20 FLOOD RISK AND COASTAL DEFENCE

20.1 Introduction

This section of the EIA Report considers the following potential environmental impacts:

- Impacts to coastal / tidal protection and flood defence.
- Effects on the hydrodynamic and sedimentary regime.
- Effects on the integrity of flood defences and the risk of tidal flooding.
- Effect of fluvial flows on flood risk.
- Effects of the frequency of overtopping.

20.2 Policy, guidance and consultation

20.2.1 Policy

20.2.1.1 National Planning Policy Framework

The NPPF (Ministry of Housing, Communities and Local Government, 2019) and the accompanying PPG for Flood Risk and Coastal Change (2014) set out the requirements for Flood Risk Assessments (FRA) and provides technical guidance on flood risk management, including the Sequential and Exception Tests, consideration of climate change allowances and development classifications. The information contained in these documents form the basis of flood risk documentation.

The NPPF sets out the Government's planning policies for England and seeks to ensure that flood risk is considered at all stages of the planning and development process, to avoid inappropriate development in areas at risk of flooding and to direct development away from areas at risk of flooding.

The PPG for Flood Risk and Coastal Change provides direction on how flood risk should be considered at all stages of the planning and development process, with additional guidance on flood risk vulnerability classifications and managing residual risks (**Table 20.1**). The PPG for Flood Risk and Coastal Change provides further description of Flood Zones, Vulnerability Classifications and their compatibility in order to assess the suitability of a specific site for a certain type of development.

Table 20.1 Summary of flood zone definitions

Flood zone	Probability of flooding	Return periods
1	Low	Land having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%).
2	Medium	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% - 0.1%); or Land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% - 0.1%).
3a	High	Land having a 1 in 100 or greater annual probability of river flooding (≥ 1%); or Land having a 1 in 200 or greater annual probability of sea flooding (≥ 0.5%).
3b	High – Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency.

20.2.1.2 National Policy Statement for Ports

The assessment of potential impacts on flood risk and coastal defence has been made with reference to the policy guidance for this topic area contained within the NPS for Ports.

The "minimum requirements for FRAs" as outlined within the NPS for Ports Paragraph 5.2.5 state that they should:

- be proportionate to the risk and appropriate to the scale, nature and location of the project;
- consider the risk of flooding arising from the project, in addition to the risk of flooding to the project;
- take the impacts of climate change into account, clearly stating the development lifetime over which the assessment has been made;
- be undertaken by competent people, as early as possible in the process of preparing the proposal;
- consider both the potential adverse and beneficial effects of flood risk management infrastructure, including raised defences, flow channels, flood storage areas and other artificial features, together with the consequences of their failure;
- consider the vulnerability of those using the site, including arrangements for safe access;
- consider and quantify the different types of flooding (whether from natural or human sources and including joint and cumulative effects) and identify flood risk reduction measures, so that assessments are fit for the purpose of the decisions being made;
- consider the effects of a range of flooding events, including extreme events on people, property, the natural and historic environment and river and coastal processes;
- include the assessment of the remaining (known as 'residual') risk after risk reduction measures have been taken into account and demonstrate that this is acceptable for the particular project;
- consider how the ability of water to soak into the ground may change with development, along with how the proposed layout of the project may affect drainage systems;
- consider if there is a need to be safe and remain operational during a worst case flood event over the development's lifetime; and
- be supported by appropriate data and information, including historical information on previous events.

The requirements identified above were incorporated into the FRA (**Appendix 15**) undertaken for the proposed scheme, which has in turn informed this section of the EIA Report.

Table 20.2 summarises the requirements of the NPS which are of relevance to this section of the EIA Report.

Table 20.2 Summary of NPS requirements with regard to flood risk

NPS for Ports requirement	NPS reference	EIA Report reference
The applicant and the decision-maker should take account of the policy on climate change adaption in section 4.13.	Section 5.2, Paragraph 5.2.2	**Section 20.4.3**, **Section 22** (climate change) and **Appendix 15** (Flood Risk Assessment)
The aims of planning policy on development and flood risk are to ensure that flood risk from all sources of flooding is taken into account at all stages in the planning process, to avoid inappropriate development in areas at risk of flooding and to direct development away from areas at highest risk.	Section 5.2, Paragraph 5.2.3	**Section 20.4** and **Appendix 15** (Flood Risk Assessment)

NPS for Ports requirement	NPS reference	EIA Report reference
Where new development is, exceptionally, necessary in such areas, including 'water compatible' development, policy aims to make it safe without increasing flood risk elsewhere and where possible, reducing flood risk overall. Port development is water-compatible development and therefore acceptable in high flood risk areas.	Section 5.2, Paragraph 5.2.3	**Sections 20.4, 20.5 and 20.6** and **Appendix 15** (Flood Risk Assessment)
The decision-maker should not consent development in Flood Zone 2 (in England), unless it is satisfied that the Sequential Test requirements have been met. It should not consent development in Flood Zone 3 (or Zone C) unless it is satisfied that the Sequential and Exception Test requirements have been met.	Section 5.2, Paragraph 5.2.12	Section **20.5** and **Appendix 15** (Flood Risk Assessment)
Full account of climate change impacts and the increased probability of extreme weather events is taken in applications, in order to ensure, so far as reasonably possible, that no commercial loss will be experienced through inadequacy of infrastructure.	Section 5.2, Paragraph 5.2.17	**Section 20.4.3**, **Section 22** (climate change) and **Appendix 15** (Flood Risk Assessment)
The decision-maker should ensure that the applicant has considered the impact of the port development on the risk of flooding outside the port area and has taken reasonable measures to reduce this as far as possible.	Section 5.2, Paragraph 5.2.19	**Sections 20.5** and **20.6**

20.2.1.3 Flood Risk Assessments: Climate Change Allowances

The Environment Agency's online advice note 'Flood Risk Assessments: Climate Change Allowances', published in February 2016, and last amended in July 2020, has been used to inform this section.

This advice note provides guidance on the application of climate change allowances which considers the geographical location, lifespan of the proposed scheme, flood zones, vulnerability classification associated with the type of development and critical drainage areas. Guidance is provided for determining appropriate climate change allowances for fluvial events, tidal / sea level rise and peak rainfall intensities.

20.2.1.4 Local Policy and Guidance

This section of the EIA Report and the FRA has been guided and informed by relevant local policy, studies and guidance documents.

The following documents have been reviewed as part of the FRA and were then used to inform the assessment within both the FRA and the existing environment section, as well as the wider proposed scheme:

- River Tees Catchment Flood Management Plan (CFMP).
- Northumbria River Basin Management Plan.
- River Tyne to Flamborough Head SMP2 .
- Redcar and Cleveland Borough Council Local Flood Risk Management Strategy (LFRMS).
- Redcar and Cleveland Borough Council Preliminary Flood Risk Assessment (PFRA).
- Redcar and Cleveland Borough Council Level 1 Strategic Flood Risk Assessment (SFRA).
- Redcar Surface Water Management Plan.
- Tees Valley Water Cycle Study.
- Tees Valley Investment Plan 2019-29.
- Redcar & Cleveland Development Plan (Local Plan).
- South Industrial Zone Environmental Statement Volume 3 Technical Appendices (Water Management and Flooding).
- Tees Tidal Flood Risk Management Strategy.

- Tidal Tees Integrated Flood Risk Modelling Study.

20.2.2 Consultation

20.2.2.1 Environment Agency

The Environment Agency were contacted to request the Product 5 and 8 data packages relevant to the site. This was received from the Environment Agency on 22nd July 2020 and included the Tidal Tees Integrated Flood Risk Modelling Study as well as the data from the 2011 ISIS-TUFLOW model which covers the Tees Estuary from Teesmouth at the coast to the Tees Barrage upstream.

Additionally, as part of the September 2020 scoping consultation, the Environment Agency provided comments on their requirements when considering the potential impact of dredging on the estuary, the need to consider all sources of flooding, any mitigation measures required to ensure a safe development in a 1 in 200 year event, guidance on the climate change guidelines to be reviewed and information related to the potential consents / permits that may be needed for the proposed scheme. This scoping opinion was reviewed and used to inform the assessment for this section of the EIA Report and the FRA.

20.2.2.2 Lead Local Flood Authority

Following consultation with the Lead Local Flood Authority (LLFA) as part of the September 2020 scoping consultation, which for the proposed scheme is RCBC, they offered no additional comments regarding the contents and methodology outlined in the scoping report (submitted July 2020).

20.2.2.3 Canals and River Trust

The Canals and River Trust provided information relating to the flows and water levels upstream and downstream of the Tees Barrage. This information was used to inform this section of the EIA Report, as well as hydrodynamic and sedimentary plume modelling reported in **Section 6**.

20.3 Methodology

20.3.1 Study area

The study area for this section of the EIA Report comprises the area which has the potential to be both directly and indirectly impacted by the proposed scheme. In this case, the maximum extent of the potential impact has been determined to be the area over which the potential effects of the proposed scheme on flood risk may occur, which includes the Tees estuary and the land immediately to the east of the channel.

20.3.2 Methodology used to describe the existing environment

This section of the EIA Report has been informed through a combination of desk-based assessment and modelling studies. An FRA must consider the issues associated with all sources of flooding in accordance with NPPF and the supporting PPG for Flood Risk and Coastal Change. Therefore, the desk-based assessment has included a review of publicly available information, namely Environment Agency Product 5 & 8 data packages and relevant planning documents to assess the risk of flooding from tidal, fluvial, surface water, groundwater, reservoirs and other sources. A review of findings from previous FRAs within the Tees estuary has also been undertaken.

Online flood datasets which have been reviewed include:

- Flood Map For Planning (Flood Zone 2, Flood Zone 3 ,Flood Storage Areas, Flood Defences, Areas Benefiting from Defences);
- Risk of Flooding from Rivers and Sea; and,

- Historic Flood Map.

The Environment Agency data consists of the following elements:

- Product 5: Detailed flood risk assessment data package including maps of flood zones, defences and storage areas, areas benefitting from defences, historic flood event outlines and model extent, reports, including flood modelling and hydrology reports and modelling guidelines;
- Product 8: Flood defence breach hazard map including, maximum flood depth, maximum flood velocity and maximum flood hazard.

20.3.3 Methodology for assessment of potential impacts

The assessment methodology used for determining the potential environmental impacts on flood risk and coastal defence associated with the proposed scheme is provided within **Section 5**.

Professional judgement has been used to determine potential environmental impacts which could arise during the construction and operational phases of the proposed scheme based on our existing knowledge of the sensitivity of the Tees estuary.

The findings of the EIA with regard to the hydrodynamic and sedimentary regime (as set out in **Section 6**) are of relevance to this section and reference to this topic is made in this section.

20.3.3.1 Assessment of receptor sensitivity and magnitude

Section 5 provides general definitions, guidelines and examples for determining the sensitivity of receptors and the magnitude of impacts in this EIA Report.

In the context of this section, specific examples of receptor sensitivity and receptor magnitude relevant to flood risk and coastal defence are provided in **Table 20.3** and **Table 20.4**. The examples provided have been selected using professional judgement and knowledge of the relevant policies and guidance.

Table 20.3 Sensitivity of receptor

Sensitivity	Topic specific description
Very High	• Increased risk of flooding to nationally significant infrastructure as a result of the proposed scheme; • Internationally or nationally designated planning policy areas; • Major residential and commercial developments not currently at risk from flooding neighbouring the proposed scheme; or • Risk to life associated with significant flood depth and flow velocity.
High	• Increased risk of flooding to locally significant infrastructure as a result of the proposed scheme; • Residential and commercial developments not currently at risk from flooding neighbouring the proposed scheme; or • Potential risk to life associated with significant flood depth and flow velocity.
Medium	• Local planning policy designated sites; • Residential property situated in existing flood zones; or • Commercially farmed agricultural land.
Low	• Drainage that does not discharge to high sensitivity sites or existing functional floodplain; or • Waterside, amenity land uses specifically sited adjacent to channel or watercourse
Very Low	• Drainage that does not discharge to sites of any significance or sensitivity to flood risk; or • Water compatible land uses which need to be sited either in or adjacent to channel or watercourse.

Table 20.4 Impact magnitude

Magnitude	Topic specific description
Very High	• Significant number of properties or people at risk of flooding as a result of the proposed scheme during construction and operation; • Causing residential and commercial developments (existing and proposed) to be at permanent risk of flooding as a result of the proposed scheme; or • Increase in surface water runoff from the site having a significant permanent impact on the catchment hydrology in the vicinity.
High	• Localised impact on properties or people at risk of flooding as a result of the proposed scheme during construction; • Causing existing residential and commercial developments to be at permanent risk of flooding as a result of the proposed scheme; or • Increase in surface water runoff from the site having a permanent impact on the catchment hydrology in the vicinity.
Medium	• Small number of properties at flood risk during construction; or • Increase in surface water runoff from the site having a moderate permanent impact on the catchment hydrology in the vicinity.
Low	• Minor temporary increases in flood depths with no new flooding internally in properties expected.
Very Low	• No impact on the long term land use or no material change to land use of any duration has been identified.

20.4 Existing environment

20.4.1 Review of flood risk studies

20.4.1.1 Tees Tidal Flood Risk Management (FRM) Strategy

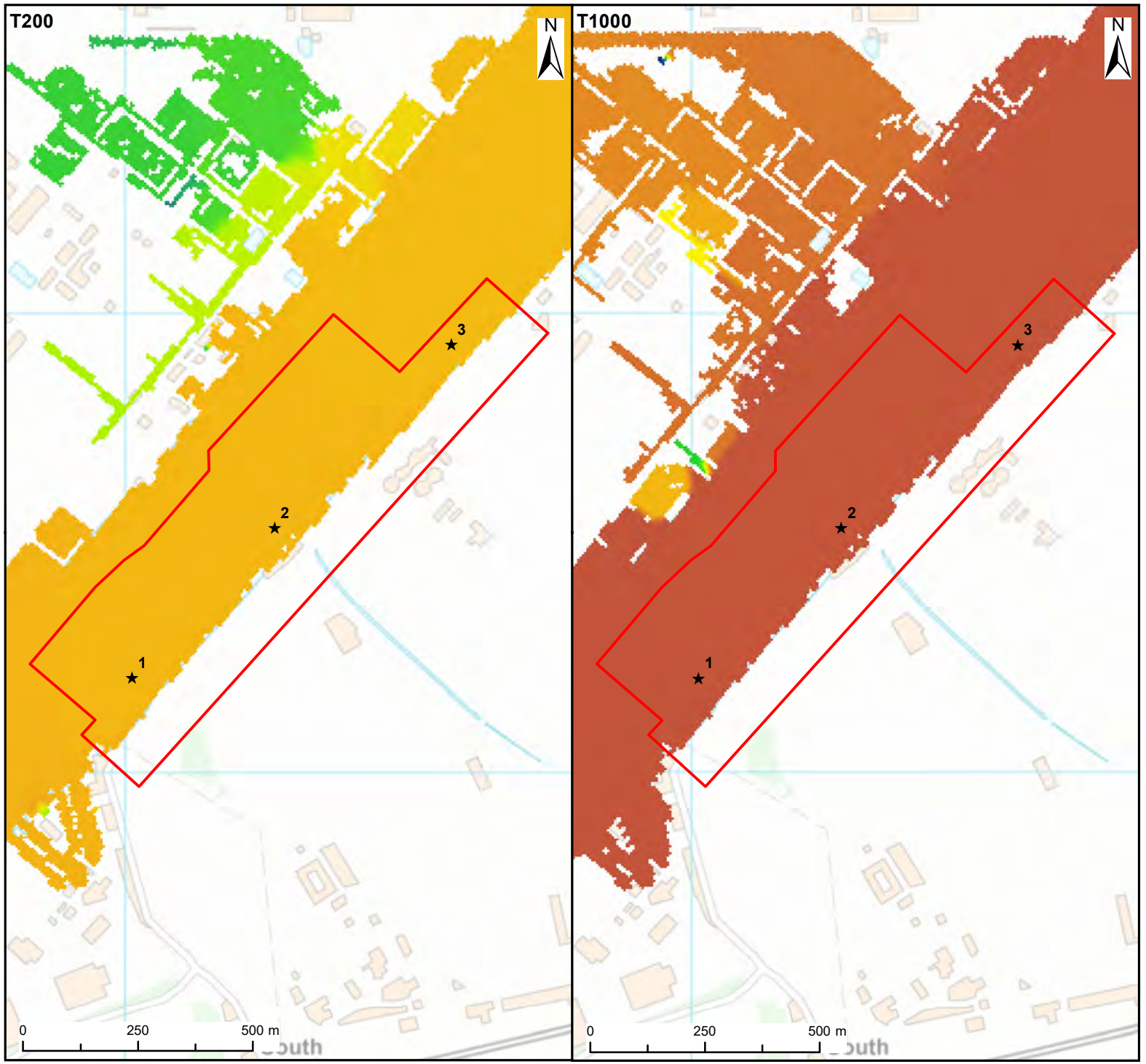
The Tees Tidal Flood Risk Management (FRM) Strategy (Environment Agency, 2009) identified the need for improvements or raising of existing flood defences within the Tees estuary, up to the Tees Barrage. This report also highlighted areas which may be at risk of flooding, either at present or in the future. Areas identified as being at risk are those located where ground levels are less than 5.0m AOD. This level relates to a 0.1% (1 in 1,000) probability of a flood event occurring in any one year. A water level with a 0.5% (1 in 200) probability of occurrence in any one year is classified in the Tees Tidal FRM Strategy as being 4.19m AOD (Environment Agency, 2009). The highest recorded flood event along the Tees occurred in 1953 and reached a level of 4.0m AOD.

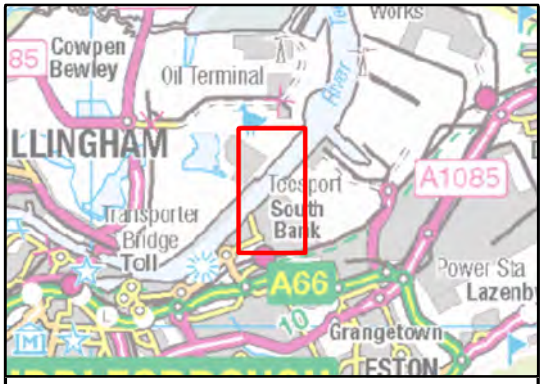
20.4.1.2 Tidal Tees Integrated Flood Risk Modelling Study

The Tidal Tees Integrated Flood Risk Modelling Study (Environment Agency, 2011) expanded upon the Tees Tidal FRM Strategy through development and application of an ESTRY-TUFLOW model that covers the Tees estuary from Teesmouth at the coast to its upstream extent at the Tees Barrage.

The report concludes that some of the area shown as being within the footprint of the proposed scheme, namely the proposed dredge footprint, is in Flood Zone 3, associated with the 1 in 200-year return period event as a result of tidal flooding.

Table 20.5 presents the level in m AOD for a 1 in 200-year and 1 in 1,000-year return period event, taken from the 2011 Tidal Tees Integrated Flood Risk Modelling Study. The data was taken from three points spaced across the entire quay frontage as outlined on **Figure 20.1**. The proposed quay would be constructed at a level of 5.84m AOD, providing suitable protection against the 0.5% (1 in 200) and 0.1% (1 in 1,000) annual exceedance probability event for the present day.





Legend:

Redline Boundary*

★ Modelled Location Points

Water Levels from Tidal Tees Integrated Flood Risk Modelling Study (Environment Agency, 2011)

4.4
4.3
4.2
4.1
4.0
3.9
3.8
3.7
3.6
3.5
3.4
3.3

* The proposed dredge footprint at the Tees Dock turning circle has been omitted from the figure as the modelled water levels are relevant to the assessment of flood risk at the quay wall and the land adjacent to the quay rather than the proposed in-channel works

Client:	Project:
Tees Valley Combined Authority	South Bank Quay

Title: Present Day Modelled Water Levels

Figure: 20.1 | Drawing No:

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	06/10/2020	FC	HW	A4	1:12,000

Co-ordinate system: British National Grid

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Table 20.5 Data taken from the 2011 Tidal Tees Integrated Flood Risk Modelling Study

Study node point name	Return period (years)	Modelled Water Level (m AOD)
Point ID 1	200	4.133
	1,000	4.392
Point ID 2	200	4.128
	1,000	4.390
Point ID 3	200	4.125
	1,000	4.386

For the purposes of this assessment, it is assumed that the baseline water levels for the whole site should be rounded to two decimal places, which for the 1 in 200-year and 1 in 1,000-year return periods are 4.13m AOD and 4.39m AOD respectively.

20.4.1.3 South Industrial Zone Environmental Statement

STDC submitted an ES (July 2020) for general industry and storage or distribution uses within the part of the South Industrial Zone that lies immediately south of the proposed scheme footprint.

The proposed scheme which is the subject of this report is required to support STDC's landside proposals and as such, the water management and flooding report and associated FRA submitted for that application was reviewed in order to understand the interactions between the two sites. A summary of relevant information is presented below.

The SIZ FRA outlines that the site of the proposed landside development adjacent to the proposed scheme footprint is at very low risk from fluvial flooding. There is a moderate risk of tidal / coastal flooding. However, the ground level for the SIZ application is to be set above the 1 in 200-year tidal flood level, including climate change adjustment until 2100. Additionally, the surface water flood risk ranges from low to high, resulting in an overall moderate risk. However, the higher risk areas are predominantly due to localised depressions, and mostly surface flows are shallow and do not follow any clear overland flow paths.

The Sustainable Drainage Strategy for the site aims to reduce the surface water flood risk at the site. The report states that low permeability concrete surfaces are proposed for the majority of the ground across the site, where run off will be collected and passed through appropriate Sustainable Drainage System (SuDS) treatment.

20.4.2 FRA undertaken specifically for the proposed scheme

To inform this section of the EIA Report a separate FRA has been undertaken specific to the proposed scheme footprint and is included as **Appendix 15**. Key information from the FRA related to flood risk from all sources to the proposed scheme footprint is set out in the following sections.

20.4.2.1 Flooding from the sea (tidal/coastal)

The Environment Agency Flood Map for Planning (Rivers and Sea) identifies that the proposed scheme footprint is partially located in Flood Zones 1, 2 and 3.

The majority of the site falls within Flood Zones 2 and 3, which are contained within the banks of the River Tees. Flood Zone 2 is defined as "*Land having between a 1 in 200 and a 1 in 1,000 annual probability of sea flooding (0.5% - 0.1%)*", whereas Flood Zone 3 is defined as "*Land having a 1 in 200 or greater annual probability of sea flooding (≥0.5%)*".

The small section of land required for the proposed scheme is wholly located within Flood Zone 1 and therefore at low risk of flooding. Flood Zone 1 is defined as *"Land having less than a 1 in 1,000 annual probability of sea flooding (<0.1%)".*

Due to the proposed scheme being partially located within the banks of the tidally influenced River Tees, the risk of tidal and coastal flooding is assessed to be high. However, it is noted that as a new port facility, the proposed scheme is considered 'Water Compatible' under the NPPF.

20.4.2.2 Flooding from groundwater

Borehole records indicate that groundwater levels could be linked to tidal levels in the River Tees. This is considered highly likely as the proposed scheme footprint is adjacent to the watercourse and there is likely to be percolation of water through the existing banks into adjacent ground.

The occurrence of groundwater flooding does not generally pose a significant risk to life due to the slow rate at which the water level rises. However, groundwater flooding can cause significant damage to property and can pose further risks to the environment and ground stability. There are several mechanisms that increase the risk of groundwater flooding including prolonged rainfall and high in-bank river levels.

No mapping of Areas Susceptible to Groundwater Flooding were available in the Redcar SFRA. Given the distance from the River Tees and potential connectivity between tidal and groundwater levels, it is considered that there is a medium risk of groundwater flooding; however, as this is likely to be inherently linked to tidal flooding it would comprise a limited flood risk to the site when compared with tidal flood risk.

20.4.2.3 Flooding from surface water

The Environment Agency Surface Water Flood Risk map[10] highlights that the proposed scheme footprint is predominantly in areas at 'Very Low' risk of surface water flooding (*i.e. less than 1 in 1,000 years*).

There are two areas on the proposed scheme footprint that have an increased risk of surface water flooding:

- The southernmost corner of the proposed scheme footprint includes areas at 'low' (*i.e. between 1 in 1,000 and 1 in 100 years*) and 'medium' risk (*i.e. between 1 in 100 and 1 in 30 years*); and,
- The area of the proposed scheme footprint associated with the oil depots, boiler house and offices (to be removed prior to the proposed scheme) contains areas at 'low', 'medium' and 'high' (*i.e. greater than 1 in 30 years*) risk.

The pockets of low, medium and high surface water risk are likely to be as a result of localised low points within the current topography. It is understood that prior to construction of the proposed scheme, any residual features associated with the prior use of the site will be removed and the site levelled to remove any potential localised areas of ponding.

As a result, the surface water falling onto the heavy lift areas, which is proposed to be surfaced with concrete, would be captured through a series of gullies and discharged into the Tees estuary through the Quay wall, via an interceptor. Therefore, the site is assessed to be at Very Low risk of surface water flooding.

20.4.3 Summary of flood risk

Table 20.6 summarises the risk of flooding from all sources to the proposed scheme footprint. The overall risk of flooding to the proposed scheme footprint is considered to be low, given that all aspects of the

[10] *Environment Agency, Long term flood risk information. Available at https://flood-warning-information.service.gov.uk/long-term-flood-risk/map (Accessed 23/01/2019)*

proposed scheme will be 'water compatible' and therefore less affected by flooding. However, there remains a residual risk of flooding in the event of a defence failure or overtopping.

Table 20.6 Summary of flood risk

Source of flood risk	Probability of flooding	Description
Fluvial	Low	The proposed scheme is partially located within the River Tees and is therefore situated in either Flood Zone 2 or 3. However, at this location the River Tees is tidally influenced. The remaining elements of the proposed scheme i.e. quay and cranes are located in Flood Zone 1. Therefore, the risk of flooding from fluvial sources is assessed to be low.
Tidal / Coastal	High	The proposed scheme is partially located within the River Tees and is therefore situated in either Flood Zone 2 or 3. However, the proposed scheme will be 'Water Compatible' and therefore less affected by tidal flooding. The remaining elements of the proposed scheme i.e. quay and cranes are located in Flood Zone 1.
Groundwater	Medium	Borehole records have been reviewed for the proposed scheme footprint, which reported groundwater was encountered at 2.05m AOD. These findings indicate that groundwater level could be linked to tidal levels in the River Tees, especially due to its proximity, i.e. adjacent, to the watercourse itself. Given the distance from the River Tees and potential connectivity between tidal and groundwater levels, it is considered that there is a medium risk of groundwater flooding.
Surface water	Low	The Environment Agency's Surface water flood risk map shows that the proposed scheme footprint is primarily at low surface water flood risk, except a few isolated low-lying pockets. Water falling on the proposed scheme footprint is discharged directly into the River Tees.
Sewers	Very Low	There are currently no sewers present within the proposed scheme footprint. During construction there will be no requirement for a connection to the wider sewer system. Additionally, welfare facilities are not proposed on the quay as part of the proposed scheme during the operational phase. Therefore, there is no risk of flooding from sewers and this risk is classified as very low.
Reservoirs and other sources	Low	The proposed scheme footprint has been identified as within the maximum flood extent for reservoirs. However, this area of risk is confined to within the banks of the River Tees and does not cover the small section of land within the proposed scheme footprint. There are no additional canals or artificial sources in the local area. Therefore, the risk of flooding from reservoirs, canals and other sources is considered to be low.

20.4.4 Flood vulnerability

In terms of flood risk and vulnerability, Table 2 of the PPG for Flood Risk and Coastal Change classifies the proposed scheme as 'water compatible'. Table 3 of the PPG for Flood Risk and Coastal Change indicates that developments of this classification are considered appropriate in all Flood Zones.

As set out above, the NPS for Ports states that all applications for port development of 1 hectare or greater in Flood Zone 1, as well as all proposals for projects in Flood Zone 2 and 3, should be accompanied by an FRA. Given the location of the proposed scheme within Flood Zone 2 and Flood Zone 3, an FRA has been undertaken for the proposed scheme (**Appendix 15**).

20.4.5 Hydrodynamic modelling

Hydrodynamic modelling studies assessed the effects of fluvial flows on water levels within the Tees estuary as a result of the proposed scheme (see **Section 6**).

Water levels during a 1 in 100 year fluvial input scenario through the Tees Barrage were modelled, as this was considered the most severe case in terms of flood risk.

Three 'monitoring' points were chosen which ranged from approximately 2.6km upstream and 3.5km downstream of the proposed scheme, as well as adjacent to the proposed scheme footprint. A time-series over a duration of two weeks was plotted showing the baseline water levels and predicted water levels as a result of the proposed scheme at each of the three monitoring locations for the 1 in 100 year fluvial event. The modelled high water levels under each scenario, for each of the monitoring locations were calculated and are shown in **Table 20.7.**

Table 20.7 Modelled high water levels for a 1 in 100 year fluvial event through the Tees Barrage

Scenario	Upstream (m AOD)	At Site (m AOD)	Downstream (m AOD)
Baseline	2.92	2.91	2.83
With proposed scheme	2.92	2.91	2.83

The results show that there is no change in the high water levels at the monitoring locations as a result of the proposed scheme. This also suggests that the fluvial elements of flow in the estuary are minimal when compared with the influence of the tidal proportion of the flow, even during an extreme (1 in 100 year) fluvial event.

20.4.6 Climate change guidance

UK guidance on climate change has been updated through the publication of the Environment Agency's online advice note 'Flood Risk Assessments: Climate Change Allowances' (Environment Agency, 2020).

The principal climate change which could affect flood risk at, or adjacent to, the proposed scheme footprint relates to changes in rainfall and sea level rise. Fluvial flows are less critical because of the location of the proposed scheme within the estuary where tidal and coastal processes are still dominant.

20.4.6.1 Changes in rainfall

Table 20.8 shows the Environment Agency's anticipated changes in extreme rainfall intensity in small and urban catchments which is relevant to the surface water flood risk. The proposed scheme is anticipated to have a 50-year lifespan (i.e. until 2073), as such a 20% (central) and 40% (upper end) allowance for peak rainfall intensity is considered appropriate.

Table 20.8 Peak rainfall intensity allowance in small and urban catchments (use 1961-90 baseline) (Source: Table 2, Environment Agency Climate Change Allowances 29/09/20)

Applies across all of England	Total Potential Change Anticipated for the '2020s' (2015-2039)	Total Potential Change Anticipated for the '2050s' (2040-2069)	Total Potential Change Anticipated for the '2080s' (2070-2115)
Upper End	10%	20%	40%
Central	5%	10%	20%

20.4.6.2 Sea Level Rise

Table 20.9 presents the projections of sea level rise during the proposed scheme's 50-year operational phase (i.e. 2023 – 2073). The baseline (2011) still water levels for the 1 in 200 year and 1 in 1,000 year events were obtained from the 2011 ISIS-TUFLOW model which forms part of the Tidal Tees Integrated Flood Risk Modelling Study (Environment Agency, 2011).

Using the latest higher central and upper end sea level climate change allowances for the Northumbria river basin district (Environment Agency, 2020), the uplift during each epoch was calculated and is presented in **Table 20.9**.

Table 20.9 Change in still water level across the operation phase of the proposed scheme

Extreme Water Level Analysis Results (m AOD)				
	Higher Central		Upper End	
	1 in 200 year	1 in 1,000 year	1 in 200 year	1 in 1,000 year
Still water level (m AOD) (2011)	4.13	4.39	4.13	4.39
Still water level (m AOD) (2023)	4.19	4.45	4.20	4.46
Still water level (m AOD) (2073)	4.55	4.81	4.68	4.94

The proposed quay would be constructed at a level 5.84m AOD, providing suitable protection against the 0.5% (1 in 200) and 0.1% (1 in 1,000) annual exceedance probability event for both the higher central and upper end scenarios throughout the 50-year lifetime of the proposed scheme (i.e. 2023 – 2073).

20.4.7 Future evolution of the baseline in the absence of the proposed scheme

As detailed above, predicted sea level rise is likely to result in a greater degree of flood risk to the site in the future, independently of any potential impact of the proposed scheme. There is, therefore, the potential for more regular flood events of the land within the footprint of the proposed scheme.

20.5 Potential impacts during the construction phase

20.5.1 Potential for effect on risk of flooding at and adjacent to the proposed scheme

The proposed scheme has the potential to alter the risk of flooding during construction as a result of temporary works within either the channel or on the floodplain, both to the proposed scheme footprint and to other areas within the Tees estuary which are determined to be low sensitivity receptors.

Section 20.4 and the FRA (**Appendix 15**) identified that tidal flooding and groundwater flooding represents the predominant sources of flood risk in the vicinity of the proposed scheme. However, It is considered that the flood risk during construction will be not be exacerbated beyond the existing flood risk as identified in the FRA. The proposed scheme will have a very limited change to the defence line taking into account the defences that already exist in this location and the design of the proposed scheme. As such, the potential effect on flood risk is determined to have a very low magnitude of effect. Therefore, **no impact** is predicted.

Mitigation measures and residual impact
As part of the proposed scheme the quay wall will comprise the maintenance of the existing defence line which will then incorporate a revised defence line, set at a level of 5.84m AOD. During the construction phase, a continuous defence line will need to be retained, using the existing, revised or a combined defence line (i.e. quay) such that a continued standard of protection will be provided throughout construction that is comparable with the existing. No further mitigation measures are required. There would be **no residual impact**.

20.5.2 Vulnerability to flooding of those using the site

The location of the proposed scheme within and immediately adjacent to the Tees estuary inherently presents risks to construction workers and other construction related site users associated with drowning or accidents during flood, storm or tidal surge events within the estuary.

As the level of severity of any flood events / storms in the estuary is a controlling factor in predicting the significance of potential impacts to construction workers, a worst case scenario is assumed. In this case, the site users are designated as very high sensitivity receptors and the magnitude of impact to these site users is high magnitude. Therefore, without the implementation of mitigation measures the impact is of **major** a**dverse** significance.

Mitigation measures and residual impact
The risk of a flood event occurring and its impact on human health can be controlled through the implementation of the following mitigation measures:

- Development of a construction phase Flood Risk Emergency Plan (FREP).
- Prior to works commencing, all construction workers will undergo site induction training prior to being allowed access to the proposed scheme site. This will include actions required in the event of a flood risk emergency incident, such as those included in the FREP including obtaining flood warnings /alerts, responding to warning sirens and following escape routes in the event of a site evacuation.
- No workers would be allowed on site unless they have undergone a site induction.
- Arrangements will be identified and made for safe access to and from the site.
- In the event of tidal surge and / or significant storm events, prior warning will be given to the site users in order to cease construction works and evacuate site workers to higher ground.

These measures will minimise the potential risk to human health as far as possible and significantly reduce the magnitude of the effect. On this basis, the residual risk to site users is determined to be of **minor adverse** significance.

20.6 Potential impacts during the operational phase

20.6.1 Potential for effect on risk of tidal flooding at and immediately adjacent to the proposed scheme

The principal issue in relation to flood risk and coastal defence is whether the risk of flooding could be altered by the proposed scheme, both to the proposed scheme footprint and the surrounding areas.

The FRA (**Appendix 15**) has identified that the proposed scheme footprint is at risk from sea (tidal/coastal) flooding, and this represents the predominant source of flood risk to the proposed scheme. The majority of the proposed scheme footprint lies within the River Tees, which falls within Flood Zones 2 and 3. The small

section of the proposed scheme footprint on land, comprising the quay and cranes, is wholly located within Flood Zone 1 and therefore at low risk of flooding.

The proposed quay would be built at a level 5.84m AOD, which is above the 5.0m AOD threshold which the Tees Tidal Flood Risk Management (FRM) Strategy identified as being at risk during a 1 in 1,000 year event.

In accordance with the NPS for Ports (Department for Transport, 2012) and NPPF (Ministry of Housing, Communities and Local Government, 2019), the proposed scheme is classified as 'water compatible'. To ensure the operation of the proposed scheme, once constructed the quay structure would comprise the revised river bank of the Tees estuary, as such it will provide the revised defence line and would not affect the flood risk in the vicinity. As a result, the receptor sensitivity is very low. The tidal flood risk to the site has the potential to have a low magnitude effect. Therefore, the impacts from tidal/coastal flooding has **negligible** significance.

Mitigation measures and residual impact
As part of the proposed scheme the quay wall will comprise the incorporation of a revised defence line, set at a level of 5.84m AOD, and therefore providing a standard of protection that is comparable with the existing once operational. No further mitigation measures are required. There would be **no residual impact** with regard to tidal/coastal flooding.

20.6.2 Potential for effect on risk of tidal flooding elsewhere in the estuary system

The predicted effect of the proposed scheme on flows and water levels has been assessed as part of the hydraulic modelling studies (reported in **Section 6**) and outlined in **Section 20.4.4**. For the purposes of this assessment, the impact of fluvial flows in raising water levels in the estuary is considered. An increase in high water levels could have the potential to increase the tidal flood risk, should they occur coincidentally.

The estuary is determined to represent a medium sensitivity receptor. The results of the hydrodynamic modelling for the 1 in 100 year fluvial event through the Tees Barrage show there is no effect on the high water levels between the baseline scenario and the scenario with the proposed scheme in place.

As a result, it can be concluded that there is **no impact** predicted on the tidal flood risk throughout the estuary as a result of the proposed scheme.

Mitigation measures and residual impact
No mitigation measures are required. There would be **no residual impact**.

20.6.3 Surface water runoff and foul sewage

The risk of surface water flooding has been considered as part of this assessment. However, it is understood that the landside parts of the proposed scheme footprint would be levelled prior to construction in order to remove any localised areas of ponding. Therefore, the surface water flood risk to the site is not assessed further here. Instead, the main flood risk relates to the performance of surface water drainage systems and foul sewage, which is assessed below.

It is understood that the current surface water runoff and drainage from the land is likely to be directly into the Tees estuary. It is anticipated that as part of the proposed scheme the quay would be surfaced with crushed stone and surface water would drain into the underlying material without the need for a formal drainage system. A drainage system collecting surface runoff through gullies would be required on the heavy lift areas, as such areas are proposed to be surfaced with concrete. The collected water will be discharged into the Tees estuary through the quay wall, via an interceptor.

Welfare facilities are not proposed on the quay itself in order to maximise the available space to support operations; therefore there would be no foul sewage generated as a result of the proposed scheme.

It has been determined that there is likely to be a very low magnitude of effect, on a low sensitivity receptor. As a result, it is concluded that there would be a **negligible impact** as a result of the proposed scheme.

Mitigation measures and residual impact
No mitigation measures are required. There would be **no residual impact**.

20.6.4 Potential effect on frequency of overtopping

The potential for increased overtopping frequency has been informed by the studies into the effects of the proposed scheme on wave climate throughout the estuary system (**Section 6**). The modelling outlines the baseline conditions on both swell waves and local generated waves under extreme wind.

The baseline swell waves do not extend up the Tees estuary to the proposed scheme footprint, indicating that the site is well sheltered from the North Sea waves.

The swell waves that reach the area downstream of Tees Dock and the Tees Turning Area reach at magnitude of approximately 0.05m to 0.15m. The swell waves of any significance (>1.5-2.0m) only reach the estuary mouth. Therefore, a low magnitude effect is predicted, on a low sensitivity receptor, resulting in a potential impact of **negligible** significance.

The wave model results show that locally generated waves under extreme wind are of more significance at the proposed scheme footprint. Due to the proposed scheme being set-back into the riverbank and in addition to the raised quay level compared with the present day, local bathymetric differences to the model immediately surrounding the quay are expected. However, the changes are unlikely to be significant and will be extremely localised. The modelling results indicate that the local generated wind waves can reach a height of 0.3m to 0.4m for a 1 in 1 year return period and 0.5m to 0.7m for a 1 in 100 year return period at the proposed scheme footprint.

The amplitude of these waves is equivalent to the increase in water levels that would occur at the proposed scheme during a locally generated extreme wave event. For the purpose of this assessment, the upper limits were used in order to represent the worst-case scenario (**Table 20.10**).

Table 20.10 Worst-case scenario locally generated wind waves

Return period	Wave height (m)	Amplitude (m)
1 in 1 year	0.40	0.20
1 in 100 year	0.70	0.35

If a locally generated extreme wind event, as predicted above, was to occur at the same time as an extreme tidal event, it would have the effect of raising the water level beyond that expected based on tidal still water levels alone, in turn increasing the flood risk to the proposed scheme.

Table 20.11 quantifies this water level increase under baseline conditions, as well as taking sea level rise due to climate change into account. The size of the waves predicted for the most extreme locally generated wind wave is unlikely to change significantly due to climate change, and therefore the calculated increase in water level is appropriate for use through the lifetime of the proposed scheme.

Table 20.11 Cumulative water levels under an extreme tidal event and extreme locally generated wind wave event

Extreme tidal event for Upper End return period (years)	Modelled Water Level (m AOD)	Increase in water level due to extreme 1 in 100 year wind event (m)	Cumulative Water level (m AOD)
2011 (Baseline)			
200	4.13	0.35	4.48
1,000	4.39	0.35	4.74
2023			
200	4.20	0.35	4.55
1,000	4.46	0.35	4.81
2073			
200	4.68	0.35	5.03
1,000	4.94	0.35	5.29

The proposed quay would be constructed at a level of 5.84m AOD, providing suitable protection against the worst-case scenario for wind waves and still water levels, including climate change.

As a result, the effects of the locally generated wind waves are determined to have a medium magnitude effect on a low sensitivity receptor. Overall, a **negligible** impact is predicted.

Mitigation measures and residual impact

No mitigation measures are required in regard to the impact of swell waves or locally generated waves. The residual impact would be of **negligible** significance.