Port of Mostyn

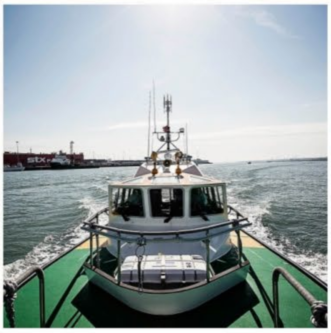
Mostyn Energy Park Extension

Environmental Statement
Chapter 6: Physical Processes

December 2022







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Mostyn Energy Park Extension

Environmental Statement
Chapter 6: Physical Processes

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6.1 Introduction

This chapter provides an assessment of the potential significant effects of the MEPE Project on physical processes (flows, waves, dredge plumes and sediments) and how they may potentially impact the estuary and dynamic bank and channel system. This chapter has been prepared by ABPmer.

The following receptors have been considered as part of the assessment:

- Existing port infrastructure;
- Wider Dee Estuary; and
- Local and regional intertidal and subtidal banks and channels.

Section 6.2 provides a definition of the study area for this topic; Section 6.3 presents the impact assessment approach that has been followed and Section 6.4 details the consultation which has taken place. Section 6.5 describes the legislation, policy and guidance position in respect of this topic and Section 6.6 describes the baseline conditions of the study area. An impact assessment describing changes to the baseline environment is then presented in Section 6.7, mitigation measures and residual effects are reviewed in Section 6.7 and Section 6.9 provides an overall final summary of the topic assessment.

A number of figures included in this chapter assist in describing the existing environment (baseline). Figure 6.1 illustrates the location of the existing licensed disposal sites in the study area; Figure 6.2 shows the local bathymetry in and around the Port; Figure 6.3 shows the mean spring tide current speed on peak ebb and peak flood; Figure 6.4 shows the wave rose at the entrance to the Dee Estuary; Figure 6.5 and Figure 6.6 show the grab sampling from the wider study area. Meanwhile, the assessment of impacts is informed by the model outputs shown in Figure 6.8 to Figure 6.13.

The physical processes assessment has been informed by a conceptual understanding of the estuary based on many years of study and monitoring, and project specific hydrodynamic and sediment modelling.

Relevant aspects of the physical processes assessment have enabled an assessment of effects on physical features or environmental receptors, such as the estuary, bank and channel system, to be undertaken. In terms of changes that may influence other environmental receptors, the physical processes assessment has also informed the outcomes of the water and sediment quality assessment (Chapter 7), the nature conservation and marine ecology assessment (Chapter 8), the flood risk and drainage assessment (Chapter 11), and the cultural heritage and marine archaeology assessment (Chapter 12).

Furthermore, the physical processes assessment has informed the Waste Hierarchy Assessment (WHA) included in Appendix 6.1, the Water Framework Direct (WFD) assessment included in Appendix 7.1 and the Habitats Regulations Assessment (HRA) included in Appendix 8.5.

6.2 Definition of study area

The study area is the extent over which potential direct and indirect effects of the MEPE Project may occur during construction and operation. The direct effects on physical processes are those confined to within the footprint of the proposed development, e.g. the new quay wall, dredge and disposal of dredge material (Figure 3.1 in Chapter 3). Indirect effects are those that may arise due to wider changes in the estuary flow and sedimentary regime and any change to the estuary morphology as a result of the proposed works (including dredge disposal plume dispersion).

The study area for the physical processes topic is considered to be the Dee Estuary, particularly the areas adjacent to Mostyn and the existing licensed disposal sites at Mostyn Deep (IS102) and Mostyn Breakwater (IS203) (see Figure 6.1 for locations of the disposal sites). In addition, the assessment includes the approaches to the Dee Estuary, across the southern part of Liverpool Bay and the north Wales coastline.

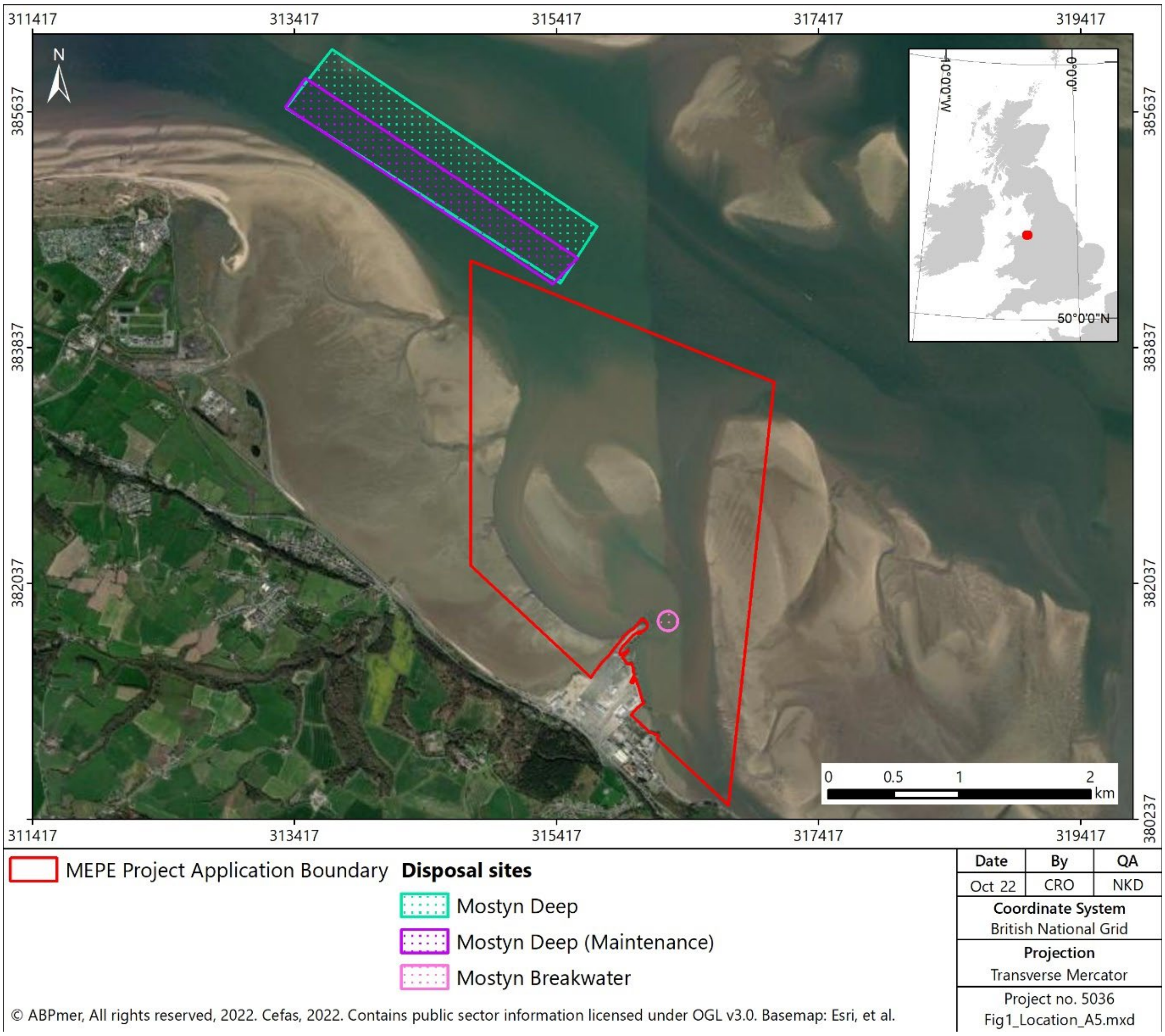

Figure 6.1. Location of the existing licensed dredged disposal sites

6.3 Impact assessment methodology

Survey, modelling and conceptual analysis of the physical processes of the Dee Estuary has been undertaken by ABPmer (and others) for many years. Due to this vast knowledge and experience, it has been possible to draw upon more historical data and past work than would normally be the case for an assessment of this kind, as described below.

6.3.1 Data and information sources

Current baseline conditions have been determined by a desk-based review of available information. The main desk-based sources of information that have been reviewed to inform the current baseline description within the vicinity of the proposed development and study area include:

- ABPmer (2017). Review of Dredge and Disposal Monitoring, Overview of survey work carried out by the Port in the Dee Estuary from 2005 to 2016, ABPmer Report No. R.2713. A report produced by ABPmer for Port of Mostyn, March 2017;
- ABPmer (2019a). Overview of Maintenance Dredge and Disposal, Report to accompany Progress Note 48; June 2019, ABPmer Report No. R.3230TN. A report produced by ABPmer for Port of Mostyn Ltd., July 2019;
- ABPmer (2019b). Mostyn Deep bed sample PSA Memorandum. 18 January 2019;
- ABPmer (2020). Maintenance Dredge and Disposal Surveys, Annual review of monitoring during 2019 and into early 2020 under Marine Licence DML1542v2, ABPmer Report No. R.3375. A report produced by ABPmer for Port of Mostyn Ltd., August 2020;
- ABPmer (2021a). Maintenance Dredge and Disposal Surveys, Year-end annual review of monitoring during 2019 and 2020 (DML1542v2), ABPmer Report No. R.3566. A report produced by ABPmer for Port of Mostyn, February 2021;
- ABPmer (2021b) Maintenance Dredge Monitoring Progress Note DML1542v2. R3597PN;
- Port of Mostyn (2013). Mostyn Energy Park Development (MEP) at the Port of Mostyn. Environmental Statement Volume 1 - EIA Text July 2013;
- North West and North Wales Coastal Group (2011). North West England and North Wales Shoreline Management Plan SMP2.

6.3.2 Determining significance of effects

The methods adopted for the assessment of the changes to physical processes changes (flows, waves, dredge plumes and sediments) are slightly different to those adopted for other environmental topics. This is because whilst the proposed development has the potential to cause changes to hydrodynamic and sedimentary processes, these are not, in themselves, generally recognised as environmental features/receptors and, therefore, the changes do not equate to 'impacts'. The impacts will instead be the consequence of these changes on other environmental features or receptors. For example, 'changes' in the transport and deposition of sediment may 'impact' on the structure and function of marine habitats and their associated species.

It should be noted, therefore, that the assessment undertaken in relation to physical processes, has applied the same standard impact assessment methodology as described in the Impact Assessment Approach Chapter 5 and assessed the potential 'exposure to change' resulting from the impact pathways that have been scoped into the assessment, but not the significance of any effects. The consequent significance of effects resulting from changes to physical processes changes on other environmental features/receptors have been assessed in other topic-specific chapters of this ES, namely

Water and Sediment Quality Chapter 7, Nature Conservation and Marine Ecology Chapter 8, Flood Risk and Drainage Chapter 11 and Cultural Heritage and Marine Archaeology Chapter 12.

It is recognised that physical processes changes may potentially impact on physical environmental receptors, such as the estuary, and bank and channel system. For these physical receptors, therefore, an assessment of impact significance has been undertaken following the methodology presented in the Impact Assessment Approach Chapter 5. In accordance with published guidance and an established approach that has been used in numerous previous EIAs, the assessment has included an evaluation of the sensitivity and importance of relevant physical processes receptors.

The scale of potential physical processes changes that are likely to occur as a result of the MEPE Project are considered to be small. This is because the magnitude of the physical changes brought about by the proposed development is very small in the context of the scale of ongoing natural changes in the study area. This ongoing background variability both in the short and long term is discussed and illustrated in Section 6.6. Project-specific numerical modelling to inform the physical processes assessment has been undertaken to provide predictions of likely changes to hydrodynamics, suspended sediment concentrations (SSC), and potential sedimentation (erosion/accretion) patterns adjacent to the Port of Mostyn and the wider study area. Analyses of the likely fate of sediment plumes from marine construction (i.e. capital dredging and disposal) and operational activities (i.e. maintenance dredging and disposal) have also been undertaken.

The assessment methodology which has been applied and which is presented in the following sections, is designed to incorporate the key criteria and considerations without being overly prescriptive.

6.4 Consultation

Consultation with regard to the outcomes of the formal scoping process and whether there are any likely effects of the MEPE Project on the physical processes topic has been undertaken with NRW.

The consultation that has been undertaken, along with the outcome of such consultation and how it has influenced this assessment is provided in Table 6.1.

Table 6.1. Summary of consultation to date

Consultee	Reference, Date	Summary of Response	How Comments have Been Addressed in this Chapter
NRW	Scoping Opinion, 06 January 2022	It is recommended that you follow the NRW GN41 guidelines with specific reference to Data Requirements for EIA Baseline Characterisation, which can be obtained from the NRW website or from the link below: ▪ guidance-on-best-practice-for-marine-and-coastal-physical-processes-baseline-survey-and-monitoring-requirements-to-inform-eia-of-major-developement-projects.pdf (naturalresources.wales)	Consideration of the NRW GN41 guidelines has been applied to the assessment undertaken within this physical processes chapter of the ES.
NRW	Scoping Opinion, 06 January 2022	Additionally, if using numerical model simulations within the assessment of environmental effects for physical processes, we recommend following the NRW GN41 guidelines with specific reference to 'Advice to Inform Development of Guidance on Marine, Coastal and Estuarine Physical Processes Numerical Modelling Assessments'. Which can be accessed from the following link: ▪ Contents (naturalresources.wales)	Consideration of the NRW GN41 guidelines has been applied to the assessment undertaken within this physical processes chapter of ES (with specific relevance to the numerical modelling tasks).
NRW	Scoping Opinion, 06 January 2022	NRW are in the process of developing a position around the sustainable management of marine and coastal sediment, and it is likely to encourage retention of sediment, followed by beneficial uses which support ecosystem resilience ahead of other options. The position statement is likely to be available by Spring 2022; however, we are currently providing general advice to applicants ahead of this formal position statement. This advice has been presented within Annex 1.	This has been considered within the WHA and within the physical processes assessment, and has been informed by the modelling of the dredge disposal at the Mostyn Deep site.

Consultee	Reference, Date	Summary of Response	How Comments have Been Addressed in this Chapter
NRW	Scoping Opinion, 06 January 2022	Within Section 5.2.1 (Legislation, policy and guidance position) we would recommend the following: ▪ TAN14 Technical advice note (TAN) 14: coastal planning | GOV.WALES and TAN15 Technical advice note (TAN) 15: development, flooding and coastal erosion | GOV.WALES ▪ SMP2 North West and Wales – section 11a5 Dee Estuary ▪ Marine Physical Processes Guidance to inform Environmental Impact Assessment (EIA) marine-physical-processes-guidance-to-inform-environmental-impact-assessment-eia.pdf (cyfoethnaturiol.cymru)	Consideration of the TAN14 guidelines has been referenced within Section 6.5 of this physical processes chapter.
NRW	Scoping Opinion, 06 January 2022	We agree with the impacts scoped into the assessment but advise that the following impacts must also be considered: ▪ Coastal squeeze through HTL activities in relation to SMP2 North West and Wales (section 11a5 Dee Estuary). ▪ Removing sediment from the estuary system, if the option to use the sediment as infill is progressed. ▪ The increased need for maintenance dredging, the capacity for the disposal sites to sustainably dissipate material and the additional environmental disturbance it may cause.	Medium to long-term morphology changes – both locally and across the wider Dee Estuary have been considered in Section 6.7.5 (changes to sediment transport pathways); The disposal of material from the dredge at the Mostyn Deep disposal site has been assessed in Section 6.7.1; The maintenance dredge requirements have been assessed in Section 6.7.6; The potential impacts of the scheme on the wider estuary banks and channels have been assessed in Section 6.7.7.
NRW	Scoping Opinion, 06 January 2022	When discussing 'local' impacts, we recommend further definition is placed here.	The term 'local' has been described with reference to the 'near-field' and 'far-field' areas of effect.
NRW	Scoping Opinion, 06 January 2022	A discussion of present monitoring requirements will also aid understanding on the current licence conditions (DML2001 and DML1542v2) and how that will relate to the project application and proposal moving forward.	A review of the current monitoring requirements (in terms of proposed future monitoring campaigns) is included in Section 6.8.3 of this chapter.
NRW	Scoping Opinion, 06 January 2022	We advise that the Marine Physical Processes Guidance to inform Environmental Impact Assessment (EIA) is followed (link provided above).	Consideration of the NRW GN41 guidelines has been applied to the assessment undertaken within this physical processes chapter of the ES.

6.5 Implications of legislation, policy and guidance

This section of the chapter sets out key aspects and implications of policy and guidance that are relevant to the assessment of likely impacts on physical processes. It builds upon the overarching chapter covering Legislation, Policy and Guidance (Chapter 4). This will be kept under review as the assessment progresses.

6.5.1 Legislation

The Marine and Coastal Access Act 2009 (MCAA)

The MCAA provides the legal mechanism to help ensure clean, healthy, safe, productive and biologically diverse oceans and seas by putting in place a new system for improved management and protection of the marine and coastal environment.

The Habitats Regulations

The Conservation of Habitats and Species Regulations 2017 (as amended), known as the "Habitats Regulations", transposed the Habitats Directive (Directive 92/43/EEC) (European Union, 1992) and the Birds Directive (2009/147/EC) (European Union, 2009) into English law. The Conservation of Habitats and Species Regulations 2017 (as amended), remain part of domestic legislation now following the UK's departure from the European Union form part of EU-derived domestic legislation.

The Habitats Regulations provide for the designation and protection of 'European sites', the protection of 'European protected species' and the adaptation of planning and other controls for the protection of European sites. The Regulations also require the compilation and maintenance of a register of European sites in England, to include Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) (classified under the Birds Directive). These sites form the Natura 2000 network. In addition, Natural England (2017) advice suggests that these regulations apply to Ramsar sites (designated under the 1971 Ramsar Convention for their internationally important wetlands), candidate SACs (cSAC), potential Special Protection Areas (pSPA), and proposed and existing European offshore marine sites.

Where a development project is located close to, or within, a European/Ramsar Site, the "Habitats Regulations" apply. This requires the Competent Authority to determine whether the proposed works have the potential to create a likely significant effect (LSE) on the interest features and/or supporting habitat of a European/Ramsar site either alone or in-combination with other plans, projects and activities and, if so, to undertake an Appropriate Assessment (AA) of the implications of the proposals in light of the site's conservation objectives.

The overlapping and nearby European/Ramsar sites in relation to the proposed development are shown on Figure 8.4 in the Nature Conservation and Marine Ecology Chapter 8. An HRA has been undertaken given the direct overlap of the proposed development with the Dee Estuary SAC, SPA and Ramsar site and is included in Appendix 8.5.

The outcomes of the physical processes assessment reported within this chapter have informed the HRA, in particular with respect to the following key potential impact pathways:

- Changes to benthic habitats and species as a result of sediment deposition during piling, and capital/maintenance dredging and disposal activities;
- Indirect changes to seabed habitats and species as a result of changes to hydrodynamic and sedimentary processes due to new quay wall and reclamation, and capital/maintenance dredging and disposal activities;

- Changes in water and sediment quality during piling, and capital/maintenance dredging and disposal activities; and
- Indirect changes to seabed habitats for fish as a result of changes to hydrodynamic and sedimentary processes due to capital/maintenance dredging and disposal activities.

The Water Framework Regulations

The Water Framework Directive (WFD) (2000/60/EEC) establishes a framework for the management and protection of Europe's water resources. It is implemented in England and Wales through the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (as amended), known as the "Water Framework Regulations".

The overall objectives of the WFD as implemented by the "Water Framework Regulations" is to achieve "good ecological and good chemical status" in all inland and coastal waters by 2021 unless alternative objectives are set or there are grounds for time limited derogation. For example, where pressures preclude the achievement of good status (e.g. navigation, coastal defence) in heavily modified water bodies (HMWBs), the WFD provides that an alternative objective of "Good ecological potential" is set.

In terms of physical processes, "Good ecological status/potential" has regard to hydromorphological elements. The Good ecological status/potential assessment also considers biological and physicochemical quality elements, and specific pollutants. "Good chemical status" has regard to a series of priority substances and priority hazardous substances.

A WFD Compliance Assessment has been undertaken to determine whether the proposed development complies with the objectives of the WFD and is provided in Appendix 7.1. This includes consideration of the potential risks for several key receptors, including hydromorphology. The WFD Compliance Assessment has been informed by the outcomes of the physical processes assessment reported within this chapter.

The Waste Regulations

Waste policy and, consequently, the Waste Hierarchy Assessment (WHA) are strongly governed by the waste hierarchy set out in Article 4 of the Waste Framework Directive (2008/98/EC). This Directive was transposed in England and Wales through the Waste (England and Wales) Regulations 2011. The waste hierarchy ranks waste management options according to what is best for the environment.

The waste hierarchy places emphasis on waste prevention or minimisation of waste, followed where possible by re-use of the material. For any dredging project, the *in-situ* characteristics of the material (physical and chemical), the method and frequency of dredging (and any subsequent processing), determines its characteristics in the context of securing a consent that is in compliance with the waste hierarchy. This understanding is central to the consideration of management options for dealing with dredged material in light of the requirements of the WHA.

Where avoidance of dredging is not possible, then the volume to be dredged should be minimised, and options for the re-use of the material, recycling and other methods of recovery must be considered in the first instance. In the context of re-use and recycling of dredge material this could include engineering uses, agricultural and product uses, environmental enhancement or post treatment of the dredge material to change its character with a view to determining a potential use. Should no practical and cost-effective solutions be identified, only then can options for the disposal of the dredged material be considered. These include marine disposal in licensed deposit sites or land-based disposal in terrestrial landfill.

A WHA for the MEPE Project has been undertaken to determine the Best Practical Environmental Option (BPEO) for dealing with the dredge arisings. The WHA is included in Appendix 6.1 and has been informed by the outcomes of this physical processes assessment.

6.5.2 National policy

National Policy Statement for Ports (NPSfP)

The NPSfP provides the framework for decisions on proposals for new port developments (DfT, 2012). This policy requires that in order to meet the requirements of the Government's policies on sustainable development, new port infrastructure should, amongst other things, assess the impact on coastal processes, be adapted and resilient to the impacts of climate change and provide high standards of protection for the natural environment.

It also advises that applicants should assess the impact of the proposed project on coastal processes and geomorphology, including by taking account of potential impacts from climate change. If the development has an impact on coastal processes, the applicant must demonstrate how the impacts will be managed to minimise adverse impacts on other parts of the coast.

The policy advice extends to the need also to assess the vulnerability of the proposed development to coastal change in the context of climate change during the project's operational life and any decommissioning period (Section 5.3 of the NPSfP).

UK Marine Policy Statement (MPS)

The MPS is the framework for preparing marine plans and taking decisions affecting the marine environment. The MPS also sets out the general environmental, social and economic considerations that need to be taken into account in marine planning and provides guidance on the pressures and impacts that decision makers need to consider when planning for and permitting development in the UK marine areas.

Section 2.6.8 of the MPS is relevant to the physical processes assessment. In particular, paragraph 2.6.8.4 states, amongst other things, that - "*Marine plan authorities should be satisfied that activities and developments will themselves be resilient to risks of coastal change and flooding and will not have an unacceptable impact on coastal change…*". In addition, paragraph 2.6.8.6 notes that the impacts of climate change throughout the operational life of a development should be taken into account in assessments, and that any geomorphological changes that an activity or development has on coastal processes, including sediment movement, should be minimised and mitigated.

UK Marine Strategy

The aim of the UK Marine Strategy is effectively to protect the marine environment across the UK. The Strategy sets out a comprehensive framework for assessing, monitoring and taking action to achieve the UK's shared vision for clean, healthy, safe, productive and biologically diverse seas (Defra, 2019). It aims to achieve good environmental status of marine waters by 2020 (followed by a six-year review) and to protect the resource base upon which marine-related economic and social activities depend. The Strategy constitutes the vital environmental component of future maritime policy, designed to achieve the full economic potential of oceans and seas in harmony with the marine environment.

The UK Marine Strategy applies to the landward boundary of coastal waters as defined under the WFD (i.e. from mean high water springs (MHWS)) to the outer limit of the UK Exclusive Economic Zone (EEZ), as well as the area of UK continental shelf beyond the EEZ. Reporting against the Strategy is a cyclical process, and updated assessments and Marine Strategy documents are anticipated in due course. The anticipated pressures exerted on the marine environment by the MEPE Project are considered to be of sufficiently small magnitude, in the context of UK Marine Regions, that they are unlikely to be a significant issue. The Strategy is, therefore, not considered further in this ES with regards to the physical processes assessment.

Welsh National Marine Plan

The Welsh National Marine Plan (Welsh Government, 2019) is the first marine plan for Wales and represents that start of a process to shape seas to support economic, social, cultural and environmental objectives. The plan was prepared and adopted under the MCAA 2009 for the purposes of Section 51 of the MCAA and in accordance with the UK MPS.

The following marine plan policies are of particular relevance to the physical processes topic:

- **Policy SOC_08 Resilience to coastal change and flooding**: Proposals should demonstrate how they are resilient to coastal change and flooding over their lifetime;
- **Policy SOC_09 Effects on coastal change and flooding**: Proposals should demonstrate how they: avoid significant adverse impacts upon coastal processes; and minimise the risk of coastal change and flooding; Proposals that align with the relevant Shoreline Management Plan(s) and its policies are encouraged; and
- **Policy SOC_11 Resilience to climate change**: Proposals should demonstrate that they have considered the impacts of climate change and have incorporated appropriate adaptation measures, taking into account Climate Change Risk Assessments for Wales. Proposals that contribute to climate change adaptation and/or mitigation are encouraged.

The implications of the proposed development on these policies and other WNMP policies are reviewed in the marine plan conformance assessment included in Appendix 4.1 of this ES.

Well-being of Future Generations (Wales) Act

The Well-being of Future Generations (Wales) Act is concerned with improving the social, economic, environmental and cultural well-being of Wales. It requires public bodies to consider the long-term issues, work better with people and communities and each other, look to prevent problems and take a more joined-up approach.

Environment (Wales) Act

The Environment (Wales) Act 2016 sets out the legislative framework to promote the 'Sustainable Management of Natural Resources in Wales'. The Act received Royal Assent in 2016. It delivers against Welsh Government Programme for Government commitment to introduce new legislation for the environment (Welsh Government, 2016).

North West Marine Plan

The North West Marine Plan covers the north west inshore and north west offshore marine plan areas. The Plan introduces a strategic approach to planning within the English inshore and offshore waters between the Solway Firth border with Scotland and the River Dee border with Wales. It provides a clear, evidence-based approach to inform decision-making by marine users and regulators on where, when or how activities might take place within the north west inshore and north west offshore marine plan areas. The plan was prepared and adopted under the MCAA 2009 for the purposes of Section 51 of the MCAA and in accordance with the UK MPS.

Given the Dee Estuary overlaps both the Welsh and English jurisdictions, the following marine plan policies are considered of particular relevance to the physical processes topic:

- **NW-CC-3**: Proposals in the north west marine plan areas, and adjacent marine plan areas, that are likely to have significant adverse impact on coastal change, or on climate change adaptation measures inside and outside of the proposed project areas, should only be supported if they can demonstrate that they will, in order of preference: a) avoid b) minimise c) mitigate -adverse impacts so they are no longer significant.

This policy complements and is in line with WNMP Policy SOC_09 Effects on coastal change and flooding and Policy SOC_11 Resilience to climate change. The implications of the proposed development on WNMP policies are reviewed in the marine plan conformance assessment included in Appendix 4.1 of this ES.

6.5.3 Guidance

Technical Advice Note (TAN) 14

TAN 14 'Coastal Planning' was published in March 1998 by the WAG and gave guidance to planning authorities in Wales on the considerations to be given for proposed developments in coastal zones. This has since been incorporated into the December 2021 update to TAN 15 ('Development and Flood Risk').

6.6 Description of the existing environment

The proposed works are located within the Mostyn Statutory Harbour Authority (SHA) on the southern shoreline of the Dee Estuary. The Dee is a funnel-shaped estuary, around 30 km in length and with a maximum width of 8.5 km towards its mouth, where Mostyn is situated. The River Dee rises in Snowdonia, Wales, flows east via Chester, England and discharges into the Dee Estuary between the Wirral Peninsula in England and Wales where the Port of Mostyn is situated.

6.6.1 Bathymetry

The bathymetry in the outer and mid-estuary is governed by the variation in tidal flow passing into the estuary on the Welsh side (through the Welsh Channel), and the proportion which passes out on the English side through the Hilbre Channel. The bathymetry suggests that the subtidal flood flows are typically dominant in the Welsh Channel. The ebb flow, however, is variable between the Hilbre and Welsh Channels.

The Port of Mostyn sits between Mostyn Bank and Salisbury Bank, both of which sit at between 0 and 4 m above CD. To the northwest of the Port is the Welsh Channel, which is over 20 meters deep (see Figure 6.2). Throughout the Dee Estuary, a complex system of intertidal and subtidal banks and channels exists, which are in constant flux. The overall estuary morphology is defined by the relative dominance of the main flood and ebb channels.

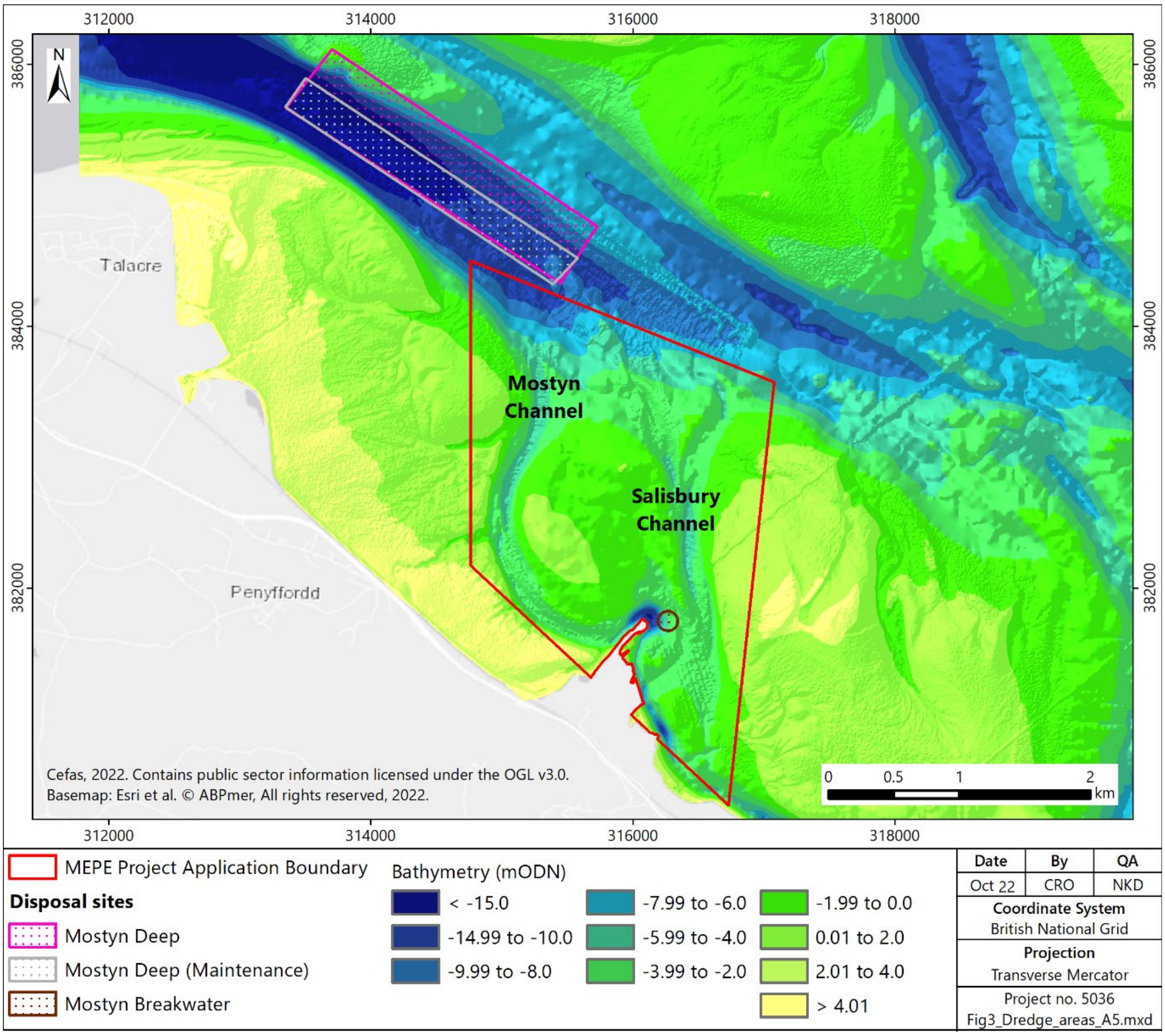

Figure 6.2. Bathymetry in the area of the proposed development

6.6.2 Tides and water levels

The Dee Estuary is hyper-tidal (>6 m tidal range on mean spring tides). The tidal regime is semi-diurnal with mean spring tidal ranges of 7.8 m and 4.1 m on mean neap tides (UKHO, 2021). Further towards the mouth of the estuary, spring and neap ranges at Hilbre Island are similar at 7.7 m and 4.1 m, respectively. Standard tidal water levels for the Port of Mostyn and Hilbre are provided in Table 6.2.

Maximum tidal ranges at Mostyn approach 10 m. Near the head of the estuary the tidal extent is restricted by a weir at Chester where mean spring and neap tidal ranges are 3.4 m and 1.7 m respectively. On average tides, water levels are generally similar across both the English and Welsh sides of the estuary mouth. On maximum tidal ranges (approaching astronomic tidal ranges) water levels are generally slightly higher on the east (English side) causing a small tidal gradient across the mouth. The average tidal prism for the Dee Estuary is of 4 x 10^8 m^3 with a mean annual river discharge of 31 m^3/s, meaning the estuary is tidally dominant (Bolaños *et al.*, 2009).

Table 6.2. Tidal levels for the Port of Mostyn and Hilbre Island

Tidal Level	Tidal Elevation (m above CD)	
	Mostyn	Hilbre Island
Highest Astronomical Tide (HAT)	9.8	10.2
Mean High Water Spring (MHWS)	8.9	9.0
Mean High Water Neap (MHWN)	7.0	7.2
Mean Tide Level (MTL)	4.89	5.15
Mean Low Water Neap (MLWN)	2.9	3.1
Mean Low Water Spring (MLWS)	1.1	1.3
Lowest Astronomical Tide (LAT)	0.2	0.1
Astronomic Range (HAT - LAT)	9.6	10.1
Mean Spring Range (MHWS - MLWS)	7.8	7.7
Men Neap Range (MHWN - MLWN)	4.1	4.1

Source: Admiralty Tide Tables (2022)

6.6.3 Flows

In general, the large tidal ranges in the Dee Estuary result in strong tidal currents and create a very high energy, dynamic system (Moore *et al*., 2009). Flow speeds are typically lower in the Welsh Channel than the Hilbre Channel, peaking at around 0.8 m/s on both the flood and ebb tides. In contrast, flows within the Hilbre Channel peak at over 1.2 m/s.

Flood tide duration is *circa* 1.5 hrs shorter than the ebb tide, indicating generally faster flows on the flood and suggesting a flood dominated flow regime during spring tide phases. The difference in flood/ebb tide duration increases with distance up-estuary, due to tidal propagation. Throughout the upper part of estuary (generally south of Flint), the flood tide has a shorter duration by approximately 2 to 3 hours, compared to over 9 hours on the ebb (Pye, 1996; Parsons *et al*., 2013). This asymmetry in the tide throughout the estuary is a dominant factor in causing residual sediment transport and morphological changes (Moore *et al*., 2009).

Baseline current speed and flow vectors for peak ebb and flood (mean spring) tidal states are presented in Figure 6.3.

These figures show that the main flows into and out of the Dee Estuary are through the main Welsh and Hilbre Channels, continuing up-estuary through the central part of the estuary. Within and around the Port of Mostyn, flows are concentrated within the Mostyn and Salisbury Channels, which cut through the intertidal Mostyn and Salisbury Banks. Due to the continued southwesterly migration of the Mostyn Channel, it is the Salisbury Channel (the eastern-most of the two, see Figure 6.2) which the Port currently uses to provide access to and from the existing berths.

Up-estuary of the Port, along the foreshore between Mostyn and Llannerch-y-Môr, the deeper channel (to the south of the intertidal Salisbury Bank) carries local flows up-estuary, where they join the main channel before continuing along the Welsh coastline from Holywell to the canalised section upstream of Connah's Quay.

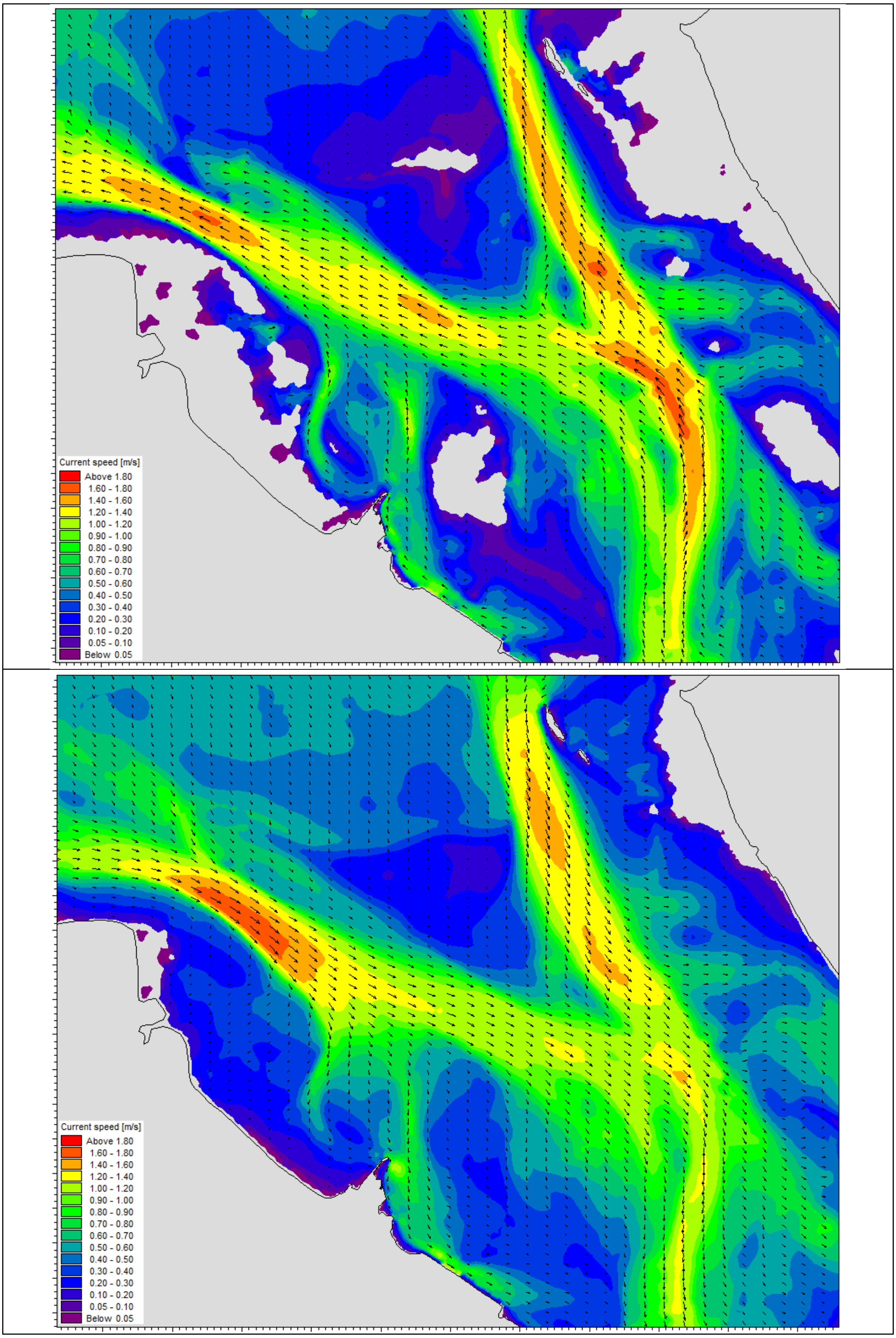

Figure 6.3. Mean spring tide current speed on peak ebb (top) and peak flood (bottom)

6.6.4 Freshwater flows and salinity

A salinity gradient within the Dee Estuary occurs due to an interface between freshwater fluvial discharge of the River Dee, and saline water entering the estuary mouth from Liverpool Bay and the Irish Sea. The overall regime has been observed and assessed within a number of existing research studies (e.g.. Barber *et al.* (2009); Bolaños *et al.*, 2009; ERM, 2007), particularly using numerical models to determine how density effects within the estuary vary as a result of forcing parameters such as wind, waves and fluvial discharge.

The freshwater flow of the River Dee is regulated by a series of weirs, reservoirs and dams along its length prior to entering the estuary (Lambert, 1988). However, maximum discharge can reach over 180 m^3/s during extreme cases. Freshwater influence is greatest towards the head of the estuary (Parsons *et al.*, 2013), lowering the salinity of the upper estuary compared to the estuary mouth. Average fluvial discharge into the estuary is suggested to be *circa* 35 m^3/s based on a long record at Chester Weir and equates to between 10 and 15% of the combined estuary discharge (Pye, 1996).

6.6.5 Waves

The general wave climate throughout the Flintshire and Wirral coastlines is primarily driven from offshore generation in the Irish Sea. A limited amount of sheltering from the westerly directions is provided by Anglesey. The most exposed directions are typically northerly or north-westerly, where waves can propagate generally unaffected from the northwest coast of England (northerly) and the east coasts of Ireland and Northern Ireland (north-westerly). The only interfering land mass is the Isle of Man, however, the effective fetch from this is still significant at over 110 km. The majority of waves are, therefore, generated from within the Irish Sea, which is effectively a closed basin. Consequently, long-period Atlantic swell waves rarely occur. Most storm wave energy that affects the entrance to the Dee Estuary has periods of the order of 5 to 7 seconds. A wave rose at the entrance to the Dee Estuary, derived from hindcast wave model data over the period between 1979 and 2021, is presented in Figure 6.4.

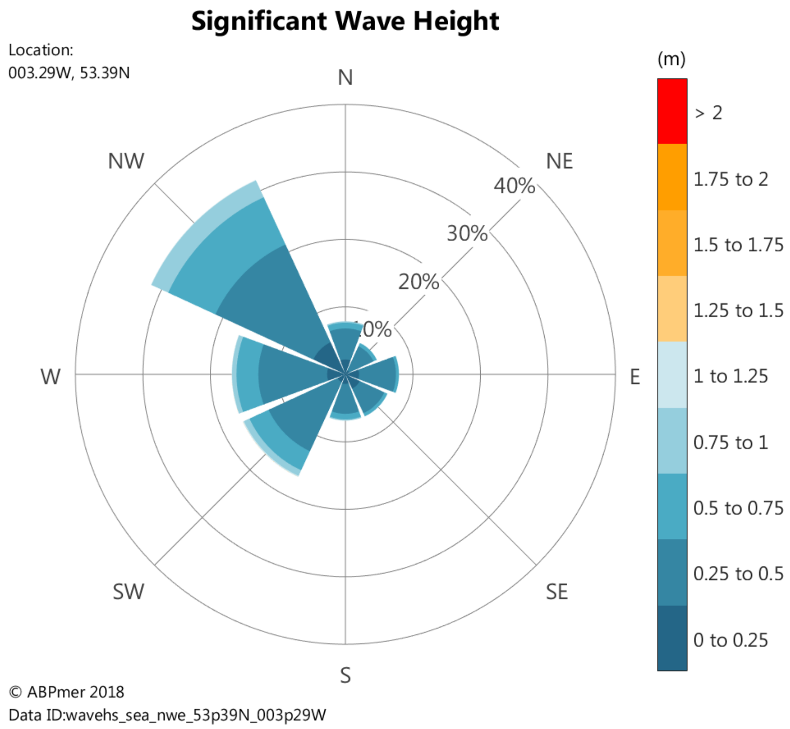

Figure 6.4. Wave rose at the entrance to the Dee Estuary

It is understood that mid and upper sections of the estuary are predominantly sheltered from the offshore derived wave conditions, with large intertidal sandbanks in the outer estuary and approaches across the southern part of Liverpool Bay (namely the West Hoyle Spit, West Hoyle Bank and East Hoyle Spit) providing considerable protection to the inner estuary (Wolf *et al.*, 2006, Parsons *et al.*, 2013). This is particularly the case during lower tide levels, where most of the high-energy waves are partially dissipated via wave shoaling and/or wave breaking. At the Port of Mostyn, there is effectively no fetch available for a period of around 3 hours either side of low water, as a result of the sheltering by the local banks. Consequently, the wave regime at the Port only exists over the top part of the tide (and more notably on spring tides).

6.6.6 Sediments

Seabed sediments

A variety of seabed sediment types are found in the Dee Estuary (Port of Mostyn, 2013). The bed comprises recent deposits of sand and mud in a trough eroded in glacial deposits of boulder clay, silts, sands and gravel deposited by ice. The post glacial inundation of the valley by the sea started the process of sediment accretion and the underlying solid geology is now overlain generally by 20 m to over 30 m of subsequently deposited sediment. The estuary sand is generally of uniform grading within a narrow envelope (Port of Mostyn, 2013). The majority of the sediment in the area of the Inner Channel and berthing area is a medium grained sand, with only a small proportion of finer material present. The particle size of the sand on the seabed along the whole navigation channel (outer and inner) shows little variation between offshore Prestatyn and the Port (ERM, 2007).

Seabed grab sampling has been undertaken to support the application for the MEPE Project (Figure 6.5), along with boreholes for contamination analysis, which are described in more detail in the Water and Sediment Quality Chapter 7. In addition, long-term annual monitoring for the existing dredge and disposal licences held by the Port of Mostyn also require the periodic collection of seabed grab samples across the wider study area (Figure 6.6). The Particle Size Distribution (PSD) of the project-specific seabed grab samples (Figure 6.5) is summarised in Table 6.3. Further detail is provided in Appendix 8.1.

Table 6.3. Summary PSD of MEPE intertidal and subtidal seabed grab samples

Sample	% composition		
	Silt (< 63 µm)	Sand (63 µm to 2 mm)	Gravel (> 2 mm)
Intertidal 1	66.7	33.3	0.0
Intertidal 2	84.9	15.1	0.0
Intertidal 3	81.5	18.5	0.0
Intertidal 4*	16.7	83.3	0.0
Intertidal 5*	1.7	98.3	0.0
Intertidal 6*	3.8	96.2	0.0
Intertidal 7*	9.3	90.7	0.0
Subtidal 1*	46.7	52.6	0.6
Subtidal 2	79.8	20.2	0.0
Subtidal 3	72.0	27.9	0.0
Subtidal 4	13.9	86.0	0.1
Subtidal 5*	9.3	90.5	0.2
Subtidal 6	4.8	95.0	0.3
Average (all samples)	**37.8**	**62.1**	**0.1**
Average* (capital dredge)	**14.6**	**85.3**	**0.1**
* Samples within the MEPE berth pocket capital dredge area			

The most recent seabed grab sampling, to inform the ongoing annual monitoring for the existing dredge and disposal licences, was carried out in June 2022. The sample locations across the wider study area are shown in Figure 6.6, with summary PSD information provided in Table 6.4. The latest annual sampling campaign was unable to collect samples from three of the predefined locations as a result of natural variability in the extents and alignments of the local banks and channels (meaning the three locations in question were subtidal at the time of sampling). During the Spring 2022 survey, only relatively minor changes in habitat were recorded with key characteristics remaining broadly similar to previous monitoring at the majority of sites.

Figure 6.5. Project specific grab sample locations

In summary, tide-swept sandflat habitat continued to extend through much of the intertidal areas surrounding the central and outer Approach Channel. This included much of the central and eastern sections of Transects A, B and Y (Sites A5-A8, B4-B6 and Y6), the western sections of Transects C and W (Sites C1-C2 and W1-W2) and Transect D (Sites D2-D3).

There was stable mudflat habitat, as observed during previous years, along the inner sections of the eastern Mostyn Bank (Sites A3 and B2) and on the eastern margins of the Mostyn Channel (B3). Observations also suggest that the muddy sand habitats of the middle of Salisbury Bank (W4, C3 and C4) have remained largely unchanged in recent years.

The main habitat changes were focused within the area between the Mostyn Channel and Salisbury Channel (Y5) and the W Transect (broad areas where changes were also observed in 2021). As in previous years, these changes are deemed to be a function of natural morphological shifts in these locations, rather than a response to the very limited dredging work that takes place.

Table 6.4. Summary PSD of June 2022 monitoring seabed grab samples

Sample	% Composition		
	Silt (< 63 µm)	Sand (63 µm to 2 mm)	Gravel (> 2 mm)
A3	36.7	63.3	0.0
A4	43.6	56.4	0.0
A5	8.5	91.5	0.0
A6	6.9	93.1	0.0
A7	0.0	100.0	0.0
A8	3.5	96.5	0.0
B2	51.0	49.0	0.0
B3	57.2	42.8	0.0
B6	0.3	99.7	0.0
C1	4.3	95.7	0.0
C2	6.1	93.9	0.0
C3	30.5	69.5	0.0
C4	34.4	65.6	0.0
D2	5.6	94.4	0.0
D3	6.2	93.8	0.0
W1	0.0	100.0	0.0
W2	0.0	100.0	0.0
W3	36.2	63.8	0.0
W4	43.2	56.8	0.0
W5	24.5	75.5	0.0
Y4	5.7	94.3	0.0
Y5	46.8	53.2	0.0
Y6	0.0	100.0	0.0

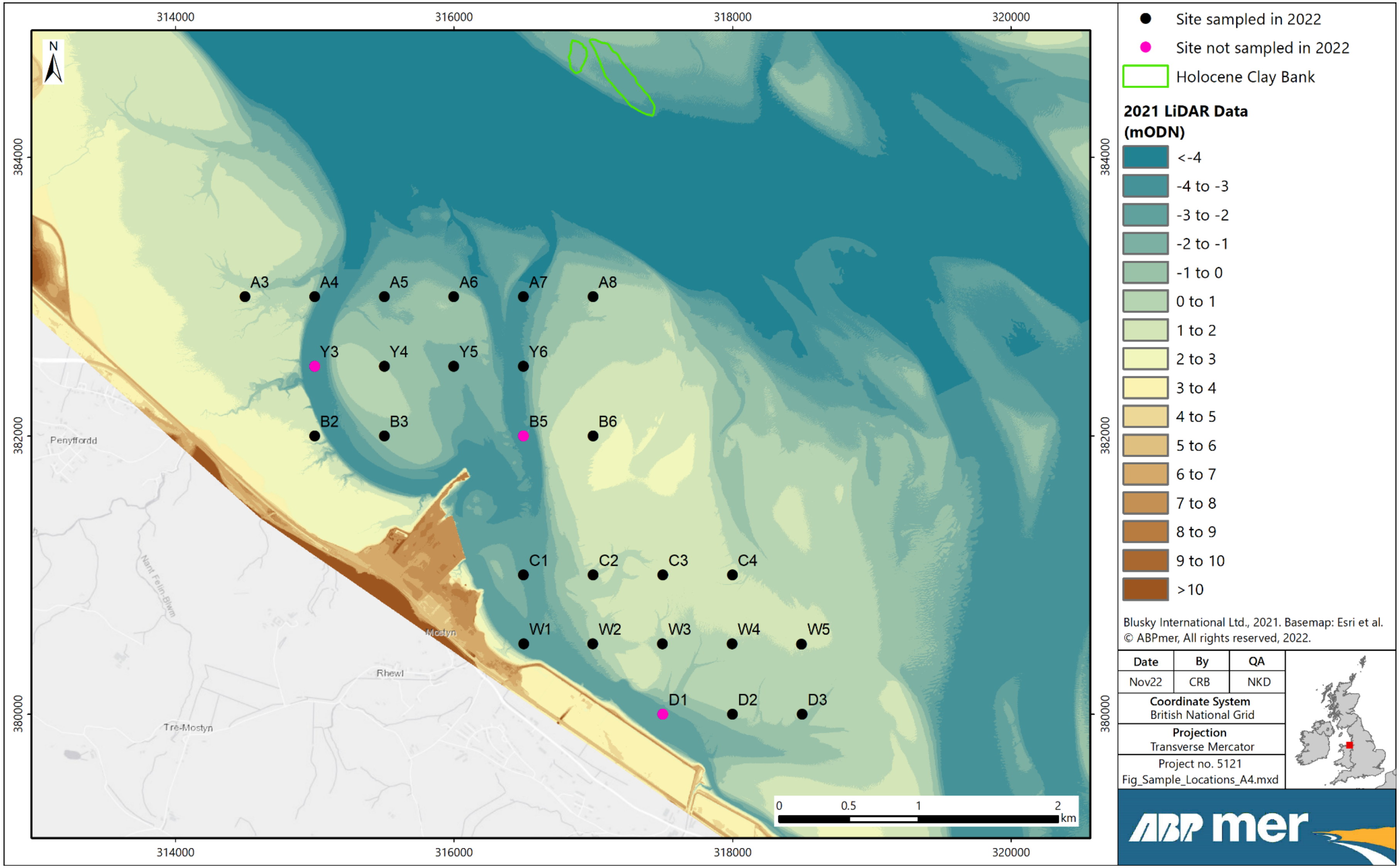

Figure 6.6. Grab sampling from June 2022 across the wider study area

Suspended sediments

Water quality monitoring has been undertaken by NRW (as part of the Shellfish Waters monitoring) between 2000 and 2012. Within the main estuary channels (Welsh Channel and Hilbre Channel), this annual monitoring data revealed suspended solid concentrations (SSC) to be consistently higher within the Welsh Channel, with values ranging from 23.9 to 57.2 mg/l (mean 37.2 mg/l), compared to the Hilbre Channel, with values ranging from 11.8 to 45.5 mg/l (mean 21.9 mg/l). Suspended and seabed sediments in the Dee contain a diverse assemblage of non-cohesive and cohesive sediments (Bolaños *et al.*, 2009). Typical maximum SSC in the mouth of the Dee Estuary is around 200 mg/l (NWP, 2002).

It is noted that this past annual monitoring data represents spot samples at two sampling points within the estuary and does not provide information of the full spatial coverage or possible temporal variability in SSC. To assess this further the Port obtained SSC readings from areas in front of the Port during Phase 1 and 2 of the original Port of Mostyn MEP development. The results obtained from water samples varied greatly (from around 50 to 200 mg/l outside the Port) due to differences in the tidal state. This temporal variability was also identified by continuous water logging data (Figure 6.7), which describe a typical tide-driven pattern of high turbidity levels on the flooding tide with smaller peaks on the ebb.

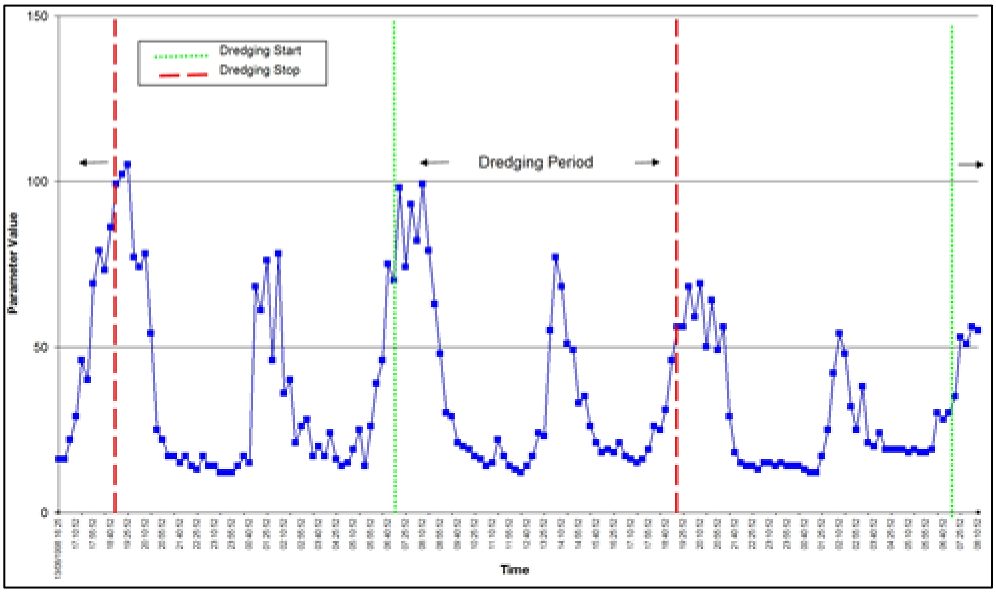

Figure 6.7. Typical turbidity readings (NTU) at Port of Mostyn during dredging activity

6.6.7 Morphology

The morphological conditions and evolution of the Dee Estuary were reviewed by Barber *et al.* (2009) and are the subject of the ongoing annual monitoring surveys undertaken by the Port (e.g. ABPmer, 2022). They undertook a review of available historic charts and put forward a conceptual interpretation of the changes that were observed. This study generally concluded that variability of the bathymetry in the outer and mid-estuary is governed by the variation in tidal flow passing into the estuary on the Welsh side, and the proportion which passes out on the English side through the Hilbre Channel.

6.6.8 Future baseline

At present, the Dee Estuary has been identified as an overall sediment sink, and material imported into the estuary consists primarily of sand and finer silts/muds, with very small amounts of coarser gravels. The principal source of material into the estuary is from Liverpool Bay.

The overall hydrodynamic properties in the Dee Estuary are complex, with the main channels within the estuary having different dominant characteristics and flow patterns. Numerous studies have investigated the influence of stratification, river flow, meteorological forcing, waves and wind effect and their respective contributions to the overall hydrodynamics and sediment transport regime.

Hydrodynamic and sedimentary processes will continue to be influenced by natural and human-induced variability, ongoing cyclic patterns and trends (e.g. ongoing maintenance dredging and disposal) with or without the proposed development.

It is also important to recognise the potential effects of climate change on the Dee Estuary's future baseline. Future changes in Relative Sea Level (RSL) are quoted as the net effect of geological adjustments in land levels and the projected absolute changes in mean sea level. A summary of the United Kingdom Climate Projections (UKCP18) relative Sea Level Rise (SLR) projections (Palmer *et al.*, 2018) up to 2100 has been extracted from the UKCP18 database for the grid cell at the entrance to the Dee Estuary. The 2100 SLR prediction is calculated to be an increase in mean sea level of 0.93 m from 2021 levels, based on the conservative RCP 8.5 95%ile emissions scenario. Water levels in the future, as now, will also be affected by meteorological surge and weather-related events.

6.7 Impact assessment

This section identifies the potential likely effects on physical processes and associated relevant receptors as a result of the construction and subsequent operation of the MEPE project.

The following impact pathways have been assessed:

Construction phase

- Changes to SSC and sedimentation as a result of construction activities (piling, dredging and disposal); and
- Changes in seabed bathymetry as a result of dredged disposal.

Operational phase

- Changes to hydrodynamic regime (flow speed and direction) as a result of the new quay wall (piling) and capital dredging;
- Changes to the wave regime, as a result of the new quay wall (piling) and capital dredging;
- Changes to the sediment transport pathways, as a result of localised changes to the driving hydrodynamic (and wave) forcing;
- Changes SSC, sedimentation and seabed bathymetry as a result of maintenance dredging and disposal;

Following the impact pathway assessments described above, consideration of the significance of potential impacts to defined physical process receptors has also been undertaken:

- Potential impact on receptors, including marine infrastructure and (local and regional) estuary banks and channels.

In addition, the potential risks to human health, the potential impacts on climate and the vulnerability of the proposed development to climate change, as well as to risks of major accidents and/or disasters have been considered in the context of the potential likely effects on physical processes.

Cumulative impacts on physical processes could arise as a result of other coastal and marine developments and activities. These have been considered as necessary as part of the cumulative impacts and in-combination effects assessment included in Chapter 13 of this ES.

6.7.1 Changes to SSC and sedimentation as a result of construction activities

The disposal of dredged material at sea associated with the construction phase of the proposed development will be fulfilled at the licensed Mostyn Deep (IS102) disposal site (see Project Methodology Chapter 3 of this ES).

The potential impact of dredge arisings (and spoil from removal to licensed disposal sites) on SSC and sedimentation has been assessed. The approach has used the dredge volumes provided by the project engineers and expert knowledge of the likely dredging process and of the availability of open disposal sites. The assessment has been informed through application of the calibrated numerical hydrodynamic modelling tool, which has been used to drive a Danish Hydraulic Institute (DHI) particle tracking module.

It is anticipated that most of the dredging for the berth pockets will be carried out by a cutter suction dredger on a continuous cycle of dredging. Dredging of the main approach channel is likely to be undertaken by Trailer Suction Hopper Dredger (TSHD). These dredging methods have been assessed here as a worst-case for potential impact on SSC (resulting from release of material at the bed during dredging and throughout the water column during disposal). The number of 'dredge/disposal' cycles will be determined by the vessel size and the time of transit to and from the disposal grounds. For this assessment, a continuous process has been assumed such that the works will be a 24/7 operation until dredging is complete. This assessment has assumed that vessel access to the berth and disposal sites can be achieved throughout the full tidal cycle (this is considered to be a conservative, worst-case assumption for dredging and disposal operations and the subsequent plume development). Current dredge volume estimates (based on the latest available site-specific geotechnical and geophysical information) are for up to 600,000 m^3 of material to be pumped ashore for reuse as fill, alongside up to 3 million m^3 (*in situ*) of material for disposal at the Mostyn Deep site.

The numerical modelling tools (described further in Appendix 6.2) have been applied to assess the repeating cycle of dredging at the planned berth pockets and approach channel and disposal of material (primarily from the approach channel) at the Mostyn Deep (IS102). The composition of the dredged material (and that of the subsequent disposal) has been informed by the sediment sample analysis carried out for the project, as described in Section 6.6. In addition, the following assumptions have informed the plume assessment, based on an understanding of the method and equipment to be used:

- A continuous dredge operation (and associated disposal) would provide maximum production and greatest potential for magnitude in plume;
- Typical rates, vessel speeds and distance to disposal site have been used to calculate typical dredge cycle times.
- Deposit time at the disposal site is 10 minutes;
- Characteristic sediment distribution is informed by the bed sampling (detailed in Section 6.6.6 and in Appendix 6.2);
- The dredged (and disposed) material consists of a mixture of muds, silts and sand material, based on the PSD of the grab sampling (summarised in Appendix 6.2);

- Inputs to the plume modelling from the dredge are applied 2 m above the bed, accounting for the action of the cutter head, with the majority of the berth dredge arisings subsequently used for the infill of the new quay wall;
- Inputs to the plume modelling from the deposit at the disposal site are applied both at the bed (from the deposit) and also just below the surface (from the initial release, based on the loaded draught of the hopper); and
- At the disposal site, the sediment predominantly falls to bed as a density current and is then available for onward advection through bed erosion processes.

The model has then been used to test a range of dredge/disposal scenarios:

- Continuous dredge/disposal operations on a continuous cycle;
- Single disposal of loaded hopper on the peak of the spring flood tide;
- Single disposal of loaded hopper on the peak of the spring ebb tide;
- Berth dredge plume arising from operations over the peak of the spring flood tide; and
- Berth dredge plume arising from operations over the peak of the spring ebb tide.

Spatial dispersion of dredge plume and sedimentation

Following the above approach (numerical modelling of repeating dredge/disposal operations), the particle tracking model has been run with sequential 'dredge > disposal > dredge > ... etc.' cycles. The initial dredge commences during a mean spring tide and the cycle repeats for the remainder of the model run period. Dredge locations are centred within the proposed berth, whilst disposal inputs are at the centre of the Mostyn Deep (IS102) disposal site.

Figure 6.8 shows the maximum spatial extent of the combined dredge/ disposal SSC plume over peak flood and peak ebb tidal flows (on a spring tide).

For dredge arisings disposed at the Mostyn Deep (IS102) disposal site, it is anticipated that material will initially remain in suspension (when deposited during flood or ebb tidal flows), before settling to the bed during slack water around high water (HW) and low water (LW) periods. Once deposited to the bed, the material will return to the background sedimentary system for subsequent transport under flood or ebb tidal flows. Maximum SSC levels are associated with the disposal activities (with relatively small increases in SSC arising from the dredge itself). Peak excess SSC levels resulting from the disposal activities are greatest (above 2,000 mg/l) at the point of release, reducing to around 600-800 mg/l within a distance of around 500 m from the disposal location. As the plume disperses, the peak excess SSC values reduce further, typically reaching 100-200 mg/l within a distance of around 1 km from the edges of the Mostyn Deep disposal site. Overall, the resultant plume typically extends up to 3.5 km from the disposal site, aligned with the dominant northwest / southeast tidal flow axis (Figure 6.8).

Increased SSC as a result of the dredge activity is generally limited in extent to the dredge site itself. Across the proposed berth and reclamation area, excess SSC values of up to 500-700 mg/l are predicted, quickly dispersing to less than 20 mg/l within a distance of around 300 m of the dredge site.

In practice, due to the high magnitude of (and wide envelope of variability in) background SSC levels (see Section 6.6.6), the predicted increase in concentrations resulting from the disposal activities is likely to become immeasurable (against background) within approximately 1-2 km of the disposal site. Furthermore, the effects of the proposed dredge and disposal operations are considered to be no different to those arising from the ongoing maintenance dredge/disposal activities that are presently carried out within the existing berths and approach channel. The measurable plume from each disposal operation is only likely to persist for a single tidal cycle (less than 6 hours from disposal). After this time, the dispersion under the peak flood or ebb tidal flows means concentrations will have reverted to background levels. Increased concentrations arising from the dredge operations are of lower magnitude and persist over a shorter distance (and time) than that from the disposal (Figure 6.8).

Across the whole modelled period with continuous dredging/disposal operations, the maximum SSC (throughout the full modelled period) is shown in Figure 6.8. Associated sedimentation (Figure 6.8) to the bed extends up- and down-estuary from the disposal site and in proximity to the dredged berth pocket. Peak sedimentation depths within the disposal site are around 50-60 mm, reducing to around 4-6 mm within a distance of approximately 1 km from the disposal site. At the dredge location, increased sedimentation above 10 mm is predicted within around 500 m, mainly across the proposed reclamation area, with sedimentation reducing to 1-2 mm off the end of the existing breakwater. Outside of these areas, the majority of deposition levels across the study area are less than 1 mm. Once on the bed, the deposited material returns to the background system to be put back into suspension on subsequent peak flood or ebb tides to be further dispersed.

Example timeseries plots of predicted excess SSC and associated sedimentation (from the combined dredge/disposal operations) are provided in Figure 6.9 for three locations: one just up-estuary and one just down-estuary of the Mostyn Deep (IS102) disposal site, and a third in proximity to the berth pocket dredge. As described above, peak SSC and sedimentation values are predicted at the disposal site whilst, at locations approximately 1 km up- and down-estuary, the timeseries plots show the temporal nature of the excess material. Each disposal results in peak SSC of around 200 mg/l at the selected locations (approximately 1 km from the disposal source). Each peak in SSC generally persists for a single timestep before the tidal forcing transports the plume further up/down estuary on the prevailing flood/ebb tide, respectively. Due to the timing of successive disposal events (and the subsequent tidal dispersal of the resultant plume), there is no evidence of cumulative increases in SSC (i.e. the impact from each disposal is dispersed sufficiently before the next disposal, such that there is no predicted positive trend in excess SSC with sequential disposal events). In the vicinity of the berth pocket dredge timeseries location, increased SSC values are up to around 80 mg/l. Dispersion over the spring tides results in higher concentrations when compared to the lower flows on the neap tide.

Associated with this, each disposal operation results in sedimentation of around 1-2 mm at locations around 1 km from source. Once deposited, this material remains on the bed during slack water periods, before being put back into suspension on the subsequent flood or ebb tide. Thus, material is returned to the existing (baseline) sediment regime, and retained within the wider Dee Estuary system following disposal at Mostyn Deep. Similarly, dredged material settling in the vicinity of the berth pocket dredge, is also remobilised on subsequent peak flows. The current speeds associated with both spring and neap tidal states are sufficient to entrain any settled material back into suspension for subsequent dispersion.

It should be noted that the map plots in Figure 6.8 do not show the instantaneous SSC and sedimentation levels at any given point in time, rather they show the maximum SSC and sedimentation value at any location during the complete model run time. As a result, the plots show the extent of overall effect from the dredge and the disposal within the estuary, without reference to how soon after commencement of operations they occur, nor how long these values persist at any given location.

Piling disturbance

The new quay wall will be constructed as a combination pile wall ("combi-wall"), involving tubular piles with AZ sheet piling infill. This will require *circa* 200 steel tubular piles of a maximum diameter of 2.0 m and approximate length of 30 m. The piles will be driven using both impact (percussive) and vibratory piling methods to reach the required design depths. It is anticipated that each pile will involve approximately 20 minutes of vibro-driving and up to 2 hours of percussive driving. Piling works are anticipated to be carried out by up to two piling rigs working 24/7, with each rig installing around one pile per day. The piling rig(s) will be either set up on jack up barges or, alternatively, a temporary raised stone bund will be constructed behind the line of the new quay wall to provide a stable platform or pad for the crane and associated piling rig(s). The overall programme for the piling works is approximately 12 months subject to weather conditions.

Each pile will cause vibration, disturbing the surface sediment near to the bed. Flow speeds along the line of the new berth are around 0.8 to 1.0 m/s and, therefore, distribution of the disturbed sediment across the near-field region will be moderate. The worst case for SSC will occur if the piles are driven prior to dredging, exposing the surface silts to the disturbing forces. On the flood, the sediment would be moved alongside the Quay towards end of the existing breakwater and on the ebb up-estuary towards the existing berths. Most of the sediment will move predominantly within 1 m of the bed, meaning settling distances will be small. Based on the assumption that the volume of the pile is displacing material into the water column, then concentrations of *circa* 750 mg/l could be evident close to each pile. This, however, is considered to be a gross over-estimate as compaction will occur in sediment, rather than complete disturbance. The overall impacts are, therefore, considered to be an increase in SSC in the order of 100 mg/l confined to within 2 m of the pile location.

The overall impact on SSC will be smaller than that from the dredging of the adjacent berth pockets. The disturbed material that re-settles will be removed by dredging as part of the capital dredge and/or subsequent maintenance dredge by the Port.

Should the dredging take place before the piling for the new quay wall, then the material disturbed is likely to be coarser and would all be expected to settle back to the bed along the quay.

Assessment of exposure to change

The greatest increase in SSC from the dredging and disposal activities will occur during the depositing of material at the licensed disposal site. Material within the passive plume will be dispersed throughout the water column as the load drops to the bed, with the potential to be transported up- and down-estuary through the full tidal excursion (dependent on tidal state at the point of release). Initial SSC levels within the dynamic plume will be very high but, given the existing high natural levels within the estuary, excess levels are likely to be reduced to below natural storm disturbance conditions very quickly (and before the next disposal operation commences). This is typically the same scenario that occurs for the current maintenance dredging of the existing berths/approach channel, which is generally undertaken on a regular basis (on average, twice monthly).

At the disposal site, the effect of deposition of capital dredge arisings will be similar to that which already occurs as a result of ongoing maintenance dredging and disposal. Local changes to the bathymetry (as a result of material disposal to the bed) within the disposal site will be small in the context of the existing depths. As is currently the practice, disposal activity will be targeted to the deeper areas within the site, ensuring that bed level changes are not excessive in any one area, thus minimising the overall change. As a result, associated changes to the local hydrodynamics (and sediment transport pathways) will be negligible. Ongoing monitoring of depths within the disposal site (an activity already undertaken to assess bed level changes as a result of existing dredge disposal activities) will continue into the future (Section 6.8.3). Consequently, the impact of the disposal from both capital and future maintenance dredging of the proposed berth and approach channel will be monitored.

The local hydrodynamics, the existing (background) SSC levels within the wider Dee Estuary and the proposed dredge and disposal works have all been considered within this assessment. The increase in SSC and potential sedimentation in the marine environment is likely to be the same as that which already occurs from existing maintenance dredging and disposal activity in the area (which has been occurring for many years). Moreover, peak increases will generally remain within the envelope of natural variability in background SSC. As a result, the probability of occurrence is considered high although the magnitude of change is assessed as small as a worst case, resulting in an overall **low** exposure to change.

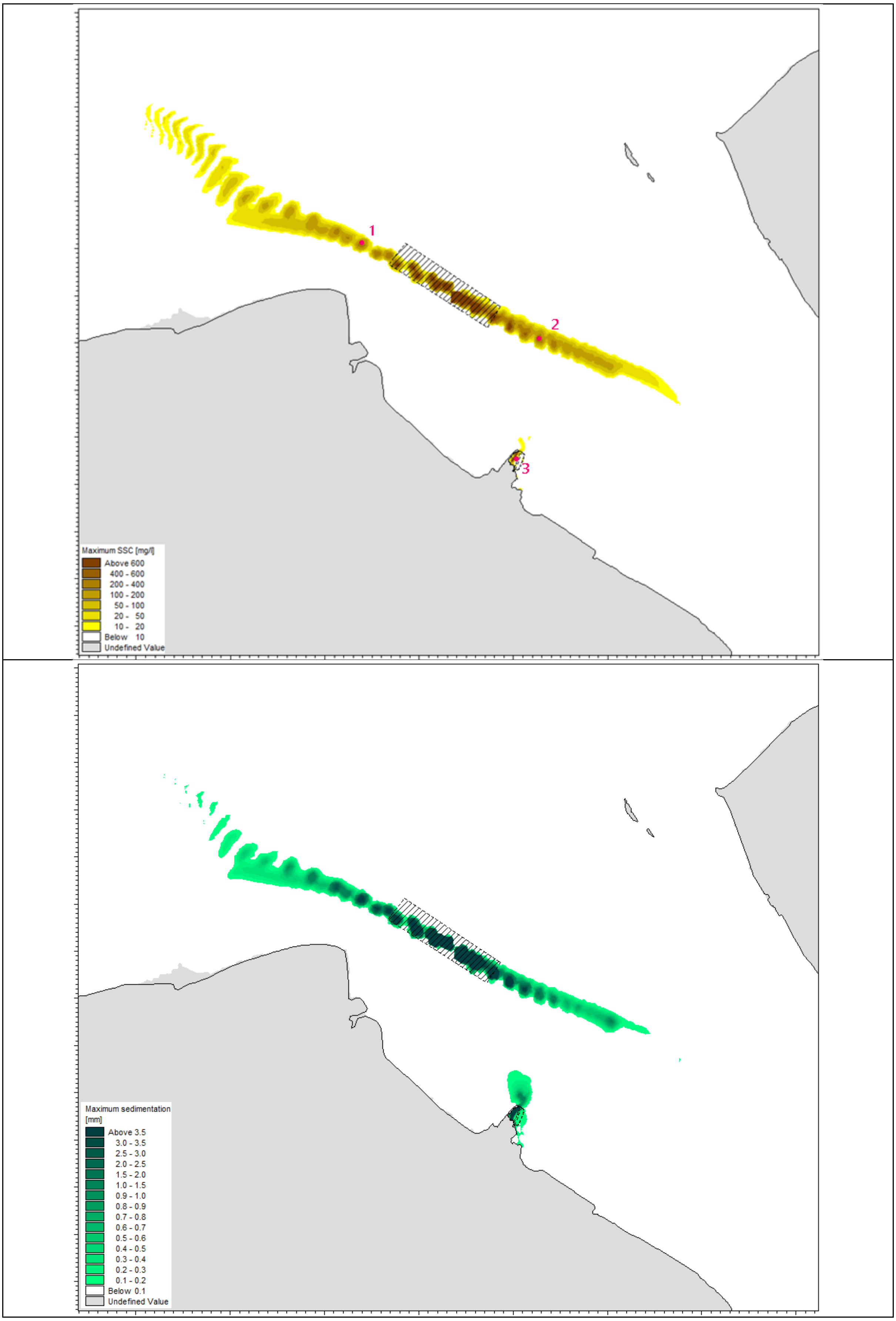

Figure 6.8. Maximum predicted increase in SSC (top) and sedimentation (bottom) from berth dredge and disposal activities

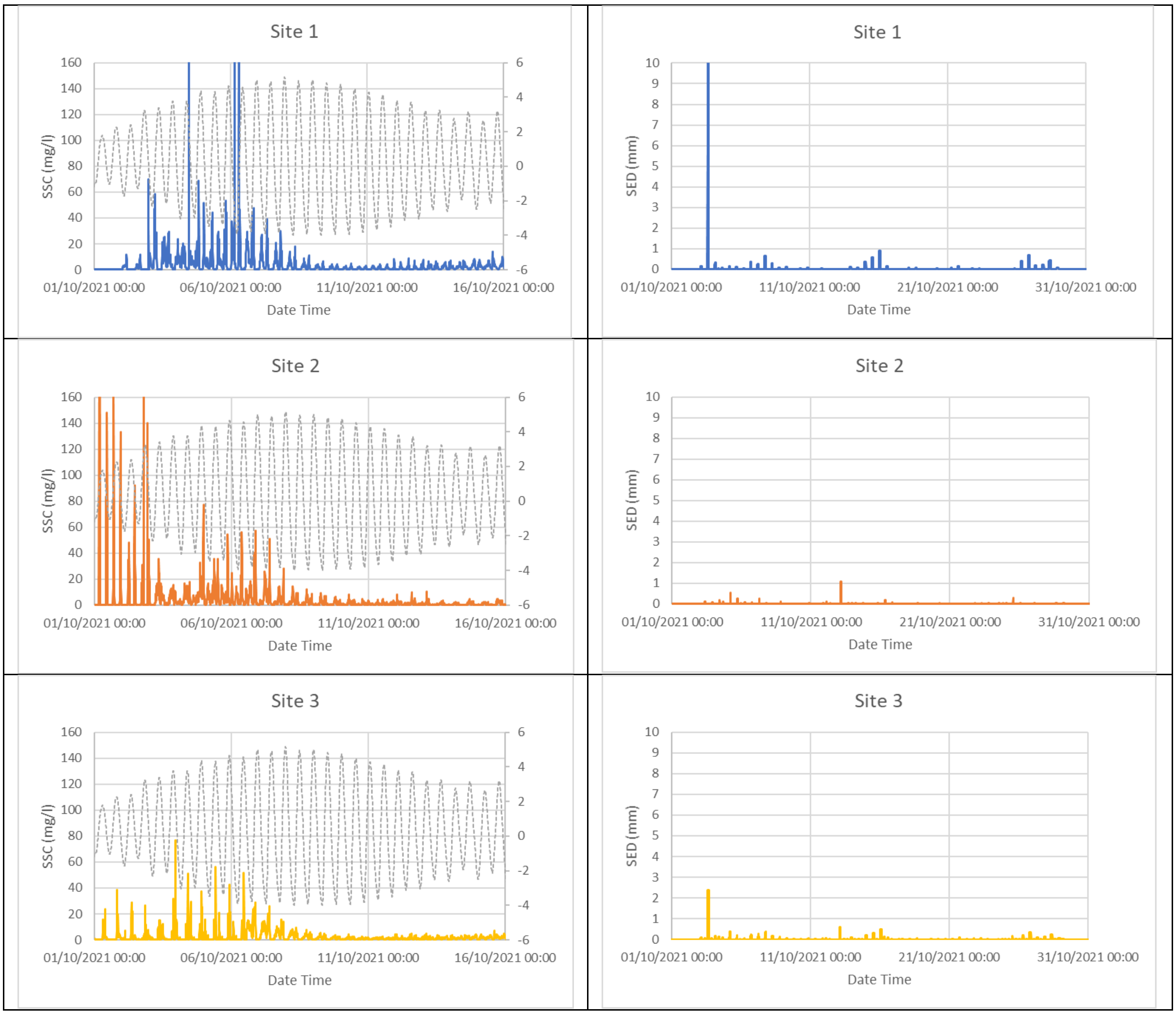

Figure 6.9. Timeseries of predicted increase in SSC (left) and sedimentation (right) from berth dredge and disposal activities

6.7.2 Changes to seabed bathymetry as a result of dredge disposal

At the Mostyn Deep (IS102) disposal site, the effect of the deposition of capital dredge arisings on the seabed bathymetry will be similar to that which already occurs as a result of ongoing maintenance dredging and disposal. Local changes to the bathymetry (as a result of material disposal to the bed) within the disposal site will be small in the context of the existing depths. As is currently the practice, disposal activity will be targeted to the deeper areas within the site, ensuring that bed level changes are not excessive in any one area, thus minimising the overall change. As a result, associated changes to the local hydrodynamics (and sediment transport pathways) will be negligible.

Ongoing monitoring of depths within the disposal site (an activity already undertaken to assess bed level changes as a result of existing dredge disposal activities) will continue into the future (Section 6.8.3). Consequently, the impact of the disposal from both capital and future maintenance dredging of the proposed MEPE Project will be monitored.

Assessment of exposure to change

As a result of the assessment described above, the probability of occurrence of changes to bathymetry (as a result of the construction phase dredge disposal) is considered high although the magnitude of change is assessed as negligible, resulting in an overall **negligible** exposure to change.

6.7.3 Changes to hydrodynamics

Impacts on hydrodynamics have been assessed using numerical modelling tools and conceptual analysis. The modelling has been completed using an updated version of the existing ABPmer calibrated and validated MIKE HD FM model of the Dee Estuary and approaches. The updated model mesh has been refined around the study area and adjacent coastline.

The bathymetric datasets used in the creation of the model mesh consist of a combination of survey data collected for the MEPE Project, existing data provided by the Port of Mostyn from ongoing monitoring surveys in and around Mostyn, the approach channels, Mostyn Deep and the Mid Hoyle Channel, along with topographic LiDAR data from the NRW Lle portal and the Environment Agency Open Data portal.

The updated model has been subject to performance verification checks using available survey data for the local area, over a mean spring and neap tide. Full details of the model setup, calibration and validation are provided in Appendix 6.2.

Although not specifically mapped on a figure within this assessment, it should be noted that the assessment of the proposed development on local hydrodynamics reveals no impact on water levels across the near- or far-field area. Timeseries comparison of water levels, between baseline and scheme scenarios (showing no predicted effect) are provided in Figure 6.11. Consequently, water levels across the existing berths are not predicted to change as a result of the MEPE Project. In addition, there is no predicted impact on the baseline water levels across the rest of the Dee Estuary.

The predicted impacts on the local flow regime, obtained through hydrodynamic modelling of the area, are summarised both spatially, in the immediate vicinity of the new berth/reclamation (MEPE facility), and approach channel, and temporally at a series of point locations identified as strategic locations and areas of greatest impact.

The spatial hydrodynamic effects of the MEPE Project are shown in Figure 6.10 for the approximate time of peak flood and ebb spring flows. The results of the hydrodynamic modelling show that the proposed development causes generally small impacts, confined predominantly to the vicinity of the MEPE facility and approach channel areas.

During the flood tide, a reduction in flows of up to 0.2 m/s is predicted within the southern end of the dredge pocket and up to 0.6 m/s at the northern end of the new berth. Up-estuary of the Port, slight increases to flow speed of up to 0.1 m/s are predicted within 500 m of the MEPE facility. Away from the MEPE facility, flow reductions of less than 0.1 m/s extending across the Mostyn Channel and the adjacent Salisbury Bank. Within the approach channel, an increase in flow speed of around 0.15 m/s is predicted.

These changes in flow speed on the flood tide are relatively small with regards to the baseline flow speeds. Baseline flows are up to around 1.2 m/s off the end of the existing breakwater. As a result, maximum predicted changes in flow speed as a result of the MEPE facility tend to be limited in extent to the dredge pocket itself and are generally around ±30 to 40 % of baseline flow speeds. Further afield, changes remain constrained to the areas adjacent to the Port and approach channel, with flow speed changes generally around ±5 to 10 %.

On the ebb tide, the assessment shows a slightly different pattern of change compared to the flood tide. Here, the change is more aligned with the proposed MEPE berths (and existing berth). At the southern end of the proposed new berth pocket, flow speeds are predicted to reduce by around 0.1 m/s, whilst at the northern end, the ebb tide flow is predicted to increase by around 0.5 m/s. Up-estuary of the Port, increased flows, by up to 0.2 m/s, are predicted on the ebb tide. Away from the MEPE facility, reductions in flow speed of up to 0.1 m/s are predicted over the Mostyn Channel and Salisbury Bank. Within the approach channel, ebb flow speeds are increased by up to 0.2 m/s.

These changes in flow speed on the ebb tide are slightly larger than those predicted on the flood, with regard to the baseline flow speeds. Baseline peak flows are around 1 to 1.1 m/s across the proposed dredge pocket. As a result, predicted maximum changes in ebb peak flow speed within the dredge pocket generally tend to be around ±20 to 50 % of baseline flow speeds. Outside of the berth pocket, relative reductions in flow speed are notably lower (-5 to -10 % of baseline).

Timeseries plots have been provided to illustrate a predicted temporal change throughout a mean spring tide at key locations (see lower left panel of Figure 6.10). These timeseries plots are provided in Figure 6.11, which show the comparison of current speeds over baseline and scheme scenarios. The tidal signal is also included to illustrate flood, ebb and slack water periods.

Up-estuary of the Port (locations 1 to 3), the MEPE facility results in a slight reduction in peak flow speed on the flood tide (up to 0.2 m/s at Point 3) and a slight increase (by less than 0.1 m/s) over the peak of the ebb tide.

At either end of the new berth pocket (locations 4 and 5), opposing impacts are predicted. At the up-estuary (southern) end of the berth pocket (Site 4), the dredge results in a general reduction in flow speed (by around 0.5 to 0.6 m/s on the flood) over the peak of both the flood and ebb spring tide. In contrast, at the down-estuary (northern) end of the berth pocket, peak flood speeds are generally unaffected, whilst peak ebb flow speeds are predicted to increase by around 0.3 m/s.

Within the entrance of the deepened approach channel (location 8), the dredge leads to a slight reduction in peak flood flow speeds (by less than 0.1 m/s). Over the peak of the ebb tide, the entrance to the approach channel shows increased flow speeds by less than 0.2 m/s.

Across the existing Mostyn Channel and the Salisbury Bank (either side of the Salisbury Channel), the timeseries of changes to flow speeds are show at locations 6, 7 and 9 (Figure 6.11). Within the Mostyn Channel (Site 6), flows are reduced over both the peak flood and the peak ebb, by around 0.2 m/s in both cases. Further offshore, across the Salisbury Bank, the timeseries from Site 7 and Site 9 also shows reduced flow speeds over both peak ebb and flood states. At Site 7, reductions are around 0.1 to 0.2 m/s, whilst at Site 9, flood speeds are reduced by around 0.2 m/s and ebb flows by around 0.3 m/s as more flow is attracted to the dredged approach channel.

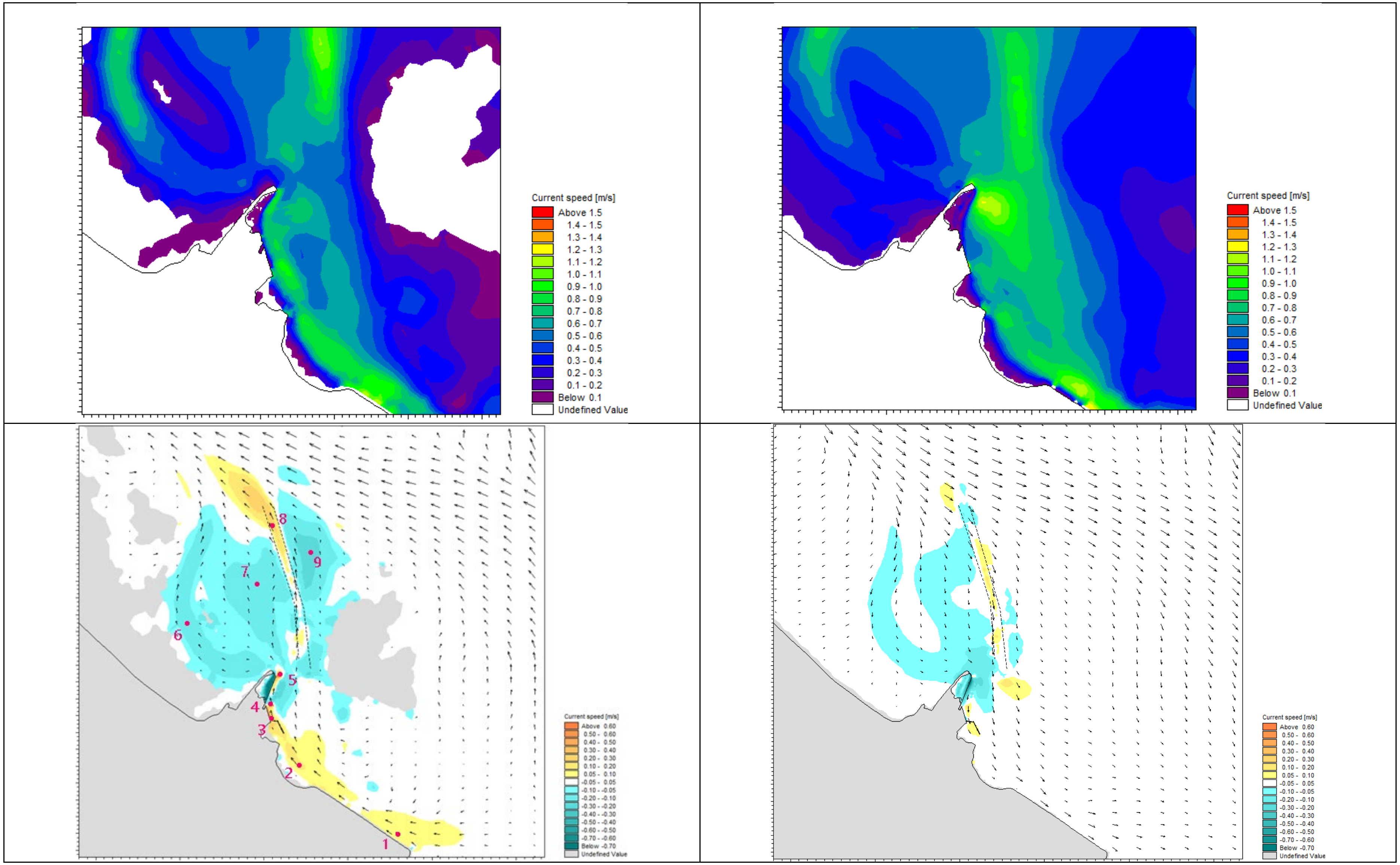

Figure 6.10. Baseline (top) and predicted changes (bottom) to flow speed under peak ebb (left) and peak flood (right) on a mean spring tide

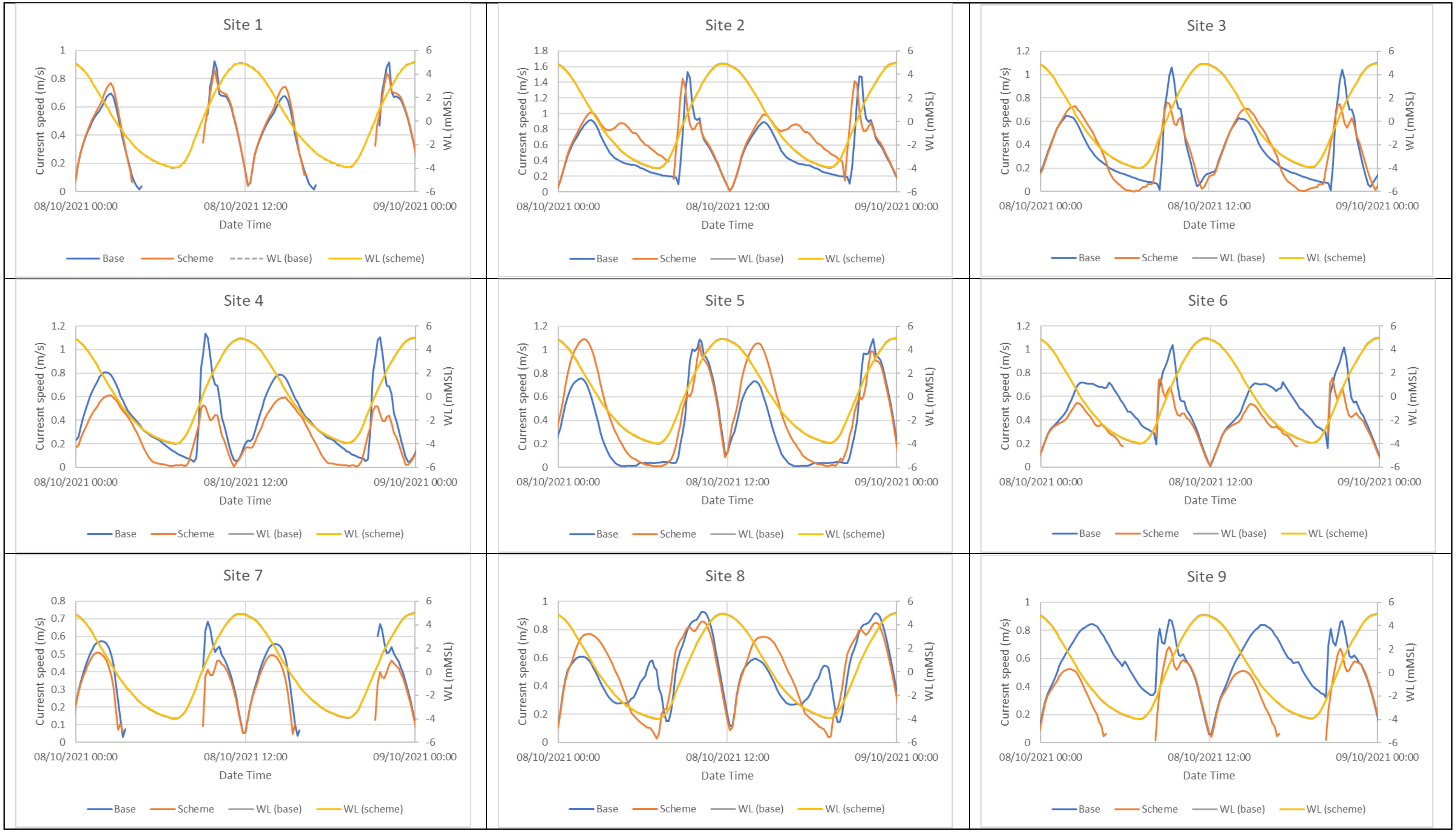

Figure 6.11. Timeseries of predicted changes to flow speed and water level over a mean spring tide (site locations are shown on Figure 6.10)

Assessment of exposure to change

Marginal changes to hydrodynamics (local flow speed) are likely to result from the MEPE facility within, and adjacent to, the proposed berth pocket and within the approach channel. Slight changes in flow speed are predicted to extend around 2 km up-estuary of the Port and down-estuary across the Mostyn Channel and Salisbury Bank. The largest predicted magnitude of change is anticipated within the berth pocket itself (particularly towards the northern end). Overall, the probability of occurrence is considered high, although the magnitude of change is assessed as small, giving rise to an overall **low** exposure to change.

6.7.4 Changes to wave regime

Impacts on waves have been assessed using numerical modelling tools and conceptual analysis. The modelling has been completed using the existing ABPmer calibrated and validated MIKE SW model of the Dee Estuary (Appendix 6.2). The model has subsequently been used to examine how waves conditions will be affected during extreme events.

The model utilises the same bathymetric data as the hydrodynamic model (as described above). This updated model has been subject to performance checks by simulating wave conditions at the entrance to the Dee Estuary and comparing against industry guidance values and long-term hindcast data.

The assessment of potential wave impacts from the proposed MEPE facility has applied a set of wave conditions (including Hs, peak wave period (Tp) and wind speed (WS)), for a 1 in 50-year return period event (HSE, 2010) from the dominant approach direction (as described above). The wave event has then been applied to the numerical model under existing (baseline) and scheme scenarios. The predicted difference in modelled wave heights, as a result of the berth pocket dredge, the new quay wall and the proposed approach channel deepening, have then been calculated.

The spatial wave effects of the construction of the proposed development are shown in Figure 6.12. Results of the wave modelling show that the new MEPE facility and approach channel dredge pocket cause generally small impacts, confined predominantly to the area in the vicinity of the channel works. The location of the new berth and new quay wall means they are generally sheltered from the dominant wave approach direction by the existing breakwater.

The effect on wave height for the 50-yr, dominant direction event is negligible, with a very small (less than 500 m) area of reduced wave heights (within the approach channel) of less than 0.12 m. Either side of the approach channel, (within a distance of approximately 500 m), very small, predicted increases to Hs are shown, less than 0.05 m. Baseline wave heights for this event tend to be in the region of 1 to 1.2 m around the marine facilities, meaning the maximum predicted change in wave height is around ±5-10 % of baseline values.

Within the new berth pocket, reductions in wave height are, again, negligible, with changes of less than 0.1 m. This change is limited in extent to the area of the berth pocket and a distance of around 200 m up-estuary. Across this site, baseline wave heights for the event in question are up to 0.6 m, meaning the relative reduction in Hs as a result of the MEPE facility is around 15 %.

Given the negligible effects of the extreme wave from the dominant wave direction, additional assessment of less extreme waves and from less-dominant directions are considered to result in smaller impacts, both in terms of a lower magnitude of change and over a smaller extent.

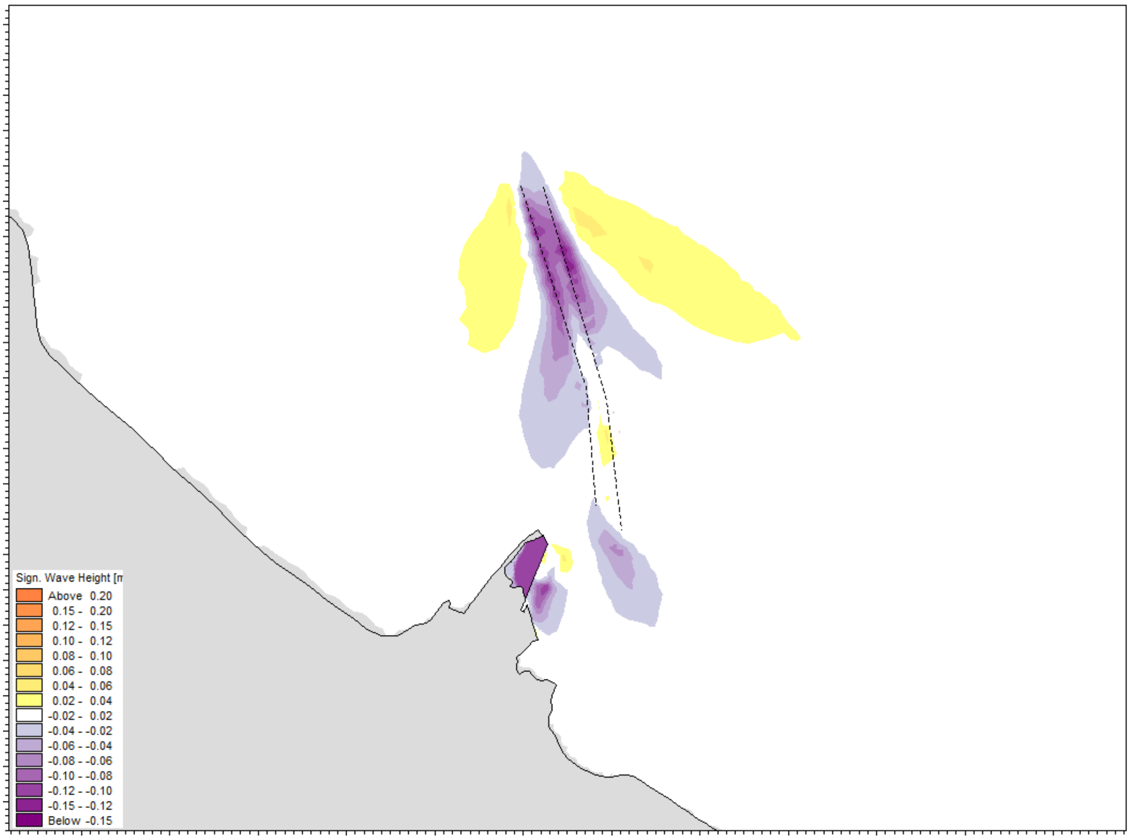

Figure 6.12. Predicted change in extreme 1 in 50-year wave event from the dominant approach direction

Assessment of exposure to change

Marginal changes to Hs are likely to result from the MEPE facility and approach channel deepening. The extent of impact is generally constrained to the areas within, and adjacent to, the dredge works. For the assessed extreme event, slight changes in wave height (typically less than ±5-10 % of baseline values) are predicted to extend around 500 m either side of the approach channel and around 200 m up-estuary of the proposed berth pocket. The largest predicted magnitude of change is within the reclamation area (as a result of the reclaim itself) and within the dredged berth pocket/ approach channel.

The probability of occurrence is considered high, although the magnitude of change is assessed as small giving rise to an overall **low** exposure to change.

6.7.5 Changes to sediment transport pathways

Changes to the local hydrodynamics, as a result of the MEPE Project (as described above) have the potential to affect local sediment transport (i.e., faster flows may increase bed erosion, and lower flows may encourage sedimentation).

To investigate the potential impact of the marine facilities and dredging on sediment transport, the movement of bed material (as identified across the project specific grab sampling survey) has been investigated using the MIKE sediment transport module (with further detail of setup provided in Appendix 6.2). The model is driven by the hydrodynamic model described above.

The modelling tool has been applied to model the existing baseline and the MEPE Project (including the approach channel deepening), and the difference in bed thickness over a 15-day mean spring neap cycle has been calculated.

Figure 6.13 shows the predicted change in bed thickness of bed material, as a result of the proposed development, over a mean spring/neap tidal cycle. This represents the response of the local sediment transport system to the MEPE scheme elements and indicates the direction of change in the pathways as they attempt to reach a new equilibrium state. In general, it is predicted that the changes in accretion and erosion patterns are generally small in both magnitude and extent, with the changes tending to be limited to the areas around the dredged berth pockets and approach channel.

Where predicted, changes tend to be a balance between areas of erosion and accretion, as the bed readjusts to the new flow regime, indicative of a general 'levelling' of the bed. This is most notable around the side slopes of the new berth pocket, up-estuary of the Port and along the central part of the approach channel. The reduction in flow speeds along the edges of the approach channel, as well as up-estuary of the Port, result in associated changes to bed shear stress (BSS), allowing for small adjustments in the bed transport, when compared against the baseline condition. Within the approach channel and the berth pocket, the slight increase in flow speed (particularly over the ebb tide; Figure 6.10) results in a small, predicted area of erosion, which has the potential to help keep the channel and the berths generally free of accretionary material.

The difference to baseline in the bed transport rate over the 15-day modelled period is up to -0.5 m within the approach channel and berth pocket. In contrast, reductions in flow speed along the margins of the channel and up-estuary of the Port, result in small areas of accretion (by around 0.5 to 1 m over the modelled period. These are predicted changes to bed load and areas of predicted erosion tend to be balanced by adjacent areas of accretion. In this way, the response of the near-field area to the MEPE Project is for slight changes to the bed transport pathways, rather than larger-scale shifts in transport rate across the wider estuary.

The results above reflect the predicted changes over the modelled spring neap period. As bed levels change through small shifts in accretion and erosion processes, so the flow regime over the local area will also become affected, and the associated sedimentation and erosion rates will respond. In this way, extrapolating rates of local bed level change is not necessarily a linear process, as the bed will seek to achieve some level of equilibrium over the longer-term.

During operation, the movement of vessels on and off berth will also help to remobilise some of the newly deposited material within the pocket and through the approach channel. In addition, over time, any deposited material will consolidate, causing the *in-situ* sediment thickness to reduce. Consequently, the actual future rate of bed level change within the berth pocket is likely to be lower than the conservative, worst case estimate described above.

Across the wider study area of the Dee Estuary, the MEPE Project will have no impact on the existing (baseline) accretion and erosion rates or sediment transport pathways (Figure 6.13). Overall, there is predicted to be limited magnitude and extent of predicted change, resulting from the MEPE Project (in terms of both hydrodynamics across the range of tidal states and the associated negligible impact on estuary tidal prism and far-field sediment transport pathways). This, coupled with the in-estuary disposal of the majority of the capital and maintenance dredge material from the MEPE Project (thus maintaining the sediment as part of the wider estuary sediment budget), indicates that the proposed development will not result in long-term changes to the wider estuary morphology.

Assessment of exposure to change

Hydrodynamic forcing within (and adjacent to) the proposed MEPE facility will only be marginally altered and, therefore, changes in the sediment pathways will be small. Predicted changes to future sediment transport are greatest within the proposed dredge pocket and deepened approach channel, which may require future maintenance dredging to ensure sufficient underkeel clearance for vessels on berth. Outside the proposed berth pocket and approach channel, the proposed development has limited impact on the baseline sediment transport pathways.

Figure 6.13. Predicted change in sedimet transport patterns as a result of the proposed scheme

As a result, the probability of occurrence is considered to be high, and the magnitude of change is assessed as small as a worst case, resulting in an overall **low** exposure to change.

6.7.6 Changes to SSC, sedimentation and seabed bathymetry as a result of maintenance dredging and disposal activities

As described above, changes to sediment transport pathways as a result of the MEPE Project are expected to be at worst small in magnitude and limited in extent to the immediate vicinity of the proposed new berth and the deepened approach channel. Overall, future maintenance dredge requirements are expected to be similar to that which is already required by the Port and significantly less than the assessed capital dredge volume.

The actual requirements for the level and frequency of potential future maintenance dredging of the berths and channel will be dependent on a number of commercial factors (including vessel type, size and berthing requirements). However, assuming an increased level of use to that currently required (and by deeper-drafted vessels), it would be reasonable to assume that the proposed new berths would require a slightly lower level of maintenance to that which is presently afforded. Based on the predicted rates of change derived from the numerical modelling (see above), depths along the edges of the approach channel and in areas up-estuary of the Port, might be expected to shallow initially, as the system responds to the changes. Conversely, areas within the channel and berth pocket may generally be swept clear of accretionary material by the faster ebb flows. Overall, a maintenance dredge campaign similar to that which is undertaken currently, is considered reasonable (although, as noted above, this will be dependent on a range of factors).

As described above, as bed levels change, the rate of further accretion/erosion will reduce as flow speeds over the area approach a new equilibrium. Furthermore, scour from certain vessel movements at lower states of the tide, and from increased flows whilst a vessel is at berth will also act to help mobilise freshly deposited material.

Volumes of material from maintenance dredging of the new berth pocket and approach channel will be lower than those from the original proposed capital dredge. Furthermore, the density of any newly settled material will be less than that from the consolidated bed dredged during the capital campaign and, rather than a sustained dredge campaign of the full amount, the future maintenance dredge will be from a larger number of smaller individual dredging events (in response to operational requirements at the Port). As a result, maintenance dredge arisings and disposal will have a notably lower magnitude and will be more dispersive than the impacts described above for the capital works.

Consequently, the impact of maintenance dredging and disposal is considered to be considerably less than that described from the capital dredge above, with lower excess SSC values, and less frequent intermittent sedimentation on the bed. Placement of the majority of dredged material (both capital and maintenance) at either the proposed Mostyn Deep (IS102) or Mostyn Breakwater (IS103) disposal sites will help maintain the overall sediment budget of the wider Dee Estuary system. In this way, material remains distributed throughout the wider region, rather than being removed. The overall distribution of the sediment over the wider Dee Estuary, as a result of any maintenance dredging and disposal activity, will be similar to that shown in Figure 6.8 for the capital works, although the magnitude will be lower.

Assessment of exposure to change

As a result of a less intensive dredge programme (and an overall lower predicted dredge volume), future maintenance dredging will result in smaller changes in SSC and sedimentation (within the dredge plumes and at the disposal site(s)) compared to the capital dredge (as described above). Furthermore, the predicted impacts from future maintenance dredging will be similar to that which already arises from the ongoing maintenance of the existing Port and channel areas. As a result, the probability of occurrence is considered high although the magnitude of change is assessed as negligible, resulting in an overall **negligible** exposure to change.

6.7.7 Potential impact on receptors, including marine infrastructure and (local and regional) estuary banks and channels

Identified changes to the existing (baseline) hydrodynamics, waves and associated sediment transport pathways have the potential to impact existing features. Such features, which include existing marine infrastructure across the Port (including the breakwater and existing berth/quay) and estuary banks and channels, have been identified in the relevant sections above and the significance of the potential impact from the MEPE Project on these features is assessed in this section.

Changes to flows, waves and sediment transport pathways are predicted to be generally limited in extent to the proposed MEPE facility and deepened approach channel. The predicted impacts to the existing infrastructure (including the breakwater and the existing berth/ quay wall) are (where predicted) generally small in magnitude, relative to baseline conditions. This is also the case for the features across the wider study area, including the local and regional subtidal and intertidal banks and channel. With distance from the proposed development, the predicted impacts reduce further and are not predicted to occur over the far-field region (including the wider Dee Estuary).

Changes to local and regional sediment transport pathways are only predicted in close proximity to the MEPE facility and the deepened approach channel, meaning the existing banks and channels of the wider Dee Estuary are not predicted to be impacted by the development. This includes the entrance channels of Welsh Channel and Hilbre Channel and the up-estuary channels into (and including) the canalised section up-estuary of Connah's Quay.

Assessment of exposure to change and significance of impact

Changes to flows and waves (and associated sediment transport pathways) are likely to result from the MEPE facility within, and adjacent to, the proposed berth pocket and the deepened approach channel. These changes are predicted to be greatest in closest proximity to the development, reducing in magnitude with distance.

Across the near-field, the probability of occurrence is considered high, although the magnitude of change is assessed as a worst case as small giving rise to an overall **low** exposure to change. The local banks and channels in and around the Port are already subject to ongoing natural variability in their alignment, orientation and relative dominance in the tidal frame. Consequently, they are considered to have a low sensitivity, resulting in an overall **low** vulnerability to impact. Locally, the estuary banks and channels are considered of moderate importance. Overall, therefore, the potential impact on the estuary banks and channels located near to the proposed development is assessed as **insignificant to minor adverse**.

Across the far-field, the probability of occurrence is considered low, and the magnitude of change is assessed as negligible, giving rise to an overall **negligible** exposure to change. As with the local features, the wider region and the banks and channels across the Dee Estuary are already subject to ongoing natural variability in their alignment, orientation and relative dominance in the tidal frame. Consequently, they are considered to have a low sensitivity, resulting in a vulnerability assessment of **none**. Due to the estuary itself being a designated interest feature of the Dee Estuary SAC, it is considered of high importance. Overall, therefore, and the impact on the wider Dee Estuary is assessed as **insignificant**.

6.7.8 Potential risks to human health

All physical processes changes arising from the construction (piling, reclamation, dredging and disposal) and operation of the MEPE Project are confined to the marine water environment and are not considered to result in a potential risk to human health.

6.7.9 Potential impacts on climate and vulnerability of proposed development to climate change

The bathymetric and hydrodynamic changes resulting from the dredging and disposal activities are small in the context of the existing hydrodynamic and sediment regime within the Dee Estuary. The magnitude of these changes is insufficient to cause morphological change that would significantly affect tidal propagation, saline intrusion, wave activity or a change to the sediment regime. As a result, the works will have no impact on the predicted ongoing effects of climate change in the marine environment. Equally, the effects of climate change in the future will not cause a significant change to the physical processes impact that are anticipated to occur as a result from the MEPE Project.

6.7.10 Risks of major accidents and/or disasters

The nature and scale of the changes in physical processes that will result from the MEPE Project are such that they are not anticipated to cause any risk of a major accident and/or disaster.

6.8 Mitigation and residual impacts

6.8.1 Secondary mitigation

None of the impact pathways identified for physical processes are expected to give rise to a measurable exposure to change or significant adverse effects and, therefore, no secondary mitigation measures are required (i.e. actions that will require further activity in order to achieve the anticipated outcome and identified as necessary through the assessment process).

6.8.2 Tertiary mitigation

Tertiary mitigation measures (i.e. actions that would occur with or without input from an environmental impact assessment process) will be undertaken to manage commonly occurring environmental effects. Although these are not likely to alter the assessment conclusions, they are considered to be standard good practice. In terms of physical processes, these are as follows:

- **Even disposal deposition**: Targeting disposal loads in the central/deeper area of the Mostyn Deep disposal site (IS102) site to reduce depth reductions. This will minimise the initial reduction in water depth and any environmental changes at this site.

6.8.3 Ongoing monitoring

The Port of Mostyn currently monitors a wide range of descriptive metrics for the local and regional Dee Estuary (as set out in the current licence conditions). Analysis of these repeat surveys, over a period of nearly 20-years, has revealed ongoing evolution of the wider system as a result of natural variability (driven primarily by the relative dominance of the Welsh and Hilbre Channels). The assessment has shown ongoing trends in the alignment and elevation of a range of features, including the Mostyn Deep, Mid-Hoyle Channel, banks and channels across the full width of the estuary downstream of the Port and, locally, across the Mostyn and Salisbury Channels. Furthermore, repeat numerical modelling of a

-4 mCD channel dredge (following collection of estuary-wide LiDAR data) has consistently predicted an overall low magnitude and limited extent of impact. These findings are corroborated by the modelling studies described in this assessment of the MEPE scheme.

Over the many years that this monitoring schedule has been in place, the data collected (and subsequent analysis) has confirmed that the local changes are negligible and not linked to the ongoing dredging activity at the Port. Furthermore, the larger-scale changes in estuary evolution are also not linked to the ongoing activities at the Port. Rather, in both cases, the changes observed are a result of the ongoing natural variability in the alignment, orientation and relative dominance of the local and regional intertidal and subtidal banks and channels across the Dee Estuary (e.g. ABPmer, 2022).

Moving forward, the intention will be for a single marine licence to cover all of the Ports activities (including the existing maintenance dredging and disposal activity, and the proposed MEPE facility, as described in the Project Methodology Chapter 3).

Following the findings of the assessment of potential impacts on physical processes (as a result of the MEPE scheme) presented in this chapter and further informed by the wealth of historic repeat monitoring survey data and analysis (which shows no impact on the wider estuary from any of the ongoing Port operations), the following future monitoring schedule is proposed:

- Continued repeat multibeam bathymetric survey of the Port Harbour and approach channel at a frequency dictated by the Port's operational requirements, but with a minimum of three surveys per annum:
    - Bathymetric analysis will be undertaken three times per year and reported only if an issue is identified. Otherwise, analysis of the bathymetric datasets will be reported in an Annual Monitoring Summary report;
- Repeat bathymetric survey of the Mostyn Deep disposal site, carried out annually, to help inform the placing of subsequent maintenance dredge material:
    - Bathymetric analysis will be undertaken on the annual survey dataset and reported in an Annual Monitoring Summary report;
- Repeat benthic sampling (following the sample locations of the existing LA5 monitoring survey) initially annually, with aim to reduce frequency to every other year after 4-years (informed by the findings of the interim surveys):
    - Particle Size Analysis (PSA) for comparison against historic sampling, with results and analysis reported in an Annual Monitoring Summary report.

The proposed approach would maintain a proportionate ongoing monitoring of the local estuary morphology, over the anticipated extent of potential impact arising from the Port operations. Conditions could be included to increase frequency or extent of any given survey in the event of any issues being flagged by the data collection or analysis.

6.9 Summary of impacts

A summary of the impact pathways that have been assessed, the identified residual impacts and level of confidence is presented in Table 6.5.

Table 6.5. Summary of potential impact, mitigation measures and residual impacts for nature conservation and marine ecology

Impact pathway	Exposure to change	Impact Significance	Mitigation Measures	Residual Impact	Confidence
Construction Phase					
Changes to SSC and sedimentation as a result of the construction activities	Low	N/A	None	NA	Medium
Changes to seabed bathymetry as a result of dredge disposal	Negligible	N/A	None	NA	Medium
Operational Phase					
Changes to hydrodynamics	Low	N/A	None	N/A	Medium
Changes to wave regime	Low	N/A	None	N/A	Medium
Changes to sediment transport pathways	Low	N/A	None	N/A	Medium
Changes to SSC, sedimentation and seabed bathymetry from maintenance dredge and disposal activities	Negligible	N/A	None	NA	Medium
Potential impact on receptors, including marine infrastructure and (local and regional) estuary banks and channels	Low (near-field) Negligible (far-field)	Insignificant to minor adverse (near-field) Insignificant (far-field)	None	Insignificant to minor adverse (near-field) Insignificant (far-field)	Medium

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6.11 Abbreviations/Acronyms

AA	Appropriate Assessment
BPEO	Best Practical Environmental Option
BSS	Bed Shear Stress
CC	Climate Change
CD	Chart Datum
cSAC	candidate Special Area Conservation
DfT	Department for Transport
DHI	Danish Hydraulic Institute
EC	European Commission
EEC	European Economic Community
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ERM	Environmental Resources Management
ES	Environmental Statement
EU	European Union
FM	Flow Model
GOV	Government
HAT	Highest Astronomical Tide
HD	Hydrodynamic
HMWB	Heavily Modified Water Bodies
HRA	Habitats Regulations Assessment
HSE	Health and Safety Executive
HTL	Hold the Line
HW	High Water
ICE	Institute of Civil Engineers
LAT	Lowest Astronomical Tide
LSE	Likely Significant Effect
LW	Low Water
MCAA	Marine and Coastal Access Act
MEP	Mostyn Energy Park
MEPE	Mostyn Energy Park Extension
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MPS	Marine Policy Statement
MTL	Mean Tide Level
NPSfP	National Policy Statement for Ports
NRW	Natural Resources Wales
NTU	Nephelometric Turbidity Init
NW	North West
NWP	National Wind Power
PSA	Particle Size Analysis
PSD	Particle Size Distribution
pSPA	potential Special Protection Area
Ramsar	Wetlands of international importance, designated under The Convention on Wetlands (Ramsar, Iran, 1971)
RCP	Representative Concentration Pathway
RSL	Relative Sea Level

SAC	Special Area Conservation
SHA	Statutory Harbour Authority
SLR	Sea Level Rise
SMP	Shoreline Management Plan
SOC	Society
SPA	Special Protection Area
SSC	Suspended Sediment Concentration
ST	Sand Transport
SW	Spectral Waves
TAN	Technical Advice Note
TSHD	Trailing Suction Hopper Dredger
UK	United Kingdom
UKCP	United Kingdom Climate Projections
UKHO	United Kingdom Hydrographic Office
WAG	Welsh Assembly Government
WFD	Water Framework Directive
WHA	Waste Hierarchy Assessment
WNMP	Welsh National Marine Plan
WS	Wind Speed

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

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