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## 1 Qualifications and Experience

1.1 I am Captain Peter J McArthur. I hold UK (MCA) issued STCW II/2 (unrestricted) Master Mariner certification and am self-employed as a senior Manchester Ship Canal pilot, a job that I have held for 20 years.

1.2 In addition to my maritime professional qualifications, I hold an MBA (business administration) and have a law degree (LLB (Hons)) – both through the Open University. I hold further qualifications as both an International Arbitrator and a Civil and Commercial Mediator. I hold professional memberships of the London Maritime Arbitrators Association (**LMAA**), the London Shipping Law Centre (LSLC) and the Chartered Institute of Arbitrators (**CIArb**) and I am accredited as a mediator through the Standing Committee on Mediation Advocates (**SCMA**).

1.3 In 2016, I was elected as a Younger Brother of the Corporation of Trinity House, London. I am a Liveryman of the Honourable Company of Master Mariners (**HCMM**) and sit on the Technical and Education and Training Committees for that organisation and am the Deputy Chair of the Chartered Master Mariner Registration Authority. Additionally, I am the HCMM nominated nautical adviser to the Admiralty Court of Appeal and have carried out the role of expert witness (appointed by various inns of court and international clients) in maritime related incidents.

1.4 My professional maritime credentials are further supplemented by having been appointed as a Fellow of the Nautical Institute (**FNI**) and a Fellow of the Institute of Marine Engineers, Science and Technology (**FIMarEST**). I am a Chartered Marine Technologist (**CMarTech**) an award given by the IMarEST in recognition of my contribution to the development of maritime safety arising from my personal research into the field of hydrodynamics and ship-interactions.

1.5 Since 2002 I have undertaken independent research into the formation, development and physical attributes of ship-generated hydrodynamic pressure fields. My published works on ship hydrodynamics derive from substantial personal experience gained in handling craft of all sizes and construction. My research is recognised and independently verified by the Technical and Scientific committees of:

1.5.1 The Institute of Marine Engineering, Science and Technology (**IMarEST**);

1.5.2 Royal Institute of Naval Architects (**RINA**);

1.5.3 University of Ghent – Maritime Technology Division;

1.5.4 Flemish Government – Flanders Hydraulics Research Unit;

1.5.5 Norwegian University of Science and Technology – Dept. of Marine Technology;

1.5.6 UK and European Maritime training establishments;

1.5.7 The Nautical Institute; and

1.5.8 UK, European and International Maritime Pilot Associations.

1.6 My works on hydrodynamic pressure fields and the effects of interaction have been published globally and translated into a several languages for use by pilot services and nautical training establishments.

1.7 Further to this area of personal research, in recognition of the global benefits (and saving of life) that this work has afforded, in 2016 I was recognised by the maritime industry, the State and my peers in being one of the first recipients of the new Merchant Navy Medal for Meritorious Service (**MNM**).

1.8 During my worldwide seafaring career I gained experience on all sizes and types of vessel - from small coastal craft to very large crude carriers (**VLCCs**) and ultra-large crude carriers (**ULCCs**). I spent several years plying the busy routes around the European coast and English Channel where the highest navigational competence is essential. Latterly, as a Manchester Ship Canal Pilot and senior training officer for the pilot service, close quarters navigation in extremely confined waterways has become part and parcel of the normal day to day operations in this district. Navigation in this district requires that I regularly transit the numerous docks, locks, sluiceways and water-level barrages. The Manchester Ship Canal forms part of the main-drain for the Western Pennines and is an integral part of the flood-defence mechanism for the industrial heartland of the UK North West, which encompasses the conurbations of Manchester, Salford, Warrington and outlying areas.

1.9 Having regard to the current matter, my relevant small craft experience includes, but is not limited to:

1.9.1 Childhood spent aboard cabin cruisers, navigating Scottish sea-lochs and inland lochs, learning to operate, maintain and service the craft.

1.9.2 Servicing and maintaining lifeboat-size craft on ocean going merchant ships.

1.9.3 Small sailing boat instructor – Glasgow Nautical College (1977 – 1978).

1.9.4 Participating in sailing flotillas and sail racing events.

1.9.5 Commanding and safely directing flotillas of canal barges along the Manchester Ship Canal, through locks, along rivers and into city centre harbour and basins.

1.9.6 Setting-up and administering bunkering operations which involved directing and ordering a variety of small craft, bunker barges and work tenders.

1.9.7 As a berthing Master and hydrographic surveyor on the Rivers Humber, Trent and Ouse (Immingham, Killingholme, Salt-end, Grimsby, Goole, Howdendyke, Flixborough and Gunness Grove), directing small craft (coasters, pleasure craft, sailing yachts, fishing boats, bunker barges and narrow boats) in close quarter navigational situations.

1.9.8 Advising harbour authorities on legal, technical and navigational issues in respect of work tenders, transient pleasure craft and construction craft.

1.9.9 Acting as legal advisor to several UK ports - deemed too small to have their own legal department.

1.9.10 Acting as on-scene-commander (**OSC**) for small craft during search and rescue (**SAR**) operations.

1.9.11 Piloting, conducting and physically steering virtually every kind of small craft imaginable.

1.9.12 Piloting and steering naval fast craft, including fast-rescue boats, patrol boats and minesweepers.

1.9.13 Liaising with and advising pleasure-craft marina operators.

1.9.14 Undertaking research into aspects of safety and stability relating to small craft manoeuvring alongside large vessels underway or when moored in a tideway.

1.9.15 Carrying out practical research using 1/25th scale ship models in test lakes.

1.9.16 Acting as legal advisor and expert witness in small-craft structural damage cases.

1.9.17 Technically analysing and reporting upon maritime casualties involving small craft, tugs, dumb barges and similar size craft.

1.9.18 Expert witness to the courts: critically analysing and reporting upon traffic separation schemes and vessel management services, including practical aspects of their operation.

1.9.19 Developing and delivering safety training courses for tug masters, towing operations, and tow operators.

1.9.20 Developing safety training courses for port mooring personnel and berth staff.

1.9.21 Developing safety training courses for marine pilots and related shore (**VTS**) operators.

1.10 Prior to this matter, I have been called upon by port operators and harbour authorities, High courts, legal clients (pursuing actions to the Supreme Court) and private parties to perform assessments and undertake independent investigations in respect of:

1.10.1 Maritime wet casualties;

1.10.2 Close quarters, enclosed water and tidal-estuary near miss incidents;

1.10.3 Marine incidents where hydrodynamic interaction is suspected;

1.10.4 High profile, public interest, port and river-side development proposals;

1.10.5 Maritime related pre-construction planning and mitigation projects;

1.10.6 VDR, data and video analysis of some of the foregoing; and

1.10.7 Seagoing fatality investigations.

1.11 In 1981, I changed my seagoing career path and elected to work in the European and near Continental trade routes, and spent a significant amount of the period between 1981 and 1998 trading in the North Sea, which included the UK east-coast ports of the Rivers Tyne, Tees and Humber, Great Yarmouth, Harwich Haven, Felixstowe and Ipswich, and the Wash ports of Kings Lynn and Boston. I became very familiar with the tides and currents of the UK east coast, including the Wash, and occasionally conducted small bulk-carriers through the lock into the wet-dock of the port of Boston.

1.12 In addition to my current position as a Manchester Ship Canal pilot, I am an examining pilot for the service, having previously held the role of the senior training officer for the pilot service. Outside of the pilot service, I am an independent training provider and have developed a range of courses and provide seafarer training in subject areas relevant to this evidence.

## 2 Scope and Structure of Evidence

2.1 I am presenting independent evidence on behalf of the Environment Agency.

2.2 My evidence will describe various aspects of boat handling, including relevant information regarding power to weight ratios of various craft, the effect of different length and beam ratios, rudder sizes for craft and the relative impact on board handling, engine manoeuvres when manoeuvring in the haven and both before, during and after transiting the barrier and various states of tide.

2.3 So far as it is within my knowledge experience and capability, I comment upon matters where I have relevant experience to the extent that it can and may inform the inquiry.

2.4 Where possible, I respond to the objections raised that within the scope of my knowledge, practical ability, experience and professional capacity.

2.5 The evidence structure presented herein is as follows:

2.5.1 Section 3: Introduction to my involvement in the Boston Barrier and River Witham project and will identify those issues within the statement of matters that fall within my area of expertise and knowledge

2.5.2 Section 4: Comment upon boat handling and associated matters for the various craft the regularly operate on the haven and a likely to transit the barrier

2.5.3 Section 5: Matters relating to navigating in tidal waters will be examined and commented upon

2.5.4 Section 6: Mariner obligations and collision regulations (**COLREGS**)

2.5.5 Section 7: Port and Navigational Control measures

2.5.6 Section 8: Haven traffic, navigation and associated issues

2.5.7 Section 9: Modelling and simulations

2.5.8 Section 10: Response to Statement of Matters

2.5.9 Section 11: Issues raised in objection

2.5.10 Section 12: Conclusion

2.5.11 Section 13 Statement of Truth

## 3 Introduction

3.1 I was appointed and brought into this project at a late stage when it became clear that a previous witness could not attend the inquiry. Consequently, I come to the case with no preconceived opinions, lacking bias of any kind, and with a fresh set of eyes.

3.2 So far as was reasonable and practical in the time available, I have endeavoured to familiarise myself with as much of the material as possible, to attend upon simulations at HR Wallingford, practically integrate with the craft handling simulations and to comment upon them within the realm my own (very extensive) vessel handling experience.

3.3 Notwithstanding the obvious limitations that the foregoing presents, I consider that I have adequate information available to me in order to provide informed evidence to the inquiry in this proof of evidence. I have also set in place a range of meetings including practical excursions on the Haven for the purpose of vessel and district familiarisation and, by the time the inquiry takes place will be thoroughly familiar with the town of Boston, the port and harbour, the worksites and the Haven. I will update and supplement my evidence at the inquiry as appropriate following this further experience.

3.4 For the avoidance of doubt, I was a resident of North Lincolnshire for approximately 25 years, was a regular visitor to the town of Boston, transited the Haven on small ships and on at least one occasion was required to enter the wet dock. As someone who lived fairly nearby, and who participated in a range of outdoor activities, I have, in the distant past, developed personal and sporting relationships with the some of the local townspeople. The town is not unknown to me, and I come to the matter with a reasonable degree of local knowledge and familiarity.

### 3.5 Statement of Matters

3.5.1 Of the matters about which the Secretary of State particularly wishes to be confirmed, the following elements have been identified as aligning with my knowledge, training and practical experience and are therefore matters which I have been asked to consider for the purposes of the public inquiry.

3.5.2 Matter 5: The justification for the location, design and operation of the scheme including:

(a) the implications for navigation around the siting of the barrier.

3.5.3 Matter 12: The adequacy of the current flow calculations and engineering proposals as presented with particular regard to:

(a) flow velocity concerns in relation to the fishing fleet’s ability to use the river.

3.5.4 Matter 13: the likely impacts of constructing and operating the barrier on navigational safety including:

(a) that the phasing of the works accommodates a minimum level of operations to allow river and port operations to continue in safety.

(b) the adequacy of the provisions relating to navigational risk within the accompanying environmental statement

3.5.5 Matter 14: the likely impacts of constructing and operating the scheme on the operation of businesses in the area, including:

(a) issues around perceived increased flow velocities creating difficulty for the fishing and pleasure craft industry to operate safely.

## 4 Boathandling (on the Haven) and Associated Matters

4.1 The Haven is a tidal waterway and, as such, there are various risks inherent to navigating in such waters. The Haven forms part of the Port of Boston (**PoB**) and comes under the statutory direction of the Harbour Master (**HM**), who has the authority to control navigational conduct in the district. The presence of larger seagoing vessels introduces additional factors that must be taken into account by those navigating on the Haven (including narrowboat operators and transient (summer season) visitors) who are reasonably be expected to possess sufficient experience to ensure their own safety on the water. Responsibility for personal safety and that of other waterway users is addressed further in section 6 (below).

4.2 Experienced boat-handlers should have a working knowledge of their craft, how they perform under a range of circumstances (including the normal tidal and meteorological influences they are likely to encounter) and should be familiar with the manoeuvring parameters of the craft that they have charge of. This sections addresses some of those handling parameters and the equipment for achieving the desired response and will include commentary on:

4.2.1 General boat handling principles;

4.2.2 Manoeuvring equipment;

4.2.3 Power and tonnage ratio of vessels;

4.2.4 Length and Beam of craft and their impact on handling;

4.2.5 Water depth, width and hydrodynamic factors;

4.2.6 Vessel speed control;

4.2.7 Turning capability; and

4.2.8 Cant of the vessel.

### 4.3 General Boat Handling Principles

*Factors affecting manoeuvrability*

4.3.1 Manoeuvrability with regard to any vessel includes a range of factors that, either singularly or in combination, describes the capacity of the vessel to:

(a) speed up

(b) slowdown (either in a controlled fashion or very suddenly (for example, in an emergency))

(c) turn around (for example, in a tight circle)

(d) maintain its directional heading once the helm has been set to the port or starboard (left or right) - a quality that is generally referred to as the vessels ‘directional stability’

(e) recover from the turn and re-establish a steady heading.

4.4 In normal seafaring parlance, all of these factors when taken together will offer comparable measure of the vessel’s capacity to perform a range of handling functions when being compared with another craft.

4.5 How a vessel handles depends on a number of factors, including the manoeuvring equipment that the vessel is fitted with. Vessels that are designed to carry out different functions will be fitted with different equipment so that the craft will generally perform to the commissioned specifications. These may change throughout the life of the vessel, according to the owner’s requirements.

4.6 At a very basic level, the equipment that is provided with which to manoeuvre a vessel may include, but is not limited to:

4.6.1 the rudder

4.6.2 the size and type of the rudder

4.6.3 the steering gear provided to drive the rudder, and the speed with which the gear is able to turn the rudder from one side to the other.

4.6.4 the power of the engine relative to displacement (weight) of the craft

4.6.5 the mathematical ratio between the length and beam of the craft

4.6.6 the form of the hull (i.e. whether the whole is fine formed, that is, the vessel is designed to move quickly through the water, whether it is full formed in which case it is likely to be more stable, and be able to carry more weight which, in the general scheme of things, may make the boat less agile, although this is a generalisation because heavy boats with powerful engines (such as the fishing boats on the Haven) can also be very agile as circumstances demand.

4.7 The hydrodynamics of the particular situation will have a significant effect on the handling of any vessel. Hydrodynamics with regard to ship and vessel handling will encompass such factors as:

4.7.1 the vessel’s draft in relation to the available depth of water

4.7.2 the proximity of unusually deep water, shoals, banks, nearby infrastructure and any other features that have the capacity to alter or change the water flow.

4.7.3 The density of the water, that is whether it is fresh, salty, contain significant amounts of mud, silt, suspended sands or other fluvial particulates.

4.8 The foregoing factors are generally borne in mind by those handling vessels, and whilst they are accommodated within the scope of vessel-handling skills, as a rule the majority of Mariners are aware that these are factors to be contended with at all times. However, balancing these elements is generally considered to be more of an art than a science.

4.9 The water flow around the craft hull can be affected by any protrusions, weed growing on the bottom, barnacles or materials hanging over the side - amongst other things.

4.10 **Manoeuvring and Related Equipment - Detail**

4.11 Rudder

In general, the performance of the rudder is directly proportional to the area of the rudder and the mathematical square of the speed of the water passing over the rudder. Other factors which may affect the rudder are shallow water (see sections 4.27 to 4.37), the rudder type, the shape of the hull just forward of the rudder (as a fine form will allow water to more easily flow into the propeller), the location of the rudder relative to the propeller and the maximum designed rudder angle. As a rough guideline, normal rudders will have a length proportional to the length of the vessel (traditionally, this was approximately 1 inch (2.5 cm) for every foot of the boat length). Vessels that are required to have a much tighter turning capability or more efficient turning circle can modify the length, shape and design of the rudder. For most craft, the range of rudder angles would be from 35° on one side to 35° on the other side and in most circumstances this should be achievable through the full range in under 20 seconds.

4.12 **Power / Tonnage Ratio**

4.13 As a rule, a vessel with a main engine horse power / displacement tonnage ratio of less than 1 (that is, having an engine horsepower of one for each metric tonne of displacement) will be more difficult to manoeuvre in shallow and confined waters at slow speed.

4.14 Underpowered vessels may be described as those that lack sufficient power to provide a reasonable “kick” when engine power is suddenly increased (for a very short period) in order to increase the water flow over the rudder.

4.15 Fishing vessels and motor boats tend to have a power/tonnage ratio of greater than 1 and therefore respond well to “kicks” ahead. Fishing vessels such as those of the Boston fleet (that are often required to tow significant weight behind them, as part of their work) generally have a ratio of 2 or more and therefore have ample power to manoeuvre, especially when they do not have fishing gear run out - as when navigating in the Haven.

4.16 Fishing boats, including those of the Boston fleet, almost without exception, have diesel engines as their main means of propulsion. Power is transferred to the propeller through a control lever to a controllable gearbox. The control lever will have initial settings for forward, neutral and reverse (F/N/R) and once the gearbox direction is ‘clicked’, additional power is achieved by moving the lever further in the appropriate direction so that it opens the throttle and increases revolutions. This means of operation has been confirmed in an email by the

Boston fishermen's representative. The first movement of the lever from central (neutral) position engages the gear either ahead or astern at "tick over" revolutions. Minimum or "tick over" revolutions ahead will generally generate a speed through the water of around 3 knots - depending on the power of the engine, the size of the propeller and the weight of the boat.

4.17 In order to control the speed of the vessel below minimum tick over revolutions, the gear must be disengaged to stop the propeller. Steerage is, thereafter, controlled by means of periodically engaging the gear to ahead at "tick over" revolutions or higher. This technique of controlling speed and direction through the water is quite normal for all craft that have a gearing system within their propulsion unit. The technique works equally well whether the vessel in question is a fishing vessel, a narrow boat, or a large merchant vessel; for work boats (such as the Boston fishing fleet or Boston Belle) the technique would be a normal manoeuvring practice, whether engaged in fishing or during mooring and unmooring operations.

4.18 Larger sailing vessels generally have an auxiliary engine which is relatively low powered and may also be offset (from the vessels fore and aft centre-line) in the case of an outboard engine. When moving ahead sailing yachts steer well due to the larger size of the rudder (when compared to a motor boat) and the finer lines that these craft often possess. It is not unusual for smaller sailing vessels to have an auxiliary engine, particularly if they are likely to be navigating in rivers or tidal waters where there are numerous craft, if the wind (that drives them) may be affected by surrounding structures (buildings of high banking).

4.19 **Length /Beam Ratio**

4.20 Increasing the vessel beam whilst leaving the length unchanged reduces a vessel's overall length-to-beam ratio. This length to beam ratio is of importance to boat handlers in understanding the likely manoeuvring characteristic of a vessel.

4.21 As a broad guideline, a craft having a length/beam ratio of 7 (the vessel is 7 times longer than its beam – for example, the wide riverboat used during manoeuvring simulations) indicates that a vessel is directionally neutral, that is, it will turn normally and have no tendency to either increase or decrease the rate of turn when the rudder is returned to midships after the turn is initiated.

4.22 With a ratio in excess of 7, the vessel is likely to be directionally stable – that is, the rate of turn will slow down over time after the helm has been returned to the mid-ships position.

4.23 With ratios of less than 7 (typical of many fishing boats, including the Boston fishing fleet) the vessel is likely to be directionally unstable – that is, it will continue to turn quickly and may even increase its rate of turn after the helm is restored to the mid-ships position following a manoeuvre.

4.24 Broadly speaking, fishing vessels and motor boats are directionally unstable and therefore can initiate a turn easily but need constant helm movements to maintain a steady course. This was advised by the representative of the Boston and District Fishermen's Association (**BDFA**) who attended the HR Wallingford simulator on 19 / 20 October 2016. The simulator at HR Wallingford was configured to provide these characteristics (as appropriate) for the Boston fishing fleet and the Boston Belle.

4.25 Sailing vessels are more stable and will maintain a steady course with small helm movements either side of amidships.

4.26 **Under Keel Clearance, Hydrodynamics and Pressure Field Interaction**

4.27 One of the factors described earlier (see section 4.7) that has a significant effect on the handling ability of craft is the draft in relation to the available depth of water. Depending on a number of factors, including the size of the vessel, there is a general conception that when the depth of water (which in the Haven will be a combination of the low water depth plus the height of tide above ordnance datum (AOD), plus or minus any modifying effects of local weather conditions) exceeds twice in the draft of the vessel, any hydrodynamic effects are likely to be significantly reduced, that is, they will have less of an impact on the handling of the vessel and will require less consideration for the boat-handling Mariner.

4.28 A detailed explanation of why under keel clearance changes with speed and proximity to the sea-bed is available at appendix 5, but very briefly, as the bottom of the hull comes into close proximity with the sea-bed, a 'venturi' effect is set up under the hull. This resultant effect is that the water flows much faster under the vessel hull, causing a 'low-pressure' effect which, in turn, causes the vessel to both change its trim (the angle that it sits in the water, measured as the difference between the forward and after draft marks) and also to sink deeper in the water, so coming even closer to the sea-bed.

4.29 This combined effect (change of trim and sinking deeper in the water) is known as 'squat' (see **Appendix 6, Figures 5 & 6)**.

4.30 The generation of 'squat' changes what are known as the 'parametrics' of the vessel (those factors that determine how it handles at sea) and typically will alter the turning point of the vessel which, in turn, changes both the ability of the vessel to turn and the characteristic of its turning circle (see **Appendix 2, figure 2**).

4.31 Changing the vessel 'parametrics' can also result in a change of the craft stability (the capacity to return to the upright position when heeled over to an angle) and this, in turn, will also impact on handling ability.

4.32 The under keel clearance (**UKC**) is the measure of the amount of water underneath the vessel's hull. It is generally expressed as a numerical ratio related to the deepest draft of the vessel. So, for example, when the observed water depth is twice that of the draft of the vessel, there is column water underneath the lowest part of the vessel's hull equivalent to the column water extending from the waterline to the lowest part of the hull. This can be expressed in one of two ways:

4.32.1 the water depth to draft ratio is 2:1, or;

4.32.2 the UKC (in relation to the vessel draft) is 1.

4.33 The horizontal influences of hydrodynamic pressure fields may be experienced at distances ahead of the vessel equivalent to three or four times a vessel's length. Again, modifying factors need to be taken into consideration in determining precisely what that distance is likely to be. Experienced and practical ship handlers, which I would anticipate would include the Boston fishermen, the Master of the Boston Belle, wide and narrow boat handlers who regularly navigate tidal waters and, of course, the Haven pilots, would be familiar with these influences and would be well versed in recognising and compensating for these effects. Occasional boat users (of whom I would expect only a few, and then usually limited to the favourable conditions experienced in the summer months) may be less practised in the recognition of tell-tale signs, but will nevertheless have some perception of the effects. The influences refer to in this paragraph are widely promulgated throughout the Maritime community and are included, for example the Maritime guidance notice MGN199(M) entitled 'dangers of interaction' (**Appendix 3**). Training in simulators tends to deal extensively with interaction and the associated problems.

4.34 Issues of interaction between vessels are dealt specifically in the Annual Notices from the Port of Boston Harbour Master department, number 16, entitled 'interaction' (see Appendix 3 to the proof of Gillian Watson (**EA/4/2**))

4.35 Returning to the specific matter of under-keel clearance, my previous comments in this section (which should be read in conjunction with **Appendix 5**) can be very broadly summarized as:

4.35.1 boat-handling responses will become increasingly sluggish as the UKC ratio reduces below 1. This will be characterised by an increased turning circle and the feeling of the boat handling becoming lazy (see **Appendix 5, Figure 3**).

4.35.2 with a significant reduction in UKC, the turning circle of the craft may increase so that it becomes twice, or even more, than that experienced in open water and under normal conditions (see **Appendix 5, Figure 1 & 3**).

4.35.3 the foregoing can be further modified by tidal flows and currents affecting the vessel from ahead, astern, or from another quarter. An experienced Mariner would be aware of these factors and probably quite instinctively, have them in contemplation.

4.36 Vessel manoeuvers undertaken in circumstances of reduced underkeel clearance may cause the generated hydrodynamic pressure fields to extend some distance horizontally from the vessels hull and will require more use of the helm and engine power to compensate for these influences, or to initiate and maintain a turn.

4.37 To summarise, the turning circle that may be achieved under normal manoeuvring conditions can change significantly as the UKC reduces and may make completing a turn more challenging than is typically experienced in open water with greater depth. A detailed explanation as to why this occurs is given in appendix 5. note however,

4.37.1 as explained in **Appendix 5**, the initial speed at which the turn is carried out has no effect on the diameter or the turning circle under shallow water conditions.

4.37.2 speed (through the water) does, however, have a significant effect on the intensity of pressure fields generated by a vessel.

4.38 For the sake of clarity and certainty, I have undertaken hydrodynamic calculations that provide figures for squat, reduction in UKC and horizontal extension of hydrodynamic pressure fields for a range of craft that regularly operate on the Haven and, as part of that exercise, for each vessel I have calculated the effects both in the upper Haven (above the swing bridge) and for a barrier transit (see **Appendix 2, Figure 12**). The vessels considered in these calculations include:

(a) The largest of the fishing vessels (see **Appendix 2, Figures 12 & 13** and **Appendix 4, App 4.1 – App 4.5**)

(b) Wide canal boat (see **Appendix 4, App 4.6 & App 4.7**)

(c) Narrow boat (see **Appendix 4, App 4.8 & App 4.9**)

(d) Boston Belle (see **Appendix 2, Figure 5** and **Appendix 4, App 4.10 & App 4.11**)

4.38.2 For each of these vessels, I have assumed the normal condition and that they will be proceeding at 4kt through the water. Because of comments relating to the speed of fishing vessels, a second set of calculations for these vessels proceeding at 8kt is also included. I also provide a quick summary of the results at **Appendix 4.1**. There are several squat calculations in use by various maritime bodies and they each give slightly different results as they make different assumptions. The calculations I have provided takes account of all methodologies and the mathematical equation relating to each method can be viewed at the top of the relevant calculation field.

4.38.3 Hydrodynamic calculations for the small WSC sailing craft would be meaningless in the circumstances as they are too small to have any significant effect, although they would feel the effect from other craft navigating in the vicinity.

4.38.4 My conclusion is that there is very little observable difference in what is likely to be experienced by vessels navigating in water depths of twice their draft for both the upper Haven and when transiting the barrier. Consequently, it is my opinion that any concerns expressed relating to the hydrodynamic impact of barrier transits, as opposed to current river transits, are unfounded.

**Slow Speed Control**

4.39 Consistent with the international regulations for the prevention of collision at sea (COLREG 6 – Safe Speed), and the guidelines issued in the Port of Boston Annual summary of notices to Mariners (No 14 – Speed limit), navigation in a narrow channel or fairway should be carried out at low speed through the water.

4.39.1 The speed should be sufficient to maintain control of the craft and, so far as practicable, maintained below the maximum of the craft so that, in an emergency, extra power is available to aid the rudder, if necessary.

4.39.2 Consistent with COLREG 8(a) - action to avoid collision - where a reduction in speed is required, should be made in good time and with due regard to the observance of good seamanship.

4.39.3 Control of a vessel depends on the efficiency of the rudder which in turn depends on the flow of water around it. The effectiveness of the rudder is therefore reduced when the engine is stopped. Putting the engine astern when the vessel is moving ahead can render the rudder ineffective at a critical time as the action of putting the engine astern reduces, negates or can reverse the flow of water over the rudder.

4.39.4 An effective strategy for maintaining control at slow speed is to reduce speed through the water to a minimum and momentarily increase propeller revolutions (which increases the water flow over the rudder) whilst at the same time using the rudder to maintain or change heading. This compound action (known as a "kick ahead") will significantly improve control of virtually any vessel (from the smallest R.I.B up to the largest merchant ship).

This is a well-known technique that would within the capability of any competent yachtsman or professional mariner, who is required to undertake vessel manoeuvring in confined waters and would, in my professional experience, be well within the capability of the Boston fishing fleet skippers, the Boston Belle and any of the small craft (including wide boats, narrow boats and powered yachts) that frequent the Haven.

**Turning**

4.40 As previously outlined, the ability of a vessel to turn depends on the vessel's dimensions, the shape of the hull, the power of the engine and the type and size of the rudder (see sections 4.3 - 4.25 of my proof). As a vessel starts to turn, it has a tendency to slide sideways through the water (see **Appendix 2**, **Figure 2**). This results from a build-up of water resistance (lateral resistance) which opposes the rudder force. The balance between rudder force and lateral resistance plays a significant part in determining the turning circle.

4.41 An improvement in a vessel's ability to turn can be made by slowing down prior to a turn and increasing engine power whilst making the turn, but see section 4.27 of my proof for comments on shallow-water turning performance.

4.42 The ability of a vessel to turn will be modified by the influence of any tidal stream or current present during the manoeuvre.

4.43 This has relevance in the present circumstances due to the proposed site of the barrier being located on a bend in the river. This location, however, does not make it unsafe for navigation, particularly when the dredging proposed as part of the Scheme is taken into consideration.

4.44 Per COLREG 9(f), mariners are aware that navigation on a bend requires careful positioning of the vessel prior to the turn and constant monitoring of the speed of the vessel and rate of turn during the turn. For further amplification on relevant COLREGS, see section 6 (below)

4.45 That 'cant' of the craft (sometimes referred to as the paddle-wheel effect) relates to the direction (to port or starboard) that the bow of the boat will begin swinging towards when the engine controls are set astern whilst a steady heading is being maintained when under-way in calm water. When the engine is put astern, as described, and the bow tends to swing the starboard, the vessel is said to act right-handed, or left-handed if the tendency of the bow is to swing the port. Experienced boat-handlers will use this principle to considerable effect when manoeuvring and turning their vessel.

4.46 Boat-handling skills that apply to modern power driven craft (of all descriptions) have been developed over many centuries and are frequently updated as new manoeuvring equipment comes into use. None of the information provided in this section should be unfamiliar to experienced boat handlers who choose to navigate in the Haven and, indeed, who have been doing so for many years, without issue. Paramount, with regard to boat handling and navigational skills, is the exercise of 'common sense' and application of the accumulated knowledge of the ages, generally referred to in COLREG 2 as the 'ordinary practice of seafarers'. Simple application of that common sense and the forethought that is expected as part of the 'ordinary practice of seafarers' would, in my opinion, render the barrier safe for all competent navigators. A robust passage plan (see section 5.1) would take account of any issues and allow new information or developments to be incorporated into the mariners' preparations.

## 5 Navigation in Rivers and Tidal Waters

### Passage Planning

5.1 Navigation in tidal waters is, by its very nature, potentially hazardous and, under current good practice, requires that a passage plan be made.

5.1.1 Under Safety at Life at Sea (SOLAS) Regulation 34 (see **Appendix 7**) the Maritime and Coastguard Agency (MCA) requires ALL mariners to undertake (and document) a careful assessment of any proposed passage taking appropriate account of all dangers to navigation, weather forecasts / tidal predictions and any other relevant factors that may occur, no matter how remote.

5.1.2 The MCA expectation is that Regulation 34 applies to small craft users who should adhere to passage planning principles when sailing in categorised waters such as the Haven.

5.1.3 Passage planning is part and parcel of the 'ordinary practice of seafarers' and failure to have such a plan in place would, in my experience, be construed as neglect with regard to those practices, as stated under COLREG 2(a) (see section 6.9 of my proof).

### Crew Competence and Skill levels

5.2 SOLAS Regulation 34 (referred to in 5.1.1 of my proof) also includes the requirement to realistically assess the competence of the crew with regard to qualifications and experience and to determine, with regard to the crewing, any limitations of the vessel. The competence of the crew, by international law, is one of the measures of 'seaworthiness' of a vessel. Failing any other standard of measurement, mariner competence is generally achieved by means of regulatory certification (whether RYA or STCW) and provides a basic standard for proving the experience and practical competencies of mariners. Under STCW, a mariner cannot achieve certification without having first provided evidence of qualifying sea-service.

5.3 Inshore fishermen may be regarded as both experienced and skilled and it could be reasonably assumed that they have been examined by the appropriate statutory authorities and are sufficiently versed in the ways and rules of the sea (including having a working knowledge of the COLREGS) and are deemed competent within their particular sphere of operation. Fishing is a purely commercial activity and local knowledge of the area is crucial for fisherman to be able to make a profit. It is therefore entirely reasonable to assume that local fishermen (as in Boston) have a high degree of local knowledge and are intimately attuned to local tides, currents and navigational practices. Information on any changes that occur in the Haven from one season to another will be readily available from the Harbour Master department and acquisition of this information should be sufficient to inform the seasonal boatmen on any developments that they should have in their consideration when planning a passage through the Haven.

5.4 There are no mandatory qualifications for the master of vessels less than 16.5m registered length, although mariner prudence often dictates that the more capable and competent may have elected (for their own safety and security) to obtain a Skipper certification which is equivalent to an RYA yacht master coastal certificate which is relevant for commercial vessels operating up to 20 miles offshore.

5.5 Inshore Skippers will have a good knowledge of boat handling, coastal navigation and meteorology and will have the skills to take charge a fishing vessel in very challenging conditions throughout any part of the year for which their certification (or any limitations thereon) is relevant.

5.6 Commercial tour boat skippers are experienced and skilled mariners and, as a rule, must prove a certain degree of qualification in order to obtain relevant operator insurances.

5.7 Skippers of small passenger vessels under 24 metres and carrying more than 12 passengers must hold a Boatmaster Licence issued by the MCA. This basic certification will stipulate the limitations that apply, for example limitation for use in inland waterways, tidal waters or up to 5 miles offshore. To qualify for the MCA Boatmasters Licence, skippers must demonstrate (under examination conditions) a broad range of professional maritime skills and knowledge including safety training (certification), boat handling and local knowledge.

5.7.1 Following discussions with the Master of the Boston Belle (please see **Appendix 2, Figure 4**) I was left in no doubt that his knowledge of the Haven, the tidal ranges and any seasonal or meteorological influences that might alter what could normally be expected and the resultant effects on the navigability of the rivers were well considered and certainly within his navigational capability.

5.8 There are no mandatory qualifications for privately owned leisure boat skippers. However, the competence and skill levels expected by the MCA (see 5.2 – 5.4 above) of yachtsmen and leisure boat owners in tidal waters are those equivalent to the RYA Day Skippers Certificate. Those conducting and commanding private pleasure craft should have a knowledge of pilotage, boat handling, seamanship and navigation, sufficient to enable the skipper to take charge of a small yacht in familiar waters during daylight hours. The more experienced and competent yachtsmen and leisure boat owners, if for no other reason than their own safety and for obtaining cheaper insurance, may hold RYA qualifications which attest to their knowledge and competence in excess of that required at day skipper level.

5.9 It is my experience (as a provider of boat-operator training courses) that those who obtain Boatmaster Licences do so due to commercial pressure. The costs (in terms of courses taken and, in many cases, the lost earnings from having to take time off work to undertake the relevant courses) means that boat operators cannot afford to fail. I have never encountered a boat operator (who was required to take the course) who did not contend that they had far more experience than was necessary (or had to be demonstrated) to hold the qualification and on this fairly general basis I would expect experienced boat operators who do not hold a formal qualification to, at least, have equivalent experience

5.10 Summarising this section;

5.10.1 The Haven is a waterway that is connected to the sea, therefore navigable by seagoing vessels (COLREG 1(a), **Appendix 1**). Consequently, international law in the form of the SOLAS regulations and the COLREGS (see section 6 of my proof) apply with regard to navigational safety and competence levels for mariners.

5.10.2 Given that there are no exceptions in mariners' obligation to observe navigation regulations (see section 5.8 above and section 6.2 below) it would be reasonable to expect that mariners and boat operators operating on the Haven were both experienced and qualified to prescribed minimum standards, consistent with the obligation to navigate safely.

5.10.3 Regardless of any requirement to hold Boatmaster qualifications, COLREG 2 (see **Appendix 1**) stipulates that: 'Nothing in these rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any neglect to comply with these rules [COLREGS] or of the neglect of any precaution which may be required by the ordinary practice of seamen, or of the special circumstances of the case'.

5.10.4 International law, therefore, anticipates a degree of competency consistent with 'the ordinary practices of seamen' from those handling any craft that may be encountered when navigating on the Haven.

5.10.5 Additionally, COLREG 2(a) anticipates that 'special circumstances' may be met and dealt with by observing the rules. This 'special circumstance' would, within the meaning of the rules, be applicable to the proposed flood defence barrier on the Haven.

5.10.6 Having regard to these matters, it is my experience there is nothing that may be construed as part of the proposed barrier project that should be beyond the navigational or boat handling competencies of any mariner who chooses to navigate on the Haven. Further, given the requirements of both UK and International law, there is an obligation on all mariners to ensure that they are competent to handle their craft in any conditions that they choose to take their craft into. Therefore, it is entirely reasonable assume that any mariner navigating through the proposed barrier is capable of doing so and as such, nothing that is proposed as part of the barrier project should be beyond the boat handling competencies of any mariner navigating on the Haven.

## 6 International Regulations for Preventing Collisions at Sea 1972 (COLREGS)

6.1 The relevant sections of the International Regulations for the Prevention of Collisions at Sea (the COLREGS) are attached as **Appendix 1**.

### Application of the COLREGS within the Haven

6.2 COLREG 1(a) (at **Appendix 1**) stipulates that the rules for safe navigation shall (not 'may', but 'shall' – there is no exception) '*apply to all vessels sailing upon the high seas and in all waters connected therewith navigable by seagoing vessels*' [emphasis mine]. For the sake of clarity, within the Haven and within the context of the proposed barrier project, there are no vessels, no mariners and no navigational situations that are not covered by the COLREGS.

6.3 Contravening the COLREGS is a criminal matter and serious breaches resulting in accidents may give rise to prosecution by the MCA. In such instances, offenders are interviewed under caution with a view to initiating legal action. Consequently, it is a rare occasion when mariners disregard their obligations under the COLREGS.

6.4 For the avoidance of doubt, regardless of whether the barrier is there or not, the COLREGS always apply in the Haven and any connected waters. The barrier and any associated works is nothing more than a 'special situation' that is anticipated within the meaning of the COLREGS. There is nothing new or unusual in citing their application in the present context.

6.5 This applies to all vessels sailing upon the high-seas and in all waters connected, therewith navigable by seagoing vessels. In the same way that motor-traffic regulations apply to all road user, without exception, there are no exceptions to the obligation to observe collision regulations at sea, regardless of whether the mariner is a professional seafarer or an amateur leisure user.

6.6 The COLREGS apply to all mariners in charge of any vessel intending to navigate through the barrier or the cofferdam-passage during the construction-phase. Within the meaning of the COLREGS, there are no exceptions to application of the rules, regardless of whether those in charge of vessel are professionals, amateurs or leisure users. All mariners, irrespective of experience or qualification, have the same absolute obligation to comply with the rules.

6.7 With mariners following these rules, even when rounding the bend with the barrier as anticipated in the scheme of works - a scenario specifically contemplated in COLREG 9(f) (See **Appendix 1**) – the barrier, should present little, if any, difficulty to experienced mariners such as those within the Boston fishing fleet, commanding the Boston Belle or any other boat handler who frequents the Haven (see 5.2 – 5.9 above).

6.8 Generally, the COLREGS are sufficient to deal with any known, anticipated or unanticipated navigational risks - COLREG 2(b) unusual situations as 'special circumstances', one of which, is not alluded to until COLREG 17 - the 'errant mariner'.

6.8.1 Whilst the rules assume navigational practices of the ordinary seafarer exercising common sense and complying with the rules, as with any scenario where people are involved, not everyone takes appropriate action as required by the rules. Discussing the matter with stake-holding objectors, a comparison was drawn with road users who, despite the obvious dangers of errant driving, may not always observe the Highway Code and, therefore, represent a risk to both themselves and other road users.

6.8.2 COLREGS 17(a)(i) and 17(b) (see **Appendix 1**) alights on this possibility in the maritime scenario and prescribes actions for 'stand-on' vessels in such circumstances. The barrier and construction-phase cofferdam, however, are immovable and errant mariners (irrespective of whether they are allowed for in the COLREGS) may pose a risk to the barrier, the cofferdam and those working inside it.

6.8.3 The very occasional errant mariner is a fact of life at sea (as are errant drivers on the roads). The NMP takes into consideration the prospect of errant mariners. To deal with the issue, NMP incorporates a range of measures (include chamfering of the upstream and downstream corners of the cofferdam, locating appropriate fendering, illumination, navigation marks, pre-warning signage and a safety workboat for the construction phase) that will, so far as is reasonable, mitigate the risks from errant mariners.

6.9 Should there be any question or doubt as to the primacy of international law and the express obligations of vessel operators within any of the scenarios envisaged in relation to the barrier, simple reading of COLREG 2(a) stipulates "nothing in these rules shall exonerate any vessel of the owner, master or crew thereof of the consequences of any neglect to comply with these rules". This simple principle should be uppermost in the mind of anyone who is unsure as to what responsibility they have in relation to transiting the barrier (see 6.6). The reason for this is that (per COLREG 2) "in construing and complying with the rules due regard should be had all dangers of navigation, and any risk of collision, and of the special circumstances of the case, which, as pointed out at 6.8 (above) anticipates unforeseen, unexpected and residual risks, and even contemplates the possibility of an errant mariner.

6.10 There are no exceptions to the rules, as is made clear at 6.6 (above).

6.11 Given the primacy of the COLREGS and that they anticipate any navigational situation, strictly speaking, the NMP represents something of a 'belt and braces' approach to supplementing safety of navigation around the barrier and proposed works.

6.12 Any imperative with regard to navigational safety when transiting the barrier remains with the master of the vessel and it is up to them to ensure their own safety and to give due consideration to all other craft that they are navigating in close proximity to. Apart from that, it is my opinion that the NMP is sufficiently robust to minimise or negate any residual navigation risks.

6.13 Safety of navigation is the preserve of the individual mariner and that has always been the way of the sea. Taking all factors into consideration, I consider that the proposed barrier channel is inherently safe for through traffic and the COLREGS prescribe sufficient control mechanisms to allow vessels to proceed safely - providing the common-sense and prudence expected of a mariner is observed.

## 7 Port Navigational Control and Safety Measures

### Port Marine Safety Code (PMSC)

7.1 Notice 21 of the Port of Boston Annual Standing Local Notices to Mariners (No 21: General) expressly states that the Port of Boston complies with the Port Marine Safety Code.

7.2 To comply with the PMSC, the Port of Boston is required to have robust and properly managed systems in place to assess a range of risks and to put control or mitigation measures into action where dangers to navigation, infrastructure or other relevant, safety related concerns do, or may, exist.

7.2.1 The Port of Boston is designated the Competent Harbour Authority (**CHA**) and, statutorily, the Harbour Master (**HM**) is the position in whom Crown Authority vests with regard to navigation.

7.2.2 Within the meaning of the COLREGS the HM has authority to govern and direct navigation in all areas designated as the Port of Boston. This includes all tidal areas from the Grand Sluice down to the seaward extremity of the port.

7.2.3 The HM authority to control navigation may also extend beyond Grand Sluice, however this would depend on whether it is deemed to be part of the Port of Boston.

7.2.4 The Port of Boston certainly incorporates the Haven and the proposed project site.

7.3 Having discussed the Port of Boston PMSC, it does not currently include the barrier or any works associated with it as they do not currently exist and, until they do, an appropriate risk assessment cannot be carried out. This is anticipated by the HM, but until the barrier or construction works actually exist, he cannot adequately assess the safety impact on the port and its infrastructure.

7.4 The area that may be subject to navigation restrictions related to the scheme extends over a distance of approximately 630 m, from Geest Point to the swinging railway bridge, and is only a small part of the whole port area to which the PMSC relates.

7.5 The principle underpinning any risk based approach to safety of navigation is that risks should be identified at an early stage and the likelihood of the risk becoming a reality evaluated in context, thereby allowing problems to be anticipate and either mitigated or controlled. This type of pre-planning has already been alluded to in relation to 'passage planning'.

7.6 Consistent with adhering to the PMSC commitment and the COLREGS (**see Appendix 1, 1.12 – 1.14**) the Port of Boston Annual Standing Local Notice to Mariners No.14 (see Appendix 3 to the proof of Gillian Watson (**EA/4/2**)) complies with its obligation to regulate the speed limit (see **Appendix 2, figures 3 & 4**) within the Haven and, further states that the Harbour Authority may monitor the speed of vessels and that if the Harbour Authority considers excessive speed is causing a hazard to navigation will take necessary action.

7.7 Transit through the construction-phase cofferdam passage or the post-construction barrier passage are navigational matters that ought to be in the contemplation of any competent mariner who thinks ahead or a visiting mariner with an adequate passage plan. Whilst it is the boat-handling skills that are vital to actually achieving the passage, a proper and pro-active passage plan will continually look ahead, so that it is regularly supplements the plan with new information, consistent with the ordinary practices of seafarers (COLREG 2(b)), so that that it accommodate passage of the barrier. The PMSC and port operational plan should allow for promulgation of appropriate navigational warnings as part of its safety management strategy. Thus, the location of, and any navigational restrictions associated with, the barrier should never come as a surprise to mariners.

7.8 The construction and operation of the scheme and any perceived additional navigation risks associated therewith would, under SOLAS (passage planning) guidelines, be addressed in a proper (that is, fully inclusive) passage plan. Therefore, transiting the Boston barrier (either during or post construction) provided certain common sense measures are followed (in compliance with the normal seamanship practices (per COLREG 2(b) – **Appendix 1**) should not be an unexpected event or come as a surprise during a properly planned passage and neither should it come as any surprise to a mariner acting as required by the Annual Summary of Notices to Mariners (see Appendix 3 to the proof of Gillian Watson (**EA/4/2**)).

7.9 For a competent boat-handler (and that includes everyone who would normally navigate on the Haven (see sections 5.1.1 – 5.1.3), navigating the new barrier should not present any significant or unexpected navigational risk as all potential risks are predictable and should be both anticipated and prepared for.

## 8 Navigation and Associated Issues

### 8.1 Port of Boston and the Haven – General Navigation

8.1.1 The Haven is the tidal section of the River Witham between the Wash and the Grand Sluice. The river is open to the Wash at the outer end of the New Cut, but at the inner end of the Haven navigation is controlled by navigation locks at the Grand Sluice and the Black Sluice. The Port of Boston (PoB) is located approximately half way along the Haven

8.1.2 Leisure traffic on the Haven is generally governed by the weather, with the local adage being 'sun out, leisure boaters out'. Please see Gillian Watson's proof (**EA/4/1)** for a more detailed description of the Haven and its commercial and seasonal traffic patterns.

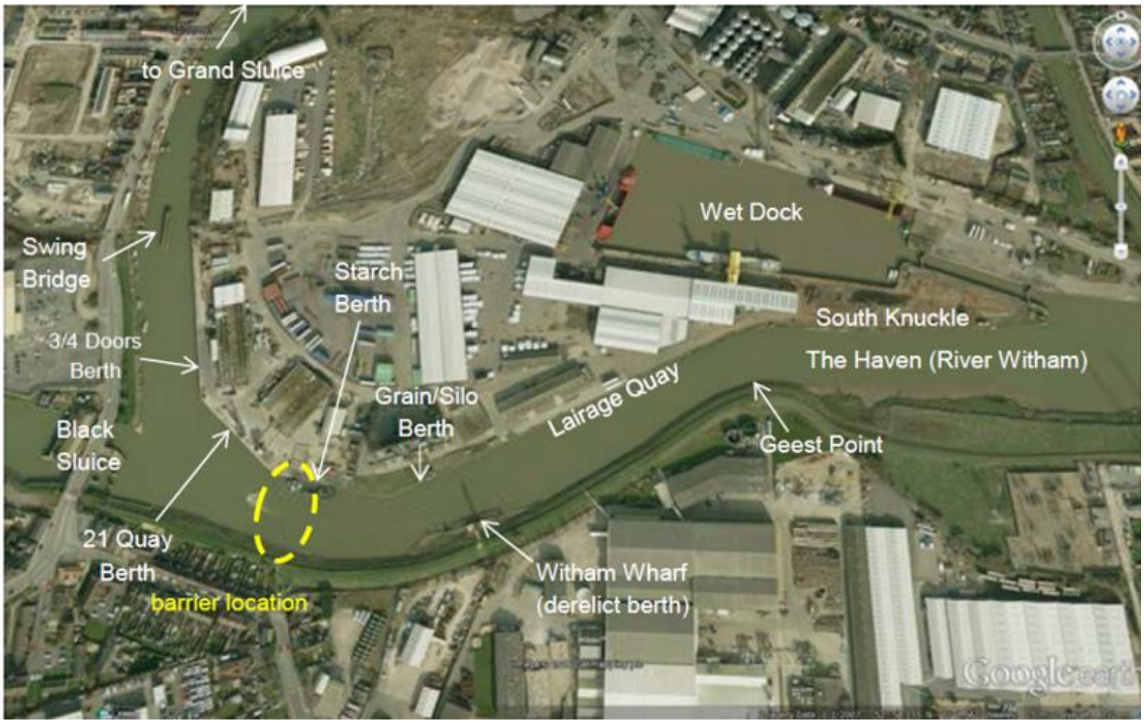
8.1.3 The River is called the Witham above the Grand Sluice and below the sluice, where it is tidal, it is generally known as the Haven. For the most part, the River Witham fed from the Lincolnshire fens (see Appendix 2, Figure 1) and water flow in the river is both seasonal and dependent on rainfall. It should be noted that there are certain conditions (Low Water spring tides, when the Haven virtually dries out, or High water spring tides, or when there is a storm surge and vessels cannot get under fixed bridges) where navigation in the Haven becomes virtually impossible due to meteorological and water-level factors (see **Appendix 2, Figures 6, 7 & 8**)

(a) The Harbour Master and the pilots confirmed to me that the tidal cycle in the Haven is considered to be symmetrical, that is, the flood and ebb tides are of roughly equal duration. The lock keeper at Grand Sluice (Mr Michael Moran) agrees that the tidal cycle in the lower Haven (in the area of the wet dock) is symmetrical, but advises me that at the Grand Sluice the tidal cycle is asymmetrical, that is, the flood tide lasts for 5 hours and the ebb tide (due to the modifying effect of fresh water outflow from the sluice) can last for up to 7 hours. The skipper of the Boston Belle (Mr Rodney Bowles) independently of the Grand Sluice lock keeper affirmed this dual tidal pattern in the Haven. This tidal data is consistent with tidal graph presented in the evidence of Sun Yan Evans (**EA/2/1**) (Figures 4, 6 & 7: Water Velocity v Tidal curve at different locations and conditions)

(b) It is common knowledge to any mariner (and available from any set of local tide tables) that the time of High Water advances daily (over the normal twice daily tidal cycles) from anywhere between 20 minutes to 40 minutes.

(c) In order to understand the various potential risks at issue, I have found it helpful to have both an (aerial) overview of the Boston port area and an understanding of the water-flows and silting / mud build-up within area and approaches of the proposed barrier. The diagram (below) has been particularly helpful in helping me to describe the issues, in particular, those relating to water flow.

8.1.4 The existing channel at the proposed barrier is located on a bend in the river where (as required by COLREG 9(f) (**Appendix 1 (1.27)**) mariners are expected to navigate with particular caution, exercise good navigation and seamanship skills and proceed at a safe speed.




*Aerial view of the Port of Boston, showing the relevant points, quays and proposed barrier location. (Source: Google Earth, December 2007)*

8.1.5 In practice, the considerations associated with any tidal / fluvial river bend are complicated in this situation, before the construction of the barrier, due to the regular practice of grain ships mooring grain/silo berth, so that they protrude extensively into the navigable fairway (see **Appendix 2, Figure 9**). In practice, this has the effect of reducing the navigable width of the channel to approximately 24 m and significantly reducing the sight-lines for vessels navigating either side of the bend. The current situation is further complicated by the derelict 'Witham Wharf', located on the south bank, which has an extensive mud accumulation around the base (and underwater) in the immediate location of that berth.

8.1.6 At present, this dual complexity, which both restricts the navigable width of the channel and introduces a significant reduction in sight-lines for vessels navigating both inbound and outbound, is taken for granted as being simply a part of the operational nature of this district and does not presently represent an insurmountable obstacle for mariners navigating the Haven through the town of Boston.

8.1.7 From the charts and simulations, I noted extensive mud accumulations seaward of Geest Point, on the south side by way of Witham Wharf and, on the south bank, inward of Black Sluice. As a result of mud accumulation, there is very little space to the west of the swing bridge and vessels passing through the bridge are required to pass very close to the wooden piling of the swing bridge. The gap to the east of the swing bridge piling is completely unnavigable, being extensively silted up (see **Appendix 2, Figure 7**). Additionally, there are also hanging electric cables in the channel at this point, making any attempt to transit that gap significantly more dangerous. Having personally witnessed the mudbanks from the area located approximately 1.5 km below the wet dock (the proposed temporary location of the Witham Sailing Club (**WSC**)) and all the way up to Grand Sluice at several times during a Spring-tide cycle, I am satisfied that the representation on the HR Wallingford simulator is a fair reflection of what really exists. (Further information is available from the evidence of Gillian Watson) (**EA/4/1**).

8.1.8 Essentially, only parts of the Haven are navigable, and then only with local knowledge of the changing mud banks. At certain states of the tide, I am advised from 2 hours before to 2 hours after low water, the river is unnavigable to fishing vessels, private craft and commercial ships (see **Appendix 2, Figures 6 & 7**). Following a lengthy discussion with the Port of Boston Harbour Master and the Skipper of the Boston Belle, they assured me that when the water was low, and navigation was only just feasible, the navigable width of the Haven was barely half (less than 28 m) that which might be expected when the water was high (see **Appendix 2, Figure 10**).

8.2 As a Master who has previously been required to make assessments of unknown rivers prior to navigating them with loaded merchant ship, and using the skills required in order to carry out that assessment, I surmised that on the flood tide, water funnelling through Geest Point would have a slightly higher than average velocity (for that part of the Haven) which would then reduce as it entered the wider part of the Haven (on the approaches to the proposed barrier site). The nature of water is that it will flow towards the outside of a bend, in this case the south side, and will tend to scour that part of the river and naturally maintain the depth without the need for dredging.

8.2.1 I rationalized (from experience) that Inward of the Black Sluice, as the river turns to the north, where it then narrows significantly shortly before the location of the swinging bridge is approached (to the west of the bridge support piling). Water exiting from Black sluice, on the south bank, has the effect of diverting both flood and ebb-tidal flows away from the south bank, towards '21 Quay berth'. The resulting effect of this flow modification is that mud presently builds up on the south bank, partly silting the location of the proposed barrier. My expectations are consistent with the data included in Sun Yan Evans (**EA/2/1**) evidence and as modelled on the HR Wallingford simulator.

8.2.2 Generally, as an experienced ships Master, I concluded that water flows through the Haven are as I would expect on a normal river, save that where the flow is modified by the inflow of Black sluice and the mud accumulations take place on the opposite side to where they may be naturally expected. In my opinion, this would be more likely to catch out an unwary mariner than would the altered (scouring flows) through the proposed barrier passage.

8.2.3 From the navigational perspective of an experienced mariner, the barrier is likely to have the effect of making the flood and ebb flows take a more natural path around the outer extremity of the bend in the river. In my opinion, the consequential benefit of this altered water flow is that it is likely to improve the sight-lines for craft navigating rounding the bend (through the barrier) and not cutting the bend (to find the deep water, as at present). Thus, they will get earlier warning of ships tied up on Lairage Quay or anything protruding out into the river.

8.2.4 My assessment of the water-flows in the Haven (as described at sections 8.2.1 to 8.2.4) - undertaken from the viewpoint of someone who has not navigated in river for a number of years – is that this was a useful exercise in demonstrating that it is possible for a transient vessel operator, using the common sense required by ordinary practice of seafarers (as required by COLREG 2(b), acting without prior knowledge, to make an reasoned assessment of risks to water-flow and associated navigational issues. My subsequent discussions with the Haven Pilots and some of the seasonal boatmen who operate on the Haven validated my assessment. I am, therefore, further convinced that it will be possible to navigate the proposed barrier using the common sense, vessel handling and navigational skills that are expected of the ordinary mariner.

## 9 Modelling and Simulations

9.1 My Haven simulation runs took place at the HR Wallingford simulator on 22nd February 2017. The simulated vessels used in this instance are as detailed in the following table.

| BOAT MODELS USED FOR SIMULATION RUNS | | | | |
|---|---|---|---|---|
| VESSEL | LENGTH | BEAM | DRAFT | Comments |
| | (All Dimensions in mtrs) | | | |
| Boston Fishing Boat | 14.0 | 6.0 | 1.8 | 90t Displacement with 164Kw power (220 hp): Power / Weight ratio = 2.45<br>L/B ratio = 2.3 Directionally unstable. |
| Boston Belle | 15.5 | 5.0 | 1.1 | 52t Displacement with 75kw (100hp)<br>Power/Weight ratio = 1.92<br>L/B ratio = 3.1 Directionally unstable. |
| Narrow canal boat | 22 | 2.1 | 0.5 | L/B ratio = 10.5<br>Directionally very stable |
| Wide beam canal boat | 22 | 3.3 | 1.0 | L/B ratio = 6.7<br>Directional stability, neutral. |

9.1.1 The craft handling that I did not simulate were those of the British Motor Yacht Club (**BMYC**) and Witham Sailing Club (**WSC**) yachts and motor craft. However, given the performance of those that I did simulate, and the conversations of regular Haven users who have the opportunity to test them in the simulator (one operator reporting that his craft was easier to operate in reality than in the simulator), and based on my own experience of those craft I did not simulate, I believe I can be reasonably confident that those simulated craft are reasonably accurate representations of the real craft.

9.1.2 In the case of the craft that I did simulate, once I was satisfied that I was happy with the operation of the simulator controls (and at least as familiar as an experience pilot would be on those craft), I insisted that, following a test run, I should undertake simulation runs under the worst-case scenarios that had been prepared. My rationale for this request was the possibility, however remote, that an unfamiliar (with the district) mariner should find themselves navigating the construction cofferdam gap or the post-construction barrier passage.

9.1.3 Aside from carrying out repeated runs through the three simulation databases (see the evidence of Gillian Watson (**EA/4/1**)) I drew on my personal knowledge and experience of these types of craft to consider the handling accuracy of the simulated vessels. In my experience, notwithstanding slight draft, trim and power differences, I found the simulated vessel performance and handling to be comparable to what might reasonably be expected to be experienced with real vessels.

9.1.4 At the time of writing, I have very recently returned from the Haven, River Witham (above Grand Sluice), Port of Boston offices, the port, Harbour Master and pilots. I have familiarised myself with the port, the riverside quay, dredger (Mary Angus) and a work boat and coxswain was laid on for me to experience the port and river from the water.

## 9.2 HR Wallingford Simulator Configuration

9.2.1 HR Wallingford has developed simulation databases for three scenarios (baseline, cofferdam and post - construction) based on drawings and environmental data supplied by Mott MacDonald (please refer to Gillian Watson's proof (**EA/4/1**) for additional details).

9.2.2 I noted that the simulator used for the Boston Barrier simulation was configured to provide accurate bathymetry, representative visuals and a variety of modelled tidal/current flows of the Haven. Having very recently transited the Haven (see 9.1.4) the visual representation (apart from my observations at 9.2.3) was accurate enough to familiarise me with the Haven before I visited and the fresh water flow modelling (there was water coming through Grand Sluice) and incoming tidal set were consistent with what I encountered. During my conversation with the Port of Boston Harbour Master and, later, with the Haven pilots, each confirmed (independently of the others) that they thought HR Wallingford had 'got it about right' in respect of the modelled water flows, and thought the simulator compared with what they encounter in reality.

9.2.3 The simulator presents a 2D image, therefore judging distance is more difficult than I experience in my daily work as a pilot. Consequently, I noted an increased tendency to rely upon electronic position fixing instruments (and the electronic chart) to improve my spatial awareness and gain a more accurate appreciation of distance. Eventually, with increasing confidence in the visual representation, I resorted to my habit as an experienced pilot (and trainer of pilots) and felt, with some confidence, that I could start to rely upon the visual output. To some extent, given the distortion of visual reality, the simulations represent a worst-case exercise as visual acuity is less than accurate.

9.2.4 I have significant experience with different types and manufacture of simulators acquired in association with a number of training providing establishments throughout the UK Additionally, I have been engaged by simulator designers to comment upon the realistic (or otherwise) performance of vessels modelled within these simulators. I have also extensively commented upon the differences between simulation and real pilotage situations in a variety of still water and tidal situations and have often noted that some simulators perform (both in terms of graphic output and vessel handling characteristics) better than others.

9.2.5 It is my considered opinion that the HR Wallingford simulator provides a reasonably accurate representation of the vessel-related water dynamic that I have experienced in reality with the four types of vessels that I conducted during the simulations. In view of these findings, I am confident that this simulator represents a useful facility for enabling assessment of risks and aiding in developing navigation and risk mitigation strategies for the Boston Barrier Scheme.

**Construction Phase - Simulation**

9.2.6 The simulation study that I took part in allowed me to satisfy myself that, within the scope of normal seafarer boat-handling skills, it is safe to navigate each of four vessels types tested (see section 9.1)) through the cofferdam bypass channel during construction of the barrier. Simulations were carried out under a full range of conditions developed by HR Wallingford for testing. For my part, I insisted that we re-run the simulations with the strongest expected tidal flows astern of (that is, pushing ahead, so adversely affecting the manoeuvrability of) the various craft being tested.

9.2.7 In most conditions, I was satisfied that safe navigation through the 18m wide cofferdam bypass channel was possible with even basic boat-handling skills and the application of common sense and prudence that is generally attributed to skilled and competent boat-handlers.

9.2.8 I qualify my observation at 9.2.7 (above) for two sets of conditions: the first of those being on a full-flood spring tide following an inward bound vessel and the second being for an outward-bound vessel experiencing full-ebb conditions with the addition of maximum fluvial flow. In my experience, these conditions are potentially manageable through both the cofferdam bypass channel and the barrier, but with the narrower channel in the cofferdam (18 m during construction, as opposed to the 25m channel through the barrier) the vessels - particularly short narrow (directionally unstable) vessels such as the fishing boats - handled a little less surely and perhaps more skittishly - requiring the slowest possible approach and judicious ‘kicks’ ahead on the engine to maintain both position and steerage.

9.2.9 The direction of current through the construction-phase cofferdam bypass channel entered and left the channel at an oblique angle, instituting a tendency for the craft to transit the gap and set to one side or the other, and requiring careful observation and compensation. This ‘set’ is partly due to the water flowing out of Black sluice and pushing the flow to the north east and is consistent with both the water modelling provided in the proof of Sun Yan Evans (**EA/2/1**) and correlates with the statements made to me when I visited the Port of Boston. A further observation was that there was a mud deposit on the north side of the cofferdam channel.

9.2.10 Whilst the construction-phase cofferdam channel is the more challenging in the worst conditions, due to the following currents and tidal flow causing the vessels experience an increase in speed over the ground and a noticeable set towards the north wall in each case, careful pre-positioning and alignment of the vessel prior to transiting the gap ensured that passage was carried through without any mishap.

9.2.11 Whilst transit with a following flow is achievable and requires earlier and more considered preparation, transit through the cofferdam channel whilst stemming the flow was noticeably more controlled, with ground speed being reduced (due to the flow from ahead), and all vessels were able to transit successfully and without event.

9.2.12 From the simulations, it is my conclusion that two-way navigation through the cofferdam channel is possible for the smallest vessels (i.e. small sailing boats) during an ebb tide, but that the fishing boats and the Boston Belle should be restricted to single vessel transit in all tidal conditions. Further, due to the more 'skittish' manoeuvrability in the following (water coming from astern) high-flow conditions, I would recommend against directionally unstable craft making the cofferdam transit (either inward or outward). However, should vessels insist that they will navigate through the cofferdam with the water flow from astern (that is, with inbound vessels navigating on the flood tide and outbound vessels navigating on the ebb, and with fluvial flow), I would suggest that such a manoeuvre should only by carried out by prior arrangement – so that the work-force can be removed from the cofferdam, and that it is clearly understood the transit is carried out with the vessel involved assuming all risks and consequences – consistent with COLREG 2(a).

9.2.13 Construction phase mitigation plans will, if complied with, effectively remove any need for fishing vessel transits as it is planned that they will be offered relocations to temporary berths on the Lairage Quay (see NMP). Strictly speaking, the proposed fishing vessel relocation is not necessary for safe navigation (bearing in mind that all navigational risk vests with the vessel) but it would eliminate any residual risk that would otherwise arise from fishing boats passing through the cofferdam channel.

**Post Construction Scenario - Simulation**

9.2.14 The simulation study for the post construction phase entirely satisfied me that, within the scope of normal seafarer boat-handling skills, it is safe to navigate each of four vessels types tested (see 9.1) through the 25m wide navigation channel located to the south side of the Haven. Part of my reason behind this conclusion was that both the inward tidal flow and the outward ebb and current aligned with the direction of the navigation channel, effectively drawing vessels into the centre of the navigable passage and away from the barrier side. This aspect of water modelling is entirely consistent with what I experience on a regular basis when navigating on the Manchester Ship Canal (**MSC**) following heavy rainfall events (NOTE: The MSC is the main drain for the western Pennines and can experience very significant sluicing flows). As the vessel exited the gap, the sight-lines were noticeably better than for a vessel currently navigating the bend, where the deeper water is to the north, near 21 Quay (see **Appendix 2, Figures 8, 15 & 16**). At no time did I record any issues with any of the vessels during these test simulations.

9.2.15 From my discussions with the project engineer (Mr Peter Mallin) I am informed that a further feature of the water flow through the post-construction barrier is that the water (both inflow and outflow) acts to continually scour the river bottom inside the barrier gap, so maintaining a clear channel (devoid of mud deposits) at all states of the tide (see **Appendix 2, Figure 11**).

9.2.16 Channel clearance will be achieved by the inclusion of crenulations constructed into the barrier structure to ensure that the scouring action is always maintained when there is water flowing. This represents a significant improvement on the extensively silted-up shores of the Haven that currently exist and will, in my opinion and experience, make transiting the new barrier one of the safest and most predictable navigational acts that is capable of being carried out in the Haven.

9.2.17 As a control exercise, additional transit simulations were carried out. In this exercise, fishing vessels (rafted together) were moored alongside Lairage Quay in the position anticipated for them from the NMP. This proved successful in demonstrating that transiting the barrier can be achieved without difficulty and that the fishing vessels came into view in sufficient time to make an assessment of what the vessels are and what they are doing. Further, this exercise demonstrated that, when exercising normal prudence, the sight-lines are sufficient to permit pre-emptive collision avoidance manoeuvres, should they ever prove necessary.

9.2.18 From a water flow perspective, these simulations showed a tendency for all craft approaching the barrier to be drawn towards south (outer edge) of the bend, as might be expected, but as the vessel closed upon the barrier gap, water flow did, in fact, align with the barrier direction ensuring that the streamlines of the flow match the course to steer by transiting craft.

9.2.19 The prudent boat-handler should always monitor set, drift and position on approaching the barrier. As I have explained, these navigational practices should be well within the capability of a competent skipper navigating in familiar waters or the skills that may be anticipated from visiting mariners who are conversant with basic river navigation techniques.

9.2.20 In every scenario run on the simulator, it was apparent (and consistent with my regular ship handling reality) that key to any successful manoeuvre is basic speed control and forward thinking.

9.3 **Navigational Risks**

**Navigational Safety – Width**

**Present Situation – Navigable Widths and Sight Lines**

9.3.1 The existing river width at the Haven at the proposed barrier location is 56 metres, although, due to shallow water on the outside of the bend, the navigable channel will vary depending on draft and the state of the tide.

9.3.2 The navigable channel width at the barrier will be 25 m. This equates to that currently available when ships are berthed alongside the Silo berth port side and, for operational reasons, find it necessary to overhang the berth by as much as 25 m (please see **Appendix 2, Figures 9, 16 & 17** and refer to Gillian Watson's proof (**EA/4/1**)) or the limited width encountered at Geest Point when ships are berthed on Lairage Quay – which is also on a bend.

9.3.3 During present operations, the situation at the Silo berth creates a hazard for outward bound vessels that may not be aware of the presence of the ship until they are abeam of 21 Quay berth and may potentially be affected by the current setting them onto the ship.

9.3.4 Inward of Black Sluice, the river narrows very rapidly, and as a vessel approaches the swing bridge the navigable width is significantly reduced as the channel to the east side of the bridge becomes unnavigable at any state of the tide due to the presence of mud. To the west side, the navigable channel is mostly confined to approximately 2/3 of the width on the side of the wooden piles that support the swing bridge (see **Appendix 2, Figure 6**). The rest of the channel west of the bridge piles, and towards the shore has extensive accumulations of mud.

9.3.5 Inward bound, beyond the railway bridge, lies a series of 3 concatenated bends (please refer to Gillian Watson's proof (**EA/4/1**) for additional details), the widest of which is 32 m, and which represents a further significant restriction to the inflow of water as these bends contain significant quantities of deposited mud, making them unnavigable for a significant period during each tidal cycle. There are often small craft moored along the banks in this area and sometimes rafted-up alongside one another - thus reducing the navigable width further. Yet, in the current situation they are not considered to be a significant restraint to navigation, and neither is the limited sight-line for boat-handlers as, in negotiating these bends, they are required to complete the turn of one bend without straightening up and having clear sight of the next bend before commencing the turn into it.

9.3.6 My assertions (made from the viewpoint of a practical mariner) with regard to objections concerning water-flow problems and the likely impact on navigation through the barrier - as opposed to water-flow navigational restrictions inward of the swing bridge - which I consider to be of more relevance to vessel operation in the Haven, are supported by the modelling carried out and reported upon in the evidence of Sun Yan Evans (**EA/2/1**).

9.3.7 It is my considered professional opinion that, in view of the guaranteed width and the depth water that will be assured through both the barrier (post construction) and through the cofferdam navigable channel (during construction), it is the navigable restrictions represented by the concatenated bends inward of the railway bridge, and toward the Grand Sluice, that will, for most practical purposes, determine navigation in the Haven and River Witham for inland vessels navigating to and from the Wash - rather than any restriction anticipated, or imagined, as a result of the flood defence barrier project (please refer to Gillian Watson's evidence (**EA/4/1**) for additional details).

**Sight lines**

9.3.8 Sight lines around the barrier may not be ideal, but they are certainly no worse than those presently experienced when attempting to round the bend when a vessel is protruding off the Silo Quay and extending anything up to 25 metres into the main fairway – thereby limiting both line of sight and navigable width – neither of which currently pose a problem for navigation (see **Appendix 2, figures 9, 16 & 17**).

9.3.9 Notwithstanding the control measures, ALL mariners navigating in the Haven have a strict obligation under the COLREGS (Rule 9(f)) when approaching a bend or area of a narrow channel where other vessels may be obscured by an obstruction, to navigate with particular alertness and caution (see section 6.6 of my proof and COLREG 9(f)).

9.3.10 It is my opinion, based on the simulations, that the barrier will present a known quantity, requiring outbound vessels to navigate further to the south, and in water that is clear of mud deposits all the way across, and so actually improve the sight lines and give earlier warning of vessels on the Silo Berth or Lairage Quay (see **Appendix 2, Figures 16 & 17**).

(a) Navigationally speaking, the importance of good sight lines under the COLREGS is to aid in the keeping of a save navigational watch (COLREG 5) and, more specifically, to allow the Mariner to make an early assessment of the situation so that they can determined whether risk of collision exists (COLREG 5 & 7). Within that context, the requirement of good sight lines is that it enables the Mariner to take early and effective action to avoid collision (COLREG 8(e)) and have sufficient time to slow down or stop the vessel if that is required.

(b) There is nothing new or unusual in my explanation of sightlines or their importance to navigation. I merely restate the relevant parts of the COLREGS that already exist and amplify on the reasons why sightlines are of importance to those in charge of boats. As such, sightlines should already be in the contemplation of any Mariner operating on the Haven (COLREG 2(b)) and navigating in close proximity to any other craft - as is the current situation on the Haven. With regard to the proposed construction works and the new barrier, nothing has changed in that respect.

(c) Having regard to sightlines and whether they are adequate for safe navigation on the Haven, what is of critical importance is whether the view allows sufficient time for someone handling a boat to be able to slow down, stop, change direction or take any other avoiding action to reduce the risk of collision as required under COLREG 8.

(d) In my experience of the type of craft being considered (both the regular and occasional users of the Haven) and which are likely to transit the barrier, the manoeuvrability and stopping distance of these craft is such that the sight lines under consideration are, in my opinion, more than adequate for safe navigational purposes, as explained in 9.2.17 above.

9.4 My perception of the improved sight lines does not take account of the additional information that may be obtained by mariners keeping a listening watch on VHF Channel 12 and / or seeking information from the Port of Boston by this means. These additional measures improve watch-keeping awareness.

**Proposed Barrier and Cofferdam**

9.4.1 The barrier side walls will be clearly defined and distinctively mark the extent of the extremities of the navigable channel. This will be unlike the current situation, where the navigable width is often unclear as and boat-handlers are unable to accurately determine the true extent of the navigable water on the outside of the bend. Inevitably human nature is to shy away from the “invisible” submerged bank and stay close to the “visible” boundary (i.e. the quay wall and/or ship hull).

9.4.2 It is my experience that ship and boat handlers find it much easier to navigate into a lock (on low level) that has high sides, aided by their ability to naturally, and constantly, reference off of the sheer sides. This is a factor that was not obvious from the simulation activities due to the absence of 3D binocular vision. This will, however, be the position for craft transiting both the post-construction barrier and the navigable channel through the construction-phase cofferdam, making navigation easier than in the simulation in this respect.

9.4.3 By comparison, entering a lock on high-level is considered a more difficult exercise, due to the limited ability to reference the vessel’s hull off of any sheer sides. This appears to be a factor not considered by any of the objecting parties.

9.5 **Navigational safety – visibility (sight lines)**

9.5.1 Sight lines around the barrier are obscured to an extent, but they are no worse than anything currently experienced in practice. As mentioned above (see section 9.2.17), locating the barrier gap to the south of the river will actually improve the exit sight-line position for vessels transiting the barrier. In any case, all mariners, of any description (including small boat handlers – see section 6.6) have an absolute obligation, under COLREG 9(f), when navigating a vessel nearing a bend or area of a narrow channel where other vessels may be obscured by an obstruction, to navigate with particular alertness and caution. COLREG 2(a) makes clear, there are no exceptions to this obligation and ignorance of the rules is not an excuse in law.

9.5.2 The sight lines are no worse than the existing situation when a grain ship is berthed alongside the Silo berth and which can overhang the berth and extend out into the Haven by up to 25 metres. In fact, the barrier will present a known quantity, whereas currently the sight lines may vary depending on the position of the grain ship on the berth.

9.5.3 In this section I have explained (at 9.3.10 (a-d)) the need for, and relevance of, adequate sight lines as a necessary feature of safe navigation. In view of the improvement to sight lines that is anticipated for the bend on the Haven, particularly given that there will no longer be any requirement for the grain vessel to overhang it's discharge berth and extend out into the Haven (as it presently does) improvement in sight lines for the bend is, in my opinion, a realised benefit when navigating through the barrier. This in turn, given my explanations at 9.3.9.1 – 9.3.9.4, facilitates the keeping of a safe navigational watch and, within the meaning of the COLREGS, actually improves safety of navigation in the Haven.

## 9.6 Navigational safety – Navigational Management Plan (NMP)

9.6.1 The navigational management plan is an extensive document which attempts to identify the navigation and related issues and, thereafter, to put in place compensating, management, or mitigation measures to minimise both the risks identified, and the disturbance to mariners, the port and occasional users that may occur during the term of the project (please see the NMP prepared by Peter Mallin (**EA/3/2**)).

9.6.2 The management measures include delineating lines of responsibility and authority, measures for supporting, improving and, so far as necessary but with minimal disruption, interpreting, supplementing and improving the navigation functionality within the affected area of the Haven Witham and the Port of Boston, plus a wide range of other relevant considerations.

9.6.3 The navigation mitigation, which is incorporated within the plan includes, but is not limited to:

(a) Provision for the relocation of fishing fleet to below the barrier works site before commencing barrier works.

(b) Providing an 18m minimum width navigable by-pass to the barrier works site for craft still moored above the barrier or transiting to or from the Grand Sluice lock (River Witham) or Black Sluice lock (South Forty Foot Drain).

(c) Providing temporary facilities for the Witham Sailing Club downstream of the barrier so they do not need to navigate past the site during construction.

(d) Enabling dredging works carried out prior to any other river works (see NMP and Peter Mallin's proof of evidence (**EA/3/1** and **EA/3/2**)).

(e) Final dredging works after all other river works.

### Cofferdam and Construction Phase – Control Measures

9.6.4 Within the NMP for the construction phase, the anticipated measures include:

(a) Control of movement of vessels through the channel north of the cofferdam;

(b) One way passing, transit at High Water slack or stemming the current;

(c) Vessel reporting and priority signalling system by means of temporary matrix message boards;

(d) Chamfering the corners on the cofferdam to minimise the risk of direct collision and any ensuing damage to vessels that may result from a direct impact with a 90-degree angled corner;

(e) Provision of suitable fendering, also to mitigate any damage that may result from craft impact;

(f) Putting in place a work-safety boat outside the cofferdam, to ensure the safety of men working on the cofferdam and to aid any boats that might develop navigational difficulties as they transit the navigation channel;

(g) Endeavouring, at the design and pre-start stage, to ensure that the navigation channel width is maximised adjacent to the cofferdam;

(h) Setting in place measures to coordinate passage through the construction area so as to minimise disruption, especially to the Boston fishing fleet and other commercial traffic; and

(i) Times and planned transits to ensure that, so far as possible, traffic stems the flow or passes at slack water.

9.7 Ensuring that construction flood lights are so positioned and, where necessary, shielded so as not to dazzle navigating vessels or shore-side residences or works

9.7.1 Location of grab-chains on the sides of the cofferdam or barrier

9.7.2 Provision of tying-up or waiting pontoon upstream and down-stream of both the construction site and the post-construction barrier site.

9.7.3 These measures, when considered and implemented will be effective in reducing identified and developing risks to the lowest possible level throughout the duration of the project.

**Barrier Post Construction - Control Measures**

9.8 Post construction safety and control of navigation measures will include, but not be limited to:

9.8.1 Reporting on marine band VHF channel 12 at the Swing Bridge and Wet Dock to avoid any risk of passing at the barrier;

9.8.2 Vessel priority system whereby vessels proceeding with the tide / flow have priority;

9.8.3 Provision of suitable fendering around the structure, lead-ins and approaches to each side of the barrier; and

9.8.4 Where appropriate, to location of additional grab chains on the side walls either side of the barrier.

9.9 **Risk of Collision (allision) with the Barrier or Cofferdam**

9.9.1 There appears to be some perception that there is a significant hazard that relates to the possibility of a vessel making contact with the barrier that could result in catastrophic harm to both the vessel and either the barrier or the construction-phase cofferdam.

9.9.2 This concern pre-supposes that any vessel that is likely to impact the structure will be travelling at full speed and approaching on a course perpendicular to either the side of the barrier or the cofferdam

9.9.3 In reality, and my experience of 20 years of close-quarters navigation, both with other vessels and in-and-out of locks, does not bear out these concerns. In practice, it is a very rare occasion when a properly controlled craft will strike another vessel or object head-on and / or at full speed

9.9.4 The more likely scenario is that of a vessel colliding with another vessel or structure at an oblique angle so that the consequent 'velocity of impact' will be commensurately reduced.

9.9.5 By way of example, consider the following matrix:

| | **ANGLE VESSEL DRIFT OFF THE FORE & AFT LINE THROUGH THE BARRIER (degrees).** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 15 | 20 | 30 | 45 | 60 | 75 | 90 |
| **SPEED (Kts)** | | | | **Direct Impact Velocity (kts)** | | | | | | | |
| 1 | 0.02 | 0.02 | 0.03 | 0.09 | 0.17 | 0.26 | 0.34 | 0.50 | 0.71 | 0.87 | 0.97 |
| 2 | 0.03 | 0.07 | 0.17 | 0.35 | 0.52 | 0.68 | 1.00 | 1.41 | 1.73 | 1.93 | 2.00 |
| 3 | 0.05 | 0.10 | 0.26 | 0.52 | 0.78 | 1.03 | 1.50 | 2.12 | 2.60 | 2.90 | 3.00 |
| 4 | 0.07 | 0.14 | 0.35 | 0.69 | 1.04 | 1.37 | 2.00 | 2.83 | 3.46 | 3.86 | 4.00 |
| 5 | 0.09 | 0.17 | 0.44 | 0.87 | 1.29 | 1.71 | 2.50 | 3.54 | 4.33 | 4.83 | 5.00 |
| 6 | 0.10 | 0.21 | 0.52 | 1.04 | 1.55 | 2.05 | 3.00 | 4.24 | 5.20 | 5.80 | 6.00 |
| 7 | 0.12 | 0.24 | 0.61 | 1.22 | 1.81 | 2.39 | 3.50 | 4.95 | 6.06 | 6.76 | 7.00 |
| 8 | 0.14 | 0.28 | 0.70 | 1.39 | 2.07 | 2.74 | 4.00 | 5.66 | 6.93 | 7.73 | 8.00 |
| 9 | 0.16 | 0.31 | 0.78 | 1.56 | 2.33 | 3.08 | 4.50 | 6.36 | 7.79 | 8.69 | 9.00 |
| 10 | 0.17 | 0.35 | 0.87 | 1.74 | 2.59 | 3.42 | 5.00 | 7.07 | 8.66 | 9.66 | 10.00 |
| 11 | 0.19 | 0.38 | 0.96 | 1.91 | 2.85 | 3.76 | 5.50 | 7.78 | 9.53 | 10.63 | 11.00 |
| 12 | 0.21 | 0.42 | 1.05 | 2.08 | 3.11 | 4.10 | 6.00 | 8.49 | 10.39 | 11.59 | 12.00 |
| 13 | 0.23 | 0.45 | 1.13 | 2.26 | 3.36 | 4.45 | 6.50 | 9.19 | 11.26 | 12.56 | 13.00 |

9.9.6 This matrix demonstrates the actual impact velocity for virtually every vessel speed and angle of approach anticipated during the Boston Barrier project.

9.9.7 As an example, a vessel travelling at 8 knots in relation to the barrier or cofferdam and drifting away from the fore and aft line through the navigable channel of, say, 10 degrees, will experience a 'glancing' impact with a maximum approach speed of 1.39 knots.

9.9.8 Consider another extreme case example; that of a vessel that gets its approach seriously wrong and ends up traversing the gap (still doing 8 knots, however unlikely) but with an angle of drift of, say 60 degrees off the ideal line through the barrier or cofferdam gap. This extreme situation will result in a vessel having an impact velocity of 6.93 knots.

9.9.9 Although this information has no bearing on 'risk of collision', it offers an insight into why the effect of a particular contact may not be as damaging as some objectors suggest.

## 9.10 **Transiting the Haven – Current Port safety requirements**

9.10.1 The Port of Boston Annual Standing Local Notice to Mariners (2017)) states that "it is a local requirement of the Port of Boston, that all vessels navigating within the Ports waters have adequate means of communications which will normally mean carrying a Marine Band VHF Radio capable of receiving and transmitting on VHF channel 12".

9.10.2 Further it is a requirement that "Mariners navigating the River Witham seawards of Grand Sluice and extending to the outer limits of the Port of Boston Jurisdiction Area are to monitor VHF Channel 12".

9.10.3 The Port of Boston has previously stated that it "expects that the lock keepers at Grand Sluice Lock and Black Sluice Lock to ensure that every vessel proceeding into the tidal waters is equipped with the necessary VHF Radio" (Canal and River Trust Notice 192 (2012) (see Gillian Watson's proof of evidence (**EA/4/1**) for additional details).

## 9.11 **Impact on Fishermen**

9.11.1 At worst, the Boston fishermen may experience minor delays (of a few minutes) associated with one-way traffic through the barrier post-construction, commensurate with any navigation management plan and associated priority system

9.11.2 Given the manoeuvrability of these vessels, I do not anticipate that the barrier itself will pose any significant risk to the navigation of fishing boats.

9.11.3 The Boston fishing fleet and back-up operation will be offered temporary relocation to the Port of Boston riverine berths after the wet dock works and prior to cofferdam construction. Specific details of the temporary facility can be found in the evidence of Mr Richard Scriven (**EA/7/1**). The adequacy of these temporary provisions is discussed in the Proof of Evidence by Mr Patrick Franklin (**EA/6/1**).

## 9.12 **Impact on Port of Boston**

9.12.1 In order to operate to allow the construction works to be carried out, and to administer and operate the barrier post-construction, the Port of Boston may need to implement a series of new bye-laws or issue additional notices to mariners and promulgate changes to navigation within the port and its environs.

9.12.2 The Port of Boston will lose access to a number of its berths inward of the proposed barrier site. There is a pre-construction plan to mitigate that loss by widening the wet dock lock pit to accommodate larger (wider) vessels than is currently possible in the wet dock.

9.12.3 The silo berth offloading facilities will be modified, moved and upgraded so that there will no longer be any need for vessels discharging on the silo berth to extend out into the Haven, thereby restricting the navigable width of the river or compromising the sight-lines for vessels intending to transit the barrier passage.

9.12.4 Arguably, these modifications in mitigation of lost berth space will make the port more commercially attractive for larger size commercial ships.

9.12.5 As part of the Boston Barrier Scheme, the Port of Boston will be furnished with new aids to navigation and channel navigation marks. These aids will comprise International Association of Lighthouse Authorities (**IALA**) signals and port and starboard lights at the bypass, and automated information boards on both approaches to the barrier. An additional automated information board will be located near the entrance to the Haven to provide maximum advance warning to mariners (see **NMP EA/3/2)**.

## 10 Response to Statement of Matters

10.1 The Secretary of State has set out the Matters that need to be addressed. My evidence covers a number of those matters (or aspects of them), to the extent that they relate to navigation.

10.1.1 Matter 5**:** The justification for the location, design and operation of the scheme including:

(a) the implications for navigation around the siting of the barrier

10.1.2 This matter is covered at paragraphs 4.1 - 4.38, 7.7 – 7.9, 9.1 - 9.1.4, 9.2.16, 9.3.8 - 9.4 and 9.5.1 - 9.5.3 of my evidence.

10.1.3 Matter 12: The adequacy of the current flow calculations and engineering proposals as presented with particular regard to:

(a) flow velocity concerns in relation to the fishing fleet's ability to use the river

10.1.4 This matter is covered at paragraphs 4.27 – 4.39.3, 8.1.1 - 8.2.4, 9.2.9 - 9.2.14 and 9.2.17 **-** 9.2.19 of my evidence.

10.1.5 Matter 13: the likely impacts of constructing and operating the barrier on navigational safety including:

(a) that the phasing of the works accommodates a minimum level of operations to allow river and port operations to continue in safety

10.1.6 This matter is covered at paragraphs 9.6.3 – 9.8.4 of my evidence.

(a) the adequacy of the provisions relating to navigational risk within the accompanying environmental statement

10.1.7 This matter is covered at paragraphs 6.1 – 6.13 and 9.9.1 – 9.9.9 of my evidence.

10.1.8 Matter 14: the likely impacts of constructing and operating the scheme on the operation of businesses in the area, including:

(a) issues around perceived increased flow velocities creating difficulty for the fishing and pleasure craft industry to operate safely.

10.1.9 This matter is covered at paragraphs 4.1 - 4.38, and 9.11.1 – 9.11.3 of my evidence.

## 11 Issues Raised in Objections

11.1 In this section of my evidence, I respond to the main issues raised by objectors.

11.2 ISSUE: Sight lines and lines of sight in the region of the barrier.

11.2.1 Raised by: Councillor David Brown (OBJ /07), Captain BDC Franklin (OBJ/08), Mr Gren Messham (OBJ/09), Mr Rodney Bowles (OBJ/14)' Mr Terry Despicht (OBJ/15), Mr Howard M Smith (OBJ/21), Mr Ken Bagley (OBJ/22), Mr David Pullen (OBJ/24), Mr Roger Ackroyd (REP/04).

11.2.2 A number of objections and one representation have been received on the issue of sight-lines and clear visibility with regard to navigating the barrier.

11.2.3 Within my evidence, I have addressed the issue of sight lines when approaching the barrier at sections 9.2.16, 9.3.8 – 9.4 and 9.5.1 – 9.5.3.

11.2.4 Siting the barrier on a corner may not be ideal from a navigation perspective, but given current practices in this port whereby vessels extend up to 25 m out into the navigable fairway, effectively reducing the clear navigable width to 24m at times, it is improbable that there will be any significant alteration with regard to the risks that presently exist. From the simulation exercises carried out at HR Wallingford, my observations from a boat navigating on the Haven and the control measures being proposed in the NMP, I consider that the situation with regard to navigational safety will actually improve post construction.

11.3 ISSUE: Water flow and stream velocity through the barrier and water flow modelling.

11.3.1 Raised by: Mr David Matthews (OBJ/02), Mr Gren Messham (OBJ/09), Mr Robert Booth (OBJ/10), Mr Rodney Bowles (OBJ/14), Mr Shane Bagley (OBJ/17), Mr Jamie Lee (OBJ/18), Mr Howard M Smith (OBJ/21), Mr Ken Bagley (OBJ/22), Royal Yachting Association (REP/05)

11.3.2 The issue of water flow, how it is modelled, and expected velocities of water in the Haven and through the proposed barrier has been raised by a number of objectors.

11.3.3 The topic is addressed at paragraphs 8.1.1 – 8.2.4, and 9.1 – 9.3.7of my proof. The issue is also addressed in the proofs of Gillian Watson (**EA/4/1**) and Sun Yan Evans (**EA/2/1**).

11.3.4 Water flow simulations show that the construction-phase cofferdam bypass channel and post-construction barrier navigation channel will be maintained clear of mud deposits and at full depth of the full width of the proposed passage.

Consequently, these are known factors and not subject to the variations that are not only likely, but probable, with the changing bathymetry and water flows of the Haven in its current state.

11.3.5 Water modelling which has been incorporated into the simulation databases shows that there would be a difference in flows during difficult winter conditions between baseline and post-construction phases. The assessment is that there is likely to be an increase of 1.2 knots at the barrier. Vessel handling simulations were undertaken using these conditions and, with appropriate care, I found that vessel handling and navigation was within perfectly acceptable limits for the normally experience boat-handler.

11.3.6 Those simulations indicate that there is likely to be an average flow through the barrier of approximately 3.7 kt in normal to high winter conditions and this modelled assessment is consistent with my own (albeit empirical) experience of high water-flow along the Manchester Ship Canal (the main drain for the western Pennines).

11.3.7 None of the simulations produce the ‘vortex’ that is referred to by Stuart Carruthers (REP/05) and, in my experience of navigating in narrow and very restricted channels, I have yet to see such a feature arise in a confined waterway such as the Haven. The simulation database shows that relatively weak eddies may form immediately either side of the barrier structure and, will, if correct, represent a safe ‘run-off’ for vessels that elect to abort a barrier transit. That said, tidal eddies are commonly encountered at many locations within ports and rarely cause navigational problems and should be well within the boat-handling capability of most competent mariners.

11.3.8 The non-commercial craft that transit the Haven from the inland waterways and from seaward tend to be seasonal, with the highest numbers being between April and September (see the evidence of Gillian Watson (**EA/4/1**) for data on Haven traffic). The passenger carrying Boston Belle puts to sea on the incoming tide, and returns to its berth on the ebbing tide. Consequently, it is highly unlikely that the vessel will ever be subject to fluvial flows from astern. Further, it is my understanding that most of the work carried out by this vessel is undertaken in the peak tourist season, during those months when weather conditions are favourable and water flows are at their lowest. My meeting with the skipper of the Boston Belle convinced me that he is an experienced mariner, who exemplifies what it means to practice the normal prudence of seafarers. The chances of him taking risks with his craft or passengers are, in my opinion, non-existent.

11.3.9 The navigation simulations have tested the handling capability of a range of vessels, including small and relatively low powered recreational craft (yachts) to navigate through the post-construction navigation channel in a controlled and safe manner in a range of river conditions including adverse fluvial events.

11.3.10 General concerns with regard to risk of collision resulting from strong water flows have been dealt with in significant detail in my report. I cannot agree that the proposed barrier would create a dangerous situation during construction or that water flow-rates would be a significant problem for craft or that the siting of the barrier is dangerous. Finally, given that the upper haven is no more than 32 metres wide (at town bridge, with extensive fouling and mud accumulations evident) and the barrier will be 25m wide and maintained clear and to full depth, I cannot agree with the assertion that the barrier would make the Haven unnavigable.

11.4 ISSUE: Navigation restriction / Completely blocking navigation and making the river unnavigable / Prohibitive width of barrier and cofferdam gap / Risk of collision at the barrier/

11.4.1 A number of related issues have been grouped together as they appear to express the same broad concerns.

11.4.2 These are raised by: Captain BDC Franklin (OBJ/08), Mr Rodney Bowles (OBJ/14), Mr Terry Despicht (OBJ/15), Mr R A Brewster and Sons (OBJ/16), Mr Shane Bagley (OBJ/17), Mr Jamie Lee (OBJ/18), Mr Howard M Smith (OBJ/21), Royal Yachting Association (REP/04). Witham Sailing Club (REP/05)

11.4.3 The subject matter of these objections and representations are addressed fairly extensively in sections 6.1 - 6.13, 9.3 - 9.3.7 and 9.4.1 - 9.4.3 of my evidence.

11.4.4 A number of objectors, key among them the Boston fishermen have raised concerns regarding the safety of their boats and crew, and have referred to the location of the barrier on a bend in the river causing an increase in water-flow speeds with a resulting increase in risk of colliding with the solid structure.

11.4.5 Further, there don’t appear to be any issues in navigating the significantly narrower gap to the west side of the railway bridge, or in proceeding inward past the railway bridge where there is a maximum width of no more than 32 to 35 m, with significant accumulations of mud on either side of the river.

11.4.6 Currently, boats are able to negotiate the section of the river above the proposed barrier locations (with its constantly changing depths and mud banks) without difficulty. By comparison, the fixed 25 m of the barrier channel will have a fixed width and depth and known tidal flows, making it one of the few known quantities in the Haven.

11.4.7 Navigationally, transiting narrow gaps is a very regular function of my pilotage practice where close monitoring of set and the position of the vessel within the channel is required, but this is a normal practice in restricted waters. Mariners experienced in a district tend to develop the habit of using fixed marks and transits to navigate problematic channels. Even from the simulations, I was able to determine that there are a number of features that navigators could line up on, those features became very apparent when I visited the Haven. Further, it is my experience that boat handlers find it easier to reference off the steep sides of a sheer-sided channel as they approach it. With regard to the channel itself, it is my experience that as the vessel closes in to the barrier, the flows begin to align with the barrier, becoming almost laminar towards the centre, thus ensuring that the flow streamlines will match the ideal course to steer by the vessel transiting the barrier.

11.4.8 The simulations I took part in (for the post-construction barrier) included this flow feature on approaching the barrier.

11.4.9 The length of the Boston fishing boats is approximately 14 m, whilst the beam is approximately 6 m. The barrier channel will be 25 m and, as part of the control mitigation measures, will be fitted with adequate fendering to accommodate the impact of any transiting craft. Thus, the barrier gap is at least four times that of the fishing boat width.

11.4.10 Even without the navigation control and safety mitigation measures that are included as part of the navigation management plan, with normal control of speed as required under the Port of Boston annual summary of notices (No14) (Appendix 3 to Gillian Watson's proof (**EA/4/2**)) and as statutorily required by the COLREGS (Rules 6 and 9(f)) – and indeed, as required by common sense and good seamanship – I would have difficulty in understanding how a highly manoeuvrable boat with the weight to power ratio possessed by the fishing vessels might fail to safely negotiate the 25 m barrier gap that is presented to them.

11.4.11 Control measures proposed in the NMP requiring observance of one-way passing will act ensure that the vessels can use the full extent of the channel when approaching and passing the barrier.

11.4.12 The proposed 25 metre navigation channel at the barrier is not only similar to the current situation when a grain ship is moored on the Silo Berth, but the predictable width, depth and flow direction of the water within the barrier gap, in my opinion, serves to improve the navigational safety and reduce the risk of collision.

11.4.13 The COLREGS (Rule 9(f)) place an obligation on the skipper to navigate with particular caution on approaching a bend in a narrow channel or fairway where other vessels may be obscured by an intervening obstruction.

11.4.14 The control measures that will be set in place will further reduce any risks to an acceptable level and will, in my opinion, actually improve the overall situation.

11.4.15 Assuming the experience of the Boston fishing fleet skippers and the experience they already possess in respect of the Haven and narrow confines of the River Witham, inward of the swing bridge, I would not anticipate that they will have any particular difficulty navigating through the barrier, particularly given the manoeuvrability of these vessels.

11.4.16 Simulations also carried out using the 22m narrow boat and 22 m long, 4.0 m beam wide-boat indicated that there would be no issues with navigating these craft through the barrier or construction-phase cofferdam, provided that the prudent caution required by the ordinary practices of seamen (see COLREG 2(b)) is complied with.

11.4.17 The navigation simulations have tested the handling capability of a range of vessels, including small and relatively low powered recreational craft (yachts) to navigate through the post-construction navigation channel in a controlled and safe manner in a range of river conditions including adverse fluvial events.

11.4.18 It is my considered opinion, based on both the simulations and a long career of navigating a wide range of much larger vessel through narrow channels, that the issues raised in objection are somewhat overstated and that, given current practices, the 25 m barrier gap should present no real issues to mariners operating on the Haven.

11.5 ISSUE: Vessel hydrodynamics, squat, pressure field interaction and the impact on other craft.

11.5.1 Raised by: Mr Terry Despicht (OBJ/15)

11.5.2 The issue of vessel hydrodynamics and the effects of squat and interaction are highly specialised fields of knowledge.

11.5.3 My evidence deals extensively with the issues of vessels hydrodynamics at sections 4.26 – 4.38.4and **Appendices 3, 4 & 5**).

11.6 ISSUE: Boat handling and manoeuvring problems

11.6.1 Raised by: Mr R A Brewster and Sons (OBJ/16), Mr Shane Bagley (OBJ/17), Mr Jamie Lee (OBJ/18), IWA East Midlands Region (OBJ/24).

11.6.2 A number of objections have been raised with regard to potential boat-handling problems arising both from changed water flows and the need to navigate either the cofferdam channel (during construction) or the barrier channel

11.6.3 Boat handling matters are addressed extensively in my evidence in paragraphs 4.1 – 4.46 and 9.1 – 9.5.

11.6.4 For the avoidance of doubt, from the Silo Quay to inward of the tying-up berth above Black Sluice, a distance of no more than approximately 300 m, nothing in the proposed scheme will change or modify any of the factors that the boat handlers should have in their consideration.

11.6.5 The objection alights on the possibility that proposed location of the barrier on a bend in the river will cause an increase in water-flow speeds resulting in an increased risk of colliding with the solid structure.

11.6.6 Currently, there does not appear to be any issue with navigating the significantly narrower gap to the west side of the swing bridge or in proceeding inward past the railway bridge where there is a maximum width of no more than 32 to 35 m, but which is reduced due to significant accumulations of mud on either side of the river. It seems odd, that the fishing boats that are able to negotiate this section of the river with its constantly changing depths and mud banks, appear to anticipate difficulty in negotiating a fixed 25 m channel that possesses constant water depth across its entire width, and will have known currents and tidal flow. Further, when there is a vessel on the Silo Berth protruding 25 metres into the river, the navigable width is reduced to only 24m, and the depths at this point, due to mud accumulations, are not assured.

11.6.7 The barrier navigation channel is at least four times that of the fishing boat width. Even without the navigation control and safety mitigation measures that are included as part of the NMP, with normal control of speed as required under the Port of Boston annual summary of notices (No14, also see **Appendix 2, Figure 3**) and as statutorily required by the COLREGS (Rules 6 and 9(f)) – and indeed, as required by common sense and good seamanship, given the high manoeuvrability of the fishing boats and the weight to power ratio possessed by these vessels, they should be perfectly able to safely negotiate the 25 m barrier channel.

11.7 ISSUE: Crew Competence / decision making / lack of boatmen experience

11.7.1 Raised as: Captain BDC Franklin (OBJ/08)

11.7.2 The concerns raised with regard to crew competence and, more specifically, the possibility that boat skippers may be pushed into making rash decisions is covered in my evidence in sections 5.1 – 5.10.6 and 6.1 – 6.13.

11.7.3 My evidence deals extensively with the responsibility that attaches to mariners and their obligations to take appropriate account of all the circumstances, consistent with the ordinary practices of seaman. This is not simply my opinion, it is clearly stated within the COLREGS (at 2(a) and (b)) and the rules allude to this responsibility in several places throughout.

11.7.4 For the most part, the regular Haven users are experienced mariners and boat handlers who take their command obligations seriously and deal with the day to day issues of navigation on the Haven conscientiously.

11.7.5 Safety measures have been put in place as part of the NMP to seek to address the risks posed by errant boat handlers.

11.7.6 So far as general boat-handler experience is concerned, maritime insurers require that boat owners observe the common-sense prudence of seafarers and that includes making decisions that are in the best interests of safety of the boat and of other mariners that should be in the competent skipper's contemplation.

11.7.7 Within the present context nothing will change with regard to crew competence levels and, for the normally prudent mariner exercising the common sense that is required (under COLREG 2) of the ordinary mariner, the barrier should be a perfectly safe place to navigate.

11.8 ISSUE: Navigational Mitigation

11.8.1 Raised by: Mr Gren Messham of the Inland Waterways Association (OBJ/09), Mr Howard M Smith (OBJ/21).

11.8.2 Mr Messham and Mr Smith raise concerns with regard to navigational mitigation and how this will be delivered.

11.8.3 The issues are dealt with in detail in my evidence at sections 6.8.2 – 6.13 and 9.6.1 - 9.8.4

11.8.4 The various control measures identified from simulations as being appropriate mitigations have been incorporated into the NMP and the HR Wallingford databases were modified to undertake simulations for the project.

11.8.5 Extensive simulations have been run with these measures in place and, in my opinion, the issues raised have been adequately dealt with as part of the mitigation measures proposed in the NMP for the barrier project.

11.8.6 I am confident that with the NMP that mitigation is both clearly defined and secured and will be effective in mitigating all the risks to a level which is as low as reasonably possible.

11.9 ISSUE: Boston fishing fleet impact

11.9.1 Raised by: Mr David Matthews (OBJ/02), Cllr. David Brown (OBJ/07), Mr Shane Bagley (OBJ/17), Mr Jamie Lee (OBJ/18), Mr Ken Bagley (OBJ/22)

11.9.2 The Boston fishing fleet are some of the regular commercial users of the Haven. The fishing fleet currently moor inward of the swing bridge and would have to pass the proposed barrier construction site when heading to, or returning from, sea.

11.9.3 My evidence in respect of the fishing fleet can be found in sections 9.11.1 – 9.11.3. For further detail regarding impact on the fishing fleet please see Patrick Franklin's proof (**EA/6/1**).

11.9.4 The objectors cite concerns regarding the safety of navigation through the proposed barrier and believe that the location of the barrier on a river bend will impact on safety of navigation, potentially making the Haven completely unnavigable.

11.9.5 Navigationally, given the experience and current practices of the Boston fishing fleet skippers I would not anticipate that they will have any difficulty navigating through the barrier post-construction, particularly given the manoeuvrability of these vessels. The risks associated with the cofferdam channel are fully mitigated in the offer to relocate the fleet during the construction phase.

11.10 ISSUE: Siting of the barrier

11.10.1 Raised by: Captain BDC Franklin (OBJ/08), Mr Gren Messham (OBJ/09), Mr Robert Booth (OBJ/10), Mr Terry Despicht (OBJ/15), Mr R A Brewster and Sons (OBJ/16), Mr Howard M Smith (OBJ/21).

11.10.2 The objection arises from concerns about siting the barrier on a bend in the river and the impact on local commercial and seasonal traffic on the river.

11.10.3 This matter is covered in my evidence at sections 9.3 – 9.5.

11.11 ISSUE: Marchionesse / Bowbelle incident

11.11.1 Raised as: Mr Rodney Bowles (OBJ/14), Mr Terry Despicht (OBJ/15).

11.11.2 This objection relates to the Bowbelle/Marchioness incident that took place in the River Thames 20th of August 1989 and is raised in consideration of concerns that a similar might arise in respect of passenger vessels or other craft operating on the Haven in the region of the proposed barrier.

11.11.3 It should be noted that there was no 'barrier' in the Marchioness / Bowbelle scenario.

11.11.4 The situation, time of day, circumstances, traffic density, tidal flows and number of contributory factors relating to the Marchioness/Bowbelle incident are unlike anything that is likely to be experienced on the Haven. The circumstances surrounding that incident cannot, and would not, in my opinion, be repeated in this district and in respect of the Boston Belle. Moreover, statutory regulations have significantly changed since the incident and the likelihood of the occurrence, even on the Haven, is improbable. For further details, see the evidence of Gillian Watson.

11.12 ISSUE: Provision of lock as part of the barrier project

11.12.1 Raised by: Mr Rodney Bowles (OBJ/14), Mr Terry Despicht (OBJ/15), Mr Howard M Smith (OBJ/21), Mr Ken Bagley (OBJ/22)

11.12.2 The provision of a lock would not mitigate navigational issues as is claimed by objectors.

11.12.3 The issues outlined as being mitigated by the inclusion of a lock would, in my experience, be equally applicable to vessels intending to transit a lock because there are operational and manning issues, including extensive delays and traffic management concerns associated with lock operation. It is worth noting that the transiting Grand Sluice lock can only be undertaken if 24 hours advance notice is given. Vessels cannot transit the Grand Sluice gates, even when the water is slack, as there is a robust protection wire (buoyed at water level) in place across the sluiceway, to prevent craft getting near to the sluices.

11.12.4 In comparison, the barrier allows free-flow of traffic at all times, provided there is sufficient water. The barrier is only expected to be raised (closed to traffic) on an as-needed basis, testing and maintenance notwithstanding.

11.13 ISSUE: Safe navigation of narrowboats

11.13.1 Raised by: Mr Howard Smith (OBJ/21), David Pullen (OBJ/24), Gren Messham (OBJ/09)

11.13.2 This matter is dealt with in my evidence at sections 9.1 - 9.4 and 9.6 – 9.7.

11.13.3 Simulations were carried out using the 22 metre narrow boat and 22 m long, 4.0 m beam wide-boat (see section 9.1of my proof). Those simulations indicated that there would be no issues with navigating these craft through the barrier or construction-phase cofferdam, provided the traffic management plan (and prudent caution required by the ordinary practices of seamen (see COLREG 2(b)) are complied with.

11.13.4 Whilst I understand why the IWA might have had concerns at an early stage of the project, I am of the opinion that the IWA concerns are either met or resolved with the measures proposed in the NMP and that there are no remaining issues which ought to be of concern to any IWA member.

11.13.5 In many respects, navigational safety in this part of the Haven will be better with the barrier in place and NMP enacted, than it currently is at times.

11.13.6 In my opinion, and from observation of the current facilities and those proposed as part of the NMP, this objection is fully addressed no longer represents an issue or grounds for objection.

11.14 ISSUE: Safe-haven moorings from storms

11.14.1 Raised by: Mr Gren Messham (OBJ/09), Mr Howard M Smith (OBJ/21)

11.14.2 This matter is dealt with in my evidence at section 9.6 – 9.7. It is also covered at 4.2.4 in the NMP (**EA/3/2**).

11.14.3 Concerns relating to the facility for small craft so shelter from storms were raised,

11.14.4 I am confident that with the NMP, which includes reference to the provision of safe haven moorings upstream and downstream of the barrier, mitigation is both clearly defined and secured and will be effective in mitigating all the risks not only to a level which is acceptable but also to a level that is as low as reasonably possible.

11.14.5 Storms are, for the most part, fairly predictable nowadays and the prudent mariner will check the forecast before setting sail and make appropriate arrangements as part of his passage planning.

11.15 ISSUE: Navigational conduct above and below the barrier, including VHF radio use

11.15.1 Raised by: Mr Howard M Smith (OBJ/21), Mr Roger Ackroyd (REP/04), Mr Stuart Carruthers (Royal Yachting Association) (REP/ 05).

11.15.2 A number of concerns have been raised with regard to navigation above and below the proposed barrier site, including an assertion that there has been a gross under-estimation of navigation problems associated with the siting of the barrier. The objectors and representations are put forward by those contending the position of small boat handlers and seasonal traffic.

11.15.3 The issues and concerns are extensively covered in my evidence at sections: 6.1 - 6.13, 7.1 - 7.9, 9.10 - 9.10.3.

11.15.4 The navigation simulation study assessed these issues in detail. The ability of vessels, including a 6.5m yacht, to manoeuvre through the proposed 25m barrier navigation channel and the narrower cofferdam bypass navigation channel was tested. Recommendations for suitable navigation risk mitigation measures were made following simulations and have been detailed in the NMP.

11.15.5 In addition to the control measures and mitigations incorporated in the NMP, which includes preview traffic and barrier situational information displayed on the river side and barrier Information Matrix Boards, there are additional measures available to mariners, for example Automatic Identification of Ship (**AIS**) transmissions which (failing the presence of statutorily required navaid equipment) are available on most smart-phones that have even a basic data package. Use of AIS, or monitoring VHF

Channel 12, as anticipated in the NMP, or observing the Information Matrix Signs should provide sufficient warning of oncoming traffic.

11.15.6 Moreover, observation of the international regulations for collision at sea, specifically COLREG 6 (Safe speed), and 9(f) (Navigating near a bend where there is an intervening obstruction) offer statutorily recognised mitigations, with the final caution being found in COLREG 2(b).

11.15.7 Private recreational craft of less than 13.7m in length are not required to carry radio communications equipment. However, there are recommendations published by the Canal and Rivers trust recommending that vessels proceeding into tidal waters should carry VHF equipment. The PoB has previously stated that it “expects that the lock keepers at Grand Sluice Lock and Black Sluice Lock to ensure that every vessel proceeding into the tidal waters is equipped with the necessary VHF Radio. Whether the operators of small craft choose to comply with this, or not, is a matter for them to decide, but failure to carry a VHF set does not, of itself, make navigation unsafe and neither does it negate the legal responsibility that accrues to any mariner (detailed on COLREG 2) from their obligation to navigate with caution and observe the common sense that is required as part of the ordinary practices of seamen.

11.15.8 The regulations pertaining to the safe navigation of vessels (COLREGS) should, if observed by the prudent mariner, be more than sufficient to ensure safe navigation. My evidence at paragraphs 6.3 and 6.6 makes absolutely clear that these rules apply to all vessels and there are no exceptions. Any residual risks that arises from either the construction or the siting of the barrier is anticipated within the NMP. These factors, taken singly or in combination, in my view, make navigation around the proposed barrier no more hazardous than on any other part of the Haven.

## 12 Conclusions

12.1 In my experience, and considered professional opinion deriving from the insights gained from the evidence I have seen from the simulations that I have undertaken, and from my own experience navigating and piloting vessels for 20 years in extremely confined waters (often with line of sight is obscured by an intervening obstruction) the mitigation and control measures that are proposed will be more than adequate - especially when taken in combination with the statutory obligations set out in the collision regulations - to ensure safety of navigation around the area of the proposed flood defence barrier.

12.2 As explained in my commentary the issue of lines-of-sight appear somewhat contrived as the situation during construction and post construction will be no worse than at present, that being a situation that does not currently warrant undue concern or require any special measures by the Mariner other than appropriate observance of the collision regulations and adherence to the customary caution and practices of prudent seamen.

12.3 Navigationally, given that the upstream and downstream basins on either side of the barrier will be dredged to full depth across the entire width of the Haven during the construction of the barrier, and the direction of water flows through the barrier will ensure that it is constantly scoured and maintained at full depth across the 25 m width of the barrier (without mud deposits impacting unnavigable width or depth), it is my belief based on significant practical experience, that the barrier will eventually represent possibly one of the few absolutely known quantities for navigation in the Haven. Given this prospect, and the anticipated water flows that been modelled for the barrier, I consider that the barrier will, in fact, make navigation round the bend and on either sides of the barrier, both safer and more controlled.

12.4 As explained in my evidence, it is my considered opinion that the limiting factor for navigation in the Haven is not the barrier. Rather, it is the concatenated bends inbound of the railway bridge, and towards the Grand Sluice, that will eventually be the limiting factor for navigation in this district.

12.5 Having dealt with the issues of water-flow, navigational impact, lines of sight, traffic management, hydrodynamics, and extreme weather scenarios, I am convinced that that there are no real navigational issues that remain. Indeed, any residual concerns are, in my opinion, more than adequately addressed within the navigation management plan and I am confident that the issues expressed are certainly no greater than those currently experienced in practice.

## 13 Statement of Truth

I, Captain Peter J McArthur hereby declare that:

13.1 I am bound by the Codes of Professional Conduct of the Honourable Company of Master Mariners (a City of London Livery Company) and the Institute of Marine Engineering, Science and Technology (IMarEST) which has granted me professional Chartered status, to exercise due diligence and conduct myself with integrity and honesty in all professional circumstances. In compliance with those obligations:

13.2 Insofar as the facts stated in this Proof of Evidence are within my own knowledge and experience, I believe them to be true.

13.3 The opinions I have expressed represent my true and complete professional opinion.

13.4 This Proof of Evidence, so far as is reasonably practicable in the circumstances, includes those facts which I regard as being relevant to the opinions which I have expressed and that I have drawn the inquiry's attention to any matter which would affect the validity of those opinions.

13.5 I understand that my duty to the Inquiry is to assist with those matters that are within my expertise and I have complied with that duty.