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1 Qualifications and Experience

1.1 My name is Gillian Watson. I am employed by HR Wallingford Ltd as a Principal Engineer within the ‘Ships Group’ team.

1.2 I have a BA and MA (Cantab.) in Engineering from the University of Cambridge. I also have a MSc in Marine Resource Development and Protection from Heriot Watt University. I am a member of the International Navigation Association (PIANC).

1.3 I have worked with the marine and port industries in the fields of civil engineering and environmental hydraulics for over 24 years. I have undertaken roles that include numerical and physical modelling of marine, coastal, estuarine, river and inland waterway environmental conditions and interactions with both fixed and floating structures, as well as vessel navigation simulation, vessel mooring assessment, vessel interaction assessment (passing ship studies) and also navigation risk assessment. I work closely with professional mariners, port and harbour authorities, vessel and terminal/facility owners as well as with port engineers and scientists/modellers from other expert specialties.

1.4 Since 2003, I have been a vessel navigation specialist. I have managed consultancy services projects that have informed, assessed and supported port and marine terminal development projects at sites not only in the UK, but throughout the world. These have covered a wide range of navigation situations, vessel types and have considered both major and minor facilities. I have worked on all phases of project development, from the early concept assessment and selection stages, through design development, optimisation and approval, to construction. I have also worked on studies to assess and support on-going operational activities and to investigate navigation issues and incidents.

1.5 Examples of past navigation-related studies that I have worked on which have similarities to the navigation situation at the Boston Barrier include the Port of Ipswich and River Orwell Navigation Channel Study (2003), the Poole Second Lifting Bridge Marine Traffic Study (2005), the Kilkeel Harbour Navigation Review and Risk Assessment (2006), the Cork Docklands Crossing 50m Bascule Bridge Navigation Simulation Study (2006) and the Great Yarmouth Third Crossing Navigation Simulation Study (2009).

1.6 In addition, I have sailed a variety of boats and yachts since early childhood. I currently have RYA Yachtmaster Offshore and Yachtmaster Ocean qualifications and I own and regularly sail an 8.1m (27 foot) sailing yacht. I have crewed in yachts up to 72 feet and skippered yachts of up to 42 feet. I have sailed extensively throughout UK and Irish waters, northern Europe, the western Mediterranean and north African coast, Scandinavia and the Baltic, the Caribbean and in New Zealand and Western Australia. I have worked as a dinghy sailing instructor (summer job when I was a student), and I have also undertaken delivery trips on yachts through the Canal du Midi (France), the Kiel Canal (Germany) and on a trans-Atlantic crossing.

1.7 Since August 2016 I have managed HR Wallingford’s contract (with Mott MacDonald) to provide navigation simulation services to support the Transport and Works Act Order (TWAO) application for the Boston Barrier Scheme. I also led HR Wallingford’s Boston Barrier navigation simulation study.
2 Scope of Evidence

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

2.2 My evidence discusses the navigation situation on the Haven at present as well as the main navigation features of the Scheme. I also describe the process of navigation simulation and present an overview of the navigation simulations that have been undertaken to support the TWAO application for the Boston Barrier Scheme. I discuss the navigation context for the proposed Navigation Management Plan (NMP) (please see the appendices to Peter Mallin’s proof of evidence (EA/3/2)) that has been developed for the Scheme, and consider the residual impact of the Scheme on navigation on the Haven once the proposed NMP is implemented. I also present a summary review of alternative schemes for managing the tidal flood risk at Boston from a navigation viewpoint.

2.3 In my evidence I also

2.3.1 respond to matters raised within objections which relate to the scope of my evidence; and

2.3.2 summarise my evidence in respect of the aspects of the Statement of Matters that I address. These are:

- **Matter 5(a)** The implications for navigation around the siting of the barrier
- **Matter 12(a)(iii)** Flow velocity concerns in relation to the fishing fleet's ability to use the river
- **Matter 13(a)** The likely impacts of constructing and operating the barrier on navigational safety including details of what navigational mitigation is to be provided, how it will be delivered and ‘who does what’ to ensure safety of the fleet and fishermen;
- **Matter 13(b)** The likely impacts of constructing and operating the barrier on navigational safety including the adequacy of the provisions relating to navigational risk within the accompanying Environmental Statement;
- **Matter 13(c)** The likely impacts of constructing and operating the barrier on navigational safety that the phasing of the works accommodates a minimum level of operations to allow river and port operations to continue in safety;
- **Matter 14(a)** 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 recreational craft industry to operate safely.
3 Introduction

3.1 My evidence considers navigation aspects related to the Boston Barrier Scheme. My evidence is structured as follows:

3.1.1 An overview of the Haven at present, from a navigation viewpoint (Section 4);

3.1.2 A discussion of the baseline navigation situation in the Haven, focusing in particular on navigation in vicinity of the Boston Barrier Scheme site (see Section 4.6);

3.1.3 A description of navigation-related aspects of the Boston Barrier Scheme, with a focus on the navigation situation in the vicinity of the proposed cofferdam and barrier structures (Section 5);

3.1.4 An introduction to the use of navigation simulation to examine the feasibility of navigation for proposed port layout designs and associated navigation risks (Section 6);

3.1.5 A description of HR Wallingford’s Ship Simulation System and Ship Simulators (Section 6.3);

3.1.6 A description of the Boston Barrier navigation simulation study conducted by HR Wallingford on behalf of Mott MacDonald and the Environment Agency (Section 7);

3.1.7 The conclusions and recommendation arising from the navigation simulation study (Sections 7.7.4 (a)(v) and 7.7.5 (a)(v));

3.1.8 A discussion on the underlying premise for, and overall objectives of, the Boston Barrier Scheme Navigation Management Plan (NMP) (please see the appendices to Peter Mallin’s proof of evidence (EA/3/2)) (Section 8);

3.1.9 A review of the residual impacts on navigation associated with the Boston Barrier Scheme once the proposed NMP is implemented (Section 9);

3.1.10 A summary review of alternative scheme locations from a navigation perspective (Section 10);

3.1.11 Responses to comments made by objectors related to navigation aspects of the Scheme (Section 11);

3.1.12 Commentary addressing the Statement of Matters issued by the Secretary of State (Section 12);

3.1.13 My conclusions statement (Section 13);

3.1.14 A statement of truth (Section 14).

3.2 In addition to this proof of evidence (EA/4/1), there is a separate volume of Appendices (EA/4/2). This includes, at Appendix 1, a set of Figures (EA/4/2) which presents the photographs, maps and diagrams that I refer to in my evidence text. A further 8 Appendices to my evidence provide additional background and supporting information referred to in the text.
The Haven – Navigation Overview

4.1 In this section I present a brief overview description of the Haven from a navigation viewpoint.

4.2 The Haven

4.2.1 The Haven is the tidal section of the River Witham between the Wash and the Grand Sluice (see Figure 1). 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 (as shown in Figure 2).

4.2.2 The site of the proposed Boston Barrier is also shown on Figures 1 and 2.

4.2.3 The Haven is important to navigation because it links the PoB with the coastal waters of the Wash. It also acts as a gateway access point and link between otherwise separated inland waterways networks (see Figure 3). The Haven is also the base for the Boston fishing fleet, commercial sightseeing cruises and for a range of local and visiting recreational river users.

4.2.4 The Maritime and Coastguard Agency (MCA) has classified the Haven as Category C ‘inland waters’. This category covers ‘tidal rivers, estuaries and large, deep lakes and lochs where the significant wave height could not be expected to exceed 1.2 metres at any time’. In other words, the Haven is relatively sheltered, with benign wave conditions compared with the open coastal and offshore waters.

4.2.5 The Haven is not, however, an easy waterway to navigate. The river channel through the Haven is relatively narrow, with several significant river bends. Furthermore, due to its nature as a tidal river, the water level in the river varies significantly with both the tidal conditions and with the freshwater river and sluice discharge conditions. As the water level varies, the width of the navigation channel also varies. This is discussed further in Section 4.6.3.

4.2.6 The Haven is subject to moderate to strong tidal and fluvial currents at times. This is discussed further in Section 4.6.6. This is important because navigation on the river is dominated by the river conditions. Flows through the Haven are generally strongest when a large tide coincides with a high freshwater discharge event.

4.2.7 There are also numerous existing hazards to navigation on the Haven (see Figure 1). These include submerged shoal areas, river bends, the derelict Witham Wharf, the Swing Bridge, a series of low bridges and several wrecks. The principal existing hazards to navigation are described further in Section 4.6.8.

4.2.8 A range of vessel types and sizes navigate on the Haven undertaking different activities, and subject to different operating constraints. These vessels are used by river users for both commercial and recreational purposes (see Sections 4.3 and 4.4).
4.2.9 When compared with many UK estuaries, rivers and waterways serving ports and harbours there is a low volume of marine traffic on the Haven. The marine traffic levels are discussed further in Section 4.5.

4.3 Haven River Users

4.3.1 A wide range of vessel types and sizes navigate on the Haven at present. The most common vessel types are described in Section 5.13 of A17/2D – Volume 2d: Technical Report: Navigational Impact Assessment, and are also summarised briefly here.

4.3.2 The principal commercial Haven river users are:

(a) PoB ships including the ships that lock into the PoB Wet Dock, and the ‘grain ships’ that operate from the riverine Silo Berth (for Frontier Agriculture). These ships may be up to 92m in length, 14m wide (beam) and 6,000dwt;

(b) PoB support vessels, including the PoB pilot boat, PoB tugs and the PoB dredger;

(c) Fishing vessels, which are described further in Patrick Franklin’s proof of evidence (EA/6/1);

(d) The ‘Boston Belle’ – a passenger tour vessel which operates commercial sightseeing cruises for up to 60 passengers; and

(e) Miscellaneous other commercial vessels e.g. survey vessels, construction vessels etc.

4.3.3 The principal recreational Haven river users are:

(a) Sailing yachts and dinghies, including members of the Witham Sailing Club (WSC);

(b) Motor boats, including members of the Boston Motor Yacht Club (BMYC).

(c) Rigid Inflatable Boats (RIBs);

(d) Inland waterways craft e.g. narrowboats and ‘widebeam’ canal boats; and

(e) Miscellaneous man-powered craft e.g. kayaks and canoes.

4.3.4 Most of the vessels using the Haven are locally-based, and therefore very familiar with the Haven, but there are some visitors, usually in the summer months.

4.3.5 In general, the commercial vessels navigate on the Haven throughout the year, but the ‘Boston Belle’ operates in the summer months only. The recreational vessels tend to operate in the summer months only.
4.4 Navigation Patterns Within The Haven

4.4.1 In this section I discuss the patterns of navigation within the Haven at present.

4.4.2 Overview

(a) Vessels can enter and/or exit the Haven at four possible locations (see Figure 1):

(i) Via the New Cut at the mouth of the river, where it meets the Wash;

(ii) Via the PoB Wet Dock navigation lock;

(iii) Via the Grand Sluice navigation lock into the non-tidal River Witham; or

(iv) Via the Black Sluice navigation lock into the non-tidal Forty Foot Drain.

(b) In addition, small craft (e.g. dinghies, RIBs, kayaks, jetskis etc.) can be launched at designated ramps.

(c) Individual vessel movements on the Haven are largely governed by:

(i) the state of the tide and, in particular, the water depth available in the navigation channel;

(ii) the location of the vessel’s mooring; and

(iii) the operating constraints of the navigation locks (at Grand Sluice, Wet Dock and Black Sluice).

(d) Many vessels pass through the Haven as a means to reach their destination (e.g. the Wash, the PoB Wet Dock, or to the River Witham above the Grand Sluice). However, some vessels (including the Boston fishing fleet) operate from moorings within the Haven itself.

(e) The position of the vessel moorings within the Haven are described in Section 5.14 of the Navigational Impact Assessment provided within Volume 2d of the Environmental Statement (A17/2D).

4.4.3 PoB Ships

(a) Due to water depth constraints the PoB ships can only manoeuvre within the Haven over the high water period (approximately HW ± 2hours). These ships moor at berths either within the Wet Dock or at riverine berths within the Haven (see Figure 2). The riverine berths are classed as Not Always Afloat But Safely Aground (NAABSA) berths.

(b) The most heavily utilised PoB riverine berth is the ‘Silo Berth’ operated at present by Frontier (see Figure 2). In 2016 there was a ship moored on
the Silo Berth on 81 days (PoB records). ‘Grain ships’ up to 92m in length and 14m beam are accommodated on this berth at present. To facilitate cargo transfer operations the position of the moored grain ship may be shifted along the quay, and the stern (or bow) of the ship may extend beyond the quay knuckle and encroach into the navigation fairway, as illustrated in Figures 5 and 6.

(c) The Port of Boston (PoB) dredger ‘Mary Angus’ routinely undertakes dredging tasks throughout the Haven (as far as the Swing Bridge), and discharges spoil at site(s) in The Wash. Due to water depth constraints the vessel typically operates within the Haven only over the top of the tide, approximately HW ± 2 hours. At present, the dredger routinely moors at the 21 Quay Berth or the Starch Berth (see Figure 2). Post-construction of the proposed barrier (which would be located here), it is proposed to berth the dredger, pilot and tug boats on riverine berths at the South Knuckle.

4.4.4 Fishing Vessels

(a) Commercial fishing vessels (the Boston Fishing Fleet) operate at present from permanent riverine quayside moorings, which are mostly located at the London Road Quay immediately above the Swing Bridge (see Figures 1 and 7).

(b) The Boston Fishing Fleet operates throughout the year, and may transit the river in both directions on both the flood and ebb portion of the tide. The pattern of fishing vessel movements is described in more detail in Patrick Franklin’s evidence (EA/6/1).

(c) The fishing vessels moor alongside the river side wall, either singly or rafted up in pairs, and the vessels typically unload their catch and perform maintenance activities etc. at this location (see Figures 7 to 9). At some of these moorings the fishing vessels may take the ground, or dry out completely, at some states of the tide (see, for example, Figure 9). Water depth constraints at the moorings, and lower in the river, mean that the fishing boats can typically manoeuvre at their berths only when the water level is above 0.6mOD (=2.27mCD).

4.4.5 Grand Sluice Navigation Lock

(a) All vessels passing between the non-tidal River Witham and the Haven must pass through the Grand Sluice navigation lock (see Figure 1 and Figure 13).

(b) The Grand Sluice navigation lock is relatively small at only 12.5m long by 3.7m wide. Furthermore, all vessels must pass under two low bridges to transit the lock so vessel movements at the lock are also subject to air draught constraints.

(c) The operation of Grand Sluice navigation lock is dependent on the relative water level between the tidal section of the river and the non-tidal inland sections of the river.
Vessels less than 12.5m long (i.e. those that fit within the lock) can lock through at any time provided there is sufficient water depth in the tidal Haven for the vessel to operate. In practice this means that small vessels can pass the lock approximately HW±3 hours.

Vessels longer than 12.5m can only pass through the lock “on the level” when the water levels in the tidal and non-tidal sections of the river are effectively equal allowing both lock gates to be open at the same time. Vessels can only pass through the lock on the level during two short windows per tide, each of approximately 5 minutes’ duration. The “first level” window occurs as the tidal level rises past the non-tidal Witham level. The “second level” window occurs when the tidal level drops again past the non-tidal Witham level.

The Canal and River Trust (CRT) has an advisory caution note that states that locking through at Grand Sluice is not possible on strong spring tides. In practice, however, this is treated as a precautionary covering notice and vessels have passed through the lock successfully during such periods.

Passage through the Grand Sluice navigation lock has to be booked 24 hours in advance by contacting the lock keeper, or on a phone booking line. The Grand Sluice lock is not, however, usually manned outside of the boating season (i.e. during the winter period).

4.4.6 ‘Boston Belle’

The ‘Boston Belle’ operates commercial sightseeing cruises for up to 60 passengers at a time from a boarding station near the Boston Gateway Marina, just above the Grand Sluice navigation lock (see Figure 1). The cruises operate in the summer months only. It is noted that at present the majority of the ‘Boston Belle’ cruises take place on the non-tidal River Witham, and only an estimated 10% of the cruises currently go to the Wash.

When undertaking a cruise to the Wash, the ‘Boston Belle’ always heads down-river on the flood portion of the tide, and returns up-river on the ebb portion of the tide, in a manoeuvring window that is governed by the Grand Sluice navigation lock operating times (discussed further in Section 4.4.5). This means the ‘Boston Belle’ is always stemming the current.

4.4.7 Recreational Vessels

Many of the recreational vessels that use the Haven are based at the Boston Gateway Marina, which is located just above the Grand Sluice navigation lock (see Figure 1). The manoeuvring window for these vessels is also governed by the Grand Sluice navigation lock operating times (discussed further in Section 4.4.5). In addition there are fixed low bridges between the Swing Bridge and the Grand Sluice which impose air draught restrictions (discussed further in Section 4.6.8(a)). All yachts must lower their masts to pass under the bridges.
There are some drying riverine berths for small craft on the river banks in the area between the Black Sluice and the Grand Sluice (see Figures 10 and 11). There are no air draught restrictions at these berths (so yacht masts can remain stepped), but some of these moorings are severely tidally constrained due to water depth availability.

Inland waterways craft (canal boats) also occasionally navigate through the Haven. These vessels typically use the Haven to access the Wash to go to Fosdyke for repair or refurbishment or to transfer between separated sections of inland waterways network (see Figure 2). The vessels usually moor in the non-tidal section of the river, above the Grand Sluice and so their manoeuvring window through the Haven depends on the Grand Sluice navigation lock operating times (discussed further in Section 4.4.5). Inland waterways craft are generally not designed to operate in tidal and coastal waters, and so are strongly advised to navigate through the Haven in benign conditions only, and during the summer months. Inland waterways vessels intending to cross the Wash typically start to move down-river from the Grand Sluice lock on the falling ebb tide. Inland waterways vessels entering from the Wash typically arrive in the Haven on the rising, flood tide.

4.4.8 Black Sluice Navigation Lock

(a) Inland waterways vessels may also use the Haven to access the South Forty Foot Drain via the Black Sluice navigation lock. The dimensions of the Black Sluice lock are 21m x 6m, with minimum water depth of 2.8m (see Figure 14). Vessels are generally transferring between the non-tidal River Witham and the South Forty Foot Drain waterways and so their manoeuvring window through the Haven depends on the Grand Sluice navigation lock operating times (discussed further in Section 4.4.5). The Forty Foot Drain is at present a ‘dead end’ waterway with no onward links, and as such the volume of traffic through the Black Sluice navigation lock is very low.

(b) Locking through the Black Sluice lock onto the South Forty Foot Drain takes place when the (Haven) tide level is higher than the non-tidal water level, i.e. vessels ‘lock down’ onto the South Forty Foot Drain.

(c) The Black Sluice navigation lock is not permanently manned. Passage through the Black Sluice must be booked a minimum of 24 hours in advance, during office hours on a phone booking line, or by contacting the Grand Sluice lock keeper.

(d) There is a waiting pontoon on the Haven just above Black Sluice (see Figures 11 and 12). This facility is intended as a waiting area for vessels using the Black Sluice navigation lock, but yachts may also moor temporarily to raise or lower their masts. At present this pontoon and its approaches dry out completely at many states of the tide (see Figure 11).
This Section has explained the patterns of navigation that occur at present on the Haven to provide context for the consideration of the effects on navigation of the Boston Barrier Scheme.

### Marine Traffic Levels

**4.5.1** In this section I discuss briefly the data available on the level of marine traffic on the Haven at present.

**4.5.2** Fully comprehensive, detailed marine traffic records are not available for the Haven as a whole. There are, however, records available that describe separately the number of vessel movements at key locations within the Haven, including:

(a) PoB’s commercial ship movement records; and

(b) Grand Sluice Navigation Lock traffic records (2000 to 2013). The Grand Sluice data provides details of the number of vessel movements through the navigation lock each month, but does not provide data on the type of vessels, or the pattern of vessel movements on a day-to-day basis.

**4.5.3** In addition, there is CCTV footage available from cameras mounted on the Black Sluice which shows the approaches to the proposed barrier site, as illustrated in Figure 4. Mott MacDonald has analysed vessel movement statistics for this area based on a review the CCTV footage for the periods 1st September to 11th November 2013 and 1st May to 30th June 2014.

**4.5.4** Based on the analysis undertaken, the average number of vessel movements on the Haven as a whole at present is estimated to be:

(a) 8 PoB ship movements per week (less than 1 per day). All of PoB ship movements are restricted to the area down-river of the Swing Bridge (see Figures 1 and 2). The ships operate largely to and from the Wet Dock and at the riverine berths on Lairage Quay, which are down-river of the Boston Barrier Scheme site. There might be some changes to the berthing arrangements during the construction phase of the Scheme, but otherwise navigation of these vessels will not be affected.

(b) The CCTV footage at Black Sluice indicates that there are between 22 and up to approximately 540 fishing vessel movements per month past the barrier site. As an upper estimate, if all of the approximately 26 Boston-based fishing vessels choose to fish on the same day then there could be up to approximately 52 fishing vessel movements per day. The CCTV data also shows that there are many days when no fishing vessels navigate through the Haven.

(c) Up to approximately to 480 vessels movements a year through the Grand Sluice navigation lock have been recorded. Of these 25-30 are narrowboats and 4 are ‘widebeam’ canal boats. Most, if not all, of these vessels are expected to pass the barrier site. July and August are generally the busiest months, with up to 201 vessel movements per month (August 2000). However, during periods of bad weather and high summer
rainfall the number of vessel movements through the lock can be very low. For example, during the summer of 2007 only 39 vessel movements through the lock were recorded in the 3 month period June to August, with only 2 vessel movements through the lock in the whole of July 2007.

(d) At the Black Sluice navigation lock there are on average 8 vessel movements a year. The Black Sluice lock leads into the Forty Foot Drain waterway, which is a dead end, and so this represents an average of 4 narrow boats per year using the lock.

4.5.5 In general terms, there is a higher volume of marine traffic in the summer months than over the winter, but even during the busiest summer months it is estimated that there are fewer than 800 vessel movements per month (averaging fewer than 30 vessel movements per day). During the winter months there may be fewer than 120 vessel movements per month (averaging fewer than 4 vessel movements per day).

4.5.6 The actual number of vessel movements on the Haven on any given day is highly variable, and depends on the season, the tidal and weather conditions, and to some extent on the day of the week.

4.5.7 Almost all the vessel movements will occur during relatively short ‘tidal operating windows’, usually over the high water period. This means that the marine traffic tends to ‘cluster’ to an extent and vessels can encounter other marine traffic at any position within the Haven.

4.5.8 Overall, there is a low volume of marine traffic on the Haven. Most of the vessels using the Haven are locally-based, and therefore very familiar with the Haven. There are some visitors, usually in the summer months when the river conditions are, in general, favourable to navigation. Vessels are expected to encounter other manoeuvring vessels within the Haven at times, which is normal for most waterways.

4.6 Baseline Navigation Situation on the Haven

4.6.1 In this section I describe the ‘baseline’ navigation situation on the Haven at present, with a particular focus on the navigation situation in the vicinity of the proposed site of the barrier. I discuss the navigable channel width, the river bend at the barrier site, the flow conditions, and the existing sight lines. I also describe the existing hazards to navigation in other parts of the Haven. Finally I describe the existing marine traffic management systems.

4.6.2 The baseline conditions on the Haven in general are also described in Section 5 of the Navigation Impact Assessment in Volume 2d of the Environmental Statement (A17/2D).

4.6.3 Navigable Channel Width

(a) The River Witham through the Haven is a tidal river with a relatively narrow permanent channel fringed with intertidal areas. The intertidal areas are
banks of differing extents that are submerged at high tidal water levels, but which can dry at low tidal water levels.

(b) The tide at Boston is semi diurnal (two high waters and two low waters in any 24 hour period). The extreme tidal range is greater than 7m i.e. the water level can rise and fall by up to about 7m due to the tide. As the water level varies, the width of the river, and the navigable channel, also varies as the water depth over the intertidal banks vary.

(c) The existing full river width at the site of the barrier is approximately 56m. However, in Figure 15 the areas marked in green indicate the full extent of the intertidal bank areas in the central section of the Haven. This shows that at the proposed site for the barrier there is at present an intertidal bank that extends from the south bank to approximately half-way across the river.

(d) This feature is also illustrated in Figure 16, which presents the river profile in cross-section at the site of the barrier, and which shows the existing ground and river bed profile superimposed on the cross section through the barrier structure.

(e) The intertidal bank can also be seen in the right hand image in Figure 4, and Figures 5 and 6. Figure 4 shows a CCTV image of a fishing vessel passing the barrier site. Note the dry intertidal mud bank extending from the south side of the river, and the position of the fishing boat in the middle of the river, to avoid the shallow water on the vessel’s port side.

(f) At some states of the tide, due to the intertidal bank, the river channel at the location can be reduced to approximately 30m. The width of the navigable channel available to manoeuvring vessels will be less than this (due to water depth constraints), but the precise width will vary depending on the state of the tide and the vessel’s draught. Furthermore, mariners cannot be confident of the navigable channel width available because they cannot ‘see’ or know the extent of the shallow water underwater and so there is a tendency for vessels to stay towards the centre of the river.

(g) The navigable channel width is reduced further when there is a grain ship on the Silo Berth. At present when a grain ship is moored at the Silo Berth in its most extreme moored position, the stern (or bow) of the ship extends approximately 25m beyond the quay knuckle (see Section 4.4.3(b) and Figures 5 and 6). In this position, the ship’s hull encroaches significantly into the navigation fairway. Any vessel transiting the Haven must pass the moored ship but must also stay clear of the shallow water adjacent to the south bank and the derelict Witham Wharf structure. In these circumstances the navigable channel width at this location is significantly less than 25m, but the precise width at any particular time would not be certain to mariners.

(h) Overall, in this section I have described how the full width of the river is not necessarily available at all times for navigation currently. At present, in the
worst case (when a grain ship is on the Silo Berth), the existing navigable channel width at the barrier site would be significantly less than 25m.

4.6.4 Navigating the ‘Barrier’ River Bend

(a) The proposed site for the barrier is on a bend in the river (see Figures 1, 2 and 15). The radius of the existing navigable channel around the bend is approximately 175m (see Figure 17).

(b) The ability of a vessel to ‘drive’ around a bend will depend largely on the inherent turning circle of the vessel, which depends on the vessel dimensions, the shape of the hull, the details of its propulsion system and the size and design of its rudder(s). In general, the larger the vessel the larger the turning circle.

(c) The turning manoeuvre will also be affected by the environmental conditions; vessels effectively turn more tightly when stemming a current than in a following current and the ability of vessels to initiate and then maintain the rate of turn required may be affected by strong wind conditions. There are, however, vessel handling techniques that can be used to increase the vessel’s rate of turn and to ‘tighten’ the turn to some extent e.g. use of a ‘kick’ ahead or astern on the engine combined with hard-over rudder, vessels with twin engines/propellers can use differential engine settings (or even split the engines), some vessels are equipped with lateral bow (and/or stern) thrusters.

(d) In addition, as vessels turn, they tend to generate lateral (sideways) drift as the hull ‘slides’ around the turn (see, for example Figure 18). A tightly turning vessel can take on a significant drift angle during the manoeuvre which increases the overall swept path occupied by the vessel. The amount of lateral drift generated will depend on the shape of the hull, the vessel draught, the vessel speed and the rate of turn.

(e) This means that it can sometimes be difficult to position a vessel precisely during a turn, and the vessel’s swept path may be wider than the vessel hull dimensions.

(f) It is clear, however, that all of the vessels that currently access locations up-river of the site can navigate this bend successfully at present without undue difficulty, although when a grain ship is overhanging the Silo Berth this may be navigationally more challenging.

4.6.5 Existing Sight Lines

(a) The sight lines around the river bend at the proposed barrier site are restricted at present. This means that, when compared with straight sections of river, it can be more difficult to look ahead any distance around the bend to see if the fairway is clear, or if there is another vessel approaching the bend from the opposite direction.
The sight lines at this bend are particularly poor whenever there is a grain ship moored on the Silo Berth (see Figure 2). In the worst case, when the grain ship is in its most extreme moored position when the stern (or bow) of the ship extends approximately 25m beyond the quay knuckle (see Sections 4.4.3(b) and 4.6.3(g) and Figures 5 and 6) this is effectively a blind bend, as illustrated in Figure 19.

4.6.6 Existing Current Conditions

(a) Navigation on the Haven is dominated by the river conditions, including the current/flow conditions.

(b) The existing river conditions (tidal and fluvial) on the Haven as a whole are described in detail in Sun Yan Evans’ evidence (EA/2/1).

(c) At the proposed site of the barrier, the currents flow in both directions (up-river and down-river) depending on the state of the tide. The current speed at this location depends not only on the state of the tide (and the tidal range), but also on the freshwater discharge through the Grand Sluice and the Black Sluice.

(d) Appendix 2 presents modelled current speed and vector plots for the central section of the Haven for the existing layout. The conditions presented in Appendix 2 were taken from those selected for use as input to the navigation simulations (discussed further in Section 7.5.5). Full details of the flow modelling process, as well as the model calibration and validation, are presented in Sun Yan Evans’ evidence (EA/2/1).

(e) The plots in Appendix 2 show that at any snapshot in time the current speed is not uniform throughout the Haven. The current speeds are noticeably higher in the narrowest sections of river (e.g. near Town Bridge, off Smith’s Wharf and South Terrace, and near Geest Point).

(f) Current speeds at the site of the barrier are at present generally slightly lower than at Geest Point (see, for example Appendix 2 (Figures A1.3 and A1.8)). The current speeds are also generally lower than at Town Quay, and off Smith’s Wharf and London Road Quay (where the fishing boats are moored) and through the concatenated bends near Town Bridge although this may not be the case when there is high discharge from Black Sluice (see, for example Appendix 2 (Figure A1.4)).

(g) The currents at the barrier site are consistently well aligned with, and parallel to, the river banks, even on the flood tide when water is discharging through the Black Sluice (see, for example Appendix 2 (Figures A1.5 and A1.7)).

4.6.7 Navigating in Currents

(a) It is routine for vessels of all types to navigate in currents.
(b) The principal effect of the current on the manoeuvring vessel will be on the vessel's speed (and direction) over the ground relative to its speed (and direction) through the water. When a vessel is stemming the current (heading into the current) the vessel's water speed will be higher than its speed over the ground. Similarly, in a following current, the vessel's water speed will be lower than its speed over the ground.

(c) Typically vessels that are stemming a current have a greater level of navigational control than vessels with a following current.

(d) In general terms, it is more difficult for vessels to undertake close-quarters manoeuvres (e.g. berthing, unberthing, swinging) in strong currents than to navigate through the Haven.

4.6.8 Existing Hazards to Navigation

(a) There are several existing hazards to navigation on the Haven, which include:

(b) The Swing Bridge

(i) The Swing Bridge is located on a straight section of the river approximately 275m up-river of the barrier site (see Figures 1 and 2). The Swing Bridge is a component of the branch railway line that leads to the PoB.

(ii) The bridge structure is supported on a central pier located in the middle of the river. The bridge deck pivots horizontally around its mid-point on the central support pier. The soffit level (deck level) of the Swing Bridge is 0.2m above Highest Astronomical Tide (HAT) level (approximately +4.9m AOD/ +7.8mCD).

(iii) For most of the time the Swing Bridge is ‘open’ and aligned parallel with the river (see Figures 7, 12 and 15).

(iv) When the Swing Bridge is open (see Figure 20), navigation is permitted through the western (right bank) opening only. The eastern (left bank) opening is obstructed by cables and shallow water.

(v) The effective navigation channel width through the Swing Bridge is approximately 17m. Navigation through the Swing Bridge is, in practice, one-way only at present.

(vi) The Swing Bridge must ‘close’ to allow trains to cross the river. When closed, the bridge swings across, and is aligned perpendicular to the river (see Figure 21).

(vii) When the Swing Bridge is closed, the vertical clearance under the closed Swing Bridge is only approximately 2.0m at mean high water springs (MHWS). At some states of the tide some low air
draught vessels (such as narrowboats and motorboats with low super-structure and low aerials) may be able to pass beneath the bridge when it is closed, as the tidal water level and the vessels’ air draught permits.

(viii) However, at many states of the tide there is insufficient vertical clearance between the water surface and the bridge deck to allow many vessels (including the fishing boats) to pass underneath the closed Swing Bridge. In these circumstances, the closed Swing Bridge is unpassable, and navigation for these vessels is effectively blocked at this location.

(ix) The Swing Bridge is controlled and operated by PoB. At present the Swing Bridge operates 5 days/week (weekdays), twice a day (approximately 7am in, 11am out). The bridge is closed for 45 minutes each time. There is no formal notification of bridge closures (as the bridge operations are considered routine), but there is a contact phone number displayed on a sign on the bridge that can be used to request information.

(x) There is no formal marine traffic management system at the Swing Bridge at present. Mariners rely on their ability to see through the bridge to confirm visually that there is no oncoming traffic and that it is, therefore, safe to proceed.

(xi) There is a central red light that is illuminated when the bridge is closed, but there are no other warning signs or lights to alert river users that the bridge is about to swing across the river.

(xii) At present vessels ‘work around’ the Swing Bridge closure times. The fishing fleet sometimes call PoB, as required, when they see the Swing Bridge is closed at a time they wish to manoeuvre.

(c) Low Bridges

(i) There are three fixed low bridges across the Haven between the Swing Bridge and the Grand Sluice (namely the Haven Bridge, Town Bridge and St Botolph’s Bridge – see Figure 17).

(ii) Of these bridges the lowest is the Town Bridge, with a soffit level of +5.1m AOD (+8.0m CD). At mean high water springs (MHWS) the vertical clearance under this bridge is only approximately 1.2m.

(iii) Yachts must always lower their masts to transit under these bridges.

(iv) At some states of the tide, low air draught vessels (such as narrowboats and motorboats with low super-structures etc.) may be able to pass beneath the bridge, but at high tidal levels this bridge will be unpassable by all vessels (see, for example, Figure 22).
(d) River Bends

(i) There are six navigationally significant river bends in the Haven between the PoB Wet Dock and the Grand Sluice (Geest Point, the bend at the barrier site, the bend at London Road Quay, and three more bends further up-river which I have referred to here as Bends ‘1’, ‘2’ and ‘3’).

(ii) The most difficult bends to navigate are Bends ‘1’, ‘2’ and ‘3’ (see Figure 17). The full river width at these bends is narrow (between 30 and 35m) but the navigable channel is less wide than this as there are often vessels moored at the banks (and sometimes rafted up). The river sides at these locations are vertical with sheet piling and other fixed obstructions. Furthermore these three bends are concatenated (they form a linked sequence of bends with no straights between the bends). Concatenated bends are more difficult to navigate than single separated bends because the vessel master cannot complete one turn and settle onto a straight course and reduce the residual lateral drift before needing to initiate the next turning manoeuvre.

(iii) In addition, the sight lines around these bends are poor (see for example Figure 23) and so it is difficult to see on-coming traffic.

(e) Wrecks

(i) There are several abandoned vessels and/or wrecks within the Haven (see, for example, Figures 23 and 24). The presence of these hazards reduces the width of safe navigation channel available.

(f) Witham Wharf

(i) Witham Wharf is a derelict ship berth on the south side of the river, roughly opposite the Silo Berth (see Figures 2 and 5).

(ii) The structure extends approximately 12m into the river from the south bank and reduces the channel width available.

(g) Grain Ships

(i) At present when a grain ship is moored at the Silo Berth in its most extreme moored position, the stern (or bow) of the ship extends approximately 25m beyond the quay knuckle (see Sections 4.6.3(g), 4.4.3(b) and Figures 5 and 6). In this position, the ship’s hull encroaches significantly into the navigation fairway, and so could also be classed as a navigation hazard.
4.6.9 Marine Traffic Management

(a) The PoB Control Office controls the movements of large commercial ships, but at present there is no formal traffic management system for smaller vessels (such as the fishing boats, recreational vessels etc) transiting through the Haven.

(b) It has already been established that there are sections of the Haven that are suitable for one-way navigation only (see Section 4.6.8(b)(v) or which are impassable to navigation in some conditions (see Sections 4.6.8.(b)(viii) and 4.6.8(c)).

(c) In the absence of a formal marine traffic management system, river users in this section of the river rely on a combination of:

(i) their ability to see other manoeuvring vessels and oncoming traffic;

(ii) their local knowledge of the navigation patterns on the Haven (e.g. fishing fleet movements);

(iii) their local knowledge of the operating times of the navigation locks and the Swing Bridge; and

(iv) their local knowledge of the river conditions, the extent of shoal areas and the water level at the time of the manoeuvre.

(d) The PoB Port Control Office (call sign ‘Boston Port Control’) can provide commercial ship traffic forecasts and shipping movements on the PoB berths, but the office is manned only at tide times when commercial shipping movements are planned to occur and so this service is not available 24 hours a day.

(e) In addition, the PoB Standing Annual Notice to Mariners (2017) Appendix 3 states:

‘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’.

(f) 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’.

(g) At present ‘Boston Port Control’ and PoB Pilots use VHF radio to communicate with other river users as required to avoid conflicts between the PoB ships and other vessels.
PROOF OF EVIDENCE OF GILLIAN WATSON (EA/4/1)

(h) 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’ (Canal and River Trust Notice 192 (2012)\(^1\)).

4.6.10 This Section has explained the ‘baseline’ navigation situation on the Haven at present to provide context for the consideration of the effects on navigation of the Boston Barrier Scheme.

5 Boston Barrier Scheme

5.1 In this section I describe navigation-related aspects of the Boston Barrier Scheme, with a particular focus on the navigation situation in the vicinity of the proposed cofferdam and barrier structures.

5.2 The proposed structures to be located within the river in relation to the Boston Barrier Scheme are described in detail in Peter Mallin’s evidence (EA/3/1).

5.3 The river conditions (tidal and fluvial) on the Haven as a whole with the construction phase cofferdam and post-construction barrier structures in place are described in detail in Sun Yan Evans’ evidence (EA/2/1).

5.4 Construction Phase Cofferdam

5.4.1 During construction of the barrier structure a cofferdam will be installed on the south side of the river at the barrier site. This will allow excavation of the recess for the moveable gate and construction of the foundations and side walls of the barrier structure on the south side of the river. During this period a navigation channel will be maintained at the barrier site, on the north side of the river.

5.4.2 The cofferdam navigation channel will be a minimum navigable width of 18m and will be dredged to -3.00mOD (-0.2mCD).

5.4.3 In addition, the ‘Phase 1’ dredging activities will ensure that vessel manoeuvring areas immediately either side of the cofferdam are also dredged to -3.00mOD (-0.2mCD) as indicated in Drawing IMAN001472-EVT-MMO-001 (see Appendix 4).

5.4.4 Appendix 5 presents modelled current speed and vector plots for the central section of the Haven with the cofferdam in place. The conditions presented in Appendix 5 are those selected for use as input to the navigation simulations (discussed further in Section 7.5.5). Full details of the flow modelling process, as well as the model calibration and validation, are presented in Sun Yan Evans’ evidence (EA/2/1).

5.4.5 Comparing Mott MacDonald’s numerical flow model predictions for the baseline and cofferdam layouts (see Appendices 2 and 5) indicates that the presence of the cofferdam structure modifies the flow pattern noticeably within about 150m of the structure, but the flows are little changed beyond this area. The most

\(^1\) [https://canalrivertrust.org.uk/notice/192/boston-lock-port-of-boston](https://canalrivertrust.org.uk/notice/192/boston-lock-port-of-boston)
significant feature is a zone of accelerated flow through the relatively narrow gap between the cofferdam structure and the north wall of the river, which also serves as the cofferdam navigation channel.

5.4.6 The flow model predictions indicate that peak current speeds of between 0.8 to 1.6 knots may be experienced in the cofferdam navigation channel during ‘typical’ summer conditions (see Appendix 5 (Figures A3.1 and A3.2)). Moderate currents up to about 2 knots are expected in the cofferdam navigation channel in ‘typical’ winter conditions (see Appendix 5 (Figures A3.3 and A3.4)).

5.4.7 The flow modellers did not predict ‘difficult’ summer or winter flow conditions with the cofferdam, and so these were not included in the navigation simulation. It is not in any event considered that vessels should navigate through the cofferdam navigation channel in difficult conditions and this will be controlled through the measures outlined in the Navigation Management Plan.

5.4.8 At all times the flow in the final approaches to, and within, the cofferdam navigation channel are reasonably well-aligned with the navigation fairway. This means vessels should not experience strong cross components of current during transits of the channel.

5.4.9 The flow model also predicts that currents will be weaker on the south side of the river adjacent to the cofferdam structure. At some states of the tide weak back eddies may form in these areas, but these do not extend into the main navigation fairway.

5.4.10 During the barrier construction period the Boston Fishing Fleet have been offered temporary relocation to berths down-river of the cofferdam and within the Port of Boston (please see Patrick Franklin’s evidence (EA/6/1) for further details of the proposed temporary moorings). Accordingly, fishing vessels that choose to relocate will not need to transit the cofferdam on a routine basis.

5.4.11 It is proposed that the relocated fishing vessels would moor on temporary berths on Lairage Quay. At some times the fishing vessels may need to moor rafted up in pairs. To ensure a clear approach to the cofferdam navigation channel, the first moored fishing boat would be moored at least 55m east of the quay knuckle. Any vessels moored on the Lairage Quay berths will tend to reduce the width of the navigation fairway available to local navigation along this stretch of the river, but this presents no change from the current situation when vessels are moored there.

5.5 Post-Construction

5.5.1 The location of the proposed barrier (see Figures 1 and 2) means that it is up-river of the PoB Wet Dock and most of the PoB riverine berths. As such, the presence of the barrier should have no impact on navigation of vessels at the Wet Dock or vessels manoeuvring to the Lairage Quay berths.

5.5.2 The barrier structure includes a 25m wide moveable gate, which is designed to rotate around a hinge and ram mechanism that allows the gate to retract into a recess in riverbed. This allows for a 25m wide navigation channel through the barrier structure, on the south side of the river. The moveable gate will only be
deployed (raised) in the event of a flood event, or for short periods for maintenance purposes.

5.5.3 The barrier navigation channel will have a minimum navigable width of 25m and will have a sill level of -3.00mOD (-0.2mCD).

5.5.4 Ongoing dredging activity will ensure that vessel manoeuvring areas immediately either side of the barrier have a maintained depth of at least -3.00mOD (-0.2mCD) as shown in Drawing IMAN001472-CIV-DR-011 (see Appendix 6).

5.5.5 In addition:

(a) the derelict Witham Wharf (see Figure 2) will be removed and there will be maintained depth of at least -3.00mOD (-0.2mCD) across the full width of the river in this location; and

(b) the existing Frontier berth is proposed to be relocated slightly further east along Lairage Quay, as indicated in Drawing IMAN001472-CIV-DR-073 (see Appendix 7). This ensures a clear approach to the barrier navigation channel.

5.5.6 Appendix 8 presents modelled current speed and vector plots for the central section of the Haven with the completed barrier. The conditions presented in Appendix 8 are those selected for use as input to the navigation simulations (discussed further in Section 7.5.5).

5.5.7 Comparing Mott MacDonald’s numerical flow model predictions for the baseline and post-construction layouts (see Appendices 2 and 8) indicates that the presence of the barrier structure and associated dredging modifies the flow pattern noticeably within about 150m of the structure, but that flows are little changed beyond this area. The most navigationally significant feature is a zone of accelerated flow through the 25m wide barrier navigation channel on the south side of the river.

5.5.8 Mott MacDonald’s numerical flow model predictions indicate that moderate to strong peak currents (up to approximately 3.7 knots) may be experienced at the barrier in ‘difficult’ winter conditions (see Appendix 8 (Figure 6.8)). This represents an increase in peak current speed of up to approximately 1.2 knots at the barrier site compared to the present river layout (compare Appendix 8 (Figure A6.8) with Appendix 2 (Figure A1.8)). An increase in current speed of this magnitude is well within acceptable vessel handling limits for powerful and manoeuvrable vessels such as the fishing boats.

5.5.9 Peak current speeds at the barrier are predicted to be less than 1.0 knot at all states of the tide during ‘typical’ summer conditions (see Appendix 8 (Figure A6.1)) and less than approximately 2 knots during ‘difficult’ summer and ‘typical’ winter conditions (see Appendix 8 (Figures A6.3 and A6.6)).

5.5.10 At all times the flow in the final approaches to, and within, the barrier are well-aligned with the navigation fairway. This means vessels should not experience strong cross components of current during transits of the channel.
5.5.11 The flow model also predicts that currents will be significantly weaker immediately either side of the barrier structure on the north side of the river. At some states of the tide weak back eddies may form in these areas, but these do not extend into the main navigation fairway (see, for example Appendix 8 (Figures A6.1, A6.3 and A6.7 and A6.8)).

5.5.12 Full details of the flow modelling process, as well as the model calibration and validation, are presented in Sun Yan Evans’ evidence (EA/2/1). It is noted that the Mott MacDonald flow modellers also predicted flow speeds through the barrier associated with larger river flood events. In a scenario with a river flood that has a 1 in 100 chance of occurring in any given year (1% AEP) combined and a tidal curve of MHWS the peak velocity through middle of the barrier navigation channel is 2.6m/s (~ 5knots). This peak velocity occurs when the water level is relatively low (+1.7 mOD, or roughly the level of MLWN). Note that it is not reasonable to expect any vessels to be operating in and around the barrier and port in such extreme river conditions.

5.6 In this section I have discussed navigation-related aspects of the Boston Barrier Scheme, with a particular focus on the navigation situation in the immediate vicinity of the proposed cofferdam and barrier structures. I have described the navigation channel widths and navigable depths in the approaches to the structures as well as the predicted flow conditions that navigating vessels can reasonably expect to encounter.

6 Navigation Simulation

6.1 In this section I introduce the process of navigation simulation and its uses in terms of port and navigation channel design assessment. I also briefly describe HR Wallingford’s navigation simulation experience and the HR Wallingford Ship Navigation Simulation System and facilities. This is intended to provide additional background to the Boston Barrier real time navigation simulation study, which is described in Section 7.

6.2 Overview

6.2.1 Navigation simulation has been developed over many years as a technique to assess port, harbour and navigation channel layout designs and navigability, to help to quantify navigation risk, and to help to identify appropriate navigation risk mitigation measures.

6.2.2 The simulation systems consist of simulation software, mathematical ship manoeuvring models, geographical area databases and replay and analysis tools.

6.2.3 The systems are usually described as two main types – fast-time simulation or real-time simulation. The main difference is that fast-time simulation uses autopilot algorithms to control the ship and tugs, whereas real-time simulation systems use a real mariner or marine pilot to control the simulated ship and tugs.

6.2.4 Real-time navigation simulation (the technique used in the Boston Barrier navigation simulation study) is the most comprehensive modelling tool available as it ensures that the important aspects of vessel handling, geographical and human factors can be examined in combination.
6.2.5 Real-time simulators for engineering design can have various levels of sophistication. Some can be very simple with a bridge view and control panel displayed on a single monitor or projection screen. Some can have a multiscreen display and even have real bridge controls for the pilot's direct use. The most advanced real-time simulators for approach channel and port layout design are full-mission simulators, which can also be used for pilot familiarisation and mariner training.

6.2.6 The simulator's geographical database describes the area where the simulations take place i.e. the navigation channel. The reality of the geographic representation depends on the available bathymetric, topographic and hydraulic data, which can influence the hydrodynamic response of the manoeuvring vessels and the visual scene for the pilots.

6.3 HR Wallingford Ship Navigation Simulation System and Simulators

6.3.1 HR Wallingford is an independent company, established for over 60 years, offering applied research and specialist consultancy services in civil engineering and environmental hydraulics to clients worldwide. The company has gained an international reputation for scientific and engineering excellence, and has no vested interest in any particular methods of solving problems, only in finding suitable solutions.

6.3.2 With a staff of over 250 including engineers, scientists, mathematicians, technicians and support staff, a wide range of skills and expertise is available. HR Wallingford is also the UK national centre for civil engineering hydraulics.

6.3.3 HR Wallingford is a world leader in assessing and simulating ship navigation and manoeuvring, and has been involved in the use of ship navigation simulation in port and similar design since the late 1980s.

6.3.4 We have designed, developed, constructed and operate 10 real time simulators from our two Ship Simulation Centres (one in the UK and one in Australia). Our simulators are full bridge, real time manoeuvring simulators specifically designed for port design and ship operations applications, but are also used for training and pilot familiarisation purposes.

6.3.5 HR Wallingford’s advanced Ship Navigation Simulation System and simulators are specifically designed for port and similar design and vessel operations applications. They have been developed over 30 years and have been used successfully in over 450 studies world-wide in the last 15 years alone.

6.3.6 The simulators consist of software that realistically simulates the dynamic behaviour of a vessel and its systems in a simulated maritime environment and an interface that consists of a realistic mock-up of the vessel's bridge and control consoles, and screens or projectors providing up to 360-degree virtual view of the vessel's surroundings, and that allows the person using the simulator to control the vessel and interact with its simulated surroundings. In this way the results, conclusions and recommendations can be based on a thorough review of technical aspects, as well as the important human factors, such as response times.
6.3.7 The simulation system and simulators are described in more detail in Appendix 9.

6.3.8 HR Wallingford has previously successfully used the simulators in a series of high-profile navigation simulation assessments.

6.3.9 A recent example of a Harbour Revision Order (HRO) supported by navigation simulations conducted by HR Wallingford is the Aberdeen Harbour Revision Order (SI 2016 No. 414). Amongst numerous on-going navigation simulation projects, the HR Wallingford simulators are currently used to simulate navigation of construction vessel manoeuvres associated with the Thames Tideway Tunnel project through central London.

6.3.10 The HR Wallingford simulation system was also used during the Formal Investigation into the Marchioness / Bowbelle fatal marine accident on the River Thames on 20 August 1989. The pleasure steamer Marchioness collided with the dredger Bowbelle in the early hours of the morning near the Cannon Street railway bridge. Following the collision the Marchioness sank resulting in the deaths of 51 people. The incident led to introduction of additional traffic management technologies and systems to reduce the risk of collision which remain in use on the River Thames today.

7 Boston Barrier Navigation Simulation Study

7.1 HR Wallingford has undertaken a real-time navigation simulation study of the Boston Barrier Scheme that aimed to assess in detail the feasibility of navigation at the barrier site during the construction and post-construction phases of the Scheme. The study was conducted on the behalf of Mott MacDonald and the Environment Agency.

7.2 The navigation simulation study used real time navigation simulation and focused on the manoeuvres of vessels that transit the barrier site and on the area between the Boston Swing Bridge and the South Knuckle (see Figure 2).

7.3 All of the navigation simulations were carried out using HR Wallingford’s Ship Navigation Simulation System and simulators at HR Wallingford’s UK Ship Simulation Centre in Wallingford, Oxfordshire.

7.4 A description of the navigation simulation study is structured as follows:

7.4.1 The configuration of the Boston Barrier navigation simulation and the vessel models is described in Section 7.5. This includes a description of the model verification tests performed ahead of the simulation sessions to ensure the simulation is working correctly;

7.4.2 Section 7.6 presents the aims and objectives of the three navigation simulation sessions, as well as the participants in each of the sessions;

7.4.3 Section 7.7 details the simulation runs performed; and

7.4.4 The main conclusions and recommendations arising from the simulation study are described in Sections 7.7.4(e) and 7.7.5(g).
7.5 Simulator Configuration

7.5.1 River Channel Layouts Simulated

(a) HR Wallingford developed simulation databases for three river channel layouts based on drawings and environmental data supplied by Mott MacDonald. The river channel layouts simulated in the navigation simulation study represented the existing (baseline) layout, the construction-phase 'cofferdam' layout, and the post-construction layout.

(b) The structures associated with the construction and post-construction phases of the Scheme are described in more detail in Peter Mallin’s proof of evidence (EA/3/1).

(c) The baseline layout represents the existing layout at the site (see Figure 25). This layout includes the derelict Witham Wharf structure on the south bank of the river, just below the barrier site. This layout represents the existing river bathymetry.

(d) The construction-phase 'cofferdam' layout simulated is shown in Figure 26. During the barrier structure construction works a cofferdam will be installed on the south side of the river at the barrier site. During this period a navigation channel with minimum navigable width of 18m will be maintained at the barrier site, towards the north bank of the river. The cofferdam layout represented in the simulator is indicative only, as the design and footprint of the cofferdam structure is not finalised. For the purposes of the simulations a worst case scenario of 18m wide bypass channel with Witham Wharf remaining in place was adopted.

(e) In the post-construction layout, all construction works on the barrier structure are complete and the derelict Witham Wharf has been demolished (see Figure 27). This layout includes the Scheme dredging as shown in Drawing IMAN001472-CIV-DR-011 (see Appendix 6)

7.5.2 Visual Scene

(a) A realistic visual scene was implemented in the simulation to provide the mariners with sufficient visual cues to assist in manoeuvring the vessels. The visual scene was created using drawings and photographs provided by Mott MacDonald along with satellite imagery and other publically available images.

(b) Where detailed information on the appearance of the layout was not available, and was not critical for navigation, reasonable assumptions were made based on the available information.

(c) Examples of the visual scene for the construction phase layout (including an indicative cofferdam) in Figure 28, and for the post-construction layout are presented in Figure 29 and Figure 30.
7.5.3 Vessels Manoeuvring Models

(a) HR Wallingford was instructed to develop six vessel models for use in Boston Barrier navigation simulations:

(i) 14m commercial fishing vessel (see Figure 31)
    14m x 6m x 1.7m*, displacement 90t**

(ii) ‘Boston Belle’ (see Figure 32)
    15.5m x 5m x 1.2m*, displacement 52t**

(iii) PoB dredger ‘Mary Angus’ (see Figure 33)
    37.3m x 10.0m x 2.2/3.4m*, displacement 574t/887t**

(iv) 6.5m yacht (based on a Jaguar 21) (see Figure 34)
    6.5m x 2.5m x 1.2m*, displacement 1.1t**

(v) 21.3m (70’) narrowboat (see Figure 35)
    21.3m x 2.1m x 0.76m*, displacement 29t**

(vi) 22m (72’2”) ‘widebeam’ canal boat (see Figure 36)
    22.0m x 4.4m x 0.76m*, displacement 63t**

* principal vessel dimensions: length (L) x beam (B) x draught (T)

** the vessel displacement is the volume of water displaced by the vessel which, by Archimedes’ principle, is also equivalent to the mass of the vessel

(b) These vessels were selected by Mott MacDonald and the EA to represent the primary vessels known to navigate the Haven and include:

(i) most common commercial vessel (fishing vessel) which are also the vessels most likely to operate throughout the year and in the widest range of conditions;

(ii) the commercial vessel which represents the highest overall risk to the general public (the commercial sightseeing vessel ‘Boston Belle’ with up to 60 passengers);

(iii) the largest vessel expected to need to pass through the barrier (PoB dredger);
(iv) a range of different types and sizes of recreational vessels including the largest recreational vessel ('widebeam' canal boat) expected to navigate the Haven).

(c) Two versions of the dredger model were produced (with vessel in laden and in ballast (unloaded) condition).

(d) Two versions of the yacht model were produced (one with the mast stepped (raised), and one with the mast lowered).

(e) During the simulation runs the behaviour and performance of the vessels, in terms of their response to any helm, engine control, and the local environmental conditions etc., are governed by mathematical ship manoeuvring models. The models aim to behave in such a way that the position, velocity, swept path and heading of the simulated vessel are always representative of real vessel behaviour.

(f) The ship manoeuvring models included motions in 6 degrees of freedom (6DOF) to ensure that both horizontal and vertical responses were taken into account in the simulation. The models also included representations of vessel squat and shallow water effects to ensure representative manoeuvring behaviour in shallow water.

(g) The ship manoeuvring models were based on the following data:

(i) The fishing vessel model was based on publically available drawings and vessel specifications describing similar fishing boats of this size and type;

(ii) The ‘Boston Belle’ vessel model was based on information supplied by the owner/operator Mr Rodney Bowles;

(iii) The model of the ‘Mary Angus’ was based on drawings, photographs and detailed vessel specifications supplied by PoB;

(iv) The yacht was based on publically available drawings, photographs and vessel specifications on the Jaguar 21 class of yacht, and on discussions with the owner one of these yachts; and

(v) The narrowboat and ‘widebeam’ canal boat models were based on drawings, photographs and detailed vessel specifications supplied by a canal boat boatbuilder, as well as other publically available data, and on discussions with the owners of examples of these vessels.

(h) The vessel manoeuvring models were calibrated using standard ship trials tests such as acceleration, deceleration, turning (advance and transfer), zig-zag, circle and emergency stop tests.
In addition, the handling performance of each of the vessel models was verified using a series of test manoeuvres in a range of environmental conditions as follows:

(i) The fishing boat model was verified by a mariner (a former fisherman who owned and operated a similar fishing vessel) who regularly works with HR Wallingford as a tug master in navigation simulation studies;

(ii) The Environment Agency Pilot (Captain Alan Cox) verified the performance of the ‘Boston Belle’, the yacht and the narrowboat models. Captain Cox not only has experience of handling his stone barge locally, but he also has direct experience of operating the ‘Boston Belle’ on the Haven, and also owns and sails a yacht based at Boston. Captain Cox has also previously acted as an expert pilot guide for convoys of narrowboats passing through the Haven;

(iii) I also tested the yacht model, and was satisfied that the vessel performance was both credible and in keeping with my experience of such vessels; and

(iv) The narrowboat and ‘widebeam’ canal boat models were also verified by an owner of these types of vessels.

In each case the handling performance of the vessel manoeuvring models were found to both realistic and credible.

7.5.4 Moored Vessels

(a) As explained further below, various moored vessels were included during the simulation runs. In each run, the mooring position and the type of moored vessel(s) was appropriate to the navigation scenario being tested. The overall intention was to test a worst case scenario for each river channel layout.

(b) In a small number of ‘familiarisation’ runs with the baseline layout, no moored ships were included. This represents the navigation situation when none of the PoB riverine berths are occupied.

(c) During the majority of the baseline layout runs, a 91.5m grain ship was included moored on the Silo Berth as this represents a worst case navigation situation at the barrier site at present (see Sections 4.4.3(b) and 4.6.3(g)). The grain ship was moored in a range of positions on the quay, including in its most extreme position with the stern of the ship extending 25m beyond the quay knuckle, as indicated in Figure 37.

(d) In the cofferdam layout runs, pairs of rafted fishing boats were moored at the proposed relocated temporary moorings on the Lairage Quay. The clearance between the quay knuckle and the stern of the first moored fishing boat was 55m, as shown in Figure 38.
During the post-construction layout simulation runs, a 91.5m grain ship was included moored on the Silo Berth with the stern of the ship at least 55m from the quay knuckle, as indicated in Figure 39. This is in line with the agreed post-construction berthing plan as shown in Drawing IMAN001472-CIV-DR-073 (see Appendix 7).

7.5.5 River Conditions Simulated

(a) The intention of the navigation simulations was to test navigation at the barrier site in both ‘typical’ river conditions, and also for ‘difficult’ river conditions i.e. conditions which are navigationally challenging, but still credible and appropriate for vessel navigation. It is not reasonable to expect vessels to be navigating on the Haven in ‘extreme’ tidal or fluvial flood conditions as the navigation risks are excessively high and therefore unacceptable.

(b) In March 2016 Mott MacDonald held meetings with the Boston District Fishing Association (BDFA) (which represents members of the Boston Fishing Fleet) and separately with the Witham Sailing Club (WSC) to establish suitable ‘difficult’ river conditions for navigation i.e. the most severe river conditions in which these river users would, in practice, consider navigating their vessels within the Haven.

(c) The BDFA identified two recent ‘difficult’ winter periods - 3 to 20 January 2016 and 9 to 12 March 2016. Each of these was a period associated with high fluvial discharge and spring tides. Of these, the March 2016 period proved to be the more severe (similar fluvial discharges, but higher tidal range), and was therefore selected to be modelled as the ‘difficult winter’ river conditions for the navigation simulations.

(d) WSC suggested that the period 19 to 21 September 2013 should be used to represent ‘difficult’ summer conditions.

(e) Mott MacDonald’s analysis of the combined tidal and fluvial data available shows that conditions with the severity of the ‘difficult’ winter river conditions occurred only twice in the past nine years (2007 to 2016). The slightly less severe winter conditions equivalent to those in the January 2016 period occurred eight times in the same period. Similarly, conditions with the ‘difficult’ summer severity occurred approximately eight times during the summer months (April to September) in the past nine years (2007 to 2016).

(f) In other words, the ‘difficult’ summer and winter conditions used in the navigation simulations occur on average roughly once per year.

(g) HR Wallingford were supplied with four modelled river conditions by Mott MacDonald for use in Boston Barrier navigation simulations as detailed in Table 1.
**Table 1: Summary of river conditions simulated**

<table>
<thead>
<tr>
<th>River condition</th>
<th>Tidal condition</th>
<th>Peak fluvial discharge (m³/s)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grand Sluice</td>
<td>Black Sluice</td>
</tr>
<tr>
<td>Typical summer</td>
<td>Mean spring tide Maud Foster level + 4.0mOD</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Difficult summer*</td>
<td>Higher than mean spring tide Maud Foster level +4.6mOD</td>
<td>2</td>
<td>37</td>
</tr>
<tr>
<td>Typical winter</td>
<td>Mean spring tide Maud Foster level + 4.0mOD</td>
<td>55</td>
<td>19</td>
</tr>
<tr>
<td>Difficult winter*</td>
<td>Higher than mean spring tide Maud Foster level +4.55mOD</td>
<td>101</td>
<td>65</td>
</tr>
</tbody>
</table>

* indicates that this condition was modelled for the baseline and post-construction layouts only

(h) In the simulation the four river conditions were represented on a 5m x 5m grid and over a period of several hours of a tidal cycle. The river condition data (flows and water depths) were taken from the outputs from Mott MacDonald’s TUFLOW numerical flow model runs with the three river channel layouts.

(i) Current speed and vector plots for the central section of the Haven for the baseline, cofferdam and post-construction river channel layouts are presented in Appendices 2, 5 and 8 respectively.

(j) The selected river conditions are described in more detail in Sun Yan Evans’ evidence (EA/2/1) and in Sections 2 and 3 of the Navigation Impact Assessment (NIA) provided in volume 2d of the Environmental Statement (A17/2D).
7.5.6 Simulator Bridges Used

(a) The simulation runs with the Port of Boston dredger, the narrowboat and ‘widebeam’ canal boat were performed in one of HR Wallingford’s ship simulator bridges (see Figure 41 and Appendix 9).

(b) The simulation runs for the remaining vessels were performed in one of HR Wallingford’s tug simulator bridges, as this is better suited to relatively small vessels (see Figure 42 and Appendix 9).

(c) Observers could monitor the runs either from the simulator bridges, or from one of the dedicated observation rooms.

7.5.7 Simulator configuration testing and verification

(a) A series of simulation set-up checks were undertaken prior to the simulation sessions to confirm that all components of the Boston simulation were configured correctly, and were interacting as expected. These checks included:

(i) spatial and orientation checks on the relative positions of the infrastructure, channel boundaries and aids to navigation;

(ii) spatial checks on water depths and current speeds;

(iii) confirmation of the vessel footprint and location with the simulation visual scene and situation display;

(iv) vessel engine and helm control tests;

(v) the effect of wind, waves and/or current on stationary vessels; and

(vi) the wind forces acting on vessels.

7.6 Simulation Sessions

7.6.1 The Boston Barrier navigation simulation study runs were performed in three separate simulation sessions. The overall aim was to assess the requirements for safe navigation, between the Boston Swing Bridge and the South Knuckle (see Figure 2).

7.6.2 Simulation Session 1

(a) The first navigation simulation session took place over 3 days from Tuesday 6 to Thursday 8 September 2016.

(b) The simulation session participants were:

(i) Steven Wilby (Mott MacDonald);

(ii) Peter Mallin (Mott MacDonald);
(iii) Adam Robinson (Environment Agency);
(iv) Captain Alan Cox (Environment Agency, pilot);
(v) Gillian Watson (HR Wallingford);
(vi) Captain Mark Murrison (HR Wallingford, pilot); and
(vii) Dr Mark McBride (HR Wallingford);

(c) The primary aims of this session were:

(i) to critically assess the credibility of the Boston simulation i.e. does the simulation ‘feel’ like the navigation situation in this section of the Haven at present? Are the Boston Barrier Scheme structures correctly represented in the cofferdam and post-construction simulation layouts?

(ii) to simulate vessel manoeuvres at the barrier site during the construction and post-construction phases of the Scheme, focussing on manoeuvres of a fishing vessel, the ‘Boston Belle’ and the yacht

(d) Captain Cox (the Boston-based local Environment Agency Pilot) considered the simulation both credible and representative of the existing navigation situation.

(e) Adam Robinson, Steven Wilby and Peter Mallin all considered the representation of the cofferdam and the barrier within the simulation to be accurate.

(f) The runs and outputs from the session simulation are described in Section 7.7.

7.6.3 Simulation Session 2

(a) The second navigation simulation session took place over 3 days from Tuesday 18 to Thursday 20 October 2016.

(b) The simulation session participants were:

(i) Captain Richard Walker (Port of Boston, Harbour Master);
(ii) Andy Roper (BDFA);
(iii) Rodney Bowles (owner/operator of the ‘Boston Belle’);
(iv) Roger Ackroyd (Witham Sailing Club);
(v) Ceri Morgan (Witham Sailing Club);
(vi) Steven Wilby (Mott MacDonald);
(vii) Peter Mallin (Mott MacDonald);
(viii) Adam Robinson (Environment Agency);
(ix) Captain Alan Cox (Environment Agency, pilot);
(x) Gillian Watson (HR Wallingford);
(xi) Captain Mark Murrison (HR Wallingford, pilot); and
(xii) Dr Mark McBride (HR Wallingford).

(c) The primary aims of this second session were:
(i) To simulate manoeuvres of the PoB dredger ‘Mary Angus’ through the barrier in the post-construction layout; and
(ii) To provide local interested parties including the PoB, the BDFA, the operators of the ‘Boston Belle’, and Witham Sailing Club (WSC), with the opportunity to participate in the study and to explore the navigation situation at the barrier for themselves.

(d) The outputs from the session simulation are described in Section 7.7.

7.6.4 Simulation Session 3

(a) The third navigation simulation session took place on Wednesday 22 February 2017.

(b) The simulation session participants were:
(i) Steven Wilby (Mott MacDonald);
(ii) Peter Mallin (Mott MacDonald);
(iii) Adam Robinson (Environment Agency);
(iv) Captain Peter McArthur (Master Mariner and EA Expert Witness, pilot);
(v) Captain Alan Cox (Environment Agency, pilot); and
(vi) Gillian Watson (HR Wallingford).

(c) The primary aims of this session were:
(i) to allow Captain McArthur to review the navigation situation at Boston with the baseline, cofferdam and post-construction river channel layouts, and to review the navigation simulation study’s conclusions;
(ii) to simulate manoeuvres of the narrowboat and ‘widebeam’ canal boat at the site of the proposed barrier during the construction and post-construction phases of the Scheme;

(iii) to consider proposals for contingency measure ‘safe haven’ berths at which leisure craft can moor temporarily either side of the barrier in exceptional circumstances. Two such berths were included in the post-construction layout model:

(aa) the existing lay-by waiting pontoon at Black Sluice (which is in an area due to be dredged and maintained at -3.0mOD, and so will be afloat and available to vessels at all states of the tide); and

(bb) a 35m length of wall (with rubbing strips, mooring rings, grab chains and ladder access) at the down-river end of the new sheet pile wall opposite the Silo Berth (near where Witham Wharf was previously located).

(d) The details of the runs performed in each of the simulation sessions are described in Section 7.7.

7.7 Simulation Runs

7.7.1 This section presents information on the simulation runs undertaken, and also discusses the runs performed broken down by river channel layout (baseline, cofferdam and post-construction) and by vessel type.

7.7.2 Overview

(a) In all, 94 navigation simulation runs were performed.

(b) The runs considered all three river channel layouts (baseline, cofferdam and post-construction – see Section 7.5.1), and simulated manoeuvres of each of the vessels (see Section 7.5.3) in a range of river conditions.

(c) The overall intention of the runs was to evaluate vessel manoeuvres in both ‘typical’ and ‘difficult’ navigation conditions, but with a particular focus on worst credible case manoeuvring scenarios.

(d) The navigation scenario for each individual run was based on the known tidal operating window of each type of vessel and their manoeuvring pattern within the Haven (for example, if the vessel only operates during the summer months, or tends to be navigating in the Haven with a following current, or stemming the current). The navigation patterns on the Haven at present are described in Section 4.4.

(e) The scenarios for 67 of the runs were selected by members of the Boston Barrier Scheme navigation simulation project team (HR Wallingford, Mott MacDonald and the Environment Agency).
The PoB Harbour Master (Captain Richard Walker) participated not only in the 15 dredger simulations but also took the opportunity to simulate manoeuvres of the fishing vessel, the ‘Boston Belle’ and the yacht for himself with the construction phase cofferdam or the post-construction barrier in place. These run scenarios were selected by Captain Walker.

33 runs simulated manoeuvres of the fishing vessel. Three of these runs were selected and witnessed by BDFA representative Andy Roper. Mr Roper was given the opportunity to select and observe further runs, but he declined. Mr Roper also chose not to ‘drive’ the fishing vessel himself in the runs, but he did closely observe the manoeuvres. Other members of the BDFA were invited to attend the simulations, but did not take up this opportunity.

16 runs simulated manoeuvres of the ‘Boston Belle’, of which 6 runs were selected and piloted by Mr Rodney Bowles, the owner and operator of the ‘Boston Belle’. Following feedback from Mr Bowles, a minor adjustment was made to the response rate of the rudder in the vessel’s ship manoeuvring model, but otherwise he seemed satisfied with the model performance. Mr Bowles did comment that he found it easier to navigate the ‘Boston Belle’ in real life than in the simulator.

29 runs simulated manoeuvres of recreational vessels (6.5m yacht, narrowboat and widebeam canal boat). Seven of the yacht runs were selected and piloted by Witham Sailing Club members Mr Roger Ackroyd and Mr Ceri Morgan.

7.7.3 Baseline Layout Runs

(a) 16 runs simulated manoeuvres with the baseline river channel layout (see Figure 25).

(b) The objectives of the baseline layout runs were to:

(i) Familiarise and acclimatise the simulation participants to the simulator and to establish current navigation practice;

(ii) Critically assess the realism and credibility of the simulation system and the simulation of the Haven; and

(iii) Provide a baseline experience against which manoeuvres with the barrier and cofferdam in place could be directly compared.

Based on feedback, comments and discussions held during the sessions, all of the locally-based river user participants (i.e. Captain Cox, Captain Walker, Mr Roper, Mr Bowles, Mr Ackroyd and Mr Morgan) considered the baseline Boston simulation to be both credible and representative of the existing navigation situation.
(d) The baseline runs demonstrated that the transit and turn through the existing river bend was manageable in all of the conditions tested, but also confirmed that:

(i) the existing sight lines around this river bend are poor (see also Section 4.6.5);

(ii) when there is a grain ship moored on the Silo Berth:

(aa) sight lines around the moored ship are particularly poor and this essentially becomes a ‘blind’ bend;

(bb) due to the limited navigation fairway width and associated water depth constraints, at present the transiting vessel must be precisely positioned between the moored ship and the Witham Wharf structures; and

(cc) if the moored grain ship is positioned with the stern (or bow) beyond the quay knuckle (see for example Figure 39) the hull of the moored ship encroaches significantly into the navigation fairway. This makes the transit of this section of river more challenging to navigate.

7.7.4 Cofferdam Layout Simulation Runs

(a) Overview

(i) In all, 22 runs considered vessel manoeuvres through the temporary cofferdam navigation channel (see Figure 26).

(ii) At the time of the first and second simulation sessions, the width of the cofferdam navigation was not yet finalised. The simulation team recommended that the width of the cofferdam navigation channel should be made as wide as practicable, both to maximise the manoeuvring space available, and to reduce the current speeds within the channel as far as possible. Subsequently, the navigable width of this channel has been finalised as a minimum of 18m.

(iii) At 18m wide, the cofferdam navigation channel is similar in width to the navigation channel at the Swing Bridge (see Section 4.6.8.(b)(iv)). Navigation through the Swing Bridge is in practice one-way for all vessels at present, and so it is reasonable to anticipate navigation at the cofferdam will be one-way also.

(iv) The cofferdam navigation channel is on the north side of the river, and on the inside of the bend. As such, the sight lines for mariners are expected to be poor. The sight lines are, however, similar to the situation at present with a grain ship on the Silo Berth (see Section 4.6.5).
(v) The cofferdam layout simulations considered inbound and outbound transits of the barrier navigation channel in a range of typical river conditions (as illustrated in, for example, Figures 44 to 48).

(vi) Due to the narrow nature of the cofferdam channel the simulation team did not attempt to manoeuvre the PoB dredger through the cofferdam channel, and the manoeuvres of the other vessels were simulated in ‘typical’ conditions only (see Section 7.5.5 Table 1).

(b) Fishing Vessel

(i) Seven runs considered fishing boat transits through the cofferdam navigation channel in typical winter conditions.

(ii) The 18m wide cofferdam channel is three times the 6.0m beam (width) of the fishing vessel hull. With the fishing vessel on the centreline of the channel there was horizontal clearance of approximately 1 x vessel beam on both sides. This is at the limit of acceptable horizontal clearance, and confirms that the cofferdam channel is suitable for one-way navigation only with this type of vessel. Navigation is already one-way at the Swing Bridge at present so this will not impact on navigation significantly.

(iii) Five runs examined transits through the cofferdam channel with a following current. In each case the fishing vessel experienced a noticeable and sudden increase in ground speed in the zone of accelerated flow through the narrowest section of the navigation channel. The vessel needed to be positioned precisely in the approach to the cofferdam structure, and once in the cofferdam channel there was little the skipper could do to correct the vessel position or alignment, if required. This means there is no margin for errors or misjudgements. Despite this, all of the simulated transits were achieved without incident. During the transit of the cofferdam channel the vessel was essentially ‘carried’ through the channel on the current, reaching ground speeds in excess of 5.5 knots. At these ground speeds the consequences of a fishing vessel making contact with the structure could be severe (both for the vessel, and for the structural integrity of the cofferdam and the construction personnel working within the cofferdam).

(iv) By contrast, in two runs the fishing vessel transited the cofferdam navigation channel stemming the current (see Figure 44). As the vessel is stemming the current, the skipper has enhanced steering, positioning and speed control. The vessel experienced a noticeable and sudden decrease in ground speed in the zone of accelerated flow through the cofferdam navigation channel, but had sufficient power, water speed and directional control to manage the transit acceptably and in a fully controlled manner.
Whilst it is considered possible for fishing vessels to safely transit the cofferdam navigation channel, during the barrier construction period, I recommend such vessels should not do so with a following current. The Environment Agency has offered to temporarily relocate members of the Boston Fishing Fleet to temporary berths down-river of the cofferdam with the Port of Boston. Accordingly, fishing vessels that choose to relocate will not need to transit the cofferdam on a routine basis.

(c) ‘Boston Belle’

(i) Six runs simulated the ‘Boston Belle’ manoeuvring through the cofferdam navigation channel in ‘typical’ summer river conditions. In each case, in keeping with present standard operations for this vessel, the ‘Boston Belle’ was stemming the current.

(ii) The 18m wide cofferdam channel is just over three times the 5.0m beam (width) of the ‘Boston Belle’ hull. With the vessel on the centreline of the channel there was horizontal clearance of just over 1 x vessel beam on both sides (see, for example, Figure 45). The simulation runs confirmed that the cofferdam channel is suitable for one-way navigation only. Navigation is already one-way at the Swing Bridge at present so this will not impact on navigation significantly.

(iii) The vessel’s ground speed was reduced noticeably in the zone of accelerated flow through the cofferdam navigation channel, but the vessel had sufficient power and speed available to complete the transits acceptably and, assuming one-way navigation, with acceptable horizontal clearances throughout.

(iv) In one of the runs piloted by Mr Bowles there was a minor steering issue in the approach to the cofferdam structure, but Mr Bowles repeated the manoeuvre in a fully controlled manner with a comfortable approach.

(d) Recreational Vessels

Yacht

(i) Seven runs simulated yacht manoeuvres through the cofferdam navigation channel in ‘typical’ summer river conditions.

(ii) In each case the yacht made the transit of the structure with a following current. The small overall dimensions of the 6.5m yacht (see Section 7.5.3(a) and see Figure 46) means that there is proportionately more manoeuvring space available for this vessel in the cofferdam channel than for the other vessel types, but the successful transit still relied on a suitable line of approach to the structure. The yacht’s ground speed in the zone of accelerated
flow through the cofferdam channel was typically less than 3.5 knots.

(iii) At such ground speeds the consequences of a light displacement recreational vessel (such as a sailing yacht or motor yacht) making contact with the structure can be expected to result in relatively minor damage to the yacht, and should not threaten the structural integrity of the cofferdam significantly.

Inland waterways vessels

(iv) The ‘widebeam’ canal boat is the largest vessel that reasonably may expect to transit through the cofferdam navigation channel.

(v) The 18m wide cofferdam channel is just over four times the 4.4m beam (width) of this vessel’s hull. With the vessel on the centreline of the channel there would be horizontal clearance of up to 6.8m (just over 1.5 x vessel beam), however the clearances in practice may be less because this type of vessel is particularly prone to lateral drift which could set the vessel off the centreline towards the cofferdam wall.

(vi) One run simulated the ‘widebeam’ canal boat transiting the cofferdam channel in ‘typical’ summer river conditions with a following current (see Figures 47 and 48). Although the vessel passed through the cofferdam navigation channel without making contact with the structures, the horizontal clearance at the stern was low to marginal in these conditions, even with one-way navigation. In addition the ground speed was relatively high (approximately 4 knots) which increased the potential consequences (to both the vessel and the cofferdam) if contact occurs.

(vii) Although not simulated the ‘widebeam’ canal boat is expected to have an enhanced level of navigation control if the cofferdam channel transit manoeuvre is timed to enable the vessel to stem the current.

(e) Cofferdam Layout Simulation Runs - Summary Conclusions and Recommendations

(i) In this Section I have described the cofferdam layout simulation runs. The main conclusions and recommendations arising from the simulations were:

(ii) The cofferdam navigation channel is unsuitable for the largest vessels (i.e. the PoB Dredger). The Port of Boston Limited is aware of this constraint, and has agreed with this restriction.
(iii) Based on the outcomes of the cofferdam layout simulation runs I recommend that some other vessels types should observe additional current-related manoeuvring windows as follows:

(aa) Larger vessels, such as fishing vessels and the Boston Belle, can transit the cofferdam navigation channel when stemming the current, or at HW slack. I recommend that such vessels should not transit the cofferdam navigation channel with a following current;

(bb) The widebeam canal boat was able to transit the cofferdam navigation channel with a following current, but the horizontal clearances were low. I suggest this type of vessel should plan to transit the cofferdam navigation channel stemming the current.

(iv) Small craft, such as the 6.5m yacht, can transit the cofferdam navigation channel stemming the current, or with a following current, subject to existing tidal operating windows.

(v) It is noted that vessel manoeuvres have not been simulated in ‘difficult’ river conditions. I recommend that each vessel master should plan to transit the cofferdam navigation channel only when they are confident that the river conditions, and in their own vessel handling ability, are suitable for safe navigation.

(vi) As expected the simulations confirmed that:

(aa) The cofferdam navigation channel is suitable for one-way navigation only. Navigation is already one-way at the Swing Bridge at present.

(vii) Sight lines around the river bend and the cofferdam structure are poor, but are no worse than the situation at present with a grain ship on the Silo Berth. I consider that marine traffic management and control would be beneficial with the overall aim of ensuring that vessels do not meet at the cofferdam. Suitable measures have been developed by the Environment Agency and have been included in the Environment Agency’s proposed Navigation Management Plan (please see the Appendices to Peter Mallin’s evidence (EA/3/2) for a copy of the proposed Navigation Management Plan).

(viii) At first sight, the cofferdam navigation channel is visually intimidating to navigate in the simulation. This was due in part to the sharp corners on the structure and the hard materials on the navigation channel sides. This can be mitigated by:

(aa) Shaped corners on the cofferdam. This should also encourage smooth flow streamlines and help to minimise turbulence within the channel; and
(bb) Adding suitable fendering on the cofferdam structure and on both sides of the navigation channel. This fendering obviously aims to reduce the consequences of any allision event (a vessel making contact with the structure), but it should also make the navigation channel visually less intimidating to mariners.

(ix) All of the mariners who participated in the navigation simulations were confident they could navigate vessels through the cofferdam channel successfully in ‘typical’ conditions.

7.7.5 Post-Construction Layout

(a) Overview

(i) 56 runs simulated manoeuvres through the site of the proposed barrier in the post-construction layout (see Figure 27).

(ii) The post-construction layout simulations considered inbound and outbound transits of the barrier navigation channel in a range of ‘typical’ and ‘difficult’ river conditions (see Section 7.5.5 Table 1) and with all of the vessel models (see Section 7.5.3). The post-construction layout simulation runs are also illustrated in Figures 49 to 57).

(iii) At 25m wide, the barrier navigation channel is wider than the navigation channel at both the Swing Bridge (see Section 4.6.8.(b)(iv)) and the temporary cofferdam navigation channel (see Section 5.4.2). The barrier navigation channel is also wider than the worst case existing navigable channel width at the barrier site (i.e. when a grain ship is overhanging the Silo Berth) (see Section 4.6.3(g)).

(iv) The barrier navigation channel is, however, narrower than the existing navigable channel at its widest at present (i.e. when there are no vessels moored on the Silo and 21 Quay berths combined with the particularly high water levels).

(v) The barrier navigation channel is on the south side of the river on the outside of the bend. As such, the sight lines for mariners are expected to be poor, but no worse than the situation at present with a grain ship overhanging the Silo Berth (see Section 4.6.5(b)).

(b) Fishing Vessel

(i) 16 runs simulated the fishing vessel manoeuvring both outbound and inbound through the barrier in the full range of ‘typical’ and ‘difficult’ winter river conditions, which includes the conditions representative of the most severe river conditions in which BDFA indicated that they would, in practice, consider navigating their vessels within the Haven at present (see Section 7.5.5(c)).
(ii) All of the inbound and outbound barrier transit manoeuvres were successful regardless of whether the vessel was stemming the current or had a following current.

(iii) The flow speed at the barrier was noticeably stronger than at present, but does not exceed 3.7 knots even during the ‘difficult’ winter river conditions. Furthermore, the flow direction and streamlines were well aligned with the vessel’s track both within the navigation channel and in the approaches to the structures.

(iv) When stemming the current, the vessel’s ground speed was reduced noticeably in the zone of accelerated flow through the barrier, but the vessel had sufficient power and speed available to complete the transits acceptably, even in strongest flows associated with the difficult winter conditions.

(v) With a following current, the vessel’s ground speed increased noticeably in the zone of accelerated flow through the barrier, but the vessel retained sufficient steerage and control to turn acceptably around the bend and through the barrier navigation channel.

(vi) The 25m wide barrier navigation channel is just over four times the 6.0m beam (width) of the fishing vessel hull. With the vessel on the centreline of the channel there was horizontal clearance of just over 1.5 x vessel beam on both sides, which is an acceptable horizontal clearance for this type of vessel navigating through the channel at the (water and ground) speeds demonstrated during the simulation runs (typically 4 to 6 knots).

(vii) The majority of the runs considered a single fishing vessel transiting the barrier (see, for example, Figure 49). The successful outcome of all of these runs confirmed that the barrier channel is suitable for one-way navigation with this type of vessel in all of the test conditions.

(viii) The simulation team investigated the potential for two-way navigation of fishing vessels at the barrier. Even if the two fishing vessels are perfectly positioned within the barrier channel so as to ensure the maximum and equal horizontal spacing between the fishing vessels’ hulls, and between each vessel hull and the barrier side walls, the horizontal clearances are less than 4.5m (0.75m x vessel beam). In practice, it is highly unlikely the vessels will be perfectly positioned within the barrier channel, and so at least one of the clearances will be less than this. In one simulation run a second fishing vessel was included in the simulation in the barrier channel, to represent a vessel manoeuvring in the opposite direction (see Figure 50). This was a high-precision manoeuvre that relied on each vessel being alerted to the presence and intentions of the other well before reaching the barrier. Even then,
clearances achieved between the vessels and to the barrier sides were low (less than 3m). At the typical vessel transit speeds there could be significant adverse interactions between the two vessels and the barrier structure which will raise the navigation risk to an unacceptable level. Two-way navigation of fishing vessels through the barrier site may be possible, but it is not recommended.

(c) PoB Dredger

(i) 15 runs simulated manoeuvres of the PoB dredger ‘Mary Angus’ through the barrier with the post-construction layout. In all of the simulations the dredger was simulated with an operating draught of 2.2m.

(ii) With a length overall of 37.3m and beam of 10m, the dredger is over one and a half times as long, and roughly twice as wide, as the largest of the other vessels simulated. As such, the relative manoeuvring space available for this vessel through the barrier structure is noticeably more restricted and this reduces the horizontal clearance between the vessel hull and barrier structures.

(iii) The 25m wide barrier navigation channel is only two and a half times the 6.0m beam (width) of the fishing vessel hull. With the vessel perfectly aligned with, and on the centreline of, the channel there is horizontal clearance of only 7.5m (0.75 x vessel beam) on both sides. This is less than the ideal minimum clearance and indicates not only that the barrier is suitable for one-way navigation only by this vessel, but also that the transit manoeuvre must be conducted at low speed and will require a high level of precision.

(iv) In addition, the dredger has a significantly larger inherent turning circle than the other vessels considered. This means that in effect the dredger must turn proportionately more tightly than any of the other vessels, to transit river bend and barrier. The runs showed that due to the position of the barrier near the apex of the river bend, the dredger is noticeably turning as the vessel transits through the (straight) barrier navigation channel. The tightly turning vessel takes on a significant drift angle during the manoeuvre (see, for example, Figure 51) which increases the overall swept path occupied by the ship. This further reduces the clearances achieved between the dredger hull and both sides of the barrier structure.

(v) All of the dredger simulation runs demonstrated that this vessel could transit the barrier location but that it requires the full 25m width of the barrier channel to manoeuvre safely. This vessel should not encounter another vessel when seeking to transit the barrier location.
(vi) Initially the pilots attempted to 'drive' the ship through the barrier channel maintaining 'typical' vessel water speeds of at least 3 knots. When stemming the current the runs indicated that the transit of the barrier is achievable, but requires high-precision manoeuvring. The minimum horizontal clearances achieved were generally significantly less than 5m (half the vessel beam) on both sides. In following current conditions the dredger's ground speed is increased to between 4 and 6 knots, which means that the vessel must effectively turn even tighter through the barrier. This increases the vessel's drift angle and reduces the clearances even further. This increases both the likelihood and consequences of a vessel contact with the structure, significantly increasing the overall navigation risk.

(vii) The pilots also experimented with an alternative manoeuvring strategy in which the vessel speed was reduced just before reaching the barrier, followed by a slow speed transit through the structure. The simulation runs demonstrated that the alternative manoeuvring strategy has significant advantages, e.g. higher bow thruster effectiveness and the consequence of any contacts with the structure is much reduced.

(viii) Overall the second (alternative) manoeuvring strategy is considered preferable.

(ix) The runs also indicated that it should be feasible to swing the dredger in the area between the barrier and the Black Sluice, however, the pilot must take careful account of the (modified) flow patterns in this area and adopt a suitable swing strategy.

(d) 'Boston Belle'

(i) Four runs simulated the 'Boston Belle' manoeuvring through the barrier navigation channel in 'difficult' summer river conditions. In each case, in keeping with present standard operations for this vessel, the 'Boston Belle' was stemming the current.

(ii) The vessel's ground speed was reduced noticeably in the zone of accelerated flow through the cofferdam navigation channel, but the vessel had sufficient power and speed available to complete the transits acceptably and, assuming one-way navigation, with acceptable horizontal clearances throughout.

(iii) The 25m wide barrier channel is five times the 5.0m beam (width) of the 'Boston Belle' hull. With the vessel on the centreline of the channel there was horizontal clearance of 10m (2 x vessel beam) on both sides (see, for example, Figure 52). This is a relatively generous horizontal clearance with one-way navigation. However, given that this vessel is carrying up to 60 passengers the consequences of a collision incident would be particularly onerous.
Therefore, as with the fishing boat, I recommend that this vessel should not meet another vessel in the vicinity of the barrier.

(e) Recreational Vessels

Yacht

(i) 8 runs simulated yacht manoeuvres through the barrier. The runs considered the feasibility of navigation through the barrier in both directions and in a range of ‘typical’ and ‘difficult’ summer river conditions.

(ii) The runs indicated that transit of the barrier was manageable for this type of small craft in a safe and controlled manner in both directions, in all the conditions tested. This was demonstrated regardless of whether the vessel was stemming the current or had a following current.

(iii) Initially, the runs considered a single yacht transiting the barrier (see, for example, Figures 53 and 54) but it was clear that, due to the relatively small dimensions of the yacht, there was proportionately significantly more manoeuvring space available for this vessel in the barrier channel than for the other vessels considered. Therefore in subsequent runs, a second yacht was included in the simulation in the barrier channel, to represent a small vessel manoeuvring in the opposite direction (see Figure 55). The runs indicated that there was sufficient manoeuvring space available for two such small craft to pass each other within the barrier structure, but the skipper of each vessel should know if there is a risk of meeting another yacht in the vicinity of the barrier to ensure good positioning of both vessels within the barrier channel (i.e. ready for the vessels to pass ‘port-to-port’, which is the standard practice).

(iv) In some circumstances, it is expected that yachts that are heading up-river will opt to lower their masts below the barrier site. The swept path of a yacht with mast down will be greater than the same vessel with mast raised, therefore in three of the runs the inbound yacht was modelled with mast down. This did not appear to significantly impede manoeuvres through the barrier.

(v) The Witham Sailing Club (WSC) pilots were satisfied that they were able to manoeuvre the yacht through the barrier successfully, even in ‘difficult’ following current conditions.

Inland waterways vessels

(vi) Two runs simulated the narrowboat transiting the barrier channel (one run inbound, one run outbound) in ‘difficult’ summer river conditions with a following current (see Figure 56).
(vii) The 25m wide barrier navigation channel is almost twelve times the 2.1m beam (width) of this vessel’s hull. However, this is also the largest L/B ratio of the vessel types considered, which makes this vessel the most directional stable of the vessels simulated (i.e. the most difficult to initiate turning manoeuvres). This type of vessel is also known to generate high lateral drift during turns and tends to ‘slide’ very noticeably when turning.

(viii) The runs showed that the barrier transit manoeuvre is manageable for the narrowboat, but also that the vessel did ‘slide’ noticeably towards the outside of the bend and takes on a significant drift angle which increases the overall swept path. On this basis, it is recommended that this vessel requires the full barrier navigation channel width for safety, and therefore should not encounter another vessel in the vicinity of the barrier.

(ix) In addition two runs simulated manoeuvres of the ‘widebeam’ canal boat, each in ‘difficult’ conditions with following current (one run inbound, one run outbound) (see Figure 57).

(x) The 25m wide barrier navigation channel is over five times the 4.4m beam (width) of this vessel’s hull, but the pilots noted that this vessel displayed an even greater tendency to ‘slide’ as she turns. On this basis the pilot deliberately kept the water speed relatively low to keep control margin in reserve. As the vessel passed through the barrier structure he adopted a manoeuvring technique in which the engine is generally stopped, but using ‘kicks’ of engine and helm as required. The vessel generated significant lateral drift as she turns, and so the pilot needed to adopt a significant drift angle which increases the overall swept path. The barrier transit manoeuvre is manageable, but this type of vessel requires the full barrier navigation channel width for safety, and therefore should not encounter another vessel in the vicinity of the barrier.

(f) Failure Scenarios

(i) Three runs briefly considered failure situations at the barrier.

(ii) In each case a vessel lost engine power in the final approaches to the barrier in following current conditions. As the water speed reduced, the vessel started to drift on the current towards the structure, but the flow streamlines carried the disabled vessel away from the lead-in structure, and cleanly through the barrier channel, without making contact.

(iii) It was noted that if a vessel suffered engine failure whilst stemming the current, the vessel will tend to be swept away from the barrier by the current and there will be little risk of making contact with the structure.
(g) Safe Haven Berths

(i) During the third simulation session, proposals for contingency measure ‘safe haven’ berths either side of the barrier were considered. These berths are intended for leisure craft to moor at temporarily in exceptional circumstances when it is not safe to transit the barrier channel.

(ii) Two such berths were included in the post-construction layout simulations:

(aa) the existing lay-by waiting pontoon at Black Sluice (see for example Figure 58);

(bb) a 35m length of wall (with rubbing strips, mooring rings, grab chains and ladder access) at the down-river end of the new sheet pile wall opposite the Silo Berth (near where Witham Wharf was previously located). This is illustrated in Figure 59.

(iii) The simulations confirmed that the provision of additional ‘safe haven’ berths in these locations did not conflict with safe navigation of passing vessels.

(h) Post-Construction Layout Simulation Runs - Summary Conclusions and Recommendations

(i) The main conclusions and recommendations arising from the post-construction layout simulation runs were as follows:

(ii) All the vessels considered could navigate the barrier navigation channel successfully;

(iii) The barrier navigation channel is suitable for one-way navigation only for larger vessels such as the PoB dredger, the fishing vessel, the ‘Boston Belle’, the narrowboat and the ‘widebeam’ canal boat;

(iv) The barrier navigation channel is suitable for two-way navigation for two small craft, such as the 6.5m yacht;

(v) The fishing vessel could navigate both outbound and inbound through the barrier channel in the full range of ‘typical’ and ‘difficult’ winter river conditions, which includes conditions identified as representative of the most severe river conditions in which BDFA indicated they would, in practice, consider navigating their vessels within the Haven at present (see Section 7.5.5(c)). The barrier transit manoeuvres were successful regardless of whether the fishing vessel was stemming the current or had a following current;

(vi) The PoB dredger can transit of the barrier navigation channel satisfactorily when stemming the current, noting that manoeuvre
requires a high level of precision. This vessel requires the full width of the barrier channel and should not encounter another vessel in the vicinity of the barrier. The dredger can also be swung in the area between the barrier and the Black Sluice, but it is noted that the pilot must take careful account of the (modified) flow patterns in this area and adopt a suitable swing strategy. The overall level of navigation risk for this vessel at the barrier increases in following current conditions, and as the current speed increases. PoB are aware of these constraints and agree with the associated dredger operating restrictions;

(vii) The ‘Boston Belle’ could navigate both outbound and inbound through the barrier channel in the full range of ‘typical’ and ‘difficult’ summer river conditions;

(viii) The yacht could navigate through the barrier channel in the full range of summer river conditions tested. This includes the ‘difficult’ summer conditions identified as representative of the most severe river conditions in which WSC have indicated they would, in practice, consider navigating their vessels within the Haven at present (see Section 7.5.5(c)). The barrier transit manoeuvres were successful regardless of whether the yacht was stemming the current or had a following current. The also runs indicated that there was sufficient manoeuvring space available for two such small craft to pass each other within the barrier structure;

(ix) Both the narrowboat and the ‘widebeam’ canal boat could navigate through the barrier channel successfully in ‘difficult’ summer river conditions with a following current. These vessel types required the full barrier navigation channel width for safety, and therefore should not encounter another vessel in the vicinity of the barrier; and

(x) In the event that a vessel loses engine power in the final approaches to the barrier channel in following current conditions the current carried the disabled vessel cleanly through the barrier channel without making contact. If a vessel suffers engine failure whilst stemming the current, the vessel will tend to be swept away from the barrier there will be little risk of making contact with the structure.

(xi) As expected the simulations confirmed that:

(aa) For many of the vessel types considered, the barrier navigation channel is suitable for one-way navigation only. As such, navigating through the proposed barrier location would operate on a similar basis to navigation through the existing Swing Bridge which also requires one way navigation;
(bb) Sight lines around the river bend and the barrier structure are poor, but are no worse than the situation at present with a grain ship on the Silo Berth.

(xii) I consider that marine traffic management and control would be beneficial in the vicinity of the barrier. Suitable measures have been developed by the Environment Agency and have been included in the Environment Agency's proposed Navigation Management Plan (please see the Appendices to Peter Mallin's evidence (EA/3/2) for a copy of the proposed Navigation Management Plan).

(xiii) The navigation risk at the barrier can be mitigated further by:

(aa) Adding protection around the ram and hinge mechanisms of the moveable barrier gate to reduce the risk of accidental damage (to both the gate and vessels).

(bb) Adding suitable fendering on the barrier structure and on both sides of the navigation channel. This fendering is partly to make the navigation channel visually less intimidating, but will obviously also reduce the consequences of any collision or allusion event.

(xiv) All of the mariners who participated in the navigation simulations seemed confident in their ability to manoeuvre their vessel through the barrier channel successfully.

7.8 In this Section I have described in detail the real-time navigation simulation study of the Boston Barrier Scheme including the simulation configuration, the participants and objectives of the three navigation simulation session, the simulation runs performed as well as the main conclusions and recommendations of the simulation study. The study has shown that all of the vessels considered (other than the PoB dredger) can navigate the cofferdam and barrier navigation channels successfully in reasonable navigation conditions, but that both the cofferdam and barrier navigation channels are generally suitable for one-way navigation only, and with the cofferdam layout some vessels types should observe additional current-related manoeuvring windows.

7.9 Based on the insights gained during the navigation simulation study, I consider that the navigation situation with Boston Barrier Scheme structures (the cofferdam or the barrier) is similar overall to the existing navigation situation when a grain ship is moored on the Silo Berth. Vessels are able to navigate successfully in these circumstances at present and so navigation should continue to be feasible with the Scheme without any significant alteration with regard to the risks that presently exist.

7.10 I recommend, however, that additional navigation risk mitigation measures would be both beneficial and appropriate to ensure that the risk level is not only acceptable but is also reduced as far as reasonably practical. Suitable navigation risk mitigation measures have been developed by the Environment Agency and are described in the proposed Navigation Management Plan (discussed further in Section 8).
8 Navigation Management Plan

8.1 A draft Navigation Management Plan (NMP) (please see the Appendices to Peter Mallin’s evidence (EA/3/2)) has been developed to set out the procedures to be followed and aids to navigation to be provided to mitigate the risks to navigation arising from the construction and operation of the Boston Barrier to a level that is as low as reasonably practical.

8.2 In this Section I outline the underlying premise for, and overall objectives of, the draft NMP from a vessel manoeuvring viewpoint and based on the findings of the navigation simulation study.

8.3 The draft NMP is presented in full in the Appendices to Peter Mallin’s evidence (EA/3/2). The draft NMP has been developed taking into account the findings and recommendations arising from the Boston Barrier Scheme navigation simulation study (described in Section 7). The draft NMP has been developed in close collaboration with the Port of Boston Limited in its capacity as the statutory harbour authority.

8.4 Overall the draft NMP measures aim to eliminate, reduce or control the navigation risk during construction and operation of the Boston Barrier Scheme as far as reasonably practical.

8.5 During the construction phase, the draft NMP includes measures to:

8.5.1 minimise the number of vessels that must navigate through the cofferdam navigation channel (see Section 3.2 of the draft NMP). This eliminates the navigation risk associated with navigating through the cofferdam channel for as many vessels as possible;

8.5.2 ensure there is suitable protective fendering on the cofferdam structure (see Section 4.2.2 of the draft NMP). This reduces the consequences of a vessel making contact with the structure;

8.5.3 provide contingency berthing options for leisure craft to moor temporarily both up-river and down-river of the cofferdam (see Section 3.8.4 of the draft NMP). These temporary facilities allow vessels to wait in a safe position for short periods until conditions are suitable to transit the cofferdam channel safely. This reduces the level of risk to such vessels.

8.5.4 provide temporary aids to navigation (see Section 3.8.3 of the draft NMP) that alert all vessels to the presence of the cofferdam and advise on:

(a) the status of the cofferdam (bypass) channel (i.e. open or closed to navigation);

(b) the inbound/outbound navigation priority status depending on the state of the tide (i.e. if the vessel has navigation priority or must be ready to give way);

(c) reminders to monitor VHF 12 and to request permission to transit the channel using VHF 12 in suitable positions on the river (i.e. in locations where the vessel still has time and space to take action as required).
Provide 24 hour traffic control to direct and manage all vessels such that there is one-way traffic through the cofferdam navigation channel and the Swing Bridge with priority to vessels transiting with a following current Section 3.8.2 of the draft NMP. This is proposed because the cofferdam layout simulations (see Section 7.7.4) indicated that the cofferdam navigation channel is suitable for one-way navigation only.

During the barrier operational phase the draft NMP includes measures to:

Ensure there is suitable protective fendering at the barrier (see Section 4.2.2 of the draft NMP). This reduces the consequences of a vessel making contact with the structure.

Provide contingency berthing options for all types of vessel to moor temporarily both up-river and down-river of the barrier (see Section 4.2.4 of the draft NMP). This ensures that in the event of unexpected adverse conditions vessels can wait for short periods in a safe position until conditions are suitable to transit the barrier safely.

Manage the traffic through the barrier navigation channel (see Section 4.1.3 of the draft NMP). There will be one way traffic through the barrier and priority will be to the vessel travelling with the current. All vessels are to announce their intent to transit the barrier on VHF 12. The responsibility to agree priorities for transit through the barrier will be with the vessel masters using VHF 12. In some circumstances masters may agree to two way traffic through the barrier for their vessels.

Provide permanent aids to navigation (see Section 4.2.1 of the draft NMP) that alert all vessels to the presence of the barrier and advise on:

- the status of the barrier (i.e. barrier open, barrier closed (raised) in planned closure (e.g. for maintenance) or barrier closed (raised) for emergency event or incident (e.g. tidal surge expected);
- the inbound/outbound navigation priority status depending on the state of the tide (i.e. if the vessel has navigation priority or must ready to give way);
- reminders to monitor VHF 12 and to advise of transit through the barrier channel using VHF 12 in suitable positions on the river (i.e. in locations where the vessel still has time and space to take action as required).

Vessels transiting one-way navigation channels with a following current require priority because these vessels have less control over their speed, heading and position than vessels stemming a current. This makes it both easier and safer for a vessel stemming the current to hold position temporarily in a safe and controlled manner.

Proposals for contingency measure ‘safe haven’ berths either side of the barrier were considered briefly (see Section 7.7.5(g) and Figures 58 and 59). These contingency berths are intended for leisure craft to moor at temporarily in exceptional circumstances when it is not safe to transit the barrier channel. The simulations confirmed that additional ‘safe haven’ berths in these locations did not conflict with safe navigation of passing vessels.
8.9 In my professional opinion the mitigation measures detailed in the draft NMP are both suitable and practical in the context of the site, and should be effective in further reducing the navigation risk at both the cofferdam and barrier not only to an acceptable level but also as far as reasonably practical.

9 Impacts of the Boston Barrier Scheme on Navigation

9.1 In this section I describe the anticipated impacts on navigation on the Haven of the Boston Barrier Scheme during the construction and post-construction phases, once the measures proposed within the draft Navigation Management Plan (NMP) (see Section 8 and please see the Appendices to Peter Mallin’s evidence (EA/3/2)) are implemented.

9.2 Construction Phase

9.2.1 A description of the construction activities and an assessment of the temporary potential impacts on navigation during the construction phase of the Scheme is presented in Section 6 of the Navigational Impact Assessment (A17/2D).

9.2.2 There is expected to be an increase in traffic on the Haven generally due to the presence of construction vessels (i.e. either vessels delivering construction materials, or vessels directly involved in construction activities). There is a low volume of traffic on the Haven at present (see Section 4.5) and so an increase in marine traffic is not expected to cause problematic marine traffic congestion.

9.2.3 All construction vessels will be subject to the existing and ongoing PoB vessel traffic management systems (see Section 4.6.9) as well as the 24 hour control of vessel movements at the cofferdam as described in Section 3.8.2 of the draft NMP. In addition there will be a contractor safety boat present during the construction period to help ensure safe vessel practices (see Section 3.3.3 of the draft NMP).

9.2.4 The CCTV footage available from cameras mounted on the Black Sluice (see Section 4.5.3) shows vessels navigating successfully past various jack-up barges, dredger barges and support vessels (safety boat) without apparent difficulty during September, October and November 2013.

9.2.5 Dredging work is already carried out successfully on the Haven. The dredging associated with the Scheme will be conducted in accordance with the PoB’s existing dredging procedures and so there is no reason to think the safety of navigation will be compromised.

9.2.6 PoB ships manoeuvring to and from the Wet Dock and the Lairage Quay berths should not be affected by the cofferdam works.

9.2.7 The only total closure of the river to navigation at the barrier site expected during the construction phase is during the installation of the barrier gate structure (see Section 6.7.5 of the Navigational Impact Assessment (A17/2D). It is expected that the barrier site will be unpassable for up to 2 days whilst the barrier is being lifted into position as this process will require marine and land-based plant and the use of divers for specific tasks. This restriction should only affect the navigation of vessels that must pass the cofferdam.
Cofferdam Navigation Channel

(a) In this section I supplement the NIA assessment with further details of navigation-related impacts associated with transits of the cofferdam navigation (bypass) channel, based on the outcomes of the navigation simulation study (see Section 7).

One way navigation

(b) The navigation simulations have indicated that the cofferdam navigation channel is suitable for one-way navigation only and Section 3.8.2 of the draft NMP states that there will be 24 hour traffic control to ensure one-way traffic only through the cofferdam channel and the existing Swing Bridge.

(c) Given that there is already one-way navigation (in practice) at the Swing Bridge approximately 275m upriver of the barrier site (see Section 4.6.8(b)(viii)) at present, the one-way restriction at the cofferdam channel is not expected to affect navigation significantly.

River conditions

(d) It is noted that vessel manoeuvres have not been simulated in ‘difficult’ river conditions. I recommend that each vessel master should plan to transit the cofferdam navigation channel only when they are confident that the river conditions, and their own vessel handling abilities, are suitable for safe navigation.

(e) This advice is, however, no different to the situation at present.

PoB dredger

(f) The cofferdam navigation channel is unsuitable for the largest vessels (i.e. the PoB Dredger) and so this vessel will not be able to navigate past the cofferdam.

(g) PoB are aware of this constraint, and agree with this restriction.

Boston Fishing Fleet

(h) The fishing fleet have been offered relocation to temporary berths downriver of the proposed cofferdam within the Port of Boston. Fishing vessels that relocate will not need to transit the cofferdam on a routine basis, and therefore there should be no additional navigational constraints on their operations compared to at present.

(i) Fishing vessels that choose not relocate to the temporary berths will be, like all other vessels, subject to the 24 hour control of vessel movements at the cofferdam as described in Section 3.8.2 of the draft NMP. There will be one-way traffic only through the cofferdam channel, with priority given to vessels transiting with a following current. All transits will require
advance request and permission over VHF 12. In addition, based on the simulation outcomes, I have recommended that fishing vessels should not transit the cofferdam channel with a following current.

(j) Overall, this means that fishing vessels that do not relocate to the temporary berths provided will need to pre-book every passage through cofferdam channel, and may be subject to delays of typically between a few minutes (whilst waiting for a priority vessel to pass through the cofferdam channel) to several hours (waiting for the tide to turn to enable the channel transit to be made at slack water or whilst stemming the current). In a worst case, the Contractor may advise that transits are not permitted whilst a critical construction activity is ongoing, or if the river conditions are considered too severe for safe navigation. This could potentially result in delays of several hours up to a few days. The fishing vessels do, however, have the option to use the temporary berths provided on Lairage Quay.

‘Boston Belle’

(k) To undertake cruises to the Wash from her base at Grand Sluice the ‘Boston Belle’ must pass the cofferdam. It is noted that at present the majority of the ‘Boston Belle’ cruises take place on the non-tidal River Witham, and only an estimated 10% of the cruises currently go to the Wash.

(l) Like all other vessels, the ‘Boston Belle’ will be subject to the 24 hour control of vessel movements at the cofferdam as described in Section 3.8.2 of the draft NMP. In addition, based on the simulation outcomes, I have recommended that ‘Boston Belle’ should not transit the cofferdam channel with a following current (see Section 7.7.4(e)(iii)).

(m) On this basis the ‘Boston Belle’ will need to pre-book every passage through cofferdam channel, but given that there is already the requirement to book passage through the Grand Sluice navigation lock this should not be difficult. The vessel may be subject to delays of typically a few minutes whilst waiting for a priority vessel to pass through the cofferdam channel. This vessel’s standard operating procedure is always to stem the current within the Haven, so there should be no additional delays associated with waiting for a suitable tidal window.

(n) In a worst case, the Contractor may advise that transits are not permitted whilst a critical construction activity is ongoing, or if the river conditions are considered too severe for safe navigation. This could potentially result in periods of few hours up to a few days when the cofferdam is unpassable. In this case, the ‘Boston Belle’ could make alternative arrangements to conduct a cruise on the non-tidal River Witham.

Recreational vessels
Like all other vessels, the recreational vessels will be subject to the 24 hour control of vessel movements at the cofferdam as described in Section 3.8.2 of the draft NMP.

Small craft, such as the 6.5m yacht, can transit the cofferdam navigation channel stemming the current, or with a following current, subject to existing tidal operating windows. On this basis, such vessels will need to pre-book every passage through cofferdam channel, but given that many of these vessels have moorings in the non-tidal River Witham and there is already the requirement to book passage through the Grand Sluice navigation lock this should not be difficult. The vessels may be subject to delays of typically a few minutes whilst waiting for a priority vessel to pass through the cofferdam channel.

Like all vessels, an inland waterways vessel will need to pre-book every passage through cofferdam channel, but given that there is already the requirement to book passage through both the Grand Sluice and Black Sluice navigation locks this should not be difficult. I suggest that inland waterways vessels (narrowboats and ‘widebeam’ canal boats) should plan to transit the cofferdam navigation channel stemming the current (see Section 7.7.4(e)(iii)). If stemming the current (as recommended) the vessel may be subject to transit delays of typically a few minutes whilst waiting for a priority vessel to pass through the cofferdam channel, however the vessel’s passage plan for the whole journey will need to be adjusted to suit the tidal windows at the cofferdam. This may mean the journey as a whole takes a few hours longer than at present. If navigating with a following current (not recommended, but typical current practice) the vessel may be subject to no transit delays but will be proceeding at their own risk.

In a worst case, the Contractor may advise all recreational vessels that transits through the cofferdam channel are not permitted whilst a critical construction activity is ongoing, or if the river conditions are considered too severe for safe navigation. This could potentially result in periods of several hours up to a few days when the cofferdam is unpassable.

9.2.9 Flood Wall Works

There will be construction activity on both the left and right river banks downstream of the barrier site associated with works to raise the flood walls.

The main impact on navigation is expected to be a slight channel width restriction due to the presence of marine-based working platforms at the sides of the river. The reduction in channel width available to navigation is not expected to be any worse than at present when a PoB ship is moored on a riverine berth.

It is noted that there is at present extensive intertidal areas adjacent to both banks in the central portion of the Haven (see Figure 15). On this
basis, at many states of the tide the water depth is likely to be too shallow for many vessels to navigate close up to the river banks successfully anyway.

9.2.10 Wet Dock Works

(a) During works to upgrade the existing entrance to the Wet Dock and replacement the existing Wet Dock Entrance Gates, it will be necessary to relocate ships from the Wet Dock berths to the riverine berths along Lairage Quay and the South Knuckle. PoB ships are manoeuvred successfully to and from the Lairage Quay berths at present.

(b) The presence of ships on the PoB riverine berths reduces the channel width available to navigation for passing vessels on this stretch of the river. The PoB riverine berths may be used more heavily than normal during the period of the Wet Dock works but the impact on the navigation of passing traffic is not expected to be any worse than at present when a PoB ship is moored on a riverine berth.

9.3 Post-Construction

9.3.1 A description of the permanent impacts on navigation during the post-construction operational phase of the Scheme is presented in Section 7 of the Navigation Impact Assessment (A17/2D).

9.3.2 The PoB ships operate largely at the Wet Dock and at the riverine berths on Lairage Quay, which are down-river of the Boston Barrier Scheme site. Navigation of these vessels will not be affected by the Scheme.

9.3.3 Transits Through The Barrier Navigation Channel

(a) In this section I supplement the NIA assessment with further details of navigation-related impacts associated with transits of the barrier navigation channel, based on the outcomes of the navigation simulation study (see Section 7).

One way navigation

(b) The navigation simulations have shown that the barrier navigation channel is generally, but not exclusively, suitable for one-way navigation only (see Sections 7.7.5(h)(iii) and 7.7.5(h)(iv)). Given that there is already one-way navigation (in practice) at the Swing Bridge approximately 275m upriver of the barrier site (see Section 4.6.8(b)(v)), the one-way restriction at the barrier channel is not expected to affect navigation significantly.

River conditions

(c) The navigation simulations have tested navigation at the barrier site in both 'typical' river conditions, and also for 'difficult' river conditions i.e. the most severe river conditions in which river users have indicated they would, in
practice, consider navigating their vessels within the Haven at present (see Section 7.5.5).

(d) All of the vessels considered could navigate the barrier navigation channel successfully in reasonable river conditions. On this basis I do not expect there to be any additional impact on navigation due to the river conditions.

(e) I recommend that each vessel master should plan to transit the barrier navigation channel only when they are confident that the river conditions, and their own vessel handling ability, are suitable for safe navigation. This is no different to the situation at present.

(f) It is noted that it is not reasonable to expect vessels to be navigating on the Haven as a whole in ‘extreme’ tidal or fluvial flood conditions as the navigation risks are excessively high and therefore unacceptable. In this respect, this Scheme does not alter the navigation situation at present.

PoB dredger

(g) The barrier navigation channel is suitable for one-way navigation by this vessel.

(h) The PoB dredger can transit the barrier navigation channel satisfactorily when stemming the current, but the overall level of navigation risk for this vessel increases in following current conditions and as the current speed increases.

(i) Like all vessels, the PoB dredger will be subject to the vessel movements management system described in Section 4.1.3 of the draft NMP. There will be one-way traffic through the barrier channel, with priority given to vessels transiting with a following current. All vessels must announce their intent to transit the barrier on VHF 12 on approach. The responsibility to agree priorities for transit through the barrier will be with the vessel masters using VHF 12.

(j) 9.3 In practice the dredger may be subject to delays of typically between a few minutes (whilst waiting for a priority vessel to pass through the barrier channel) to several hours (waiting for the tide to turn to enable the channel transit to be made at slack water or whilst stemming the current). The dredger can moor on one of the PoB riverine berths up-river of the barrier (e.g. 3/4 Doors or 21 Quay) if required

(k) The Port of Boston Limited is aware of these constraints and agrees with the associated dredger operating restrictions.

Boston Fishing Fleet

(l) Like all vessels, the Boston Fishing Fleet will be subject to the vessel movements management system described in Section 4.1.3 of the draft NMP.
(m) In the simulations the barrier transit manoeuvres were successful in the most severe river conditions tested regardless of whether the fishing vessel was stemming the current or had a following current (see Section 7.7.5(h)(v)). To be clear, the simulations tested fishing vessel transits in ‘difficult’ winter river conditions i.e. the most severe river conditions in which BDFA have indicated they would, in practice, consider navigating their vessels within the Haven at present (see Section 7.5.5).

(n) Overall, this means that fishing vessels will need to make a VHF broadcast approaching the barrier (the vessel should be monitoring VHF 12 at all times anyway), and may need to hold a VHF conversation with any on-coming traffic to agree which vessel(s) have priority. If the fishing vessel does not have priority the vessel is required to hold position (whilst waiting for a priority vessel to pass through the barrier channel) and as such could be subject to delays of a few minutes.

'Boston Belle'

(o) To undertake cruises to the Wash from her base at Grand Sluice the ‘Boston Belle’ must pass the barrier. This vessel’s standard operating procedure is always to stem the current within the Haven.

(p) Like all other vessels, the ‘Boston Belle’ will be subject to the vessel movements management system described in Section 4.1.3 of the draft NMP. The vessel must make a VHF broadcast approaching the barrier (the vessel should be monitoring VHF 12 at all times anyway), and may need to hold a VHF conversation with any on-coming traffic to agree which vessel(s) have priority. The vessel may be subject to delays of typically up to a few minutes whilst waiting for a priority vessel to pass through the barrier channel.

Recreational vessels

(q) Like all other vessels, the recreational will be subject to the vessel movements management system described in Section 4.1.3 of the draft NMP.

(r) Small craft, such as the 6.5m yacht, can transit the barrier navigation channel stemming the current, or with a following current. There is also sufficient manoeuvring space available for two such small craft to pass each other within the barrier structure. The vessel will need to make a VHF broadcast approaching the barrier (the vessel should be monitoring VHF 12 at all times anyway), and may need to hold a VHF conversation with any on-coming traffic to agree which vessel(s) have priority. In some circumstances (e.g. two small craft) masters may agree to two way traffic through the barrier for their vessels using VHF 12. Overall, this type of vessel may be subject to delays of typically a few minutes whilst waiting for a large priority vessel (such as the PoB dredger, a fishing vessel, the ‘Boston Belle’ or a large inland waterways vessel) to pass through the barrier.
Inland waterways vessels (such as narrowboats and ‘widebeam’ canal boats), can transit the barrier navigation channel stemming the current, or with a following current, but this channel is suitable for one-way navigation only for these types of vessel. The vessels will need to make a VHF broadcast approaching the barrier (the vessels should be monitoring VHF 12 at all times anyway), and may need to hold a VHF conversation with any on-coming traffic to agree which vessel(s) have priority. If navigating with a following current (not ideal, but typical current practice) the vessel may be subject to no transit delays.

**9.3.4 Barrier Maintenance Periods**

(a) The barrier maintenance activities are described in Section 7.8 of the Navigation Impact Assessment (A17/2D).

(b) During the barrier maintenance periods it will be necessary to raise the barrier gate for short periods, making the river unpassable to vessels.

(c) During the monthly and yearly maintenance the barrier gate must be raised for only approximately 50 minutes and 1 hour and 50 minutes respectively. This maintenance is expected to be undertaken over the low water period when there is little or no navigation on the Haven due to insufficient water depths. On this basis, there should be little or no impact on vessels.

(d) Every 5 years the barrier requires a major period of maintenance and inspection lasting 1-2 days. During this period the barrier gate would be raised clear of the water into an ‘overhead’ position (rotated through 180°) and will effectively become a low bridge over the navigation channel with soffit level of approximately +6.7mOD (+9.6mCD).

(e) At mean high water springs (MHWS) the vertical clearance under the raised gate will be approximately 2.8m. This means that:

   (i) low air draught vessels (such as narrowboats and motorboats with low super-structures etc.) may be able to pass beneath the gate, at some states of the tide. Subject to review between the Environment Agency and the Harbour Authority vessels may be permitted to navigate under the barrier gate in this ‘overhead’ position,

   (ii) many vessels (including yachts with their masts raised and potentially the fishing boats) will have insufficient vertical clearance between the water surface and the gate overhead to pass underneath, making the barrier unpassable.

(f) Clearly it will be desirable to minimise the impact on navigation as much as possible, and therefore this major maintenance period is expected to be scheduled to coincide with periods of low navigation activity on the Haven (e.g. winter months). The Environment Agency will endeavour to undertake maintenance at times to minimise impact – subject to any emergency works that may or may not occur.
(g) Dredging work is already carried out successfully on the Haven. The dredging associated with the Scheme will be conducted in accordance with the PoB’s existing dredging procedures and so there is no reason to think the safety of navigation will be compromised.

9.3.5 Barrier Gate Operation During Tidal Flood Events

(a) Operation of the barrier gate is described in Section 7.7 of the Navigation Impact Assessment (A17/2D).

(b) With the barrier gate raised, the barrier will be unpassable by all vessels. The barrier gate would only be raised when tidal flood levels are predicted to exceed a level of +5.3mOD. This is an extreme and therefore rare event. It is anticipated that the barrier closure during a surge tidal event is likely to last a maximum of nine hours. It is noted, however, that it is not reasonable to expect vessels to be navigating on the Haven in ‘extreme’ tidal flood conditions as the navigation risks are excessively high and therefore unacceptable. In this respect, the navigation situation is no different to at present.

(c) Overall, I consider the impact on navigation of barrier gate operations during tidal flood events to be low or minimal.

9.4 In this section I have described the anticipated residual impacts on navigation on the Haven of the Boston Barrier Scheme during the construction and post-construction phases. During the Scheme construction phase, the impact of most construction activities on navigation on the Haven as a whole is expected to be low. In a worst case, there could be periods of few hours up to a few days when the cofferdam is unpassable. Post-construction navigation of PoB ships will not be affected by the Scheme. The impact of the Scheme on other navigation on the Haven is also expected to be generally low. During barrier maintenance periods the barrier will be unpassable for short periods (generally less than 2 hours), but the maintenance is expected to be scheduled to coincide with periods of little or no navigation activity on the Haven. The barrier will also be unpassable by all vessels when the barrier gate is raised during a tidal flood event, but these are both extreme and rare. It is not reasonable, however, to expect vessels to be navigating on the Haven in general in ‘extreme’ tidal flood conditions as the navigation risks are excessively high and therefore unacceptable. In this respect, the navigation situation is no different to at present.

10 Navigation Review of Alternatives to the Scheme

10.1 Several alternative schemes for managing tidal flood risk have been proposed over the years, as described in James Anderson’s proof of evidence (EA/1/1). In this section I present a summary review of the alternative schemes from a navigation viewpoint.

10.2 In his evidence, James Anderson lists eleven locations that have been considered for a barrier and/or a barrage since 1994. Each location was designated by a letter (a) to (k). I have marked the approximate positions of each location on Figure 60.

10.3 It is noted that locations (a) to (d) are the four positions considered for a barrage and sea lock as reported in the Boston Sea Lock Preliminary Feasibility Study (1994) (please see the
appendices to James Anderson’s evidence (EA/1/2) for a copy of this report), and location (i) is the proposed barrier site.

10.4 The main navigation considerations for any scheme are given below. I go on to discuss each point briefly below.

10.4.1 The type/design of flood defence structure;
10.4.2 The position of the structure relative to key navigation locations on the Haven (e.g. PoB Wet Dock, PoB riverside berths, fishing fleet moorings, the Swing Bridge, the existing navigation locks);
10.4.3 The number and type of vessels that must navigate through the structure;
10.4.4 whether the structure is on a straight section of river or on or adjacent to a navigationally-significant river bend;
10.4.5 Navigation channel width and navigable depth at the site and its approaches;
10.4.6 Navigation windows and delays;
10.4.7 The river conditions at the site;
10.4.8 The extent of the site’s exposure to wind and waves;
10.4.9 Traffic management issues; and
10.4.10 Availability waiting areas, suitable for all types of vessels, on each side of the structure.

Structure type

10.5 The alternative schemes fall into two categories based on the type of structure:

10.5.1 Barriers; or
10.5.2 Barrages.

10.6 In general terms, a barrier allows free-flow of traffic, provided there is sufficient water depth. By contrast a barrage prevents navigation at all times, and provision must be made to incorporate one or more navigation locks into the design. Navigation lock operations generally introduce extensive delays. In addition, navigation lock operations are subject to considerable traffic management and manning issues. In terms of free-flow of navigation I consider a barrier type of structure is preferable.

Number and type of vessels affected

10.7 In very general terms, the higher the number (and types) of vessels that must pass the site of the barrier, the greater the effect will be on navigation as a whole, and the more extensive the marine traffic management and/or control issues will be. On this basis, the barrier should be located as far up-river as possible, to minimise the number of vessels that must pass the structure.
10.8 A barrier or barrage at any of locations (a) to (g) would affect navigation of all river users including all PoB ships and the Boston Fishing Fleet.

10.9 All river users except PoB ships using the Wet Dock will be affected by a barrier or barrage at locations (h) to (j), although it is noted that most PoB ships use berths down-river of location (i).

10.10 Only location (k) is up-river of the moorings used by the Boston Fishing Fleet. A barrier or barrage in this location will still affect the ‘Boston Belle’ as well as most recreational vessels (as most of these vessels have moorings up-river of this location).

Proximity to key existing manoeuvring areas and hazards

10.11 Locations (f) and (g) are immediately adjacent to the PoB Wet Dock and the PoB swinging area. As such, structures at these locations are likely to interfere with close-quarters manoeuvres of PoB ships (e.g. vessel swings, and entry and exit manoeuvres at the Wet Dock navigation lock/channel) to an unacceptable degree and so should be rejected.

10.12 Location (j) is immediately adjacent to the Swing Bridge, which is already a significant hazard to navigation. It will be difficult to maintain navigation past this obstruction during the construction period.

On bend or straight section of river

10.13 Locations (a) to (c) are in the New Cut, which is not completely straight but has such a large radius of channel curvature that it should ensure adequate sight lines ahead and behind. This means vessels should not be turning significantly through the structure, and the master should be able to see on-coming traffic relatively easily.

10.14 Location (d) is at a position where the river naturally forms a pair of concatenated minor bends. The navigation approach to any structure at this location would need to be realigned (straightened) during construction.

10.15 Locations (e) and (h), (j) and (k) are on straight sections of river, but are all also immediately adjacent to navigationally-significant river bends. Whilst from a navigation viewpoint it is advantageous to site the structure on the straight, if the structure is close to a bend it may be difficult to see on-coming traffic at any distance. This will be particularly problematic at location (k), which is immediately down-river of the tight concatenated blind bends in the vicinity of the Haven and Town Bridges (see Section 4.6.8(d)(ii)).

10.16 Location (i) is actually on a significant bend. As I explained previously in Section 4.6.4 siting a barrier or barrage structure on a significant bend is not ideal from a navigation viewpoint, as vessels will be turning during transits of the structure, but this does not necessarily prevent safe navigation.

River width and water depth in the approaches to the structure

10.17 Location (k) is in a particularly narrow section of the river, and also in an urban area where both river banks are already heavily built upon and occupied by roads, buildings etc. The construction works associated with a major flood defence structure would occupy most, if not all of the river channel. It will be difficult, if not impossible, to maintain navigation past this site.
during the construction period (lasting many months) as there is no space available to provide an alternative navigation route (e.g. a bypass channel).

10.18 **Figure 57** shows the water depths in the Wash immediately adjacent to the Haven entrance. The very extensive areas marked in green are intertidal (submerged at high tidal water levels, but dry at low tidal levels). The areas marked in the darker blue have water depths of less than 2m at the lowest tide levels. Navigation is not possible in these areas over the low tide period due to water depth constraints.

10.19 A scheme that combines a barrage structure (with water level management) and navigation lock(s) potentially lengthens the navigation window within sections of the Haven up-river of the structure, but navigation between the Haven and the Wash would still be constrained to the existing tidal windows due to water depth constraints down-river of the structure.

10.20 To increase the navigation window between the Haven and the Wash in general, a very large quantity of capital (and maintenance) dredging would be required. This will be both expensive and intrusive.

**River conditions**

10.21 The baseline current speeds at locations (e), (h) and (k) are all relatively high (see Appendix 2). Current speeds at any barrier or barrage/lock at these locations are likely to be higher than at location (i) (the proposed barrier site). This will affect the navigability.

**Exposure**

10.22 Locations (a) to (d) are all in relatively open and therefore exposed positions. Vessels undertaking close quarters manoeuvres (e.g. entering or exiting a lock) or transiting a barrier at these locations would be subject to higher wind loads, which can adversely affect the handling of some vessel types (e.g. inland waterways vessels). Location (a) is the most exposed, and due to the long fetch lengths extending into the Wash this location may also be subject to significant wind-generated waves at some states of the tide and in some wind conditions (e.g. strong winds from between northeast and southeast). This will adversely affect many vessels, and could make mooring alongside in lock waiting areas untenable. In comparison, locations (e) to (h) are moderately exposed and (i) through (k) are relatively sheltered.

**Traffic management**

10.23 All of the locations will present traffic management and control issues. In very general terms, the higher the number of vessels that must pass the site, the more extensive the marine traffic management and/or control issues will be. On this basis, the barrier or barrage should be located as far up-river as possible.

10.24 In general terms, due to the extra traffic management issues and navigation delays associated with navigation lock operations, the waiting areas both up-river and down-river of a barrage/lock structure will need to be more extensive than for a barrier structure. It will not be easy to identify suitable waiting areas that do not conflict with existing marine and land-based activities.
Conclusion

10.25 In this Section I have presented a summary review of alternative schemes for managing the tidal flood risk at Boston from a navigation viewpoint. Overall, I consider that for navigation a barrier is preferable to a barrage, and that there is no better location for a barrier than at location (i) downstream of Black Sluice Outfall in the location proposed by the Environment Agency.

11 Issues raised in Objections

11.1 In this section of my proof, I respond to navigation-related issues raised by some of the objectors to the Environment Agency’s application for the Order which relate to the scope of my evidence.

11.2 Captain McArthur has also responded to objectors’ concerns in so far as these relate to navigation in his evidence (EA/5/1). I have reviewed, and agree with, Captain McArthur’s responses and observations.

11.3 I note that the objectors’ Letters of Objection and/or Statements of Case were submitted to the Secretary of State before the proposed Navigation Management Plan (NMP) was available for their consideration and review. The draft NMP has proposed risk control and mitigation measures which will, in my opinion, mitigate the potential risks not only to a level which is acceptable, but also to a level that is as low as reasonably practical.

11.4 In addition, I note that since the Objectors’ Letters of Objection and/or Statements of Case were submitted to the Secretary of State, several of the Objectors (including the PoB Harbour Master (OBJ/04), the Boston District Fisherman’s Association (BDFA – OBJ/22), Mr Rodney Bowles the owner and operator of the ‘Boston Belle’ (OBJ/14) and the Witham Sailing Club (WSC) (REP/04) were invited to participate in the navigation simulation study. Those that took up this opportunity were able to explore and assess the navigation situation at the barrier for themselves. All of the simulation participants seemed confident in their ability to manoeuvre their vessel through the cofferdam and barrier navigational channels successfully.

11.5 A common concern expressed by numerous objectors relates to the safety of navigation at the barrier due to one or more the following contributory factors:

11.5.1 the reduced width of the river;

11.5.2 the increase in flow rates;

11.5.3 the proposed barrier location on a bend;

11.5.4 the reduced sight lines; and

11.5.5 the increased risk of collision.

11.6 Each of these issues has been examined in the navigation simulation study, and discussed in detail in my evidence. In summary, I make the following points:

11.6.1 The barrier navigation channel is wider than the existing navigable channel width at the barrier site when a grain ship is overhanging the Silo Berth. Furthermore, I
agree with Captain McArthur’s evidence (EA/5/1) when he points out that the predictable navigable width, depth and flow direction through the barrier channel serves to improve the navigational safety at the site compared to the present situation.

11.6.2 The detailed flow modelling that has been undertaken (see Sun Yan Evans’ evidence (EA/2/1) has shown that, as expected, there is an increase in the current speed at the barrier. However, the flow rates predicted at the barrier are not as high as the objectors’ seem to expect and fear. The flow model assessment is that in ‘difficult’ winter conditions (i.e. the most severe river conditions in which river users have indicated that they would, in practice, consider navigating their vessels within the Haven) the peak currents within the barrier are up to approximately 3.7 knots. This represents an increase in peak current speed of up to approximately 1.2 knots at the barrier site compared to the present river layout. Again, I agree with Captain McArthur that this is within acceptable vessel handling limits for powerful and manoeuvrable vessels such as the fishing boats and that I would not expect recreational vessels, passenger-carrying commercial vessels or visiting vessels to be operating in and around the barrier and port in such severe river conditions.

11.6.3 Siting the barrier on a bend in the river is not ideal from a navigational viewpoint. However, this clearly does not make the barrier unnavigable. As at any river bend, mariners are expected to comply with the international collision regulations and so are expected to navigate with particular caution, exercise good navigation and seamanship and proceed at a safe speed.

11.6.4 There is also no doubt that the sight lines at the barrier are poor. However, from the navigation simulations it is clear that the sightlines with the barrier are no worse at this river bend than the existing situation when a grain ship overhangs the Silo Berth.

11.6.5 With regards to the risk of vessel collisions at the barrier, additional vessel traffic management and control measures have been proposed in the draft NMP (please see the appendices to Peter Mallin’s proof of evidence (EA/3/2)) to mitigate this risk. These measures include enhanced communications and situational awareness procedures (using VHF 12) and one-way navigation through the barrier for most vessels, with priority given to vessels navigating with following current. I am confident that the measures detailed in the draft NMP are both suitable and practical in the context of the site, and should be effective in reducing the collision risk at the barrier not only to an acceptable level but also as far as reasonably practical.

11.7 Several of the objectors have also suggested that a second alternative navigation channel (with a navigation lock) is required alongside the barrier for safety and/or navigation continuity reasons.

11.8 I consider a second navigation channel and lock at the barrier site is unnecessary, and of no navigation benefit. As I have discussed in my evidence:
11.8.1 There is a low volume of traffic on the Haven so the proposed barrier channel is not expected to be congested, even though navigation will be generally one-way.

11.8.2 Navigation through the Swing Bridge only 275m up-river of the barrier site is in practice one-way for all vessels at present. On this basis the one-way restriction at the barrier site is not expected to affect navigation on this section of the Haven significantly.

11.8.3 The navigation simulations have demonstrated that all vessel types that transit this section of the Haven at present can navigate the barrier navigation channel successfully in reasonable navigation conditions (i.e. the most severe river conditions in which river users have indicated they would, in practice, consider navigating their vessels within the Haven at present).

11.8.4 I also consider that the navigation risks, difficulties and potential delays and traffic management issues associated with transiting a navigation lock at the barrier site (even when both gates are open so vessels can pass through ‘on the level’) will be equivalent to, if not greater than, with the barrier channel proposed.

11.8.5 It is correct that the barrier will be unpassable when the barrier gate is raised during tidal surge flood events and during maintenance periods. Tidal surge flood events are extreme and therefore rare events. I also consider that it is not reasonable to expect vessels to be navigating on the Haven in ‘extreme’ tidal flood conditions as the navigation risks are excessively high and therefore unacceptable. During barrier maintenance periods the barrier will be unpassable for short periods (generally less than 2 hours), but the maintenance is expected to be scheduled to coincide with periods of little or no navigation activity on the Haven.

11.8.6 I also note that at present the Grand Sluice navigation lock, at least three fixed low bridges and the Swing Bridge (when ‘closed’) are all unpassable by vessels at times, and unlike the barrier, these closures often coincide with periods when vessels do wish to navigate. There are no alternative navigation channels at any of these locations.

11.9 In the following sections I consider other navigation-related concerns raised by individual objectors.

11.10 Port of Boston Limited (Obj/4)

11.10.1 The Port of Boston Limited is the statutory Harbour Authority for the Haven. The Environment Agency has worked in close consultation with the Port of Boston Limited throughout the development of the Boston Barrier Scheme. The Port of Boston Limited has recently written to the Secretary of State to withdraw its objections and to express its full support for the Scheme and all matters of concern previously raised by it have now been satisfactorily addressed.

11.10.2 The Environment Agency has also been closely liaising with the Port of Boston Limited as regards the provisions of the proposed Navigation Management Plan (NMP). This has been developed to set out the procedures to be followed and aids to navigation to be provided to mitigate the risks to navigation arising from the
construction and operation of the Boston Barrier to a level that is as low as reasonably practical.

11.10.3 Further it is my opinion that additional navigation risk mitigation measures would be both beneficial and appropriate at this river bend location and regardless of whether or not the Boston Barrier Scheme proceeds.

11.11 Inland Waterways Association (IWA) (Obj/9)

11.11.1 Mr Gren Messham is a Trustee of the Inland Waterways Association (IWA) and is acting on its behalf. As such he has a particular interest in navigation of inland waterways vessels. In addition to the navigation matters that I have covered in Section 11.6, Mr Messham has raised concerns over navigational mitigation measures and the hazards presented by construction and operation of the Barrier, water traffic and traffic patterns, safe haven moorings and closure of navigation during operation and maintenance of the barrier, all of which I have considered elsewhere in my evidence.

11.11.2 I note that the Mr Messham’s Statement of Case was submitted to the Secretary of State before the Boston Barrier Scheme Navigation Management Plan (NMP) (please see the appendices to Peter Mallin’s proof of evidence (EA/3/2)) was available for his consideration and review. The NMP has proposed risk control and mitigation measures which will, in my opinion, mitigate the potential navigation risks at the barrier site to a level which is not only acceptable, but also to a level that is as low as reasonably practical. Safe haven moorings have also been identified, and these will be located both up-river and down-river of the barrier site during both the construction and operational phases of the Scheme.

11.11.3 I have discussed the water traffic and traffic patterns within my evidence, and these factors have been taken account of within the navigation simulation study. There is a low volume of traffic on the Haven, and it has been established that on average fewer than 30 narrowboats and 4 ‘widebeam’ canal boats pass the barrier site per year. In addition it is reasonable to expect such vessels will only be navigating on the Haven in relatively benign weather and river conditions.

11.11.4 The navigation simulations have considered navigation of both narrowboats and ‘widebeam’ canal boats at the barrier site. Both vessel types could pass the barrier site successfully with both the construction and post-construction layouts in reasonable navigation conditions.

11.11.5 Any vessel (such as the inland waterway vessels) that is transiting the river between the Grand Sluice and the Wash must pass the three concatenated bends near the Town Bridge (see Section 4.6.8.(d)(ii) and Figure 17). Although this section of the river has not been assessed with navigation simulations, in my professional opinion these bends represent a greater allision, collision and vessel control hazard than the barrier (or the cofferdam) with the proposed NMP implemented. I consider that it is the ability of vessels to manoeuvre successfully through these bends, and not the barrier, that will continue to govern the safe transit of the Haven. I note that Captain McArthur is also of this opinion.
11.11.6 One-way navigation has been proposed at the cofferdam and the barrier (as set out in the draft NMP). Given that navigation through the Swing Bridge only 275m up-river of the barrier site is in practice one-way for all vessels at present, the one-way restriction at the barrier site is not expected to affect navigation on this section of the Haven significantly.

11.11.7 It is correct that the barrier will be unpassable when the barrier gate is raised during tidal surge flood events and during maintenance periods. Tidal surge flood events are extreme and therefore rare events. I also consider that it is not reasonable to expect vessels to be navigating on the Haven in ‘extreme’ tidal flood conditions as the navigation risks are excessively high and therefore unacceptable. During barrier maintenance periods the barrier will be unpassable for short periods (generally less than 2 hours), but the maintenance is expected to be scheduled to coincide with periods of little or no navigation activity on the Haven.

11.11.8 I also note that at present the Grand Sluice navigation lock, at least three fixed low bridges and the Swing Bridge (when ‘closed’) are all unpassable by vessels at times, and unlike the barrier, these closures often coincide with periods when vessels do wish to navigate.

11.12 Mr Rodney Bowles (OBJ/14)

11.12.1 Mr Bowles is the owner and operator of the ‘Boston Belle’ commercial passenger tour vessel. In addition to the concerns that I commented on above in Section 11.6, Mr Bowles raises the following navigation-related concerns.

11.12.2 Mr Bowles mentioned a ‘near-miss’ incident at the proposed location of the barrier on 30 August 2016.

11.12.3 I am aware that this incident took place. I did not witness the incident, and I have not been involved with the investigation that the PoB Harbour Master conducted. I am advised, however, that the Harbour Master reviewed the CCTV footage and concluded that the incident was not sufficiently serious to warrant further action. The incident is certainly not under investigation by the MAIB.

11.12.4 Based on the insights gained during the navigation simulation study, it is my opinion that this incident illustrates why additional navigation risk mitigation measures would be both beneficial and appropriate at this location (regardless of whether or not the Boston Barrier Scheme goes ahead).

11.12.5 Mr Bowles also refers to the Marchinesse / Bowbelle collision incident on the Thames on 20 August 1989.

11.12.6 Captain McArthur has covered this in his response to Mr Bowles. I will point out, however, the HR Wallingford ship simulation system was used to perform a navigation simulation assessment for the Formal Investigation into this incident. The incident lead to a series of navigation risk mitigation measures that are in use on the Thames today. The traffic management system operated on the River Thames upper reaches has reduced the risk of collision and gives priority to vessels proceeding downstream. Recommendations for similar suitable navigation
risk mitigation measures at Boston were made following the navigation simulations. These are described in detail in the proposed Navigation Management Plan.

11.13 Mr Terry Despicht (OBJ/15)

11.13.1 Mr Despicht has mentioned concerns regarding the effect of hydrodynamic interactions between manoeuvring vessels and structures, and with other manoeuvring vessels.

11.13.2 Captain McArthur is an expert in such matters, and has discussed interactions at length in his evidence. I add to his comments by pointing out that concerns regarding adverse interactions between vessels is one of the reasons why one of the recommendations arising from the navigation simulation study is that the barrier navigation channel is suitable for one-way traffic only for larger vessels and that the cofferdam navigation channel is suitable for one-way traffic only, and may be unsuitable to transit in adverse river conditions.

11.13.3 Mr Despicht also mentions the ‘near-miss’ incident at the proposed location of the barrier on 30 August 2016 and to the Marchinesse/Bowbelle collision incident on the Thames on 20 August 1989. Please see my responses to Mr Rodney Bowles objection (OBJ/14) on these topics.

11.14 Mr Shane Bagley (OBJ/17) and Jamie Lee (OBJ/18)

11.14.1 Mr Shane Bagley and Mr Lee are active commercial fishermen within the Boston area. Mr Bagley is the Chairman of the BDFA's Quay Committee and Mr Lee is also a member of the same committee. They have raised concerns regarding the safety of navigation once the barrier has been built (which I covered in Section 11.6 of my evidence), and have referred to the angle of the flow to the barrier structure.

11.14.2 The fishermen (through BDFA) were invited to participate in the navigation simulation study and to explore the navigation situation at the barrier for themselves, but the only BDFA representative who attended was Mr Andy Roper. (Mr Bagley's and Mr Lee's letters of objection were submitted before Mr Roper attended the navigation simulations).

11.14.3 The angle of the flow relative to the barrier structure was included within the navigation simulations. The navigation simulation runs showed that at all times the flow in the final approaches to, and within, the cofferdam and barrier navigation channels are well-aligned with the navigation fairway. This means vessels should not experience strong cross components of current during transits of the channel.

11.14.4 Mr Bagley and Mr Lee both refer to a risk that a vessel navigating the barrier could broach.

11.14.5 Broaching occurs when a vessel loses directional stability and yaws (turns) uncontrollably, generally in waves. Once a vessel turns beam-on (side on) to the waves there is a tendency for the vessel to heel over, and in extreme circumstances may capsize. Broaching is normally associated with the vessel running with, or being slowly overtaken by, following waves (or a sailing vessel carrying too much sail and being overpowered by the wind force). In these
circumstances the yawing moments may coincide with a loss of rudder effectiveness bringing the vessel broadside on to the waves.

11.14.6 In smooth water (such as expected at the barrier site) a powerful power-driven vessel, such as a fishing boat, is highly unlikely to broach.

11.14.7 During the navigation simulations there were no indications of any vessels losing directional stability and control in this manner in the approaches to, and at, the barrier site.

11.15 Howard M Smith (OBJ/21)

11.15.1 Mr Smith’s principal interest (with respect to navigation issues) is with inland waterway vessels.

11.15.2 Amongst numerous other concerns, Mr Smith has stated that there has been ‘a gross under estimation of navigation problems of such vessels associated with location and design of the Barrier’, and that there is ‘a significant lack of understanding of current UK inland waterway craft designed specifically for inland navigation but using the Boston Tideway, their transit routes, needs and the frailty of such craft in tidal environment’. Mr Smith also states that ‘the barrier with permanent one-way traffic, is a major and permanent reduction in ease of navigation’.

11.15.3 I cannot agree with any of these statements. See my responses to Mr Gren Messham of the Inland Waterways Association (OBJ/9) on this topic.

11.15.4 Captain McArthur also addresses to Mr Smith’s concerns in some details.

11.16 Boston District Fisherman’s Association (BDFA) (OBJ/22)

11.16.1 Mr Ken Bagley is a Boston fisherman and Chairman of the BDFA.

11.16.2 I note that BDFA were invited to participate in the navigation simulation study and to explore the navigation situation at the barrier for themselves, but the only BDFA representative who attended was Mr Andy Roper. (Mr Ken Bagley’s letter of objection was submitted before Mr Roper attended the navigation simulations).

11.16.3 I also note that the Mr Bagley’s letter of objection was submitted to the Secretary of State before the Boston Barrier Scheme Navigation Management Plan (NMP) was available for his consideration and review. The draft NMP has proposed risk control and mitigation measures which will, in my opinion, mitigate the potential navigation risks at the barrier site to a level which is not only acceptable, but also to a level that is as low as reasonably practical.

11.16.4 Mr Bagley refers to the barrier as a ‘hazard to navigation’ and that ‘the river will become non-navigable’.

11.16.5 I agree that, in the strictest sense of the term, the proposed barrier scheme will be an additional hazard to navigation, because by its very nature the construction of a barrier introduces an additional fixed structure into the river that vessel masters
must take account of when navigating in the river. There are, however, numerous other existing hazards to navigation on the Haven, ranging from wrecks to submerged shoal areas and including the Swing Bridge. Provided the navigation risks have been correctly identified and assessed, and suitable navigation risk mitigation measures are put in place (which has been done in this case), the presence of a hazard to navigation would not mean the river is ‘non-navigable’.

11.16.6 During the barrier construction period the Boston Fishing Fleet have been offered relocation to temporary berths down-river of the cofferdam within the Port of Boston. This proposal is explained in further detail in the evidence of Richard Scriven and Patrick Franklin. Fishing vessels that choose to relocate will not need to transit the cofferdam on a routine basis. The navigation simulations have shown that fishing vessels can transit the cofferdam navigation channel successfully when stemming the current, or at HW slack. I have recommended, however, that such vessels should not transit the cofferdam navigation channel with a following current.

11.16.7 Once construction works have completed the navigation simulations have shown that fishing vessels can navigate both outbound and inbound through the barrier channel in the full range of ‘typical’ and ‘difficult’ river conditions, which includes conditions identified as representative of the most severe river conditions in which BDFA indicated they would, in practice, consider navigating their vessels within the Haven at present. The barrier transit manoeuvres were successful regardless of whether the fishing vessel was stemming the current or had a following current.

11.16.8 Mr Bagley’s other navigation-related concerns regarding the safety of navigation due to the proposed barrier location on a bend, the reduced width of the river, the increase in flow rates, the reduced sight lines and the increased risk of collision are covered in Section 11.6.

11.17 Inland Waterways Association East Midlands Region (OBJ/24)

11.17.1 Mr David Pullen is Chairman IWA East Midlands Region. Like Mr Messham (OBJ/09) and Mr Smith (OBJ/21) Mr Pullen’s principal interest (with respect to navigation issues) is with inland waterway vessels.

11.17.2 Mr Pullen’s main navigation-related concerns are those I cover in Section 11.6. He does, however, describe the ‘appallingy poor visibility that exists even before the barrier is constructed’.

11.17.3 Based on the insights gained during the navigation simulation study, I tend to agree that additional navigation risk mitigation measures would be both beneficial and appropriate at this river bend location at present and regardless of whether or not the Boston Barrier Scheme goes ahead (see my response to the Port of Boston Limited (OBJ/4)).

11.18 Witham Sailing Club (REP/4)

11.18.1 Mr Roger Ackroyd has written a letter of representation on behalf of the Witham Sailing Club (WSC).
11.18.2 Mr Ackroyd and another WSC member Mr Ceri Morgan also took the opportunity to participate in the navigation simulation study and to explore the navigation situation at the barrier for themselves. (WSC’s letter of representation was submitted before they took part in the navigation simulations). Like all of the mariners who participated in the navigation simulations, they seemed confident in their ability to manoeuvre their vessels through the barrier channel successfully.

11.18.3 In the letter of representation Mr Ackroyd states that WSC’s ‘remaining concerns’ regarding the safety of navigation for leisure craft and refers to the proposed barrier location on a bend, the reduced width of the river, the reduced sight lines and the increased risk of collision, which are all points I cover in Section 11.6 of my evidence. Mr Ackroyd states that ‘it is quite obvious that the barrier structure and operations will increase the hazards of navigating in the Haven and these dangers must be mitigated against.’

11.18.4 I note that the Mr Ackroyd’s letter of representation was submitted to the Secretary of State before the Boston Barrier Scheme Navigation Management Plan (NMP) was available for his consideration and review. The draft NMP has proposed risk control and mitigation measures which will, in my opinion, mitigate the potential navigation risks at the barrier site to a level which is not only acceptable, but also to a level that is as low as reasonably practical.

11.18.5 WSC have also been offered temporary relocated facilities near Maud Foster Drain (down-river of both the port and the barrier site) during the construction period. Safe haven moorings have also been identified, and these will be located both up-river and down-river of the barrier site during both the construction and operational phases of the Scheme.

11.19 Royal Yachting Association (RYA) (REP/05)

11.19.1 Mr Stuart Carruthers of the RYA observed that ‘there is a presumption that all craft navigating through the barrier during construction and operation will be controlled by VHF radio. Private recreational craft of less than 13.7m in length are not required to carry radio communications.’

11.19.2 Whilst Mr Carruthers’ statement is strictly speaking correct, I note that the RYA, IWA and CRT all strongly advise every vessel that is heading into tidal waters to carry and use such equipment. Furthermore, it is a requirement of the PoB Standing Annual Notice to Mariners (2017) (Appendix 3).

11.19.3 I consider VHF radio equipment to be such a fundamental item of safety equipment that I consider it to be reckless for any recreational vessel to proceed to sea without it.

11.19.4 Mr Carruthers also quotes the EA Navigation Impact Assessment that ‘there a risk of a vortex to the south of the barrier tie-in that will have a significant effect on recreational and fishing craft during permanent operation, increasing the risk to navigation and collision’.

11.19.5 The flow modelling outputs that I have reviewed show that relatively weak eddies may form immediately either side of the barrier structure, but north of the navigation
fairway, at some states of the tide, but tidal eddies are commonly encountered at
many locations within ports and rarely cause navigational problems.

12 Response to Statement of Matters

12.1 The Secretary of State has set out the Matters about which she particularly wishes to be
informed. My evidence has address the following matters (or aspects of them):

Matter 5(a) The implications for navigation around the siting of the barrier

12.2 The anticipated impacts of the Boston Barrier Scheme on navigation are discussed in detail in
Section 9 of my evidence.

12.3 Based on the insights gained during the navigation simulation study, I consider the barrier will
have a few minor implications, but no major implications for navigation on the Haven. This is
because:

12.3.1 The barrier site is up-river of the PoB Wet Dock, and all of the heavily used PoB
riverine berths (see Figures 1 and 2). This means that the barrier should have no
impact on navigation of PoB ships in terms of ship manoeuvring, although it will be
necessary to relocate some ships to alternative berths.

12.3.2 Furthermore, the navigation simulations have demonstrated that all vessel types
that transit the barrier site at present can navigate the barrier navigation channel
successfully (see Section 7.7.5(h)). This includes the Boston Fishing Fleet, the
‘Boston Belle’ as well as recreational craft such as yachts and inland waterways
vessels.

12.3.3 I consider the barrier navigation channel is generally suitable for one-way
navigation only (see Section 7.7.5(h)). However, given that there is already one-
way navigation (in practice) at the Swing Bridge approximately 275m upriver of the
barrier site (see Section 4.6.8(b)(v)) at present, the one-way restriction at the
barrier site is not expected to affect the navigation situation significantly.

12.3.4 As discussed in Section 4.5 of my evidence, there is a low volume of traffic on the
Haven. Therefore, I do not expect there to be significant marine traffic congestion
at the barrier site, even though navigation through the barrier channel will be
generally one-way.

12.4 Siting the barrier on a bend in the river is not ideal from a navigational viewpoint. However,
the navigation simulations have clearly demonstrated that turn through the barrier channel is
achievable in a safe manner (see Section 7.7), and risk mitigation measures have been
proposed to deal with the sight line and traffic management issues (see Section 8)

Matter 12(a)(iii)Flow velocity concerns in relation to the fishing fleet’s ability to use the
river

12.5 I have seen no real evidence that current speeds in the vicinity of the barrier will attain the
values quoted by the fishermen (i.e. 8 to 10 knots).
The detailed flow modelling that has been undertaken (see Sun Yan Evans’ evidence (EA/2/1), and discussed in Sections 5.5.6 to 5.5.12 and 7.5.5 of my evidence) has shown that, as expected, there is an increase in the current speed at the barrier. However, the flow rates predicted at the barrier are not as high as the objectors’ seem to expect and fear.

The flow model assessment is that in ‘difficult’ winter conditions (i.e. the most severe river conditions in which river users have indicated that they would, in practice, consider navigating their vessels within the Haven) the peak currents within the barrier channel are well within acceptable vessel handling limits for powerful and manoeuvrable vessels such as the fishing boats.

The navigation simulations have shown that fishing vessels can navigate both outbound and inbound through the barrier channel in the full range of both ‘typical’ and ‘difficult’ river conditions (see Sections 7.5.5 and 7.7.5). The barrier transit manoeuvres were successful regardless of whether the fishing vessel was stemming the current or had a following current.

It is not reasonable to expect any vessels to be navigating in the Haven in general, in more extreme river conditions.

**Matter 13(a) Details of what navigational mitigation is to be provided, how it will be delivered and ‘who does what’ to ensure safety of the fleet and fishermen**

A Navigation Management Plan (NMP) has been developed that sets out the procedures to be followed and aids to navigation to be provided to mitigate the risks to navigation arising from the construction and operation of the Boston Barrier.

The draft NMP is presented in full in the appendices to Peter Mallin’s evidence (EA/3/2) and discussed further in Section 8 of my evidence.

The draft NMP has been developed taking into account the findings and recommendations arising from the Boston Barrier Scheme navigation simulation study and in close consultation with the Harbour Authority.

**Matter 13(b) That the phasing of the works accommodates a minimum level of operations to allow river and port operations to continue in safety;**

The phasing of the works associated with construction of the Scheme are described in detail in Peter Mallin’s evidence (EA/3/1).

The navigation simulations have considered vessel manoeuvres past the site during the construction of the barrier (see Section 7.7.4 of my evidence) and an assessment of the temporary potential impacts of the construction activities is presented in Section 9.2 of my evidence.

The draft NMP also sets out set out the procedures to be followed and aids to navigation to be provided to mitigate the risks to navigation arising from the construction of the Boston Barrier to a level that is as low as reasonably practical. This is described further in Section 8.5 of my evidence.
12.16 Overall I have concluded that the impact on navigation during the construction phase is both low and acceptable.

Matter 13(c) The adequacy of the provisions relating to navigational risk within the accompanying Environmental Statement

12.17 The navigation risk mitigation measures set out in the Environmental Statement have been developed further and clarified in the proposed Navigation Management Plan (see Section 8 of my evidence).

12.18 In my professional opinion the mitigation measures detailed in the draft NMP are both suitable and practical in the context of the site, and should be effective in reducing the navigation risk at both the cofferdam and barrier not only to an acceptable level but also as far as reasonably practical (as required in the Port Marine Safety Code (PMSC))

Matter 14(a) 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 recreational craft industry to operate safely.

12.19 As I explain above (in Section 12.5 to 12.9) I have seen no real evidence that current speeds in the vicinity of the barrier will attain the values quoted by the fishermen, and other some objectors,

12.20 In Section 9 of my evidence I have discussed in detail the anticipated impacts on navigation during the construction and post-construction phases of the Scheme. In most circumstances, vessels passing the barrier site may be delayed by up to a few minutes. In a worst case, during critical construction tasks, there could be periods of few hours up to a few days when the cofferdam is unpassable.

12.21 Overall I have concluded that navigation-related impacts on both commercial and recreational river users during the construction phase are both low and acceptable.

13 Conclusions

13.1 In this section I set out my overall conclusions regarding navigation on the Haven with the Boston Barrier Scheme.

13.2 The Haven is important to navigation because it links the PoB with the coastal waters of the Wash. It also acts as a gateway access point and link between otherwise separated inland waterways networks. The Haven is also the base for the Boston fishing fleet and for a range of local and visiting recreational river users.

13.3 The Haven is not, however, an easy waterway to navigate. The river channel through the Haven is relatively narrow, with several significant river bends. Furthermore, due to its nature as a tidal river, the water level in the river varies significantly with both the tidal conditions and with the freshwater river and sluice discharge conditions. As the water level varies, the width of the navigation channel also varies. Navigation on the river is dominated by the river conditions. Flows through the Haven can be moderate to strong at times. There are also numerous existing hazards to navigation on the Haven.
13.4 A range of vessel types and sizes navigate on the Haven undertaking different activities, and subject to different operating constraints. These vessels are used by river users for both commercial and recreational purposes.

13.5 When compared with many UK ports and harbours there is a low volume of marine traffic on the Haven. Almost all vessel movements, however, tend to occur during relatively short ‘tidal operating windows’, usually over the high water period. This means that the marine traffic tends to ‘cluster’, and vessels can encounter other marine traffic at any position within the Haven.

13.6 Construction and operation of the Boston Barrier Scheme will alter the navigation situation on the Haven to some extent, particularly in the vicinity of the barrier site. The main navigation considerations associated with the Scheme are the siting of the barrier on a bend in the river, the modified sight lines with the structures in place, the width of the navigable channel, the flow conditions at the site and the risk of collision.

13.7 The Boston Barrier navigation simulation study conducted by HR Wallingford has demonstrated that all vessel types (except the PoB dredger) can navigate the cofferdam navigation channel and all vessel types can navigate the barrier navigation channel successfully in reasonable navigation conditions i.e. the most severe river conditions in which river users have indicated they would, in practice, consider navigating their vessels within the Haven at present. The cofferdam and barrier navigation channels are generally suitable for one-way navigation only, and with the cofferdam layout I recommend that some vessels types should observe additional current-related manoeuvring windows.

13.8 From a navigational viewpoint siting the barrier on a bend in the river is not ideal. However, the navigation simulations have clearly demonstrated that turn through the barrier channel is achievable in a safe manner.

13.9 The barrier navigation channel is obviously narrower than the full width of the river at this location at present, but with a guaranteed navigable width of 25m the barrier navigation channel is also wider than the existing navigable channel at present when a grain ship is moored on the Silo Berth.

13.10 The sight lines within the vicinity of the barrier and cofferdam are poor, but no worse than at present when there is a grain ship moored on the Silo Berth.

13.11 Comparing Mott MacDonald’s numerical flow model predictions for the baseline, cofferdam and post-construction layouts indicates that the presence of the cofferdam and barrier structures (and associated dredging) modifies the flow pattern to some extent within about 150m of the structure, but that flows are little changed beyond this area. The most navigationally significant features are zones of accelerated flow through cofferdam and barrier navigation channels. Mott MacDonald’s numerical flow model predictions indicate that moderate to strong peak currents (up to approximately 3.7 knots) may be experienced at the barrier in ‘difficult’ winter conditions. This represents an increase in peak current speed of up to approximately 1.2 knots at the barrier site when compared to the present river layout.

13.12 The navigation simulations showed that all of the vessels considered could navigate the barrier successfully in reasonable conditions (i.e. up to and including the conditions most
severe river conditions in which river users have indicated they would, in practice, consider navigating their vessels within the Haven at present (see Section 7.5.5(c)).

13.13 Based on the insights gained during the navigation simulation study, I consider that the navigation situation with Boston Barrier Scheme structures (the cofferdam or the barrier) is similar overall to the existing navigation situation when a grain ship moored on the Silo Berth. Vessels are able to navigate successfully in these circumstances at present and I can see no reason why navigation should not continue to be feasible with the Scheme without any significant alteration with regard to the risks that presently exist.

13.14 I recommend, however, that additional navigation risk mitigation measures would be both beneficial and appropriate to ensure that the risk level is not only acceptable but is also reduced as far as reasonably practical. These mitigation measures should include additional marine traffic management and control at the barrier site.

13.15 A Navigation Management Plan (NMP) (please see the appendices to Peter Mallin’s proof of evidence (EA/3/2)) has been developed that sets out the procedures to be followed and aids to navigation to be provided to mitigate the risks to navigation arising from the construction and operation of the Boston Barrier.

13.16 In my professional opinion the mitigation measures detailed in the draft NMP are both suitable and practical in the context of the site, and should be effective in reducing the navigation risk at both the cofferdam and barrier as far as reasonably practical, and to an acceptable level.

13.17 During the Scheme construction phase, the impact of most construction activities on navigation on the Haven as a whole is expected to be low. In a worst case, there could be periods of few hours up to a few days when the cofferdam is unpassable. Post-construction, navigation of PoB ships will not be affected by the Scheme. The impact of the Scheme on other navigation on the Haven is also expected to be generally low. During barrier maintenance periods the barrier will be unpassable for short periods (generally less than 2 hours), but the maintenance is expected to be scheduled to coincide with periods of little or no navigation activity on the Haven. The barrier will also be unpassable when the barrier gate is raised during a tidal flood event, but these are both extreme and rare. It is not reasonable, however, to expect vessels to be navigating on the Haven in general in 'extreme' tidal flood conditions as the navigation risks are excessively high and therefore unacceptable. In this respect, the navigation situation is no different to at present.

13.18 I have also conducted a brief review of alternative schemes for managing the tidal flood risk at Boston from a navigation viewpoint. Overall, I consider that for navigation a barrier is preferable to a barrage, and that there is no better location for a barrier than the location proposed by the Environment Agency.

14 Statement of Truth

I, Gillian Watson, hereby declare as follows:

14.1 Insofar as the facts stated in this Proof of Evidence are within my own knowledge I believe them to be true, and that the opinions I have expressed represent my true and complete professional opinion.
14.2 This Proof of Evidence includes all 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.

14.3 I understand that my duty to the Inquiry is to help it to help it with matters within my expertise and I have complied with that duty.