Great Yarmouth Third River Crossing

Application for Development Consent Order

Document 6.14: preliminary Navigation Risk Assessment

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 (as amended) (“APFP”)

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Foreword

This preliminary Navigation Risk Assessment accompanies an application ("the Application") submitted by Norfolk County Council ("the Applicant") to the Secretary of State for a Development Consent Order ("DCO") under the Planning Act 2008.[1]

If made by the Secretary of State, the DCO would grant development consent for construction, operation and maintenance of a new bascule bridge highway crossing of the River Yare in Great Yarmouth, and which is referred to in the Application as the Great Yarmouth Third River Crossing ("the Scheme").

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 (as amended) require that an application for a DCO be accompanied by the documents specified at Regulation 5(2)(a) to (r). This is one of those documents and is specified at Regulation 5(2)(q).

[1] Reference to legislation in this document are to that legislation as amended at the date of this document.

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Glossary of Abbreviations and Defined Terms

ALARP	As low as reasonably practicable
COLREGs	International Regulations for Prevention of Collision at Sea, 1972
DCO	Development Consent Order
DfT	Department for Transport
ES	Environmental Statement
GLA	General Lighthouse Authority
GYPA	Great Yarmouth Port Authority
GYPC	Great Yarmouth Port Company
IALA	The International Association of Marine Aids to Navigation and Lighthouse Authorities
LOA	Length Overall
LPS	Local Port Service
MAIB	Marine Accident Investigation Branch
MCA	Maritime and Coastguard Agency
MGN	Marine Guidance Note
NRA	Navigation Risk Assessment
NWG	Navigation Working Group
pNRA	preliminary Navigation Risk Assessment
SHA	Statutory Harbour Authority

1 Introduction

1.1 Scope of the Assessments

1.1.1 This report covers the preparation of a preliminary Navigation Risk Assessment (pNRA) based on the design prepared for the DCO application. It covers both the construction and operational phases of the proposed scheme as designed at pre-tender stage. Any material changes to the bridge design or construction methodology will need to be considered and the Risk Assessment amended accordingly.

1.2 Objectives

1.2.1 The objectives of the pNRA were to establish;

- The hazards to navigation created by the presence of the scheme bascule bridge;
- The existing control and mitigation measures in place within the Port that will influence the identified risks;
- The risk levels associated with the identified hazards;
- Any additional control or mitigation measures that are required to ensure the risks identified are “as low as reasonably practicable”.

2 Scheme Description

2.1 Overview

2.1.1 Chapter 2 of Volume I of the Environmental Statement (ES) (DCO Document **6.1**) provides a full description of the Scheme, and is accompanied by the General Arrangement Plan (DCO Document **2.2**). Both documents should be read alongside the preliminary Navigation Risk Assessment, as a detailed project description is not provided in this document to prevent unnecessary duplication.

2.1.2 The Scheme involves the construction, operation and maintenance of a new crossing of the River Yare in Great Yarmouth. The Scheme consists of a new dual carriageway road, including a road bridge across the river, linking the A47 at Harfrey's Roundabout on the western side of the river to the A1243 South Denes Road on the eastern side. The Scheme would feature an opening span double leaf bascule (lifting) bridge across the river, involving the construction of two new 'knuckles' extending the quay wall into the river to support the bridge. The Scheme would include a bridge span over the existing Southtown Road on the western side of the river, and a bridge span on the eastern side of the river to provide an underpass for existing businesses, enabling the new dual carriageway road to rise westwards towards the crest of the new crossing.

2.2 Port Operations

2.2.1 The location of the Scheme crosses the navigation waterway within the River Yare and the port has commercial quays both north and south of the location, access to the berths north of the Scheme will require an opening of the bridge should the air draft of the vessel exceed the clear height of the bridge in the lowered position.

2.2.2 The GYPA is a Trust Port, it is the Statutory Harbour Authority (SHA) for the port of Great Yarmouth and the revisionary landlord of the port estate. In 2007 GYPA leased the port of Great Yarmouth to GYPC for 99 years, GYPC becoming the owner and operator of the port business and acting as agent for GYPA in the discharge of its statutory duties.

2.2.3 The port handles a wide variety of cargos including aggregates, cement, grain, fertilisers, forest products, dry and liquid bulks, pipeline and onshore wind farm equipment as well as providing facilities for the offshore windfarm servicing industry. A total of 1.2 million tonnes of cargo passed through the port during 2017.

2.2.4 From historic data covering the period 2008 to 2016 received from GYPC, an average of 10,000 commercial vessel moves per year occurred within the Port, with approximately 40% of these involving movements to or from berths north of the Scheme location. This figure does not include Port operational vessel movements or recreational vessels.

2.2.5 The River Yare also provides access to the Norfolk Broads for recreational vessels via Breydon Water. These vessels have to pass two existing lifting bridges, the Haven Bridge and the Breydon Bridge, during a passage between the sea and the Broads.

3 Methodology

3.1 Assessment Process

3.1.1 The preliminary Navigation Risk Assessment has been prepared to assess the additional risks to vessel navigation that will arise during and following construction of the proposed bridge. It does not look to assess existing risks present during navigation or risks outside the areas of influence of the bridge or its operation.

3.1.2 The process adopted has followed the general principals of risk assessment as set out in A Guide to Good Practice on Port Marine Operations, that being a 5-stage process comprising;

- Data Gathering
- Hazard Identification
- Risk Analysis
- Risk Assessment
- Risk Control

3.2 Consultation

3.2.1 In order to ensure a robust risk assessment process a Navigation Risk Assessment workshop was held to which the principal marine stakeholders were invited to attend to contribute to the preparation of the preliminary Navigation Risk Assessment.

3.2.2 The workshop was undertaken on 26th March 2019 at the GYPC Offices at Vanguard House, Great Yarmouth.

3.2.3 The workshop was attended by;

- John Bayfield – GYPC Marine Operations Manager
- Luke Sebastian – GYPC Marine Operations Manager
- David Morrice – GYPC Port Pilot
- Peter Woolston – GYPC Launch Coxswain
- Michael Mackleworth – GYPC Port Compliance Officer

3.2.4 The workshop explained the Scheme proposal design and the proposed scheme of operations as well as the proposed methodology for preparation of this pNRA.

3.2.5 The workshop reviewed identified hazards and causational effects and gave some consideration to the likelihoods and severities associated with each based on various vessel classifications and Scheme phase.

3.3 Guidance and References

3.3.1 This preliminary Navigation Risk Assessment has been prepared with reference to the following documents;

- Port Marine Safety Code, DfT/MCA Nov 2016
- A Guide to Good Practice on Port Marine Operations, DfT/MCA Feb 2018
- The National Contingency Plan - A Strategic Overview for Responses to Marine Pollution from Shipping and Offshore Installations, DfT/MCA
- Methodology for Assessing the Marine Navigational Safety & Emergency Response of Risks of Offshore Renewable Energy Installations, DfT/MCA
- Peel Ports Marine Operations – Marine Safety Management System, Peel Ports July 2017
- Great Yarmouth Port Authority Navigation (Haven) Bye-Laws 1997, GYPC
- General Port and Pilotage Information P16 2014, GYPC
- Pilotage Information Sheet 2014, GYPC

3.4 Data Gathering

3.4.1 For the preparation of this preliminary Navigation Risk Assessment a variety of information sources have been reviewed and assessed for applicability, these included;

- Existing operational arrangements;
- Previous studies and assessments;
- Scheme studies and assessments;
- Previous bridge incident reports.

4 Hazard Identification

4.1 General

4.1.1 The following section outlines the hazards resulting specifically from navigation in the vicinity of an opening bridge and the primary causational effect which lead to such hazards.

4.2 Collision

4.2.1 Collision is the uncontrolled coming together of 2 vessels underway. It is applicable to all sizes and types of vessels. Collision hazards are present during every vessel movement where other vessels are or could be present. The main factors affecting occurrence likelihood are vessel density, navigation constraints and vessel control.

4.3 Contact

4.3.1 Contact is the uncontrolled coming together of a vessel and either a fixed structure or a moored vessel. It is applicable to all sizes and types of vessels. Contact hazards are present whenever vessel movements occur in proximity to fixed structures and during berthing operations. The main factors affecting occurrence likelihood are navigation constraints and vessel control.

4.4 Grounding

4.4.1 Grounding is the unintentional coming together of a vessel and the bed of the river, sea or dock. While applicable to all types of vessel it is more likely for larger deeper draughted commercial vessels. Grounding hazards are more likely for vessels as draught increases. The main factors affecting occurrence likelihood are navigation chart accuracy, navigation planning and vessel control.

4.5 Primary Causes

Collision

Vessel Proximity

4.5.1 Restrictions on the width of navigable water inherently increases the proximity at which vessels will need to navigate.

Visibility

4.5.2 Reductions or obstructions to visibility will increase the risks of Masters not seeing other vessels in sufficient time to navigate safely.

Equipment Failure (Collision)

4.5.3 Failure of on-board equipment can render vessels adrift and unable to maintain navigational control thereby increasing the risks of collision. Failure of bridge operating equipment can result in vessels needing to perform evasive manoeuvres increasing the risks of collision.

Human Error (Collision)

4.5.4 Human error by the Master or pilot of a vessel is a contributory cause in a significant number of marine incidents and the potential for its occurrence requires consideration in all assessments.

Contact

Knowledge of Structure

4.5.5 A Master's lack of knowledge of the presence and nature of structures constraining navigation will increase the risk of contact between their vessel and a structure.

Current Pattern Changes

4.5.6 Familiarity with existing conditions and a failure to allow for potential changes caused by the presence of new structures will increase the risks of contact.

Wind Sheltering

4.5.7 Changes to the levels of wind exposure felt by a vessel navigating within the bridge passage can lead to an increased risk of contact, this risk increases as vessel dimensions increase.

Projections or Roll

4.5.8 Vessels with projecting cargo or flying bridges have greater potential to contact structures, similarly high vessels with a susceptibility to roll or traveling with a list produce a higher risk.

Equipment Failure (Contact)

4.5.9 Failure of on-board equipment can render vessels adrift and unable to maintain navigational control thereby increasing the risks of contact. Failure of bridge operating equipment can result in vessels needing to perform evasive manoeuvres increasing the risks of contact.

Human Error (Contact)

4.5.10 Human error by the Master or pilot of a vessel is a contributory cause in a significant number of marine incidents and the potential for its occurrence requires consideration in all assessments.

Grounding

Changes in Sedimentation Patterns

4.5.11 Changes to the patterns of current flow during and following construction of new structures can lead to changes in sediment deposition areas and rates with a subsequent reduction in accuracy of available navigation chart data. This will tend to increase the risk of groundings particularly for deeper draughted vessels.

4.6 Incident Frequencies

4.6.1 A review of Marine Accident Investigation Branch (MAIB) incident reports during the period 1999 to 2018 has identified 10 events related to bridge structures. Of these 9 were contacts with the remaining one a collision.

4.6.2 Of the 10 recorded events, five were on the Thames in Central London, two each on the Ouse and Trent and the final one on the Mersey. No incidents have been recorded within Great Yarmouth.

4.6.3 GYPC have confirmed that there has been one reported incident involving a vessel contact with the Haven Bridge recorded on the Ports Risk Management System. This involved a non-powered barge under tow becoming trapped under the bridge while attempting to transit without a lift. The barge was removed by the towing vessel without further assistance.

4.6.4 An assessment of the potential future traffic frequency for each class of vessel has been undertaken as part of the scheme preparation, the results of this assessment are presented in Appendix B.

4.6.5 This assessment indicated that the anticipated annual number of vessel passages of all types through the new bridge could be around 8,000. In total around 90% of movements are anticipated to be commercial traffic with the remaining 10% recreational. Further discussions with the GYPC have indicated that this value remains a reasonable base-line.

5 Existing Operational Measures

5.1 Navigation Control

5.1.1 Navigation within the Port is controlled by the local Harbour Master under the authority of GYPA, the SHA. Control of vessels is governed by Port Bye-Laws, general and special Directions and Notice to Mariners issued as required by the Harbour Master or Deputy as appropriate.

Commercial Vessels

5.1.2 Commercial vessels are categorised as any vessel operating on a commercial basis; they are generally motor driven as opposed to sail and range from small to very large.

Piloted Vessels

5.1.3 Pilotage is required for all vessels or tows of 40.0 metres Length Overall (LOA) or more (With a few exemptions).

Non-Piloted Vessels

5.1.4 Vessels below the LOA threshold and vessels whose Master holds a Pilot Exemption Certificate are not required to take a pilot.

Recreational Vessels

5.1.5 Recreational vessels are those used by private individuals for personal or entertainment purposes; they are typically very small to small and can be either motor, sail or non-propelled (paddle).

5.2 Vessel Control

5.2.1 Individual vessel movements for commercial traffic are controlled by the Statutory Harbour Authority through a Local Port Service; all vessels must notify a controller of all intended movements and are only permitted to proceed on receipt of confirmation.

5.2.2 All vessels are governed by the requirements of the Port Bye-Laws and directions along with the “International Regulations for Prevention of Collision at Sea” (COLREGs).

5.3 Depth Control

5.3.1 Bed levels within the Port are monitored via biannual bathymetric surveys and maintained via dredging campaigns as required (currently annually).

5.3.2 The Statutory Harbour Authority publishes depths for vessel passages and produces navigation charts detailing the actual bed levels for vessel Masters to plan movements.

6 Risk Assessment

6.1 Scope of the Assessments

6.1.1 The Risk Assessment was conducted using a likelihood x severity matrix, in accordance with the methodology set out in Peel Ports Marine Safety Management System as used by GYPC.

- Likelihood;

  Rare – occurrence frequency greater than project design life,
  Unlikely – occurrence frequency between 2 years and project life,
  Possible – occurrence frequency less than biennial,
  Likely – annual occurrence frequency,
  Almost Certain – multiple occurrences expected annually.

- Severity;

  Negligible – no injuries or damage to property or environment,
  Minor – injury not requiring hospitalisation, damage not affecting operations, Tier 1 pollution incident,
  Moderate – injury requiring hospital treatment, damage requiring repair, localised Tier 2 pollution,
  Major – major injury, structural damage affecting operation, widespread Tier 2 pollution,
  Catastrophic – casualty, structural collapse/sinking or Tier 3 pollution.

(Pollution Tiers are as defined in "The National Contingency Plan - A Strategic Overview for Responses to Marine Pollution from Shipping and Offshore Installations").

6.1.2 The two values are used to form the Risk Matrix. Finally, the Risk Matrix score is assigned one of four colour coded classifications, Very Low, Low, High and Very High, as shown below.

	Negligible	Minor	Moderate	Major	Catastrophic
Rare	1	2	3	4	5
Unlikely	2	4	6	8	10
Possible	3	6	9	12	15
Likely	4	8	12	16	20
Almost Certain	5	10	15	20	25

6.1.3 This Risk Classification indicates the magnitude and acceptability of the risk and guides whether additional mitigating control measures may be required to bring the risk to ALARP (As Low As Reasonably Practicable) principles, in this case taken as being Low.

6.1.4 The initial outputs from the preliminary Navigation Risk Assessment are presented in Appendix A in the following format;

ID	Hazard	Cause	Phase	Traffic Type	Pre Mitigation				Existing Controls	New Mitigation	Post Mitigation			
					L	S	R	Rank			L	S	R	Rank

Where;

L – Likelihood, S – Severity, R – Risk.

7 Additional Mitigation Measures

7.0.1 The following additional mitigation measures have been identified during the preparation of this pNRA and are recommended to be included within the delivery of the Scheme.

7.1 Planning and Design Phase

Vessel Simulations

7.1.1 Vessel simulations have been undertaken as part of the Planning Phase to inform the preliminary design and subsequent final designs. A report on the simulations undertaken so far is included in Appendix C. Further simulations will be arranged as required.

Hydrodynamic and Sediment Modelling

7.1.2 The construction methodology and design of the final bridge must take account of the results of the hydrodynamic modelling and Sediment Transport Assessment (DCO Document **6.2 Appendix 11c**) and aim to reduce the potential impacts of changes to flow patterns and sediment deposition.

Design Development

7.1.3 The outputs of this pNRA are to be considered in all future design development, all future design decisions must consider the potential impacts on the identified risks and if they create any additional risks and any new controls or mitigation measures that may be required the pNRA should be updated to reflect this.

7.2 Construction Phase

Updates

7.2.1 Prior to commencement of the Construction Phase, a complete update of the NRA will be undertaken by the Undertaker, in conjunction with the SHA, to consider the implications of the precise methods of construction to be employed.

Monitoring

7.2.2 Monitoring of potential changes caused by the construction should be undertaken to ensure that early intervention can be commenced should any potentially hazardous conditions develop. This should include bathymetric surveys for potential sedimentation issues and may include vibration monitoring in relation to quay walls.

Notifications

7.2.3 During the Construction Phase Notice to Mariners should be issued to ensure all users are fully informed of the state of the works in relation to navigation, the frequency and format of these notices should be agreed with the SHA.

Lights and Markings

7.2.4 During the Construction Phase all plant and works that could present a hazard to navigation will be required to exhibit suitable marks and lights as may be required by the SHA. These should be notified to all local operators via a Notice to Mariners.

7.3 Operational Phase

Updates

7.3.1 Prior to commencement of the Operational Phase, a complete update of the NRA will be undertaken, in conjunction with the SHA, to consider the implications of the precise methods of construction to be employed.

Notifications

7.3.2 In preparation for the Operation Phase, Notice to Mariners should be prepared and distributed detailing the operational regime for the final bridge, this should include all necessary details to ensure port users are adequately aware of the methods of communicating with the bridge operations and the meanings of the directions associated with the final bridge.

Familiarisation and Training

7.3.3 The implementation of a suitable training and familiarisation program for pilots and other applicable port users should be established to ensure all are conversant with the changes to navigation that will be experienced both during and after construction of the bridge.

Inspections

7.3.4 A programme of surveys and inspections should be established to ensure early identification of any potentially hazardous conditions, surveys should include bathymetric surveys of the River and structural surveys of the works as required.

Lights and Markings

7.3.5 During the Operation Phase the bridge will be identified with suitable marks and lights agreed during the design development with the SHA and the GLA (Trinity House).

Information Systems

7.3.6 Provision of real-time environmental condition monitoring systems to provide information to the bridge operator and vessel masters should be incorporated into the Scheme design, these would include wind measurements, current flow measurements, tide gauges and air draft displays.

Maintenance

7.3.7 A suitable and sufficient maintenance regime should be established to ensure the mechanical reliability of the final bridge. Suitable training should be given to operational staff to allow them to safely manage the operation of the bridge.

Reviews

7.3.8 All risk assessments are live documents and must be reviewed and revised in light of any changes in conditions to remain effective, the final bridge Navigation Risk Assessment should be incorporated into the wider Port Navigation Risk Assessment and revised and updated in line with the Ports Marine Safety Management System.

Appendix A – preliminary NRA

Great Yarmouth Third River Crossing - preliminary Navigation Risk Assessment

Hazard ID	Hazard Type	Cause	Phase	Traffic Type	Pre-Mitigation L	Pre-Mitigation S	Pre-Mitigation R	Pre-Mitigation Rank	Existing Controls	Additional Mitigation	Post-Mitigation L	Post-Mitigation S	Post-Mitigation R	Post-Mitigation Rank
1	Collision	Increased traffic proximity due to construction	Construction	Commercial (Large)	3	4	12	6	LPS System, Navigation directions, Compulsory Pilotage/PEC	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks	2	4	8	4
2	Collision	Increased traffic proximity due to construction	Construction	Commercial (Small)	4	4	16	1	LPS System, Navigation directions	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks	2	4	8	4
3	Collision	Increased traffic proximity due to construction	Construction	Recreation	3	3	9	19	LPS System, Navigation directions	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks	1	3	3	39
4	Collision	Increased traffic proximity through bridge	Operation	Commercial (Large)	3	4	12	6	LPS System, Navigation directions, Compulsory Pilotage/PEC	Undertake simulations to assess the extent of potential changes to navigation, Traffic Control Signal lights	1	4	4	20
5	Collision	Increased traffic proximity through bridge	Operation	Commercial (Small)	4	4	16	1	LPS System, Navigation directions	Undertake simulations to assess the extent of potential changes to navigation, Traffic Control Signal lights	1	4	4	20
6	Collision	Increased traffic proximity through bridge	Operation	Recreation	3	3	9	19	LPS System, Navigation directions	Traffic Control Signal lights	1	3	3	39
7	Collision	Obstruction to visibility	Operation	Commercial (Small)	3	4	12	6	LPS System, Navigation directions	IALA Signal lights	1	4	4	20
8	Collision	Obstruction to visibility	Operation	Commercial (Large)	2	4	8	34	LPS System, Navigation directions	IALA Signal lights	1	4	4	20
9	Collision	Obstruction to visibility	Operation	Recreation	2	3	6	39	LPS System, Navigation directions	IALA Signal lights	1	3	3	39
10	Collision	Proximity of waiting pontoon	Operation	Recreation	2	3	6	39	None	Location selected to minimise risk, Navigation Simulation, Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks.	1	3	3	39
11	Collision	Proximity of waiting pontoon	Operation	Commercial (Large)	2	3	6	39	None	Location selected to minimise risk, Navigation Simulation, Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks.	1	3	3	39
12	Collision	Proximity of waiting pontoon	Operation	Commercial (Small)	2	3	6	39	None	Location selected to minimise risk, Navigation Simulation, Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks.	1	3	3	39
13	Collision	Requirement to hold awaiting bridge operations	Operation	Recreation	3	2	6	39	LPS System, Navigation directions	Provision of waiting pontoon, scheduled bridge opening times.	1	2	2	58
14	Contact	Equipment failure - bridge mechanism fails to open	Operation	Commercial (Large)	2	3	6	39	None	Mechanical redundancy within design, PUWER Assessment, operating and emergency protocols to be established.	1	3	3	39
15	Contact	Equipment failure - bridge mechanism fails to open	Operation	Commercial (Small)	3	3	9	19	None	Mechanical redundancy within design, PUWER Assessment, operating and emergency protocols to be established.	2	3	6	10
16	Contact	Equipment failure - Failure of navigation lighting	Construction	Commercial (Large)	3	4	12	6	LPS System	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks, inspection and maintenance programme.	1	4	4	20
17	Contact	Equipment failure - Failure of navigation lighting	Construction	Commercial (Small)	4	3	12	6	LPS System	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks, inspection and maintenance programme	1	3	3	39
18	Contact	Equipment failure - Failure of navigation lighting	Construction	Recreation	2	3	6	39	LPS System	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks, inspection and maintenance programme	1	3	3	39
19	Contact	Equipment failure - Failure of navigation lighting	Operation	Commercial (Large)	2	4	8	34	LPS System	Mechanical redundancy within design, operating and emergency protocols to be established, maintenance regime, impact protection fendering.	2	2	4	20

Note: Only risk combinations with a pre-mitigation rating of >3 are shown in the table.

Great Yarmouth Third River Crossing - preliminary Navigation Risk Assessment

					Pre-Mitigation						Post-Mitigation			
Hazard ID	Hazard Type	Cause	Phase	Traffic Type	L	S	R	Rank	Existing Controls	Additional Mitigation	L	S	R	Rank
20	Contact	Equipment failure - Failure of navigation lighting	Operation	Recreation	2	2	4	59	LPS System	Mechanical redundancy within design, operating and emergency protocols to be established, maintenance regime, impact protection fendering.	2	2	4	20
21	Contact	Equipment failure - Failure of navigation lighting	Operation	Commercial (Small)	2	3	6	39	LPS System	Mechanical redundancy within design, operating and emergency protocols to be established, maintenance regime, impact protection fendering.	2	2	4	20
22	Contact	Equipment failure - Operator fails to see vessel during bridge passage	Operation	Commercial (Large)	2	4	8	34	LPS System	Ensure adequate visibility of approaching vessels from control location, contact mechanism for vessels detailed in Notice to Mariners, provision of CCTV.	1	4	4	20
23	Contact	Equipment failure - Operator fails to see vessel during bridge passage	Operation	Commercial (Small)	3	3	9	19	LPS System	Ensure adequate visibility of approaching vessels from control location, contact mechanism for vessels detailed in Notice to Mariners, provision of CCTV.	1	3	3	39
24	Contact	Equipment failure - Operator fails to see vessel during bridge passage	Operation	Recreation	3	2	6	39	LPS System	Ensure adequate visibility of approaching vessels from control location, contact mechanism for vessels detailed in Notice to Mariners, provision of CCTV.	2	2	4	20
25	Contact	Lack of knowledge of presence of structure	Construction	Commercial (Large)	3	4	12	6	Compulsory Pilotage/PEC	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks	1	4	4	20
26	Contact	Lack of knowledge of presence of structure	Construction	Recreation	4	3	12	6	None	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks	2	3	6	10
27	Contact	Lack of knowledge of presence of structure	Construction	Commercial (Small)	3	3	9	19	None	Issue of Notice to Mariners and Harbour Works Consent, implementation of temporary lights and marks	1	3	3	39
28	Contact	Lack of knowledge of presence of structure	Operation	Commercial (Large)	3	4	12	6	Compulsory Pilotage/PEC	Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks, impact protection fendering	2	2	4	20
29	Contact	Lack of knowledge of presence of structure	Operation	Recreation	4	2	8	34	None	Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks, impact protection fendering	3	1	3	39
30	Contact	Lack of knowledge of presence of structure	Operation	Commercial (Small)	2	3	6	39	None	Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks, impact protection fendering	2	2	4	20
31	Contact	Loss of control due to changes in current patterns	Construction	Commercial (Large)	4	4	16	1	Compulsory Pilotage/PEC	Undertake modelling to assess the extent of potential changes to current patterns, Issue Notice to Mariners.	2	4	8	4
32	Contact	Loss of control due to changes in current patterns	Construction	Recreation	3	3	9	19	None	Undertake modelling to assess the extent of potential changes to current patterns, Issue Notice to Mariners	2	3	6	10
33	Contact	Loss of control due to changes in current patterns	Construction	Commercial (Small)	3	3	9	19	None	Undertake modelling to assess the extent of potential changes to current patterns, Issue Notice to Mariners	2	3	6	10
34	Contact	Loss of control due to changes in current patterns	Operation	Commercial (Large)	4	4	16	1	Compulsory Pilotage/PEC	Undertake simulations to assess the extent of potential changes to navigation, Issue Notice to Mariners, impact protection fendering, implement training programme, provision of flow monitoring equipment in control tower.	2	3	6	10
35	Contact	Loss of control due to changes in current patterns	Operation	Recreation	3	3	9	19	None	Issue Notice to Mariners, impact protection fendering, provision of flow monitoring equipment in control tower.	2	2	4	20
36	Contact	Loss of control due to changes in current patterns	Operation	Commercial (Small)	3	3	9	19	None	Undertake simulations to assess the extent of potential changes to navigation, Issue Notice to Mariners, impact protection fendering, provision of flow monitoring equipment in control tower.	2	2	4	20
37	Contact	Loss of control due to wind sheltering	Operation	Commercial (Large)	3	4	12	6	Compulsory Pilotage/PEC	Undertake modelling to assess the extent of potential changes to navigation, Issue Notice to Mariners, impact protection fendering, implement training programme.	2	3	6	10

Note: Only risk combinations with a pre-mitigation rating of >3 are shown in the table.

Great Yarmouth Third River Crossing - preliminary Navigation Risk Assessment

					Pre-Mitigation						Post-Mitigation			
Hazard ID	Hazard Type	Cause	Phase	Traffic Type	L	S	R	Rank	Existing Controls	Additional Mitigation	L	S	R	Rank
38	Contact	Loss of control due to wind sheltering	Operation	Recreation	3	2	6	39	None	Issue Notice to Mariners, impact protection fendering, provision of wind indicator at bridge	2	1	2	58
39	Contact	Loss of control due to wind sheltering	Operation	Commercial (Small)	2	3	6	39	None	Undertake modelling to assess the extent of potential changes to navigation, Issue Notice to Mariners, impact protection fendering	2	2	4	20
40	Contact	Proximity of waiting pontoon to navigation channel	Operation	Commercial (Large)	2	3	6	39	None	Location selected to minimise risk, Navigation Simulation, Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks.	1	3	3	39
41	Contact	Proximity of waiting pontoon to navigation channel	Operation	Commercial (Small)	2	3	6	39	None	Location selected to minimise risk, Navigation Simulation, Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks.	1	3	3	39
42	Contact	Vessel contact with bridge attempting to proceed without an opening	Operation	Recreation	3	3	9	19	None	Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks, provision of real-time air draft display..	2	3	6	10
43	Contact	Vessel contact with bridge attempting to proceed without an opening	Operation	Commercial (Small)	2	3	6	39	None	Issue of Notice to Mariners, update of Navigational Charts, implementation of lights and marks, provision of real-time air draft display.	1	3	3	39
44	Contact	Vessel projections or roll causes contact with bridge superstructure	Operation	Commercial (Large)	3	3	9	19	Compulsory Pilotage/PEC	Bridge designed with no oversailing when open, impact protection fendering	2	3	6	10
45	Contact	Vessel projections or roll causes contact with bridge superstructure	Operation	Commercial (Small)	2	2	4	59	None	Bridge designed with no oversailing when open, impact protection fendering	1	2	2	58
46	Contact	Vessel equipment failure	Operation	Commercial (Large)	2	4	8	34	None	impact protection fenders	2	3	6	10
47	Contact	Vessel equipment failure	Operation	Commercial (Small)	2	3	6	39	None	impact protection fenders	2	2	4	20
48	Contact	Vessel equipment failure	Operation	Recreation	2	3	6	39	None	impact protection fenders	2	2	4	20
49	Contact	Human error - Vessel operator	Construction	Commercial (Large)	3	4	12	6	None	TBC by Contractor	3	4	12	1
50	Contact	Human error - Vessel operator	Construction	Commercial (Small)	3	3	9	19	None	TBC by Contractor	3	3	9	2
51	Contact	Human error - Vessel operator	Construction	Recreation	3	3	9	19	None	TBC by Contractor	3	3	9	2
52	Contact	Human error - Vessel operator	Operation	Commercial (Large)	4	4	16	1	Compulsory Pilotage/PEC	impact protection fenders	4	2	8	4
53	Contact	Human error - Vessel operator	Operation	Commercial (Small)	4	3	12	6	None	impact protection fenders	4	2	8	4
54	Contact	Human error - Vessel operator	Operation	Recreation	3	3	9	19	None	impact protection fenders	3	2	6	10
55	Grounding	Change in sediment regime leads to shoaling	Construction	Commercial (Large)	3	4	12	6	Bathymetric surveys and navigational charts, Maintenance dredging	Modelling during design, additional surveying and control dredging (if required)	2	4	8	4
56	Grounding	Change in sediment regime leads to shoaling	Construction	Commercial (Small)	2	3	6	39	Bathymetric surveys and navigational charts, Maintenance dredging	Modelling during design, additional surveying and control dredging (if required)	1	3	3	39
57	Grounding	Change in sediment regime leads to shoaling	Operation	Commercial (Large)	3	4	12	6	Bathymetric surveys and navigational charts, Maintenance dredging	Modelling during design	1	4	4	20

Note: Only risk combinations with a pre-mitigation rating of >3 are shown in the table.

Great Yarmouth Third River Crossing - preliminary Navigation Risk Assessment

					Pre-Mitigation						Post-Mitigation			
Hazard ID	Hazard Type	Cause	Phase	Traffic Type	L	S	R	Rank	Existing Controls	Additional Mitigation	L	S	R	Rank
58	Grounding	Change in sediment regime leads to shoaling	Operation	Commercial (Small)	2	3	6	39	Bathymetric surveys and navigational charts, Maintenance dredging	Modelling during design	1	3	3	39
59	Grounding	Objects dropped into navigation channel during construction	Construction	Commercial (Large)	3	3	9	19	Statutes and Bye-laws preventing deposition of objects in water	Anti-pollution contract requirements and notification procedures	1	3	3	39
60	Grounding	Objects dropped into navigation channel during construction	Construction	Commercial (Small)	2	3	6	39	Statutes and Bye-laws preventing deposition of objects in water	Anti-pollution contract requirements and notification procedures	1	3	3	39
61	Grounding	Objects dropped into navigation channel during construction	Construction	Recreation	2	2	4	59	Statutes and Bye-laws preventing deposition of objects in water	Anti-pollution contract requirements and notification procedures	1	2	2	58

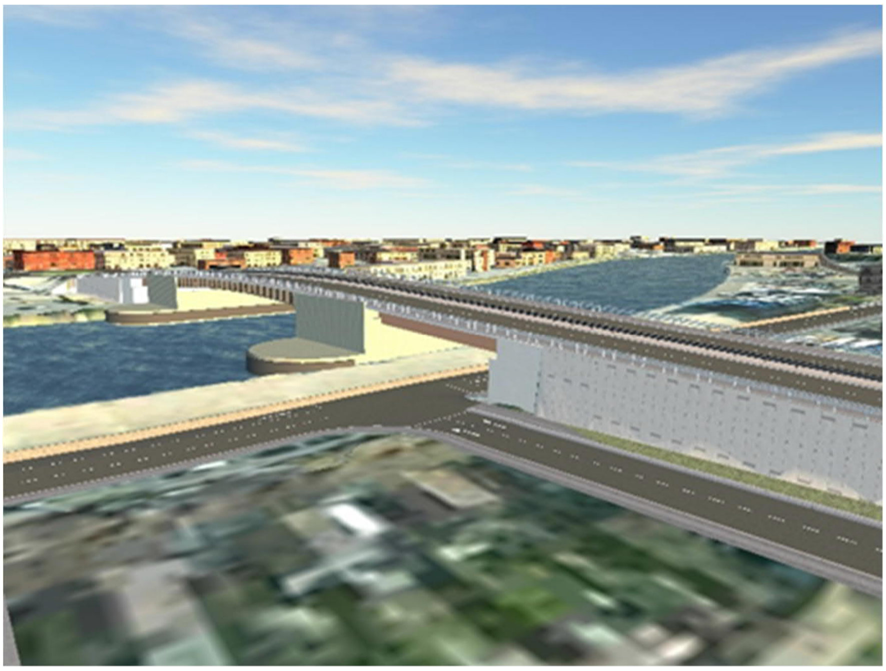
Note: Only risk combinations with a pre-mitigation rating of >3 are shown in the table.

Appendix B – Existing and Future Requirements of Peel Ports Great Yarmouth and other Port Users

1073739-MOU-MAR-GY-RP-MA-0001 - Existing and Future Requirements of Peel Ports Great Yarmouth and other Port Users

Great Yarmouth Third Crossing

Existing and Future Navigation Requirements of Peel Ports Great Yarmouth and other Port Users



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Limitations on Reporting

This report is presented to Mouchel Transport Planning Division in respect of the maritime assessment of options for a third crossing at Great Yarmouth, with the anticipation of it informing an overall options report prepared by Mouchel Transport Planning Division. Should this report be presented to Norfolk County Council in respect of a third crossing at Great Yarmouth, it may not be used or relied on by any other person. It may not be used by Norfolk County Council in relation to any other matters not covered specifically by the agreed scope of this Report.

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Contents

Introduction

Great Yarmouth is a town in the English county of Norfolk. It is situated on the east coast of the United Kingdom and has a port with direct sea access to the North Sea. The port is owned and operated by Peel Ports Great Yarmouth and is made up of two sections; the inner harbour is formed on the banks of the River Yare whilst the outer harbour is constructed from breakwaters and comprises land reclaimed from the sea.

As can be seen in Figure 1 below the town is divided in a north south direction by the river which results in a spit of land approximately 4km long being effectively separated from the remainder of the town.

Figure 1 - Aerial photograph of Great Yarmouth Haven

To overcome this separation Norfolk County Council is proposing to construct a third river crossing approximately 1.5km south of the existing Haven Bridge, which is the most southerly of the current two crossings.

The aspirations of the scheme are to improve connectivity within the town thereby reducing traffic congestion and promoting redevelopment and growth.

1 Project Appreciation

Norfolk County Council have appointed Mouchel's Transport Planning Division to prepare an Outline Business Case for the proposed third river crossing at Great Yarmouth. The proposed scheme is a new road crossing to ease the current congestion around the town centre and the existing bridges. The type and location of the proposed new crossing has the potential to impact on existing and future maritime based operations in Great Yarmouth.

The proposals are to construct a new bascule bridge that will carry land traffic across the River Yare. The proposed bridge will cross the river near the apex of the river bend between Berths 12 and 13 on the Atlas Quay (also known as Fish Wharf) on the east bank, and Berths 31 and 32 on the Bollard Quay on the west bank, see Figure 2. With the current design parameters, when raised the bridge will have a 50m clear span for navigation and when closed it will have a clear height of approximately 4.5m above the mean high water springs level. An alternative design providing a clear height of 7.5m, the maximum achievable while still maintaining a tie-in to South Dene Road, has also been considered.

Figure 2 - Proposed Bridge Location

Ships will need to routinely pass through the raised bridge to access the various berths north of the bridge site. Furthermore, there are active berths immediately adjacent to the intended bridge's location on both sides of the river. Therefore an assessment of the likely frequency of operations and the effect of future port developments on this frequency is required.

2 Scope of Service

2.1 Scope

Mouchel's Maritime Division have been asked to provide support to Mouchel's Transport Planning Division by gathering available data on existing maritime operations based in Great Yarmouth and forecasting possible future maritime operations, that will have an influence on the proposed solutions for the third crossing. Mouchel Maritime were also requested to establish possible benefits / regeneration upsides available to Peel Ports and other port users from a third crossing. This will be achieved by completing the following tasks:

- Complete a desk top study and initial consultations to identify stakeholders
- Prepare a questionnaire to be used to gather information from stakeholders
- Schedule meetings with stakeholders in preparation for a visit to Great Yarmouth
- Collate information on existing and projected future Port usage
- Prepare a report on the existing and future requirements of the Port and other users to identify constraints and opportunities for the proposed crossing and to inform the Options Study
- Attendance at an optioneering workshop
- Ongoing support to develop and select option(s) for recommendation
- Input to final report to Client

3 Existing Stakeholders of the Port

3.1 Identification of Existing Stakeholders

Stakeholders are individuals, departments or organizations whose interests may be affected positively or negatively by the execution of the project. The identification of stakeholders was carried out using a variety of methods, electronic searches and consultations to determine individuals, departments and organizations that may be impacted by or have an impact on this project.

For the purpose of this study and the focus on the existing and future maritime operations at the Port, two levels of stakeholder were identified, primary and secondary. Primary stakeholders, those directly affected by this project, were considered to be the land owners and Port tenants who have quay operations north of the proposed bridge location. Secondary stakeholders, those indirectly affected by this project, were considered to be those who have quay operations south of the proposed bridge location or do not operate vessels from their berths north of the bridge. Table 1 below lists all stakeholders identified. Stakeholders who operate at berths falling in to both primary and secondary categories have only been consulted once.

An initial consultation meeting with Peel Ports was held on 18th October to outline the aims and nature of the proposed bridge, obtain any key concerns Peel Ports had over the scheme and to identify significant port users and others who may be affected by the bridge.

	Stakeholder Name	Status	Relationship
1	Peel Ports/Great Yarmouth Port	Primary	Land Owner and Quay User
2	G.Y. Borough Council	Primary	Land Owner
3	Asco	Primary	Port Tenant and Quay User
4	Gardline	Primary	Port Tenant and Quay User
5	Alicat	Primary	Port Tenant and Quay User
6	E-on	Primary	Port Tenant and Quay User
7	Trinity Marine Services	Primary	Port Tenant and Quay User
8	Seatrax Ltd	Primary	Port Tenant and Quay User
9	Atlantic Marine & Aviation	Primary	Port Tenant and Quay User
10	EMR	Primary	Port Tenant and Quay User
11	Brineflow Ltd	Primary	Port Tenant
13	CLS Global Solutions	Secondary	Port Tenant and Quay User
14	Silverton Aggregates	Secondary	Port Tenant

Table 1 List of Identified Stakeholders

The location of the principal operational berths of the above identified stakeholders, along with the major layby berths within the Haven, are shown on Figure 3, overleaf.

Figure 3 - Berth plan

3.2 Stakeholder Details

3.2.1 Peel Ports/Great Yarmouth Port

Peel Ports are the second largest port operator in the UK and are part of the Peel Group, one of the largest property investment companies in the UK. Peel Ports Great Yarmouth are the Statutory Harbour Authority for the Port and have statutory duties regarding safety of navigation within the port and its approaches. They are owners and operators of a number of berths within the port.

3.2.2 Great Yarmouth Borough Council

Great Yarmouth Borough Council are the land owners at berths 21 and 35. Consultation with the Borough Council is being undertaken directly by Norfolk County Council and as such they were not approached in connection with this report.

3.2.3 ASCO

ASCO are an international offshore support services business providing service vessel and crew transfers for oil and gas field operations. They currently operate from Berths 12A to 12D, 31 and 32 with additional layby at 21 when required, and have between 25 and 35 vessel movements per week.

3.2.4 Gardline Marine Sciences

Gardline provide marine geophysical and geotechnical surveys including bathymetry and operate a number of survey vessels from Berth 29. Movement rates are typically less than 1 per week.

3.2.5 Alicat Workboats

Alicat are a service vessel manufacturer and repairer based at Berths 29A and B, they are part of the Gardline Group. They have an average of 7 vessel moves per week.

3.2.6 E-on

E-on operate a wind farm maintenance base for the Scroby Sands from Berth 15, with layby facilities at Berth 29 when required. They currently operate 2 vessels with movements typically twice daily for each vessel.

3.2.7 Trinity Marine Services

Trinity Marine Services (a Dalby Offshore/Gardline joint venture company) operate an offshore supply service from Berth 16, with standby mooring at 21, running between 2 and 4 vessels on a typical daily movement pattern for each vessel.

3.2.8 Seatrax Ltd

Seatrax are an offshore crane manufacturing company, supplying lifting equipment for offshore oil and gas installations. They operate a facility at Berth 28, vessel movements are limited with an average of less than 1 per month.

3.2.9 Atlantic Marine & Aviation

Atlantic Marine & Aviation are a vessel chartering company operating in the offshore & subsea markets. They have an operations base at berth 28, and have vessel movements 2 to 3 times per month.

3.2.10 EMR

EMR (European Metal Recycling) are a global metal recycling business operating a depot on Berth 18. They have few vessel movements to the berth.

3.2.11 Brineflow Properties & Handling Ltd

Brineflow are a drilling fluid supply company who have commercial interests in 2 quays north of the proposed bridge location (berths 20 and 24) with aspirations to develop these as offshore support bases. They currently have limited ship movements within the port.

3.2.12 CLS Global Solutions

CLS Global Solutions provide engineering and project management services to the offshore oil, gas and renewables industries. They operate from berth 32C & D and 33. Vessel movements to these berths are infrequent.

3.2.13 Silverton Aggregates

Silverton Aggregates operate a material supply depot from berths 30D & E, although they have not had a vessel on berth for 4 years.

3.3 Stakeholder Consultations

In order to understand the business operations, both present and future, of the individual identified stakeholders a consultation exercise was undertaken. In the majority of cases stakeholders were contacted by telephone to explain the study and discuss details of the proposal and their opinions. Table 2 below summarises all stakeholders and the type of consultation conducted.

Stakeholder Name	Status	Meeting	Telephone	E-mail	Response
Peel Ports	Primary	✓			✓
G.Y. Borough Council	Primary	Not approached as part of this survey.			
ASCO	Primary		✓	✓	
Gardline / Alicat	Primary		✓	✓	

E-on	Primary		✓		✓
Trinity Marine / Dalby Offshore	Primary		✓		✓
Seatrax Ltd	Primary		✓		✓
Atlantic Marine & Aviation	Primary		✓	✓	
EMR	Primary		✓		✓
Brineflow Ltd	Primary		✓		✓
CLS Global Solutions	Secondary		✓		✓
Silverton Aggregates	Secondary		✓		✓

Table 2 Summary of Stakeholder Consultations

4 Results of Consultations

4.1 Stakeholder Consultations

4.1.1 Peel Ports

During the initial consultation meeting held at Peel Ports Great Yarmouth offices on 18th October, the general principles of the proposed bridge design were reviewed with representatives of the ports operational, engineering and marine management teams. A number of preliminary observations on the scheme were made by Peel Ports and a request for further detail was made to Norfolk County Council.

Peel Ports agreed to supply vessel movement data from the harbours records for a period covering 2010 to 2016, along with details of their future planning for berth redevelopments. This information was subsequently supplied on 31st October 2016, with additional information sent on 24th November 2016, and has been incorporated into the report.

Peel Ports supplied a berth occupancy plan showing operators and tenants for each berth within the harbour. This was used to confirm and refine the stakeholder consultation list and ensure the most accurate information available was used.

Amongst the items discussed during the meeting with Peel Ports, 3 potential items requiring further consideration were raised by Peel Ports; vessel navigation, channel sedimentation and land plant movements. Additional items that may provide potential benefit to the port were also discussed, including construction depth of walls for channel narrowing, potential to use the land created by the narrowing and abnormal load capacity of the new bridge in terms of both weight and height.

4.1.2 ASCO

ASCO were contacted by telephone and subsequently by e-mail. No response has been received to date.

4.1.3 Gardline/Alicat

Both Gardline and Alicat were contacted by telephone and subsequently by e-mail. No response has been received to date.

4.1.4 E-on

E-on were contacted by telephone; however their contact number reroutes to offices in Aberdeen and they no longer have operational staff in Great Yarmouth.

4.1.5 Trinity Marine Services/Dalby Offshore

No suitable contact details for Trinity Marine Services were found. Contact was made by telephone with Dalby Offshore. Following an outline of the proposal they confirmed that, provided no additional limitations on vessel sizes were caused by the new bridge, they could see no significant implications for their operations. They confirmed the extent of their shipping movements and stated that these could increase over the coming years with works on the East Anglia One Windfarm. They also stated that the improved road access for travel south would be of benefit for them as they have operations in both Great Yarmouth and Lowestoft. They requested that they be kept informed of any additional information regarding the bridge as and when it became available.

4.1.6 Seatrax Ltd

Seatrax were contacted by telephone. Following an outline of the proposal they confirmed that, provided no additional limitations on vessel sizes were caused by the new bridge, they could see no implications for their operations. They confirmed the extent of their shipping movements and also stated that these should remain fairly consistent over the coming years. They requested that they be kept informed of any additional information regarding the bridge as and when it became available.

4.1.7 Atlantic Marine & Aviation

Atlantic Marine & Aviation were contacted by telephone and subsequently by e-mail. No response has been received to date.

4.1.8 EMR

EMR were contacted by telephone. They do not have any concerns regarding the new bridge and do not think it will have any impact on their operations in Great Yarmouth.

4.1.9 Brineflow Limited

Brineflow Limited were contacted by telephone. They raised concerns that if the bridge was constructed without sufficient clearance to allow unhindered passage of the smaller off-shore windfarm workboats it would restrict the access to the northern berths of the Port. This concern would not be present on the premise that commercial shipping movements would not be restricted, although they noted that this would increase the number of bridge operations and therefore disruption to road traffic. They estimated that, in total, around 15 movements per day passed the bridge location and believed that when the local wind farms were fully operational this could increase to 30 movements per day.

4.1.10 CLS Global Solutions

CLS Global Solutions were contacted by telephone. Following an outline of the proposal they confirmed that they could see no implications for their operations.

4.1.11 Silverton Aggregates

Silverton Aggregates were contacted by telephone. Following an outline of the proposal they confirmed that they could see no implications for their operations. They confirmed they have had no shipping movements for the past 4 years and stated they had recently surrendered their berth access agreement.

5 Options – Constraints and Opportunities

5.1 Current Operations

The inner River Port at Great Yarmouth has 97 distinctly identified berths, of these 51 are upstream of the proposed bridge location.

The assessment was initially undertaken assuming that any vessel accessing these 51 berths would require a bridge opening, which would certainly be the case for a bridge set at 4.5m above MHWS level. An additional assessment of vessel air drafts was also undertaken to quantify the benefit of constructing an elevated bridge with a clear height of 7.5m above high water. The related commentary is presented later in this section.

Peel Ports supplied copies of their vessel movement logs covering the period January 2008 through to August 2016. This data set comprised around 80,000 recorded **commercial** vessel moves. The data was filtered to identify those moves that were either to or from any of the 51 upstream berths and then further analysed to determine frequencies of bridge operation. The tables below detail the average and maximum numbers of vessels passing the proposed bridge locations by day and year, from 2010 onwards.

Year	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
2010	9.3	8.7	9.3	8.4	8.4	6.7	5.1
2011	11.4	10.3	10.7	11.5	11.2	7.3	6.3
2012	16.5	17.0	17.3	16.1	16.5	11.6	10.6
2013	10.8	10.7	11.7	10.5	11.1	6.9	5.7
2014	9.7	8.8	8.8	8.4	10.1	5.6	5.2
2015	8.9	8.1	9.2	9.0	9.4	5.7	4.5
2016	11.3	12.5	12.8	12.0	12.2	7.2	7.2

Table 3 - Average vessel movements passing proposed bridge location

Year	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
2010	18.0	19.0	22.0	15.0	17.0	14.0	20.0
2011	23.0	22.0	25.0	20.0	31.0	17.0	15.0
2012	36.0	29.0	38.0	33.0	31.0	26.0	27.0
2013	22.0	22.0	20.0	22.0	18.0	14.0	12.0
2014	23.0	20.0	21.0	18.0	19.0	17.0	12.0
2015	19.0	17.0	23.0	17.0	17.0	14.0	10.0
2016	21.0	29.0	23.0	23.0	22.0	19.0	18.0

Table 4 - Maximum number of vessel movements in a day passing proposed bridge location

Analysis was also undertaken to ascertain the distribution of numbers of vessel movements per day and the results of this are shown on Figure 4 below.

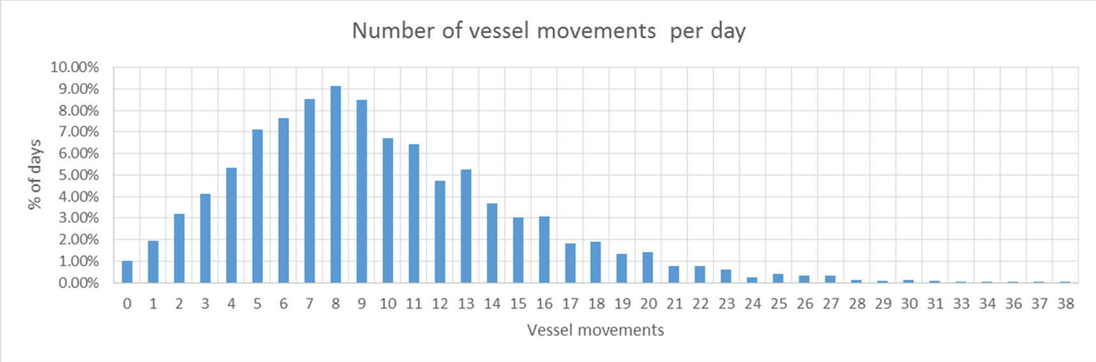

Figure 4 - Distribution of vessel movements per day

Consideration has also been given to the timing of vessel movements during the day. Figure 5, below, shows the distribution of timings of movements within the port from 2008 to 2016. This shows that the majority of movements occur during the working day, 82% between 6am and 6pm with distinct peaks occurring between 7 and 9am and 3 and 5pm.

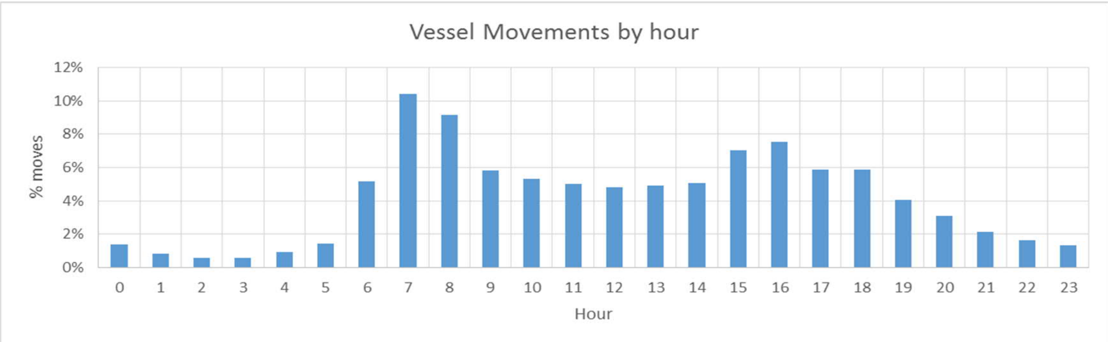

Figure 5 - % movements by hour 2010-2016

This general distribution pattern appears to hold constant for most days, Figure 6 below, showing vessel timings during August 2016, shows a good match to the overall averaged percentages.

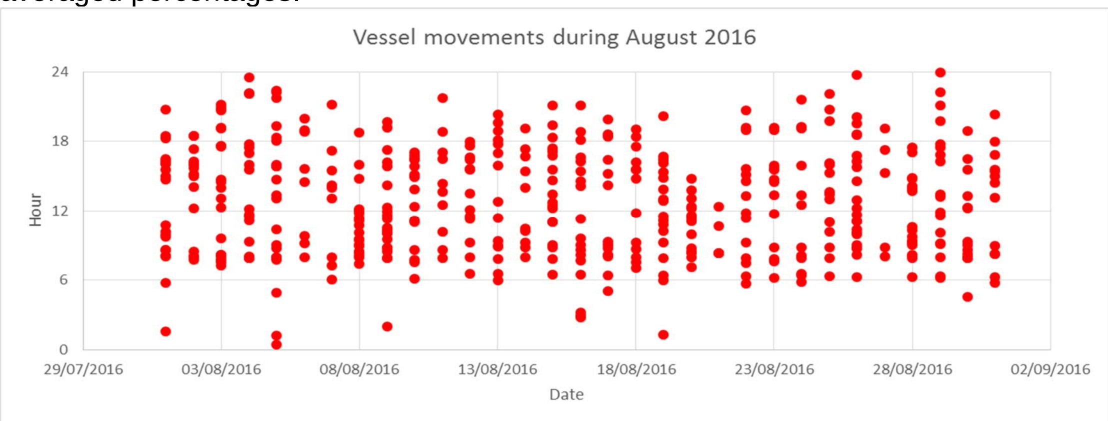

Figure 6 - Timing of vessel movements during August 2016

An analysis of vessel air drafts, for vessels historically using the port and for vessels in general, was undertaken to assess the benefits of elevating the bridge to reduce the number of openings. Constraints on the road approaches to the bridge location mean that the maximum clear height of the bridge above high water is limited to 7.5m and, allowing for safety clearance tolerances, this height would allow vessels with an air draft of less than 7m to pass under the bridge at high water without requiring an opening. Analysis of the vessels from 2008 to 2016 show that some 13% of movements past the bridge location were by vessels below 7m air draft, as shown on Figure 7, below.

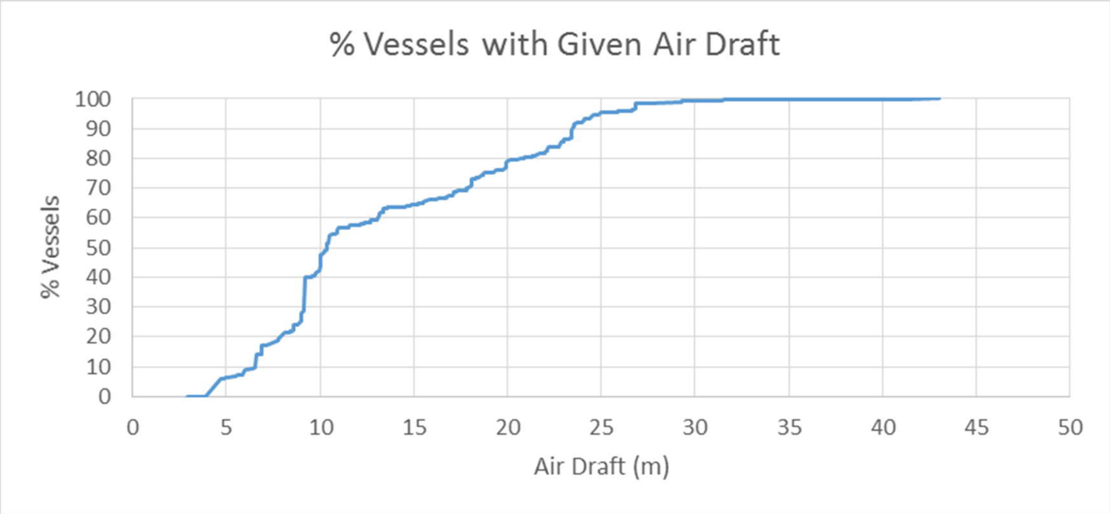

Figure 7 - Vessel passages with given air draft

Figure 8, below, shows the percentage of vessel movements with an air draft of less than 7m passing the bridge location per year. This indicates a general reduction in the number of vessels operating in the port capable of passing under a 7.5m bridge without requiring an opening.

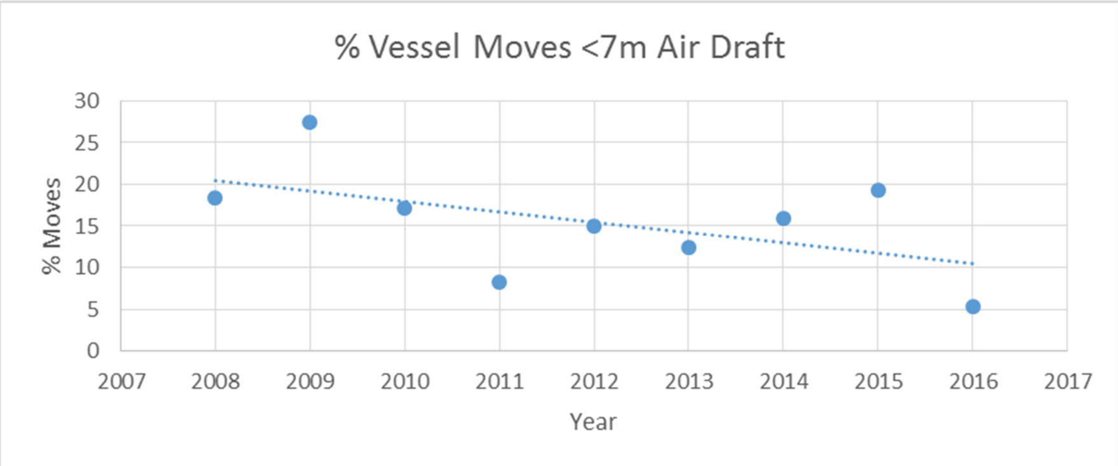

Figure 8 - Vessels <7m Air Draft per Year

A similar analysis was undertaken to assess the lengths and beams of vessels passing the proposed bridge location, this information will be used to assist in the selection of design vessels for bridge protection.

Figure 9, below, shows the percentage of vessels passing the bridge by beam, the 50%ile beam being 7.5m, the largest beam vessel to pass the location since 2008 has been the Toisa Warrior at 19m.

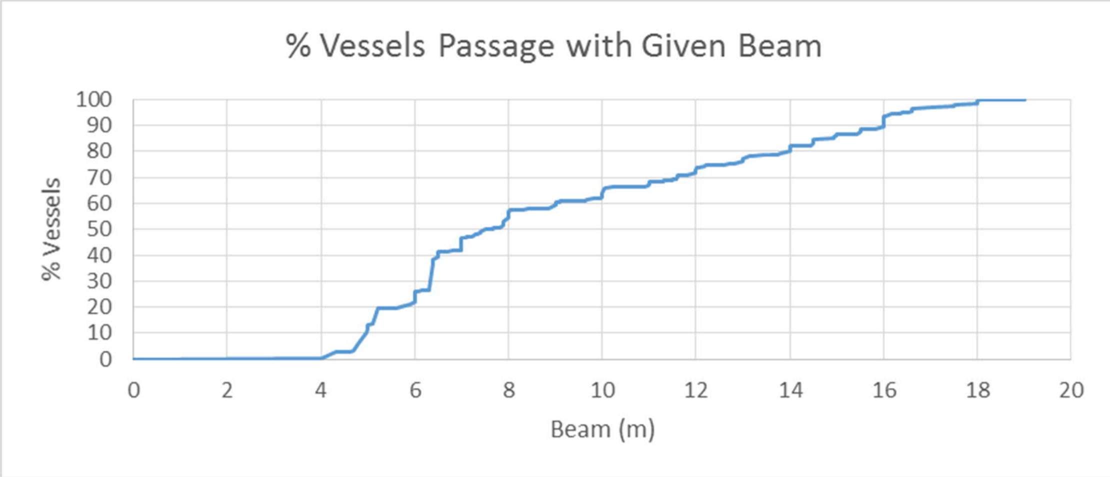

Figure 9 - Vessel passages with given beam

Figure 10, below, shows percentage passages by vessels by length, the 90%ile length being 72m and the longest vessel to transit has been the Salrix at 96.32m.

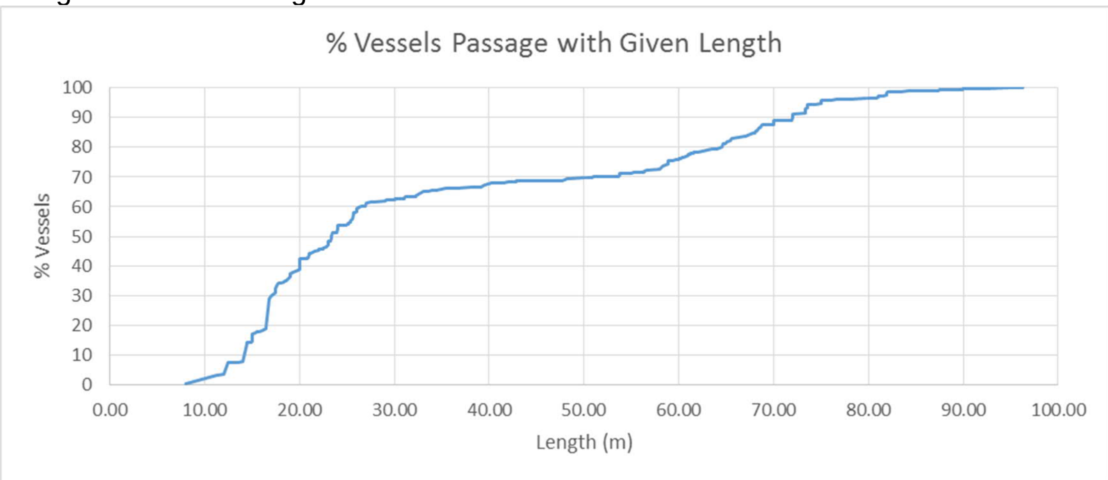

Figure 10 - Vessel passages with given length

From the data obtained and the analysis undertaken we can conclude that, currently, the long term average frequency of passage by a bascule bridge located between berths 31 and 32 would be 11 per day, with a one day per year exceedance number of 30. All of these vessel movements would require a bridge with a clear height of 4.5m to be lifted, raising the bridge to a clear height of 7.5m would reduce the openings to 87% of vessels, equating to 1 or 2 openings per day.

5.2 Future Developments

5.2.1 Vessel Size

The size of vessels entering the inner River Port is constrained by the natural width limit of the navigable channel and the length restriction of turning at the Brush Bend and, therefore, there is little prospect of the maximum size of vessels requiring transit increasing in the future. Given the existing constraints on vessel size and considering the number of berth structures that would be affected, it is not considered feasible that the depth within the river will be increased by dredging.

It is likely that the average vessel size within the port will increase, with offshore operators tending to employ larger vessels for operational efficiencies as the number of turbines serviced rises. This tendency was corroborated during the consultation with Brineflow Limited.

5.2.2 Vessel Frequency

With the future developments of further offshore windfarms in the southern North Sea, there is significant potential for an increase in the numbers of service craft accessing the port. The location of berths for these vessels clearly has the potential to affect the number of bridge openings required.

From the consultation with Peel Ports, it is apparent that there is an aspiration to increase use of the Outer Harbour Berths and it is foreseen that the provision of the new bridge will increase the potential for this by improving vehicle access to the south of the peninsular. Whether this leads to a long term reduction in the frequency of use of the Haven berths is uncertain at this stage and, as such, has not been factored into the opening frequency estimations.

From the consultation with Brineflow Limited, it is apparent that they have aspirations for the siting of two new off-shore windfarm support bases on berths north of the proposed bridge locations which could result in a significant increase in vessel movements. The vessels they envisage are the larger catamaran workboats of the 20 to 25m length class, with typical air drafts of between 10 and 14m.

5.2.3 Climate Change

The impacts of climate change on future sea levels may have an impact on the frequency of operation of the bridge, should an elevated solution be implemented. Current government models indicate a potential increase in water levels of up to +0.475m during the 21st century along the East Anglia coast. This would effectively reduce the clear height of the bridge and thus require openings for vessels with a smaller air draft than at current sea levels.

5.3 Navigation Constraints

The proposed location of the bridge, on a bend in the river, may cause visibility issues which could affect the timing of its operation. The navigation simulation, undertaken by HR Wallingford, drew certain conclusions over the operation and use of the adjacent berths during vessel transits but these were not confirmed with the Port at the time and therefore remain as potential constraints.

5.4 Bridge Operational Constraints

The opening duration of the bridge is dictated by 2 factors, bridge movement and vessel movement.

The time taken for the bridge to open and close comprises the time to clear the bridge of traffic and the time for the bridge to raise, while closing time includes the bridge lowering and the traffic controls lifting. The duration of this will vary depending on the nature of the traffic control system installed, with control of pedestrians being the probable limiting factor. In total a time of 240 seconds may be required to complete the operations of the bridge.

The vessel movement time includes the transit time, that is the time a vessel is manoeuvring through the bridge passage, and the approach time, the time taken for the vessel to approach the bridge following opening.

The initial navigation simulation, conducted by HR Wallingford, suggested an approach time equal to the travel time of a distance twice the overall length of the transiting vessel, until confirmed, or otherwise, by further simulations we have used this as a basis for calculating opening durations based on vessel lengths. Figure 11, below, shows the calculated percentage distribution of opening durations for the bridge.

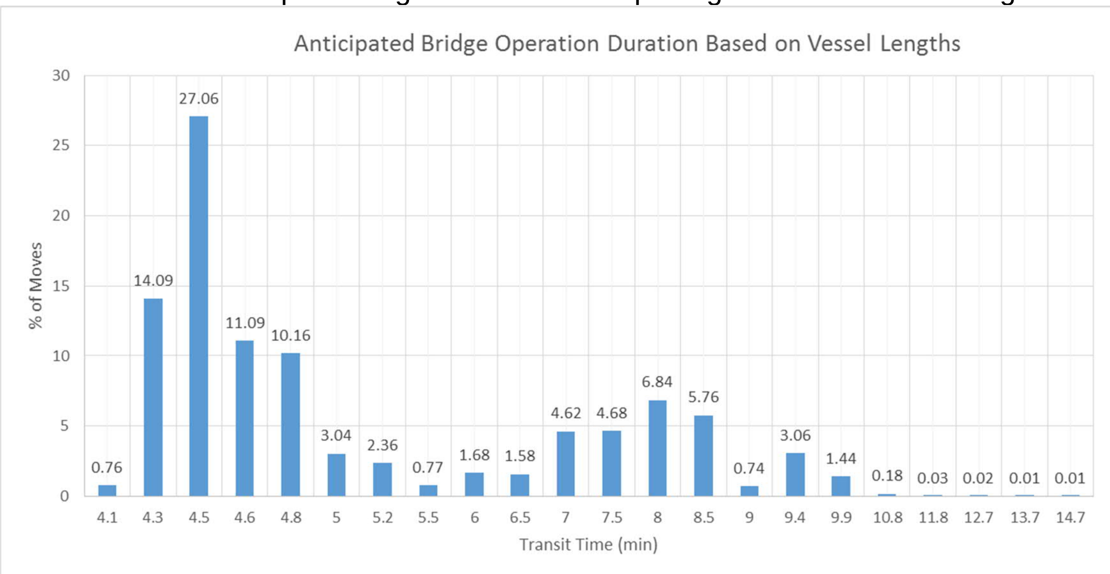

Figure 11 - Anticipated bridge operation durations

The above distribution does take into account vessels navigating with tug assistance, as determined from the vessel transit information supplied; it does not factor any platooning or marshalling of vessels outside those tug assisted manoeuvres.

This distribution has been used to produce a graph of cumulative percentage of opening durations, shown on Figure 12 overleaf. This shows that approximately 66% of bridge openings would take less than 5 minutes and 99.7% of openings would be completed in under 10 minutes. This would typically equate to only 10 moves per year taking longer than 10 minutes.

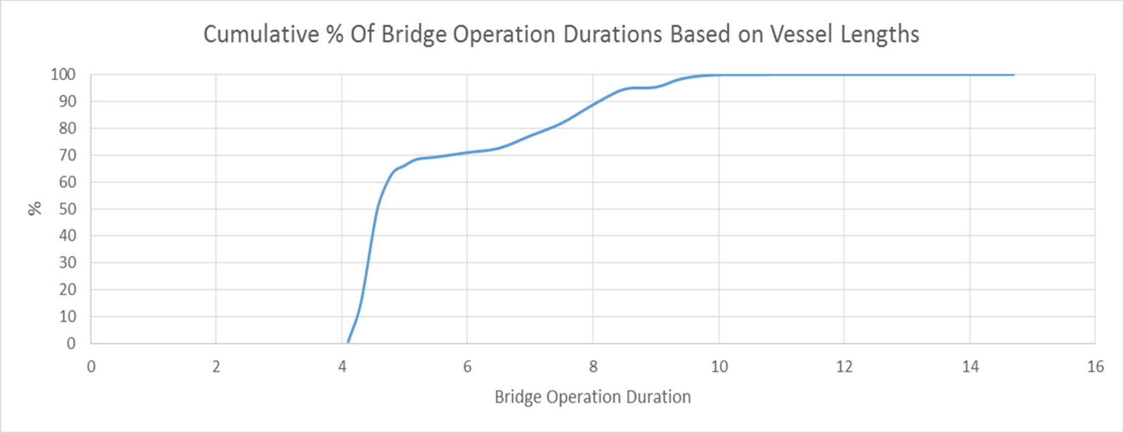

Figure 12 - Cumulative % bridge opening durations

5.5 Identified Opportunities

During the consultation process a number of potential additional benefits were identified by various stakeholder which may warrant further investigation. In particular Peel Ports enquiry on the ability of the new bridge to accommodate abnormal loads has the potential to both increase attractiveness of the port for undertaking transport of abnormal loads and reduce the traffic disruption caused during their movement.

The potential to utilise any additional land created as part of the channel narrowing may have the effect of mitigating operational land loss as a result of the bridge construction and may ameliorate the scheme for some of the affected stakeholders.

6 Summary and Conclusion

An initial assessment of the current nature and frequency of vessel movements within the River Port at Great Yarmouth has been undertaken. This assessed the vessels transiting the port between January 2008 and August 2016 in terms of dimensions and berths visited.

This assessment showed that on average 11 vessel movements per day passed the proposed location of the new bridge. All of these would require the bridge to open at the current design clear height of 4.5 while 87% were of a size that would require the new bridge to open if it were designed with a clear height of 7.5m.

A consultation exercise was undertaken with the major port stakeholders and users to ascertain the potential for increased vessel traffic within the port. This consultation showed that although the maximum size of vessels accessing the River Port was unlikely to increase due to natural constraints, the average vessel size could increase as more of the larger offshore support vessels were transferred to operations in this region.

The exercise also indicated that the number of vessels in operation and therefore the frequency of arrival and departures was likely to increase, particularly among the offshore windfarm service and support vessels.

Factoring in all potential movement increases identified in the consultation it can be estimated that the future average vessel movements at the proposed bridge location could increase to 20 movements per day. This level is a 25% increase on the maximum annual average daily movements recorded within the Port.

7 Recommendations

7.1 Navigation Simulation Modelling

While an initial navigation simulation has been carried out to assess the feasibility of the proposed bridge, it was undertaken independently of the Port Authority. From initial consultations, it is concluded that the Port Authority will require a re-run of the simulations with their own pilots, to confirm the suitability and operability of the proposed bridge. This is most likely the only way that such a proposal would be approved by Peel Ports, as the Statutory Port Authority, and the Harbour Master who have raised related concerns over the proposal. We would envisage this navigation simulation being undertaken during the next phase of the project being based on the design refinement and feeding into the scheme development prior to the application for planning permission. The principal risk associated with late commencement of a navigation simulation would be a requirement to redesign the works should the design be found to impact vessel movements more than expected, conversely a similar risk occurs with undertaking the simulations too soon as subsequent design refinements may require simulations to be re-run.

7.2 Sedimentation Transport Modelling

The effects of the new bridge on sediment transport within the Port will require further investigation to satisfy Peel Ports as the Statutory Port Authority that it will not have an adverse effect on siltation levels thus causing a hazard to navigation, or increase in their maintenance dredging requirements. We would envisage this modelling being undertaken during the next phase of the project during the design refinement and prior to the application for planning permission. As with the navigation simulation the principal risk with delaying the sedimentation transport modelling is the potential for unexpected results forcing either redesign or creating significant environmental issues requiring compensation. Likewise, the bridge design will have to have been completed to a relatively high confidence level before the modelling can be undertaken to avoid the potential for reworks due to design development.

7.3 Elevation Level of Bridge over Port Operational Areas

The elevation of the bridge while crossing operational areas of the port will need to be considered further in consultation with Peel Ports. Discussions over alternative transportation routes and plant crossings are currently being held and the outcomes will be incorporated into the design developments.

7.4 Traffic Sensitivity Analysis

Given the potential number of bridge openings required and the duration of each opening event, a worst case scenario could be used in the base case traffic assessment. A sensitivity analysis, based on various daily movement patterns, is being undertaken to establish the potential variability of effect on the road networks. It may show a potential improvement in benefits if constraints on the operation of the bridge, in terms of proximity of openings or openings during peak road traffic times, could be discussed and agreed with the Port Operator.

7.5 Recreational Vessel Movements

This report focuses on commercial vessel movements within the Haven, there are also movements of recreational vessels from within the Norfolk Broads to the North Sea, via the River Yare, and vice versa, which will have an effect on the frequency of operations of the bridge. The number of movements of these vessels is limited and they are currently controlled over the timings at which their passage through the port can occur. Discussions have taken place with Peel Ports over the requirements for staging pontoons for holding recreational vessels intending to traverse the Haven until such time as a bridge opening can be undertaken and the cost of these pontoons are presently being included within the scheme estimates.

8 References

Great Yarmouth Port Authority Navigation (Haven) Byelaws 1997

Great Yarmouth Port Company Pilot Information (River Port and Outer Harbour)

Great Yarmouth Third Crossing Navigation Simulation Study (HR Wallingford) 2009

UK Climate Projections 2009 (UKCP09)

Appendix C – Vessel Simulation Report

1073739-WSP-MAR-GY-RP-MA-0003 - Vessel Simulation Report

Norfolk County Council

GREAT YARMOUTH THIRD RIVER CROSSING

Vessel Simulation Report

1073739-WSP-MAR-GY-RP-MA-0003

Norfolk County Council

GREAT YARMOUTH THIRD RIVER CROSSING

Vessel Simulation Report

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Norfolk County Council

GREAT YARMOUTH THIRD RIVER CROSSING

Vessel Simulation Report

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FIGURES

GLOSSARY

Term	Definition
Ebb	tide flowing out to sea.
Flood	tide flowing in from sea.
GYPC	Great Yarmouth Port Company
Slack Water	the period either side of the change from Ebb to Flood tidal conditions when the flow velocity is lowest.
Squat	vessel increasing depth in water due to hydrodynamic effect (more associated with speed in shallow water)
Surge	tide flowing in from sea.
Sway	unplanned movement of vessel along short axis.
Yaw	rotation of vessel around vertical axis.

1 INTRODUCTION

1.1 GENERAL

WSP Limited have been commissioned to progress approvals, designs and agreements for a third highway crossing over the River Yare at Great Yarmouth.

1.2 SCOPE OF REPORT

This report details the commissioning, progression and outcome of a real-time vessel simulation exercise conducted to assess the navigation impacts of the third crossing.

1.3 OBJECTIVES

The objectives of the 1st vessel simulation were to establish;

- The navigability through and adjacent to the proposed bridge
- The suitability of the proposed passage width beneath the bridge
- Confirm the requirements for bridge protection
- Determine any aids to navigation that the bridge may require
- Establish the transit times for vessels through the new bridge.

The objectives of the 2nd vessel simulation were to establish;

- Any variance between navigation with the initial design and the design prepared for DCO application
- The effects of the calculated hydrodynamic modelling on navigation
- The usability of the adjacent berths post scheme construction.

1.4 LIMITATIONS

This report is presented to Norfolk County Council in respect of the Great Yarmouth Third River Crossing Project and may not be used or relied on by any other person. It may not be used by Norfolk County Council in relation to any other matters not covered specifically by the agreed scope of this Report.

Notwithstanding anything to the contrary contained in the report, WSP Limited is obliged to exercise reasonable skill, care and diligence in the performance of the services required by Norfolk County Council and WSP Limited shall not be liable except to the extent that it has failed to exercise reasonable skill, care and diligence, and this report shall be read and construed accordingly.

This report has been prepared by WSP Limited. No individual is personally liable in connection with the preparation of this report. By receiving this report and acting on it, the client or any other person accepts that no individual is personally liable whether in contract, tort, for breach of statutory duty or otherwise.

2 PROJECT DESCRIPTION

2.1 OVERVIEW

Great Yarmouth is a town in the English county of Norfolk. It is situated on the east coast of the United Kingdom and has a port with direct sea access to the North Sea. The port is owned and operated by Great Yarmouth Port Company (GYPC) and is made up of two sections; the inner harbour is formed on the banks of the River Yare, covering approximately 4.3km (2.3 nautical miles) from the Brush Bend at the sea entrance in the south to the Haven Bridge in the north, whilst the outer harbour is constructed from breakwaters and comprises land reclaimed from the sea.

As can be seen in Figure 1 below the town is divided in a north south direction by the river which results in a spit of land approximately 4km long being effectively separated from the remainder of the town.

Figure 1 – Aerial photograph of Great Yarmouth Haven

To overcome this separation Norfolk County Council is proposing to construct a third river crossing approximately 1.5km south of the existing Haven Bridge, which is the most southerly of the current two crossings.

The aspirations of the scheme are to improve connectivity within the town thereby reducing traffic congestion and promoting redevelopment and growth.

2.2 LOCATION OF SCHEME

The proposed location for the new bridge is shown on Figure 2, below. It crosses the river between Bollard Quay on the west bank and Atlas Quay (also called Fish Wharf) on the east.

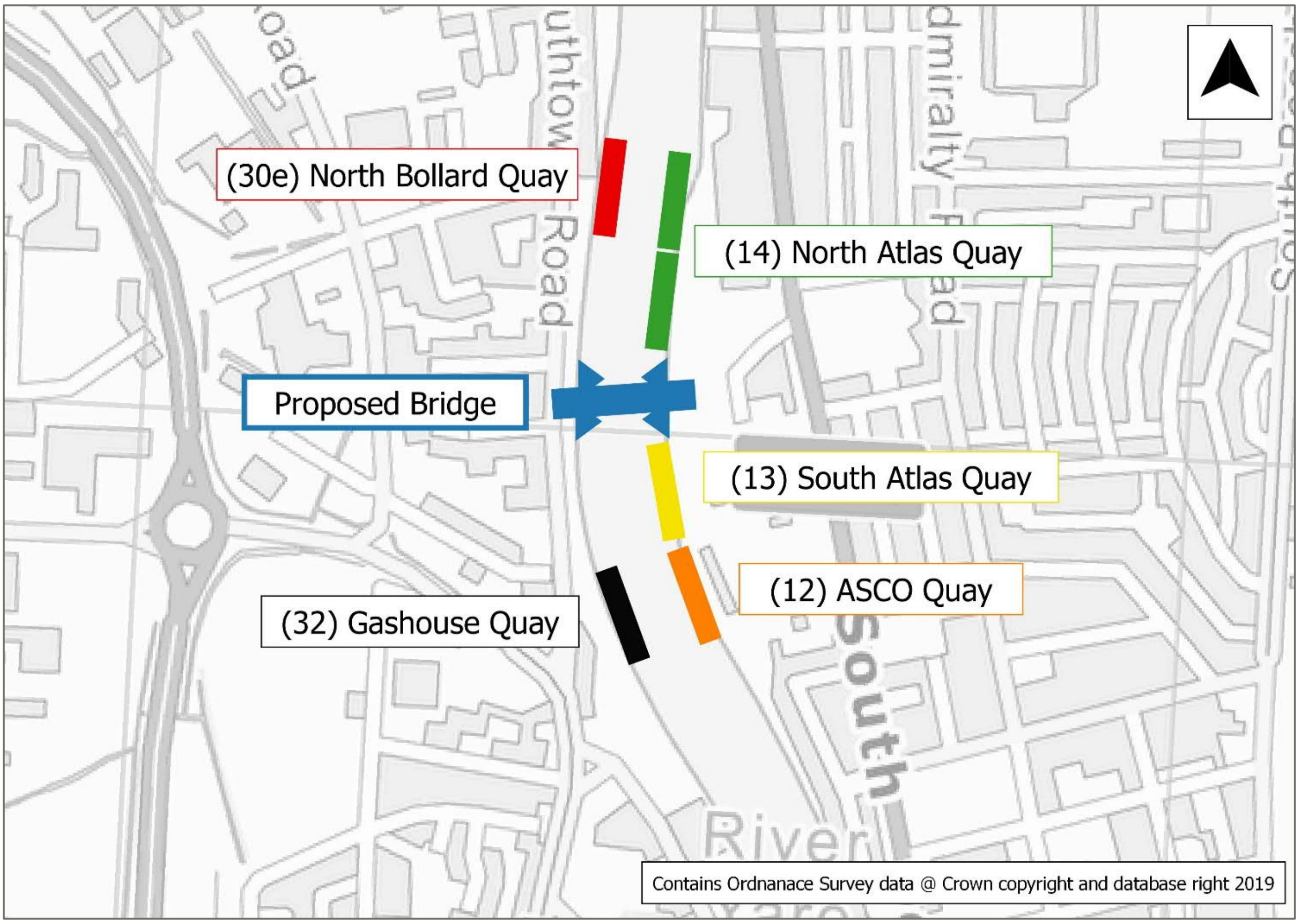

Figure 2 – New bridge location

2.3 BRIDGE DESIGN

The bridge will be constructed to provide a clear navigational channel, approximately central in the River, of 50m between fenders. The bridge deck will have a minimum clear height over water of 4.5m above Mean High Water Springs when lowered and will raise to provide infinite clearance across the whole of the navigation channel. Any fixed over water sections of the bridge will be protected from navigation impacts by passage and approach fendering.

The opening bridge will be connected to the existing road network by approach ramps and a number of fixed spans. An indicative section showing the bridge outline in both the “raised” and “lowered” position are shown in Figure 3, below.

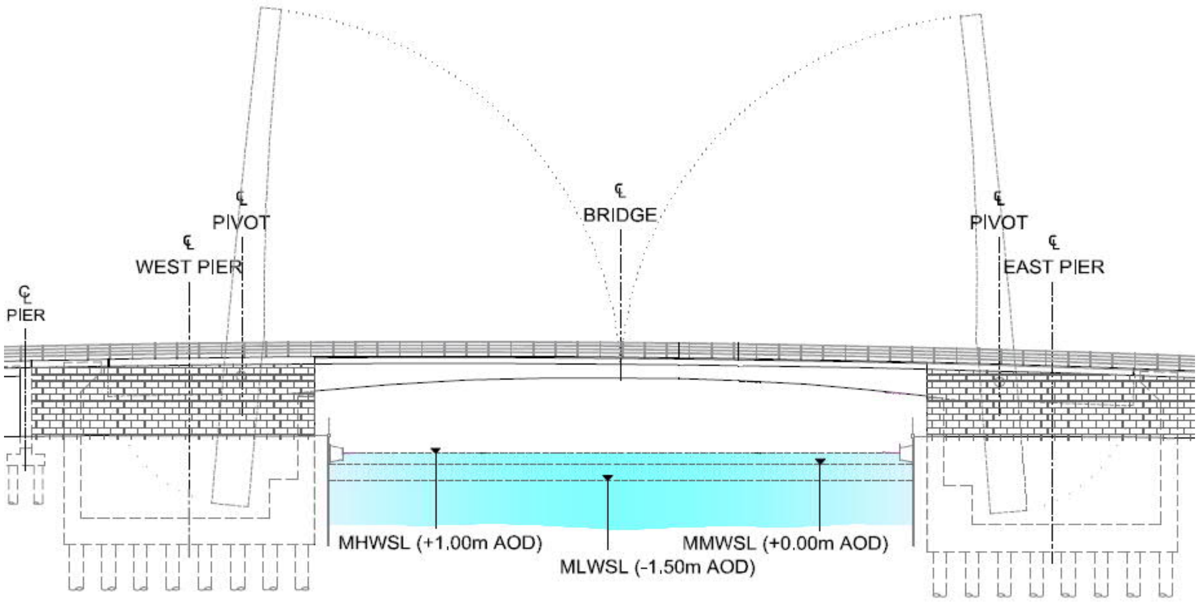

Figure 3 – Bridge cross section

2.4 PORT OPERATIONS

The location of the Scheme crosses the navigation waterway within the River Yare and the port has commercial quays both north and south of the location. Access to the berths north of the Scheme will require an opening of the bridge should the air draft of the vessel exceed the clear height of the bridge in the closed position.

The port handles a wide variety of cargos including aggregates, cement, grain, fertilisers, forest products, dry and liquid bulks, pipeline and onshore wind farm equipment as well as providing facilities for the offshore windfarm servicing industry. A total of 1.28 million tonnes[1] of cargo passed through the port during 2016.

From historic data covering the period 2008 to 2016 received from GYPC, an average of 10,000 vessel moves per year occurred within the Port, with approximately 40% of these involving movements to or from berths north of the Scheme location.

[1] Department for Transport Statistics, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/640984/port0418.ods

The River Yare also provides access to the Norfolk Broads for recreational vessels via Breydon Water. These vessels have to pass two existing lifting bridges, the Haven Bridge and the Breydon Bridge, during a passage from the sea to the Broads.

3 VESSEL SIMULATION

3.1 SIMULATION FACILITY

WSP commissioned East Coast College, Lowestoft, to use their Kongsberg vessel simulator to create a real-time navigation simulation.

The Kongsberg Polaris Full Mission Bridge Simulation Suite consists of a realistic mock-up of a ship's bridge with all conventional controls and instruments you would expect to find on a modern bridge.

These include manoeuvring and throttle controls, navigation instruments including GPS, LORAN and NAVTEX, an ARPA radar and ECDIS plotter. In addition, visuals are provided by realistic 150° visual of the outside world.

Two secondary bridges provide entry-level controls with GPS, ECDIS ARPA and Plotter, for use as tug control stations if required.

Each of these bridges can be designated as a vessel including offshore supply vessel, container vessel, ferry, fast patrol craft, bulk carriers etc. Movement, controls and instruments will then balance and respond precisely as the real ship.

All aspects of the vessel can be controlled from the instructor station. Weather, tide, visibility and sea state can be changed and varied. Facets can be introduced, including failure of the engines, steering, thrusters etc. Also included in the system is assessment software that will enable detailed evaluation of all aspects of the use of the system.

Figure 4 – Lowestoft College Kongsberg Simulator

3.2 EXISTING SITUATION MODEL

A base model of the Port of Great Yarmouth in its current form was created by Kongsberg from mapping data supplied by GYPC. This model covers an area extending approximately 1.5km downstream and 1km upstream of the proposed bridge location as shown on Figure 5, overleaf. Bathymetric data for the model was taken from the latest navigation charts produced by GYPC.

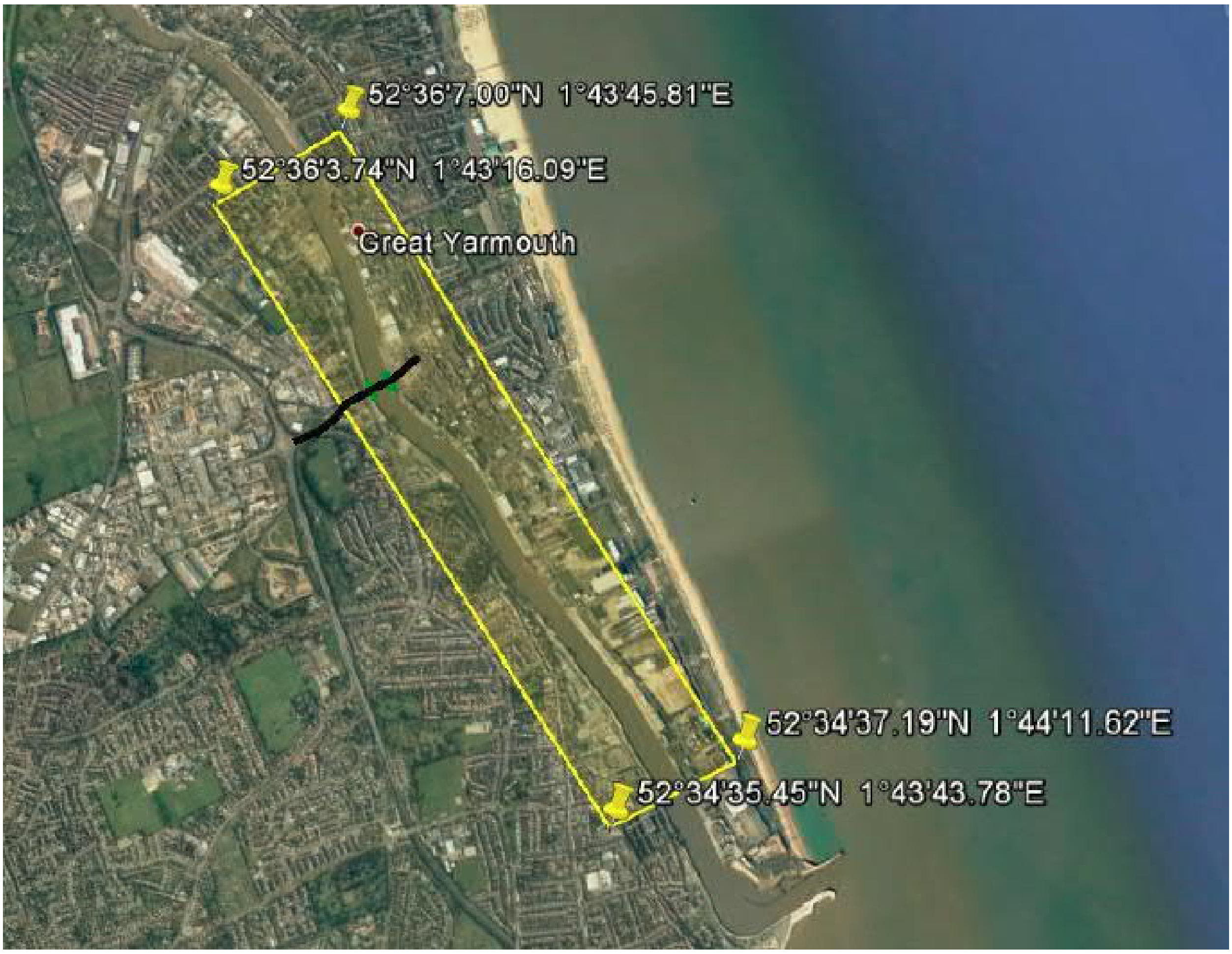

Figure 5 – Simulation model extents

3.3 THIRD RIVER CROSSING MODEL

A bridge model for the bascule design, shown on Figure 6 below, was created and run in the simulator to assess the effects on navigation during the first stage simulation.

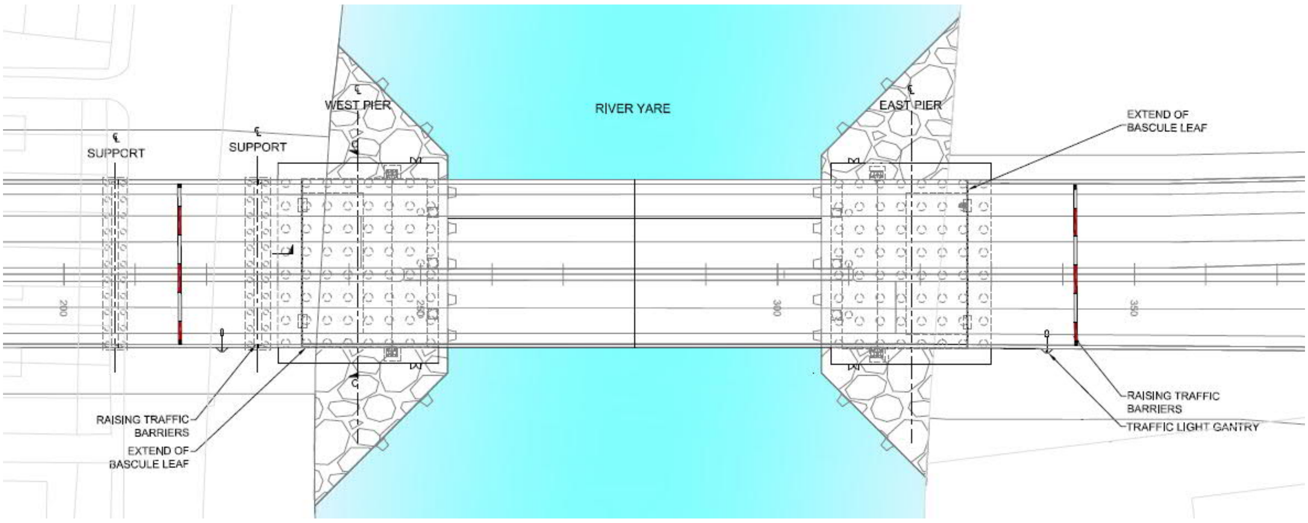

Figure 6 – Bridge plan

The same visual model was used during the second stage simulation although the hydrodynamic inputs were based on the design prepared for DCO application.

3.4 SIMULATION DATA

3.4.1 WIND

Wind conditions for each simulation run can be set for both direction and speed, constant velocity or gusting as required by the simulator operator. To ensure the model was conservative, no sheltering effects from surrounding structures other than the new bridge has been included. This sheltering is simulated by introducing a reduction in wind speed at the appropriate point in the simulation.

3.4.2 CURRENT

During the first stage simulation tidal current modelling was based on flow vectors input into the simulator directly. A hydrodynamic model was produced to ascertain the predicted changes in flow patterns which would result from the presence of the new bridge. The predicted uplift in current strengths was applied to velocities measured during an Acoustic Doppler Current Profile survey undertaken and used to calibrate the hydrodynamic model.

For the second stage simulation, a multipoint tidal profile file was produced from the calibrated hydrodynamic model for a typical spring tide condition. This file was imported into the simulator and the start time of the simulation runs varied to match the desired tidal conditions.

3.4.3 TIDE

Within the simulation, the water depths were represented by a rectangular grid divided into square cells giving the local values of seabed level throughout the study area, derived from the navigation bathymetry charts plus an appropriate height of tide, selected by the Pilot.

3.4.4 WAVE

It is anticipated that waves within the river will be limited, being considered navigationally negligible for the size of vessels under consideration, and were not included within the simulation.

3.5 SIMULATION VESSELS

Table 1 shows some details of the design vessels, taken from the Kongsberg vessel simulation models catalogue, which were agreed with GYPC as representative of the size of vessels which call at the Port of Great Yarmouth and which were available for use in the navigation simulation trials.

The longest vessel reported to have transited the proposed Scheme location in the past 10 years was the AMUR 2520, with an overall length of 115.7m, the widest vessel was the Toisa Warrior with a beam of 19m. Both of these dimensions are comparable to those of vessels available within the simulation.

Table 1 – Simulation Vessels

Vessel Designation	Vessel Description	Displacement (T)	Length between perpendiculars (m)	Length Overall (m)	Beam (m)	Draught (m)
BULKC11L	Typical small laden CCP coastal bulker	5906.00	84.98	89.99	14.00	5.68
FERRY50	Medium size ferry	5415.00	108.00	117.00	20.00	4.39
PRODC04L	Small laden product tanker	5800.00	86.34	92.8	13.60	6.16
SUPLY10L	Large laden offshore supply vessel	6550.00	75.40	86.20	19.00	6.00
TUG05A	Harbour class tugboat	550.00	30.50	32.00	10.97	2.50
PATRL19	Small shallow draughted launch	31.00	14.10	17.00	4.60	0.95
SUPLY05L	Medium laden offshore supply vessel	2302.00	57.80	66.00	14.00	4.55
TUG15	High performance ocean tug	575.00	28.00	29.50	11.00	2.78

The ship manoeuvring models include for motions in three degrees of freedom (3DOF), representing surge, sway and yaw motions (i.e. those directly affecting horizontal motions). However, the models also include representations of vessel squat and shallow water behaviour to ensure representative manoeuvring behaviour in relatively shallow water, where appropriate.

During the navigation simulation runs, the behaviour and performance of the controlled ships, in terms of responses to any helm, engine or tug control, and the local wind, wave and current conditions, is governed by a mathematical ship manoeuvring model. The mathematical model of each ship is calibrated to ensure it behaves in such a way that the position, velocity, swept path and heading of the simulated ship are representative of real ship behaviour. All models used in the simulation were Pilot Grade, these models are of the highest fidelity and are compared to the results of actual sea trials of the vessels on which the ships model is based to verify their accuracy.

4 SIMULATION EXERCISE

4.1 SIMULATION PARAMETERS

4.1.1 NUMBER OF BERTHED VESSELS

The simulation runs were carried out with a variety of different berthed vessels. The figures below indicate the position of berthed vessels in each of the quays adjacent to the proposed bridge. The figure headings describe the notation used in describing the simulation runs.

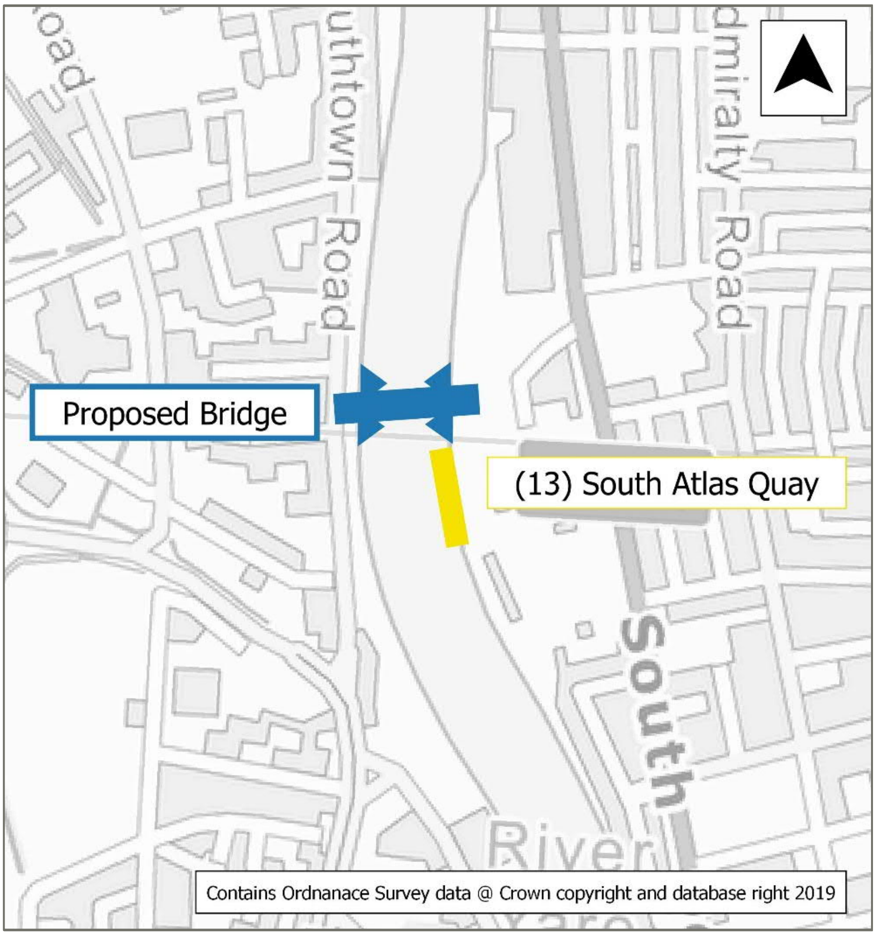

Figure 7 - Atlas Quay

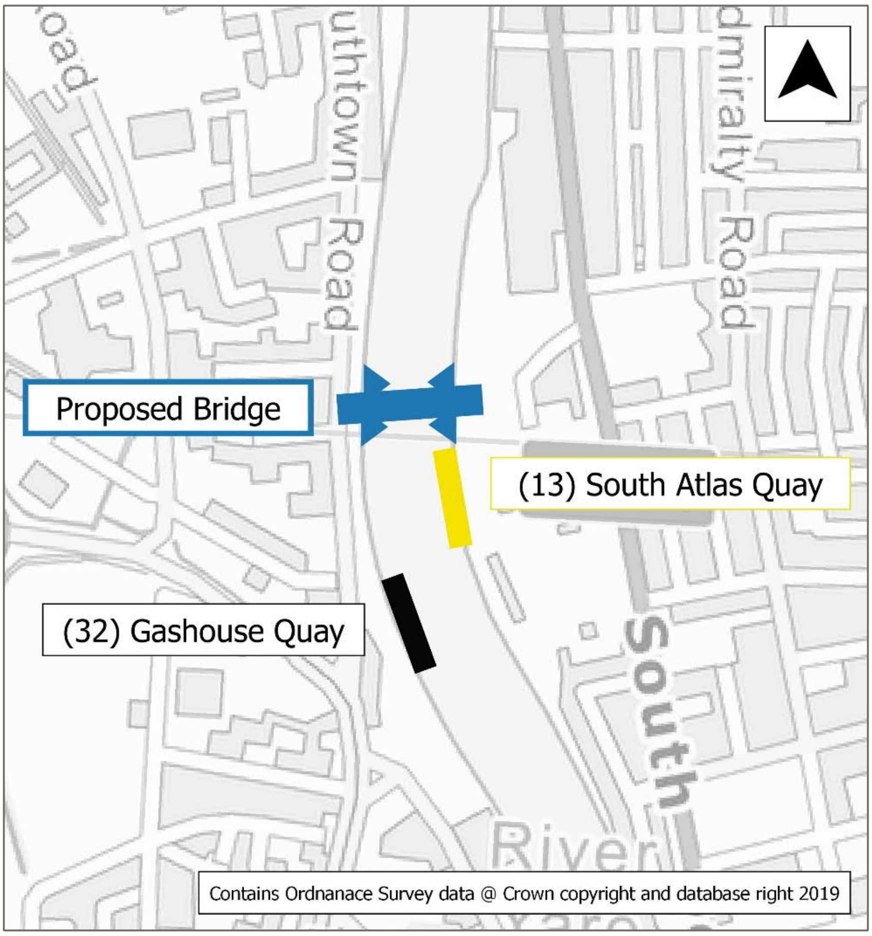

Figure 8 - Atlas & Gashouse Quays

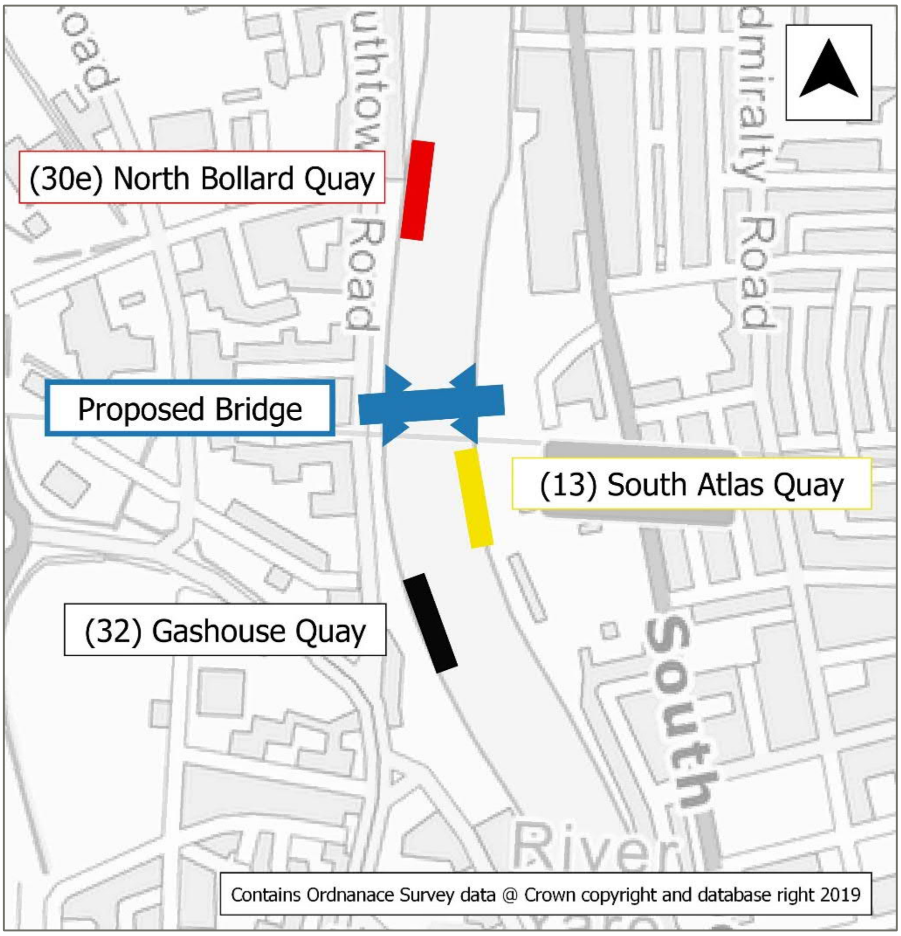

Figure 9 - Atlas, Gashouse & North Bollard Quays

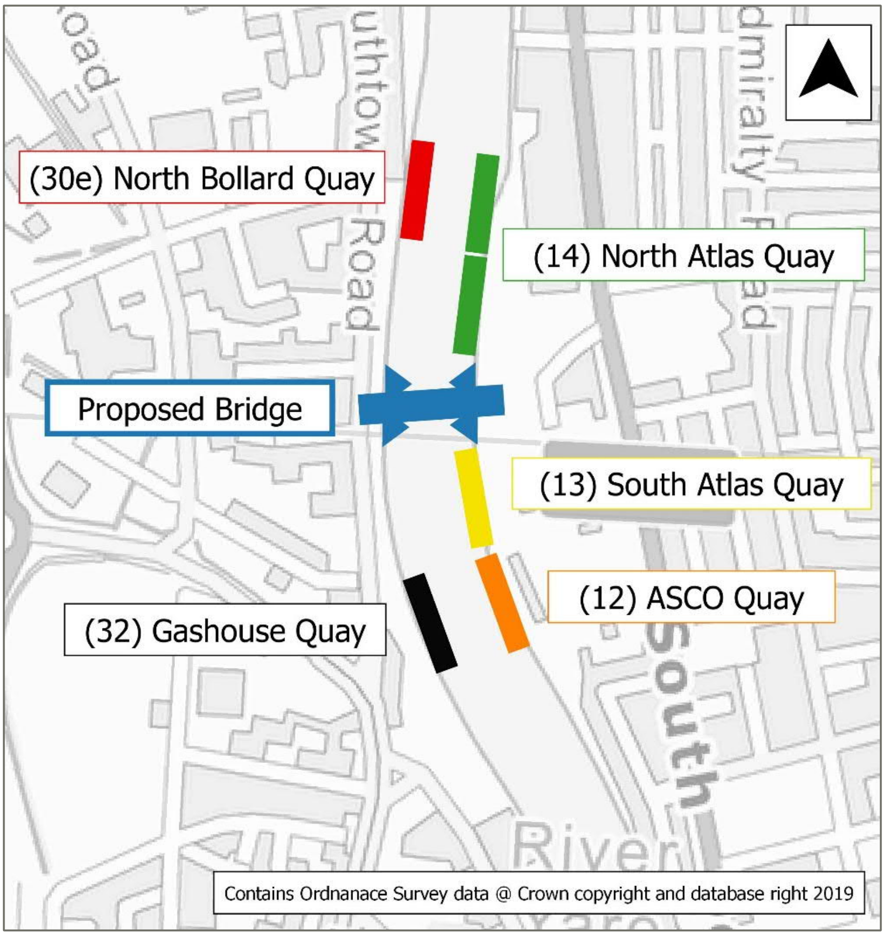

Figure 10 - All Quays

4.1.2 TYPE OF VESSEL

Table 2 below describes the vessels available within the simulation software.

Table 2 - Visual description of modelled vessels

Vessel	Visual Representation
Bulk 11	

Ferry 50	
Prodc 04	
Suply05	
Tug05	

Tug15	
Suply10	
Patrl19	

4.2 FIRST STAGE SIMULATIONS

4.2.1 GENERAL

The first stage simulation took place on 30th May 2018 and was conducted by two of the pilots from GYPC, Mr David Morrice and Mr Lindsey Wigmore.

4.2.2 SIMULATION MANOEUVRES

Firstly an initial trial run on the model with the bulk cargo ship (BULKC11L) was undertaken to ensure the simulator performed as expected, replicating the handling and responses the pilots would expect from this class of vessel. This was performed under a slack water condition, with the current set at 0.5 knots, and no wind.

Further simulations were then performed using different vessel and environmental combinations as shown on Table 3, below. Both pilots undertook simulations alternately, with some runs being repeated when sub-optimal passages were experienced.

Table 3 – List of first stage simulation runs

Run	Vessel	Tide	Wind	Transit	Notes
1	BulkC11L	0.5kts Ebb	N/A	In	Vessels on Atlas and Gashouse
2	BulkC11L	0.5kts Flood	N/A	Out	Vessels on Atlas and Gashouse Backed through passage
3	ProdC04L	0.5kts Ebb	N/A	In	Vessels on Atlas and Gashouse
4	Suply10L	2kts Flood	N/A	In	Vessels on Atlas and Gashouse
5	Suply10L	2kts Flood	N/A	In	Vessels on Atlas and Gashouse
6	Suply10L	2kts Flood	N/A	In	Vessels on Atlas and Gashouse
7	Suply10L	3kts Ebb	N/A	In	Vessels on Atlas and Gashouse
8	Suply10L	3kts Ebb	N/A	Out	Vessels on Atlas and Gashouse
9	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas and Gashouse
10	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas and Gashouse Increased current resolution
11	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas and Gashouse
12	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas
13	BulkC11L	1kts Ebb	N/A	In	Vessels on Atlas and Gashouse
14	BulkC11L	1kts Ebb	N/A	In	Vessels on Atlas and Gashouse
15	Suply10L	3kts Ebb	20kts NE	In	Vessels on Atlas and Gashouse

4.3 SECOND STAGE SIMULATIONS

4.3.1 GENERAL

The second stage simulation was undertaken on 6th March 2019 with pilot Mr David Morrice from GYPC.

4.3.2 SIMULATION MANOEUVRES

Again, an initial trial run on the model with the bulk cargo ship (BULKC11L) was undertaken to ensure the simulator performed as expected, replicating the handling and responses the pilots would expect from this class of vessel. This was performed under a moderate ebb tide, with the current set at 1 knot, and no wind.

Further simulations were then performed using different vessel and environmental combinations as shown in Table 4, below, with some runs being repeated when sub-optimal passages were experienced.

Table 4 – List of second stage simulation runs

Run	Vessel	Tide	Wind	Transit	Notes
1	BulkC11L	1kts Ebb	N/A	In	Vessels on Atlas and Gashouse
2	Suply10L	1.5knts Flood	N/A	In	Vessels on Atlas and Gashouse
3	Suply10L	1.5kts Flood	N/A	In	Vessels on Atlas and Gashouse Backed through passage
4	Suply10L	1.5kts Flood	N/A	Out	Vessels on Atlas and Gashouse Backed through passage
5	Suply10L	1.5kts Flood	N/A	In	Vessels on Atlas, Gashouse and N Bollard
6	BulkC11L	1.3kts Flood	N/A	Out	Vessels on Atlas and Gashouse
7	BulkC11L	1.3kts Flood	N/A	In	Vessels on Atlas and Gashouse
8	Suply05L	1.8knts Flood	N/A	In/Out	Vessels on Atlas and Gashouse Bow first inbound, stern outbound
9	BulkC11L	1.1knts Flood	N/A	Out	Vessels on Atlas and Gashouse
10	BulkC11L	1knt Ebb	N/A	Out	Vessels on Atlas and Gashouse
11	PRODC04L	1knt Ebb	N/A	-	Vessel on Atlas Transfer from Gashouse to ASCO
12	Suply05L	3knts Flood	N/A	In	Vessels on all berths N&S of bridge
13	Suply10L	3knts Flood	N/A	In	Vessels on all berths N&S of bridge

14	Suply10L	1knts Flood	N/A	In	Vessels on all berths N&S of bridge

5 DISCUSSION OF RESULTS

5.1 FIRST STAGE SIMULATIONS

Run	Vessel	Tide	Wind	Transit	Notes	Observations
1	BulkC11L	0.5kts Ebb	N/A	In	Vessels on Atlas and Gashouse	Runs with the bulk and product carriers were undertaken in both directions, all runs were conducted with vessels berthed on Atlas and Gashouse Quays constricting the space available for manoeuvring south of the Third Crossing. The second run simulated a large vessel backing through the bridge following unberthing from North Atlas Quay. **The first 3 runs with low currents indicate that transits of the new bridge during slack water periods would not significantly increase the difficultly of navigating the River.**
2	BulkC11L	0.5kts Flood	N/A	Out	Vessels on Atlas and Gashouse Backed through passage	
3	ProdC04L	0.5kts Ebb	N/A	In	Vessels on Atlas and Gashouse	
4	Suply10L	2kts Flood	N/A	In	Vessels on Atlas and Gashouse	The current in the simulator was then increased to 2 knots flood on the approach to the Third Crossing and accelerated to 2.5 knots through the bridge passage, in line with the increase predicted by the hydrodynamic model. Three inbound runs were undertaken using the large supply vessel, travelling with the tide; during the first two runs contact between the piloted vessel and one of the vessels moored on Atlas Quay occurred. During the first run, the Third Crossing was transited satisfactorily following the contact but the second run was abandoned following the contact and before the bridge transit. The
5	Suply10L	2kts Flood	N/A	In	Vessels on Atlas and Gashouse	
6	Suply10L	2kts Flood	N/A	In	Vessels on Atlas and Gashouse	

						third passage was successful with no contacts on any vessels. **The progressive improvements in passage on subsequent runs indicates the extent knowledge and familiarity contribute to successful navigation in constrained situations and hence the necessity for suitable and sufficient familiarisation training for the port pilots on the effects of the Scheme on navigation conditions prior to its construction.**
7	Suply10L	3kts Ebb	N/A	In	Vessels on Atlas and Gashouse	The current was then further increased to 3 knots ebb, accelerating to 3.7 knots within the bridge passage. Two runs, one inbound the other out, were undertaken using the supply vessel. **Both runs showed a further increase in the difficulty of navigation although both runs resulted in a successful transit of the bridge passage.**
8	Suply10L	3kts Ebb	N/A	Out	Vessels on Atlas and Gashouse	
9	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas and Gashouse	Following this, three runs were undertaken outbound at a moderate flood current of 1 knot, 1.3 knots in the bridge passage, utilising the bulk carrier, again with vessels on both banks. During the first of these runs a discernible draw to the east bank (the inside of the bend) was experienced
10	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas and Gashouse Increased current resolution	

11	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas and Gashouse	following a successful bridge transit. Resulting from this, the resolution of the modelling of the current stream was increased within the simulator and the run repeated. This repeat run showed an improvement in the transit, although the draw was still evident. A third run, commenced from a location earlier in the River, allowed the pilot to better position the vessel for the bridge transit and this resulted in a further improvement in the passage. **Vessel draw towards the east bank of the River is evident during the flood tides, this effect is known to occur under current conditions.**
12	BulkC11L	1kts Flood	N/A	Out	Vessels on Atlas	A single run was then undertaken using the same parameters as the previous three but without a vessel berthed on the west bank at Gashouse Quay. **This run showed an improvement on the previous runs potentially indicating that the draw effect may be a result of hydrodynamic interaction between the bridge passage and the hull of a vessel moored on Gashouse Quay.** This effect was subsequently investigated further within the Hydrodynamic model to ascertain if it was a product of the operation of the simulator model or something that is likely to be experienced during real vessel transits and is

						discussed in greater detail in Section 5.2 Overall Outcomes.
13	BulkC11L	1kts Ebb	N/A	In	Vessels on Atlas and Gashouse	Two inbound runs with the bulk carrier under an ebb current of 1 knot were undertaken with vessels moored on Atlas Quay north and south of the bridge. **There were no significant issues with these simulations.**
14	BulkC11L	1kts Ebb	N/A	In	Vessels on Atlas and Gashouse	
15	Suply10L	3kts Ebb	20kts NE	In	Vessels on Atlas and Gashouse	A final inbound simulation run using the supply vessel was then undertaken with the current set at 3 knots ebb combined with a 20 knot north easterly wind. **This showed similar outcomes to the earlier run with this current velocity suggesting that the level of wind simulated would not be a limiting factor in most bridge transits.**

5.2 SECOND STAGE SIMULATION

Run	Vessel	Tide	Wind	Transit	Notes	Observations
1	BulkC11L	1kts Ebb	N/A	In	Vessels on Atlas and Gashouse	The initial run replicated the basic runs from the first stage simulation, albeit with a marginally stronger current. **The outcome was the same as during the first stage simulation with no issues presented during this run.**
2	Suply10L	1.5knts Flood	N/A	In	Vessels on Atlas and Gashouse	Following this, a series of runs utilising the larger supply vessel was undertaken. The simulation time was set to produce an initial main stream current of 1.5 knots on the flood tide and vessels were placed on both South Atlas and Gashouse Quays. Two runs were undertaken inbound with a bow first transit; as in the first stage simulation, a noticeable draw to the east bank occurred after the bridge transit, the second run to a lesser extent that the first. A third run tried the same manoeuvre stern first; this showed a noticeable improvement in transit. A fourth run using the same initial settings simulated an outbound stern first transit and showed no problems. A fifth run replicated the first two runs, with the eastern draw still being noticeable. A final run, with an additional vessel moored on North Bollard Quay,
3	Suply10L	1.5kts Flood	N/A	In	Vessels on Atlas and Gashouse Backed through passage	
4	Suply10L	1.5kts Flood	N/A	Out	Vessels on Atlas and Gashouse Backed through passage	
5	Suply10L	1.5kts Flood	N/A	In	Vessels on Atlas, Gashouse and N Bollard	

						produced an improved transit over the earlier attempts. **These simulation runs showed the same draw towards the eastern bank as experienced during similar manoeuvres in the first stage simulation. Some permutations produced better outcomes indicating need for consideration duration passage planning.**
6	BulkC11L	1.3kts Flood	N/A	Out	Vessels on Atlas and Gashouse	Following these runs, the vessel was changed to the cargo vessel and the current lowered to 1.3 knots. **A run taking the vessel outbound showed no issues. A second run, bringing the vessel inbound stern first, indicated passage was possible in this configuration but it was slow and control was difficult.**
7	BulkC11L	1.3kts Flood	N/A	In	Vessels on Atlas and Gashouse	
8	Suply05L	1.8knts Flood	N/A	In/Out	Vessels on Atlas and Gashouse Bow first inbound, stern outbound	Next, a single simulation was performed using the smaller supply vessel with the current increased to 1.8 knots. The simulation included a bow first inbound bridge transit, a berthing manoeuvre onto North Atlas Quay, a swing in the River north of the bridge, a second bow first passage through the bridge and finally a berthing south of the bridge.

						All operations were completed successfully.
9	BulkC11L	1.1knts Flood	N/A	Out	Vessels on Atlas and Gashouse	Two runs were then undertaken to simulate the cargo vessel departing from North Atlas Berth for an outbound transit on a 1.1 knots flood tide. **In both runs the vessel had difficulty departing the berth and came relatively close to the vessel berthed on North Bollard Quay, although no contacts occurred.**
10	BulkC11L	1knt Ebb	N/A	Out	Vessels on Atlas and Gashouse	The same manoeuvre was then undertaken with the tide set to 1 knot ebb**; this showed no issues with the passage under these conditions.**
11	PRODC04L	1knt Ebb	N/A	-	Vessel on Atlas Transfer from Gashouse to ASCO	The next run simulated a product vessel (tanker) transferring from Gashouse Quay to ASCO Quay on a 1 knot ebb tide; **this showed no issues in the manoeuvre.**
12	Suply05L	3knts Flood	N/A	In	Vessels on all berths N&S of bridge	Following this, the current was increased to 3.3 knots (the maximum main stream flow from the hydrodynamic model) flood tide and vessels were

						placed on Gashouse, Asco, South Atlas, North Atlas and North Bollard Quays, to replicate the most extreme conditions possible. Two runs were attempted inbound with the smaller supply vessel; **as expected control of the vessel was difficult and in both runs although the vessel passed the bridge without contacting the passage, the eastward drift after the passage caused contact with the vessel moored on North Atlas.**
13	Suply10L	3knts Flood	N/A	In	Vessels on all berths N&S of bridge	The vessel was then changed for the larger supply vessel and the above manoeuvre attempted again. In all, five attempts were made with contacts occurring in all runs, 4 with the vessel on North Atlas and one with a contact on the bridge. **These, combined with the two previous runs suggest that inbound transits at peak flood tides would not be possible for this size of vessel without tug assistance; this is consistent with the outcome of the initial vessel simulation undertaken in 2009.**
14	Suply10L	1knts Flood	N/A	In	Vessels on all berths N&S of bridge	A final inbound run was undertaken with all berths occupied but the current lowered to 1 knot flood using the larger supply vessel.

						The passage, although challenging, was completed without contacts.

5.3 OVERALL OUTCOMES

While the presence of the new bridge had a discernible effect on the navigation of vessels in the area, during slack water conditions the effects were small and did not appear to increase the risk to navigational safety. This applied even with a number of vessels berthed on the quays immediately south of the bridge location.

As expected the effects of the narrowing at the bridge became more significant as the current increased. This appeared to be amplified by the presence of a moored vessel on Gashouse Quay.

Key Point: In slack water conditions the effects of the proposed bridge were minimal. The effects of the narrowing increased as currents and the number of moored vessels increased.

Further investigation of the hydrodynamic effects with vessels on berth was undertaken after the first stage simulation. This indicated that while there is a change in the location of the current stream the magnitude of acceleration of flow with vessels berthed on both sides of the River is reduced by the presence of the Scheme, with velocities of up to 50% higher indicated within the base model under matching conditions as can be seen in Figure 11, below.

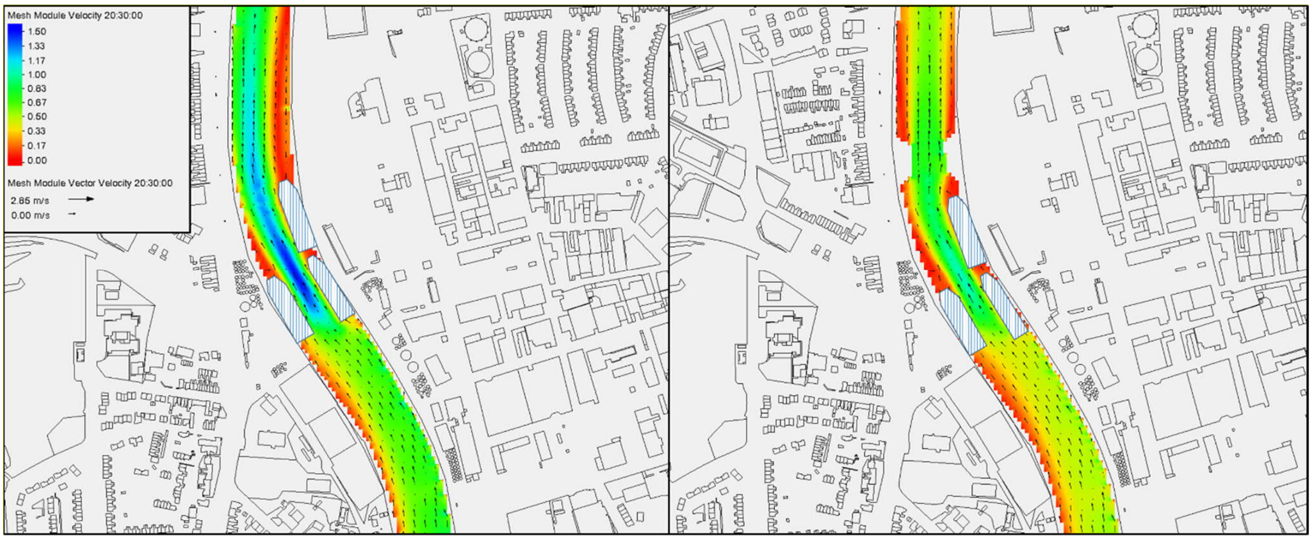

Figure 11 – Hydrodynamic Model Comparison

Key Point: The magnitude of acceleration of flow with vessels berthed on both sides of the river, decreases with the proposed bridge in place.

The change in the current stream caused by the presence of the bridge has the effect of straightening the flow earlier in the bend when compared to the baseline, this straightening combined with the reduction in velocity could result in the pilots compensating for an anticipated effect on the vessel, based on their experience of the current baseline conditions, resulting in the vessel turning more towards the east than they were expecting. Again, this effect highlights the need for a comprehensive familiarisation programme to be put in place for pilots prior to the scheme construction.

Key Point: A comprehensive familiarisation programme for pilots is necessary to compensate for the effects of flow straightening and velocity changes.

For smaller vessels, those less than 30m in length, the narrowing of the channel at the proposed Third Crossing is not considered to be navigationally significant. For these vessels the bridge opening regime will likely be the dictating factor in relation to operational conditions.

Key Point: For vessels less than 30m in length the narrowing of the proposed bridge is not navigationally significant.

5.4 COMMENTS RECEIVED FROM GYPC

Following the second stage simulation, comments were received from GYPC. These comments can be separated into 3 distinct topics, ones relating to the capability of the simulator, ones relating to the inputs and runs undertaken, and ones covering the outcomes of the simulation runs undertaken.

5.4.1 ISSUES RELATING TO THE CAPABILITY OF THE SIMULATOR

5.4.1.1 GYPC's Concerns

- Unable to load a full suite of vessels within the system reflecting the traffic using the port e.g. the simulator has a laden tanker, but not a tanker in ballast (the same applies to cargo vessels).
- The simulator cannot fully mirror the control systems of an Offshore Supply Vessel, especially when backing up. The simulator reverses the bow thruster to a stern thruster, which also does not accurately reflect the manoeuvring characteristics of vessels using the port.
- The simulator is not able to handle the granularity of variables such as tidal conditions or flow model beyond a number of tidal stream positions. This is not sufficient in order to capture the true nature of tidal streams and eddies around the proposed bridge piers.
- The tidal model is very binary in its application within the simulator.

5.4.1.2 Response

Looking at those related to the simulator facility itself, the range of vessels available within the simulations is limited by the models available from the simulator manufacturer. The vessels selected were chosen from the full range of vessels currently available, through discussion with GYPC, prior to the first stage simulation. While it is possible to have other vessel models created, without specific real-world performance testing undertaken using the actual vessel on which the model is to be based, it would not be possible to calibrate the simulator model and therefore ensure the accuracy of the resulting outputs.

Of the vessels that pass the bridge location 60% of movements were of vessels less than 30m in length, of which the scheme is not navigationally significant. 80% were less than 66m, equivalent to the medium offshore support vessel, and less than 1% of movements were for greater than 90m. As explained in section 4.5, the largest recorded vessels are represented.

In terms of the simulators ability to take varying tidal inputs, the simulator can accept any number of tide input positions and is capable of running with multi-layer tidal streams. The input file developed for the second stage simulation was prepared using an upper layer depth averaged tidal stream on the basis that all the principal test vessels were of similar draughts. The number and position of tidal data points to be used within the hydrodynamic model outputs was shared with GYPC prior to the simulation and no comments were received. Should it be considered that the number of data points was insufficient, this could be increased.

Key Point: Both the vessel and tidal data used in modelling was shared or discussed with GYPC prior to assessment, with no objection. The vessels used are representative of recorded vessels passing the bridge and the tidal data uses sufficient data points to accurately replicate tidal conditions.

Lastly, in relation to the control mechanism of the supply vessel, this comment relates to the fact that when set up with a stern facing bridge the physical controls for the bow thruster are reversed within the control panel. This has the effect of requiring the pilot to reverse his inputs on the power control over that which would normally be expected; it does not change the bow thruster into a stern thruster and does not fundamentally change the manoeuvring characteristics of the vessel model.

Key Point: With regards to the control mechanism of the supply vessel, a stern facing bridge does not fundamentally change the manoeuvring characteristics of the vessel model. It is able to replicate the control systems of an Offshore Supply Vessel.

5.4.2 ISSUES RELATING TO THE INPUTS AND RUNS

5.4.2.1 GYPC's Concerns

- No runs with any wind were conducted in the assessment which would make manoeuvring and berthing more difficult.
- No full runs from entry to berth and berth to exit were conducted to highlight the effect on the tidal flow as whole within the River.
- No runs were conducted with tug assistance for larger laden and unladen vessels through the bridge.
- It should be noted that these manoeuvres were conducted with a 3 knots tidal stream. Streams have been known to reach 6 knots in extreme conditions within the River.
- The tidal model only extended for 300m either side of the bridge. It is not known what effect the revised current flows will have on points further North and South. In particular the effects at Brush Bend and whether there will any delay or advancement of the slack water periods in this location.

5.4.2.2 Response

While no runs were undertaken with wind conditions during the second stage simulation, a run with wind of 20 knots was undertaken during the first stage simulation. In all but the most extreme wind conditions, the tidal currents will be the limiting factor on timing of vessel movements. Further testing of limiting wind conditions could be undertaken during a pilot familiarisation programme.

Key Point: Wind conditions were considered during the first simulation. Results showed tidal currents were the limiting timing factor in most instances, except for extreme wind conditions.

With regard to the next points, relating to the extent of the tidal model and equally the length of vessel movements simulated, the hydrodynamic modelling undertaken as part of the Environmental Impact Assessment (EIA) cover the entire River Yare, from outside the entrance to Breydon Water. This shows that the Scheme would have negligible effect on tidal velocities, timings or water heights beyond around 300m from the edge of the Scheme construction. For this reason, the simulations were focused on this area. The simulator model itself covers the entire River. The simulator has the facility to model vessel movements with tug assistance. No suggestion was made by the pilots during either the first or second stage simulations that they believed tug operations would have been used in the movements simulated.

Key Point: Whilst the model covers the entire river, the simulations were focused on an area 300m from the edge of the scheme construction as the EIA found the limit of change to be at this distance.

Lastly the tidal model used in the simulation was for a typical spring tide with a peak main stream velocity of 3.3 knots. The statement that flows can reach 6 knots in certain conditions is not known to apply to the whole of the River; indeed GYPC's General Port and Pilotage Information states "Out-going stream begins. Full flow normally 3 to 4 knots but can reach 6 knots with accelerated flows between the buttresses of Haven Bridge."

Key Point: The tidal model was based on a typical spring tide with a velocity of 3.3 knots. The 6 knot maximum has been recorded in a different part of the river, it is therefore not necessary to model a velocity of 6 knots for this assessment of the proposed bridge.

5.4.3 ISSUES RELATING TO THE OUTCOMES

5.4.3.1 GYPC's Concerns

- Berth 14 (North Atlas Quay) was difficult to berth on, but more hazardous to depart from.
- While attempting to berth on 31A/B (North Bollard Quay) the vessel became locked in the centre of the channel and was unable to power through to the berth.

5.4.3.2 Response

Finally, there are the comments relating to the outcomes of the simulation runs, both relating to the ability to berth and depart from the quays north of the bridge location. A number of the simulation runs in which berthing was problematic were undertaken with high current velocities. Given the restrictions on when certain vessels can safely transit the Brush Bend at the mouth of the River, it is not necessarily the case that a vessel could be in a position to require these manoeuvres at the tidal states used in the simulation.

Key Point: The difficulties encountered when berthing and departing from some quays occurred under high current velocities. In reality, existing restrictions would prevent vessels from manoeuvring at these times.

6 CONCLUSION

A navigation simulation was undertaken to assess the effects of the proposed Third Crossing of the River Yare in Great Yarmouth. The simulation involved the construction of a computer model of the approaches to the location of the proposed Third Crossing and allowed a variety of vessel passages to be attempted in various environmental conditions.

6.1 KEY FINDINGS

The following summarises the key findings:

- In slack water conditions the effects of the proposed bridge were minimal, even with vessels berthed directly adjacent to new bridge. Therefore, the 50m navigation channel is sufficient for vessels accessing the port.
- The effects of the narrowing increased as currents and the number of moored vessels increased.
- The magnitude of acceleration of flow with vessels berthed on both sides of the river, decreases with the proposed bridge in place.
- A comprehensive familiarisation programme for pilots is necessary to compensate for the effects of flow straightening and velocity changes.
- For vessels less than 30m in length the narrowing of the proposed bridge is not navigationally significant.
- Both the vessel and tidal data used in modelling was shared or discussed with GYPC prior to assessment, with no objection. The vessels used are representative of recorded vessels passing the bridge and the tidal data uses sufficient data points to accurately replicate tidal conditions.
- With regards to the control mechanism of the supply vessel, a stern facing bridge does not fundamentally change the manoeuvring characteristics of the vessel model. It is able to replicate the control systems of an Offshore Supply Vessel.
- Wind conditions were considered during the first simulation. Results showed tidal currents were the limiting timing factor in most instances, except for extreme wind conditions.
- Whilst the model covers the entire river, the simulations were focused on an area 300m from the edge of the scheme construction as the EIA found the limit of changes to be at this distance.
- The tidal model was based on a typical spring tide with a velocity of 3.3 knots. The 6 knot maximum has been recorded in a different part of the river, it is therefore not necessary to model a velocity of 6 knots for this assessment of the proposed bridge.
- The difficulties encountered when berthing and departing from some quays occurred under high current velocities. In reality, restrictions would prevent vessels from manoeuvring at these times.
- While the option to use tug assistance was available within the simulation, no runs were undertaken with vessels using tug assistance as neither pilot indicated that they would have envisaged employing tugs with the vessels used during the simulation.
- During the simulations, the average time that vessels overlapped the bridge was approximately 1.5 minutes. This is consistent with the bridge opening durations derived from the vessel movements supplied by Peel Ports and used within the Scheme traffic assessments.

6.2 RISK SUMMARY

The following table details the principal risks identified during the vessel simulations and proposes potential solutions that could be adopted to better quantify or mitigate them during the design development.

Factor	Issue	Severity	Solution	Risk
Moored Vessels	For larger vessels during higher tidal flow conditions, the simulations showed that, while navigating the proposed Third Crossing with the tidal flow is possible up to certain speeds, difficulties could be experienced in manoeuvring when vessels are berthed on both banks of the River immediately north and south of the bridge.	Medium	Even though larger vessels make up less than 1% of port traffic, the removal of one of the berthed vessels improved the ease of transit in the simulations and further consideration of this fact should be included in the Navigation Risk Assessment for the Scheme when it is prepared.	Medium
Wind Conditions	Wind conditions were not represented on all simulation runs.	Low	Apart from extreme wind conditions, tidal currents were the limiting factor on timing of vessel movements. The impact of standard wind conditions has been understood and has minimal effect on navigation through the proposed bridge.	Low
Tidal Currents	The effect of bridge narrowing was found to be velocity reduction and flow straightening, which requires both familiar and unfamiliar pilots having to compensate for the tidal changes.	Medium	A comprehensive familiarisation programme for pilots is necessary to appraise them of the potential effects of flow straightening and velocity reduction.	Medium
Tug Assistance	No simulations were ran with tug-assistance therefore the effects have not been fully understood.	Low	Neither pilot indicated they would employ tugs with the simulation vessels, additionally, there have been very few movements over the past eight years that have taken tugs.	Low

Departing / Berthing	Departing and berthing difficulties were encountered for some larger vessels from certain quays under high current velocities.	Low	Restrictions apply for when vessels can depart and berth in difficult tidal conditions. In reality, few vessel would be making these manoeuvres. Therefore, most manoeuvres are able to occur without difficulty.	Low

The following summarises the outcomes of the assessments, the impacts to activity in the port, and possible next steps:

- The removal of one of the berthed vessels improved the ease of transit in the simulations and further consideration of this fact should be included in the Navigation Risk Assessment for the Scheme when it is prepared.
- All of the simulation runs resulted in passages through the bridge that were reasonably parallel with the abutments, this indicates that the assumption of no more than 12.5° heading error during a passage used for the preliminary sizing of the passage fendering could be considered conservative.
- It is envisaged that the Scheme will be marked with standard Aids to Navigation i.e. red and green channel markers, amber fixed hazard lights and sets of traffic control signals (either stop/go or IALA E111 signals). Any additional requirements should be identified in consultation with the Great Yarmouth Port Authority as Statutory Harbour Authority and Trinity House as General Lighthouse Authority during the Navigation Risk Assessment process.
- A number of aspects of the simulations indicated that benefits could be realised by the implementation of a familiarisation programme for pilots and other designated river users prior to the commencement of construction of the scheme, the potential form and attendees for this should be considered further as part of the Navigation Risk Assessment process.

The outcomes from these simulations are not dissimilar to those from a previous simulation undertaken in 2009 during the early planning stage for the Scheme.

We consider that, with the information available at the current stage of the design process, the simulations show that the proposed Third Crossing would be unlikely to create an unacceptable level of hazard to navigation nor require the imposition of excessive restrictions on navigation within the Port of Great Yarmouth.

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