MERSEY TIDAL POWER

FEASIBILITY STUDY: STAGE 3

Navigation Options Report

Date June 2011

Report prepared by:

Project Sponsors:

www.merseytidalpower.co.uk

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Project Background

In the face of current and anticipated issues of security of supply and climate change, the need to find local sources of renewable energy has never been more urgent.

The Mersey Estuary has one of the largest tidal ranges in the UK, making it one of the best locations for a tidal power generation scheme. It has the potential to make a significant contribution to the Government's target to secure 15% of UK energy from renewable sources by 2020.

A large scheme could deliver enough renewable electricity to meet the needs of a significant proportion of the homes within the Liverpool City Region, as well as beyond. Any scheme put forward will need to take into account the ecological diversity of the Estuary, which supports internationally important bird habitats.

Phase 1 Pre-Feasibility Study - 'Power from the Mersey'

Peel, in partnership with the NWDA set out to explore the potential, the impacts and the implications of utilising the Mersey Estuary's renewable energy potential for the benefit of the Northwest region.

The Mersey Basin Campaign gave its full backing to the work and a consortium of consultants led by Buro Happold was commissioned in July 2006 to undertake a 'pre-feasibility' Phase 1 Study.

The primary objective of the Phase 1 Study was to undertake a full and open assessment of the options available for the generation of renewable energy and to undertake a preliminary assessment of viability.

A number of potentially viable schemes were identified. The continued development of marine power technology means that others may also need to be considered as the project moves into the next phase.

Meeting 2020 Renewable Energy Targets

An overall timetable was defined to ensure the project supports the policy objective of contributing to 2020 renewable energy targets. The key milestones of the project include submission of applications for planning or other statutory consents by 2012 and commissioning of the scheme by 2020.

Phase 2 Feasibility Study

Peel Energy and the Northwest Development Agency are progressing the project in line with the principles for sustainable development. A feasibility study has been commissioned to assess the options and identify a preferred scheme to take forward for submission of a planning application.

The feasibility study has been led by URS Scott Wilson, EDF and Drivers Jonas Deloitte, and supported by RSK, APEM, HR Wallingford, Regeneris, Turner and Townsend, University of Liverpool, Proudman and Global Maritime.

The feasibility study has been undertaken in three stages as follows:

- Stage 1: Definition of project strategies, data gathering and gap analysis, and selection of long list of suitable technologies
- Stage 2: Appraisal of the long list of technologies and formulation and appraisal of scheme options to identify a shortlist
- Stage 3: Further refinement and appraisal of the short list of scheme options and selection of the preferred scheme.

The project has been pursued in an open and transparent manner, building on the consultation and stakeholder engagement started in the Phase 1 study. An extensive programme of stakeholder engagement has taken place through project advisory groups, consultation with statutory and non-statutory consultees and public consultation targeted during appropriate stages of the project.

Mersey Tidal Power Scheme Objectives

The objectives of the Mersey Tidal Power scheme are:

(a) To deliver the maximum amount of affordable energy (and maximum contribution to Carbon reduction targets) from the tidal resource in the Mersey Estuary with acceptable impacts on environment, shipping, business and the community either by limiting direct impact in the Mersey Estuary or providing acceptable mitigation and/or compensation;

and in doing so,

(b) To maximise social, economic and environmental benefits from the development and operation of a renewable energy scheme, including where appropriate:

  (i) the development of internationally significant facilities and skills to support the advancement of renewable energy technologies and their supply chains,
  (ii) improvements to local utility and transport infrastructure,
  (iii) improvements to green infrastructure and environmental assets,
  (iv) the development of a leisure opportunity and tourist attraction.

Table of Contents

1 Introduction

1.1 Navigation on the River Mersey

1.1.1 The River Mersey is a busy commercial waterway with around 8,500 commercial vessel calls each year. Of these, 4,100 enter the various basins making up Liverpool Docks, while approximately 1,800 continue up the river as far as Eastham (for the QEII Dock or Manchester Ship Canal) or Garston. The remaining 2,600 vessels berth at various intermediate locations along the river including Birkenhead Docks, Tranmere Oil Terminal, and various river berths including Bromborough Wall (also referred to as Mersey Wharf) and Twelve Quays Ro-Ro Terminal.

1.1.2 A wide variety of vessel types and size enter the river. The largest, VLCC type oil tankers and cruise ships, serve the Tranmere oil terminal and the Cruise Terminal respectively. Another important vessel flow is container vessels serving the Seaforth Container Terminal within Port of Liverpool, which is the premier container terminal serving the North of England.

1.2 Navigation Impact of the Mersey Tidal Power Development

1.2.1 All of the tidal power technologies assessed as part of the Stage 2 study take the form of a linear structure spanning the River Mersey. If downstream of Eastham/ Garston, this would present an obstruction to the commercial navigation channel/s along the river. Additionally, there are potentially various secondary impacts which are outlined below:

- potential changes to current velocities upstream and downstream;
- potential changes to sediment transport regime (channel siltation);
- restricted access for navigation to existing berths & locks;
- potential changes to water levels and associated tidal windows – arrival within operational time frame;
- potential congestion and shipping delays; and
- potential increase in shipping cost.

1.2.2 These navigation impacts would be broadly similar for any scheme downstream of Eastham/ Garston irrespective of the technology applied. This is due to the linear nature of the structure of the proposed development. The extent, if any, to which these potential impacts actually occur, would be entirely dependant on the location of the proposed development. The location options are explained in further detail in Section 2.

1.3 Key Objectives

1.3.1 The key objective of Stage 3 for the navigation team is to identify a preferred navigation option based on the various navigation options presented in Stage 2. Selection of the preferred navigation option is based on an assessment of the navigation impacts of each of the options considered and the ability to which these potential impacts can be mitigated. The preferred option is the scheme that is recommended from a navigation perspective to be taken forward to further stages.

2 Methodology

2.1 General

2.1.1 The navigation aspects associated with the proposed development are best addressed as part of the planning discipline of maritime engineering. Whilst it is essential to incorporate realistic, representative and appropriate information during the planning process, this process is not an exact science. There are no established industry references, guidance lists, etc. with particular focus on options evaluation and assessment procedures. Any process adopted may therefore be considered subjective. As such a stepped approach was implemented in order to ensure full understanding and complete transparency in the process of identifying the preferred navigation option. URS/Scott Wilson worked closely with the commercial navigation stakeholders to ensure that their knowledge and views were fully taken into account during the process. Two stakeholder consultations were held for this purpose, in the form of Navigation Advisory Group (NAG) sessions.

2.1.2 Steps 1, 2 and 3 of the 3-step process undertaken by the navigation team are discussed in the following sections. Steps 1 and 2, which informed the identification and appraisal of location options (bands) and resulted in the initial identification of potential navigation mitigation options, were completed at Stage 2 of the feasibility study. Step 3 has been undertaken at Stage 3 and comprised assessment and ranking of the navigation mitigation options to identify the preferred navigation solution.

2.2 Step 1 – Region of Interest & Geographic Consideration

2.2.1 Step 1 involved considering potential location options for the study of potential tidal power schemes and whether navigation impacts associated with each location could be mitigated. This took into account the region of interest and the geographical considerations. This stage of the evaluation did not include the use of any sophisticated tools or models but required basic marine engineering judgement to be applied to the assessment based on professional opinion and experience.

2.2.2 The brief of the feasibility study was to consider the area from Queen’s Channel to Runcorn Bridge.

2.2.3 A desktop evaluation was undertaken including assessing admiralty charts, dated bathymetric surveys, existing estuary user rules and regulations (including information from vessel, dock and lock data gathering exercise), etc. to inform constraints mapping and determine the areas where the proposed development could not be located.

2.2.4 A scheme downstream of Eastham/ Garson would always present an obstruction to the commercial navigation channel/s; the extent to which the potential impacts can be mitigated is the basis of this exercise. The Estuary does not offer a deep natural water depth throughout the tide making dredging a necessity for maintaining access. The geotechnical characteristics are likely to affect the development (specifically from a dredging perspective) based on the unknown conditions and lack of availability of soils information, and there are potential areas of disadvantageously located localised current and cross-current effects.

2.2.5 The general marine requirements were not the only aspects considered – there were other basic requirements for navigation on the Estuary that were taken into account, as follows:

- possible sheltered and tranquil lock sufficiently orientated outside of existing manoeuvring and turning areas;
- achievable marine access providing sufficient channel access to the existing berths, docks and wharves;
- adequate entry and navigation area upstream and downstream of the proposed development;
- adequate manoeuvring area and turning basins for access to existing berths, docks and wharves;
- attainable capacity requirements in terms of the type, dimensions, and number of locks (1 No. vs 2 No.);
- attainable tidal requirements in terms of the tidal windows (number of hours either side of high water);
- feasible channel reach based on the channel arrangement taking cognisance of no-go areas; and
- other possible stakeholder and/or third party issues and requirements.

2.2.6 Following the identification of constraints (including the navigation constraints identified through the process described above), three location options (bands) were identified by the project team during Stage 2 (see Section 3). These three representative bands incorporated all possible types of locations in the Estuary. Specific potential configurations of the proposed development at the respective band locations were not identified, rather the bands were intended to represent typical locations. Any number of orientations may be workable at each of the band locations.

2.3 Step 2 – Preliminary Options

2.3.1 Step 2 involved assessing the three location options (bands) with respect to certain fundamental criteria that are of paramount importance in the choice of location from a navigation perspective.

2.3.2 Failure of a location option to meet the minimum navigation criteria would influence the appraisal of that location option. Depending on the degree of the constraint the location option may be considered to have a fatal flaw attached to it and could therefore be ruled out before further evaluation. A location option is only considered to have fatal flaws should there be no reasonable means of mitigating the identified constraint/s. Such fatal flaws would therefore include navigation hindrances that there is no means of overcoming. The minimum navigation criteria considered in the evaluation is outlined in Section 3.

2.3.3 The navigation assessment of location options therefore ensured the proposed development would be located where the:

- limiting factors and constraints are or can be overcome;
- primary navigation aspects essential in locating such a development are complied with; and
- stakeholder and other third party preferences are addressed.

2.3.4 All three bands were found to satisfy the minimum navigation requirements hence none were considered to have fatal flaws and any potential navigation impacts identified could therefore be mitigated (albeit some would be at significant cost and spatial requirements which may affect the viability of the proposed development).

2.3.5 The extent (if any) to which the potential navigation impacts would occur is entirely dependent on the location of the proposed development. For each of the bands there are varying degrees of mitigation measures that would be required for the same or similar navigation impacts.

2.3.6 Navigation mitigation options were identified for each band, on the basis of the amount of mitigation required for navigation impacts to be overcome in that location. No commercial navigation mitigation would be required at Band B, located upstream of Eastham and Garston.

2.3.7 During Stage 2 of the feasibility study the navigation work contributed to an overall assessment of Band C. This assessment, including non-navigation aspects, concluded that Band C is not favourable due to a number of constraints and Band C was dropped from the study.

2.3.8 A set of navigation mitigation options were produced for a proposed development at Band A, six in total, incorporating all possible configurations and orientations taking cognisance of the constraints that exist. Although the focus was on Band A, the navigation mitigation options could theoretically be applied to any location upstream of Band A but downstream of Eastham/ Garston. A description of each of these navigation mitigation options is provided in Section 3, and shown in the relevant drawings.

2.4 Step 3 – Preferred Navigation Option Selection

2.4.1 During Stage 3 of the feasibility study, the project team continued their study on Band A and Band B. However, the inability of Band B to meet various non-navigation criteria (energy yield, cost of construction, operational flexibility, etc.) resulted in this band being dropped. Therefore Step 3 has focused on Band A.

2.4.2 Step 3 involved the final navigation assessment, to determine which of the proposed navigation options would be most suitable in terms of its ability to enable the proposed development to function efficiently with limited navigation impacts.

2.4.3 This involved a more in-depth evaluation than the previous two steps and included ranking and assessing the individual navigation mitigation options as opposed to a general check-and-tick exercise for compliance with certain minimum navigation criteria.

2.4.4 The potential navigation mitigation options were initially assessed using the minimum navigation criteria for the proposed development from Step 2. Further to this, additional navigation criteria were considered in this final step of the evaluation process. This involved reviewing and ranking individual navigation mitigation options using the option ranking criteria listed in Section 5. These criteria relate to navigation aspects only; other criteria and aspects that influence the evaluation process and assessment of options are dealt with independently.

2.4.5 There are some navigation criteria that are not considered necessary in the option appraisal process due to the nature of the navigation mitigation options being evaluated. These criteria, although ordinarily important in a navigation option selection, are not considered to specifically offer any value to this evaluation process as they are considered constant for all options. These criteria are listed below:

- aggressive wind and wave climate (including extreme events);
- storm surges;
- sea level rise;
- likely overtopping of locks affecting operational functionality and efficiency;
- port restrictions and other operational criteria;
- compliance of lock structure and facility with Port regulations and industry practice/publications; and
- passing traffic issues in main channels (with the exception of Bromborough Wall).

2.4.6 The six navigation mitigation options were evaluated using a colour coding system, where the assigning of a negative influence indicator was identified as ‘amber’ or ‘red’, depending on the degree of negativity. The indicator was evaluated based on the relevant ability of the navigation mitigation option to meet each of the navigation criteria. Every option was colour coded against each criterion – the positive indicators identified by ‘light green’ or ‘dark green’, the higher (better) the option ranks. The colour coding for each criterion associated with each option and its respective ranking is outlined in Section 5.

2.4.7 Once each navigation mitigation option was colour coded against the option ranking criteria, the colours were assessed to determine the final ranking, illustrated in Section 5, and a preferred option was identified. This process adopted was a qualitative approach.

3 Lesson Learned from Stage 2

3.1 Location Options Appraisal

3.1.1 The siting of the proposed development at the Band A, Band B or Band C locations was studied in Stage 2. The location of these bands is shown in Figure 3.1 below.

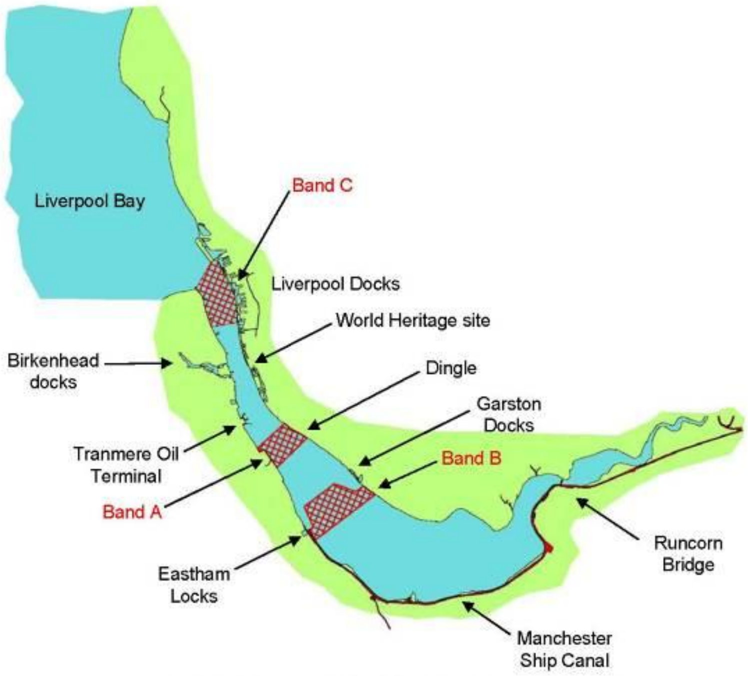


Figure 3.1: Alignment Bands

3.1.2 The potential impacts to navigation associated with each band were outlined, and the evaluation of the bands was undertaken in accordance with the minimum navigation criteria identified below:

3.1.3

- Observance of boundaries of identified manoeuvring areas, navigation zones, turning circles, etc. and remaining outside of identified limits
- Conforming to restrictions identified by requirements for entry into, navigation through, and manoeuvring in channel
- Compliance with requirements for dock, berth and wharf access and configuration of channel relative to these areas, based on manoeuvring requirements
- Maintaining acceptable configuration of lock relative to channel, based on manoeuvring requirements
- Maintaining acceptable current velocities upstream and downstream of proposed development

- Avoiding additional reduction in duration of navigable tidal windows and hence increasing congestion
- Minimising additional increases in transit times by introducing additional locking in/out times
- Minimising additional resource usage such as tugs resulting in increased shipping costs

3.1.4 A summary of the navigation impacts is presented in Appendix A. The advantages and disadvantages of each band was assessed and is shown in Appendix B.

3.1.5 The outcome of the Stage 2 study indicated the following:

- Band B is identified to be bounded downstream by Eastham and Garston Docks with no upstream limit identified. This band offers the best navigation solution due to the lack of obstruction to commercial shipping and hence no locking in/out times.
- Band C is identified to be bounded downstream by the Rock lighthouse which occurs downstream of the southern shore, and upstream by the World Heritage Site. This band presents numerous navigation constraints at river entry as well as for navigation through the band and manoeuvring. This is mainly due to the fact that majority of the Mersey traffic is required to pass through the band including the largest vessels (VLCC tankers, cruise liners, post-Panamax container vessels). As a result the navigation impacts would be difficult to mitigate and overcome.
- Band A is identified to be bounded downstream at a point occurring upstream of Tranmere Oil Terminal and upstream by Eastham and Garston Docks. This band does not offer a better navigation solution to Band B. The navigation issues associated with Band C are reduced. This band presents navigation impacts that could be mitigated and overcome.

3.2 Navigation Mitigation Option Outline

3.2.1 Various navigation mitigation options applicable in and around Band A were developed during Stage 2. These options were technically possible navigation measures to eliminate the obstruction to navigation and permit vessels to navigate through the structure. These included six options sited downstream of Eastham and Garston Docks and upstream of Tranmere Oil Refinery.

3.2.2 The final alignment of the development has not been determined but it is adequate at this stage to note that the identified structures are to be positioned within the identified boundaries of Band A. The final alignment within Band A will be dependant on many other factors (engineering, planning, environmental, etc), but the identified potential impacts will remain unchanged with exception to the degree to which some of the identified impacts occur, either to a lesser or greater extent.

3.2.3 A description of the navigation mitigation options produced is presented below. For each of the options outlined a variation of one or two locks is provided. This is a defining feature of the navigation mitigation option presented together with the configuration adopted. The dimensions of the locks and the basis of this determination is presented in Appendix C, which also includes the details of the bund for the Manchester Ship Canal extension option and proposed Garston channel dimensions.

3.2.1 Option 1 – Single Lock Liverpool Bank & Single Lock Wirral Bank

3.2.4 This option comprises two locks provided adjacent to the Liverpool and Wirral shores respectively. This positioning allows the existing Garston and Eastham navigation channels to be served.

3.2.5 The layout of this option is shown in Drawing PD0330-12-3001 Rev P1 and the lock arrangement for the Wirral bank and Liverpool bank is shown in Drawing PD0330-12-3021 Rev P1 and Drawing PD033-12-3022 Rev P1 respectively.

3.2.2 Option 2 – Single Lock Wirral Bank

3.2.6 This option is as for Option 1 above with the exclusion of the lock adjacent to the Liverpool shore. As a lock is not provided for access to Garston Docks, a new channel would be required to provide this link and is proposed to occur through Devil's Bank. This new channel would link the existing Garston navigation channel with the lock adjacent to the Wirral shore.

3.2.7 The layout of this option is shown in Drawing PD0330-12-3002 Rev P1 and the lock arrangement is shown in Drawing PD0330-12-3021 Rev P1.

3.2.3 Option 3 – Double Lock Wirral Bank

3.2.8 This option is as for Option 2 above, with the inclusion of an additional lock neighbouring the one adjacent to the Wirral shore. Access to Garston Docks is as outlined in Option 2 above.

3.2.9 The layout of this option is shown in Drawing PD0330-12-3003 Rev P1 and the lock arrangement is shown in Drawing PD0330-12-3023 Rev P1.

3.2.4 Option 4 – Single Lock Liverpool Bank & Single Lock Wirral Bank With Extension to the Manchester Ship Canal

3.2.10 This option is as for Option 1 above, with the inclusion of a non-tidal channel that extends from the Manchester Ship Canal downstream to the proposed development. This arrangement would eliminate the need for an additional lock to be traversed as the water level in the canal extension would be maintained at the same level as the Manchester Ship Canal upstream of Eastham Docks, hence allowing Eastham locks to remain permanently open.

3.2.11 The layout of this option is shown in Drawing PD0330-12-3004 Rev P1 and the lock arrangement for the Wirral bank and Liverpool bank is shown in Drawing PD0330-12-3021 Rev P1 and Drawing PD033-12-3022 Rev P1 respectively.

3.2.5 Option 5 – Double Locks Estuary Centre

3.2.12 This option is as for Option 3 above, with the exception that the locks are positioned in the centre of the Estuary as opposed to adjacent to the Wirral shore, with sufficient clearance from Devil’s Bank to enable continued navigation of the Garston channel.

3.2.13 The layout of this option is shown in Drawing PD0330-12-3015 Rev P1 and the lock arrangement is shown in Drawing PD0330-12-3023 Rev P1.

3.2.6 Option 6 – Single Lock Liverpool Bank & Tidal Channel to Manchester Ship Canal (as existing)

3.2.14 This option is as for Option 4 above, with the exclusion of the lock adjacent to the Wirral shore which would be replaced with a guide wall. The extension of the Manchester Ship Canal to the proposed development would be retained but would be tidal.

3.2.15 The layout of this option is shown in Drawing PD0330-12-3016 Rev P1 and the lock arrangement is shown in Drawing PD033-12-3022 Rev P1.

3.3 Lock Usage by Leisure Craft

3.3.1 Use of locks for commercial and leisure shipping would require regulation by the Port Authority. As such, for each of the navigation mitigation options listed above, the transit through the lock structures would be permitted to commercial vessels only. Access to leisure craft would be restricted, although alternate means are intended to be provided to mitigate the navigation obstruction. This includes use of the possible gate holes/bays of the impounding barrage for unimpeded transit of leisure craft upstream/downstream of the estuary or alternately a small boat lock may be provided.

4 Stage 3 Findings

4.1 Navigation Mitigation Option Appraisal

4.1.1 A summary of the advantages and disadvantages of each of the navigation mitigation options outlined in Section 3 is presented in Table 4.1 below.

Table 4.1: Table of Pros and Cons

Item	Navigation Option					
	1	2	3	4	5	6
Pros						
Twin locks operate independently, provide adequate capacity (90%-10% Eastham-Garston traffic split may be inefficient)	X			X		
Double locks operate independently - allow simultaneous transit in opposite direction, reduce locking times, provide maintenance / repair option			X		X	
Transit time to Eastham Docks comparable to existing – MSC lock gates open				X		
No new channel dredging to Garston required [1]					X	X
No channel dredging to MSC					X	X
No Wirral lock and channel provides adequate capacity (channel capacity as per existing)						X
Transit time to Eastham Docks possibly comparable to existing – no additional lock to transit, existing tidal restrictions and traffic movements apply				X		X
Cons						
Obstruction to some commercial shipping	X	X	X	X	X	X
Potential changed current velocities downstream	X	X	X	X	X	X
Potential impact on vessel manoeuvres at Tranmere	X	X	X	X	X	X
Additional lock for Eastham Docks traffic to transit, longer times [2]	X	X	X		X	
Additional lock for Garston Docks traffic to transit, longer times	X	X	X	X	X	X
Dredging downstream of Wirral lock to improve impacted access window [3]	X			X		X
River tugs transit lock twice (before & after berthing / unberthing) for QEII Dock – may require more tugs	X	X	X	X	X	
Passing ship effects on vessels at Bromborough Wall				X		X
New channel dredging to Garston Docks - unknown conditions		X	X			

Item	Navigation Option					
	1	2	3	4	5	6
Potential cross-current element during transit of new dredged channel to Garston Docks		X	X			
MSC channel dimensions could limit vessel size to Bromborough Wall [4]				X		
Capacity of single lock may be inadequate for turnaround – 1 vessel movement every 1.1 to 1.7 hours per tide (over 2 individual 6-hour periods)		X				
Tidal requirements for lock transit may prove unworkable		X				
Additional maintenance dredging to MSC due to likely siltation						X
Channel dredging for 2-way traffic and MSC "free flow" potentially uneconomic				X		

Notes:

1. Channel dredging refers to upstream of the Liverpool lock and/or downstream of the Wirral lock through Devil's Bank.
2. For Option 4, the water level in the canal extension would be maintained at the same level as the MSC upstream of Eastham Docks, hence allowing Eastham locks to remain permanently open.
3. Cognisance is taken of whether 100% or 90% of the traffic is transiting the Wirral lock, based on the 90%-10% Eastham-Garston traffic split. If 90% is transiting the lock then the dredging downstream of the lock would potentially restrict delays and improve the impacted access window. If 100% is transiting the lock, this impacted access window is unlikely to be improved due to probable congestion. This is irrelevant to whether a single or double lock is available on the Wirral side.
4. Size of the Wirral lock is governed by the design vessel to QEII which is significantly larger than the design vessels to Eastham or Bromborough Wall. The MSC channel width is governed by the two-way traffic requirements of the QEII design vessel (in terms of beam) and turning circle requirements of the Bromborough Wall design vessel (in terms of length). Without any increase to the QEII design vessel requiring the channel width to increase, any increase to Bromborough Wall design vessel would not be able to be accommodated. This is because the Bromborough Wall design vessel length is to be accommodated in the MSC channel width during the turning manoeuvres.

4.2 Navigation Impacts

4.2.1 Transit Times through Locks

4.2.1 Traffic data for the Manchester Ship Canal movements for 2007 was reviewed to assess the number of vessel movements through Eastham Docks and the QEII Docks, the statistics do not distinguish Eastham or QEII Docks independently. There are 2 locks operating for entrance to the Manchester Ship Canal, which are operated four hours before to four hours after high water. Arrivals and departures were plotted for the morning and afternoon to assess the arrivals around each high water at Eastham. A summary of the existing lock dimensions and tide data is provided in Appendix D.

4.2.2 The vessel movements over one tide cycle were determined and are shown in Table 4.2 below.

Table 4.2: Vessel Movements

Vessel moves	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	2	2	2	2	2	2	2	2	2	2	2	2
Average	4	5	8	6	7	5	6	5	5	5	5	7
Maximum	11	11	10	12	10	10	11	13	10	13	10	12

4.2.3 The highest vessel movement was thirteen vessels and the median figure for vessel arrivals and departures is between four and eight movements over a high water period dependant on the month, the average figure is approximately five vessels.

4.2.4 Assuming a double lock is used in Option 3 and Option 5, in the figures below, the scenario of twelve arrivals and departures is represented with a fifteen minute gap for outward vessels to clear the two locks. Vessels 1 to 6 are departing and Vessels A to F arriving. This is the best case scenario with vessels taking the least time to transit the locks.

4.2.5 The thirty minutes includes the time for a vessel to transit the lock and for the lock to be turned around in preparation for the next vessel transit.

4.2.6 Areas shaded green are where outward vessels can transit the locks, areas shaded blue are inward vessels transiting and areas shaded red are where vessels are waiting for vessels to clear the locks before commencing their transit.

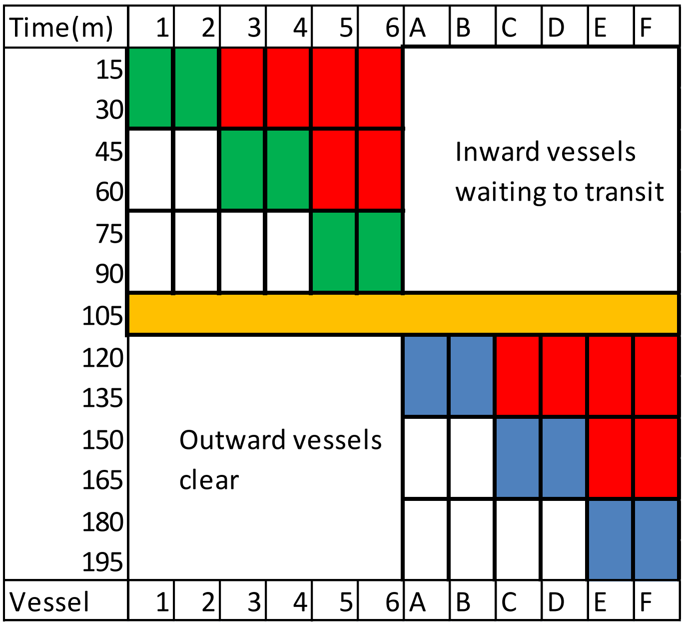


Figure 4.1: Twelve vessels transiting two locks

4.2.7 Vessel F clears the locks in 195 minutes or 3.25 hours.

4.2.8 Similar representations are shown below for eight and four vessel movements through two locks. Vessel D clears the locks in 135 minutes or 2.25 hours when there are eight vessel movements, and Vessel B clears the locks in 75 minutes when there are four vessel movements.

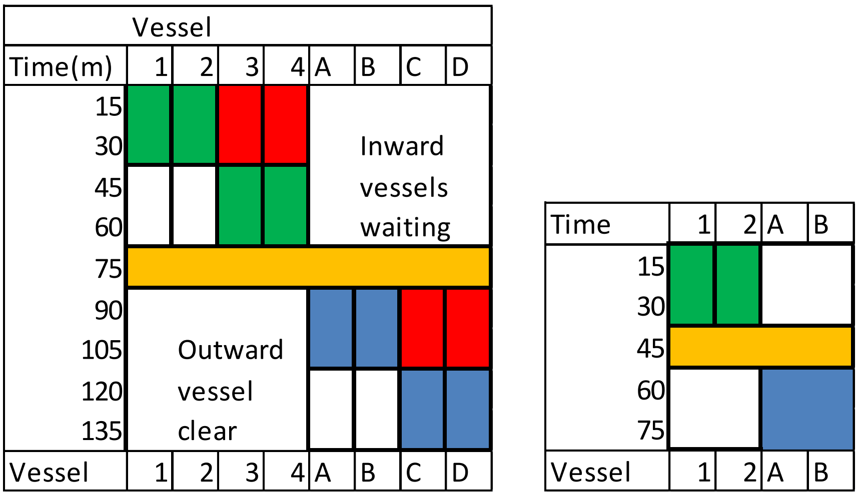


Figure 4.2: Eight and four vessels transiting two locks

4.2.9 The figures above are a basic summary of vessels moving through locks, occasionally there will be a need for vessels to transit in a particular order due to tidal constraints and this could lead to greater delays. For the purposes of this study it has been assumed that a vessel can enter a lock as soon as one becomes available and there are no priority systems/rules in place for inbound or outbound traffic.

4.2.10 The height of high water had no direct impact on the maximum number of vessels transiting the locks during 2007 however the deep draft vessels (draft of 10.0 m) for QEII Docks require a minimum high water of 11.0 m. If these vessels manoeuvre after high water this could potentially affect waiting times, albeit as a result of available tidal windows and not unavailability of locks.

4.2.2 Resources (Pilotage and Towage)

4.2.11 Any additional lock transit could have cost and time implications for pilot and tug requirements and these are discussed in more detail below

Pilotage

4.2.12 The Manchester Ship Canal and QEII Dock have a separate pilot service to the river and the existing arrangement for arriving vessels is for the river pilot to secure the vessel in Eastham or QEII Lock where the pilots are changed over (vice versa for departing vessels).

4.2.13 Vessels bound to and from Garston and Bromborough Wall use the same pilot from sea to the berth.

4.2.14 There are approximately 47 pilots available for the river and, based on the assumption that vessels will be required to lock through the tidal structure, this should not make any significant difference to the number of pilots required.

Tugs and Towage

4.2.15 The existing arrangement for tugs is that river tugs take the vessel to the berth in QEII and Garston and only to Eastham locks for the Manchester Ship Canal (where Manchester Ship Canal tugs take over).

4.2.16 The tug system for Eastham Lock is operated by securing one river tug to the bow of the vessel and the other right astern. Vessels arriving at the lock will let go the bow tug just before entering the lock and the stern tug is let go after the vessel is secure. This arrangement means that tugs are able to leave the lock before the gates are closed and do not have to transit through. The Manchester Ship Canal tugs are then secured before and during the vessel leaving the lock.

4.2.17 A slight variation to this arrangement is Garston where the vessels will transit through the lock on the level and will therefore keep the tugs secured until alongside the berth. Given the relatively short window of the open lock at high water and the time to secure the vessel alongside, the tugs will then be required to lock out.

4.2.18 Vessels transiting to QEII Dock will be required to use the river tugs to the berth, as the Manchester Ship Canal tugs do not have the power for the larger vessels. The number of tugs used would depend on the size of the vessel and this may vary between 1, 2 or 3 tugs (a vessel using 3 tugs in the river would let go the third tug prior to entering the lock as it is not required for berthing).

4.2.19 A vessel transiting the QEII Lock using 2 tugs would have one secured forward and one aft throughout although these would shift to the shoulder and quarter of the vessel when in the lock to allow the gates to close. The tugs would still overhang the length of the vessel by approximately half a tugs length at either end and would also require some clearance from the gates. Assuming a larger tug length of some 35m and a clearance of 5m at each end, this would require an approximate additional allowance of 45m for tugs within the lock.

4.2.20 Vessels to Bromborough Wall do not routinely use tugs as the vessels are smaller and there is sufficient room for them to manoeuvre off the berth using their own power and steering (most, but not all also have bow thrusters). This tug arrangement may be continued following the introduction of a lock in the tidal power structure. A time allowance would need to be considered for the tugs prior to and on completion of the manoeuvring as they will probably be required to transit the locks twice (this may not be the case if tugs used for an arriving vessel are then used for a departing vessel).

4.2.21 The additional time element and the issues involving locking in and out for the tugs may mean that additional tugs may be required in the fleets to accommodate simultaneous vessel movements.

Costs Associated with Manchester Ship Canal Pilotage and Towage

4.2.22 The MSC pilotage area of jurisdiction includes the locks at QEII and Eastham and extends a few metres to seaward of the lock lead-in structure for Eastham. In theory this should mean that arriving vessels should change from the Liverpool pilot to the MSC pilot before entering the locks (and departing vessels after the vessel has departed the lock). However in practice there is an agreement between the two pilotage services that the changeover of pilots (inbound and outbound) takes place when the vessel is in the lock as this does not require any pilot boat transfer of pilots and sensibly does not disrupt the operation.

4.2.23 This MSC harbour limit means that a lock within a tidal power option downstream of the MSC is a considerable distance outside the MSC pilotage area (i.e. totally within the Liverpool pilotage district) and therefore, after having discussions with the MSC pilots, it is thought that the new tidal structure will not affect the existing MSC operations in terms of pilotage and tug requirements.

Costs Associated with Mersey Pilotage and Towage

4.2.24 A tidal structure downstream of the MSC will directly affect the Liverpool pilots operations as they will be required to lock through the arriving and departing vessels, in addition to the existing lockings at QEII, Eastham and Garston.

4.2.25 The existing arrangements for tugs are that one or two tugs are used for berthing at Garston and Eastham and up to three tugs are used for vessels berthing at QEII. The actual number of tugs used is dependent on the prevailing weather conditions and the size of the vessel based on the guidelines set out by the Port Authority.

4.2.26 The river tugs used for arrival take the vessels through the locks to the berth at Garston and QEII but only as far as the locks at Eastham, where the MSC tugs take over to take the vessels from the lock to the berth. Conversely a departing vessel will have a similar arrangement, except for Eastham and Garston where vessels are usually able to sail into the river without tug assistance. These arrangements are summarised in Table 4.3 below.

Table 4.3: Service requirements without tidal structure

Without Tidal Structure						
Service	QEII Arrival	QEII Departure	Eastham Arrival	Eastham Departure	Garston Arrival	Garston Departure
Tugs (No.)	3	3	2	0	2	0
Pilots (No.)	1	1	1	1	1	1
Boatmen	Yes	Yes	Yes	Yes	Yes (berth only)	Yes (berth only)

4.2.27 The number of tugs shown is a conservative estimate assuming that a vessel will use the maximum number of tugs required and for the purposes of this assessment these are the numbers used in the following calculations. In practice some vessels will not use all, or in some cases any tugs, depending on size and weather.

4.2.28 If a tidal structure and lock is sited between the existing facilities and the sea, then there will implications for tug and pilot requirements to transit through the structure. For the purposes of assessing tug utilisation it has been assumed that an allowance of 30 minutes is required to lock through the structure and a further 30 minutes to transit between the structure and the upstream facility.

4.2.29 With regard to tugs, it is assumed that if a vessel is required to use them for locking in or out now, then they will also be required for transiting the structure. In this scenario it is also assumed that no additional tugs would be used, but the tugs used would need to be used for a longer time as they will be required to assist the vessel through two locks. For the purposes of this assessment it has been assumed that tugs will be required for twice the existing fee and pilots will be required for ‘time and a half’ for a two lock transit.

4.2.30 Additional tugs would however be required for vessels departing Eastham and Garston because although they would not necessarily be needed to leave the locks at these facilities they would be required for entering the lock at the tidal structure (in a similar way to departing the locks at the facilities, these vessels would not require the tug to depart the tidal structure lock).

4.2.31 The additional requirements for services with a tidal structure are shown in Table 4.4 below.

Table 4.4: Service requirements with tidal structure

With Tidal Structure						
Service	QEII Arrival	QEII Departure	Eastham Arrival	Eastham Departure	Garston Arrival	Garston Departure
Tugs	6	6	4	2	4	2
Pilots	1.5	1.5	1.5	1.5	1.5	1.5
Boatmen	Yes x 1.5	Yes x 1.5	Yes x 1.5	Yes x 1.5	Yes	Yes

4.2.32 The Liverpool pilots will still be required to navigate the vessels to and from the existing facilities and it is assumed that same pilot will remain on the vessel throughout. This would mean that on a single transit basis no additional pilots would be required however that particular pilot would be on-board for a longer period and this may have a knock on effect to his next job.

4.2.33 Vessel berthing costs will also include boatmen and as the vessels will also be required to be secured in the tidal structure lock, it is assumed that further costs will be incurred for this operation. The existing berthing fees for locking and berthing based on an average gross tonnage are about £1,000 for both (or £500 each). The cost for arrival and departure at Garston are assumed to be £500 as vessels normally transit the lock without making fast.

4.2.34 In determining the following high level cost implications for tugs, pilots and boatmen by introducing the tidal structure lock, the following assumptions have been made:

- An average cost for a tug of £2,500. It is understood that the actual tug costs vary considerably depending on the type of assistance given to the vessel and individual arrangements between tug companies and agents.
- The tug companies will view the additional time required to lock though the structure and transit to the facility as a chargeable item and for the purposes of this assessment this has been assumed as up to twice the existing cost.
- A conservative estimate of the maximum number of tugs required for each manoeuvre.
- The pilotage charges are relative to the gross tonnage of the vessel and therefore in practice this will vary. A review of the vessels calling at Eastham and QEII for 2007 showed a mean average gross tonnage of some 3,661 which equates to an average pilotage cost of about £2,000.
- The Liverpool pilots do not set the rates for the chargeable fees (this is done by the competent harbour authority) and therefore the increase in cost due to the additional time required to transit the structure is not known. The increase in cost has therefore been assumed to be 1.5 times the existing fees.

- The actual pilotage fee rates may also vary between river users although the actual amounts are not known. The average rate has been used.
- A similar boatmen increase of 1.5 times the existing fees is assumed.

4.2.35 A comparison of costs of the tugs, pilotage and boatmen between the two scenarios of with and without the tidal structure (Table 4.7) has been performed using the data contained within Table 4.5 and Table 4.6, and in line with the charges stated in the assumptions.

Table 4.5: Indicative costs without tidal structure

Without Tidal Structure						
Service	QEII Arrival	QEII Departure	Eastham Arrival	Eastham Departure	Garston Arrival	Garston Departure
Tugs (£)	7,500	7,500	5,000	0	5,000	0
Pilots (£)	2,000	2,000	2,000	2,000	2,000	2,000
Boatmen	1,000	1,000	1,000	1,000	500	500
Total (£)	10,500	10,500	8,000	3,000	7,500	2,500

Table 4.6: Indicative costs with tidal structure

With Tidal Structure						
Service	QEII Arrival	QEII Departure	Eastham Arrival	Eastham Departure	Garston Arrival	Garston Departure
Tugs (£)	15,000	15,000	10,000	5,000	10,000	5,000
Pilots (£)	3,000	3,000	3,000	3,000	3,000	3,000
Boatmen	1,500	1,500	1,500	1,500	1,000	1,000
Total (£)	19,500	19,500	14,500	9,500	14,000	9,000

Table 4.7: Cost comparison

Cost Comparison						
Service	QEII Arrival	QEII Departure	Eastham Arrival	Eastham Departure	Garston Arrival	Garston Departure
Without Structure (£)	10,500	10,500	8,000	3,000	7,500	2,500
With Structure (£)	19,500	19,500	14,500	9,500	14,000	9,000
Difference (£)	9,000	9,000	6,500	6,500	6,500	6,500

4.2.36 This cost comparison in Table 4.7 is a high level calculation which indicates that most vessel transits would incur an approximate 100% increase in costs, with the exception of departing Garston which would incur an approximate 250% increase.

4.2.37 Although it is assumed that only one pilot is required for each arrival or departure (and therefore this is the same with and without the structure) it is recognised that there may be a requirement to increase the overall number of pilots to account for the additional time taken to complete each act of pilotage.

4.2.38 This overall increase in numbers may also apply to the tugs, as they will have to spend longer times on each job and will also take longer to either reach a vessel for sailing or leave a vessel after berthing due to additional locking arrangements at the tidal structure.

4.2.39 The following comments relating to the design and operation of the tidal structure should also be considered:

- It is suggested that the tidal structure locks are designed to enable a large QEII vessel and three tugs to access the same lock (this would be for one tug at the bow and two tugs astern). This arrangement would be required to reduce transit times of the large vessels as the tugs could transit through with the vessel.
- Liverpool pilots noted that they had sighted a previous ship simulation for a lock in a tidal structure and that the results of this showed that cross currents had caused difficulties in entering the lock. This should be considered as part of future studies.
- Access to Garston, Eastham and QEII could be improved by the introduction of the tidal structure as the impounded water would extend the high water period and therefore increase the access window for the existing locks, and the entrance to the new locks in the tidal structure are in deeper water.
- Any lead-in structures for the tidal power locks are recommended to be solid (as opposed to trestle) and to be well fendered. This would allow vessels to land on them before entering the lock and offer shelter from the current.
- It is also recommended that the lead-ins are extended between the lock gates and the dog legs so that there is a continuation of the side of the lock to allow the vessels to be guided in.

4.2.40 It is recommended that a more detailed operational simulation and cost comparison study is undertaken to produce a more accurate set of costing results. This will also aid in assessing the overall increase in pilot and tug numbers required following the introduction of the development.

4.2.3 Tidal Access Windows and Channel Depths (Capital Dredging)

4.2.41 The phasing of the upstream and downstream tidal cycles, and the increased transit time due to locking, will affect the window of access for vessels entering upstream docks (if no other measures are taken), specifically at Eastham, QEII and Garston. Prolonged high water levels could potentially increase the access windows for the upstream docks. However, whilst upstream water levels are high, the downstream water level will drop and it is important that vessels leaving the docks can proceed downstream after spending time in the lock. This is particularly the case for the traffic bound to/from QEII as these vessels are the largest of the design vessels for the upstream docks. As such the QEII traffic presents the governing scenario for the downstream navigation channel. Each of the upstream docks will however be discussed individually on the basis of their access windows.

4.2.42 By dredging the navigation channels immediately downstream of the new barrage lock(s) to a sufficient depth, the proposed navigation options all ensure that the future access windows for Eastham, QEII and Garston are of duration no shorter than at present. The tidal access windows presented are applicable to all six navigation options evaluated as part of the Stage 3 study. They relate to the relevant water depths (based on determined channel depths) required to maintain an appropriate access window, for each of the upstream docks. The access windows do not take account of traffic congestion, priority systems/ rules for inbound/ outbound traffic, etc. For the purposes of this study it has been assumed that a vessel can enter a lock as soon as one is required.

4.2.43 The design vessel data for each of Eastham, QEII and Garston Docks are provided in Appendix C and the sill levels of the existing locks at each of these docks is presented in Appendix D.

QEII

4.2.44 Considering an existing channel bed level for the tidal window at QEII is -5.6mCD and corresponding required tide level of +5.4 mCD. This may give approximately an existing window of access of 2 hours for QEII vessels. Transit through the existing lock takes up to 45 mins, therefore the existing window of access is reduced to 1.25 hrs. This is based on the assumption that the existing lock sill level is the governing depth. Given that there is no specific dredging plan in place and at present dredging is undertaken in accordance with the dredging and siltation regime as identified by the soundings undertaken on a 2 to 3 weekly basis, the existing channel depth can not be identified with any certainty.

4.2.45 Working on the basis that the access windows communicated by the Mersey Pilots is accurate, then the existing access window is 3hrs for QEII traffic. This translates to a required tide level of +4.4mCD and a corresponding present channel bed level of -6.6mCD. This in fact indicates that the channel is dredged to a level deeper than the governing existing lock sill level. This greater depth can be attributed to over-dredge (circa 0.5m) and consideration of a siltation allowance (circa 0.5m).

Eastham

4.2.46 Considering an existing channel bed level of -3.46 mCD and corresponding required tide level of +6.32 mCD may give approximately an existing 45 min window of access for Eastham vessels. Transit through the existing lock takes up to 30mins, therefore the current window of access is reduced to 15 mins. This is based on the assumption of the existing lock sill level as identified above.

4.2.47 Working on the basis that the access windows communicated by the Mersey Pilots is accurate, then the existing access window is 4hrs for Eastham traffic. This translates to a presently required tide level of +4.15 mCD and a corresponding existing channel bed level of -5.63 mCD. The greater channel depth compared to existing lock sill level can be attributed to over-dredge and consideration of a siltation allowance as identified above.

Garston

4.2.48 Considering a bed level of -0.72 mCD and corresponding required tide level of +8.78 mCD may give approximately no window of access for Garston vessels. There is unimpeded access through the existing lock and so there is no reduction to the window of access as a result of transit times through the existing lock. However assuming an existing channel bed level of -0.72 mCD and corresponding required tide level of +8.78 mCD; there is approximately no window of access for Garston vessels.

4.2.49 Working on the basis that the access windows communicated by the Mersey Pilots is accurate, then the access window is 45mins for Garston traffic. This translates to a required tide level of +6.34 mCD and a corresponding present channel bed level of -3.16 mCD. The greater present channel depth compared to existing sill level can be attributed to over-dredge and consideration of a siltation allowance as identified above.

4.2.50 The above evaluation confirms that the new lock will not worsen the existing tidal windows, at worst they will remain as is presently experienced. It also confirms the dredged depths identified for the new channels to maintain these access windows.

Tidal Access Windows and Channel Depths

4.2.51 In order to maximise the window of access for vessels bound for the docks upstream of the new barrage lock, it is necessary for these vessels downstream of the new barrage lock to have tide levels of approximately +3 mCD. This corresponds to a required channel bed level downstream of the barrage lock of -8 mCD, and provides an access window of approximately 6 hrs. Transit through the new lock is assumed to take up to 1hour; therefore the window of access is reduced to 5hrs.

4.2.52 The assumed lock transit time of 1 hour is double the time it is expected to take (refer to Section 4.2.1) and is an estimate used to provide a more conservative result for the tidal access windows. In the absence of definitive information with regard to traffic congestion, priority systems/rules for inbound/outbound traffic, etc. it was determined that such conservatism is relevant and suitable to yield appropriate and meaningful results.

4.2.53 As discussed above, if the channel downstream of the barrage is dredged to -8 mCD then the tidal window downstream of the barrage can be assumed to be 5 hours (allowing for transit time through the new lock), However upstream of the lock the existing channel bed levels for the QEII, Eastham and Garston currently have bed levels of below -5.6 mCD, -3.46 mCD and -0.72 mCD. The shipping channels between the existing locks and the new barrage lock will most likely will require channel bed levels deeper than their existing channel depths to fully utilise the available tidal window downstream of the barrage. The required bed level for each channel will tend towards -8mCD as the channel approaches the new barrage lock to provide the required water depth in the main navigation channel. If the shipping channels from the new barrage lock to the existing locks are dredged and maintained at sufficient depth that they are able to fully utilise the access window of the barrage lock, then the basis of dredging (capital and maintenance) occurring to provide and maintain the -8 mCD bed level, the access window for QEII vessels entering the upstream docks at 5 hours is greater than the existing lock access windows of 3 hrs, 4 hrs and 45 mins for QEII, Eastham and Garston docks respectively.

4.2.54 Preliminary studies undertaken in Stage 2 identify a channel bed level of -8 mCD for the Eastham, QEII and Garston channels downstream of the new barrage lock structure, with channel levels upstream of the barrage lock adopted as -3 mCD for Eastham and QEII and -2 mCD for Garston. In Stage 3, these values have been verified by calculations that are based on water surface elevation output from the hydrodynamic modelling, also undertaken as part of the Stage 3 studies. Further studies of the tide levels and access windows in the form of a detailed shipping study are recommended to be undertaken at a later stage. This will serve to optimise the capital dredging based on the channel levels identified in line with the achievable access window. At this stage however, a simplified uniform channel level of -8 mCD upstream and downstream of the new barrage lock has been used to maximise the access window.

4.2.55 In summary, the study results aid in ascertaining whether tidal windows would be adversely affected by the new lock. It also assists in providing justification of the channel depths quantified. This is the best means available given the lack of a shipping study which is suited to confirm vessel movements, congestion and associated delays, access windows, etc.

5 Comparison of Schemes

5.1 Navigation Mitigation Option Evaluation

5.1.1 As outlined in Section 2, the navigation mitigation options presented in Section 3 were reviewed and ranked using various criteria that were identified to inform the decision making process and contribute effectively to the evaluation process. The navigation mitigation options ranking criteria, listed in the table below, are focussed on navigation aspects that will influence the appraisal process.

5.1.2 A summary of the navigation mitigation options evaluation and selection as outlined in Section 2 is presented in Table 5.1 below.

Table 5.1: Table of Options Evaluation

Criteria	Ranking	Navigation Options						
			1	2	3	4	5	6
Achievable throughput capacity for traffic to Garston Docks (based on 2007 traffic level which is the highest traffic level recorded prior to the 2008 recession during which demand fell). Ability to accommodate increased throughput capacity based on growth of 10% or 25%	Can accommodate 25% growth							
	Can accommodate 10% growth but not 25%							
	Can accommodate 2007 actual							
	Unable to accommodate 2007 actual							
	Unable to accommodate 2007 actual							
Achievable throughput capacity for traffic to Manchester Ship Canal (based on 2007 traffic level which is the highest traffic level recorded prior to the 2008 recession during which demand fell). Ability to accommodate increased throughput capacity based on growth of 10% or 25%	Can accommodate 25% growth							
	Can accommodate 10% growth but not 25%							
	Can accommodate 2007 actual							
	Unable to accommodate 2007 actual							
	Unable to accommodate 2007 actual							
Achievable throughput capacity for traffic to QEII Docks (based on 2007 traffic level which is the highest traffic level recorded prior to the 2008 recession during which demand fell). Ability to accommodate increased	Can accommodate 25% growth							
	Can accommodate 10% growth but not 25%							
	Can accommodate 2007 actual							
	Unable to accommodate 2007 actual							

Criteria	Ranking	Navigation Options						
			1	2	3	4	5	6
throughput capacity based on growth of 10% or 25%	Unable to accommodate 2007 actual							
Favourable operating arrangement of lock allowing flexibility to accommodate simultaneous two-way traffic or continue operations during maintenance of a single lock	Allows 2-way operation and maintenance							
	Allows 1-way operation							
	Does not allow 2-way operation and maintenance							
	Does not allow 2-way operation and maintenance							
Obstruction to commercial shipping based on traffic volumes and types/sizes of vessels expected to pass through the lock to Garston Docks	n/a							
	To accommodate design vessel <8,500DWT							
	To accommodate 8,500DWT design vessel							
	To accommodate 21,000DWT design vessel							
	To accommodate 40,000DWT design vessel							
Obstruction to commercial shipping based on traffic volumes and types/sizes of vessels expected to pass through the lock to Eastham Docks	n/a							
	To accommodate design vessel <8,500DWT							
	To accommodate 8,500DWT design vessel							
	To accommodate 21,000DWT design vessel							
	To accommodate 40,000DWT design vessel							
Achievable marine access (adequate manoeuvring area, navigation zones, etc.) to docks, berths and wharves	n/a							
	No obstruction							
	Negligible obstruction							
	Occasional intrusion on manoeuvring areas							
	Intrusion on manoeuvring areas							

Criteria	Ranking	Navigation Options						
			1	2	3	4	5	6
Impact change in coastal processes/regime with localised current and cross-current effects affecting vessel manoeuvring and navigation and severe metocean effects and navigation conditions on vessels in navigation zones, manoeuvring areas, etc. (currents, channel length, etc.)	n/a							
	No cross-current effects expected							
	Negligible localised cross-current effects expected							
	Cross-current effects expected							
	Severe cross-current effects expected							
Favourable transit times based on additional locking in/out times and tidal windows based on adjusted water levels (assuming no delays incurred due to increased throughput capacity) for traffic to Garston Docks	n/a							
	No increase							
	Negligible increase							
	Delay limited to lock transit time							
	Delay due to lock transit time and navigation conditions							
Favourable transit times based on additional locking in/out times and tidal windows based on adjusted water levels (assuming no delays incurred due to increased throughput capacity) for traffic to Eastham Docks and Manchester Ship Canal	n/a							
	No increase							
	Negligible increase							
	Delay limited to lock transit time							
	Delay due to lock transit time and navigation conditions							
Favourable transit times based on additional locking in/out times and tidal windows based on adjusted water levels (assuming no delays incurred due to increased throughput capacity) for traffic to Tranmere Oil Terminal	n/a							
	No increase							
	Negligible increase							
	Delay limited to lock transit time							
	Delay due to lock transit time and navigation conditions							
Likely attractiveness to navigation stakeholder for deliverability based on	Likely to be acceptable							
	Potential to be acceptable							

Criteria	Ranking	Navigation Options						
			1	2	3	4	5	6
comments received at navigation advisory group (stakeholder consultation) for stakeholders associated with Garston Docks	Neutral							
	Potential to be unacceptable							
	Likely to be unacceptable							
Likely attractiveness to navigation stakeholder for deliverability based on comments received at navigation advisory group (stakeholder consultation) for stakeholders associated with Manchester Ship Canal	Likely to be acceptable							
	Potential to be acceptable							
	Neutral							
	Potential to be unacceptable							
	Likely to be unacceptable							
Likely attractiveness to navigation stakeholder for deliverability based on comments received at navigation advisory group (stakeholder consultation) for stakeholders associated with QEII Docks	Likely to be acceptable							
	Potential to be acceptable							
	Neutral							
	Potential to be unacceptable							
	Likely to be unacceptable							
Likely attractiveness to navigation stakeholder for deliverability based on comments received at navigation advisory group (stakeholder consultation) for stakeholders associated with Tranmere Oil Terminal	Likely to be acceptable							
	Potential to be acceptable							
	Neutral							
	Potential to be unacceptable							
	Likely to be unacceptable							
Likely attractiveness to navigation stakeholder for deliverability based on comments received at navigation advisory group (stakeholder consultation) for stakeholders associated with Bromborough Wall	Likely to be acceptable							
	Potential to be acceptable							
	Neutral							
	Potential to be unacceptable							
	Likely to be unacceptable							

Criteria	Ranking	Navigation Options						
			1	2	3	4	5	6
Capital dredging requirements for realignment of channel/s	No volumes							
	Negligible volumes							
	Low volumes							
	Medium volumes							
	High volumes							
Maintenance dredging requirements for maintaining channel/s	No volumes							
	Negligible volumes							
	Low volumes							
	Medium volumes							
	High volumes							
Capital cost based on Stage 2 estimates – additional to baseline cost	No costs							
	Negligible costs							
	Low costs							
	Medium costs							
	High costs							
Operational cost based on ability to share resources usage (excluding requirements for maintenance dredging, pilotage, tugs, etc.) and effective resource usage (pilotage, tugs, etc.) and requirements for transit of channel/locks	No costs							
	Negligible costs							
	Low costs							
	Medium costs							
	High costs							

5.2 Navigation Mitigation Option Selection

5.2.1 The assessment undertaken is not based on a numerical analysis comprising of numbered scores or sum/s of the ratings for the criteria for each navigation mitigation option. This would be inappropriate without weighting the criteria and would propose inherent difficulties with agreeing appropriate weightings with all stakeholders. Review of the rankings of each navigation option in each category of the colour coding yields a broad understanding of the relative merits of the various navigation options. The colour coding count is listed below:

Table 5.2: Colour coding counts

Coding	Option					
	1	2	3	4	5	6
++	3	1	7	5	7	3
+	3	0	2	2	5	1
	7	4	3	7	1	12
-	7	6	3	3	3	3
--	0	9	5	3	4	1

5.2.2 From the above figures it can be seen that Option 3 and Option 5 both each present seven double positive indicators (dark green), which ranks the highest and equates to 35% of the criteria assessed being categorised as double positive indicators. Option 5 however ranks ahead of Option 3 on the number of single positive indicators (light green), where Option 5 is highest with five indicators and Option 3 is third with two indicators. As a joint evaluation of double and single positive indicators (dark green and light green), these comprise 60% of Option 5's assessment criteria which is the highest of the options assessed. Option 3 is ranked second in this joint evaluation of positive indicators with 45% of the assessment criteria marking positively.

5.2.3 It should be noted however that Option 5 has been included in the assessment for the purpose of completeness only. The option contains a fatal flaw of encroachment of the proposed lock structures on the necessary navigation zones and manoeuvring areas associated with the Tranmere Tanker Terminal. Since the minimum navigation requirements are not met in the arrangement presented in Option 5, it is therefore eliminated from further consideration. Therefore the severity of impact that this option would have on operation of the Tranmere Tanker Terminal lends it being considered unfeasible.

5.2.4 Option 3 ranks fifth on the number of double negative indicators (red) and follows Option 1, Option 6, Option 4, and Option 5. However Option 3 ranks first jointly with Option 4, Option 5 and Option 6 on the number of single negative indicators (amber).

5.2.5 Therefore Option 3 emphasises its emergence as the preferred option on the basis that it presents the most number of positive indicators of the options assessed based on the criteria used to assess the options. These criteria include:

- achievability of throughput capacity including accommodating potential growth of 10% or 25% (based 2007 traffic levels)
- favourable operating arrangements of lock allowing flexibility to accommodate two-way traffic or continue operations during maintenance of a single lock
- attractiveness to stakeholders for deliverability based on comments received at the navigation advisory group (stakeholder consultation)
- capital cost
- obstruction to commercial shipping based on traffic volumes and types/sizes of vessels expected to pass through the lock/s
- achievable marine access (adequate manoeuvring area, navigation zones, etc.) to docks, berths and wharves
- favourable transit times based on additional locking in/out times and tidal windows based on adjusted water levels

5.3 Stakeholder Comments and Suggestions

5.3.1 Two Navigation Advisory Group (NAG) sessions were held during Stage 2 and Stage 3 of the study for stakeholder consultation specifically with regard to navigation aspects. The first session held on Tuesday, 18 May 2010 was to provide an outline of the location options that were considered as part of the study, identifying the various bands considered. Comments were received and incorporated into the further Stage 2 and subsequent Stage 3 work which included identification of the various navigation mitigation options within Band A. These options were presented at the second stakeholder consultation held on Tuesday, 14 December 2010 and the general comments received, are outlined below.

5.3.1 Potential Advantages

5.3.2 Potential advantages were identified as follows:

- Impounding barrage could provide a spill containment and pollution control measure
- Impounding barrage could provide flood risk benefits
- Improved tidal windows could potentially ease congestion due to longer access periods
- Potential benefits may exist due to a reduction in the number of tugs required
- Greater water depth at Bromborough Wall

5.3.2 Aspects of Concern

5.3.3 Aspects for concern were identified as follows:

- Continuance of existing freedom of navigation and other activities that are undertaken on the Estuary (fishing, sailing, etc.), with a particular focus on potential restrictions and curtailing to established Racing Waters.

The purpose of this navigation study is to mitigate all potential impacts to navigation as a result of the obstruction that may occur due to the proposed development. This is the primary objective of the navigation study.

- Predictability of times of high water and low water
  It is intended for the patterns of times and heights of tides to be available in accordance with the agreed generating/refilling cycle and operating of the facility.

- Levying a charge for recreational navigation in the waters in the vicinity of the barrage
  It is not intended that there would be a charge for recreational use of tidal waters, as is presently the case.

- Siltation effects in navigable waters, berthing/mooring areas, etc.

- Maintenance dredging requirements and costs

- Changes to existing channels and water levels would affect the natural scour processes
  In order to determine the expected siltation and scour along the Estuary and in the changed channels, sediment transport modelling needs to be undertaken. These activities have been identified in Section 6. This will enable the maintenance dredging requirements to be ascertained. Adequate water depth will be maintained to ensure effective navigation of commercial vessels along the Estuary. This will simultaneously ensure sufficient depth of water is available for recreational use, specifically sailing.

- Effects on navigation and manoeuvrability in channels due to changed velocities

- Navigational impacts, specifically in terms of modification of strengths and locations of tidal streams
  Current data has been produced as part of the hydrodynamic modelling that has been undertaken to inform the broader study of scheme options. However, this output is based on a model that was required to cover a wide range of spatial scales using a variable and appropriately sized mesh resolution for the purposes intended. The model as presently configured does not lend favourable information for the detailed investigation required for navigation impact assessment. A higher resolution within these areas would be required to provide the necessary level of detail which is beyond the requirements for the present study. As such, the process of accurately determining the velocities expected to occur in the proposed channel/s as well as identification of any areas where localised current effect and tidal streams may occur, should be undertaken in further stages where the model grid-mesh can be suitably modified to provide sufficient level of detail required for such an assessment.

- Shipping costs including tug and pilotage fees

- Lost trade and effects on shipping costs

- Tug availability needs to be addressed as there is an existing shortage if all tugs are occupied at the Manchester Ship Canal
  The aspects of pilotage, tugs and associated fees have been addressed as part of Stage 3 and are presented in Section 4.

- Actual vessel movements should be considered as these are not linear over a 12-hour period

- Significant amounts of cross-traffic is not reflected in the vessels arrivals/departures records

  A spread of daily, weekly, and seasonal peaks is required to improve the assessment undertaken based on annual totals made available by Port of Liverpool. This will enable a refinement of the existing annual totals in order to identify any potential congestion periods based on peak periods of traffic expected to transit the channel and locks. It should also capture any cross-traffic, which can be verified against records provided by the relevant terminal operators. These activities have been identified in Section 6.

- Dredged depths at Eastham Channel needs to be addressed as there are existing tidal delays due to shallow water
  The aspect of channel dredged depths has been addressed as part of Stage 3 and is presented in Section 4.

- Congestion of through traffic is of concern due to Bromborough traffic movements
  The aspect of tidal and access windows has been addressed as part of Stage 3 and is presented in Section 4. Any potential congestion can be alleviated by increasing available tidal windows for access. These activities have been identified in Section 6.

- Impacts of construction and potential disruption to shipping movements
  A closer examination would be required once the preferred scheme is selected and the project progresses. Construction impacts would typically form part of the construction risk assessment and would required defined input of dredging areas, construction methodologies, etc.

5.3.3 Suggestions

5.3.4 Suggestions were made as follows:

- Band B offers no navigational issues and is the preferred location option from a navigation perspective.

- Option 3 is the preferred navigation solution in terms of lock structure configuration for Band A, with the recommended improvement of including the extension to the Manchester Ship Canal from Eastham Dock as in Option 4.
  The economics of this would need to be investigated with respect to the entire scheme development. Cognisance would also need to be taken of the potential impacts associated with the extension to the Manchester Ship Canal, specifically the additional capital and maintenance dredging associated with this arrangement. Option 4 did not fair well with regard to these criteria in the evaluation process. Any disadvantages to Garston dock present in Option 3, would remain pertinent to this suggested option.

- Adopt Option 3 as the preferred navigation solution and allow the impounding level to rise beyond the canal level (9.1 m). Remove the east wall of the QEII Dock allowing this to link directly with the canal thereby allowing all vessels approaching/departing at low water, to transit via the QEII lock. The level in the QEII lock will not be affected by the water levels and access to the canal and QEII Dock are maintained.
  If this suggestion were to be considered further, the function of the east berth on the east wall of the QEII Dock would need to be determined. At present it is believed that

an exit point exists on the east wall but does not link to the canal. The original plans for this arrangement for the QEII Dock would need to be reviewed. The costs associated with such an arrangement will need to be investigated. The navigation impacts would include ensuring the transit passage through the dock wall does not interfere with existing facilities within QEII Dock, does not interfere with approaches/departures from Eastham Dock, and does not alter the course of Manchester Ship Canal. These impacts would need to be addressed. A risk assessment will need to be undertaken to identify any additional risks as a result of passing traffic whilst QEII Docks are operational. As such, throughput capacity to QEII Docks and Manchester Ship Canal through QEII lock may be jeopardised during storm conditions. Cross-traffic data would need to be sourced for traffic to QEII Dock and Eastham, in the present data sets this is identified and dealt with as a single destination. Alternatively use the tidal barrage to stop the water level rising above 9.1m to allow continued access to MSC through the Eastham locks during the highest spring tides.

6 Stage 3 Recommendations

6.1 Preferred Navigation Mitigation Option

6.1.1 The preferred navigation option was selected on the basis of the information that is available at this stage of the study. It is therefore the best potential navigation option available at Stage 3 and has been subject to stakeholder consultation.

6.1.2 The preferred navigation option is identified as Option 3, as outlined in Section 2. The configuration and orientation of the navigation structures was the basis of the determination of this navigation option selection. The precise location relative to the Eastham and Garston Docks and Bromborough Wall is subject to conformation based on the outcome of other non-navigation studies (engineering, planning, environmental, etc.). The final alignment of the proposed development would be within the boundaries of Band A.

6.2 Data Gaps

6.2.1 A number of data gaps and residual uncertainties have been identified during the course of this study. These need to be addressed in future stages in order to refine the navigation option assessment, provide further clarity on the processes implemented, offer confidence in the data utilised, and generally improve the project design. These data gap areas include:

- **Physical details of the site**
  Bathymetric, geotechnical site investigation data, soils data, etc. are required for capital and maintenance dredging assessments, without which soils types, dredge volumes, etc. can be estimated at best.
- **Port operation limits**
  Port downtime requirements specifically with regard to “bad weather” periods need to be determined. Limits of manoeuvring areas can be adjusted in accordance with the allowable port operating conditions. These areas can therefore be refined from the conservative limits presently adopted based on industry guidance (PIANC, 1995 & PIANC, 1997).
- **Additional resource usage**
  Based on the port operation limits and “bad weather” downtime, the requirements for manoeuvring, turning, etc. may be improved. As such assistance by further tugs to those identified in Section 4 during navigation manoeuvres may not be required. Confirmation of the ports operating limits is therefore required as part of the resource usage assessment.
- **Shipping traffic assessment**
  Existing shipping movements need to be assessed based on actual data and locking times. Historic data may be sourced from existing recordings (held for 90 days available for download). Ideally a spread of daily, weekly, and seasonal peaks is required to

improve the assessment undertaken based on annual totals. These annual totals were made available by Port of Liverpool. This will enable a refinement of the existing annual totals in order to identify any potential congestion periods based on peak periods of traffic expected to transit the channel and locks. Forecasts of future demand for Port of Liverpool and Manchester Ship Canal have not been made available by Peel Ports at the time of this study, pending publication of a Port Master plan. This data should be obtained when available and utilised in future stages.

- **Capacity assessment**
  Existing throughput capacity needs to be thoroughly assessed as well as any forecast throughput capacity that may affect capacity requirements in future years. This assessment would include identifying future demand in terms of forecast traffic volumes, predicted design vessel types and sizes, etc. All potential future plans by stakeholders along the Mersey Estuary needs to be incorporated in the assessment.
- **Numerical modelling**
  In order to determine the expected siltation and scour along the Estuary and in the changed channels, sediment transport modelling needs to be undertaken. This will enable the maintenance dredging requirements to be ascertained.
  Once siltation effects and maintenance dredging requirements can be determined more clarity can be provided on the requirements for capital dredging, specifically with regard to channel depths and providing suitable tidal and access windows.
- **Continued stakeholder consultation**
  Continued consultation with interested and affected parties with regard to the navigation along the Mersey Estuary will need to be maintained. This will ensure an appropriate navigation solution is adopted that is suitable for the project/scheme as well as for those that will be directly affected by it.

6.3 Further Studies

6.3.1 The following further studies are recommended:

6.3.1 Numerical modelling and/or physical modelling (3D)

- Hydrodynamics based on structures (localised current effects, tidal streams, etc.)
- Sediment transport (siltation, etc.)
- Waves

6.3.2 Shipping traffic study

- Validate existing shipping movements using actual/historic data (daily, weekly, seasonal peaks) and locking times
- Review and/or assess impact of forecast demand growth
- Confirm existing transit times (delays, queuing, tidal windows/restrictions, manoeuvring obstructions, etc.), particularly high water periods

- Verify times due to transiting additional lock/s

6.3.3 Navigation simulation studies

- Using desktop studies and/or full bridge simulation
- Verify existing allocated manoeuvring areas
- Confirm potentially affected navigation areas
- Validate allocated lock dimensions and new channels for safe transit
- Determine requirement of lead-in structures for safe refuge and current training

6.3.4 Passing ship study

- Assess impact of vessels for Manchester Ship Canal and QEII Dock passing smaller vessels at Bromborough Wall

6.3.5 Resource assessment

- Further assessment of number of tugs
- Further assessment of number of pilots

6.3.6 Navigation risk assessment

- Comprehensive identification and assessment of navigation risks
- Potential navigation risks/impacts are suitably mitigated
- Unimpeded emergency craft access for search & rescue

6.3.7 Design development and Value engineering

- Optimise concept design (lock structure/s, lock gates, dredging, etc.)

6.3.8 Economic impact assessment

- Quantify impacts/mitigated impacts on operational costs

7 Assumptions and Limitations

7.1 General

7.1.1 Available Information

7.1.1 The recommendations of the study are based on the information that is presently available. These recommendations should be reviewed and confirmed should any subsequent data become available.

7.1.2 Physical Details of the Site

7.1.2 Definitive bathymetric, geotechnical site investigation data, soils data, etc. is required in order to permit validation of the concept design. This is with particular reference to confirming feasibility of maintaining a navigable channel through Devil's Bank. Without such data the design may be progressed albeit on an unconfirmed basis, however the possibility exists that the navigation solution recommended could prove to be unworkable based on the inaccessibility to Garston Docks should the channel through Devil's Bank not be achievable.

7.1.3 Maintenance Dredging

7.1.3 Maintenance dredging requirements is a significant contributor in the option evaluation process both from the perspective of operating costs as well as the potential for demurrage time due to disruption to shipping movements. These effects need to be appropriately assessed, based on the output of relevant sediment transport modelling. In the absence of such information, an educated guess can be taken at the expected movement of silt in the Estuary upon which the navigation option recommendations are based. Any variance from these assumptions could render the proposed option either more advantageous or potentially uneconomic. This is part of a wider issue of bed stability during operation of the tidal power development as well as resulting risk of changes to river bed levels, current patterns and current magnitude.

7.1.4 Navigation Demand and Capacity

7.1.4 No forecasts of future demand for Port of Liverpool and/or Manchester Ship Canal have been made available by Peel Ports at the time of this study, pending publication of a Port Master plan. This data should be obtained when available and utilised in future stages. Also, navigation demand data utilised in the study is in the form of historical annual movements. Ideally seasonal weekly and daily peaking data is required to assess the throughout capacity to gauge the representative demand and congestion during peak periods. In the absence of peak data the capacity requirements have been established on the basis of the annual totals available and may therefore not be completely representative of the navigation traffic scenarios that may occur during peak times.

7.1.5 Navigation Strategies

7.1.5 The navigation strategies including tidal windows, transit times, queuing, etc. for movements in the channel/s and specifically in the lock facilities, will need to be validated by modelling (numerical and/or simulation). Without confirmation of the adopted strategies the recommendations are based solely on professional judgement and engineering experience.

8 Conclusions and Summary

8.1.1 The key objective of Stage 3 from a navigation perspective is to identify a preferred navigation option based on the various navigation options presented in Stage 2. Selection of the preferred navigation option is based on an assessment of the navigation impacts of each of the navigation options considered and the ability to which these potential impacts can be mitigated.

8.1.2 A 3-step process was adopted for the option evaluation process. Steps 1 and 2, which informed the appraisal of study location options (bands) and resulted in the initial identification of potential navigation mitigation options, were completed at Stage 2 of the feasibility study. Step 3 has been undertaken at Stage 3 and comprised assessment and ranking of the navigation mitigation options to identify the preferred navigation solution.

8.1.3 The siting of the proposed development at different location options within the Estuary was evaluated in Stage 2. The outcome of the Stage 2 study indicated the following:

- Band B offers the best navigation solution due to the lack of obstruction to commercial shipping and hence no locking in/out times.
- Band C presents numerous navigation constraints at river entry as well as for navigation through the band and manoeuvring. As a result the navigation impacts are difficult to be mitigated and overcome.
- Band A does not offer a better navigation solution to Band B. The significant navigation issues associated with Band C are reduced. Band A presents potential navigation impacts that can be mitigated and overcome.

8.1.4 Six navigation mitigation options applicable in and around Band A were developed during Stage 2. The final alignment of the development has not been determined although it will be located within Band A and will be dependant on many other factors (engineering, planning, environmental, etc). The identified potential navigation impacts will remain unchanged with exception to the degree to which the identified impacts occur, either to a lesser or greater extent.

8.1.5 Navigation impacts assessed included tidal windows, transit times through locks, resource usage including pilotage and towage, and channel depths including capital dredging requirements.

8.1.6 The six navigation mitigation options were reviewed and ranked using various criteria that were identified to inform the decision making process and contribute effectively to the evaluation process.

8.1.7 The preferred navigation option was selected on the basis of the information that is available at this stage of the study, and is identified as Option 3. This option comprises of two locks provided adjacent to the Wirral shore. As a lock is not provided for access to Garston Docks, a new channel would be required to provide this link and is proposed to occur through Devil's Bank. This new channel would link the existing Garston navigation channel with the lock adjacent to the Wirral shore.

8.1.8 The configuration and orientation of the navigation structures was the basis of the determination of this option selection. The precise location relative to the Eastham and Garston Docks and Bromborough Wall is subject to confirmation based on the outcome of other non-navigation studies (engineering, planning, environmental, etc.). The final alignment of the proposed development will be within the boundaries of Band A.

8.1.9 Data gaps have been identified including physical details of the site, port operations limits, additional resource usage, shipping traffic assessment and capacity assessment. Based on these data gaps, the following further studies have been identified including numerical modelling and/or physical modelling, shipping traffic study, navigation simulation studies, passing ship study, resource assessment, navigation risk assessment, value engineering, and economic impact assessment.

9 References

PIANC (1995) *Approach Channels Preliminary Guidelines*. PIANC, Brussels

PIANC (1997) *Approach Channels A Guide for Design*. PIANC, Brussels

PIANC (2009) *Innovations in Navigation Lock Design - Report 106*. PIANC, Brussels

Appendix A: Potential Navigation Impacts

A.1 Band A

- Impacts traffic to MSC & QEII Dock at Eastham & Garston Docks
- Largest vessels do not transit lock, smaller lock than Band C
- Time sensitive freight ferries & cruise liners unaffected
- Clear of most navigation and manoeuvring areas
- Berthing windows may be increased
- Increase transit times with additional lock
- Possibly retain existing transit times (MSC & QEII) – option dependent
- Possible additional tugs increasing shipping costs
- Potential changed current velocities downstream
- Potential impact on vessel manoeuvres at Tranmere
- Potential risk of collision / impact by VLCC tankers from Tranmere
- Additional maintenance dredging required – option dependent

A.2 Band B

- No obstruction to commercial shipping
- No additional locking in / out times
- Potential changed current velocities downstream
- Potential impact on vessel manoeuvres at Eastham & Garston Docks
- Tidal windows could potentially change
- Small lock for leisure craft only

A.3 Band C

River Entry

- Majority of Mersey traffic to pass through including largest vessels (VLCC tankers, cruise liners, Post-Panamax container vessels)
- Potential impact on attaching to tugs - upstream (lesser impact) & downstream (greater impact)
- No impact on pilot boarding
- Possible additional tugs increasing shipping costs
- Restricted access for leisure craft

Navigation through Band & Manoeuvring

- Berthing windows may be increased
- Variety of navigation areas and manoeuvres to avoid – designated for berthing, turning, lock movements
- Greater lock capacity required for largest vessels
- Potential congestion due to inadequate capacity of locks

- Increase transit times with additional lock
- Potential delays to freight ferries - alternate routes
- Potential delays to cruise liners – passenger connections
- Impact on summer routes of cross-river tourist ferries
- Port Authority to regulate commercial & leisure shipping

Appendix B: Navigation Location Options Appraisal

B.1 Band A

Option 1

Refer to Drawing PD0330-12-3002 Rev P1

Pros

- Twin locks operate independently, provide adequate capacity (90%-10% traffic split may be inefficient)

Cons

- Obstruction to some commercial shipping
- Potential changed current velocities downstream
- Potential impact on vessel manoeuvres at Tranmere
- Additional lock for Eastham & Garston Docks traffic to transit, longer times
- Dredging downstream of eastern lock to improve impacted access window
- River tugs transit lock twice (before & after berthing / unberthing) for QEII Dock – may require more tugs

Option 2

Refer to Drawing PD0330-12-3001 Rev P1

Pros

- Nil

Cons

- Obstruction to some commercial shipping
- Potential changed current velocities downstream
- Potential impact on vessel manoeuvres at Tranmere
- Capacity of single lock may be inadequate for turnaround – 1 vessel movement every 1.1 to 1.7 hours over 12-hour period
- Additional lock for Eastham & Garston Docks traffic to transit, longer times
- Tidal requirements for lock transit may prove unworkable
- Channel dredging to Garston Docks - unknown conditions
- Potential cross-current element during transit of dredged channel
- River tugs transit lock twice (before & after attaching) for QEII Dock – may require more tugs

Option 3

Refer to Drawing PD0330-12-3003 Rev P1

Pros

- Double locks operate independently - allow simultaneous transit in opposite direction, reduce locking times, provide maintenance / repair option

Cons

- Obstruction to some commercial shipping
- Potential changed current velocities downstream
- Potential impact on vessel manoeuvres at Tranmere

- Additional lock for Eastham & Garston Docks traffic to transit, longer times
- Channel dredging to Garston Docks - unknown conditions
- Potential cross-current element during transit of dredged channel
- River tugs transit lock twice (before & after berthing / unberthing) for QEII Dock – may require more tugs

Option 4

Refer to Drawing PD0330-12-3004 Rev P1

Pros

- Twin locks operate independently, provide adequate capacity (90%-10% traffic split may be inefficient)
- Transit time to Eastham Docks comparable to existing – MSC lock gates open

Cons

- Obstruction to some commercial shipping
- Potential changed current velocities downstream
- Potential impact on vessel manoeuvres at Tranmere
- Additional lock for Garston Docks traffic to transit, longer times
- Dredging downstream of eastern lock to improve impacted access window
- Channel dredging for 2-way traffic and MSC 'free flow' potentially uneconomic
- River tugs transit lock twice (before & after berthing / unberthing) for QEII Dock – may require more tugs
- MSC channel dimensions could limit vessel size to Bromborough Wall
- Passing ship effects on vessels at Bromborough Wall

Option 5

Refer to Drawing PD0330-12-3015 Rev P1

Pros

- Double locks operate independently - allow simultaneous transit in opposite direction, reduce locking times, provide maintenance / repair option
- No dredging to Garston required

Cons

- Obstruction to some commercial shipping
- Potential changed current velocities downstream
- Encroaching on manoeuvring area at Tranmere
- Additional lock for Eastham & Garston Docks traffic to transit, longer times
- River tugs transit lock twice (before & after berthing / unberthing) for QEII Dock – may require more tugs

Option 6

Refer to Drawing PD0330-12-3016 Rev P1

Pros

- Single lock and channel provides adequate capacity (channel capacity as per existing)
- Transit time to Eastham Docks possibly comparable to existing – no additional lock to transit, existing tidal restrictions and traffic movements apply

- No channel dredging to MSC or Garston Docks

Cons

- Obstruction to some commercial shipping
- Potential changed current velocities downstream
- Potential impact on vessel manoeuvres at Tranmere
- Additional lock for Garston Docks traffic to transit, longer times
- Dredging downstream of eastern lock to improve impacted access window
- Additional maintenance dredging to MSC due to likely siltation
- Passing ship effects on vessels at Bromborough Wall

B.2 Band B

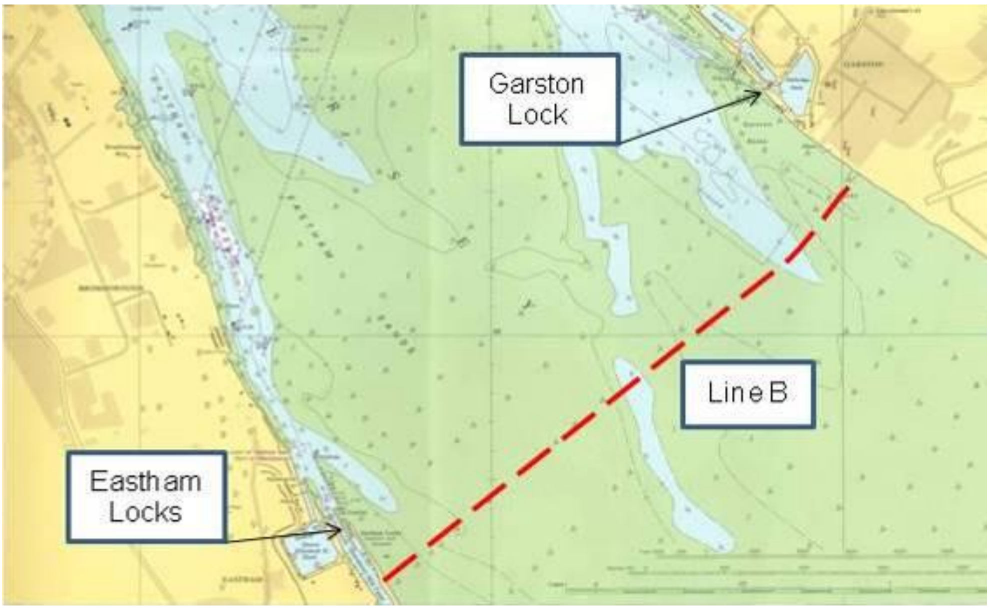


Figure 2.1 – Navigation Location Options Appraisal – Band B

Pros

- No obstruction to commercial shipping
- Small lock for leisure and service craft
- Low capital and operating cost of lock

Cons

- Potential changed current velocities downstream
- Potential impact on vessel manoeuvres at Eastham & Garston Docks

B.3 Band C

Figure 2.2 – Navigation Location Options Appraisal – Band C

Refer to Drawing PD0330-12-3006 Rev P1

Pros

- Double locks operate independently - allow simultaneous transit in opposite direction, reduce locking times, provide maintenance / repair option

Cons

- Obstruction to all commercial shipping
- Potential changed current velocities up & downstream
- Potential impact on all vessel manoeuvres specifically at Langton Dock
- New / Additional lock for majority of Mersey traffic to transit, longer times
- Dredging for realignment of channel

Appendix C: Lock and Extension Bund Details (Band A)

C.1 Single Lock – Wirral Bank

Refer to Drawing PD0330-12-3021 Rev P1

Design vessel (QEII – 40,000 DWT)

- Length = 208.79m
- Beam = 28.35m
- Draft = 10.00m

Design vessel (Eastham – 21,000 DWT)

- Length = 170.68m
- Beam = 21.94m
- Draft = 8.78m

Lock dimensions (QEII – 40,000 DWT)

- Length = 310.00m
- Width = 35.00m
- Sill level = -8.00mCD

Reference

- Lock length = 1.1 x LOA
- Lock width = 1.25 x B
- Two tugs (circa 35m LOA per tug)

C.2 Single Lock – Liverpool Bank

Refer to Drawing PD0330-12-3022 Rev P1

Design vessel (Garston – 8,500 DWT)

- Length = 150.00m
- Beam = 19.20m
- Draft = 8.50m

Lock dimensions (Garston – 8,500 DWT)

- Length = 215.00m
- Width = 27.50m
- Sill level = -6.50mCD

Reference

- Lock length = 1.1 x LOA
- Lock width = 1.25 x B
- Single tug (circa 35m LOA)

C.3 Double Lock – Wirral Bank & Estuary Centre

Refer to Drawing PD0330-12-3023 Rev P1

Design vessel (QEII – 40,000 DWT)

- Length = 208.79m
- Beam = 28.35m
- Draft = 10.00m

Design vessel (Eastham – 21,000 DWT)

- Length = 170.68m
- Beam = 21.94m
- Draft = 8.78m

Lock dimensions (QEII – 40,000 DWT)

- Length = 310.00m
- Width = 35.00m
- Sill level = -8.00mCD

Reference

- Lock length = 1.1 x LOA
- Lock width = 1.25 x B
- Two tugs (circa 35m LOA per tug)

C.4 Manchester Ship Canal Extension Bund

Refer to Drawing PD0330-12-3024 Rev P1

Bromborough Wall – 4,500 DWT

- Design vessel length = 100.00m (approximate)
- Turning circle = 200.00m

QEII design vessel passing QEII design vessel

- Channel width = 235m

QEII design vessel passing Eastham design vessel

- Channel width = 220m

Reference

- Turning circle = 2 x LOA

C.5 Garston Channel

Garston design vessel passing Garston design vessel

- Channel width = 95m

Appendix D: Existing Data

D.1 Existing Lock Summary (Band A)

Lock	Dimensions [m]	Sill Level [mCD]	Transit [mins]	Restrictions [hrs]	Max Transit [No. / HW]
QEII [40,000 DWT]	245.97 30.48	-5.60	45	HW ±3	6
Eastham (west) [21,000 DWT]	182.88 24.38	-3.46	30	HW ±4	8
Eastham (east) [21,000 DWT]	106.68 15.24	-3.46	30	HW ±4	8
Garston [8,500 DWT]	84.12 19.81	-0.72	open	HW -1 +0.75	5
Bromborough Wall [4,500 DWT]	200 quay	n/a	n/a	HW	n/a

D.2 Tide Data

Highest Astronomical Tide (HAT)	10.9m
Mean High Water Springs (MHWS)	9.6m
Mean High Water Neaps (MHWN)	7.5m
Mean Low Water Neaps (MLWN)	2.8m
Mean Low Water Springs (MLWS)	0.6m

Appendix E: Miscellaneous

E.1 Design Vessels (Band C)

Design vessel (Cruise – 19,000 DWT)

- Length = 345.00m
- Beam = 48.70m
- Draft = 10.30m

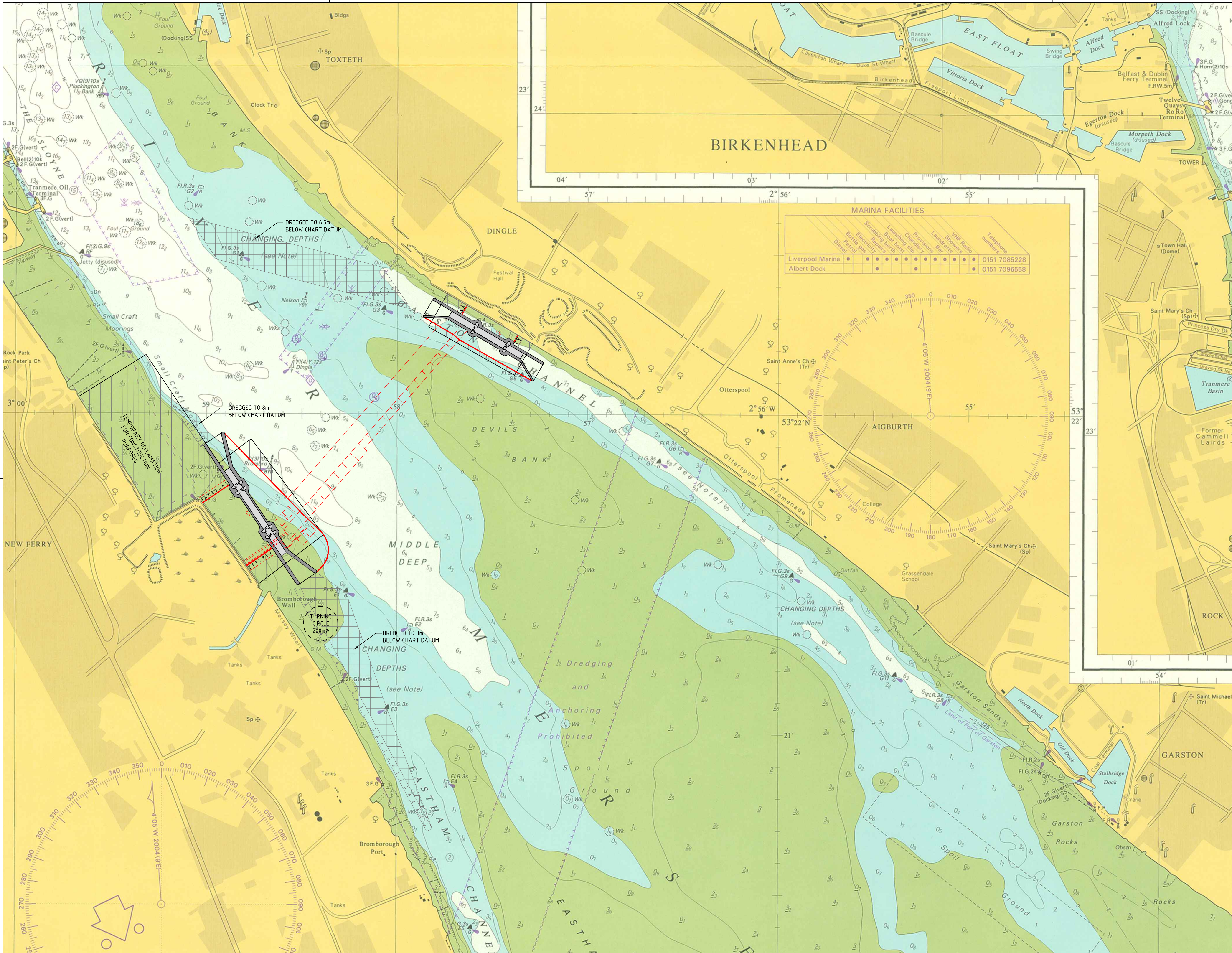
Design vessel (VLCC – 300,000 DWT)

- Length = 345.00m
- Beam = 60.00m
- Draft = 14.00m

Design vessel (Post Panamax Container – 105,000 DWT)

- Length = 347.00m
- Beam = 42.90m
- Draft = 14.50m

Appendix F: Drawings



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NOTES:

1. Levels shown are in metres and relate to Chart Datum at Albert Docks. (Chart Datum is 4.93m below Ordnance Survey Datum).

Revision Details	By	Check	Date	Suffix

Drawing Status

Project Title

THE MERSEY
TIDAL POWER PROJECT

Drawing Title

CIVIL ENGINEERING (MARINE)
LINE A - NEW FERRY TO DINGLE
OPTION A 1.01 / NA1

NAVIGATION OPTION 1
SINGLE SOUTH LOCK
AND NORTH LOCK

Scale at A1: 1:10 000

Drawn	HT	Approved	AS
Stage 1 check	Stage 2 check	Originated	Date
	HB		APR 10

Drawing Number: PD0330-12-3001
Rev: P1

DB1V

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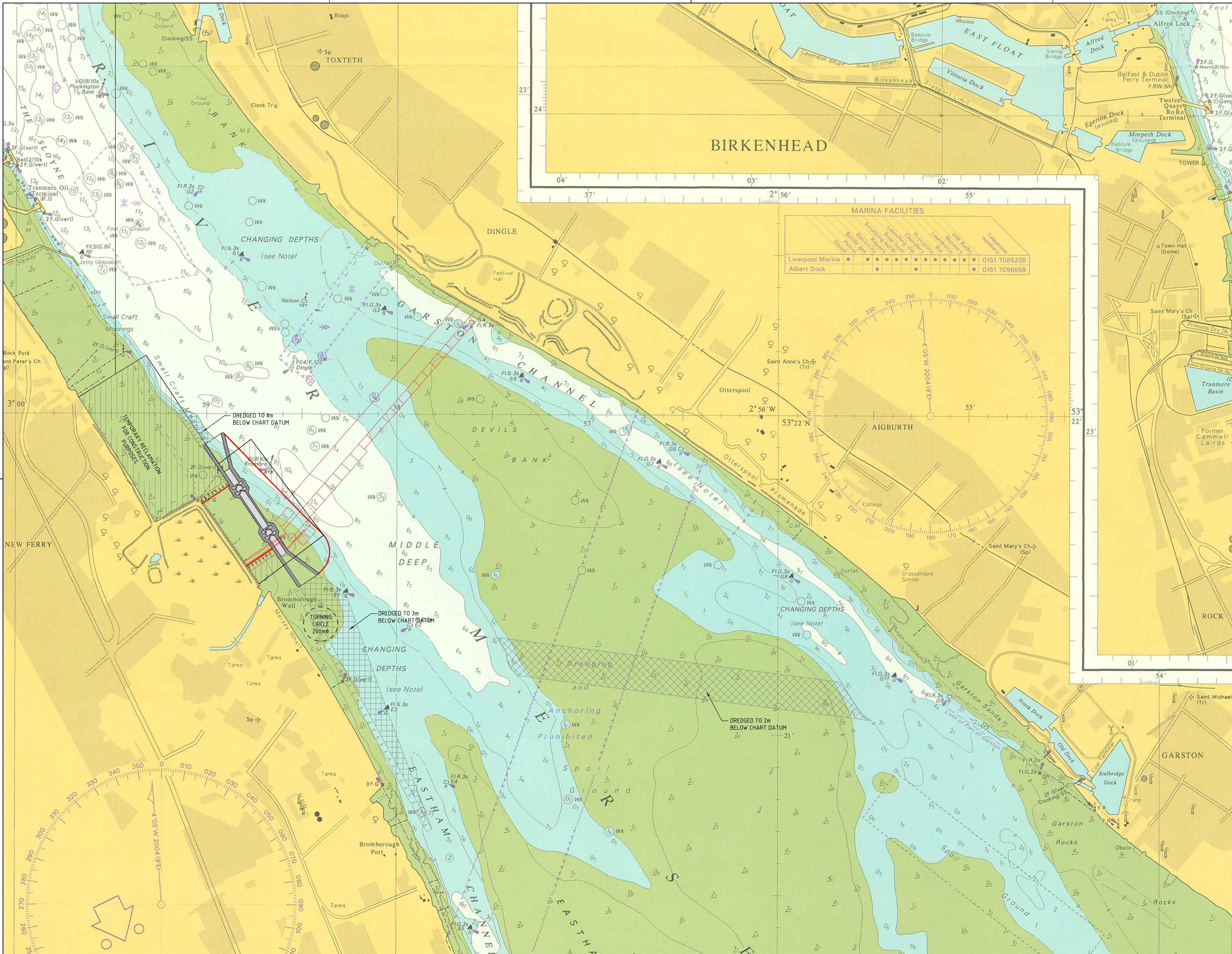

NOTES:

1. Levels shown are in metres and relate to Chart Datum at Albert Docks. (Chart Datum is 4.93m below Ordnance Survey Datum).

Revision Details	By / Check	Date	Suffix

Drawing Status

Project Title
THE MERSEY
TIDAL POWER PROJECT

Drawing Title
CIVIL ENGINEERING (MARINE)
LINE A - NEW FERRY TO DINGLE
OPTION A 1.01 / NA2
NAVIGATION OPTION 2
SINGLE SOUTH LOCK

Scale at A1: 1:10 000

Drawn	HT	Approved	AS
Stage 1 check	Stage 2 check	Originated	Date
	HB		APR 10

Drawing Number: PD0330-12-3002 Rev: P1

DB1V

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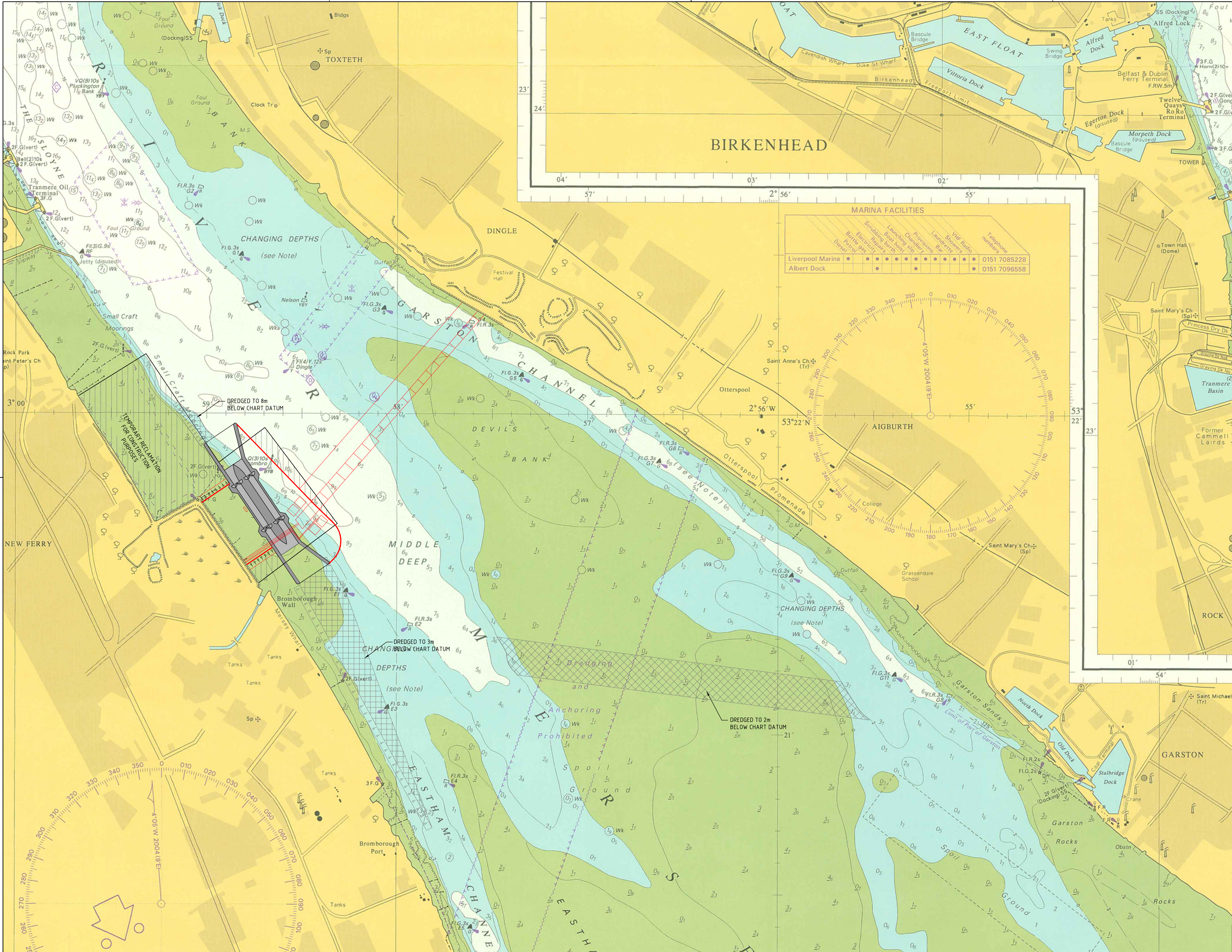


NOTES:

1. Levels shown are in metres and relate to Chart Datum at Albert Docks. (Chart Datum is 4.93m below Ordnance Survey Datum).

Revision Details	By / Check	Date	Suffix

Drawing Status

Project Title

THE MERSEY TIDAL POWER PROJECT

Drawing Title

CIVIL ENGINEERING (MARINE)

LINE A - NEW FERRY TO DINGLE

OPTION A 1.01 / NA3

NAVIGATION OPTION 3

TWIN SOUTH LOCK

Scale at A1	1:10 000		
Drawn HT		Approved AS	
Stage 1 check	Stage 2 check HB	Originated	Date APR 10

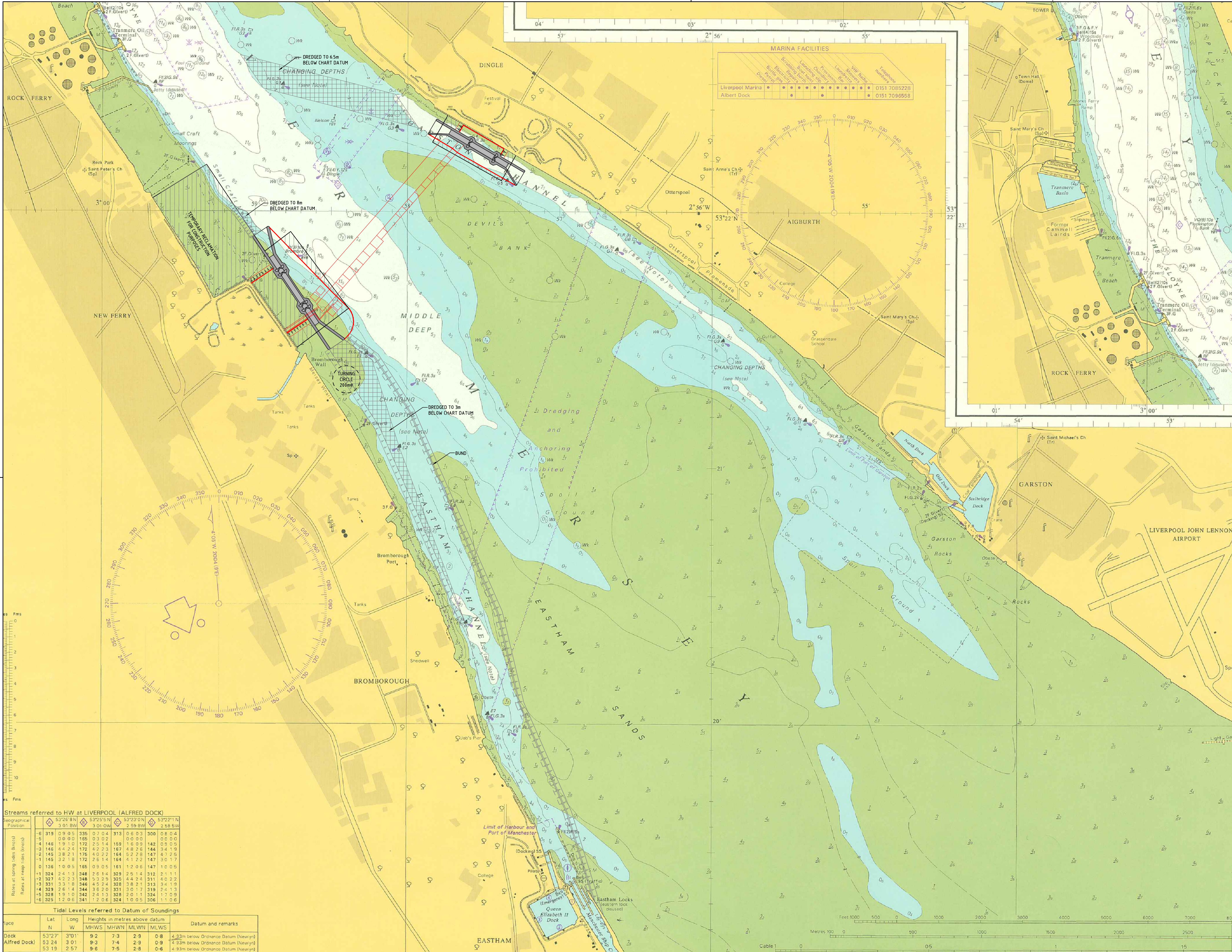
PEEL ENERGY

Northwest Regional Development Agency

Drawing Number	Rev
PD0330-12-3003	P1

DB1V

(A1) 594x841 Corporate



NOTES:

1. Levels shown are in metres and relate to Chart Datum at Albert Docks. (Chart Datum is 4.93m below Ordnance Survey Datum).

Revision Details	By / Check	Date	Suffix

Drawing Status

Project Title

THE MERSEY
TIDAL POWER PROJECT

Drawing Title

CIVIL ENGINEERING (MARINE)
LINE A - NEW FERRY TO DINGLE
OPTION A 1.01 / NA4

NAVIGATION OPTION 4
EXTENSION TO
MANCHESTER SHIP CANAL

Scale at A1: 1:12 500

Drawn	Approved
HT	AS

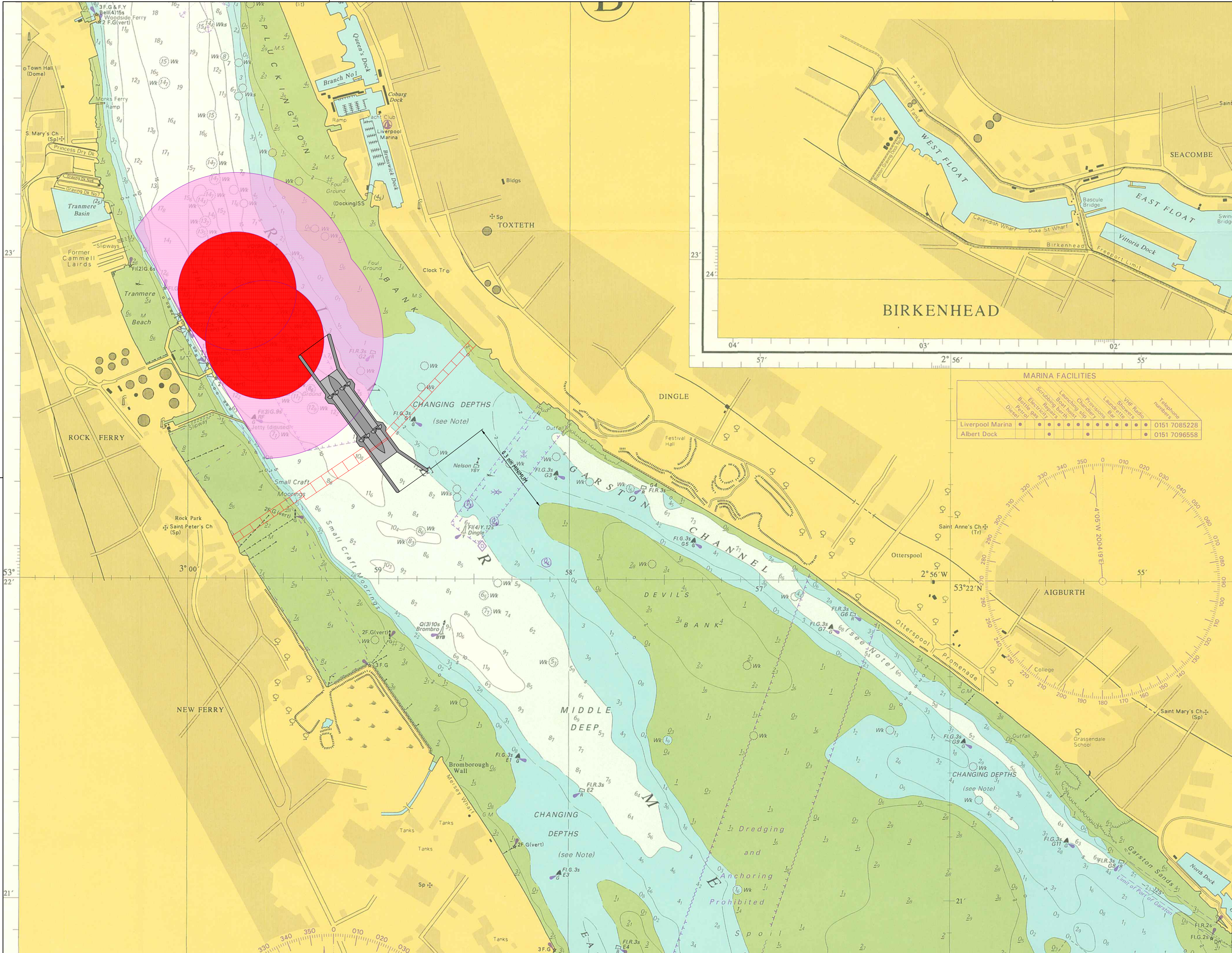
Stage 1 check	Stage 2 check	Originated	Date
	HB		APR 10

PEEL ENERGY — Northwest Regional Development Agency

Drawing Number: PD0330-12-3004 — Rev: P1

DB1V

(A1) 594x841 Corporate



NOTES:

1. Levels shown are in metres and relate to Chart Datum at Albert Docks. (Chart Datum is 4.93m below Ordnance Survey Datum).

Revision Details	By / Check	Date	Suffix

Drawing Status

Project Title
THE MERSEY
TIDAL POWER PROJECT

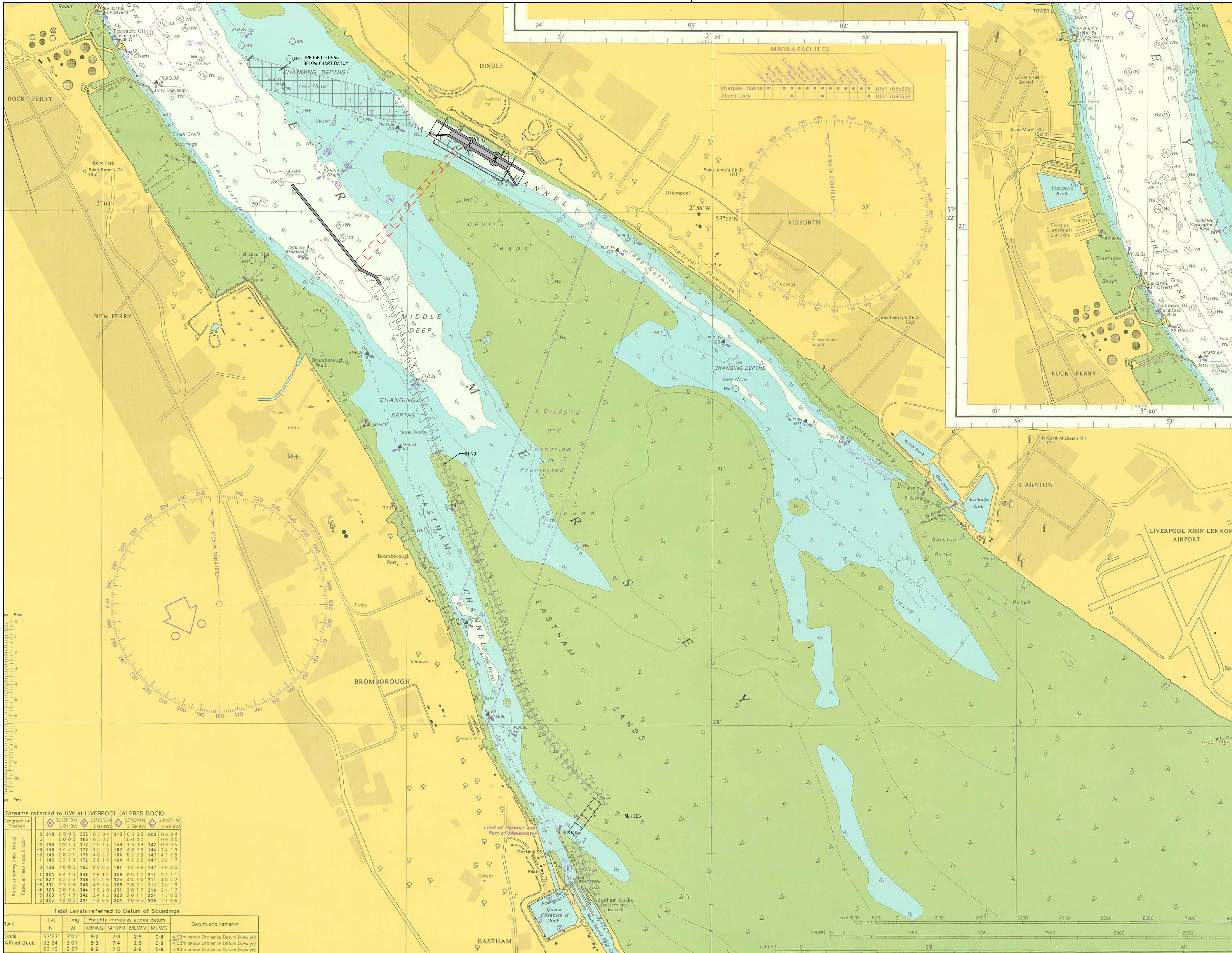
Drawing Title
CIVIL ENGINEERING (MARINE)
LINE A - NEW FERRY TO DINGLE
OPTION A 1.01 / NA5
NAVIGATION OPTION 5
TWIN LOCK CENTRAL

Scale at A1	1:10 000
Drawn: PDV	Approved: AS
Stage 1 check	Stage 2 check: HB
Originated	Date: SEP 10

PEEL ENERGY
Northwest Regional Development Agency

Drawing Number: PD0330-12-3015
Rev: P1

DB1V
(A1) 594x841 Corporate



Streams referred to HW at LIVERPOOL (ALFRED DOCK)

Geographical Position		◇A 53°26'8N 3°01·8W			◇B 53°25'5N 3°01·0W			◇C 53°23'0N 2°59·8W			◇D 53°22'1N 2°58·5W		
Rates at spring tides (knots) / Rates at neap tides (knots)	−6	319	0·9	0·5	335	0·7	0·4	313	0·6	0·3	300	0·8	0·4
	−5		0·0	0·0	165	0·3	0·2		0·0	0·0		0·0	0·0
	−4	146	1·9	1·0	172	2·5	1·4	159	1·6	0·9	142	0·9	0·5
	−3	146	4·4	2·4	172	4·2	2·3	167	4·8	2·6	144	3·4	1·9
	−2	145	3·8	2·1	175	4·0	2·2	164	5·2	2·8	147	4·7	2·5
	−1	145	3·2	1·8	172	2·6	1·4	164	4·1	2·2	147	3·0	1·7
	0	136	1·0	0·5	165	0·9	0·5	161	1·2	0·6	147	1·0	0·5
	+1	324	2·4	1·3	348	2·6	1·4	329	2·5	1·4	312	2·1	1·1
	+2	327	4·2	2·3	348	5·3	2·9	325	4·4	2·4	311	4·0	2·2
	+3	331	3·3	1·8	346	4·5	2·4	328	3·8	2·1	313	3·4	1·9
	+4	329	2·6	1·4	344	3·6	2·0	331	3·0	1·7	319	2·4	1·3
	+5	328	1·9	1·0	342	2·4	1·3	328	2·0	1·1	324	1·7	0·9
	+6	325	1·2	0·6	341	1·2	0·6	324	1·0	0·5	306	1·1	0·6

Tidal Levels referred to Datum of Soundings

lace	Lat N	Long W	MHWS	MHWN	MLWN	MLWS	Datum and remarks
			Heights in metres above datum				
Dock	53°27'	3°01'	9·2	7·3	2·9	0·8	4·93m below Ordnance Datum (Newlyn)
(Alfred Dock)	53 24	3 01	9·3	7·4	2·9	0·9	4·93m below Ordnance Datum (Newlyn)
	53 19	2 57	9·6	7·5	2·8	0·6	4·93m below Ordnance Datum (Newlyn)

NOTES:

1. Levels shown are in metres and relate to Chart Datum at Albert Docks. (Chart Datum is 4.93m below Ordnance Survey Datum).

Revision Details	By / Check	Date	Suffix

Drawing Status

Project Title
THE MERSEY TIDAL POWER PROJECT

Drawing Title
CIVIL ENGINEERING (MARINE)
LINE A - NEW FERRY TO DINGLE
OPTION A 1.01 / NA6

NAVIGATION OPTION 6
TIDAL EXTENSION
MANCHESTER SHIP CANAL

Scale at A1: 1:12 500

Drawn		Approved	
PDV		AS	
Stage 1 check	Stage 2 check	Originated	Date
	HB		SEP 10

PEEL ENERGY
Northwest Regional Development Agency

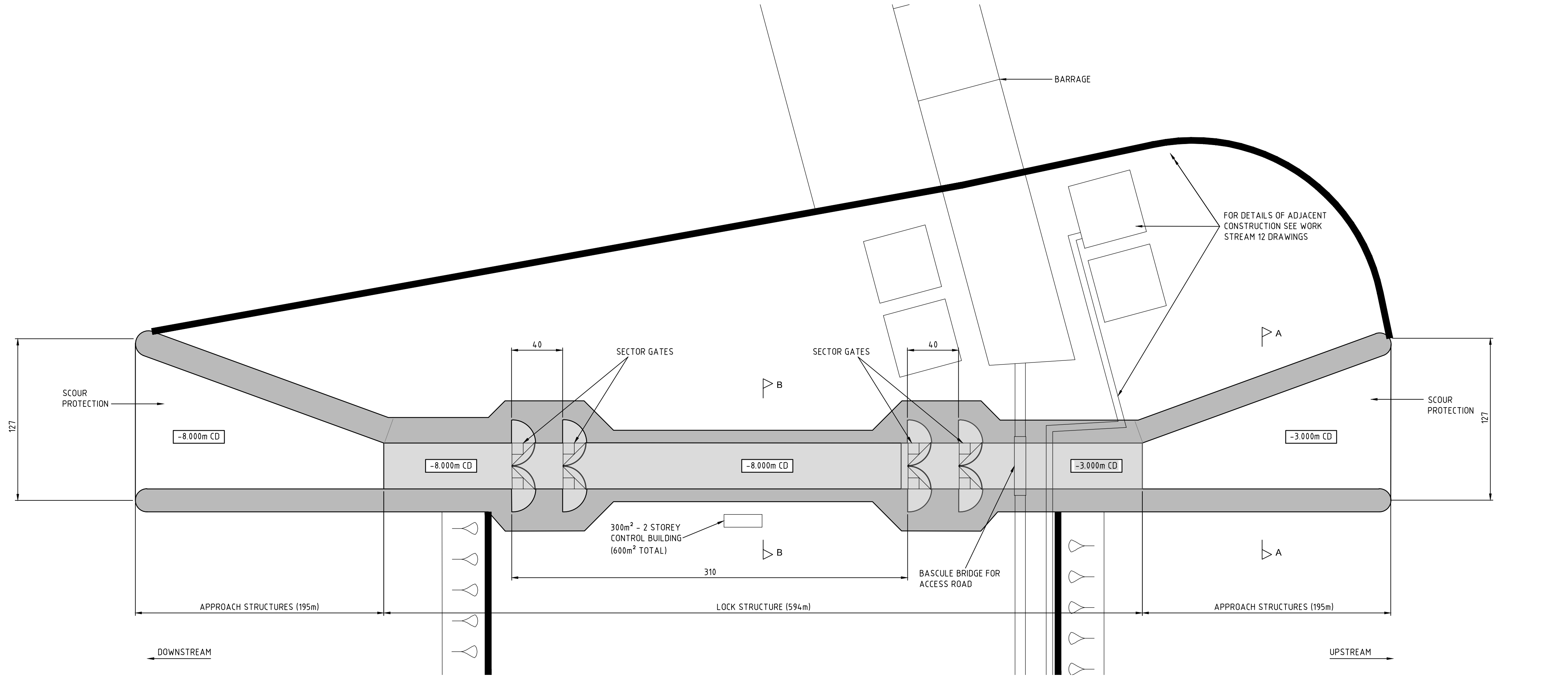
Drawing Number	Rev
PD0330-12-3016	P1

DB1V

(A1) 594x841 Corporate

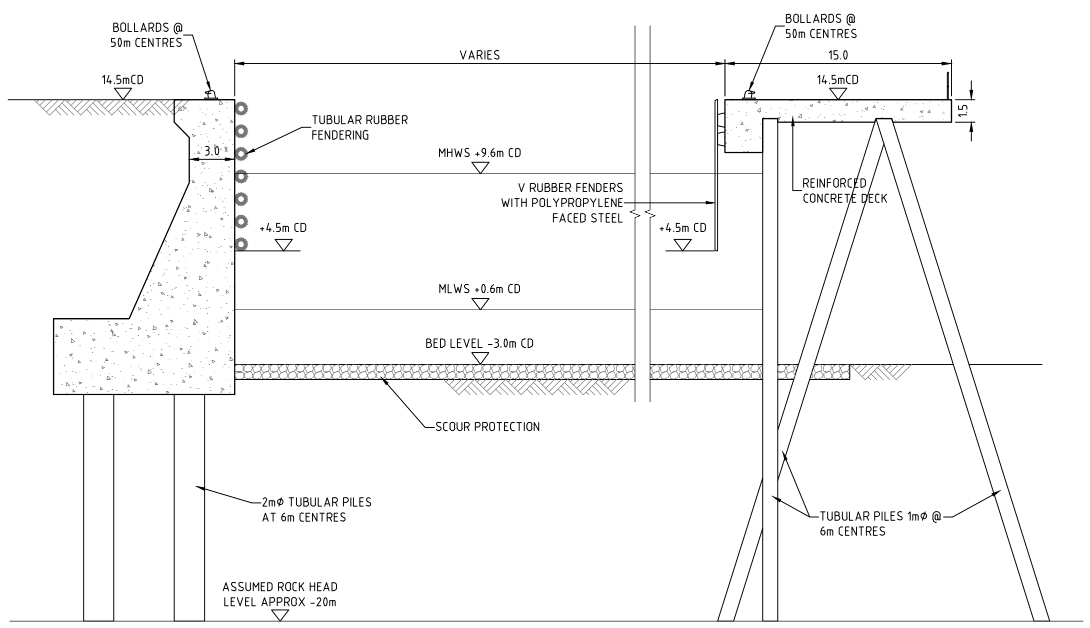
NOTES:

1. Levels shown are in metres and relate to Chart Datum at Albert Docks. (Chart Datum is 4.93m below Ordnance Survey Datum).
2. See drawing PD0330-12-2001 for location of lock structure.
3. South Lock in Navigation Options 2 & 4 (Drawing nos. PD0330-12-2002, 2004) to be similar.



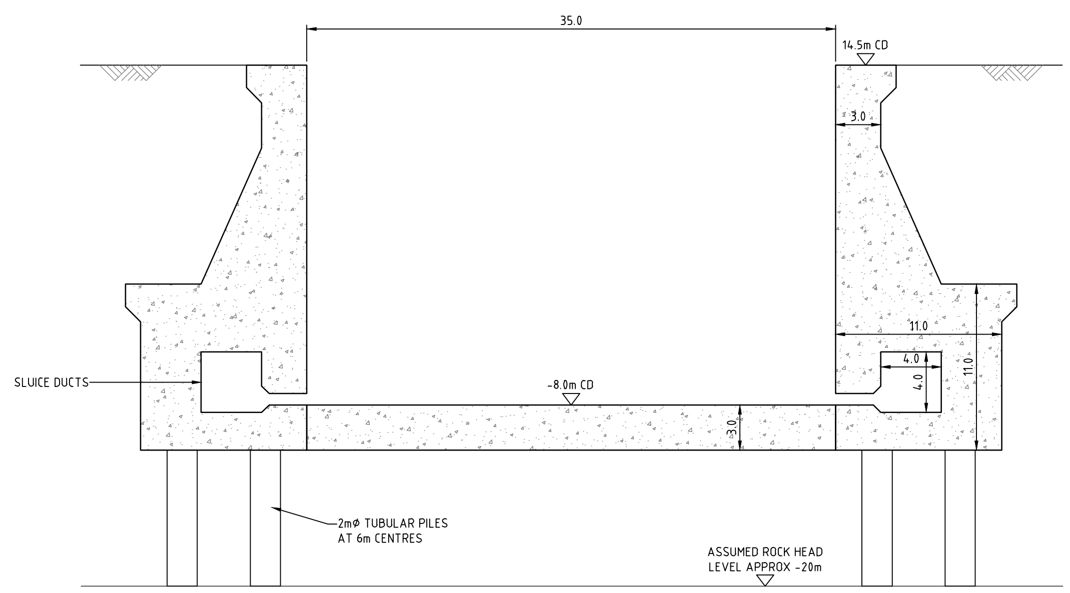
PLAN ON SINGLE SOUTH LOCK

SCALE 1:2000



SECTION A-A

SCALE 1:250



SECTION B-B

SCALE 1:250

Revision Details	By / Check	Date	Suffix

Drawing Status

Project Title
THE MERSEY TIDAL POWER PROJECT

Drawing Title
CIVIL ENGINEERING (MARINE)
LINE A - NEW FERRY TO DINGLE
OPTION A 1.01/NA1

NAVIGATION OPTION 1
SINGLE SOUTH LOCK
GENERAL ARRANGEMENT

Scale at A1: AS SHOWN

Drawn	Approved
HT	AS

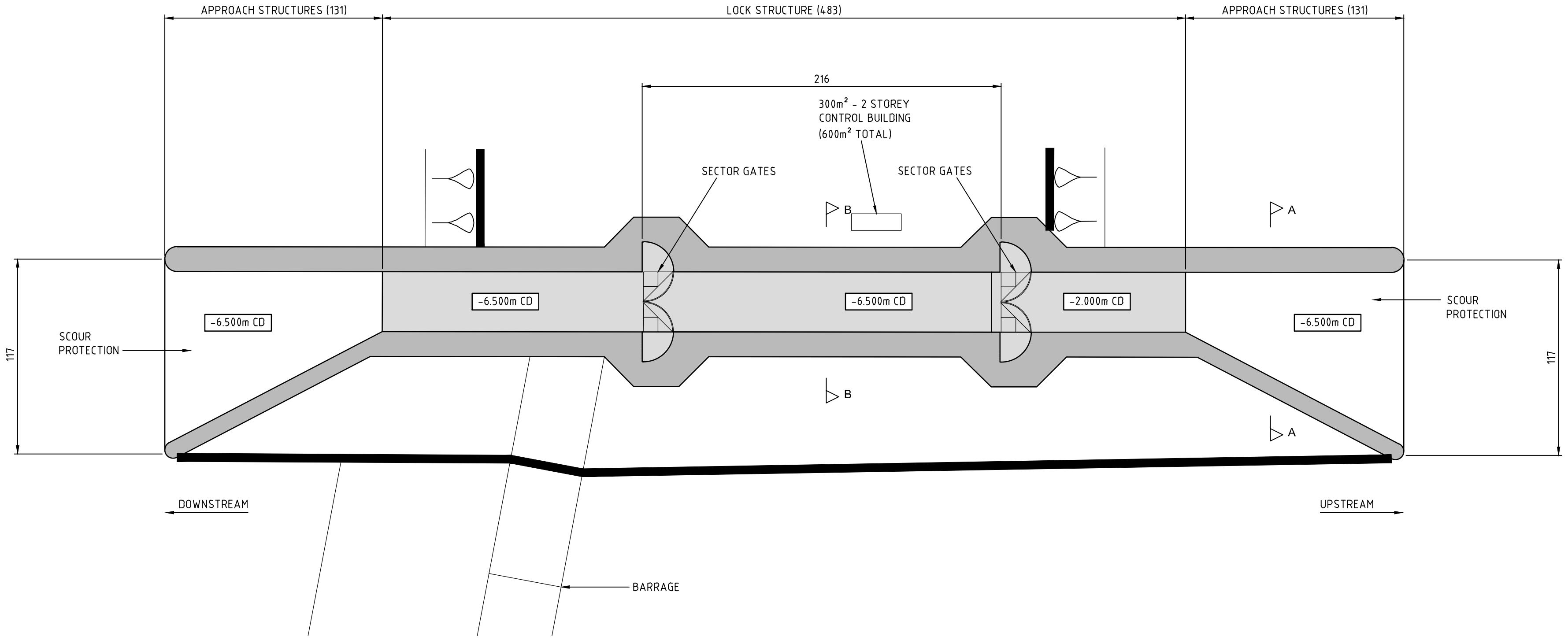
Stage 1 check	Stage 2 check	Originated	Date
	HB		APR 10

PEEL ENERGY
Northwest REGIONAL DEVELOPMENT AGENCY

Drawing Number	Rev
PD0330-12-3021	P1

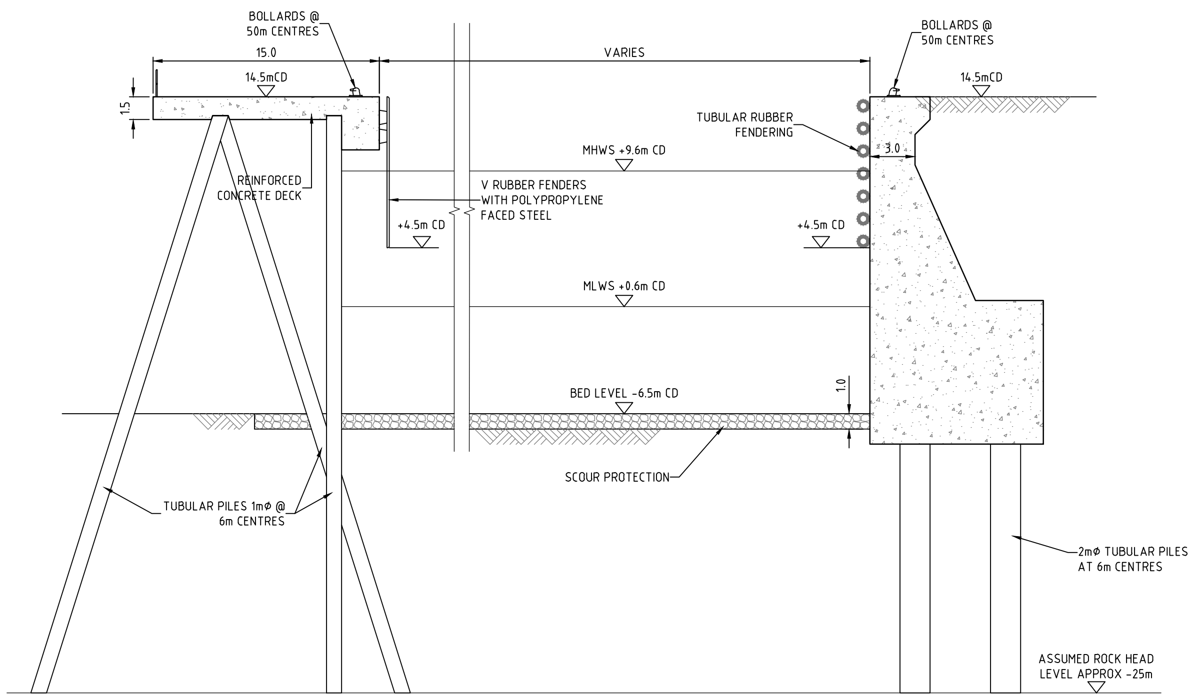
DB1V

(A1) 594x841 Corporate



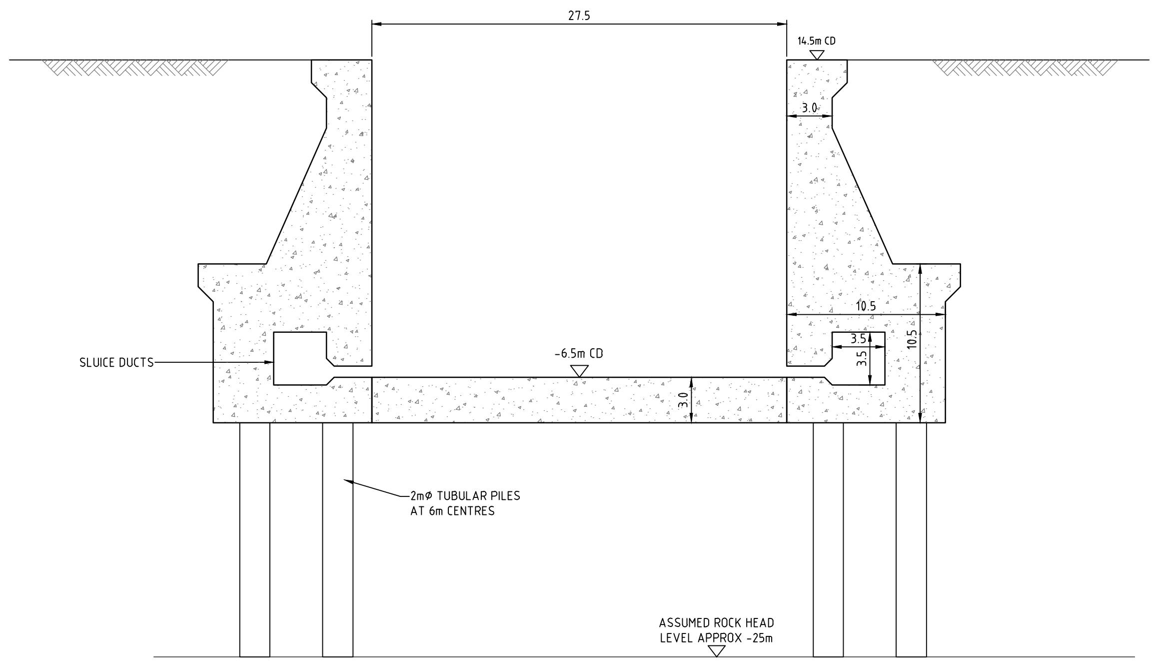
PLAN ON NORTH LOCK

SCALE 1:2000



SECTION A-A

SCALE 1:250



SECTION B-B

SCALE 1:250

NOTES:

1. Levels shown are in metres and relate to Chart Datum at Albert Docks. (Chart Datum is 4.93m below Ordnance Survey Datum).
2. See drawing PD0330-12-2001 for location of lock structure.
3. North Lock in Navigation Option 4 (Drawing no. PD0330-12-2004) to be similar.

Revision Details	By / Check	Date	Suffix

Drawing Status

Project Title

THE MERSEY
TIDAL POWER PROJECT

Drawing Title

CIVIL ENGINEERING (MARINE)
LINE A - NEW FERRY TO DINGLE
OPTION A 1.01/ NA1

NAVIGATION OPTION 1
NORTH LOCK
GENERAL ARRANGEMENT

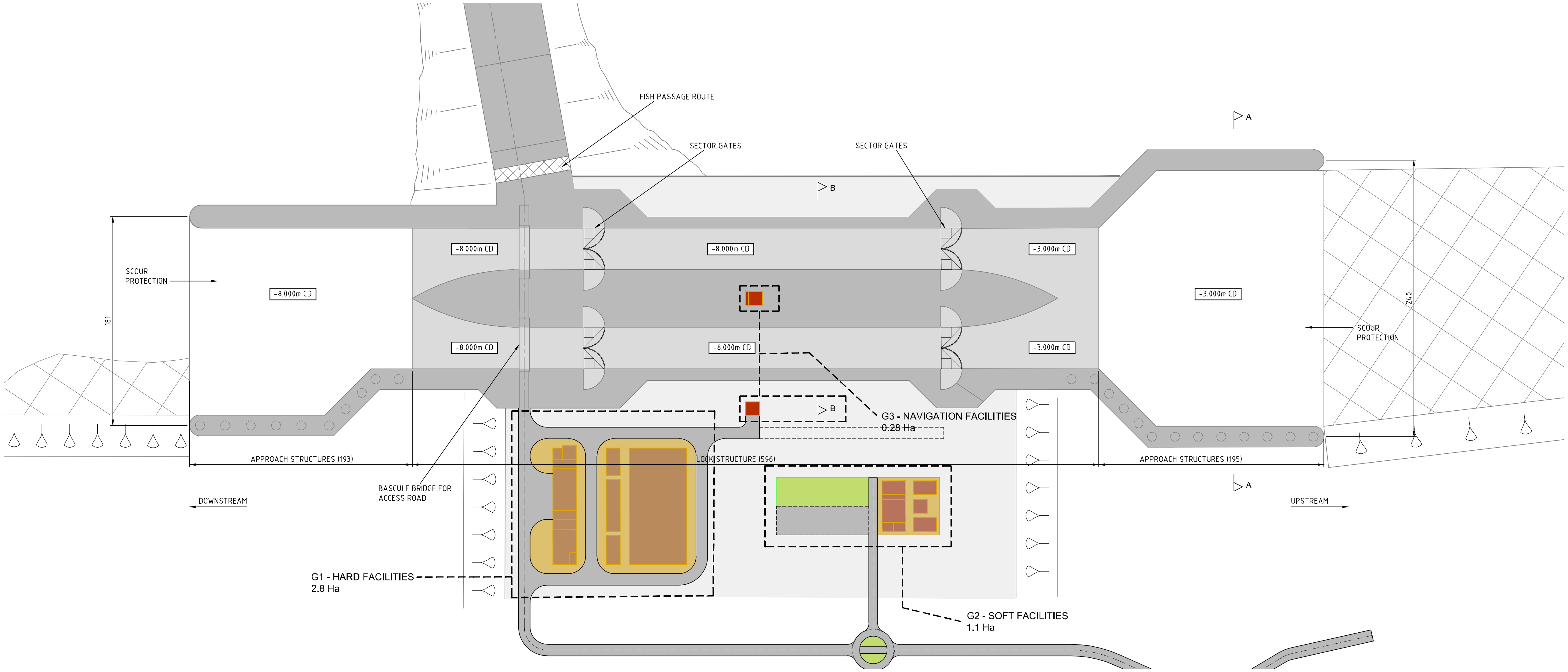
Scale at A1	AS SHOWN		
Drawn: HT		Approved: AS	
Stage 1 check	Stage 2 check: HB	Originated	Date: APR 10

PEELENERGY
Northwest REGIONAL DEVELOPMENT AGENCY

Drawing Number	Rev
PD0330-12-3022	P1

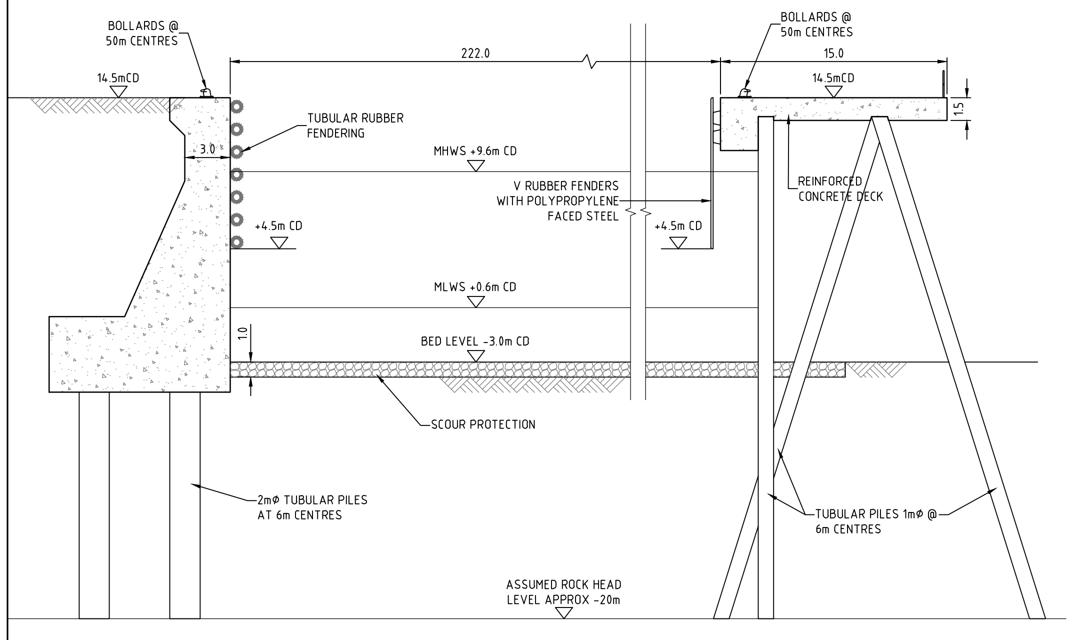
DB1V

(A1) 594x841 Corporate



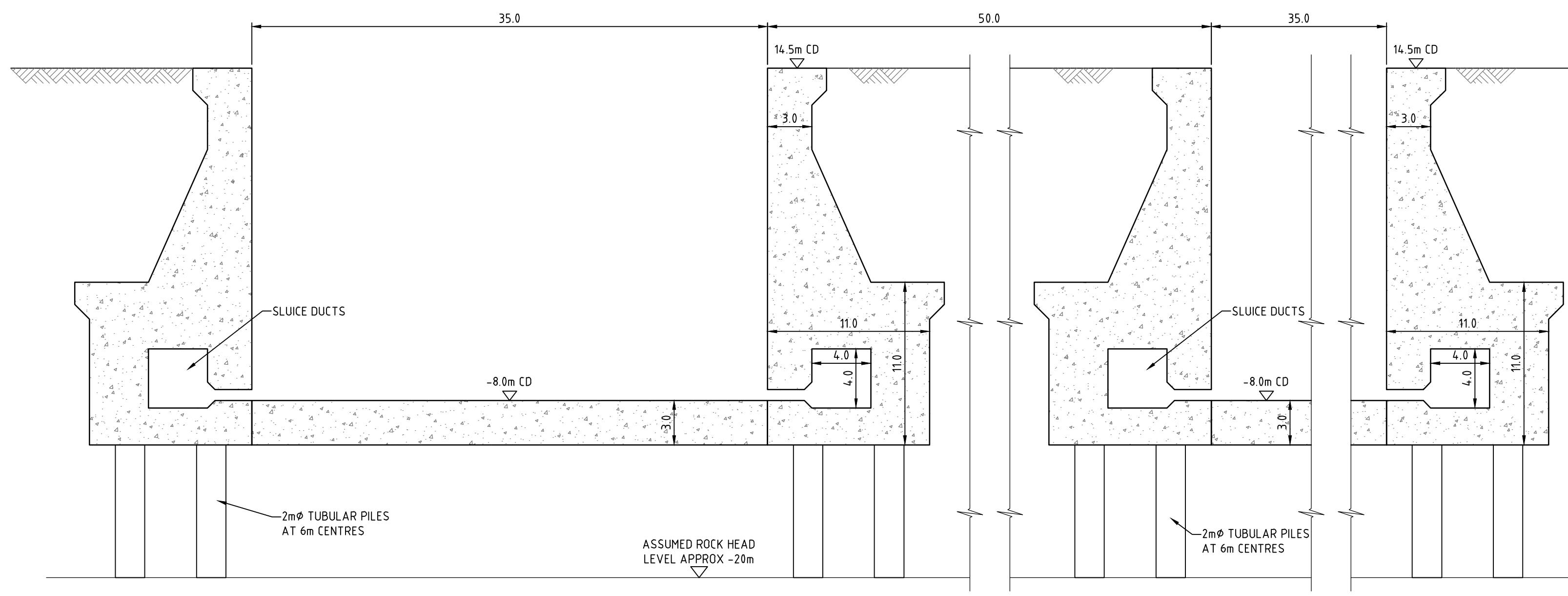
PLAN ON DOUBLE SOUTH LOCK

SCALE 1:2000



SECTION A-A

SCALE 1:250



SECTION B-B

SCALE 1:250

NOTES:

1. Levels shown are in metres and relate to Chart Datum at Albert Docks. (Chart Datum is 4.93m below Ordnance Survey Datum).
2. See drawing PD0330-12-2003 for location of lock structure.
3. Refer to Drawing No. PD0330-13-3002 for Landside General Arrangement.

Revision Details	By / Check	Date	Suffix

Drawing Status

Project Title

THE MERSEY
TIDAL POWER PROJECT

Drawing Title

CIVIL ENGINEERING (MARINE)
LINE A - NEW FERRY TO DINGLE
OPTION A1.01/NA3

NAVIGATION OPTION 3
TWIN SOUTH LOCK
GENERAL ARRANGEMENT

Scale at A1: AS SHOWN

Drawn	Approved
SJW	AS

Stage 1 check	Stage 2 check	Originated	Date
	HB		APR 10

PEEL ENERGY   Northwest REGIONAL DEVELOPMENT AGENCY

Drawing Number	Rev
PD0330-12-3023	P1

DB1V

(A1) 594x841 Corporate

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