CSO Discharge Designers Risk Assessment Permanent Case – Chelsea Embankment Foreshore

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Bazalgette Tunnel Limited

Tideway
14 January 2024

CSO Discharge Designers Risk Assessment Permanent Case – Chelsea Embankment Foreshore

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Required Approvals

	Name	Role	Signature	Date
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Reviewed by	Ed Davies	CDM Advisor (Ports and Maritime)	Ed.Davies	30/10/2024
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Executive summary

1.1 This designers risk assessment has been produced to assess the hazard created by the CHEEF CSO discharge flows to vessels on the Thames at the Chelsea Embankment Foreshore (CHEEF) site.

1.2 It has been undertaken for the permanent phase when the existing CSO is diverted into the new CSO that is situated further into the river Thames in the new CHEEF structure and the tunnel is in operation.

1.3 This designers risk assessment has assessed the risk of a CSO discharge to all types of vessels that passage past the location for the impact of changing the vessels course and the consequential harm that could be caused with a further check to vessel simu lations.

1.4 A worst-case scenario discharge rate of a 1:15-year event at mean low water springs (MLWS) has been analysed to assess the impacts to vessels within zones of impact and vessel accessibility.

1.5 All discharges should be considered as the most probable worst case where it is not possible to establish the magnitude of the discharge at the time of discharge.

1.6 With the tunnel in permanent operation the discharges are likely to occur approximately 2 to 5 times per year reducing from the current predictions of 72 times per year when the tunnel is not in operation.

1.7 It has been concluded that the impact of the discharge occurs for 90 minutes, starting 60 minutes before MLWS and concluding 30 minutes after, this period of impact should be applied for all low tides.

1.8 The assessment has concluded that the discharges cannot be predicted within 30m of the CSO outfall and all vessels should avoid that close proximity to the discharge at any state of the tide.

1.9 It is assumed that the same effects from the CSO discharges would be present when a Thames barrier closure is in operation and the river is in a permanent state of slack water.

1.10 It has been concluded that the risk to powered vessels is very low, the risk to unpowered vessels is low when the mitigations of a warning system is adopted.

1.11 The DRA has been completed with a conservative approach, adopting reasonable worst cases.

1.12 The main works contractor FLo will undertake a navigational risk assessment to consider the residual risks and confirm their mitigations from the operational plan, in consultation with the Port of London Authority, required to be in place during the phase that is covered by this DRA.

1.13 The main works contractor FLO will need to consider the detailed design and the NRA to develop an operational plan, in consultation with the PLA, outlining how they will manage a CSO discharge event with the use of a warning system in line with Tideway's "Technical Memorandum on CSO warning performance specification and strategy".

1.14 To analyse the risk in greater detail for the permanent DRA the following studies have been undertaken:

a. Simulations of the discharge flows on vessels to assess the actual impact caused by the drift angle have been completed.

b. Closed circuit television (CCTV) recording of actual vessel traffic have been completed and the report is currently being drafted.

1.15 The permanent case has been risk assessed incorporating the findings of the ship simulations and will be subject to a navigational risk assessment by the Main Works Contractor to determine, in agreement with the Port of London Authority, any permanent mitigations that may be required. The Technical Memorandum on CSO warning performance specification and strategy should be considered to confirm the mitigations.

1.1 The permanent navigational risk assessment undertaken by the Main Works Contractor FLo will need to determine, in agreement with the Port of London Authority, that the permanent mitigations provide an acceptable warning system for the established risks

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Acronyms and abbreviations

Abbreviation	Abbreviation Description
ALARP	As Low As is Reasonably Practicable
CCTV	Closed Circuit Television
CDM	Construction Design and Management Regulations 2015
CFD	Computational Fluid Dynamics
CHEEF	Chelsea Embankment Foreshore
CSO	Combined Sewer Overflow
DRA	Designers Risk Assessment
EDM	Discharge Monitor
ERIC	Eliminate, Reduce, Inform and Control
FLO	Ferrovial Laing O'Rourke
GPS	Global Positioning System
ICM	Integrated Catchment Model
LTT	London Tideway Tunnel
NRA	Navigational Risk Assessment
PLA	Port of London Authority
SCADA	Supervisory Control and Data Acquisition
TWUL	Thames Water Utilities Limited
UWWTD	Urban Waste Water Treatment Directive
VTS	Vessel Traffic Service

2. Introduction

2.1 Introduction

2.1.1 As part of the Thames Tideway Tunnel project a new foreshore structure to intercept the existing Ranelagh CSO, and to connect to the Northern Low Level Sever No.1, has been constructed at Chelsea Embankment Foreshore (CHEEF).

2.1.2 At the CHEEF site the new combined sewer overflow (CSO) outfall will be relocated from its original location, at the river wall, to discharge from the new permanent structure.

2.1.3 Jacobs as the designer for the reference design has the duty under the CDM regulations to eliminate risks as far as reasonably practicable, where the risks cannot be eliminated the risks need to be reduced as far as reasonably practicable and information provided on residual risk.

2.1.4 Under the CDM regulations the Principal Designer "Jacobs" has a responsibility to plan, manage, monitor and coordinate the health and safety in the pre-construction phase of the project.

2.1.5 During the development of the design a designer's risk assessment was undertaken to identify risks through design whilst also identifying any residual risks that would need to be considered.

2.1.6 There As part of Designers Risk Assessment PKC4X/TA the impact of the Scour was considered under risk reference CDM-CHEEF-021, as presented below in Table 2-1.

Table 2-1 Extract from Designers Risk Assessment PKC4X/TA

Risk ref.	Title / description	Phase	Activity	Potential hazards	Effect summary inc person at risk.	Severity	Probability	First Risk Rating	Design measures to eliminate hazards	Design measures to reduce risk and/or design assumptions	Severity	Probability	Risk Rating after E & R	Residual risk (if significant, etc.)	How is it communicated and / or documented?
CDM-CHEEF-021	Scour – Permanent works	Operation and Maintenance	New permanent structure in the river	Scour damage following bed erosion triggered by increasing river velocity	Potential injury due to settlement or collapse of Chelsea Embankment and adjacent bridges affecting third parties and public	3	2	Medium	Unable to eliminate hazard.	Commissioned scour study analysis assess risk as minimal. Contractor is competent to reduce/manage risk further during construction. Fluvial modelling studies carried out as part of design and design modified to minimise increase in bed velocities Commissioned scour study analysis assess risk as minimal.	3	1	Low	Potential injury due to settlement or collapse of \Chelsea Embankment and adjacent bridges affecting third parties and public.	"Scour and fluvial modelling reports in SI of ITT. "

2.1.7 Whilst CDM-CHEEF-21 recognises that there is a risk produced by increases in river velocity it does not consider any direct risk to vessels in the river or that mitigations may be required.

2.1.8 To ensure that all the relevant risks and mitigations are covered through a Designers Risk Assessment this document will be an addendum which will consider a detailed risk assessment of the new CHEEF CSO discharges impacting vessels on the river.

2.1.9 This designer's risk assessment (DRA) will consider:

(a) The permanent case with the new foreshore structure in place and the flows able to be intercepted and diverted to the main tunnel

(b) When the tunnel is out of operation for maintenance and inspection works

2.1.10 The DRA will make the assessment based on the information that has been produced by the contractor, document 4410-FLOJV-CHEEF-520-VZ-RG-100001_Ver10_HRW 2D modelling P04 and documents produced by Jacobs, Computational Fluid Dynamics (CFD) modelling technical note, Tideway Central CHEEF Traffic Survey Report 012l01 and the updated rainfall information produced by Tideway.

2.1.11 The DRA should be read in conjunction with HR Wallingford document 4410-FLOJV-CHEEF-520-VZ-RG-100001_Ver10_HRW 2D modelling P05. Within the HR Wallingford report the total discharges are modelled with a mean absolute error of 6% for neaps and 7% for springs when compared to the peak flow.

2.1.12 In addition, it will include information provided within document LL1658-R-01 Navigational Risk Assessment Review Port of London Authority, which was undertaken by Rendel Limited with Waves Group and the interim DRA 665397CH-CHEEF-DRA-Interim-Rev.01

2.2 Report Structure

2.2.1 The Structure of this report is as follows:

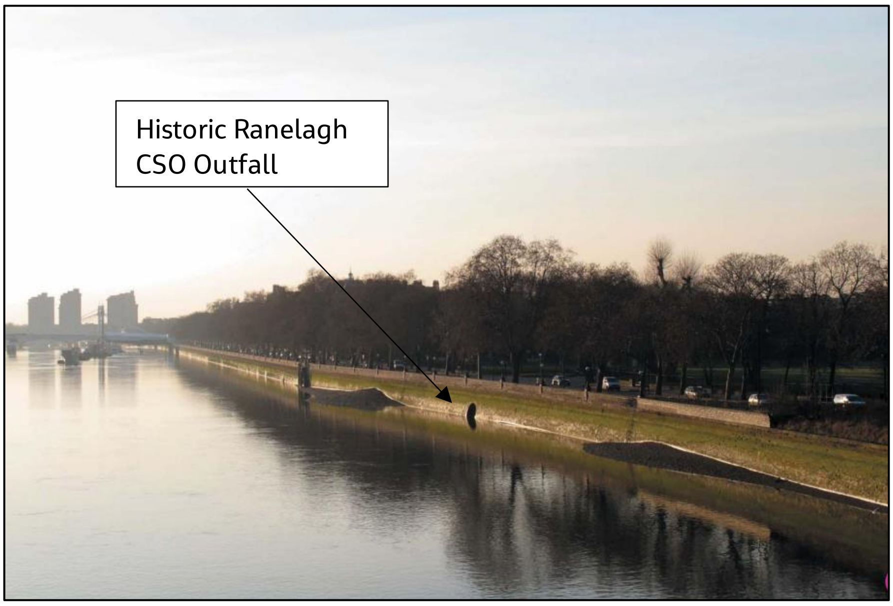
a. Section 3 – Outline methodology for producing the risk assessment
b. Section 4 – Site discharge activity
c. Section 5 – Impact on vessels on the river
d. Section 6 – Risk assessment
e. Section 7 – Mitigations
f. Section 8 – Summary and Conclusions
g. Section 9 – References

2.3 The site and CSO discharge location

2.3.1 The CHEEF site is located on north bank of the river Thames opposite the Bull Ring Gate of the Royal Hospital Chelsea in the Royal Borough of Kensington and Chelsea. The site consists of two components, the south site which will contain the new foreshore structure which will intercept the existing Ranelagh CSO and the intercepted North Low Level Sewer No.1 down into the tunnel. The new CHEEF CSO will also be contained within this structure. The second site is on the northern side of the embankment and will intercept the North Low level Sewer No.1 and direct it to the new southern structure.

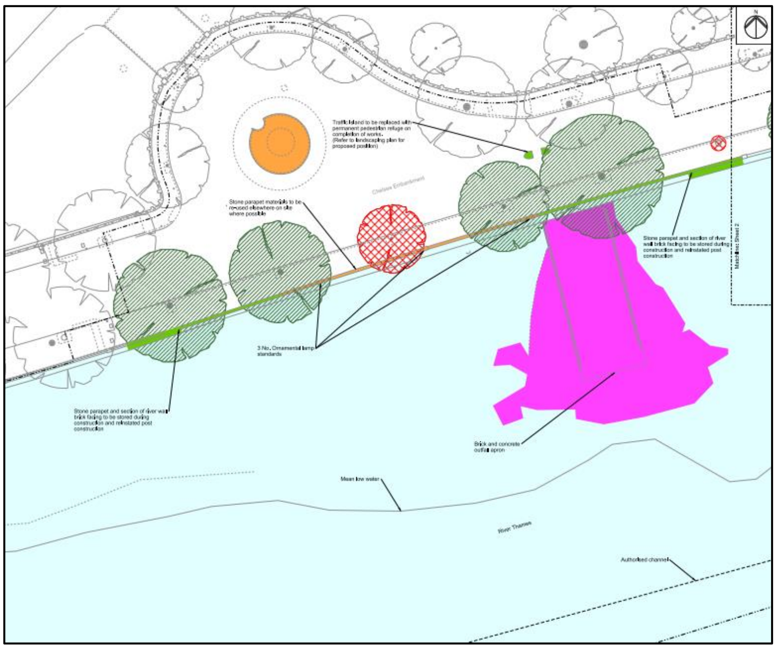
2.3.2 Prior to the construction of the site the Ranelagh CSO outfall was at the eastern end of the site and discharge through the river wall into the Thames as shown in Table2-2

Table2-2 Chelsea Embankment Foreshore Pre-Tideway (view from Chelsea Bridge)



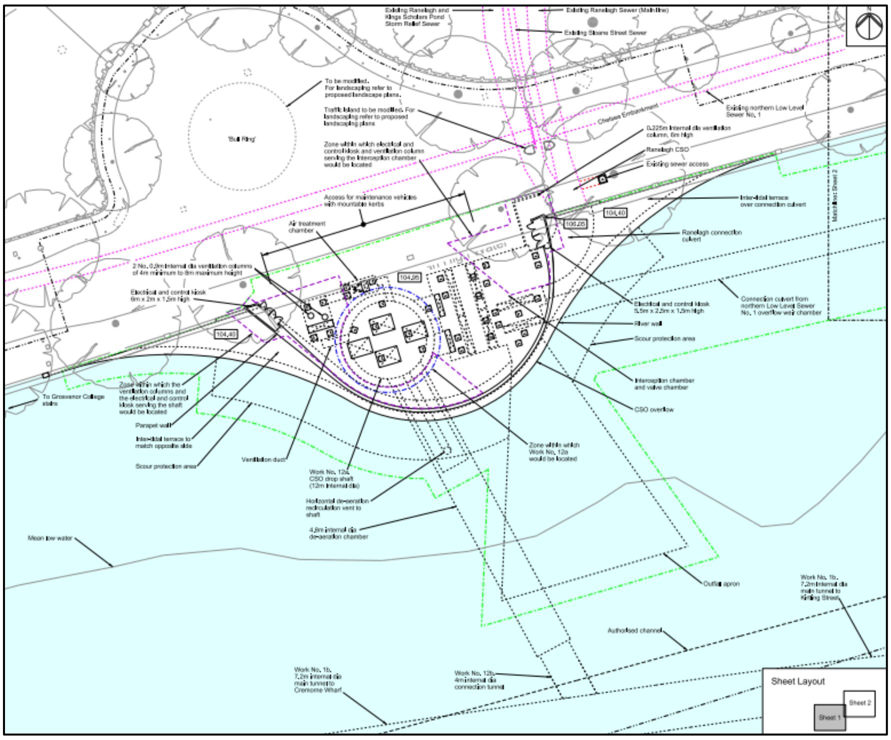
2.3.3 Table2-3 presents the historical outfall point with its scour apron. In the figure the historic scour apron is shaded in purple.

Table2-3 Extract of DCO-PP-12X-CHEEF-140004 showing the original Ranelagh CSO discharge point.



2.3.4 The new foreshore structure projects into the river and moves the CHEEF CSO outfall approximately 12m upstream and 20m further into the river. Table2-4 presents the permanent works arrangement with the new outfall location and scour apron.

Table2-4 Extract of DCO-PP-12X-CHEEF-140008 showing the permanent works arrangement.



2.3.5 In conjunction with the change of outfall location there is also a change in the size and layout of the new outfall.

2.3.6 The new CHEEF CSO outfall will discharge through three sets of flaps which discharge onto the new scour apron and have approximately 1.6 times larger area than the original Ranelagh CSO outfall.

3. Outline Methodology

3.1 To analyse the impact of a CSO discharges from the site to the river, identify the risks to vessels on the river, identify the impacted vessels, propose mitigations and present the residual risks the following has been undertaken:

3.1.1 Confirm site discharge activity by:

i) Reviewing historical rain and discharge data

ii) Reviewing resilience to climate change

iii) Analyse tidal windows to confirm worst case

iv) Review and analyse the impact of discharges on the river from 4410-FLOJV-CHEEF-520-VZ-RG-100001_Ver10_HRW 2D modelling P04.

3.1.2 Review impact of worst-case discharge on vessels on the river by:

i) Confirm areas of the river

ii) Confirming vessels that use the river in this area

iii) Confirming predicted drift angle of vessels caused by a CHEEF CSO discharge

iv) Summarise impacted vessels on the river

3.1.3 Risk assessment

i) Hazards

ii) Receptors, incorporating the CCTV survey data reports

iii) Severity of harm

iv) Likelihood of harm

3.1.4 ERIC approach to review mitigation

i) Eliminate

ii) Reduce

iii) Inform

iv) Control

3.1.5 Summary

4. Site discharge activity

4.1 Consideration of rainfall events

4.1.1 CSO discharges were produced for a range of return period storms using an InfoWorks network model of the upstream sewer catchment.

4.1.2 Synthetic storms were generated by the software based on the Flood Estimation Handbook (FEH).

4.1.3 The critical storm duration for the system (i.e., that which produces the highest flows at the outfall) was found to be 120 minutes.

4.1.4 Normally, when generating synthetic storm events, rainfall intensities are reduced as the footprint of a storm increases. However, in this instance, the storm event was applied over the entire catchment without applying an areal reduction factor.

4.1.5 With an approximate catchment area of $550km^2$, the corresponding reduction factor for the Tideway catchment would have been 0.76 – the rainfall intensities are therefore overestimated by approximately 32%.

4.1.6 In addition, the model assumes that all rainfall landing on a catchment freely enters the sewer system. In practise, for higher rainfall intensities, this cannot happen as the gullies and upstream collection pipework act as a restriction, resulting in flooding and ponding on the surface. For this reason, the modelled 100-year storm flows are considered theoretical and unlikely to ever be realised. It is the upstream sewer system that limits the peak CSO discharge rate, not the size of the CSO opening itself.

4.1.7 The InfoWorks model of the existing sewer network, without the London Tideway Tunnel, was run with free discharge as a worst-case scenario (i.e., low tide) and the peak flow rates included in the project's works information (WI 7706). These WI flows are shown in Table 4-1. The peak flow from the CHEEF CSO was found to be approximately 20m3/s for a 15-year storm.

4.1.8 Periodic updates are made to the model depending on the results of surveys/inspections. Discharge rates using the updated model are also given in Table 4-1 Peak flows are slightly less, but broadly similar. Peak flows are not significantly changed from the original model.

4.1.9 At higher tides the CSO becomes submerged and there is a corresponding decrease in discharge rates, also included in Table 4-1.

Table 4-1 Comparison of Instantaneous peak discharge rates from WI 7706 and the post 2016 model

Source		LT 1 – Year Storm	LT 2-year storm	LT 5-year storm	LT 10-year storm	LT 15-year storm	LT 30-year storm	LT 50-year storm	LT 100-year storm
Latest DA Model	Instantaneous Peak Low water (m^3/Sec)	-	10.4	14.5	17.6	20.2	26.3	30.3	34.2
Latest DA Model	Rolling Hourly Average Low water (m^3/Sec)	-	7.8	12.7	15.7	17.8	21.9	25.3	30.1
Latest DA Model	Instantaneous Peak High water (m^3/Sec)	-	5.0	13.9	18.2	20.0	22.9	24.6	26.7
WI 7706	Instantaneous Peak Flow	7.9	10.6	14.0	17.9	20.0	28.0	-	-

4.1.10 It should be noted that occasionally TWUL can make minor diversions to the sewer network upstream to facilitate maintenance access. However, these are generally local in nature and don't have a significant impact on CSO discharges.

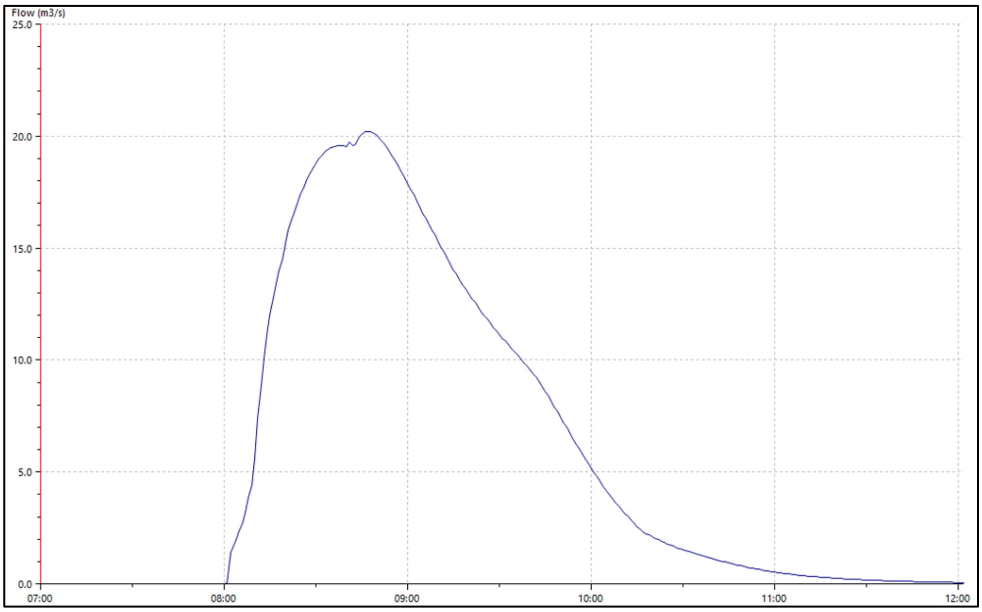
4.1.11 The developed nature of the upstream catchment means it is not possible to make substantial changes to the network connectivity that could significantly affect peak CSO discharges. Ultimately there is a fixed amount of rainfall falling on a fixed area, served by a sewer system of fixed and limited capacity.

4.1.12 Only when the works are complete will there be planned works that significantly impact CSO discharges. Every 10 years it is planned to close the tunnel for inspections – under these conditions all flow is diverted to the CSO. Whilst the exact duration of the closure is yet to be finalised, it is expected to be of the order of two weeks.

4.1.13 Given the conservative nature of the rainfall generation, the theoretical nature of the network modelling, the limited scope to significantly alter the upstream sewer network and the range of possible tide levels, 20m^3/s is considered a maximum realistic CSO discharge rate.

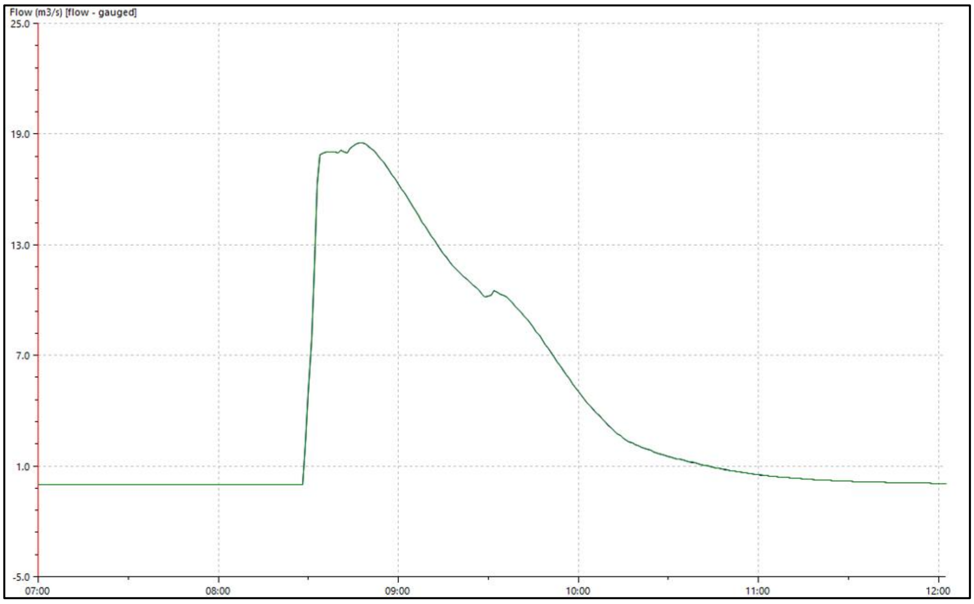
4.1.14 Figure 4-1 shows the discharge hydrograph for the 15-year storm at low tide, using the latest Design Authority model. The hydrograph represents the 'Tunnel Closed' scenario. In this instance the storm started at 07:00 - it took approximately 60 minutes for the CSO to start discharging and approximately another 45 minutes for the peak discharge (approximately 20m3/s) to be realised.

Table4-2 CSO Discharge Hydrograph for the 15-year storm, tunnel closed



4.1.15 Figure 4-2 shows the 15-year discharge hydrograph representing the 'Tunnel Operational' scenario. The onset of the CSO discharge is delayed by approximately 30 minutes. Discharge occurs because, at CHEEF, flow to the tunnel is limited to approximately 15m^3/s. When this flow is achieved the tunnel penstocks are closed and all subsequent flow is diverted to the river.

Table4-3 CSO Discharge Hydrograph for the 15-year storm, Tunnel Operational



4.1.16 At the design phase of the project, 40 years of recorded rainfall data was available, spanning 1970–2010. Following inspection of this data set it was determined that the most representative (typical) year was October 1979 to September 1980. A further review of the data up to 2020 has confirmed that this remains the case.

4.1.17 Table 4-2 summarises the peak CSO discharges at CHEEF during the typical year (1979/80).

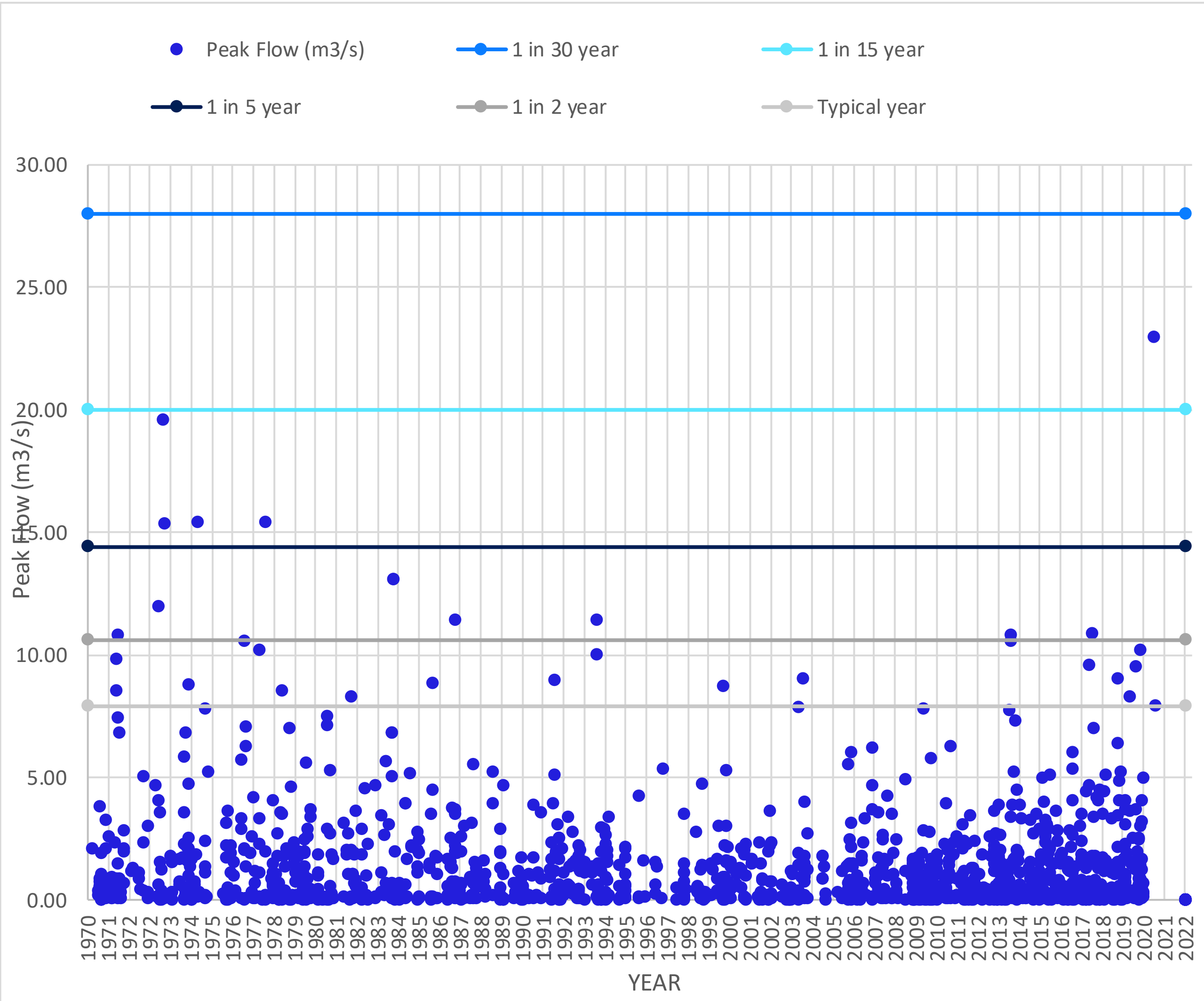
Table 4-4 Peak CSO discharges during typical year (1979/80)

Start of Spill	Spill Duration (mins)	Peak Flow (m3/s)	Spill Volume (m3)
09/10/1979 06:40	281	7.1	27,631
25/10/1979 14:11	305	4.7	23,984
26/11/1979 14:05	302	1.9	11,341
13/12/1979 04:35	175	0.2	714
27/12/1979 01:50	664	1.5	20,766
03/01/1980 22:40	254	1.7	10,025
20/01/1980 18:05	178	0.7	2,183
03/02/1980 15:30	188	1.1	3,225
22/02/1980 11:20	134	0.2	492
06/03/1980 10:15	225	2.0	7,673
07/03/1980 11:00	93	0.0	78
17/03/1980 07:51	360	1.8	15,455
01/04/1980 12:45	138	0.2	550
30/05/1980 11:15	118	0.1	255
31/05/1980 14:16	335	0.4	2,560
13/06/1980 02:56	212	1.1	4,426
13/06/1980 16:50	135	0.2	541

17/06/1980 17:32	201	0.7	2,886
Start of Spill	**Spill Duration (mins)**	**Peak Flow (m3/s)**	**Spill Volume (m3)**
22/06/1980 10:15	282	2.5	15,181
24/06/1980 10:00	201	1.3	3,835
30/06/1980 20:30	250	1.9	8,751
03/07/1980 23:37	121	0.1	228
07/07/1980 13:50	227	1.9	6,817
18/07/1980 07:49	153	0.1	207
25/07/1980 23:40	329	5.6	31,596
12/08/1980 22:05	213	2.6	8,328
14/08/1980 16:00	396	2.9	16,731
29/08/1980 13:25	189	0.8	2,543
16/09/1980 08:35	232	0.2	920
16/09/1980 20:35	77	0.1	86

4.1.18 Figure 4-3 below shows the simulated peak flows from the CHEEF CSO outfall, assuming the tunnel is not available, using the full set of actual rainfall data for 1970-2020.

Table4-5 Simulated peak flows from CHEEF CSO outfall using actual weather data from 1970-2020 against the WI 7706 return periods (assuming tunnel unavailable).



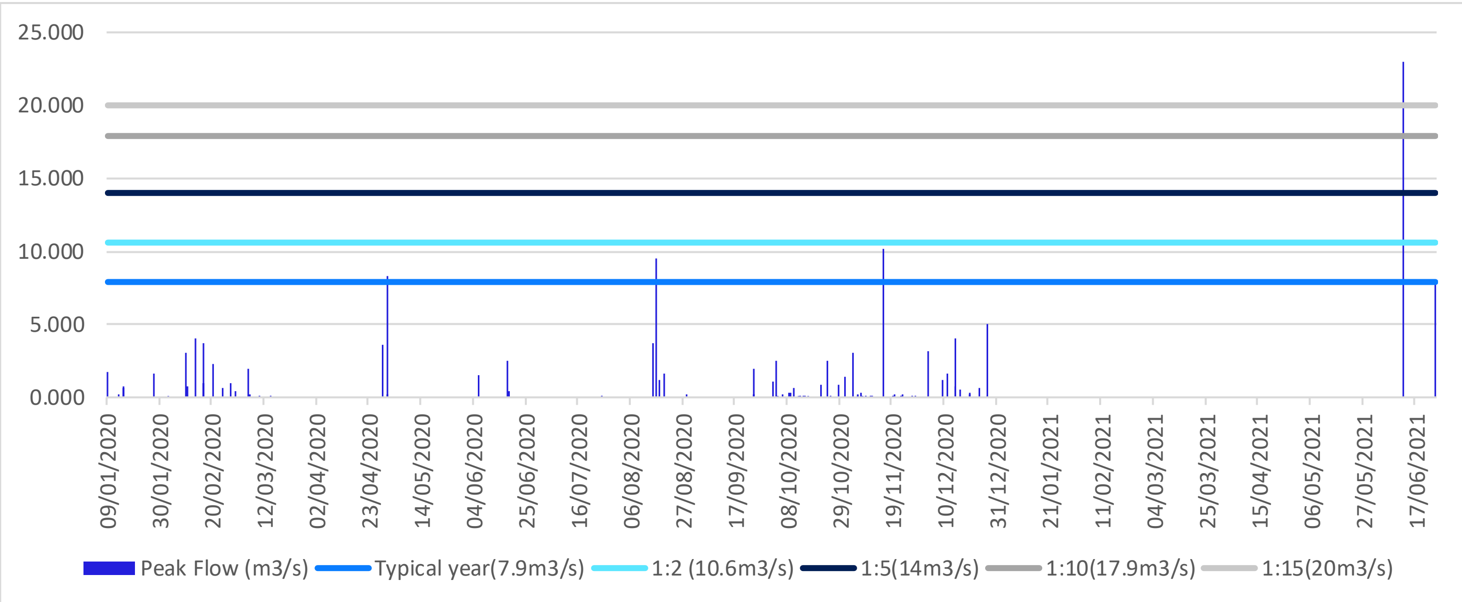
4.2 Discharge frequency and magnitude

4.2.1 The CHEEF structure will be intercepting the Ranelagh CSO discharges to the main tunnel however there will be periods when the tunnel will be taken out of operation for inspection and maintenance. During these periods the tunnel will be isolated, and the intercepted flows will discharge through the new CSO. Whilst these works will be planned to be undertaken during periods of low flow there may be storms and there the magnitude of these discharges and the potential frequency needs to be understood.

Magnitude

4.2.2 The 2020 CSO peak discharge flows have been analysed and presented in Table 4-6, this includes the two storms from July 2021 which were noted for their intensity.

Table 4-6 Modelled CHEEF CSO discharge peak rates with actual rain data for 2020, including storms from July 2021



4.2.3 From the information presented in Figure 4-4 the average instantaneous peak discharge rate during 2020 was 0.6m^3/s with a maximum instantaneous peak of 10.2m^3/s. During the 12th July 2021 summer storm the modelled CHEEF CSO peak discharge rate was 22.9m^3/s.

Frequency

4.2.4 In 2019 an event duration monitor (EDM) was installed in the Ranelagh CSO to enable TWUL to deliver against the regulatory requirement to report CSO discharges capturing the number of discharges and their duration. The records from the Ranelagh EDM started being reported from 2020 and since installation the EDM has recorded between 41 and 120 discharges per year with the current average of 71.7 discharges per year.

Climate change

4.2.5 During the development of the scheme and in support of the application for Development Consent, Tideway produced document 7.23 Resilience to Change. This document was developed to assess whether the scheme would continue to meet the Urban Waste Water Treatment Directive (UWWTD) requirements in the future whilst taking into consideration climate change and population increase.

4.2.6 The baseline data for the frequency and volume of CSO discharges was developed from the 1979/80 typical year of 588mm of rainfall depth which when modelled indicated a discharge of circa 39 million m^3 of sewage into the Thames.

4.2.7 Table 6.3 from document 7.23 presents the typical year CSO spill volumes and event count comparisons for the current climate and medium emission modelled scenarios from the UKCP09 government data on climate change. Table 4-3 below is the extract from that table for the modelled CSO discharges at CHEEF.

Table 4-7 Extract of table 6.3 from document 7.23 - typical year CSO spill volumes and event count comparisons for the current climate and medium emission modelled scenarios

LTT ID	EA Category	CSO Name	Typical Year – 2020 population and current climate			Typical year – 2080 population and medium emission scenario, 10 percentile			Typical year – 2080 population and medium emission scenario, 50 percentile			Typical year – 2080 population and medium emission scenario, 90 percentile		
			Total Volume (m^3)	No. of Spills	Spill Duration (Hrs)	Total Volume (m^3)	No. of Spills	Spill Duration (Hrs)	Total Volume (m^3)	No. of Spills	Spill Duration (Hrs)	Total Volume (m^3)	No. of Spills	Spill Duration (Hrs)
CS14X	Cat 1	Ranelagh	18,500	2	10	26,700	1	7	33,100	2	10	48,500	5	23

4.2.8 Table 4-3 demonstrates that the predicted CSO discharge frequency at CHEEF is not expected to increase significantly.

4.2.9 The UK government updated the climate scenarios and presented them as UKCP18. Tideway reviewed the information to confirm that the scheme would still meet its UWWTD requirements in the future. The review confirmed there had not been significant change in the outcomes and the resilience of the scheme as described in document 7.23 still held true.

4.2.10 Table 4-4 summarises the peak rainfall climate change allowances in England up to 2125, extracted from the DEFRA website.

Table 4-8 Peak rainfall climate change allowances up to 2125

	Storm Return Period	
	30 year	100 year
Central Range (50th %ile)	20%	25%
Upper Range (95th %ile)	35%	40%

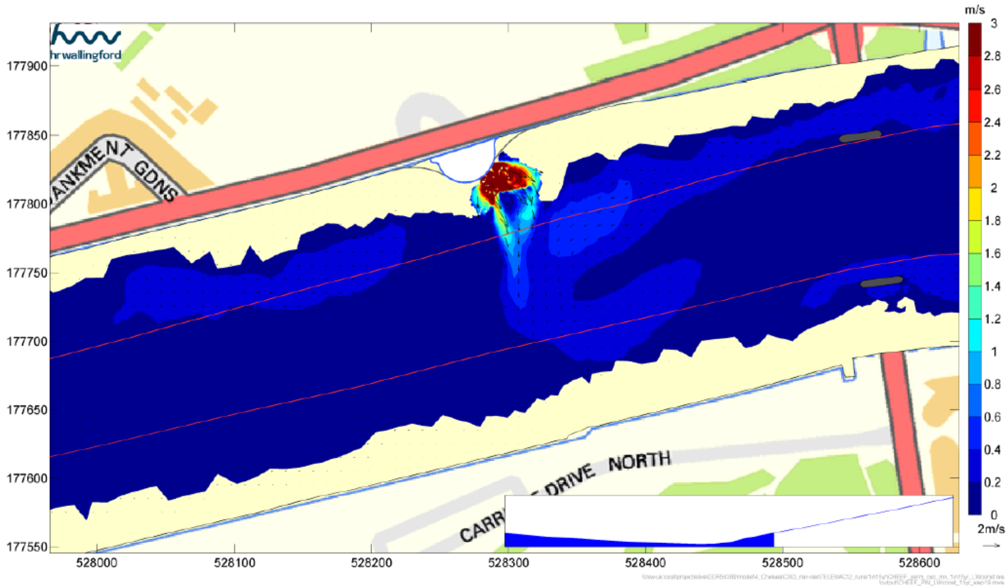
4.2.11 These allowances are of the same order of magnitude as the overestimation of the synthetic rainfall intensities explained in paragraph 4.1.5 (32%). It can therefore be considered that climate change has been adequately allowed for.

4.2.12 Notwithstanding the above, any future increase in rainfall intensities will not have a significant impact on the peak CHEEF CSO discharge rates for the reasons set out in paragraph 4.1.6.

4.3 Tidal Considerations

4.3.1 Section 4.3 of 665397CH-CHEEF-DRA-Interim-Rev.01 determined that the most likely worst case was the 1:15 year return period discharge at spring low water slacks as presented Figure 4-1 In addition the period of impact is 80 minutes from 55 minutes before low water to 25 minutes after low water. Outside of the 80 minutes the main river flow is dominant, and the navigation of the main channel is largely unaffected, this stands for the permanent case.

Figure 4-1 1:15 year return period depth average currents at spring low water slacks



4.3.2 Following the completion of the interim DRA it became apparent that the scour hole identified within the HR Wallingford report has been filled during the construction of the permanent works.

4.3.3 The Jacobs CFD modelling that was undertaken for a 1:100 year return period discharge and presented in the interim DRA and presented in Figure 4-2 and Figure 4-3 was carried out using the 2022 bathymetric data and integrated the scour apron.

Figure 4-2 Plan of Jacobs CFD output for 1:100 year return period at spring low-water slacks

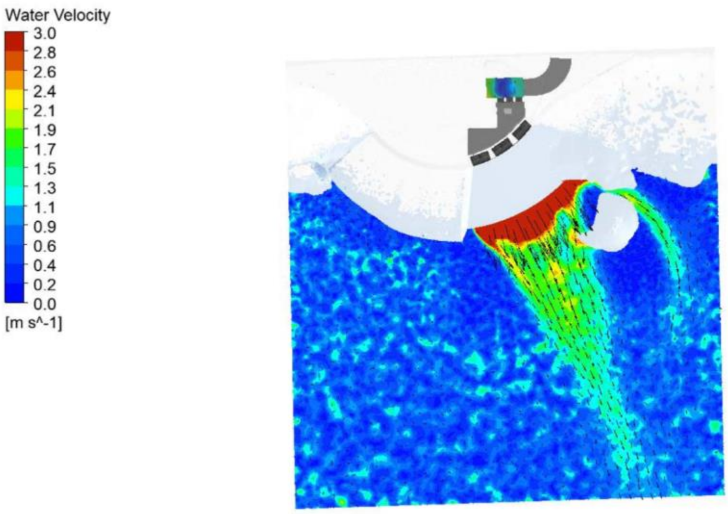
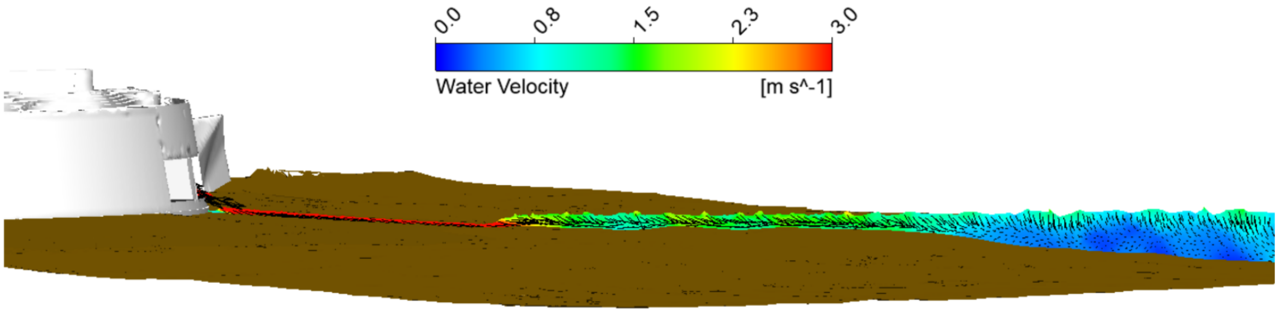


Figure 4-3 Section of Jacobs CFD output for 1:100-year return period event at spring high water slacks.



4.3.4 The outputs from the Jacobs CFD show a regular flow across the apron and foreshore before meeting the river. Despite this there is no indication that there is any increase in the lateral flow velocities across either the inshore zone or the main channel. Therefore, even if the scour hole was to reestablish the impact of the discharge would not likely change.

5. Impact on vessels on the river

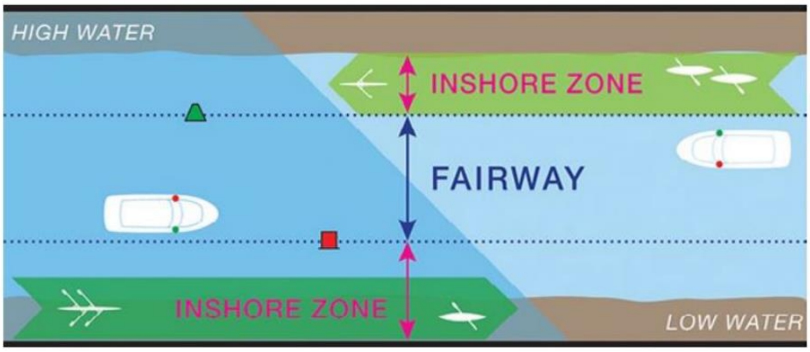
5.1 Assessment of the discharges

5.1.1 The 1:15 year event discharge plumes and sections are taken from document 4410-FLOJV-CHEEF-520-VZ-RG-100001_Ver10_HRW 2D modelling P04 and CHEEF Interim DRA 665397CH-CHEEF-DRA-Interim-Rev.01

5.1.2 As stated in 4.3.1 the assessment for the impact on vessels on the river will be carried out using a 1:15 return period CHEEF CSO discharge of 20.2 m^3/s at low water springs which produces the most probable worst case discharge plume for the site.

5.1.3 The assessment will consider the impact on vessels on the river in both the inshore zone, which is the area of the river between the main fairway edge and riverbank, and the main fairway, which is the area of the river between main fairway edges. As presented in Figure 5-1. The assessment will also consider collision with other vessels due to course change.

Figure 5-1 Diagram showing Fairway and Inshore Zones, (P58, The Tideway Code, PLA, 2019)



5.2 Outline which vessels have been assessed for and why.

5.2.1 Table 5-1 presents the vessels, and their characteristics, that have been chosen to represent the different types of vessels on the river that could be affected by a CSO discharge at Chelsea Embankment Foreshore (CHEEF)

Table 5-1 Vessels and their characteristics that could be affected by a CSO Discharge

	Vessel Classification	Vessel Type	Min Speed (knots)(SOG)	Max Speed (knots)(SOG)	Power	Manoeuvrability	VHF
1	Commercial Powered Vessels	Uber Boat	6	25	High	High	Yes
2		RIB/Emergency services	3	12 (40+ Emergency only)	High	High	Yes
3		Sightseeing/Pax	3	12	Medium	Medium	Yes
4		Restaurant/Pax	3	10	Medium	Medium	Yes
5		Tug vessel engaged in pushing	3	6	High	Low	Yes
6		Tug vessel engaged in towing	3	6	High	Low	Yes
7		Workboats	3	6	Low	Medium	Yes
8	Recreational Powered Vessels	Narrow Boat/cabin cruisers	3	4	Low	Low	No
9	Un-Powered Vessels	Dinghy	1	3	V. Low	Low	No
10		Kayak/Rowers/SUP	1	2	V. Low	Low	No

5.3 Impacts of discharge on the different classes of vessel.

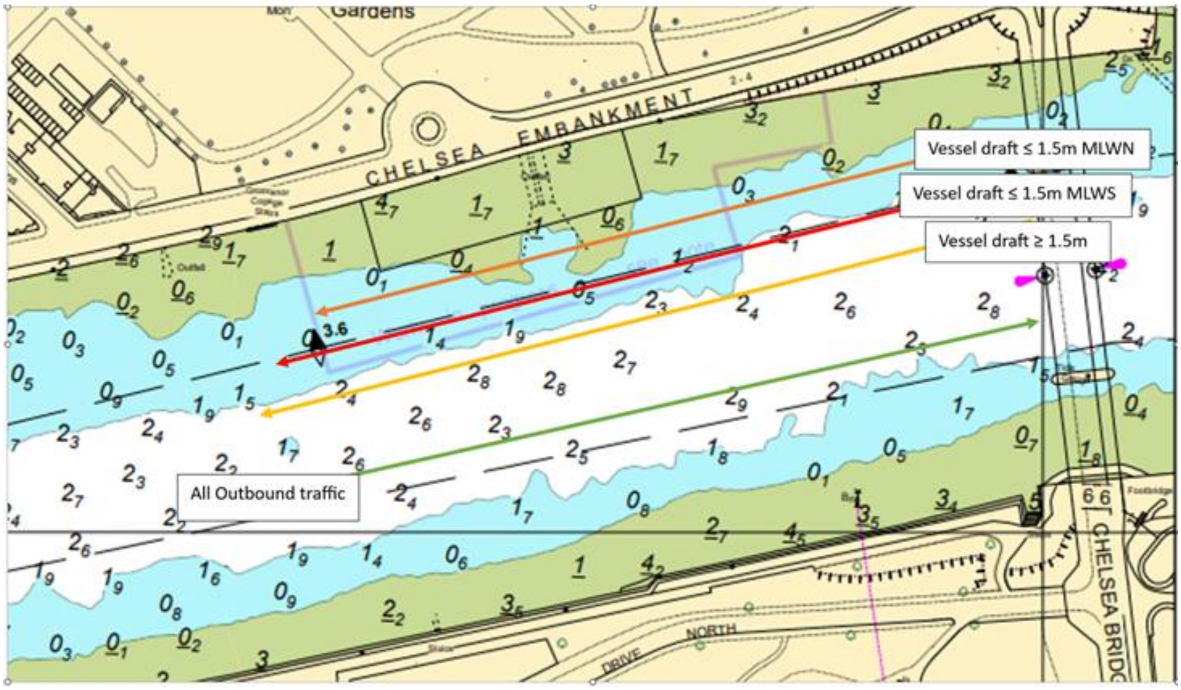
5.3.1 This section sets out the vessels that could be impacted by the CSO discharge, where the vessels are in relationship to the discharge and the corresponding drift angle that impact the vessels from the magnitude of the discharge flow.

5.3.2 CHEEF Interim DRA 665397CH-CHEEF-DRA-Interim-Rev.01 established the worst most likely case for a CSO impact and the duration of that impact. This information is presented in section 4.3.1.

5.3.3 The governing parameter of the draft of a vessel determines the minimum depth of water that the vessel needs to safely operate without grounding. This parameter is therefore listed in Table 5-1.

5.3.4 In this area at low tide vessels will operate in the fairway due to the drying heights and the lack of traffic. The closest a vessel can transit past the CSO outfall at neap low water would be approximately 50m from CSO outfall, approximately at the channel edge, therefore the vessels have been assessed passing at this distance.

Figure 5-2 Extract of PLA chart 314 Vessel Operating zones governed by draft



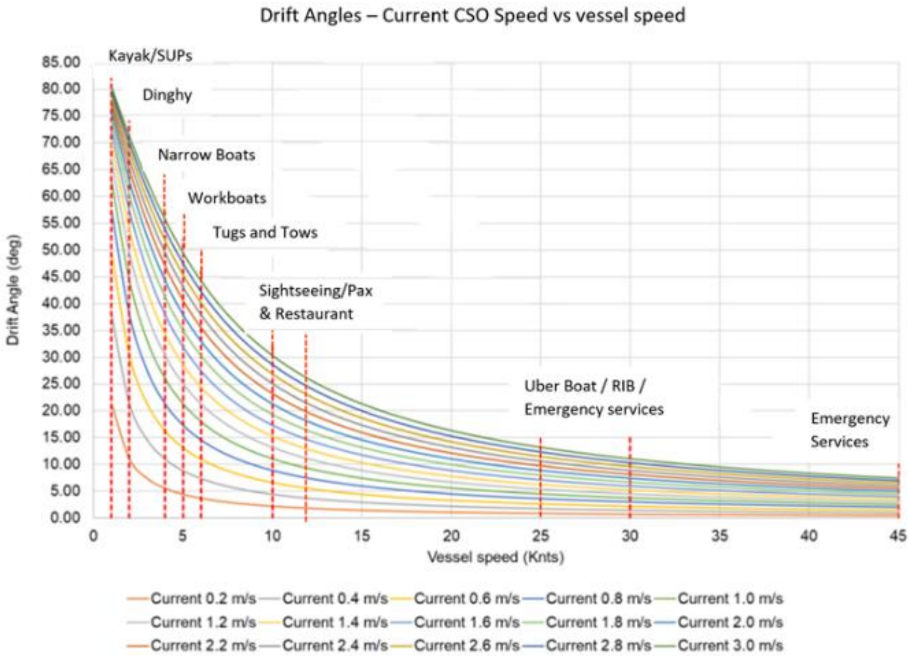
5.3.5 Figure 5-2 is an extract of PLA chart 314, which covers the Battersea reach to Chelsea Reach and highlights the passage of vessels transiting through the area. The Red arrowed line shows the closest running position for shallow draft vessels transiting upstream at low water. The orange arrowed line presents the normal running position for reporting vessels transiting upstream after clearing Chelsea Bridge. The green arrowed line presents the normal running position for reporting vessels transiting downstream towards Chelsea Bridge.

5.3.6 Whilst considering the passage of a vessel past the CSO the hydrograph in figure 4-1, without the tunnel in operation, indicates that there are 45 minutes from the start of discharge before it reaches its 1:15 year peak discharge of 20.2m^3/s, whilst the hydrograph in figure 4-2, with the tunnel in operation, indicates that whilst there is a delay in the start of the discharge the duration to reach its peak discharge peak discharge is reduced to ten minutes.

5.3.7 The drift angle will be determined in relation to the lowest operating speed at the relevant distance from the CSO (Table 5-1) where the lowest speed will incur the highest magnitude impact.

5.3.8 The drift angles of the vessels are a function of the vessel speed while impacted by the CHEEF CSO discharge current speed without any course correction, this will be taken as the worst-case scenario. The results are presented below in Figure 5-3 noting that drift angles are related to the speed of vessel and not category of vessel.

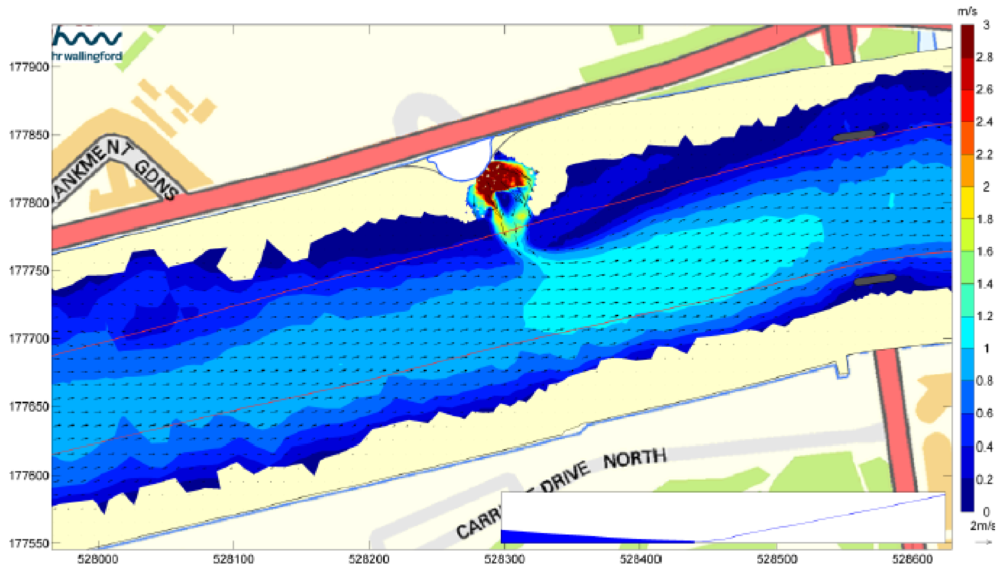
Figure 5-3 Drift angle – Current CSO vs vessel speed



5.3.9 This approach allows a direct evaluation of the CSO discharge as a potential hazard to the vessels passing the area.

5.3.10 Modelled flow velocities from CHEEF CSO outfall discharge during a 1:15-year event at ten minutes before spring low water is shown in Figure 5-4.

Figure 5-4 Modelled flow velocities for a 1:15-year discharge at ten minutes before low water springs

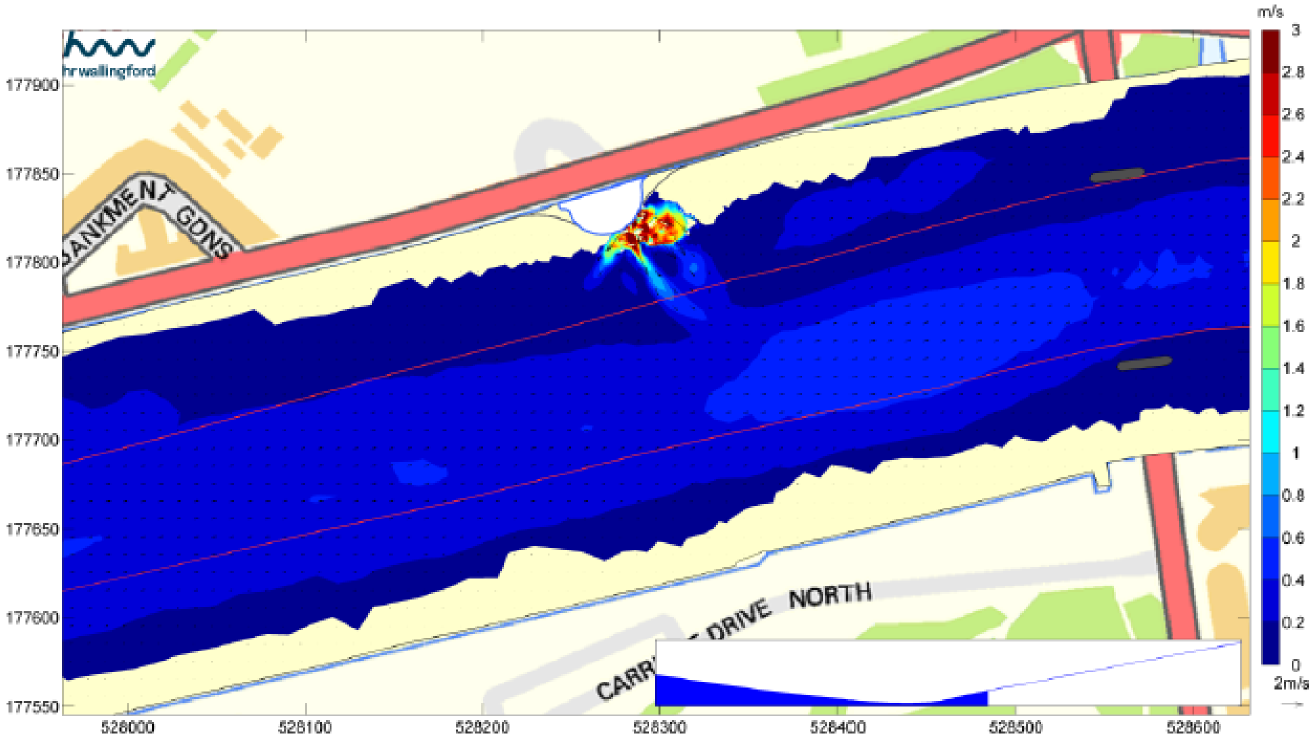


5.3.11 Figure 5-4 shows the CSO discharge velocity starting at over 3.8m/s from the outfall deteriorating across the scour apron and foreshore to approx. 2.0m/s as it contacts the river. This decreases to approximately 1.6m/s as it reaches the edge of the channel. The lateral flow crosses the channel with an average of 0.2 to 0.4m/s increase over the background current.

5.3.12 For vessels transiting upstream the on the channel edge the CSO discharge impact could be 1.8 to 2m/s. For vessels transiting upstream in the normal running position the CSO discharge impact could be 1-1.2m/s depth averaged velocity. For vessels transiting downstream in normal running position the CSO discharge would be negligible as the lateral flow has been turned to run with the main flow.

5.3.13 Modelled flow velocities for a 1:15 year return period event discharge ten minutes before low water neaps is shown in Error! Reference source not found.. There is a significant reduction in the impact of lateral flow velocity on the main channel within this case.

Figure 5-5 Modelled flow velocities for a 1:15 return period event discharge ten minutes before low water neaps.



5.3.14 Table 5-2 presents the assessed impact of a 1:15-year CHEEF CSO discharge on the different vessel types, using the drift angle curves when the vessels are operating at the different distances with the channel and from the CSO.

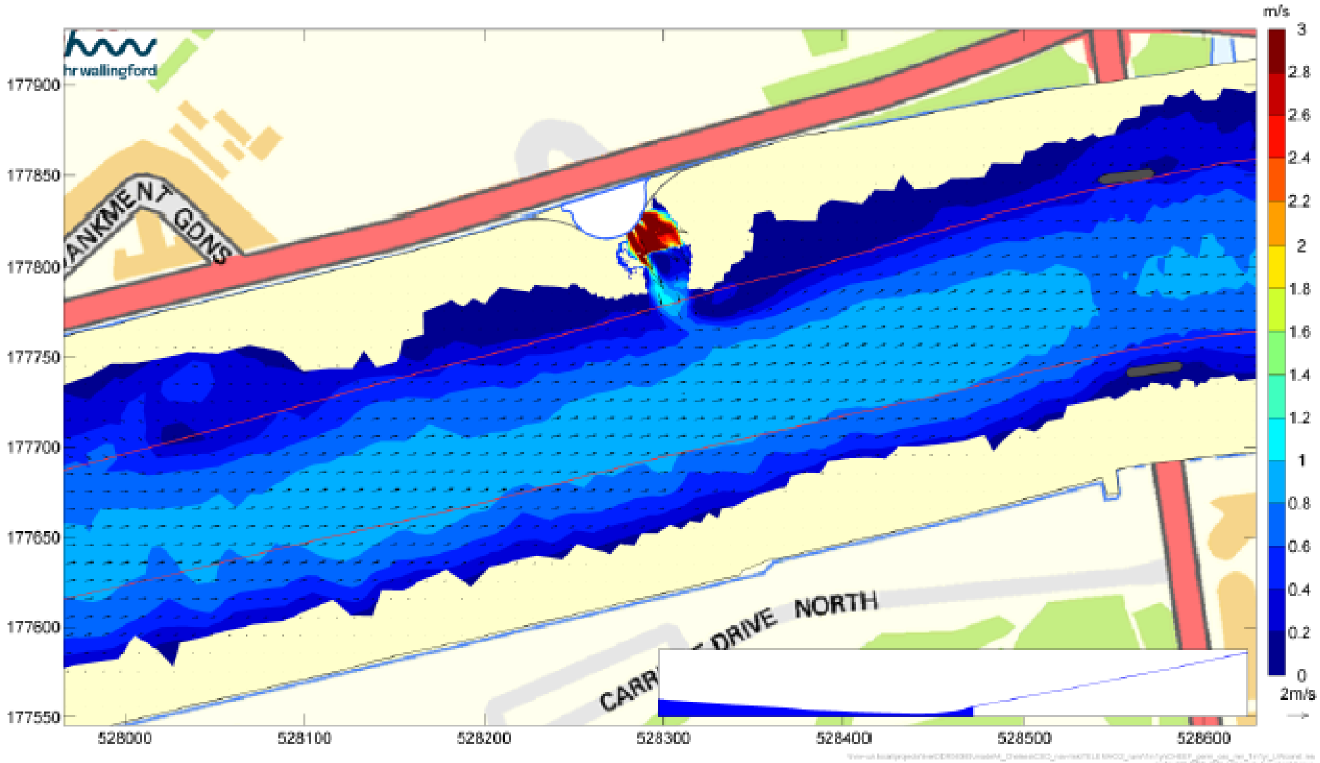
5.3.15 The estimated speed over ground for vessels passing the CSO, as stated in the Table 5-2, is recorded as an estimate of the slowest probable speed whilst still maintaining steerage.

Table 5-2 Approximated drift angle when passing the CSO in the inshore zone, during a 1:15-year CSO discharge at MLWS and MLWN

Vessel Type	Vessels Speed passing CSO. (SOG)	Minimum Vessels Draft (metres)	Water depth allowing for Under Keel Clearance (Add 0.5m)	Approximation of drift angle when passing the CSO MLWS	Approximate Distance from CSO to allow safe draft clearance at chart datum plus 1.7m (MLWN)	Approximation of drift angle when passing the CSO MLWN
Uber Boat (i.e., Hunt Class)	6 knots	1.2	1.7	21°	50m	0°
RIB/Emergency Services	3 knots	0.5	1.0	37°	50m	14°
Sightseeing/Pax	3 knots	1.5	2.0	37°	50m	0°
Restaurant/Pax (i.e., Symphony)	3 knots	1.8	2.3	37°	50m	0°
Tug vessel pushing	3 knots	3	3.5	37°	50m	0°
Tug vessel towing	3 knots	3	3.5	37°	50m	0°
Workboats	3 knots	0.5	1.0	37°	50m	14°
Narrowboats/Motor cruisers	3 knots	1.0	1.5	37°	50m	0°
Dinghy	1 knot	0.8	1.3	71°	50m	37°
Kayak/Rower	1 knot	0.2	0.2m	71°	50m	37°

5.3.16 The modelled flow velocities from CHEEF CSO outfall discharge during a typical year event at ten minutes before spring low water is shown in Figure 5-6.

Figure 5-6 Typical year discharge event at 10 minutes before spring low water slack



5.3.17 Table 5-3 has determined that there are impacts on all vessels transiting upstream past the CHEEF CSO. Vessels would be similarly impacted by speed group although the non-powered vessels are the most significantly impacted.

5.3.18 Table 5-3 presents the assessed impact of a typical year CHEEF CSO discharge on the different vessel types, using the drift angle curves when the vessels are operating at the different distances with the channel and from the CSO.

Table 5-3 Approximated drift angle when passing the CSO in the inshore zone, during a Typical year CSO discharge at MLWS and MLWN

Vessel Type	Vessels Speed passing CSO. (SOG)	Minimum Vessels Draft (metres)	Water depth allowing for Under Keel Clearance (Add 0.5m)	Approximation of drift angle when passing the CSO MLWS	Approximate Distance from CSO to allow safe draft clearance at chart datum plus 1.7m (MLWN)	Approximation of drift angle when passing the CSO at MLWN
Uber Boat (i.e., Hunt Class)	6 knots	1.2	1.7	7º	50m	0º
RIB/Emergency Services	3 knots	0.5	1.0	7º	50m	0º
Sightseeing/Pax	3 knots	1.5	2.0	7º	50m	0º
Restaurant/Pax (i.e., Symphony)	3 knots	1.8	2.3	7º	50m	0º
Tug vessel pushing	3 knots	3	3.5	7º	50m	0º
Tug vessel towing	3 knots	3	3.5	7º	50m	0º
Workboats	3 knots	0.5	1.0	7º	50m	0º
Narrowboats/Motor cruisers	3 knots	1.0	1.5	7º	50m	0º
Dinghy	1 knot	0.8	1.3	57º	50m	0º
Kayak/Rower/SUP	1 knot	0.2	0.2m	57º	50m	0º

5.4 Summary of impacted vessels and outcomes.

5.4.1 The summary of the 1:15-year CSO discharge impacts on the different vessel types for any state of tide is presented in Table 5-4 below.

Table 5-4 Impact of 1:15-year CSO discharge on vessels at different states of tide.

Vessel Type	Fairway / Inshore	Impact on vessel	
		Normal Running Position	Minimum achievable distance from CSO at MLWN
Uber Boat	Fairway	Minimal impact	Negligible
	Inshore		
RIB/Emergency services	Fairway	Moderate impact Course and/or speed adjustment required	Negligible
	Inshore		Minimal impact
Sightseeing/Pax	Fairway	Moderate impact Course and/or speed adjustment required	Negligible
	Inshore		
Restaurant/Pax	Fairway	Moderate impact Course and/or speed adjustment required	Negligible
	Inshore		
Tug vessel engaged in pushing/Towing	Fairway	Moderate impact Course and/or speed adjustment required	Negligible
	Inshore		
Workboats	Fairway	Moderate impact Course and/or speed adjustment required	Negligible
	Inshore		Minimal Impact
Narrow boat/Motor cruisers	Fairway	Moderate/High impact Course and/or speed adjustment required	Negligible
	Inshore		
Dinghy/Kayak/SUP/Rower	Fairway	High impact Unable to maintain course and/or speed, Risk of collision with other vessels due to	Negligible
	Inshore		Moderate/High impact Potential risk of collision with other vessels due to inability to maintain

5.4.2 The assessment of 1:15 year return period event impact indicates: -

- There is no impact on vessels transiting downstream in the fairway past the CSO when it is discharging at low water springs.
- There is moderate impact on most vessels transiting upstream in the fairway past the CSO when it is discharging at low water springs except for the Uber boat which receives a minimal impact and a Kayak/Dinghy/SUP/Rower which will be highly impacted.
- At low water neaps when there is a 1:15 year event discharge from the CSO there is negligible impact on all vessels using the fairway as they pass the CSO outfall.
- When passing at the CSO outfall during a 1:15 year event discharge during low water neaps at minimum achievable distance the only vessels that are impacted are the Dinghy's, Kayaks, Rowers and SUPs, although this is reduced when compared to low springs.

Table 5-5 Impact of a typical year CSO discharge on vessels at different states of tide

Vessel Type	Fairway / Inshore	Impact on vessel	
		Normal Running Position	Minimum achievable distance from CSO at MLWN
Uber Boat	Fairway	Minimal impact	Negligible
	Inshore		
RIB/Emergency services	Fairway	Minimal impact	Negligible
	Inshore		Minimal impact
Sightseeing/Pax	Fairway	Minimal impact	Negligible
	Inshore		
Restaurant/Pax	Fairway	Minimal impact	Negligible
	Inshore		
Tug vessel engaged in pushing/Towing	Fairway	Minimal impact	Negligible
	Inshore		
Workboats	Fairway	Minimal impact	Negligible
	Inshore		Minimal Impact
Narrow boat/Motor cruisers	Fairway	Minimal impact	Negligible
	Inshore		
Dinghy/Kayak/SUP/Rower	Fairway	High impact Unable to maintain course and/or speed, Risk of collision with other vessels due to inability to maintain course.	Negligible
	Inshore		Minimal impact

5.4.3 The assessment of typical year return period event impact indicates: -

- There is no impact on vessels transiting downstream in the fairway past the CSO when it is discharging at low water springs.
- There is minimal impact on most vessels transiting upstream in the fairway past the CSO when it is discharging at low water springs except for a Kayak/Dinghy/SUP/Rower which will be highly impacted.
- At low water neaps when there is a typical year event discharge from the CSO there is negligible impact on all vessels using the fairway as they pass the CSO outfall.
- When passing at the CSO outfall during a typical year event discharge during low water neaps at minimum achievable distance there is minimal impact for all available vessels.

6. Ship simulation comparison

6.1.1 As part of the works to identify the impact of a CSO discharge on the safe navigation of vessels passing the area Tideway engaged HR Wallingford to undertake a real time navigation simulation to assist in the assessment of this impacts.

6.1.2 The outputs of the simulations would be used to corroborate the desktop analysis undertaken in sections 4.3 and 4.4, which identify the period and zones of impact, and section 5 which used predicted drift angles as a function of the lateral flow velocities and the vessel velocities to determine the level of impact on passing vessels or indicate if additional considerations needed to be made.

6.1.3 Simulations for Chelsea embankment foreshore were undertaken at the HR Wallingford Ship Simulation Centre on the 5th of March 2024 with representatives from HR Wallingford, Tideway, Waves and the Port of London Authority.

6.1.4 The primary additional runs on the 5th of March 2024 were to determine the impact on vessels transiting upstream past the site during a 1:15 discharge.

6.1.5 The full table of simulations undertaken are presented in Figure 6-1 which include the comments on the run, which were agreed by the attendees following each simulation.

Table 6-1 Simulated cases for CHEEF

Run ID	CSO	Ship	Manoeuvre	Bridge arch	Tidal condition	Comments
20	CHEEF	Narrowboat close to bank (Inshore)	Inbound 4 knots	-	10 minutes before Low water slack	Vessel deflected but the vessel was able to recover. The vessel is unlikely to have been able to take this track in reality due the lack of under keel clearance
21	CHEEF	Narrowboat edge of fairway	Inbound 4 knots	-	10 minutes before Low water slack	Vessel experienced slight deflection due to the discharge, but was recovered easily
22	CHEEF	Kayak close to bank (Inshore)	Inbound 4 knots	-	10 minutes before Low water slack	Vessel deflected 35 m towards the centre of the river
23	CHEEF	Kayak 40-50 m from discharge	Inbound 4 knots	-	10 minutes before Low water slack	Vessel deflected moderately 10 m towards the centre of the river
24	CHEEF	Kayak 40-50 m from discharge	Outbound 4 knots	-	Low water slack	Vessel deflected moderately 40 m towards the centre of the river
25	CHEEF	Kayak 40-50 m from discharge	Inbound 4 knots	-	10 minutes before Low water slack	Vessel deflected moderately 40 m towards the centre of the river
26	CHEEF	28 m tug pulling 50 m unladen barge - on edge of fairway	Inbound 4 knots	-	10 minutes before Low water slack	Vessel deflected moderately, in a location which caught master un aware. Consequently tug overrun by barge.
27	CHEEF	28 m tug pulling 50 m unladen barge - on edge of fairway	Inbound 4 knots	-	10 minutes before Low water slack	Vessel deflected moderately, in a location which caught master un aware. Consequently tug overrun by barge.
28	CHEEF	28 m tug pulling 50 m unladen barge - on edge of fairway	Inbound 4 knots	-	Low water slack	Adjusting passage for the lower effect resulted in a safer transit. Vessel experienced minor deflection which was controllable
29	CHEEF	28 m tug pushing 50 m unladen barge - on edge of fairway	Inbound 4 knots	-	10 minutes before Low water slack	Vessel deflected moderately, but only 5-10 m and was in control. The effect should be considered in relation to passing vessels. Pushing was much more controlled than towing

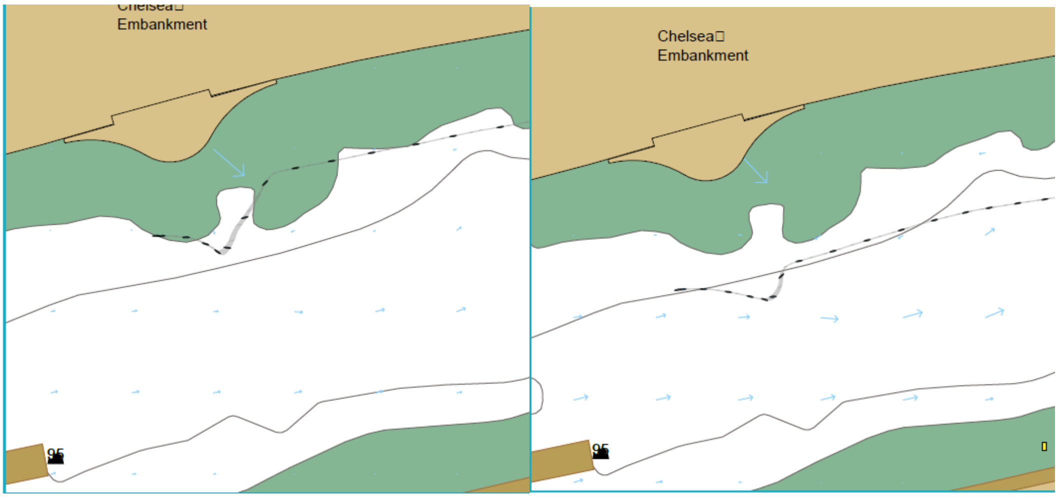
6.1.6 During the simulations the vessels were operated by a master who established the course and speed of the vessel to align with the case. Once the simulation started the master made the necessary corrections to allow the vessel to maintain course and then feedback to the group.

6.1.7 It was recognised that for the simulation of the kayak, whilst the response of the vessel to the flows is correct, the steering mechanism is simplistic and a kayaker's corrective actions would probably have an effect earlier, reducing the level of course deviation, so the tracks produced for kayak transits can be considered conservative.

6.1.8 The track of each simulated run was recorded so that it could be reviewed, Figure 6-1 shows the recorded tracks for runs 23 and 24. Run 23 is a kayak transiting the site inbound at 4 knots at 10 minutes before low water slacks. To allow the kayak to transit as close as shown there was an additional metre of water added to the simulation. The track of the kayak is in grey and was significantly affected by the discharge. Run 24 is a kayak transiting the site inbound at 4 knots at

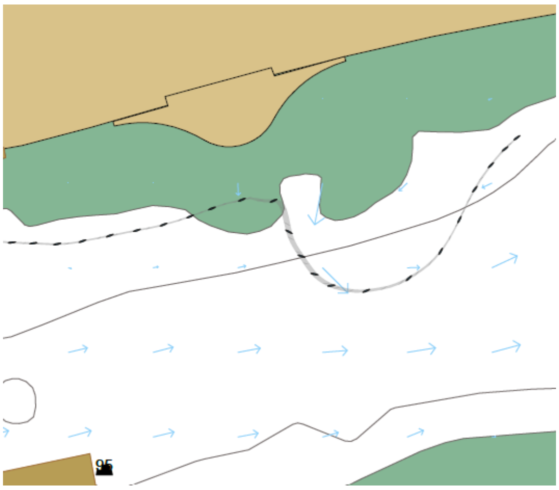
40-50m from the outfall at 10 minutes before low water slacks. It can be seen that there was small change of course created by the discharge.

Figure 6-1 Extract of run 23 and 24



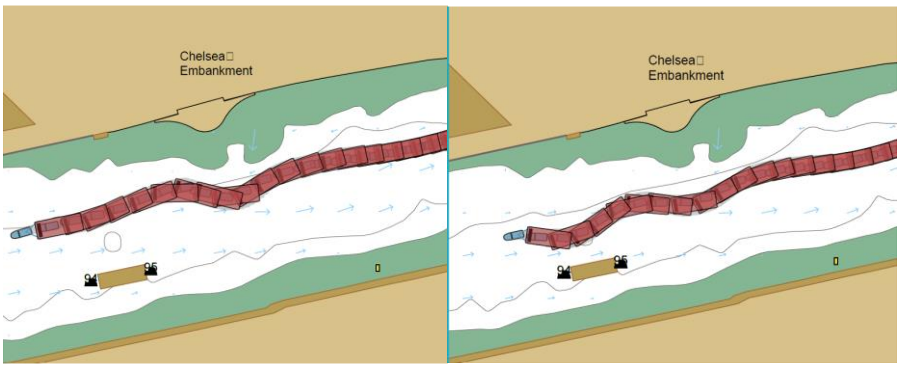
6.1.9 Figure 6-2 displays run 25 of the track for a kayak transiting downstream past the site at 4 knots at low water slacks. It can be seen that there was a significant deviation of the Kayak into the main fairway.

Figure 6-2 Extract of run 25



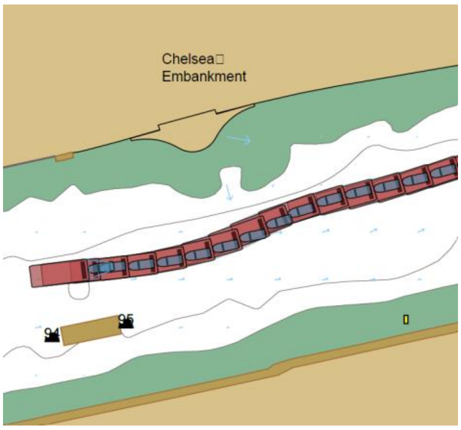
6.1.10 Figure 6-3 displays the runs 26 and 27 of a tug towing a barge upstream near the edge of the main fairway at 10 minutes before low water slacks. In both cases there was an impact on the barge, but the vessels track was recoverable despite contact between the barge and the tug.

Figure 6-3 Tracks for Runs 26 and 27



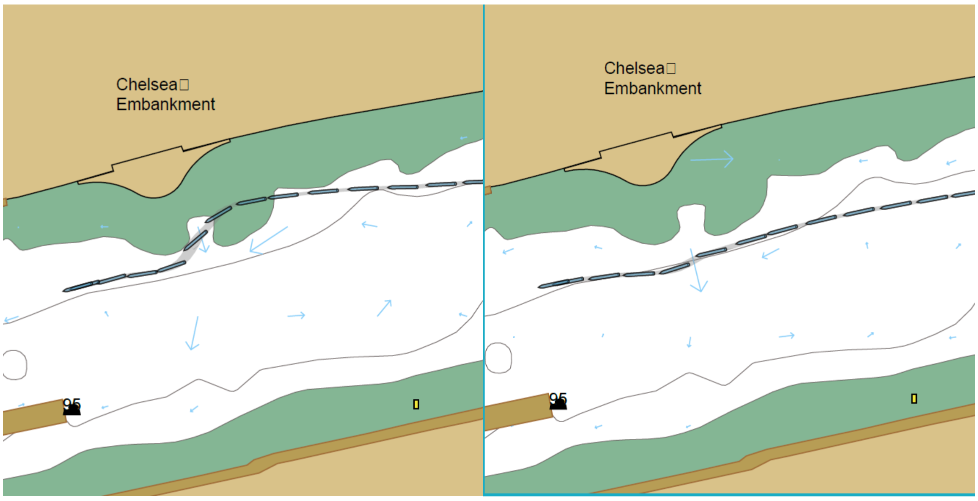
6.1.11 Figure 6-4 shows the track for Run 29 of a tug pushing a barge upstream along the edge of the main fairway past the CSO outfall at 10 minutes before low water slacks. There was a minor deviation of the vessel into the channel.

Figure 6-4 Tracks for run 29



6.1.12 Figure 6-5 shows the tracks from runs 20 and 21of a narrowboat transiting the site upstream at 10 minutes before low water slacks. Run 20 had an additional 1m of water added to allow the transit to be closer to the CSO outfall than normal, the was a significant deviation of the vessels course, but wouldn' t have impacted on the main fairway. Run 21 shows the narrowboat transiting the site upstream at 10 minutes before low water along the edge of the main fairway. There was minimal impact of the discharge on the vessels course.

Figure 6-5 Tracks for runs 20 and 21



6.1.13 There was good correlation of impacts between the simulations and the desk top studies, Table 5-4 which identified that the only vessels that would be significantly affected would be the Kayak/SUP, therefore there are no amendments required to the impacts as presented in Table 5-4.

7. Risk Assessment

7.1 Risk Assessment

7.1.1 The Risk Assessment is undertaken using the Jacobs design hazard elimination and risk reduction register and can be found in Appendix A.

7.1.2 The following sections of this document present the risk associated with the hazard linked to a CHEEF CSO discharge impacting on vessels operating on the Thames.

7.1.3 The risk assessment has been undertaken to eliminate or reduce risk to vessels on the Thames and provide mitigations for the risk so far as reasonably practicable by assessing the design and operation risks for the permanent state of the CHEEF CSO discharge.

7.1.4 The residual design / operational risks identified in this will be used to inform an NRA. The NRA will be produced by navigational experts for consideration by the PLA and any further mitigations established if required.

7.2 Hazards

7.2.1 The Risk Assessment considers the impact of the flows from the CHEEF CSO discharge to Vessels on the river with consideration to the change in drift angle incurred by contact with the flow. The hazards associated with the impact are:

i) Swamping

ii) Capsizing

iii) Grounding

iv) Collision

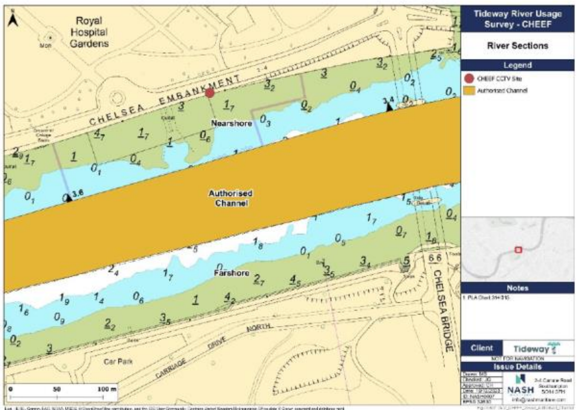
7.3 Receptors

7.3.1 CCTV surveys of the river were undertaken at CHEEF from the 22nd September 2023 to the 31st December 2023, but data has been processed from the period 22nd September 2023 to 10th of November 2023 giving a 7 week data set and the analysis of the data is presented in document "Tideway Central CHEEF Traffic Survey Report 12I01".

7.3.2 The analysis was carried out to determine the class of vessel and which area of the river the vessel was operating from nearshore, authorised channel and farshore, as indicated in

7.3.3 Table7-1

Table7-1 Nearshore, Authorised Channel and Farshore sections of the River Thames at CHEEF



7.3.4 Table 7-2 presents the data received from the CCTV surveys, which were also correlated with AIS information.

Table 7-2 Number of recorded vessels transiting nearshore, through the Authorised Channel and farshore

PLA Vessel Class	Nearshore	Authorised Channel	Farshore	Total
Uber Boat	0	1,742	10	1,752
RIB/Emergency Services	5	291	19	309
Class 5 Passenger	1	580	23	604
Tug	0	189	24	213
Tug (Pushing)	1	56	0	57
Tug (Towing)	0	112	16	128
Workboat	23	440	11	474
Recreational Cruiser	7	197	17	221
Narrowboat	0	35	1	36
Sailing Dinghy	0	26	8	34
Kayak	114	25	37	176
Rowing Boat	4	25	4	33
SUP	0	3	1	4
Coach / Safety Boat	2	30	6	38
Total	157	3742	176	4075

7.3.5 For the impacts of a discharge from the CHEEF CSO outfall the primary interest is in vessels that undertake transits within the nearshore zone past the outfall. Over the analysed period there were 157 vessel transits within the nearshore zone, which is 3.8% of all transits in the area.

7.3.6 77% of the 147 nearshore transits were by kayaks which have been demonstrated to be the most impacted craft due to a CSO discharge. Most of the these are groups that range in size from three people up to twelve, but no recorded single kayakers. The kayakers generally passed the site at least an hour before or after low water, although on one occasion they passed 25 minutes before low water.

7.3.7 There were very limited numbers of other vessels that transited past the site in the inshore zone and only three occasions where vessels, two rowing boats and a RIB/Emergency Services, passed the site at near low water.

7.3.8 Table 5-4 lists the vessels that are subject to the impact of the CHEEF CSO discharge flow and will continue to be used as the worst case, despite the recognition that vessels such as narrow boats and sups did not enter the nearshore zone, but they could do at some point in the future.

7.3.9 Figure 5-2 provide zones of impact and safe draft access respectively. It has been determined that due to the lack of power/manoeuvrability it will only be man-powered vessels, Narrowboats, workboats and emergency vessels that are likely to be able access closer to CHEEF CSO at low water neaps.

7.3.10 Only vessels with a draft less than 1.5m have been assessed as operating in the inshore zone at low water neaps.

7.3.11 Tables 5.4 and 5.5 provide the anticipated impact on vessels if they were subject to a CSO discharge at CHEEF.

7.4 Severity of Harm

7.4.1 Jacobs rate the hazard on worst potential severity:

i) 1: Nil or slight injury / illness, property damage or environmental issue.

ii) 2: Minor injury / illness, property damage or environmental issue.

iii) 3: Moderate injury or illness, property damage or environmental issue.

iv) 4: Major injury or illness, property damage or environmental issue.

v) 5: Fatal or long-term disabling injury or illness. Significant property damage or environmental issue.

vi) 10. Multiple fatalities and catastrophic event

7.4.2 The hazard identified above has potential to cause harm to the vessel users:

i) Swamping leading to a major injury or drowning.

ii) Capsizing leading to a major injury or drowning.

iii) Grounding leading to major Injury or illness due to exposure to sewage.

iv) Collision with another vessel due to a CSO discharge event forcing non-powered vessel to drift from previous course leading to major injury or drowning.

v) Collision between third party vessels caused by one of the vessels changing course to avoid collision with a non-powered vessel leading to major injury or drowning.

7.5 Likelihood of Harm

7.5.1 Jacobs risk assessment rates the likelihood of harm with the following probabilities:

1: Highly Unlikely
2: Unlikely
3: Possible
4: Likely
5: Highly Likely

7.5.2 The assessment has been undertaken by analysing the data presented in document 4410-FLOJV-CHEEF-520-VZ-RG-100001_Ver10_HRW 2D modelling P04 and CHEEF Interim DRA 665397CH-CHEEF-DRA-Interim-Rev.01. The risk assessment has also established the 20.2m^3/sec to be the most probable worst-case scenario.

7.5.3 The models produce plumes at peak flow velocities from the discharge in a completely still water scenario with no residual inputs from environmental to climatic conditions.

7.5.4 From analysis of the peak flow velocity plumes, it has been determined that the tidal window of impacts is 90 minutes, from 60 minutes before low water to 30 minutes after low water.

7.5.5 Actual annual frequency of discharge has been established as an average of 72 with a maximum record of 120 discharges which could impact river users. However when the tunnel is operational the majority of discharges will be intercepted leaving an average of just 2 discharges per year as presented in above Table 4-7.

7.5.6 From Table4-5 Simulated peak flows from CHEEF CSO outfall using actual weather data from 1970-2020 against the WI 7706 return periods (assuming tunnel unavailable)., there are only approximately 31 instances in a 50 year period that are greater than a typical year with the 1:15 year threshold only being exceeded in the July 2021 storms.

7.5.7 The analysis was undertaken for spring periods of low water but due to the variability of tides from residual effects the risk assessment will consider impacts to vessels at all states of low water.

7.5.8 Taking all the above-mentioned factors into consideration then the likelihood of harm is considered unlikely for vessels using the main fairway and the inshore channel at low water springs and unlikely for vessels using the main fairway and the inshore channel at low water neaps during a 1:15 year return period CSO discharge.

8. Mitigation

8.1.1 The ERIC, the hierarchy of risk management, approach will be adopted to review mitigation for this permanent DRA.

- ERIC stands for Eliminate, Reduce, Inform and Control.
- This is a four -level hierarchy that outlines the steps it should take to mitigate risk.

8.2 Eliminate

8.2.1 The CHEEF CSO outfall is needed to allow sewers to discharge when they reach capacity and prevent the risk of flooding upstream in the catchment area. To eliminate the flows entirely would require the closing of the CSO outfall and would flood the upstream catchment area during storm events and is therefore not feasible.

8.2.2 When the CHEEF CSO outfall is discharging the main vessels likely to be impacted are kayaks and other non-powered vessels. To eliminate this risk to kayakers and other non-powered vessels a diversion to the south bank to pass the CSO area and recross to the north bank once past the CSO area was considered. This mitigation has been deemed to be not required by the MWC's navigational risk assessor in consultation with the PLA due to the potential for collision with other river users.

Example non-powered vessel diversion

8.3 Reduce

8.3.1 The number of discharges will be reduced by bringing the main tideway tunnel into operation which will reduce the number of discharges from the average of 72 down to approximately 2 discharges a year.

8.3.2 To reduce the risk of impact to vessels a warning system could be adopted for the permanent works in line with the proof of concept which is being developed in consultation with the PLA and main works contractors.

8.3.3 The vessels could be warned of a pending discharge or a current discharge with the use of lights and signs. The lights and signs would need to be strategically placed to ensure the optimum sight by the river vessel users.

8.3.4 Consideration was made to the use of cardinal posts to warn vessel users of the potential hazard. These were not considered to be not reasonably practicable due to the size of the post due to the large tidal range and because they would be redundant for the majority of the time whilst also introducing a potential hazard to navigation.

8.4 Inform

8.4.1 During the development in the interim phase warning lights have been developed and designed by the MWC and offered for to the PLA for acceptance. Any warning lights installed as part of the agreed interim arrangements to adopted for the permanent case.

8.4.2 Promulgation of the operational plan to the local river users.

8.4.3 It is likely that the PLA will need to provide a new notice to mariners identifying new CSO operation and mitigations.

8.4.4 It is likely that the PLA will need to issue a notice to mariners during periods of LTT maintenance to identify that there could be an increased in the frequency and severity of a discharge

8.5 Control

8.5.1 All agreed CSO signage and warning lights to be installed or adopted.

8.5.2 Operation plan for the warning system to include warning trigger points, will need to be considered and agreed with the PLA.

9. Summary

9.1 Summary

9.1.1 Jacobs as Designer for the reference design have a duty to eliminate and reduce risks so far as reasonably practicable (SFARP) and to identify residual risks. Jacobs have undertaken this risk assessment to assess the magnitude of this risk for each vessel type and to consider whether mitigation measures can be adopted that can reduce the risks to an acceptable low level.

9.1.2 Overall, the residual risk has been determined as low due to: -

(a) Limited impact of CSO discharges on powered vessels,

(b) Limited number of vessel transits in the inshore zone past the CSO,

(c) The introduction of a warning light and sign to advise powered vessels that the CSO is discharging and to proceed with caution.

(d) The introduction of a warning light and sign to advise non powered vessels that the CSO is discharging and to divert to the south bank past the CSO area.

9.1.3 Powered Vessels

9.1.4 Jacobs has assessed it sufficient to provide signage and lighting to warn river users that the CSO is a discharging.

9.1.5 In the case of powered vessels, the risk is considered negligible (very low) as all powered vessels can pass safely within the navigation channel during a discharge, provided that they proceed with caution concerning non-powered craft.

9.1.6 Other than RIB's, powered vessels are physically unable to access the inshore zone due to draft restrictions.

9.1.7 Unpowered Vessels

9.1.8 Jacobs has assessed it sufficient to provide signage and lighting to warn of a CSO discharge for the limited number of river users that the use the nearshore zone.

9.1.9 In the case of manually operated or unpowered vessels the risk is considered low. Unpowered vessels could be diverted to the south bank to pass the CSO area when the lighting is showing.

9.1.10 Navigational Risk Assessment

9.1.11 A Navigational Risk Assessment (NRA) is to be undertaken by navigational specialists with expert knowledge of waterway traffic and the conditions in the area of the CHEEF CSO outfall.

9.1.12 This designers risk assessment will be considered by the MWC in addition to the navigation risk assessment as part of the iterative process to develop the detailed design and Operational Plan. The navigational risk specialists will need to consider both the DRA and the Operational Plan to produce the Navigational Risk Assessment.

9.1.13 The MWC should consider the following in the development of the detailed design and the operational plan.

- The recommendation of the NRA,

- the optimal "on" time for the live warning signal(s), taking account of the discharge hydrograph and the actions to be taken by powered vessels and unpowered vessels or a member of the public on the foreshore nearby,
- Consideration of operational mitigations (e.g. lights and signs) in consultation with the PLA.
- Consider the operational plan that will include the manner of promulgation of information and communication with the river community, including what is required of Tideway, the PLA and the river users,

9.1.14 The NRA will consider the residual risks from the DRA, the detailed design and the Operational Plan to determine the most appropriate mitigation in consultation with the PLA and other river users. In particular the NRA should consider:-

- the necessary responses of powered vessels to a discharge (e.g., adjust course as require, proceed with caution and look out for unpowered vessels affected by a discharge) and the time needed to action the responses,
- the necessary responses of unpowered vessels to a discharge (e.g. exit the river at a fixed egress point, etc.) and the time needed to action the responses,
- the assessment of any increased risk to normal river operations arising from the implementation of mitigations.

9.1.15 In the development of the NRA the timings of the mitigation implementation should also be considered and detailed for agreement with the PLA.

9.1.16 The updated NRA with its proposed mitigations will be reviewed by the MWC to confirm that the design risks have been mitigated insofar as is reasonably practicable.

9.2 Key Information

9.2.1 The most credible worst case CSO discharge is for a 1:15 year return period storm without the tunnel in operation with a discharge of 20m^3/s. The frequency of discharges once the tunnel in in operation is expected to between 2 and 5 per year when the tunnel is in operation. When the tunnel is to be taken out of operation additional information will need to be made available to stakeholders outlining the potential for increased frequency of discharges.

9.2.2 The assessment considers the river in three zones as defined in figure 7-1, and the critical discharge occurring at low water springs. The discharges are considered to impact within the following tidal windows in Table 9-1.

Table 9-1 Times of Impact

Inshore Zone (beyond 30m)		Main Fairway	
Start	Finish	Start	Finish
Mid-Ebb	Mid-Flood	LW -60 minutes	LW +30 minutes

9.2.1 It should be noted that the section 4 concluded a period of 80 minutes, 55 minutes before to 25 minutes after low water slack but Table 9-1 has been conservatively recorded at 90 minutes.

9.2.2 It should be noted it is not possible to predict the discharges within 30m of the CSO outfall at any state of the tide and in this instance that zone is in the fairway.

9.2.3 For any periods of slack water, such as a Thames Barrier closure, the same considerations should be given to low or high slack water period.

9.2.4 This document provides information on the timing and intensity of the discharges and the hydrographs are presented in Figures 4.1 and 4.2. The proof of concept document (LONDON TIDEWAY TUNNELS PROOF OF CONCEPT - CSO DISCHARGE WARNING DRAFT 27/02/24) provides further detailed discharge hydrographs that should be utilised in the development of suitable warning times in the development of the detailed design undertaken by the MWC.

9.2.5 Any unmitigated risks arising from the detail design development, such as insufficient warning time, should be identified in the MWCs design documentation and potential mitigation measures identified for consideration by the PLA.

9.2.6 A warning a system, such as lights and signs has been established as a mitigation measure suitable to reduce the risk to vessels during the development of the NRA and the operational plan the MWC should assess the suitability of the mitigation measures and substantiate their proposals within the detailed design documentation.

Appendix A. Designers Risk Assessment

Jacobs

DESIGN HAZARD ELIMINATION AND RISK REDUCTION REGISTER

Latest Meeting Date	
Phase	
C	Construction
M	Maintain/Clean
U	Use as a Workplace
D	Demolish
Project Name:	Tideway
Project Number:	665397CH
Client:	Bazalgette Tunnel Limited

Update Critical Risk Summary Tab

Probability	Worst Potential Severity (WPS) of Impact
1: Highly Unlikely	1: Nil or slight injury / illness, property damage or environmental issue.
2: Unlikely	2: Minor injury / illness, property damage or environmental issue.
3: Possible	3: Moderate injury or illness, property damage or environmental issue.
4: Likely	4: Major injury or illness, property damage or environmental issue.
5: Highly Likely	5: Fatal or long term disabling injury or illness. Significant property damage or environmental issue.
	10. Multiple fatalities and catastrophic event

Risk Rating

NOTE: The purpose of Risk Rating is to determine which risks are significant. It is a subjective assessment and not an absolute or precise determination.

Rating	Description
High	HS&D risk resulting from design is unacceptably high. Revise design to reduce HS&D residual
Medium	HS&D risk resulting from design is permitted with appropriate design controls and management oversight in place.
Low	HS&D risk resulting from design is permitted.

LIKELIHOOD	RISK				
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5
	1	2	3	4	5
	SEVERITY				

1	2	3	4	5	6	7	8	9	10	11		13	14	15	16	17
Risk ID.	**Formal Review Description**	**Phase**	**Activity**	**Potential Hazard**	**Person(s) Most at Risk**	**Prob**	**WPS**	**Initial Risk Rating**	**Discipline**	**Design Measures to Eliminate Hazards**	**Design Measures to Reduce Risk**	**Residual Prob**	**Residual WPS**	**Residual Risk Rating**	**Residual Risk Description**	**Included on Drawing No(s) or other doc. (give ref.)**
CDM-CHEEF-021-A	Non-powered craft underway - Low tide	Permanent	Kayak/Rower/Dinghy navigating in the vicinity of a CSO discharge	Swamping due to CSO discharge event	Public: Major injury and/or drowning	1	5	5	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by intercepting flows.	1	5	5	Public: Major injury and/or drowning	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM-CHEEF-021-B	Non-powered craft underway -Low tide	Permanent	Kayak/Rower/Dinghy navigating in the vicinity of a CSO discharge	Capsizing due to a CSO discharge event	Public: Major injury and/or drowning	1	5	5	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by	1	5	5	Public: Major injury and/or drowning	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM-CHEEF-021-C	Non-powered craft underway -Low tide	Permanent	Kayak/Rower/Dinghy navigating in the vicinity of a CSO discharge	Grounding due to a CSO discharge event	Public:Major Injury or illness due to exposure to sewage	1	4	4	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by	1	4	4	Public:Major Injury or illness due to exposure to sewage	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM-CHEEF-021-D	Non-powered and Rec. powered vessel underway - Low Tide	Permanent	Kayak/Rower/Dinghy and recreational powered vessel navigating in the vicinity of a CSO discharge	Collision due to a CSO discharge event forcing non-powered craft to drift from previous course	Public: Major injury and or drowning	2	5	10	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by intercepting flows.	1	5	5	Public: Major injury and or drowning	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM-CHEEF-021-E	Non-powered and Commercial powered vessel underway - Low tide	Permanent	Kayak/Rower/Dinghy and commercial powered vessel navigating in the vicinity of a CSO discharge	Collision due to a CSO discharge event forcing non-powered craft to drift from previous course	Public: Major injury and or drowning	2	5	10	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by intercepting flows.	1	5	5	Public: Major injury and or drowning	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM-CHEEF-021-F	Rec. Powered Vessel underway - Low tide	Permanent	Rec. Powered Vessel navigating in the vicinity of a CSO discharge	Swamping due to CSO discharge event	Public: Injury/Illness due to exposure to sewage or Major injury	1	4	4	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by	1	4	4	Public: Injury/illness due to exposure to sewage or Major injury	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM-CHEEF-021-G	Rec. Powered Vessel underway - Low tide	Permanent	Rec. Powered Vessel navigating in the vicinity of a CSO discharge	Grounding due to a CSO discharge event	Public: Major injury	1	4	4	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by	1	4	4	Public: Major injury	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM-CHEEF-021-H	Rec. Powered Vessel and Commercial Powered Vessel underway - Low tide	Permanent	Rec. Powered Vessel navigating in the vicinity of a CSO discharge	Collision due to a CSO discharge event forcing Rec.Powered vessel to drift from its previous course	Public: Major injury	1	4	4	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by intercepting flows.	1	4	4	Public: Major injury	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM-CHEEF-021-I	Commercial Powered Vessel underway - Low tide	Permanent	Commercial powered vessel navigating in the vicinity of a CSO discharge	Swamping due to CSO discharge event	Public: Injury/ illness due to exposure to sewage	1	3	3	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by intercepting flows.	1	3	3	Public: Injury/ illness due to exposure to sewage	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents

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DESIGN HAZARD ELIMINATION AND RISK REDUCTION REGISTER

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1	1	2	3	4	5
	1	2	3	4	5
	SEVERITY				

1	2	3	4	5	6	7	8	9	10	11		13	14	15	16	17
Risk ID.	Formal Review Description	Phase	Activity	Potential Hazard	Person(s) Most at Risk	Prob	WPS	Initial Risk Rating	Discipline	Design Measures to Eliminate Hazards	Design Measures to Reduce Risk	Residual Prob	Residual WPS	Residual Risk Rating	Residual Risk Description	Included on Drawing No(s) or other doc. (give ref.)
CDM-CHEEF-021-J	Commercial Powered Vessel underway - Low tide	Permanent	Commercial powered vessel navigating in the vicinity of a CSO discharge	Grounding due to a CSO discharge event	Public: Injury	1	3	3	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by intercepting flows.	1	3	3	Public: Injury	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM-CHEEF-021-K	Non-powered craft underway - All other states of tide	Permanent	Kayak/Rower/Dinghy navigating in the inshore zone in the vicinity of a CSO discharge	Swamping due to CSO discharge event	Public: Illness due to exposure to sewage or Drowning	1	5	5	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by	1	5	5	Public: Illness due to exposure to sewage or Drowning	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM-CHEEF-021-L	Non-powered craft underway - All other states of tide	Permanent	Kayak/Rower/Dinghy navigating the inshore zone in the vicinity of a CSO discharge	Capsizing due to a CSO discharge event	Public: Illness due to exposure to sewage or Drowning	1	5	5	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by	1	5	5	Public: Illness due to exposure to sewage or Drowning	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM-CHEEF-021-M	Non-powered and Rec. powered vessel underway - All other states of tide	Permanent	Kayak/Rower/Dinghy and recreational powered vessel navigating the inshore zone in the vicinity of a CSO discharge	Collision due to a CSO discharge event forcing non-powered craft to drift from previous course	Public: Major injury and or drowning	1	5	5	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by intercepting flows.	1	5	5	Public: Major injury and or drowning	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM-CHEEF-021-N	Non-powered and Commercial powered vessel underway - All other states of tide	Permanent	Kayak/Rower/Dinghy and commercial powered vessel navigating the inshore zone in the vicinity of a CSO discharge	Collision due to a CSO discharge event forcing non-powered craft to drift from previous course	Public: Major injury and or drowning	1	5	5	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by intercepting flows.	1	5	5	Public: Major injury and or drowning	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM-CHEEF-021-O	Rec. Powered Vessel underway -All other states of tide	Permanent	Rec. Powered Vessel navigating the inshore zone in the vicinity of a CSO discharge	Swamping due to CSO discharge event	Public: Injury or illness due to exposure to sewage	1	3	3	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by intercepting flows.	1	3	3	Public: Injury or illness due to exposure to sewage	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM-CHEEF-021-P	Rec. Powered Vessel and Commercial Powered Vessel underway - All other states of tide	Permanent	Rec. Powered Vessel navigating the inshore zone in the vicinity of a CSO discharge	Collision due to a CSO discharge event forcing Rec.Powered vessel to drift from its previous course	Public: Major injury	1	4	4	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by intercepting flows.	1	4	4	Public: Major injury	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM- CHEEF- 021-Q	Powered Emergency Vessels underway - Low tide	Permanent	Powered Emergency Vessels responding to an emergency in close proximity of a CSO discharge	Grounding due to CSO discharge event	Public: Injury/ illness due to exposure to sewage	1	3	3	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by intercepting flows.	1	3	3	Public: Injury/ illness due to exposure to sewage	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents

Jacobs

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RISK

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SEVERITY

1	2	3	4	5	6	7	8	9	10	11		13	14	15	16	17
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CDM- CHEEF- 021-R	Powered Emergency Vessels underway - All other states of tide	Permanent	Powered Emergency Vessels responding to an emergency in close proximity of a CSO discharge	Swamping due to CSO discharge event	Public: Injury/ illness due to exposure to sewage	1	3	3	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by intercepting flows.	1	3	3	Public: Injury/ illness due to exposure to sewage	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents
CDM - CHEEF - 021-S	Non-powered craft underway -Low tide	Permanent	Non-powered craft crossing the river to the south bank to avoid a CSO outfall flow	Collision with Rec. Powered and/or Commercial powered vessel underway due to non-powered craft crossing the river	Public: Major injury and or drowning	1	5	5	Civil / Structural	Unable to eliminate Hazard - The foreshore site is fixed	1. CSO Signage 2. CSO Warning light 3. Reduction in number of discharges by intercepting flows.	1	5	5	Public: Injury/ illness due to exposure to sewage	Notice to Mariners, Port Information Guide, Tideway Code and any other pertinent documents