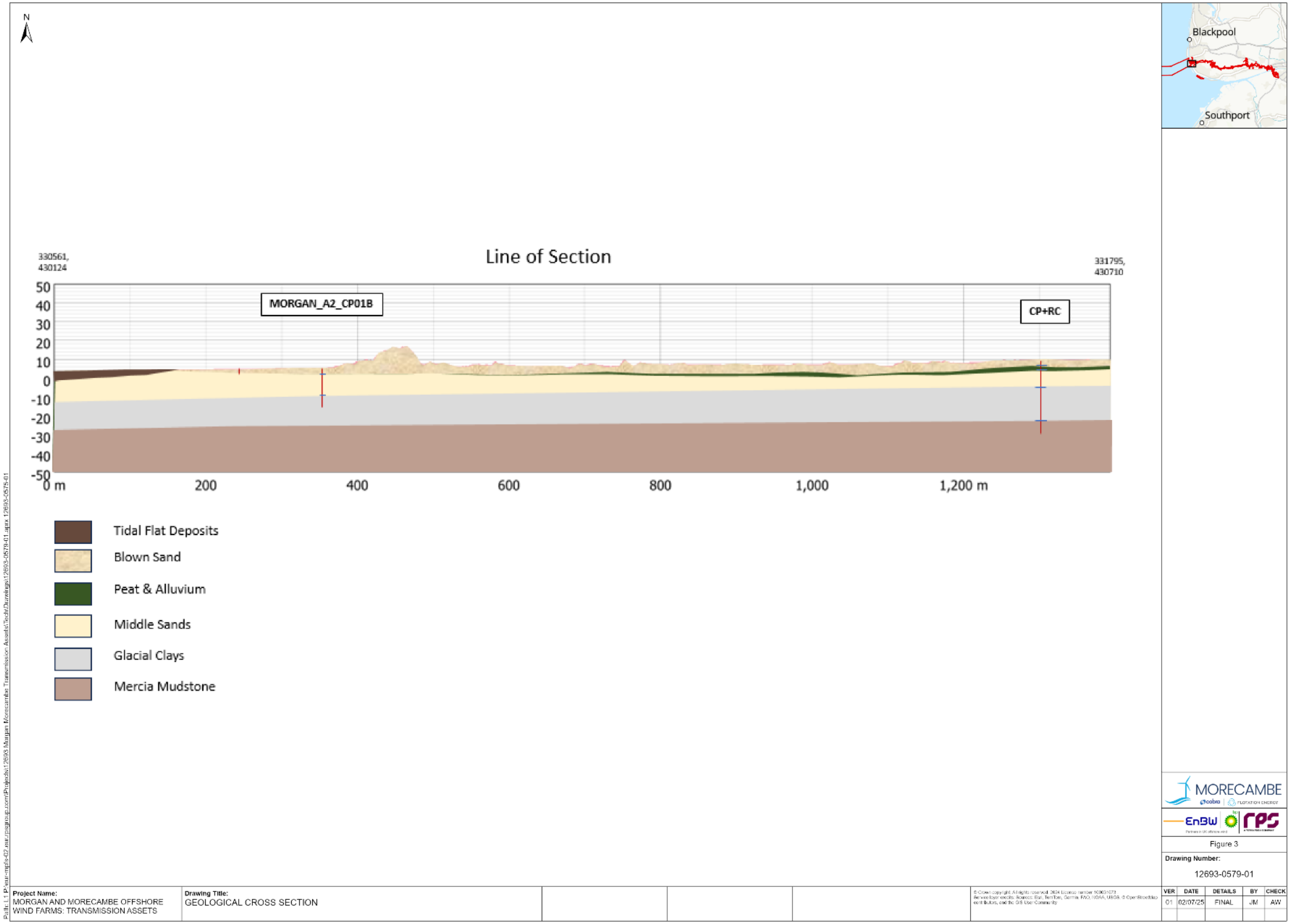

Figure 2.7: Conceptual geology section

2.5 Preliminary Hydrogeological Conceptual Model

2.5.1.1 Based on the available data set out in Section 2 of the report, a number of characteristic hydrogeological features of the current local site setting can be identified as follows.

- A relatively simple and well constrained geological sequence is present beneath the SSSI/LNR/BHS site with a likely permeable layer of surficial blown (aeolian) sands resting upon relatively impermeable, cohesive deposits comprising clays over mudstone bedrock. The blown sands strata include a coarser gravelly layer potentially capable of supporting a more permanent and laterally persistent groundwater body.
- A shallow (<1 m depth) water table is suggested to be present observed as a water strike during drilling of the borehole situated within the golf course site to the east of the SSSI/LNR within the BHS. This water table was not observed in a borehole to the west of the SSSI/LNR/BHS suggesting a laterally impersistent and potentially variable groundwater table is present.
- Any laterally continuous water table is expected to be in hydraulic continuity with the sea and fluctuate on the diurnal tidal cycle. A laterally discontinuous water table would be present as perched lenses of groundwater where local hydrogeological conditions support them, i.e., where relatively impermeable strata may be present near the surface, i.e., lenses of peat, which have been identified in the easternmost borehole.
- The surficial blown sands form a dynamic dune system that includes localised depressions (slacks) capable of retaining water under the right conditions of rainfall and surface water run-off and ponding (hydrology) as well as the supporting presence and persistence of a shallow water table and the permeability of shallow soils (hydrogeology), The interrelationship between rainfall and groundwater is not known, i.e., what groundwater recharge is typical following rainfall events or on a seasonal basis, and how the elevation of any water table or tables responds.
- The golf course to the east of the SSSI/LNR is licensed by the Environment Agency to abstract groundwater from an unknown number of abstraction points totalling 11,365 m^3 annually with a maximum daily abstraction rate of: 454.60 m^3 (c. 5.26 l/s). The actual abstraction rates and volumes for each abstraction point are not presently known. It is not known to what if any degree the current SSSI/LNR/BHS habitat and supported biodiversity is affected by these abstractions, or whether these abstractions are constrained by the prevailing hydrogeological conditions, i.e., groundwater resources are limited or ephemeral (seasonal).
- The presence, sensitivity and temporary or permanent impact on any water table or tables as a consequence of the project is considered to be the primary risk as this impact has the potential to adversely affect the current local hydro-ecological ‘steady state’ that

supports both the current SSSI/LNR/BHS biodiversity as well as the golf club abstractions. Shallower water tables are considered to have a relatively higher sensitivity than deeper ones owing to their increased potential to support dune slack habitats.

3 Outline Hydrogeological Risk Assessment

3.1 Proposed construction activities to be assessed

3.1.1.1 The oHyRA considers the potential risks the temporary construction and permanent location of the offshore export cable may have on the sand dune features of the SSSI/LNR/BHS taking into account the preliminary conceptual hydrogeological understanding of the system.

3.1.1.2 The construction activities to be undertaken at landfall and their respective Maximum Design Scenario are defined in Table 3.13 of Volume 1, Chapter 3: Project description, and are summarised below and form the basis of this assessment:

- Transition Joint Bay (TJB) 10A/10B working area:
  - TJB with six entry pits with area of 450 m^2 to a depth of 6.0 m per entry pit and total working surface area of 2,700 m^2 and permanent infrastructure area of 1,600 m^2.
  - Dry excavations are required for TJB construction, so any groundwater ingress into the excavations will be pumped out and discharge to the local surface water drainage system.
  - TJB located within Blackpool Airport at Work Nos. 10A/10B
- Trenchless drilling techniques to install the offshore export cable beneath from the TJBs / entry pits at Blackpool Airport to the Exit Pits on Lytham St Annes Beach:
  - Six trenchless installation entry pits at the TJBs with a maximum depth of 6.0 m and surface area of 450 m^2 per entry pit and total working surface area of 2,700 m^2.
  - Installation of ducting for 6 cable circuits comprising 18 cables.
  - Drilling at a diameter of 1.4 m
  - Typical permanent cable corridor width: 70 m
  - Minimum drill depth of 10 m
  - Maximum drill depth of 30 m

3.2 Potential risks to be assessed

3.2.1.1 The assessment has considered the potential risk to baseline physical and chemical groundwater conditions in the study area that is posed by the proposed temporary construction activities and presence of the cables. The potential impacts that have been considered with respect each of the activities listed above, are as follows:

- Construction of the TJBs:
    - Short-term reduction of groundwater levels due to temporary dewatering of TJB excavation.
    - Impact on groundwater quality through accidental release / emissions of polluting materials.
    - Impact on groundwater quality via surface water runoff from within the construction area.
- Installation of the offshore export cables via trenchless techniques:
    - Short term reduction in groundwater levels during drilling.
    - Long term reduction in groundwater levels due to presence of the export cables.
    - Impact on groundwater quality through accidental release / emissions of polluting materials.
    - Impact on groundwater temperature through heat dissipation from the cable.

3.3 General approach for risk assessment

3.3.1.1 The risk assessment provides a largely qualitative assessment of impacts to groundwater levels and, by association, flow, based on the outline conceptual hydrogeological model developed for the site. The qualitative assessment has been augmented by the results of the ground investigation completed to date.

3.3.1.2 The risk assessment considers the likelihood of a pathway existing that could provide a hydraulic connection between the study area and construction activities in the cable route corridor. The likelihood a connection exists are as follows:

- No Pathway;
- Unlikely;
- Possible; and
- Highly Likely.

3.3.1.3 The risk assessment then considers the likely severity that each impact may have on groundwater levels, flow and quality within the study area. Severity is determined semi quantitatively based on the nature of the impacts that can be expected in the immediate vicinity of the construction activity being considered. Based on those localised impacts to groundwater the effect to the identified receptors is evaluated through consideration of the characteristics of the hydrogeological pathway.

3.3.1.4 The incorporated mitigation measures implemented to control risk are included in the assessment and include the management plans that are produced and any additional measures that are identified through the risk assessment process.

3.3.1.5 The risk matrix provided in **Table** 3-1 is then used to determine the overall risk classification for each of the activity evaluated.

Table 3-1: Matrix for determining risk ranking classifications

		Severity of consequences if pathway exists				
		Extreme	**Severe**	**Moderate**	**Mild**	**Negligible**
Probability that the hydrogeological pathway exists	**Highly likely**	Extreme Risk	Extreme Risk	Very high risk	High risk	Moderate risk
	Likely	Extreme Risk	Very high risk	High risk	Moderate risk	Low risk
	Possible	Very high risk	High risk	Moderate risk	Low risk	Very low risk
	Unlikely	High risk	Moderate risk	Low risk	Very low risk	Very low risk
	No pathway	Moderate risk	Low risk	Very low risk	Very low risk	No risk

3.3.1.6 The risk matrix, pathway criteria and consequence criteria presented above have been developed specifically for this oHyRA to reflect the receptor being considered. The matrix approach is based on the methodology set out in Volume 1 Chapter 5: Environmental Impact Assessment Methodology (APP-034) and guidance set out in Design Manual for Roads and Bridges (DMRB) LA104 (Highways England et al., 2020).

3.4 Risk assessment

3.4.1.1 This section provides and assessment of the potential risks defined in section 3.2 for the perceived potential impacts associated with the construction of the TJBs and the installation of the offshore export cables via trenchless techniques.

3.4.1 Construction of the TJBs

Short term reduction in groundwater levels due to temporary dewatering of TJB excavation

3.4.1.1 The construction of the TJBs will require dry excavations. Dewatering of the assumed shallow, unconfined aquifer at the study area could result in:

- groundwater levels being locally reduced by up to 6 m due to the proposed depth of the TJB excavation; and
- change in local groundwater flow directions, which could become oriented towards the dewatering activities.

3.4.1.2 In order to assess the impact of the proposed dewatering the calculation of an approximate zone of influence is made using ground investigation data in Section 2 of this report. This indicative calculation does not consider other abstractions within the area, most notably the golf course abstractions (GWA_01).

3.4.1.3 It is acknowledged that the current hydrogeological baseline locally will be influenced by the current and historical groundwater abstractions at the golf course.

3.4.1.4 The zone of influence within the superficial unconfined aquifer likely to be generated by the proposed dewatering can be estimated using Sichardt's formula:

$$R = 3000\ s\ \sqrt{K}$$

R = radius of influence (m)

K = saturated hydraulic conductivity (m/s)

s = drawdown in the borehole

3.4.1.5 Hazen's method has been used to estimate permeability for soil samples using PSD data for samples of blown sands detailed in **Table 2-1**and **Table 2-2**.

Hazen's method (CIRIA, 2016) relates to permeability k (in m/s) to the D_{10} particle size (in mm):

$$k = 0.01 \times (D_{10})^2$$

3.4.1.6 The data indicates permeability values for the blown sands ranging from 3.97×10^{-5} m/s to 4.00×10^{-4} m/s. The geometric mean of the permeability values for the blown sands is 1.01×10^{-4} m/s.

3.4.1.7 Using the geometric mean permeability value of 1.01×10^{-4} m/s and a drawdown value of 1 m a radius of influence of 30 m is calculated.

3.4.1.8 The drawdown in the dewatering boreholes is currently unknown however a value of 6 m is the maximum TJB excavation depth requiring dewatering. Based on this and using the above formula a radius of influence of 180 m is calculated.

3.4.1.9 Using a 'factor of safety' of 2, a 360 m zone of influence is well within the total distance from the TJB to the SSSI (measured at approximately 600 m).

3.4.1.10 The estimated Zone of Influence for dewatering at the TJB is shown on **Figure 3.1**.

3.4.1.11 An alternative method proposed by Aravin and Numerov (1953) for unconfined aquifers using a time dependant relationship:

$$R = \sqrt{(1.9K\ s\ t\ /\ n)}$$

t = elapsed time

n = effective porosity

3.4.1.12 Using a specific yield value (as an equivalent to effective porosity) of 0.38 for a dune sand (Domenico and Schwartz) a radius of influence of 180 m (as calculated above) is reached for a dewatering duration of 124 days (c. 4 months). This gives some indication of the potential equivalence of duration as well as magnitude of dewatering impact. This will be used to further screen dewatering activities once the expected duration of these construction activities is quantified during detailed design.

3.4.1.13 In reality, a steady state (static) drawdown will be reached where the propagation of a cone of depression will cease due to aquifer recharge. This effect has not been taken into account in these formulae, which means the calculated magnitudes of radius size and duration are pessimistic.

3.4.1.14 Although based on a single observation, the stabilised water strike recorded during drilling of borehole CP+RC at a depth of 0.73 m bgl suggests a shallow water table is present within the blown sands. It is uncertain whether this water table is continuous beneath the SSSI or present as a discontinuous perched water resting above lower permeability strata.

3.4.1.15 This shallow water table observation is located approximately 300 m from the golf course abstraction, based on the grid reference provided for the location by the Environment Agency. Given the licensed abstraction from the golf course borehole of up to 454.6 m^3 per day, this is suggestive, if far from conclusive, that there is low magnitude of impact on water levels at a smaller distance to the SSSI as the location of the TJB will be located subject to temporary dewatering.

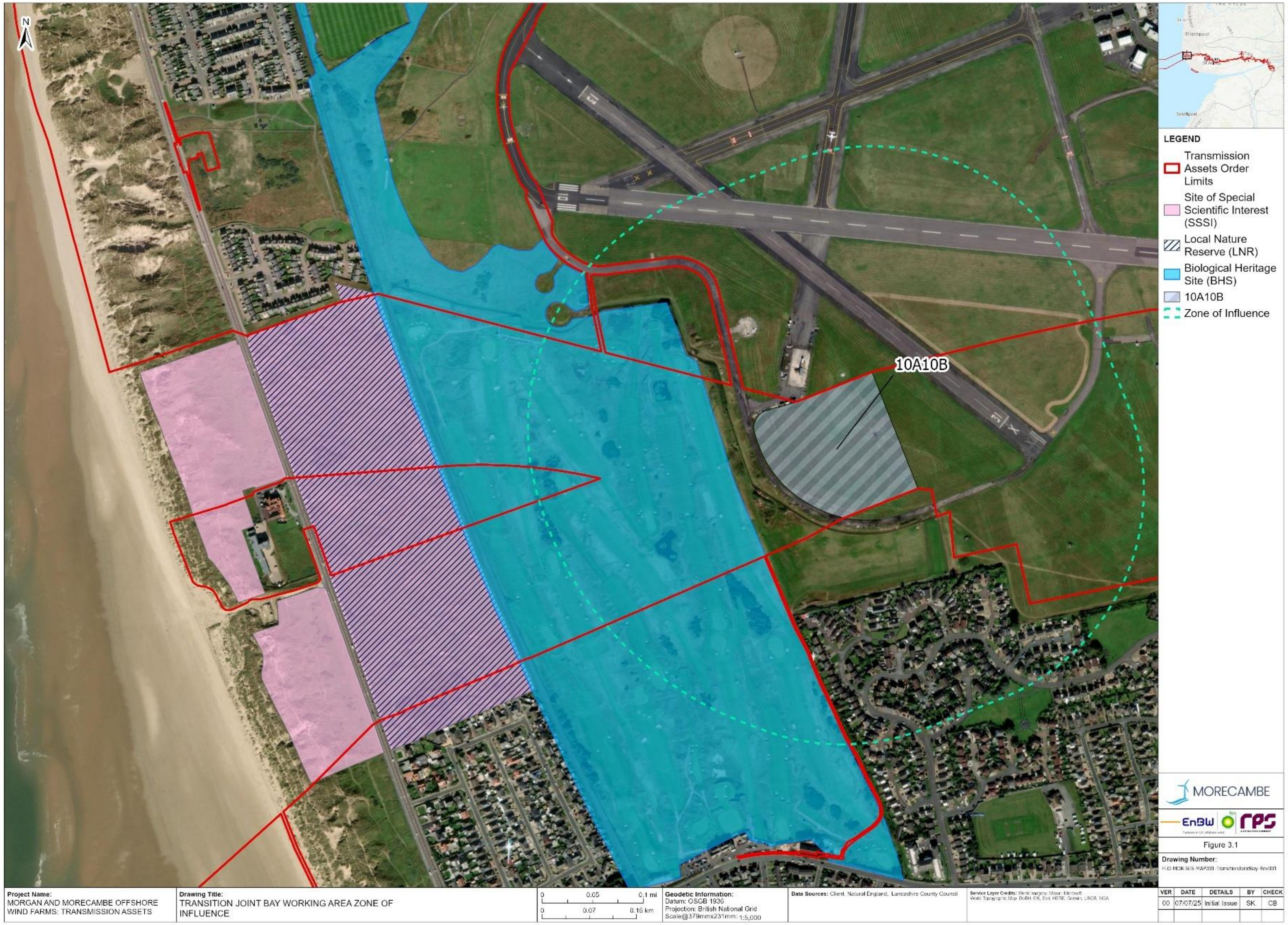

Figure 3.1: TJB working area Zone of Influence

Impact on groundwater quality through accidental release / emissions of polluting materials

3.4.1.16 The accidental release of polluting substances to ground within the cable route corridor (most notably hydrocarbons used for fuel for construction equipment) could affect local groundwater quality, particularly if lost directly to excavations. Only a small proportion of any product lost to ground could have the potential to enter the dissolved phase and be transported through unsaturated zones to saturated strata at the water table in the underlying aquifer.

3.4.1.17 Most of the product that could be lost to ground will be retained within shallow soils. The volume of hydrocarbons and other polluting substances potentially lost to groundwater will be minimised through the implementation of agreed management plans that control where the highest risk activities are undertaken (i.e., refuelling and storage) and define the necessary emergency response to any such release.

Impact on groundwater quality via surface water runoff from within the construction area.

3.4.1.18 Similarly, the uncontrolled loss of surface runoff from the construction areas into excavations could introduce silt laden waters, that potentially contain low concentrations of metals and or hydrocarbons associated with construction vehicles, into the shallow soils and groundwater. This short-term temporary effect would be minimised through implementation of standard practice effective surface water management during construction.

3.4.2 Assessment of trenchless drilling techniques

Short term reduction in groundwater levels during drilling

3.4.2.1 No groundwater dewatering is required for the installation of the offshore export cables utilising the trenchless installation techniques. These works are therefore considered unlikely to present a risk the neighbouring golf course abstractions.

3.4.2.2 However there is a potential risk to localised shallow perched water tables. These are considered below as they are also considered to be a potential long term risk of the export cable placement.

Long term reduction in groundwater levels due to presence of cable ducting

3.4.2.3 Cable ducting installed during construction will be permanently installed. The emplacement of permanent sub water table cable ducts does have the potential to affect shallow water table(s) should significant, saturated, and hydraulically connected perched water tables be intercepted, which could lead to the localised loss of such features. In the absence of evidence of the presence of a significant, shallow and laterally continuous water table beneath the SSSI/LNR/BHS, such potential risks remain.

3.4.2.4 Such potential risks and effects are anticipated to diminish with depth beneath the study area. A minimum drill depth of 10 metres as detailed in section 3.2 would place the cable duct towards the base of the blown sands strata, anticipated to be approximately 14 metres in thickness. A burial depth of 30 metres would place the cable ducts toward the base of the underlying glacial clays.

3.4.2.5 As described in section 2.4, these low permeability, clay-rich strata, whilst designated as a Secondary (undifferentiated) aquifer unit, contain groundwater restricted to localised granular lenses or layers. Placing the cable duct within these strata would not be expected to have a significant impact on shallow water tables within the permeable blown sands.

Impact on groundwater quality through accidental release / emissions of polluting materials

3.4.2.6 As is the case for the construction works associated with the TJB, this short-term temporary risk would be minimised through implementation of standard practices and management during construction. Direct pipe drilling techniques limit the use of drilling fluid and maintain separation of the drill string from the ground as the steel ducting is placed during advancement, which acts as a pipe to bring drilling materials and fluids to the safely to the surface.

Impact on groundwater temperature through operational cable heating

3.4.2.7 The offshore export cables will be permanently installed in direct pipe ducts beneath the SSSI/LNR/BHS . The installation of offshore export cables has the potential to generate heat that dissipates naturally to the surrounding ground during power transmission.

3.4.2.8 The levels of heat loss and dissipation of heat through the soil can only be determined once further details of the cable voltage, soil structure (including its thermal properties) and the final engineering design are known. This will include consideration of the cable depth (in terms of the receptor that may be affected).

3.4.2.9 However, the offshore cables themselves will consist of copper or aluminium conductors wrapped with various materials for insulation, protection, and sealing. Once installed, the electrical cables must be suitably spaced out in order to minimise the mutual heating effect of one cable circuit on another, this enables the cables to effectively carry the large power volumes required without overheating and damaging the cable.

3.4.2.10 It is therefore likely that any heat dissipation will be localised and confined to the areas immediately surrounding the offshore cables. On this basis, it is unlikely that there will be any impact on the quality or temperature of groundwater.

3.5 Risk assessment summary

3.5.1.1 Following the assessment of potential temporary and permanent risks, associated with the installation and long-term presence of the export cable on the identified receptors, risk rankings have been determined. These assessments are shown in **Table 3-2** and **Table 3-3** together with the embedded mitigation measures considered and the relative quantification of both the likelihood of effect and the potential severity of the consequence.

Table 3-2: Outcome of risk assessment of the TJB working area

Activity	Receptor	Potential impacts to groundwater	Effect	Embedded mitigation	Likelihood	Severity	Initial Risk Ranking	Secondary Mitigation Options	Likelihood	Severity	Residual Risk Ranking
Construction of the TJBs	BHS	Short-term reduction of groundwater levels due to temporary dewatering of TJB excavation	Increased vulnerability of dune slacks hydrology due to reducing dependency on shallow water table	Locating TBJ excavation outside of BHS. Small area requiring dewatering Outline Code of Construction Practice (APP-193) Outline Surface and Groundwater Management Plan (APP-202)	Possible	Moderate (temporary affect and limited in aerial extent. High sensitivity of BHS).	Moderate Risk	Refinement of options will be developed as part of detailed HyRA. Possible options include: Potential for returning abstracted clean groundwater to ground as infiltration Possible use of shuttered sheet piling to limit groundwater ingress Undertaking works during periods of reduced sensitivity, i.e. when water tables (where present) are lowest	Unlikely	Moderate (temporary affect and limited in aerial extent. High sensitivity of BHS).	Low risk
	SSSI/LNR/BHS	Impact on groundwater quality through accidental release / emissions of polluting materials and surface water runoff from with the construction area.	Accidental release of polluting material into excavations and migration into saturated strata	Use of Direct Pipe trenchless technique (CoT44) with low disturbance and reduced use and risk from drilling fluids. Outline Code of Construction Practice (APP-193) Outline Pollution Prevention Plan (APP-197) Outline Surface and Groundwater Management Plan (APP-202) Outline Bentonite Breakout Plan (APP-206)	Unlikely	Negligible	Very Low Risk	Non required	-	-	-
	Golf Course groundwater abstractions	Short-term reduction of groundwater levels due to temporary dewatering of TJB excavation.	Reducing availability of groundwater and rates of abstraction from boreholes	Small area requiring dewatering Outline Code of Construction Practice (APP-193) Outline Surface and Groundwater Management Plan (APP-202)	Possible	Mild (temporary affect and limited in aerial extent. Moderate sensitivity of abstractions)	Low Risk	Refinement of options will be developed as part of detailed HyRA following updated hydrogeological conceptual model. Possible options include: Returning abstracted clean groundwater to ground as infiltration Possible use of shuttered sheet piling to limit groundwater ingress	Possible	Mild (temporary affect and limited in aerial extent. Moderate sensitivity of abstractions)	Low Risk

Activity	Receptor	Potential impacts to groundwater	Effect	Embedded mitigation	Likelihood	Severity	Initial Risk Ranking	Secondary Mitigation Options	Likelihood	Severity	Residual Risk Ranking
		Impact on groundwater quality through accidental release / emissions of polluting materials surface water runoff from with the construction area	Accidental release of polluting material into excavations and migration into saturated strata causing pollution from hazardous liquids including fuels (hydrocarbons), hydraulic fluids and oils/grease associated with construction	Use of Direct Pipe trenchless technique (CoT 44) with low disturbance and reduced use and risk from drilling fluids. Outline Code of Construction Practice (APP-193)) Outline Pollution Prevention Plan (APP-197) Outline Surface and Groundwater Management Plan (APP-202) Outline Bentonite Breakout Plan (APP-206)	Unlikely	Negligible	Very Low Risk	None required.	-	-	-

Table 3-3 Outcome of risk assessment of the installation of the export cable via trenchless techniques and the presence of the export cable during operation

Activity	Receptor	Potential impacts to groundwater	Effect	Embedded mitigation	Likelihood	Severity	Initial Risk Ranking	Secondary Mitigation Options	Likelihood	Severity	Residual Risk Ranking
Installation of the offshore export cables via trenchless techniques	SSSI/LNR/BHS	Short term reduction in groundwater levels during drilling	Lowering of water table(s) supporting dune slacks due to dewatering	Use of Direct Pipe trenchless technique (CoT44) with low disturbance and reduced use and risk from drilling fluids Outline Code of Construction Practice (Surface and Groundwater Management Plan (APP-202).	Unlikely due to no active dewatering required	Moderate (temporary affect and limited in aerial extent. High sensitivity of SSSI)	Low Risk	Refinement of options will be developed as part of detailed HyRA following updated hydrogeological conceptual model. This may include placement of offshore export cable within low permeability glacial clays to avoid water tables where present.	No pathway	Moderate (temporary affect and limited in aerial extent. High sensitivity of SSSI)	Very low risk
		Long term reduction in groundwater levels due to presence of cable ducting	Lowering of water table(s) in hydraulic continuity with dune slacks where support of perched, shallow water tables is reduced, e.g. due to perforation of low permeability strata within blown sands.	Placement of onshore export cable beneath SSSI/LNR/BHS. Direct Pipe techniques under SSSI (CoT44)	Possible	Severe (permanent affect but limited in aerial extent. High sensitivity of SSSI.)	High Risk	Refinement of options will be developed as part of detailed HyRA following updated hydrogeological conceptual model. This may include placement of offshore export cable within low permeability glacial clays to avoid water tables where present.	No pathway	Severe (permanent affect but limited in aerial extent. High sensitivity of SSSI.)	Low risk
		Impact on groundwater quality through accidental release / emissions of polluting materials during drilling	Accidental release of polluting material into excavations and migration into saturated strata causing pollution from hazardous liquids including fuels (hydrocarbons), hydraulic / drilling fluids and oils/grease associated with construction	Use of Direct Pipe trenchless (CoT44) technique with low disturbance and reduced use and risk from drilling fluids Outline Code of Construction Practice (APP-193) Outline Pollution Prevention Plan (APP-197) Outline Surface and Groundwater Management Plan (APP-202) Outline Bentonite Breakout Plan (APP-206)	Unlikely	Negligible	Very Low Risk	None required	-	-	-

Activity	Receptor	Potential impacts to groundwater	Effect	Embedded mitigation	Likelihood	Severity	Initial Risk Ranking	Secondary Mitigation Options	Likelihood	Severity	Residual Risk Ranking
		Impact on groundwater temperature through operational cable heating	Heating of shallow groundwater and dune slacks	Cables wrapped with various materials for insulation Cables cemented within steel ducting by bentonite. Cables will be suitably spaced out to minimise the mutual heating effect. Low thermal conductivity of dry sand	Possible	Mild (ephemeral affect but limited in aerial extent. High sensitivity of SSSI.)	Low Risk	Placement of offshore export cable within low permeability glacial clays to avoid water tables where present.	Unlikely	Moderate (ephemeral affect but limited in aerial extent. High sensitivity of SSSI.)	Very low risk
	Golf Course groundwater abstractions	Short term reduction in groundwater levels during drilling	Lowering of water tables reducing rates of abstraction from boreholes	Outline Code of Construction Practice (APP-193) Outline Surface and Groundwater Management Plan (APP-202)	Unlikely	Mild (temporary affect and limited in aerial extent. Moderate sensitivity of abstractions)	Very Low Risk	None required	-	-	-
		Impact on groundwater quality through accidental release / emissions of polluting materials during drilling	Accidental release of polluting material into excavations and migration into saturated strata causing pollution from hazardous liquids including fuels (hydrocarbons), hydraulic / drilling fluids and oils/grease associated with construction	Use of Direct Pipe trenchless technique (CoT44) with low disturbance and reduced use and risk from drilling fluids Outline Code of Construction Practice (APP-193) Outline Pollution Prevention Plan (APP-197) Surface and Groundwater Management Plan (APP-202) Outline Bentonite Breakout Plan (APP-206)	Unlikely	Mild (temporary affect and limited in aerial extent. Moderate sensitivity of abstractions)	Very Low Risk	None required	-	-	-
		Long term reduction in groundwater levels due to presence of cable ducting	Lowering of water tables reducing rates of abstraction from boreholes	None.	No pathway (localised affects not affecting abstraction boreholes)	Negligible (permanent affect but highly limited in aerial extent. Moderate sensitivity of abstractions	No Risk	None required	-	-	-

Activity	Receptor	Potential impacts to groundwater	Effect	Embedded mitigation	Likelihood	Severity	Initial Risk Ranking	Secondary Mitigation Options	Likelihood	Severity	Residual Risk Ranking
		Impact on groundwater temperature through operational cable heating	Heating of shallow groundwater abstracted from boreholes	Cables wrapped with various materials for insulation Cables cemented within steel ducting by bentonite. Cables will be suitably spaced out to minimise the mutual heating effect. Low thermal conductivity of dry sand	Unlikely	Negligible (ephemeral affect but highly limited in aerial extent. Low sensitivity of abstractions due to small proportion of groundwater intake affected)	Very Low Risk	None required.	-	-	-

4 Risk Management Measures

4.1.1.1 The outline HyRA assessment has taken into account secondary mitigation options to identify risk reduction potential. The scope of secondary mitigation options will be finalised and agreed following detailed design. This section of the detailed HyRA will include refined options following an updated hydrogeological conceptual model.

5 Next Steps

5.1.1.1 The Applicants have made a commitment (CoT128 of Volume 1, Annex 5.3: Commitments Register of the ES (F 1.5.3/F03)) to undertake hydrogeological risk assessment(s) in relation to the crossing of the Lytham St Annes Dunes SSSI. These assessment(s) will be used to inform the detailed site-specific crossing design(s) for the installation of the offshore export cables beneath Lytham St Annes Dunes SSSI. This is secured by Requirement 8 of Schedules 2A and 2B of the draft DCO (REP1-008).

5.1.1.2 The Applicants have commissioned a botanical specialist to undertake an updated National Vegetation Classification (NVC) survey of the Lytham St Annes Dunes SSSI/ LNR in summer 2025, to be submitted at Deadline 5, to record a baseline for inclusion in the detailed HyRA, against which future habitat monitoring could be undertaken, if necessary. The NVC survey extent will also cover the St Annes Old Links Golf Course & Blackpool South Rail Line BHS. It is understood that a further survey of the Lytham St Annes Dunes SSSI by an ecologist on behalf of the Fylde Sand Dunes Project (FSDP) is scheduled for 2025, and therefore liaison with the FSDP team will also be undertaken to share data where possible.

5.1.1.3 Information will be requested from the St Annes Old Links Golf Club regarding the groundwater abstractions to inform the refinement of the hydrogeological conceptual model. This would include where available, and subject to data sharing agreements being reached, abstraction borehole logs and associated water table elevation observations, historical and current abstraction regimes including timings - both diurnal and seasonal - and rates of abstraction, uses of water whether consumptive or non-consumptive and understanding of any on any physical or temporal limitations or constraints on abstraction.

5.1.1.4 Depending on the required depth of burial of the export cables, further ground information may be required to establish site specific groundwater conditions below the Lytham St Annes SSSI/LNR/BHS site including monitoring to establish a suitable hydrogeological conditions baseline. This could comprise a borehole drilled to the depth of the underlying Mercia Mudstone Formation bedrock strata with a groundwater monitoring well installed at an appropriate depth and screen length to facilitate detection of a shallow water table and observations of variation in elevation as well as the recovery of groundwater samples for laboratory analysis.

6 Conclusion

6.1.1.1 The installation of the export cable using trenchless drilling techniques beneath the sand dunes at Lytham St Annes Dunes SSSI/LNR and St Annes Old Links Golf Course & Blackpool South Rail Line BHS, has the potential to affect groundwater in terms of its quality and water levels. This is due to both temporary effects associated with the construction within the TJB working areas, primarily involving dewatering of the excavation for the TJB, the installation of the export cable using trenchless techniques and long term effects associated with the presence of the export cable ducts beneath the sensitive ecological sites, known to include dune slack features.

6.1.1.2 The site has a relatively simple hydrogeological conceptual model, supported by boreholes advanced to the west and east of the dune system. These proved the thickness of the blown sands deposits making up the dunes to be 14 metres in thickness. These dune deposits are expected to support a licensed groundwater abstraction regime for the golf course to the east of the dunes and west of the proposed TJB working area. It is not currently known the location, depth, rate and timings of these abstractions. In addition to these abstractions, further evidence for a shallow water table within one metre of the surface was observed to the east of the dunes. It is not known whether this is laterally extensive further to the west. Beneath the blown sands are cohesive strata comprising glacial clay overlying mudstone bedrock. Both these strata are not anticipated to contain hydrogeologically significant groundwater.

6.1.1.3 The principal temporary effects of dewatering identified are on the assumed laterally extensive shallow water table where temporary lowering is predicted. An assessment on the potential radius of influence of this activity estimated a distance of approximately 260 metres beyond which drawdown may be considered negligible. This places the ecological sites on the sand dunes outside of this distance suggesting a moderate risk of effects on the water table if the cable ducts were located at least 10 meters below ground level or a low risk following secondary mitigation options including shuttering of pits and re-infiltration of abstracted groundwater.

6.1.1.4 The principal long term effects of dewatering identified is the lowering of water table(s) in hydraulic continuity with dune slacks where support of perched, shallow water tables is reduced, e.g. due to perforation of low permeability strata within blown sands. Given the current uncertainty on shallow, potentially perched groundwater conditions within the sand dune system, this effect is currently assessed as a high risk due the sensitivity of dune slack features to groundwater where the cable duct is placed within the blown sands deposits and a low risk where the cable duct is placed below the blown sands within the low permeability glacial clays.

6.1.1.5 The risk assessment of heating of groundwater where present requires further assessment following detailed design, but currently is assessed to represent a low risk to the dune system and a very low risk on the golf course abstractions given the cable duct’s depth and the limited zone of effect expected.

6.1.1.6 Impact on groundwater quality through accidental release of polluting materials and surface water runoff from with the construction area and the trenchless drilling methodology is expected to have a very low risk given the management of these works to avoid pollution and effectively manage surface water runoff.

6.1.1.7 The risk assessments will be revised within an updated hydrogeological risk assessment to be undertaken following completion of detailed engineering design that will be agreed with the relevant consultees and stakeholders.

7 References

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