The London Resort Development Consent Order

BC080001

Environmental Statement
Volume 2: Appendices

Appendix 17.1 – Flood Risk Assessment

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December 2020

Planning Act 2008
The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009
Regulation 5(2)(a)
The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017
Regulation 12(1)

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BURO HAPPOLD

The London Resort

Flood Risk Assessment

ES Chapter 17 Water Resources and Flood Risk Appendix 17.1

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Hannah Clement

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Glossary

Term	Definition
Annual Exceedance Probability (AEP)	The probability that a storm event will be exceeded in any given year.
Actual Risk	The risk that has been estimated based on the quantitative assessment of the performance capability of the existing flood defences.
Attenuation	A method to reduce a flood peak to prevent flooding, often utilising temporary storage, but increasing the duration of the flow.
Design Flood Level	This is the level of flooding that flood defences or mitigation measures are designed against. This is typically the 1% (1 in 100 level) for fluvial flood risk and 0.1% (1 in 1000 level) for tidal flood risk.
Flood Defence	A natural or man-made infrastructure used to prevent certain areas from inundation from flooding and/or the provision of flood warning systems.
Floodplain	Area of land adjacent to a water course which water flows or is stored during a flood event, or would otherwise be flooded in the absence of flood defences.
Flood Resilience	Improving flood resistance, e.g. reducing the risk of properties against flooding events.
Flood Risk	The level of risk to personal safety and damage to property resulting from flooding due to the frequency or likelihood of flood events.
Flood Risk Assessment (FRA)	An assessment of the flood risks to the proposed development over its expected lifetime and the possible flood risks to the surrounding areas, assessing flood flows, flood storage capacity and runoff.
Flood Warning Systems (FWS)	A system by which to warm the public of the potential of imminent flooding. This is typically linked to a flood forecasting system.
Fluvial Flooding	Flooding resulting from an exceedance event in a river or watercourse.
Groundwater	Water present within underground strata known as aquifers.
Groundwater Flooding	Water occurring below ground in natural formations (typically rocks, gravels and sands).

Impermeable Surface	A surface that does not permit the infiltration of water and, therefore, generates surface water runoff during periods of rainfall.
Inundation	Flooding of land with water
Made Ground	Soil that has been subjected to anthropogenic intervention
Mitigation	Actions taken to reduce either the probability of flooding or the consequences of flooding or a combination of the two.
Permeability	The measures of ease with which a fluid can flow through a porous medium.
DCO Limits	Boundary drawn to indicate the site area on which the planning application is based.
Refuge	Area for shelter / protection during flood events.
Residual Risk	The risk that remains after risk management and mitigation measures have been implemented.
Resilience	The degree to which an asset or development can recover from a flooding event.
Return Period	The average frequency of a specified condition. An 'n' year event is one that occurs on average over the long term, once every 'n' years.
Risk	Risk is the probability that an event will occur and the impact (or consequences) associated with that event.
Runoff	Water flow over surfaces to the drainage system. Runoff occurs when rainfall exceeds the rate of permeability of a surface.
Strategic Flood Risk Assessment (SFRA)	An SFRA is the assessment and 'categorisation' of flood risk on an area-wide basis in accordance with PPS25, usually carried out by the Local Planning Authority.
Surface Water Flooding	Surface water flooding occurs when the volume of water is unable to filtrate through the ground to enter drainage systems, and therefore runs quickly off land and results in localised flooding. This type of flooding is usually associated with intense rainfall.
Sustainable Drainage Systems (SuDS)	SuDS are used as a strategy to manage surface water in a sustainable manner or least damaging solution through management practices and physical structures.

Abbreviations

Term	Definition
AEP	Annual Exceedance Probability
DCO	Development Consent Order
EA	Environment Agency
ECC	Essex County Council
EDC	Ebbsfleet Development Corporation
FRA	Flood Risk Assessment
FWS	Flood Warning Systems
DFE	Design Flood Event
DEM	Digital Elevation Model
DFE	Design Flood Event
DSM	Digital Surface Model
DTM	Digital Terrain Model
GBC	Gravesham Borough Council
ha	Hectare
HC	Higher Central
HS1	High Speed 1
H++	H Plus Plus (Climate Change scenario)
KCC	Kent County Council
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
LPA	Local Planning Authority
m AOD	metres Above Ordnance Datum
NPPF	National Planning Policy Framework
NSIP	National Significant Infrastructure Project
PPG	Planning Practice Guidance
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage Systems
SWDS	Surface Water Drainage Strategy

SWMP	Surface Water Management Plan
TC	Thurrock Council
TE2100	Thames Estuary 2100
UE	Upper End
UKCP09	United Kingdom Climate Projection 2009
UKCP18	United Kingdom Climate Projection 2018

Executive summary

Subject	Element	Findings
Proposed Development	Background	The Proposed Development will be a nationally significant visitor attraction and leisure resort, built largely on brownfield land at Swanscombe Peninsula in Kent on the south bank of the River Thames and with supporting transport and visitor reception facilities on the northern side of the river in Essex. The focus of the Proposed Development is a 'Leisure Core' situated on the Swanscombe Peninsula. The Proposed Development will also include hotels, a water park, car parking, back of house service buildings and related housing to accommodate some of the Resort employees. The Proposed Development includes proposals to transport infrastructure including a new direct road connection from the A2(T).
Current day Site Flood Risk	Fluvial & Tidal	The Kent Project Site is situated across all three of the Environment Agency (EA) Flood Zones based on the undefended scenario. The north of Swanscombe Peninsula is Flood Zone 2, medium flood risk. The centre of Swanscombe Peninsula is Flood Zone 3, high flood risk, and the Access Road is predominantly Flood Zone 1, low flood risk (Figure 4-1 and Figure 5-1). The Kent Project Site is currently benefitting from a flood defence with a crest level of between 6.31m AOD and 8.8m AOD, providing a minimum freeboard of 300mm for the present day maximum likely water level of 6.01.m AOD during a 1 in 1000-year event. The Kent Project Site is situated downstream of the Thames Barrier. The overall current day risk of fluvial and tidal flooding is considered *low.* South from the Swanscombe Peninsula, along the proposed Access Road, the River Ebbsfleet intersects the Kent Project Site. Parts of the Order Limits are within Flood Zone 2 and Flood Zone 3 of the River Ebbsfleet.

		The Essex Project Site is located within Flood Zone 3 with the areas north of the Tilbury Cruise Buildings benefitting from defences (Figure 6-1). The Essex Project Site is currently benefitting from a flood defence with a crest level of between 6.48m AOD and 6.71m AOD, providing a minimum freeboard of 480mm for the present day maximum likely water level of 5.94m AOD during a 1 in 1,000 year event. The Essex Project Site is situated downstream of the Thames Barrier. The overall current day risk of fluvial and tidal flooding is *low*.
	Breach in Defences	At all flood defence locations there is a residual risk of a breach of those flood defences. The probability of a breach in defences is considered *low*. EA inspection records of the defences indicate that the existing defences are in 'Fair' (rated 3) condition. This is based on a rating where 1 is Good and 5 is Poor. If a breach did occur, the greatest impact would be from a breach along the west side of the Swanscombe Peninsula where land levels behind the defences are lower than the east.
	Surface Water and Sewers Surface Water Drainage Strategy (SWDS)	The Kent Project Site (Main Resort) has a *low* risk of flooding from surface water. The surface water extents produced by the EA show that risk of flooding from surface water is limited to the areas along Manor Road and in the vicinity of the HS1 line. For the remainder of the Swanscombe Peninsula there are only isolated areas in potential surface water ponding during the existing condition where there are topographic low points. The Kent Project Site (Access Road) has a *low* risk of flooding from surface water. There are isolated areas of potential flooding particularly along the River Ebbsfleet Corridor, along the A2 (T) and in the vicinity of the HS1 Line. The Essex Project site has a *medium* risk of flooding from surface water. This is due to the low lying land resulting in the ponding of surface water along the key drainage infrastructure within the Order Limits, and within the existing car parking areas.

	Groundwater	The Kent County Council (KCC) Strategic Flood Risk Assessment (SFRA) currently locates the Kent Project Site within an area shown to have a *low* risk of groundwater flooding. The Thurrock Council Local Flood Risk Management Strategy locates the Essex Project Site as being in an area shown to have a *low* risk of groundwater flooding.
	Artificial Sources	The EA flood risk as shown in the maps from flooding due to artificial sources indicates that a small portion of the Essex Project Site (the existing car parking area to the north east of the Order Limits. This area has a residual risk of flooding from a failure at the Tilbury Flood Storage Area or failure of the tidal defences at the Tilbury Dock. The likelihood of failure is low and as a result the risk to the site is *low*. There is no history of flooding from sewers or artificial sources at the Kent Project Site. The risk of flooding from artificial sources is considered to be *low*.
Future Flood Risk	Fluvial & Tidal	Sea level rise and climate change is predicted to have an impact on the extreme water levels within the Thames Estuary. It is likely that these increases in extreme water level will mean that the crest levels of the existing flood defences at both the Kent and the Essex Project Sites will not maintain the same level of protection to the Project Site for future tidal extreme water levels. Therefore, the future flood risk to the Project Site would be considered *high* and requires mitigation.
	Breach in Defences	There is a residual risk of a breach in the defences. The probability of a breach in defences is considered *low*, however measures should be taken to ensure that the condition of the defences within the Order Limits are improved if required and appropriately maintained. In the event of a breach, safe access and egress routes or alternatively safe refuges have been identified.
	Surface Water and Sewers	Climate change is predicted to increase rainfall intensities in the future between 20% and 40%. This could increase the risk from stormwater or sewer

	Surface Water Drainage Strategy (SWDS)	flooding if suitable allowances are not provided in future network designs.
	Artificial Sources	An increase in rainfall intensity as a result of climate change is considered in this appraisal. However, the residual risk from Artificial Sources is *low*.

Mitigation measures	Design Flood Event	The design flood events are defined as follows.
		• Flood risk from the River Thames:
		  o 1 in 200 year tidal flood event higher central climate change projection.
		• Flood risk from the River Ebbsfleet:
		  o 1 in 100 year fluvial flood event plus 70% allowance for climate change.
		• Flood risk from surface water overland runoff in Kent Project Site:
		  o No above ground flooding up to the 1 in 30 year + 40% allowance for climate change.
		  o Buildings not to flood during the:
		    ▪ 1 in 100 year + 40% allowance for climate change rainfall event combined with Mean High Water Spring (MHWS); or
		    ▪ 1 in 1 year rainfall event combined with 1 in 200 year tidal flood event in 2090 higher central climate change projection, and for the 1 in 100 year plus 40% CC (up to 2125 combined with the MHWS.
		• Flood risk from surface water overland runoff in Essex Project Site:
		  o No above ground flooding up to the 1 in 30 year + 40% allowance for climate change.
		  o Buildings not to flood during the:
		    ▪ 1 in 100 year + 40% allowance for climate change rainfall event combined with 1 in 20 year tidal flood

		event for 2090 using the higher central climate change projection; and, ▪ 1 in 5 year +40% CC rainfall event combined with the 1 in 200 year tidal event for 2090 using the higher central climate change projection. For residual risks and to ensure an appropriate standard of protection the following design events are considered: • Kent Project Site – 1 in 1000 year tidal event to 2070. • Kent Project Site Less Vulnerable development – 1 in 200 year higher central climate projections to 2090. • Kent Project Site More Vulnerable development – 1 in 200 year upper end climate change projections to 2125. • Essex Project Site Less Vulnerable development – 1 in 200 year higher central climate projections to 2090.
	Flood Defence	At the Kent Project Site (Main Resort) the Proposed Development includes the following flood defence measures: • At Black Duck Marsh: increase the formal flood defence crest level along the existing alignment. • At White's Jetty: replace the existing flood walls and flood gates with a flood embankment along a new alignment to the landward side of the White's Jetty. • Both crest levels will initially be set to a minimum of 7.00m AOD, which is the level required by the year 2070 under the EA TE2100 plan. • After 2050, when the EA confirms the Thames Barrier Improvement works option, a review of the standard of protection for the Project Site and the levels required will be made. • If the review indicates that additional standard of protection is required, this will be in place by 2070.

		• A new secondary flood defence embankment along the east of the Proposed Development at the Kent Project Site (the west of Botany Marsh). • The secondary flood defence crest level of the embankment will be set to 3.00m AOD, which is the level required by the year 2090 to ensure the Kent Project Site (Main Resort) is protected from the 200 year and 1000 year overtopping flood levels. At the Essex Project Site there are no proposals to alter the existing Formal Flood Defences. Refurbishment of the existing Tilbury Cruise Buildings will ensure that the existing defences are not damaged.
	Land Raising and Finished Floor Levels	Land Raising and setting of finished floor levels is used to ensure that resilience is provided to future storm events in the event of failure or overtopping of existing flood defences. At the Kent Project Site (Main Resort) the finished floor levels of sleeping accommodation, safe refuge points and invacuation routes of More Vulnerable developments, as well as the podium levels of Critical Infrastructure required to be operational during a flood event, is set above whichever is higher of the following flood events in a breach scenario: • The 1 in 200 year 2125 upper end flood level plus 300mm freeboard; or, • The 1 in 1000 year 2125 higher central flood level. At the Kent Project Site (Main Resort) and the Essex Project Site Less Vulnerable developments are made flood resilient to a minimum of whichever has a higher maximum water level of the following flood events: • The 1 in 200 year 2090 higher central flood level plus 300mm freeboard; or, • The 1 in 1000 year 2090 higher central flood level. At the Kent Project Site (Access Road) compensatory flood storage will be provided for 0.13 ha of floodplain that will be lost as a result of the Proposed Development in order that the flood risk from the River Ebbsfleet is not

		increased. The levels of the Access Road will be set above the 1 in 100 year plus 70% climate change, for the 2125 future epoch using the upper end climate change projections plus 300 mm freeboard.
Conclusion	It is concluded that with the proposed flood risk management strategy in place the flood risk to the Proposed Development is *low* both today and in the future. Analysis of the modelling undertaken as part of this Flood Risk Assessment (FRA) has indicated that the inclusion of the masterplan proposals including the flood risk management measures has no adverse impacts to flood extents and depths in surrounding areas. The measures proposed at the Kent Project Site (Main Resort) have the additional benefit of improving the standard of protection of the River Thames formal flood defences to 2125, benefitting not only the Proposed Development but neighbouring developments as well. Furthermore, the measures included in the Proposed Development include replacing manual flood gates with a passive flood defence embankment reducing the residual risk of failure and increasing resilience to future uncertainties. At the Essex Project Site, the Surface Water Drainage Strategy (document reference 6.2.17.2) has the additional benefit of reducing the flow into the East Dock Sewer, which is currently near capacity. The reduced flow into this channel reduces the risk of the system being overwhelmed during a storm event in the future. The Essex Project Site surface water will be discharged directly into the River Thames via a new independent system for the Proposed Development.	

1 Introduction

1.1 Background

This site-specific Flood Risk Assessment (FRA) has been prepared by Buro Happold to support a Development Consent Order (DCO) application by London Resort Company Holdings Limited (LRCH) for the London Resort. This assessment has been carried out in accordance with the National Planning Policy Framework (NPPF) (February 2019), the National Policy Statement for Ports (January 2012) and the National Policy Statement for National Networks (December 2014), as well as requirements of Regulation 5(2)(e) of The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009.

The purpose of this assessment is to assess and describe the impact of the Proposed Development in terms of flood risk. In order to comply with the NPPF, this FRA will identify the potential flood risks and demonstrate appropriate flood mitigation measures to ensure that the risk to the Project Site is acceptable for the level of development proposed and that the Proposed Development does not increase the flood risk elsewhere. A summary of the proposed stormwater drainage strategy is included within this report as well as Transport Assessment carried out for the proposed Access Road by WSP.

1.2 Site description

The London Resort Project Site lies approximately 30 km east-south-east of central London on the south and north banks of the River Thames, in the ceremonial counties of Kent and Essex. The Project Site is 413.07 hectares (ha) in area. For clarity the section of the Project Site to the south of the Thames is referred to in this document as the 'Kent Project Site' and that to the north of the river is identified as the 'Essex Project Site'. The sites are identified in Figure 1-1. They are not contiguous.

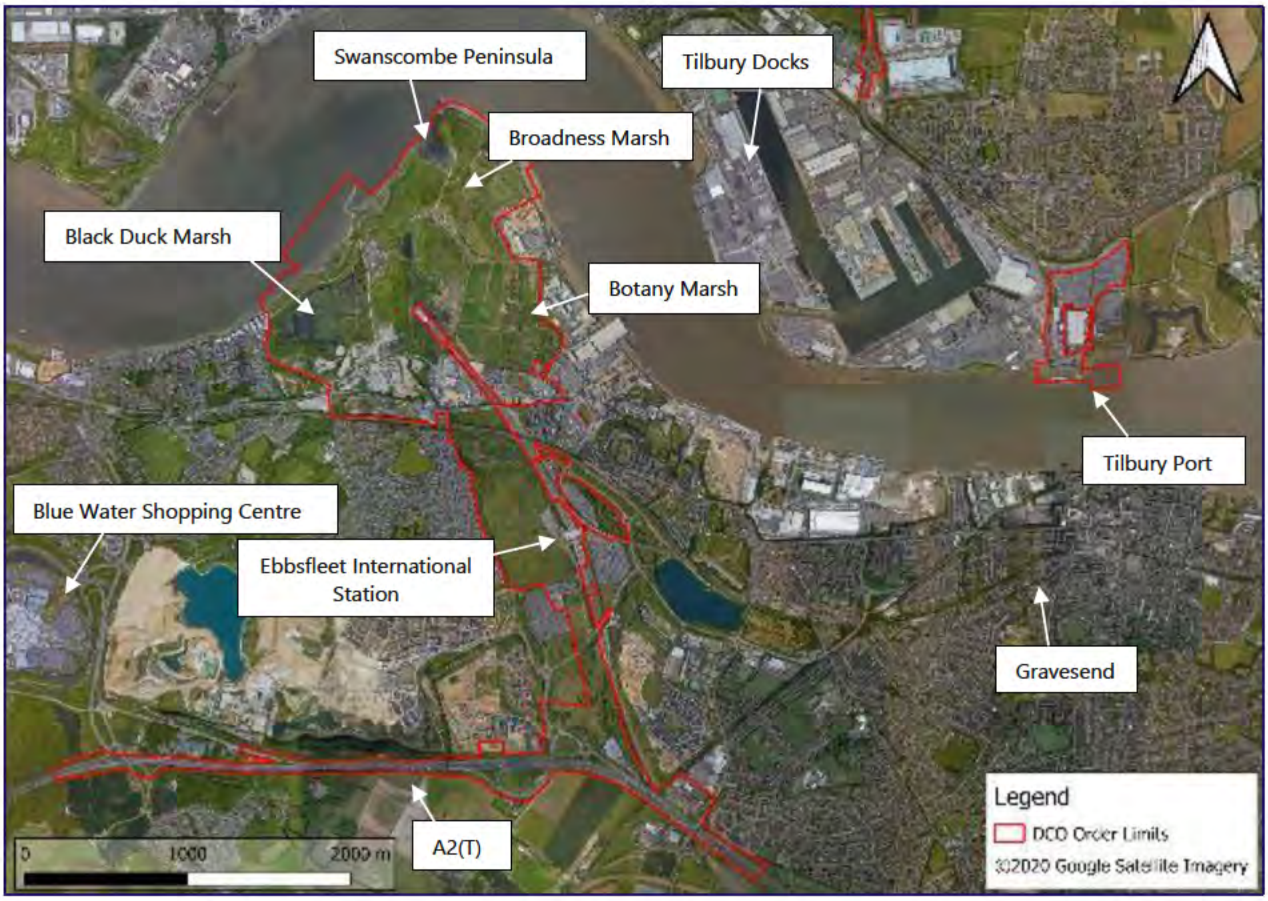

Figure 1-1: Order Limits shown in red and key places identified.

The section of the Project Site that is to the south of the River Thames is split into two further areas for the purpose of this assessment. The three areas referred to within the assessment are as follows and shown in Figure 1-2:

1. Kent Project Site (Main Resort);
2. Kent Project Site (Access Road); and
3. Essex Project Site

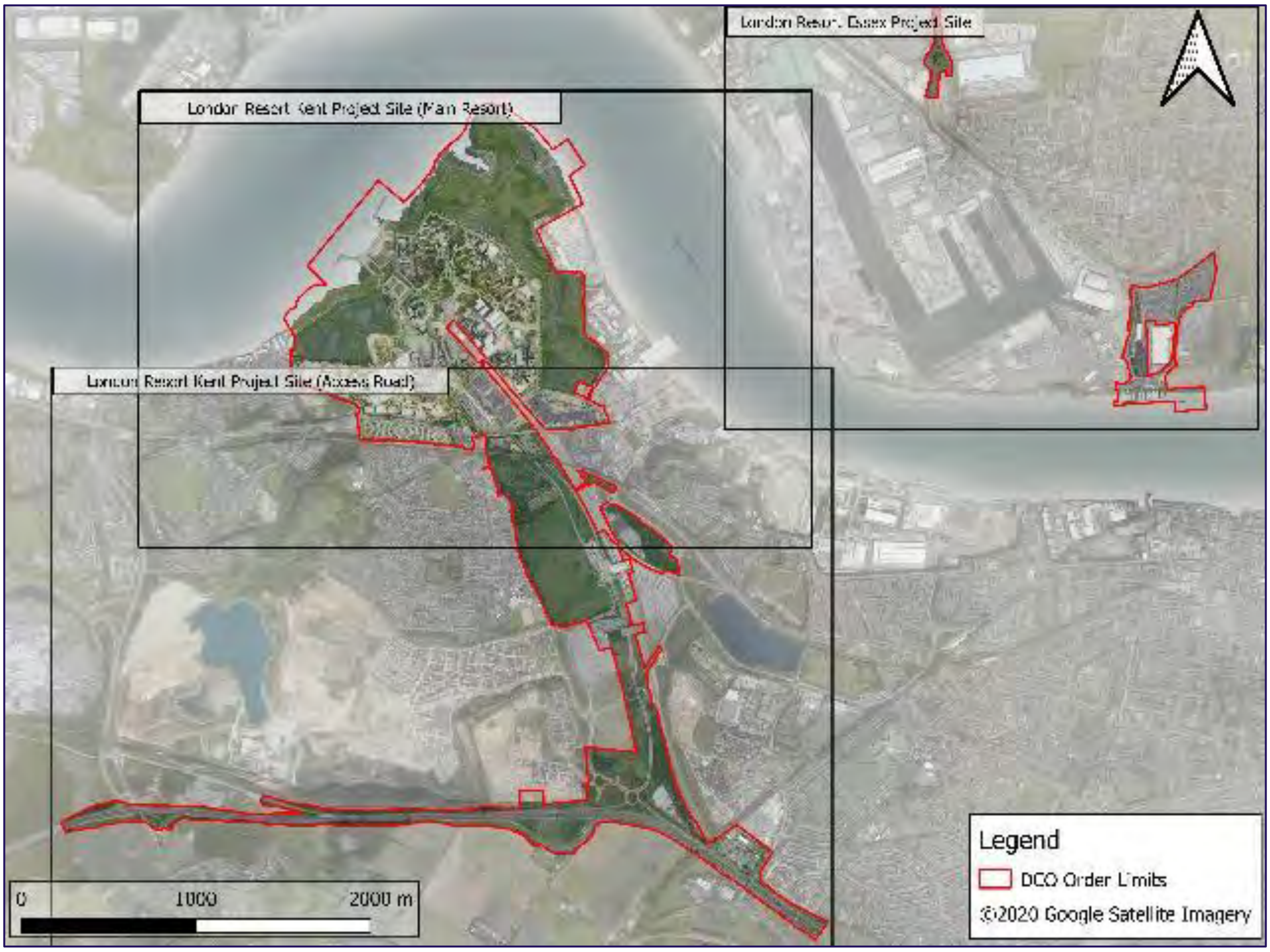

Figure 1-2: The London Resort Project Site areas

The Kent Project Site is bisected by the boroughs of Dartford Borough Council (DBC) (to the west) and Gravesham Borough Council (GBC) (to the east) and sits within both the wider administrative area of Kent County Council (KCC) who are the Lead Local Flood Authority (LLFA) and the Ebbsfleet Development Corporation (EDC) Urban Regeneration Area who are the Local Planning Authority. The Kent Project Site covers an area of approximately 387.53ha.

The Essex Project Site is within the administrative area of Thurrock Council, which is a unitary authority. The Essex Project Site covers an area of approximately 25.54ha. The majority of the Essex Project Site is on the River Thames between Tilbury Fort and Tilbury Docks. A much smaller part of the Order Limits encompasses a roundabout to the north west involving Dock Road and St Andrew's Road.

The Kent Project Sites (both the Main Resort and Access Road) are predominantly undeveloped areas. The Main Resort has existing managed marsh areas (known as Broadness Marsh, Black Duck Marsh and Botany Marsh) but is largely a historic landfill site for Cement Kiln Dust (CKD). The Main Resort has an existing functioning Leachate Water Treatment Plant to improve the water quality of overland runoff before it is discharged into the River Thames.

Topography across the Kent Project Site (Main Resort) varies from approximately 2m AOD in the marshes to greater than 8m AOD in the northern areas of Swanscombe Peninsula. Where ground levels have been artificially raised due to land fill, the peaks of the mounds can reach approximately 13m AOD (see Figure 1-3).

The Kent Project Site (Access Road), to the south of Swanscombe Peninsula, ground levels generally rise so that they are greater than 14m AOD for the majority of the site around Ebbsfleet International Station and the A2(T). There are some lower ground levels around the Ebbsfleet river valley to the east of the High Speed 1 (HS1) line (see Figure 1-4).

The Essex Project Site is currently all hardstanding and is used for storing new vehicles, car parking and the Tilbury Cruise Terminal and jetty. The topography is generally low, with the majority of the Essex Project Site below 4m AOD. The flood defences are approximately 6m AOD. Ground elevation levels reduce away from the coast (see Figure 1-5).

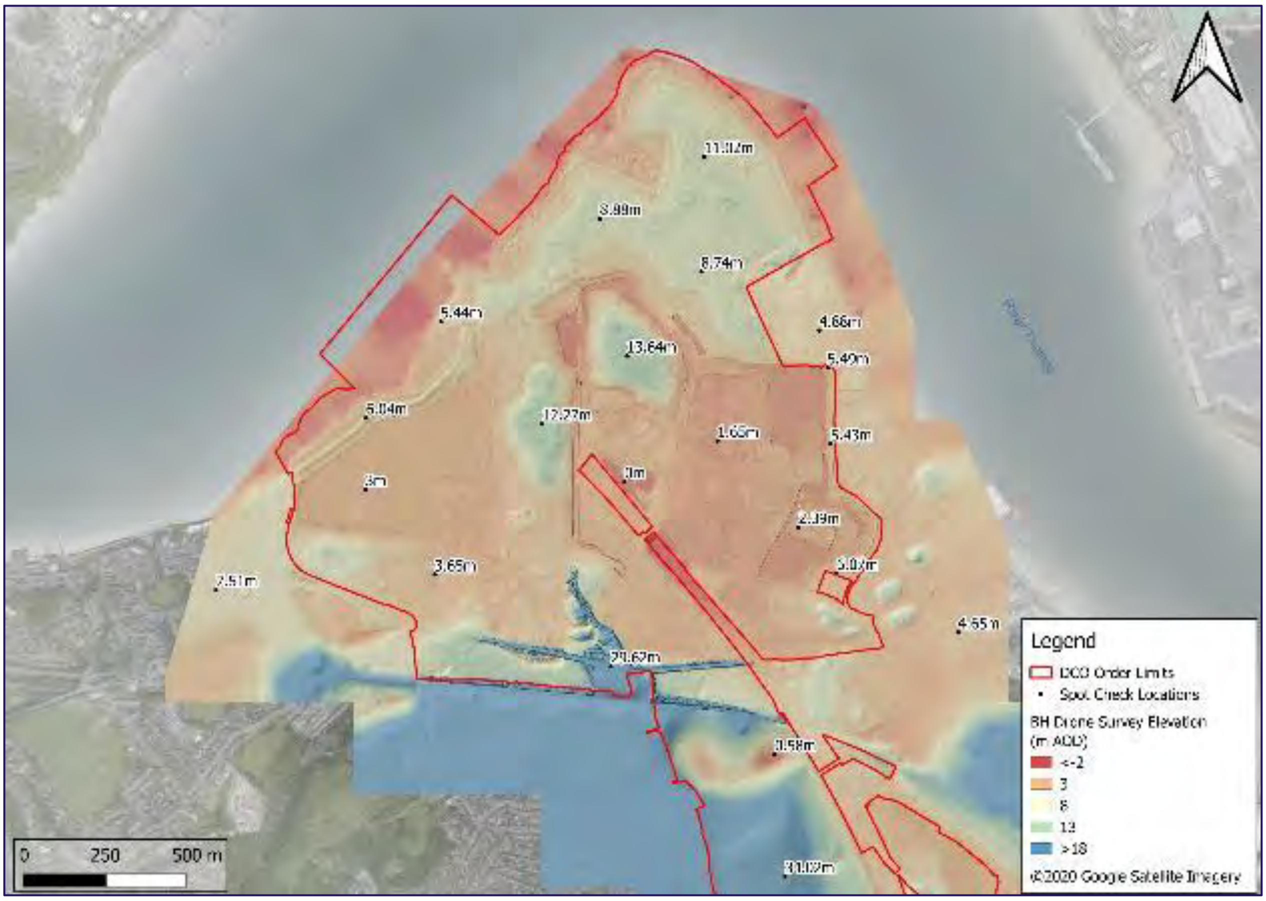

Figure 1-3: Existing flood defence alignment and crest levels for the Kent Project Site (Main Resort) taken from EA data with spot elevations from topographic survey flown July 2020.

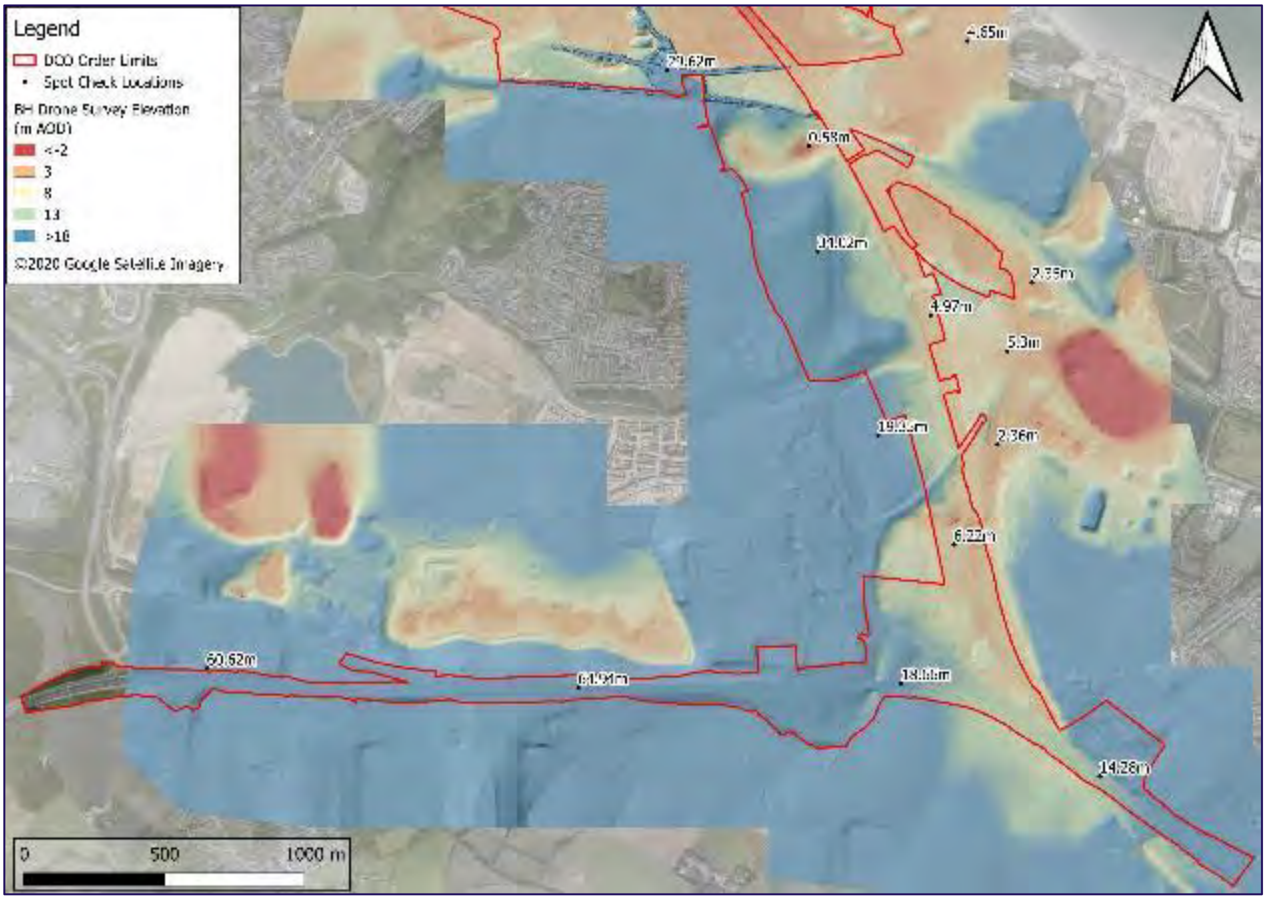

Figure 1-4: Existing flood defence alignment and crest levels for the Kent Project Site (Access Road) taken from EA data with spot elevations from topographic survey flown July 2020.

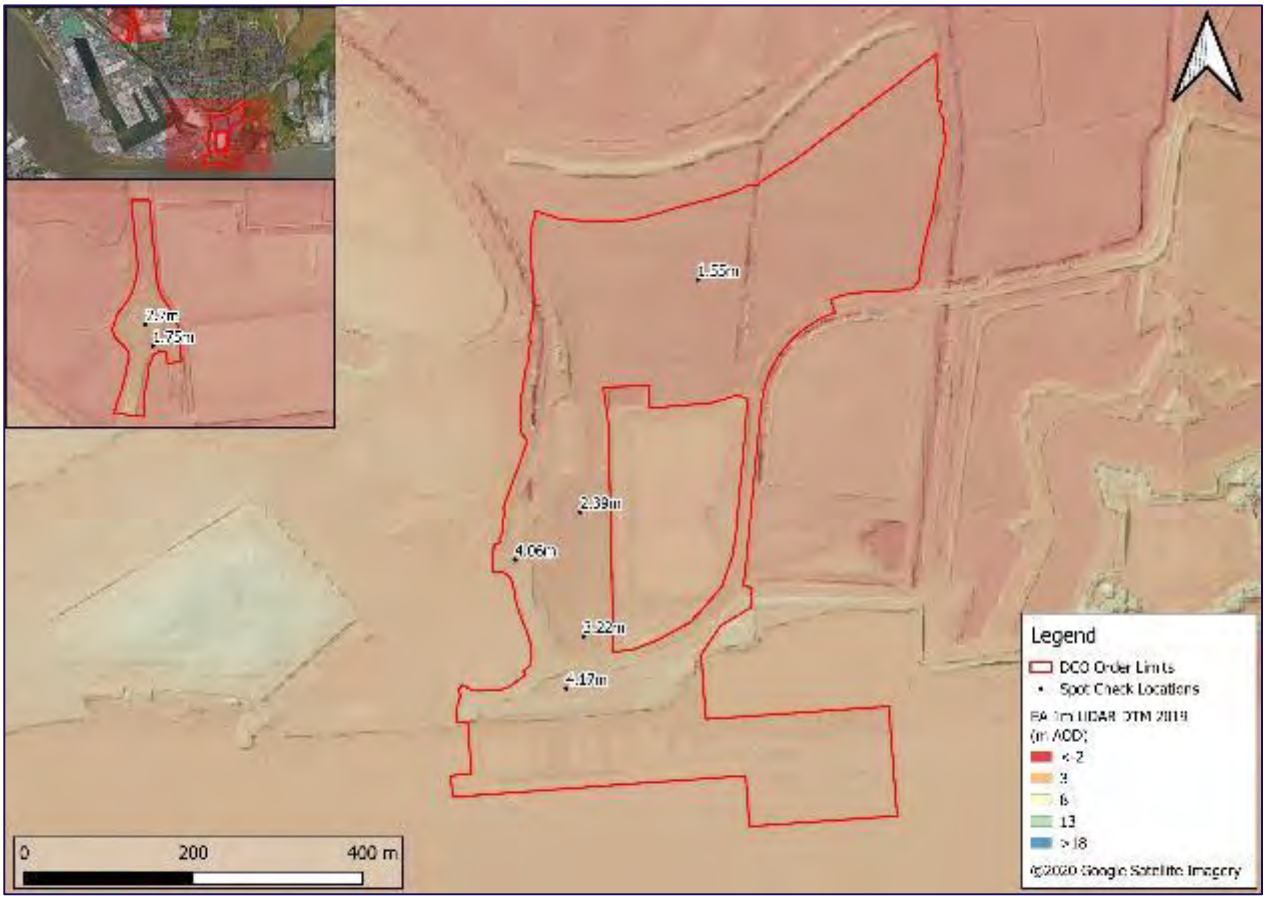

Figure 1-5: Existing flood defence alignment and crest levels taken from EA data and spot elevations of existing land levels taken from 1m LiDAR 2019 for the Essex Project Site.

1.3 Proposed Development

In summary, the Proposed Development includes:

- land remediation works;
- the Leisure Core, comprising a range of events spaces, themed rides and attractions, entertainment venues. The main theme parks would be developed in landscaped settings in two phases known as Gate One and Gate Two;
- terrain remodelling, hard and soft landscape works, amenity water features and planting;
- car parks with an overall volume of 10,750 spaces, split between the Kent and Essex Project Sites;
- pedestrian and cycle access routes and infrastructure;

- the A2(T) Highways Works comprising a signalised at-grade gyratory junction to replace two existing roundabouts at the A2(T) / B259 junction;
- public areas outside the two Gates offering a range of retail, commercial, dining and entertainment facilities in a sequence of connected public spaces including an area identified as the Market;
- four hotels providing family, upmarket, luxury and themed accommodation totalling up to 3,550 suites or 'keys'. One hotel will incorporate access to an enclosed water park;
- a 'Conferention' Centre (i.e. a combined conference and convention centre) capable of hosting a wide range of entertainment, sporting, exhibition and business events;
- a e-Sports Coliseum designed to host, video and computer gaming events and exhibitions;
- a 'Back of House' area accommodating many of the necessary supporting technical and logistical operations to enable the Entertainment Resort to function, including administrative offices, a security command and crisis centre, maintenance facilities, costuming facilities, employee administration and welfare, medical facilities, offices and storage facilities, internal roads, landscaping and employee car parking;
- a visitor centre and staff training facility;
- an operations resource centre;
- a people mover and transport interchanges;
- a Resort access road of up to four lanes (i.e. up to two lanes in each direction;
- local transport links,
- river transport infrastructure on both sides of the Thames, including the extension of the existing floating jetty at the Tilbury ferry terminal, a new floating jetty and the reconditioning of Bell Wharf at the Swanscombe Peninsula;
- utility compounds, plant and service infrastructure including an energy centre;
- a wastewater treatment works with associated sewerage and an outfall into the River Thames;
- flood defence and drainage works;

- habitat creation and enhancement and public access;
- security and safety provisions;
- data centres to support the Resort's requirements; and,
- related Housing comprising up to 500 dwellings for Resort workers. Each dwelling would typically include 4-6 bedrooms.

It is anticipated that London Resort Gate One will open in 2024, whilst Gate Two is planned to open in 2029. There is no confirmed decommission date for the Resort. The assessment is undertaken primarily on the basis of a 60-year development life (to 2090). However, considerations have been made for a 100-year development life (2125) and the flood risk impact and flood mitigation measures that may be required to keep the Resort safe in that timeframe.

1.4 Report structure

The FRA is subdivided into the following sections:

Section 3 – Planning context: This section summarises the regional and local flood risk management guidelines that apply to the Proposed Development, as well as consultation undertaken with key stakeholders. It considers the National Planning Policy Framework (NPPF) (February 2019) and sets out how the framework applies to the Proposed Development, and how the Proposed Development must satisfy the NPPF Exception Test.

Section 4 – Appraisal and management of flood risk – overview: This section summarises the approach to flood risk appraisal that is followed in the FRA. It looks at the sources of flood risk that are reviewed, the methodology followed as well as the core principles and design criteria applied.

Section 5, 6 & 7 – Appraisal and management of flood risk: These sections assess the risk from tidal, fluvial, surface water, sewer, groundwater, reservoir and artificial sources of flooding to the Project Site, divided into three main development areas: the Kent Project Site (Main Resort), Kent Project Site (Access Road) and Essex Project Site (respectively) taking into account the approach, core principles and design criteria outlined in Sections 3 and 4. The assessment considers the baseline risk to the site, identifies the flood mitigation measures required and the residual flood risk post mitigation. It also describes how the requirements of the Exception Test relevant for each site are met.

Section 8 – Stakeholder feedback: This section considers the key stakeholder requirements and summarises how the requirements have been addressed in developing the flood management strategy for the Proposed Development.

Section 9 – Summary and conclusions: This section summarises the flood risk to the site and the proposed flood risk mitigation strategy that has been developed in order to satisfy the NPPF.

2 Planning context

2.1 Overview

This FRA has been prepared in accordance with the following policies and guidelines:

- Ministry of Housing, Communities & Local Government, National Planning Policy Framework (NPPF) (February 2019);
- Department for Transport, National Policy Statement for National Networks (December 2014);
- Department for Transport, National Policy Statement for Ports (January 2012);
- Ministry of Housing, Communities & Local Government, NPPF Flood risk and coastal change Planning Practice Guidance (March 2014);
- Ministry of Housing, Communities & Local Government, Thames Estuary 2050 Growth Commission report (June 2018) (previously Thames Gateway);
- Environment Agency, Flood risk assessments: climate change allowances (July 2020);
- Environment Agency & Defra, Understanding the risks, empowering communities, building resilience: The national flood and coastal erosion risk management strategy for England (2011);
- Environment Agency, National Flood and Coastal Erosion Risk Management (FCERM) strategy for England 2011, (July 2020);
- Environment Agency, Revised National Flood and Coastal Erosion Risk Management strategy for England Policy Paper (September 2020);
- Environment Agency, Thames Estuary 2100 (TE2100) Policy Paper (May 2020);
- Environment Agency, Thames Estuary 2100 (TE2100) Plan (November 2012);
- Environment Agency, Thames Estuary 2100 (TE2100) Phase 3 Set 2 Estuary Wide Options Hydraulic modelling (December 2008);
- Environment Agency, Thames Estuary 2100 (TE2100) Design Water Levels and Future Defence Crest Levels (May 2015);
- CIRIA, The SuDS Manual (2015);
- Department for Environment, Flood and Rural Affairs, Non-Statutory Technical Standards for Sustainable Drainage Systems (TSSuDS) (March 2015);

- Environment Agency, Thames Catchment Flood Management Plan (December 2009);
- Environment Agency, South Essex Catchment Flood Management Plan – Summary Report (December 2009);
- Environment Agency, Kent North Rivers Catchment Flood Management Plan – Summary Report (December 2009);
- Kent Thameside Delivery Board, Strategic Flood Risk Assessment of Kent Thameside (2005 updated 2009);
- Kent County Council, Preliminary Flood Risk Assessment (September 2011);
- Kent County Council Draft Local Flood Risk Management Strategy (2017);
- Kent County Council, Thameside Stage 1 Surface Water Management Plan (May 2013);
- Kent County Council, Kent and Medway Growth and Infrastructure Framework (GIF) (2018);
- Dartford Borough Council, Dartford Core Strategy (September 2011);
- Dartford Development Policies Plan (July 2017);
- Dartford Local Plan Policies Map (July 2017)
- Ebbsfleet Development Corporation, Ebbsfleet Implementation Framework (2017);
- Gravesham Borough Council, Gravesham Local Plan Core Strategy (September 2014);
- Thurrock Council, Core Strategy and Policies for Management of Development, Development Plan Document (2015);
- Thurrock Council, Thurrock Local Development Framework (2015);
- Thurrock Borough Council, Strategic Flood Risk Assessment (June 2018);
- Thurrock Council, Local Flood Risk Management Strategy (2015); and
- Essex County Council, Sustainable Drainage Systems – Design Guide (2016).

2.2 National policy

2.2.1 National Planning Policy Framework

2.2.1.1 Flood zone assessment

The NPPF[1] aims to avoid inappropriate development in areas at highest risk of flooding. The Planning Practice Guidance[2] (PPG) to the NPPF contains a series of tables that help identify the risk of flooding to a development.

- Table 1 defines four flood zones based on the annual probability of river or sea flooding;
- Table 2 identifies specific land use types for each of the five flood risk vulnerability classifications (Essential Infrastructure, Highly Vulnerable, More Vulnerable, Less Vulnerable, and Water-Compatible Development). For example, office buildings are classified as Less Vulnerable; and
- Table 3 identifies where development is appropriate for each flood risk vulnerability classification and whether the Exception Test is required.

The flood zones defined in the NPPF are given in Table 2-1.

Table 2-1: Flood Zone Descriptions

Flood Zone	Annual Exceedance Probability of Flooding from Rivers or the Sea	Probability
1	Land having a less than 1 in 1,000 annual probability of river or sea flooding (land shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)	Low
2	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (land shown in light blue on the Flood Map)	Medium
3a	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding (land shown in dark blue on the Flood Map).	High
3b	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	Functional Floodplain

[1] Secretary of State for Ministry of Housing, Communities and Local Government, National Planning Policy Framework, February 2019.
[2] Ministry of Housing, Communities & Local Government, Flood Risk and Coastal Change, March 2014 https://www.gov.uk/guidance/flood-risk-and-coastal-change (accessed on 24th June 2020)

Flood Zone	Annual Exceedance Probability of Flooding from Rivers or the Sea	Probability
	and its boundaries accordingly, in agreement with the Environment Agency (not separately distinguished from Zone 3a on the Flood Map)	

2.2.1.2 Sequential Test

The Sequential Test compares a proposed development site with alternative sites to identify whether there are more appropriate locations for a given development. The NPPF guidance states that a Sequential Test is required if:

- The development is in Flood Zone 2 or 3; and
- A Sequential Test has not already been carried out for the proposed site and development type.

DBC has applied the Sequential Test[3] to a number of potential development sites within the borough, including the Swanscombe Peninsula. The Kent Project Site (Main Resort) was deemed suitable for Less Vulnerable land uses and is identified as requiring a Site Level FRA for the Exception Test.

The Swanscombe Peninsula has been identified in the Dartford Core Strategy (2011)[4], in the Gravesham Local Plan Core Strategy (2014)[5] as an area of potential development within the broader Waterfront Priority Area. In the Dartford Development Policies Plan (2017) the 'London Resort' leisure proposal has been identified within the EDC area at Swanscombe Peninsula. The document states that the project is expected to be considered as a National Significant Infrastructure Project (NSIP).

The Essex Project Site has been identified within the Thurrock Core Strategy and Policies for Management and Development [6] as a key centre for development and change.

The London Resort Environmental Impact Assessment (EIA) Scoping Opinion: Proposed London Resort Development (July 2020) and the London Resort Environmental Statement Chapter 4: Project Development and Alternatives (Chapter 4) describes the process that was applied to the selection of the Swanscombe Peninsula site for the

[3] Dartford Borough Council, June 2020; *'Flood Risk Sequential Test Dartford's Borough Wide Assessment'*
[4]Dartford Borough Council, September 2011; *'Dartford Core Strategy'*
http://windmz.dartford.gov.uk/media/inspector%20approved%20core%20strategy.pdf (Accessed on 01/07/2020)
[5]Gravesham Borough Council, September 2014; *'Gravesham Local Plan Core Strategy'*
https://drive.google.com/file/d/1bJTgQLmhbzjqZFibl-5WFb2tbvixXpLk/view (Accessed on 01/07/2020)
[6] Thurrock Council, January 2015; *'Core Strategy and Policies for Management and Development (as amended)'*
https://www.thurrock.gov.uk/sites/default/files/assets/documents/core_strategy_adopted_2011_amended_2015.pdf (Accessed on 01/07/2020)

Proposed Development. Site selection criteria were used to identify a number of areas of search, within proximity to London. Against these criteria nine other potential sites were identified, six within the Olympic Park Legacy development sites in East London, one in Marston Vale near Milton Keynes, one along the A12 to the north of Chelmsford and one on the Northern M25 corridor near St Albans. The Swanscombe Peninsula was considered the best option by the Applicant.

2.2.1.3 Exception Test

The Exception Test is a means of demonstrating that flood risk can be managed at a proposed development, allowing development to proceed when suitable sites of lower flood risk are not available. The NPPF outlines requirement for the Exception Test according to flood risk vulnerability and flood zone compatibility, as shown in Table 2-2.

Table 2-2: NPPF flood risk vulnerability and Flood Zone compatibility

Flood Zone	Flood Risk Vulnerability Classification				
	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Zone 1	Y	Y	Y	Y	Y
Zone 2	Y	Y	Exception Test Required	Y	Y
Zone 3a	Exception Test Required	Y	N	Exception Test Required	Y
Zone 3b (Functional Floodplain)	Exception Test Required	Y	N	N	N

Y = Development is appropriate

N = Development should not be permitted

The land uses identified for the Proposed Development and their vulnerability classification are given below in Table 2-3. The following sections indicate the risk associated for the different land uses from the different sources of flooding.

Table 2-3: Proposed Development vulnerability Kent Project Site (Main Resort)

Item of Proposed Development	Vulnerability Classification
Hotels	More Vulnerable
'Conferention Centre'	Less Vulnerable
e-Sports Arena	Less Vulnerable
Market	Less Vulnerable
Gate One	Less Vulnerable
Gate Two	Less Vulnerable
Plaza	Less Vulnerable
Car Parks	Less Vulnerable
Visitor Centre	Less Vulnerable
Bell Wharf warehouses	Less Vulnerable
Bell Wharf warehouses with critical infrastructure	Essential Infrastructure
Ferry Terminal	Less Vulnerable
Telecommunication Mast	Highly Vulnerable
Related Housing	More Vulnerable
Waste Water Treatment Plan	Essential Infrastructure
Back of House East	Less Vulnerable
Back of House West	Less Vulnerable
Electricity Sub Station	Essential Infrastructure

Figure 2-1 Proposed Development components of the Kent Project Site (Main Resort) and their vulnerability classifications

Table 2-4: Proposed Development vulnerability Kent Project Site (Access Road)

Item of Proposed Development	Vulnerability Classification
London Resort Access Road	Essential Infrastructure
Utility Compound	Essential Infrastructure

Figure 2-2: Proposed Development components of the Kent Project Site (Access Road) and their vulnerability classifications.

Table 2-5: Proposed Development vulnerability Essex Project Site

Item of Proposed Development	Vulnerability Classification
Car Park	Less Vulnerable
Passenger plaza	Less Vulnerable
Jetty	Water Compatible

Figure 2-3 Proposed development components of the Essex Project Site and their vulnerability classifications

Through the Exception Test, development may be permitted if it can be demonstrated that:

1. The development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment where one has been prepared; and
2. The Development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

DBC (Dartford Core Strategy 2011) has carried out a high-level assessment of the application of the Exception Test to the Kent Project Site and identified that the site as *"likely to pass the Exception Test in an FRA, subject to mitigation"*.

The Exception Test has been further detailed for each of the three Project Site areas in the following Section 5 to 7. This has been undertaken for each site based on the specific development proposals and their vulnerability classification in relation to the flood risk identified.

2.2.2 Climate change

Allowances for the predicted effects of climate change should be taken into account when preparing site specific FRAs. The guidance[7] published by the EA in July 2020 to support the NPPF contains sensitivity ranges that are recommended to be applied to peak rainfall intensities, peak river flood, sea level rises, offshore wind speeds, and extreme wave heights. The general trend is for each parameter to increase in the future, which in turn increases the risk of flooding to any site.

The UK Climate Projections 2018 (UKCP18) guidance is the most up to date climate change guidance for sea level rise in the UK.

Table 2-7 shows the guidance for sea level rise for the Higher Central and Upper End Projections. The Higher Central projections are those that are surpassed by only 30% of the projection scenarios. The Upper End projections are those that are surpassed by only 5% of projection scenarios. Table 2-8 shows the guidance for sea level rise for the H++ scenario. The H++ scenarios are climate change projections designed to explore the high-end plausible future sea level rise should sea level rise exceed model predictions. Table 2-6 shows the previous UKCP09 sea level rise guidance.

Table 2-6: UKCP09 Sea level rise guidance (mm/year)

UKCP09					
Area of England	**Allowance**	**1990 to 2025**	**2026 to 2055**	**2056 to 2085**	**2086 to 2115**
South East	-	4	8.5	12	15

Table 2-7: UKCP18 Sea Level Rise guidance (mm/year)

UKCP18					
Area of England	**Allowance**	**2000 to 2035**	**2036 to 2065**	**2066 to 2095**	**2096 to 2125**
South East	Higher Central	5.7	8.7	11.6	13.1
South East	Upper End	6.9	11.3	15.8	18.2

[7] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Table 2-8: UKCP18 Sea Level Rise guidance (H++)

Allowance Category	Total sea level rise to 2100
H++ scenario	1.9m

The recommended allowance for peak rainfall intensity is given in Table 2-9.

Table 2-9: Peak rainfall intensity allowance in small and urban catchments (use 1961 to 1990 baseline)

Allowance Category	Total potential change anticipated for 2010 to 2039	Total potential change anticipated for 2040 to 2059	Total potential change anticipated for 2060 to 2115
Upper End	+10%	+20%	+40%
Central	+5%	+10%	+20%

The recommended allowance for peak river flow is given in Table 2-10.

Table 2-10: Peak river flow allowances by river basin district (use 1961 to 1990 baseline)

Allowance Category	Total potential change anticipated for 2010 to 2039	Total potential change anticipated for 2040 to 2059	Total potential change anticipated for 2060 to 2115
H++	25%	40%	80%
Upper End	25%	35%	70%
Higher Central	15%	25%	35%
Central	10%	15%	25%

The full NPPF tables are shown in Appendix A.

2.2.3 National Flood and Coastal Erosion Risk Management Strategy

The National Flood and Coastal Erosion Risk Management Strategy (FCERM) (September 2020) authored by the EA sets out a long-term vision for a nation that is ready for and resilient to flooding and coastal change up to the year 2100. The document highlights three ambitions:

- **Climate resilient places**: working with partners to bolster resilience to flooding and coastal change across the nation both now and in the face of climate change;
- **Today's growth and infrastructure resilient in tomorrow's climate**: making the right investment and planning decisions to secure sustainable growth and environmental improvements, as well as infrastructure resilient to flooding and coastal change; and
- **A nation ready to respond and adapt to flooding and coastal change**: Ensuring local people understand their risk of flooding and coastal change and know their responsibilities and how to take action.

This strategy, published in 2020, is an update to the original National FCERM document developed by the EA and Defra in 2011. To reflect government policy the updated document emphasises greener and cleaner climate resilience measures.

2.3 Regional policy

2.3.1 The Thames Estuary 2100 Plan

The Thames Estuary 2100 (TE2100) Plan (November 2012)[8] sets out the government's recommendations for the management of flood risk in London and the Thames Estuary to the end of the century and beyond.

Policy Unit Swanscombe & Northfleet and Policy Unit Purfleet, Grays & Tilbury are identified in action zone 5 with the recommended flood risk management policy P4. They are identified to be at risk from tidal, fluvial, local drainage (and groundwater in Swanscombe & Northfleet) sources of flooding. The main floodplain management for property across Swanscombe is 'Priority Evacuation or Take Refuge'. Further details of the source of flooding are provided in Sections 5-7 of this FRA.

The TE2100 Plan and supporting documents defines the level the River Thames tidal flood defences must be raised at certain dates in the future in order to accommodate rising flood levels caused by climate change. The flood defence levels relevant to the Proposed Development are summarised in Table 2-11. The Kent Project Site (both Main Resort and Access Road) is located between model nodes 3.20 to 3.23 and the Essex Project Site at model node 3.25. The levels in the table below are based on providing a Standard of Protection (SoP) to the 1 in 1000 year flood level now and in the future with appropriate freeboard to allow for uncertainty. Uncertainties include extreme surge tide water levels and uncertainties in barrier closure water levels.

[8] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/322061/LIT7540_43858f.pdf

Table 2-11: Defence levels downriver of the Thames Barrier, extract from the 2015 TE2100 guidance (LB is left bank and RB is right bank). Values shown in bold relate to the Project Site location.

Defence Levels downriver of Thames Barrier		Existing defence levels (2009)		Options 1.4* & 3.2**		Option 1.4		Option 1.4		Option 3.2	
				Defence levels required in 2040		Defence levels required in 2070		Defence levels required in 2120		Defence levels required in 2070	
				(for period 2040 to 2070)		(for period 2070 to 2120)		(for period 2120 to 2170)		(for period 2070 to 2170)	
Location	Node	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB
Darent	3.20	6.85	6.28	7.00	**7.00**	7.50	**7.50**	8.00	**8.00**	8.50	**8.00**
	3.21	6.90	7.05	7.00	**7.00**	7.50	**7.50**	8.00	**8.00**	8.50	**8.00**
	3.22	6.85	7.05	7.00	**7.00**	7.50	**7.50**	7.90	**7.90**	8.00	**8.00**
	3.23	6.85	6.75	7.00	**7.00**	7.50	**7.50**	7.90	**7.90**	8.00	**8.00**
	3.24	6.50	6.73	6.90	6.90	7.40	7.40	7.90	7.90	8.00	8.00
Tilbury	3.25	6.95	6.87	**6.90**	6.90	**7.40**	7.40	**7.90**	7.90	**8.00**	8.00

**Option 1.4 includes the improvement of the Thames Barrier at its current location.*
***Option 3.2 includes the construction of a new Thames Barrier at Long Reach.*

Figure 2-4: Thames Estuary modelling key 1D node locations

The TE2100 Plan states that the Thames Barrier is expected to continue to protect London to its current standard up until 2070. As indicated in Table 2-11 the formal flood defences at the Project Site require a minimum crest level of **7.00m AOD** in order to provide the minimum level of protection to the site until 2070.

The TE2100 Plan indicates that there are currently three options for improving tidal defences in the River Thames as follows:

1. Option 1.4: Upgrade the existing Thames Barrier;
2. Option 3.1: Construct a new barrier at Tilbury; and,
3. Option 3.2: Construct a new barrier at Long Reach.

The TE2100 is an adaptive plan and as such, the final preferred option is unlikely to be made until closer to 2050. The indicative proposed location for each of the three options is shown in Figure 2-5.

Figure 2-5: TE2100 proposed Thames Barrier improvement locations (Existing Barrier is Option 1.4; Tilbury Barrier is Option 3.1; Long Reach Barrier is Option 3.2)

As part of the consultation to date, the EA has advised that the TE2100 model is currently being updated to take account of the latest climate change projections, as well as to assess the various tidal barrier options for the Thames Estuary strategy. The EA is not able to state when the model will be available, but it is understood that it will not be ready until after the DCO submission. The approach described in this document has been agreed with the EA through the consultation process. The final scheme will be reviewed against the updated TE2100 Plan when it becomes available post DCO submission.

The EA has also advised that the modelled water levels are slightly higher with a barrier at Long Reach (Option 3.2) because of there being less storage available in the estuary and the reflective wave off the barrier. As such, the EA advise that developers should address the worst-case future defence crest levels across the different future Thames Barrier options to preserve the ability to implement all of the options. The future crest level should therefore be taken as **8m AOD** for the Kent Project Site, based on Option 3.2, (a barrier at Long Reach) to protect against events post 2070.

The standard of protection that must be adopted for the tidal defences is 1 in 1,000-years taking account of future climate change.

2.3.2 Catchment Flood Management Plan

The Project Site is located approximately 8km downstream of the Thames Catchment Flood Management Plan (CFMP) and therefore is outside of the management policies derived in the plan. However, the North Kent Rivers CFMP and South Essex CFMP are specific to the Project Site.

The North Kent Rivers CFMP aims to establish long term flood risk management policies which will deliver sustainable flood risk management for the North Kent Rivers Catchment. The assessment considers all types of inland flooding from rivers, groundwater, surface water and tidal flooding.

The North Kent Rivers CFMP groups areas by likeness and the Kent Project Site (both Main Resort and Access Road) resides within the North Kent Marshes category. The document policy for this category supports economic, social and environmental development by maintaining the current level of risk but accepting the impacts of flooding will increase with time due to climate change. The document recommends:

- Encourage floodplain resilience;
- Ensure flood risk management does not adversely affect conservation interest in the marshes;
- Investigating opportunities to create and restore wetland habitat in the marshes; and
- Maintain outfalls for elvers and fishing interest.

The South Essex CFMP aims to establish long term flood risk management policies which will deliver sustainable flood risk management for the South Essex Catchment. The assessment considers all types of inland flooding from rivers, groundwater, surface water and tidal flooding.

The South Essex CFMP groups areas by likeness and the Essex Project Site resides within the Thames Urban Tidal category. The document recognises that the risk of flooding cannot be removed, but that flood risk is currently being managed effectively. The document recommends:

- A focus on maintenance to manage future flood risk;

- Improved public awareness and communication of flood warning systems;
- Developing emergency response plans in case of defence failure or overtopping; and
- Selecting appropriate land use types and ensuring new developments are resilient to flooding.

The document also notes that groundwater flooding is a risk in the chalk areas around Thurrock and Tilbury where there are high groundwater levels in the underlying rock. However, it goes on to state that there have been no records of groundwater flooding in the South Essex CFMP area.

2.3.3 Thames Estuary 2050 Growth Commission

The Thames Estuary 2050 Growth Commission was established in March 2016 to develop a vision and delivery plan for growth in north Kent, south Essex and east London.

The Thames Estuary 2050 Growth Commission 2050 Vision document (July 2018) identifies the Swanscombe Peninsula as one of the commissions priority areas for change, focussing on job creation and environmental reintegration. The commission encourages Joint Spatial Plans in Kent and Essex, embracing the River Thames as the heart to the region.

2.4 Local policy

2.4.1 Kent Project Site

2.4.1.1 Kent Thameside Strategic Flood Risk Assessment (2005 updated in 2009)

Local authorities are required to carry out a Strategic Flood Risk Assessment (SFRA), which is to be used by developers as guidance on the authority's approach to avoiding, reducing and managing flood risk.

The Kent Project Site is bisected by the municipal boundary between the boroughs of DBC (to the west) and GBC Council (to the east). The two authorities are combined into one area, known as Kent Thameside, for the undertaking of the SFRA.

The Kent Thameside SFRA has been carried out in three stages. The Stage 1 SFRA[9] report provides a review of the baseline date obtained for the purposes of carrying out the SFRA.

The Stage 2 SFRA report was prepared to identify:

[9] Entec UK Limited, December 2005; '*Kent Thameside Delivery Board: Strategic Flood Risk Assessment of Kent Thameside Stage 1: Collection and review of baseline information*'.

3. Areas and principal development sites that are at risk of flooding;
4. Variations in flood risk within Flood Zone 3, including the presence and standard of any flood defences;
5. The effect of flood defence failure by breaches in the flood defences; and
6. The effect of the increase in surface water run-off from Proposed Development.

The Stage 3 SFRA[10] report provides an assessment of the residual risk to development areas following the modelling and flood risk mapping carried out in Stage 2.

The following potential sources of flooding in Kent Thameside are described within the SFRA:

- The River Thames;
- Surface water;
- Failure of drainage infrastructure; and
- Groundwater.

The primary flood risk to Kent Thameside and to the Proposed Development is from a tidal surge in the River Thames, either through overtopping or failure of the existing flood defences along the riverbank. The focus of the SFRA is therefore on the consequences of the defences being overtopped by an extreme high tide and of the failure of the defences resulting in a breach event.

The SFRA provides commentary on the responsibility for flood defences and the laws in place that require works undertaken close to defences as summarised below:

'…the responsibility for provision, maintenance and improvement of flood defences rests with the riparian owner. The Environment Agency (EA) has no statutory duty to do this work, it does, however, have permissive powers to undertake flood defence works.

The River Thames within Southern Region is not a designated 'main' river. The estuary is treated as a coastal location and the Sea Defence Byelaws 1981 apply. Prior consent of the Environment Agency is required for most works between low water mark and a line fifteen metres inland from the landward toe of any flood defence. The EA seeks to retain this 15 metre wide 'byelaw margin' free from obstruction. Consent under byelaws is separate from, and additional to, any planning consent.

[10] Entec UK Limited, December 2005; '*Kent Thameside Delivery Board: Strategic Flood Risk Assessment of Kent Thameside Stage 3*'

...The River Ebbsfleet (along with some smaller watercourses in the area) are designated main rivers and the provisions of the Water Resources Act 1991 apply to works in, over or under, the channel of the watercourse. For these non-tidal main rivers an eight metre wide byelaw margin applies. In tidal rivers such as the River Thames, the margin is generally increased to at least 16 m. As above, the EA seeks to retain this eight metre wide 'byelaw margin' free from obstruction.'[11]

The original Stage 2 SFRA report was prepared in December 2005 and was subsequently revised by a SFRA Update[12] in December 2009.

2.4.1.2 Kent County Council, Preliminary Flood Risk Assessment (2011)

The Kent County Council, Preliminary Flood Risk Assessment (2011) has been prepared to identify areas in which the risk of surface water and groundwater flooding is significant and warrants further examination through the production of maps and management plans.

The document identifies surface water flooding and groundwater flooding as being sources of high risk to properties in Kent. Kent has the greatest number of properties at risk from surface water flooding than any other LLFA in the UK.

2.4.1.3 Kent County Council Draft Local Flood Risk Management Strategy (2017)

The Kent County Council Draft Local Flood Risk Management Strategy (2017) presents a strategy for managing risk from the following sources for the period 2017 - 2023:

- Surface Runoff;
- Ordinary Watercourses; and
- Groundwater.

This document is an update to the KCC local strategy developed in 2013 for the period 2013 – 2017. The document identifies six geographical areas as focus areas for local flood risk management. The Project Site is not included in any of these areas.

2.4.1.4 Kent County Council Thameside Stage 1 Surface Water Management Plan (2013)

The Kent County Council Thameside Stage 1 Surface Water Management Plan (SWMP) (2013) study area combines both Gravesham and Dartford, located south east of London and west of Medway. This study area includes the entirety of the Kent Project Site. The

[11] Page 30. Entec UK Limited, December 2005; 'Kent Thameside Delivery Board: Strategic Flood Risk Assessment of Kent Thameside'
[12] Entec UK Limited, December 2009; '*Kent Thameside Delivery Board: Updating the SFRA*'.

SWMP investigates local flood risks in Kent Thameside and identifies what further work is needed for flood risk management.

The SWMP identifies the Kent Project Site as being within the several EA designated Groundwater Source Protection Zones. The Kent Project Site (Main Resort) on the Swanscombe Peninsula is partially within Zone III. The Kent Project Site (Access Road) is within Zones I, II and III.

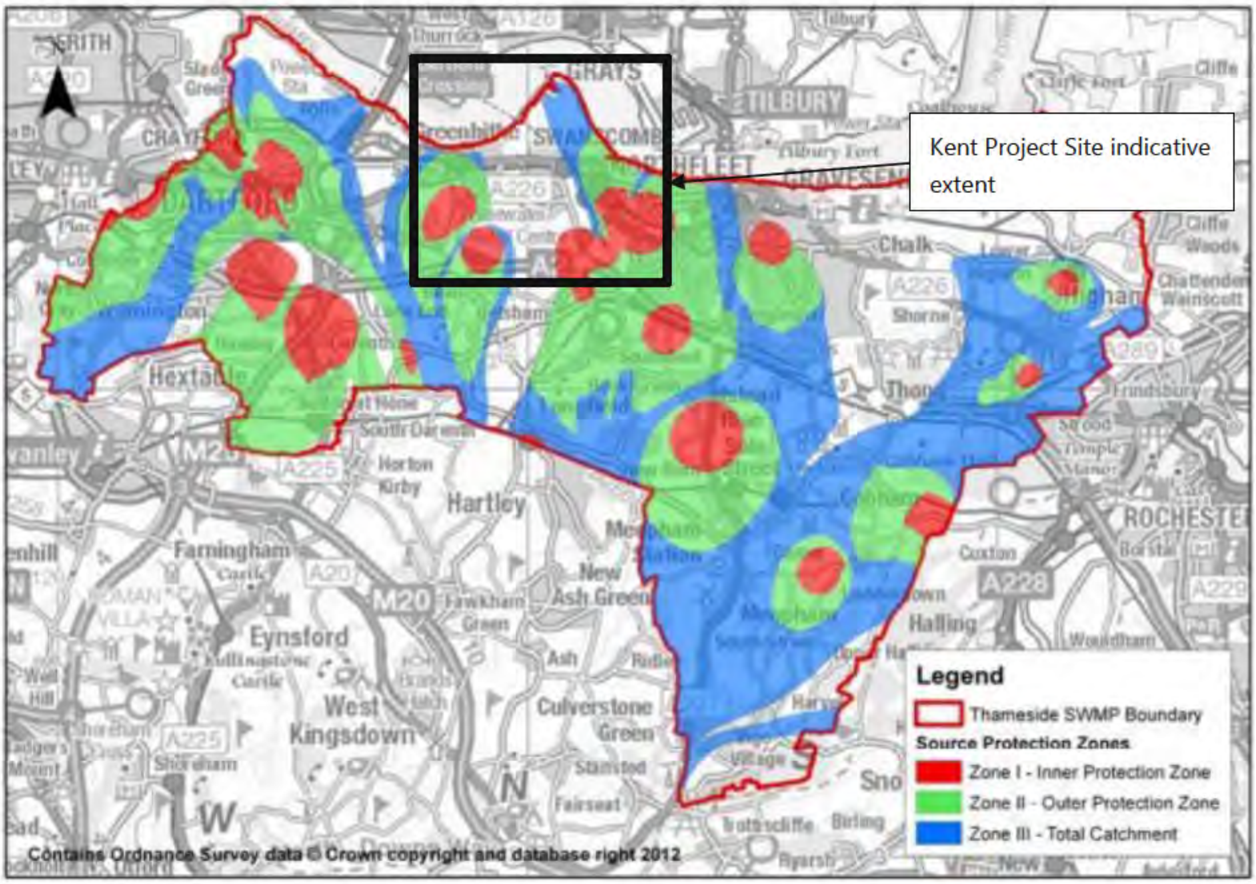

Figure 2-6: Kent Groundwater Protection Zones (adapted from an image in the KCC SWMP (12/10/2020)

The SWMP also documents that there is anecdotal evidence that Manor Way floods extensively due to surface water drainage issues. Manor Way is within the London Resort Order Limits.

2.4.1.5 Kent County Council, Kent and Medway Growth and Infrastructure Framework (2018 Update)

The Growth and Infrastructure Framework (GIF) provides a strategic framework across the County, for identifying and prioritising investment across a range of infrastructure, for planned growth up to 2031. Under flood protection, the framework recognises that

'*Sustainable Drainage Systems (SuDS) offer opportunities to mimic natural drainage that can reduce flood risk and offer other benefits, such as amenity space and habitats*.'

2.4.1.6 Dartford Borough Council. Dartford Core Strategy (2011)

This document sets out DBC's long-term spatial strategy for the Borough to 2026. Alongside with other local development framework documents this document will form the statutory development plan for Dartford, the basis for planning decisions within the Borough.

The document identifies the Ebbsfleet Valley and the Swanscombe Peninsula as being areas of interest for strategic development. The objectives this document holds for these developments are as follows:

- Improvement of the public realm;
- Physical integration with its surroundings;
- Provision of attractive gateways into Swanscombe;
- Improvement of housing quality and increasing the range of housing choice;
- Improved access to retail, cultural, leisure and commercial facilities; and
- Improved walking, cycling and public transport provision.

2.4.1.7 Dartford Borough Council, Dartford Development Policies Plan (July 2017)

The Development Plan forms the starting point for most applications on planning applications. Documents produced for the Development Plan are known as Local Plans and in Dartford these consist of the Core Strategy (2011) and this Development Policies Plan. The Development Policies Plan was adopted by Dartford Borough Council on 17 July 2017.

The Development plan identifies the 'London Resort' leisure proposal as being a NSIP proposed for the Swanscombe Peninsula.

2.4.1.8 Gravesham Borough Council, Gravesham Local Plan Core Strategy (2014)

The Gravesham Local Plan Core Strategy is the main document in the Gravesham Local Plan (a collection of planning documents that will be used to plan the future of Gravesham Borough and to determine individual planning applications) and represents the overarching strategic document. Gravesham intersects the eastern part of the Kent Project Site.

The Gravesham Local Plan Core Strategy sets out a vision for Gravesham which includes reinventing and regenerating the borough from an area with predominantly heavy riverside industry to one that offers a more diverse range of employment and housing. As with the Dartford Core Strategy, the Gravesham Local Plan Core Strategy identifies the Ebbsfleet Valley and the Swanscombe Peninsula as opportunities for development.

2.4.1.9 Ebbsfleet Development Corporation (EDC), Ebbsfleet Implementation Framework (2017)

The Implementation Framework developed by the EDC sets out the shared ambition and structure for the proposed developments that make up part of the Government sponsored Ebbsfleet 'Garden City'. The Swanscombe Peninsula is within the EDC Urban Regeneration Area.

The site allocation for the London Resort proposals within the Swanscombe peninsula are described, and the Implementation Framework comments that a comprehensive masterplan approach considering flood risk, transport and access (amongst other items) should be considered. The document sets out a further ambition that the development and infrastructure within the Swanscombe peninsula will respect the flood risk zones and be planned to the highest possible levels of resilience so as to promote a sustainable long term response to climate change.

2.4.2 Essex Project Site

2.4.2.1 Thurrock Borough Council Strategic Flood Risk Assessment (2018)

The Essex Project Site is within the Thurrock Council administrative area. The Thurrock Council Level 1 Strategic Flood Risk Assessment (June 2018)[13] was written to:

1. Refine information on the areas that may flood considering all sources of flooding and the impacts of climate change in accordance with latest guidance;
4. Inform the Sustainability Appraisal process, so that flood risk is fully considered;
5. Inform the application of the Sequential and, if necessary, Exception Tests in the allocation of future development sites, as required by the NPPF and planning application process;
6. Identify the requirements for site-specific Flood Risk Assessments;
7. Inform the preparation of flood risk policy and guidance;

[13] AECOM, June 2018; *'Thurrock Borough Council Level 1 Strategic Flood Risk Assessment'* https://regs.thurrock.gov.uk/online-applications-skin/thurrock-strategic/sfra_201806/lptech-thurrock-sfra1-201806-v01.pdf (accessed on 01/07/2020)

8. Determine the acceptability of flood risk in relation to emergency planning capability; and
9. Consider opportunities to reduce flood risk to existing communities and developments through better management of surface water, provision for conveyance and storage for flood water.

2.4.2.2 Thurrock Council Core Strategy and Policies for Management of Development 2015

The Thurrock *Core Strategy and Policies for Management of Development, Development Plan Document* (Core Strategy) (TC, 2015) is a strategic document providing broad guidance on the scale and distribution of development and the provision of supporting infrastructure. It contains core strategies (CS) for water and policies for management of development (PMD) in relation to flood risk. CSTP27 – *Management and reduction of flood risk* states, amongst others, that the Council will ensure that, where necessary, new development contains space for water including naturalisation and environmental enhancement. Developers will be required to incorporate Sustainable Drainage Systems (SuDS) as a priority and to contribute towards flood risk management infrastructure where appropriate. In PMD15 – *Flood Risk Assessment* it is further emphasised that developments will be expected to incorporate SuDS to reduce the risk of surface water flooding, both to the site in question and to the surrounding area. Where the potential for surface water flooding has been identified, site specific Flood Risk Assessments should ensure that suitable SuDS techniques are incorporated as part of the redevelopment.

2.4.2.3 Thurrock Local Flood Risk Management Strategy (2015)

This Thurrock Local Flood Risk Management Strategy (2015) was developed by TC as the LLFA in order to provide a framework for how to manage local flood risk in Thurrock. Local source of flood risk is from ordinary watercourses, surface water and groundwater.

The document identifies surface water flood risk in the Tilbury Riverside ward located in Tilbury and Tilbury Dock. The document identifies areas of critical drainage (AoCD). AoCDs are a discrete geographical area where multiple sources of flood risk may cause flooding during severe weather, affecting people, property or infrastructure. Tilbury is identified as an AoCD. Figure 2-7 shows these AoCDs on a plan.

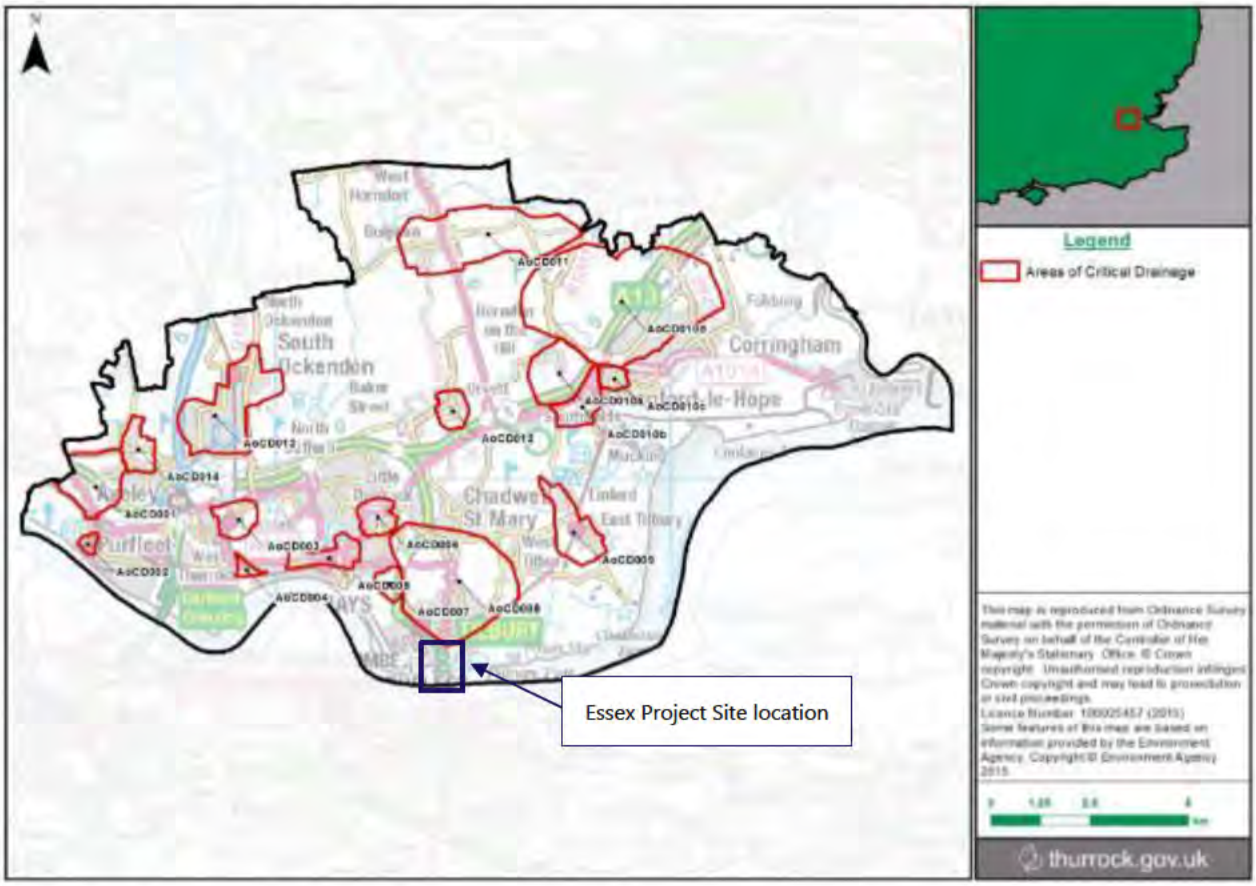

Figure 2-7: Thurrock Council Areas of Critical Drainage (Thurrock Local Flood Risk Management Strategy, Thurrock Council, December 2015)

2.4.2.4 Essex County Council, Sustainable Drainage Systems Design Guide (2016)

The Sustainable Drainage Systems – Design Guide (ECC, 2016) provides design criteria based on local principles and local standards detailing the purpose, construction and functioning of SuDS. The local standard requires that one designs for water quantity with requirements for runoff rate, runoff volume and storage volume. For an outfall to a tidal estuary, SuDS should be sized to accommodate storm run-off during times when the outfall is tidelocked. The storage provision should be calculated by modelling a 1 in 100 inclusive of climate change rainfall event and 1 in 20 inclusive of climate change tidal event coinciding. The guidance also requires that SuDS are designed with regard to water quality, based on an appropriate 'train' of SuDS components installed to reduce the risk of pollutants entering watercourses via runoff from developed sites. Interception storage should be used as part of the treatment train to ensure that pollutants are managed at source, which will reduce the risk of them contaminating water bodies.

2.5 Consultation

2.5.1 Environment Agency

The EA has provided tidal and fluvial flood model maps under the Freedom of Information Act 2000. These have been used to inform the assessment of flood risk for the Project Site as well as the potential impact on the surrounding area.

Members of the London Resort project team have met with officers from the EA to discuss the key aspects of the Proposed Development throughout the development of the masterplan and in previous iterations of the Proposed Development. Meetings with the EA based on previous iterations of the Proposed Development took place on the following dates:

- 12th December 2014;
- 20th January 2015;
- 4th June 2015; and
- 14th July 2015.

The latest meetings with the EA for the current Proposed Development took place on the following dates:

- 23rd June 2020; and
- 4th August 2020.

The primary purpose of these meetings was to discuss and agree the concept design proposals for the new flood defences and the flood risk management strategy for the Project Site. The minutes of these meetings are included in Appendix B of this report.

2.5.2 Lead Local Flood Authority

Meetings have been held with KCC who are the LLFA for the Kent Project Site. Similarly, at the Essex Project Site, meetings have been held with TC who are the LLFA for the Essex Project Site and ECC who provide assistance for the approval of development related SuDS and surface water management designs linked to the land use planning process. Meetings held to date include:

- EA and KCC – 4th August 2020;
- TC – 10th July 2020; and
- ECC – 25th September 2020.

3 Appraisal and management of flood risk – overview

3.1 Introduction

The following sections assess the different sources of flood risk to the Proposed Development at the Project Site and provides mitigation measures, where appropriate, to ensure sufficient flood protection for the Proposed Development and surrounding users. For the purposes of this assessment the following sources of flood risk are considered:

- Flooding from the sea (tidal) – from overtopping of defences or in the event of a breach / failure in the flood defences;
- Flooding from rivers (fluvial);
- Flooding from surface water runoff (pluvial) and sewer surcharge;
- Flooding from groundwater; and
- Flooding from reservoirs and artificial sources.

3.2 Historical flooding

The most significant historical flood event that affected the Project Site was the 1953 North Sea Flood. In 1953 an extreme extratropical cyclone moved south along the east coast of Great Britain coinciding with high spring tides producing a storm surge that flooded large swathes of the east coast of England on the night of the 31st of January into the morning of the 1st of February. This has been approximated as a 1 in 200 year event with an approximate level in the River Thames at Southend of 4.65m AOD. The tidal event coincided with a relatively low fluvial flow of approximately 74m^3/s. In general, defence crest levels were raised by around 1m immediately after the 1953 event[14]. The flood extent affected the majority of the Kent Project Site (Main Resort) up to the London road (A226). The flood extent did not affect the Kent Project Site (Access Road), however the flood extent came close to the Order Limits to the north east near Ebbsfleet. The flood extent covered much of the southern and eastern extent of the Essex Project Site (see Figure 3-1).

[14] Thames Estuary 2100 Phase 3 Set 2 Estuary Wide Options Hydraulic Modelling, 2008.

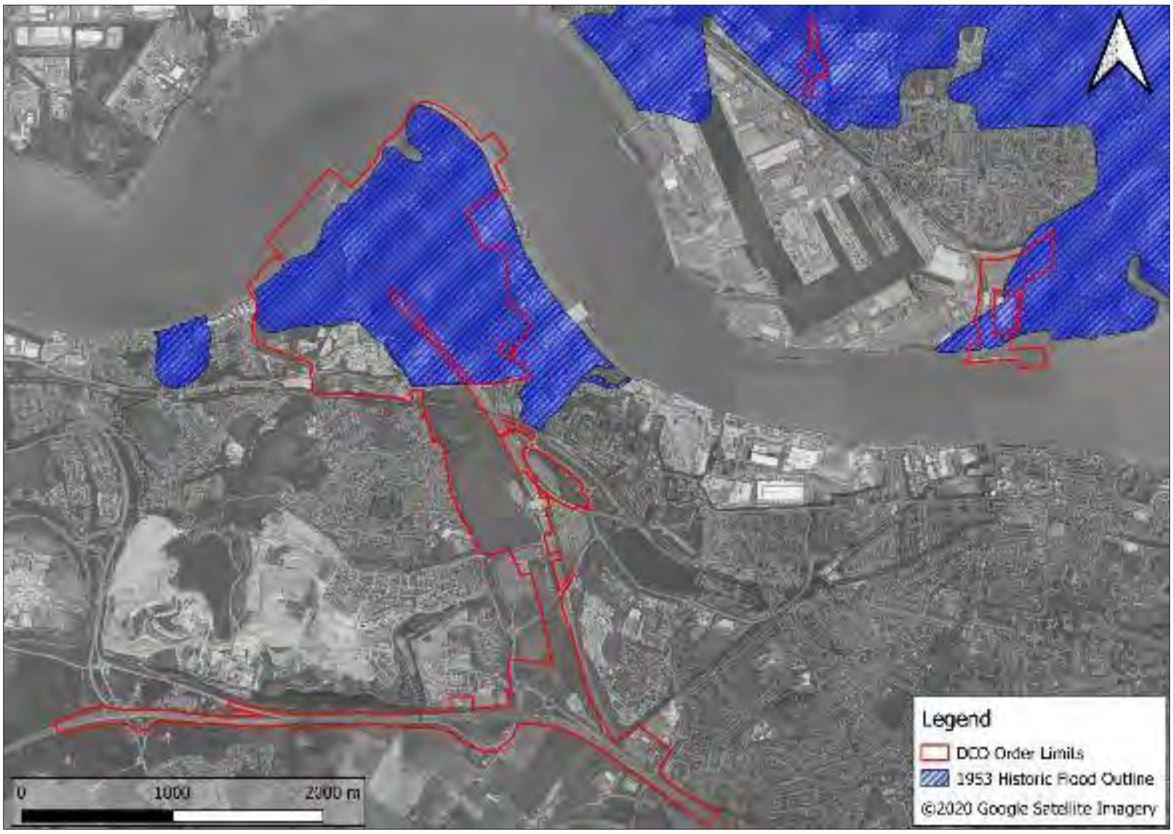

Figure 3-1: Historic Flood Map (1953) downloaded from data.gov.uk[15] (accessed on 24/06/2020).

In September 1968 the Kent Project Site was subject to fluvial flooding due to the channel capacity being exceeded. Details of the cause of the flooding is not known.

In 2013 the HS1 line almost became flooded. This was due to rocks falling in front of the tidal flap that jammed the outfall shut[16]. Unable to drain into the River Thames, the water level within the 'main river' that runs south to north across the site rose, preventing HS1 from being able to pump water out from the tunnel into the ditch. Following this, the EA installed gabion wing walls either side of the outfall to prevent this from happening again. Since this incident, there have not been any known issues with rocks jamming the outfall flap shut. As further precaution, HS1 installed high water level alarms within the ditch.

At Manor Way, as documented in the Kent County Council SWMP, there is anecdotal evidence that the drainage of the road is insufficient to manage the surface water flooding at the road and there are records of the road flooding extensively.

[15] https://data.gov.uk/dataset/76292bec-7d8b-43e8-9c98-02734fd89c81/historic-flood-map
[16] EA correspondence KT/2020/127344/01-L01, 21 September 2020

Flooding from other sources are not known to have been recorded for the Project Site.

3.3 Overview of sources of flood risk

3.3.1 Tidal and fluvial flooding

Tidal flooding occurs when particularly high tides coincide with storm surges. Storm surges are caused by low atmospheric pressure events and wind resulting in temporary localised raising of river or sea levels that are particularly prevalent in the North Sea, which funnels flow towards the Thames Estuary.

The Thames Estuary is tidally influenced as far upstream as Teddington Weir, west London. However, the Thames Barrier protects London from tidal flood events. The Project Site is currently downstream from the Thames Barrier. The River Thames within the Southern Region is not a designated 'main' river and therefore assessment of the River Thames at the Project Site is considered tidal flood risk.

Breach flooding can occur when a flood defence fails and collapses allowing water to flow from a water body onto the land that was protected by the flood defence. The potential of a failure or breach must be considered to be able to occur at any time and at any location along an existing or new flood defence. The risk of breaching increases with the severity of a storm. If a breach occurs, floodwater will be trapped behind the defences and may be present for several weeks. It poses a risk to life, buildings, and infrastructure, and will also be brackish (salty) from a breach in the River Thames defences, unlike fluvial flooding. Floodwater may drain away as the tide goes down, but many areas may remain inundated.

3.3.2 Surface water and sewer flooding

Surface water flooding occurs when the infiltration capacity during a storm event is low, or when drainage systems do not drain away rainwater. This results in water ponding or flowing over the ground surface. The excess water can develop pathways through built-up areas and open space, and pond in lower-lying areas. This type of flooding is usually localised and associated with short-duration heavy downpours of rain.

Sewer flooding is typically associated with blockage or failure of the sewer network. This can occur when drains and sewers are overwhelmed by rainfall and discharge away from where the rainwater entered them. Where the sewers are combined (that is they convey foul and surface water), contaminated water may be released. Surface water and sewer flooding generally occur as a result of intense rainfall which is relatively unpredictable and so may result in flooding without any prior warning. Flooding may also result from high river and tide levels preventing the discharge of sewers and drains.

3.3.3 Groundwater Flooding

Groundwater flooding occurs when water from sub-surface permeable strata rises above surface levels or into subterranean property such as basements. The flooded conditions often develop gradually and can last a significant period of time. Groundwater flooding can lead to:

- Flooding of basements of buildings below ground level;
- Flooding of buried services or other assets below ground level;
- Inundation of roads, commercial, residential and amenity areas; and
- Overflowing of sewers and drains.

3.3.4 Reservoir and artificial sources of flooding

Artificial sources of water include docks, canals, reservoirs, and lakes, where water is retained above natural ground level. Design failure at an artificial source of water has the potential to cause catastrophic damage to its surroundings due to the sudden release of large volumes of water. However, the likelihood of such a failure occurring is extremely low.

3.4 Principles of the Flood Risk Management Strategy

The key principles for the flood risk management strategy that will be addressed in the following chapters are as follows:

- Ensure the Proposed Development is safe for all users throughout the life of the Resort;
- Ensure that the Proposed Development does not increase the flood risk to surrounding areas;
- Ensure that design of the Proposed Development is resilient to future uncertainties;
- Maintain discharge from offsite areas within the Proposed Development to avoid increasing flood risk offsite;
- Manage existing overland rainfall runoff within the Project Site boundary to reduce impact offsite;
- Utilise passive flood mitigation measures rather than active ones that are subject to human mismanagement or mechanical failure;

- Develop mitigation measures that can provide multiple benefits and enhance the economic, social and environmental value of the Project Site.

The overall approach to flood risk management has been to ensure that the Project Site is defended in accordance with the requirements of the regional and local policy documents, and that the Proposed Development will not cause an adverse effect on flood levels or extent to other sites.

3.5 Assessment methodology

To identify the flood risk to the Project Site and inform the flood mitigation measures required, the various sources below have been used:

- National, regional and local planning policy and guidance as listed in Section 2.1 to understand flood risk from all sources;
- TE2100 Plan and supporting documents to inform setting of formal flood defence crest levels;
- EA North Kent Coastal 2018 hydraulic flood model to estimate flood levels at the Project Site now and in the future due to tidal overtopping or breach;
- EA River Ebbsfleet 2016 hydraulic flood model to estimate flood levels and extent in the Kent Project Site (Access Road).

Details of the hydraulic flood modelling undertaken has been provided in Appendix C. Three flood models have been used to inform the FRA as follows:

- Baseline 2020 Model –
    - NKC18 model + updated topography for Kent Project Site + new 2D domain at the Essex Project Site using LiDAR 2019 data + UKCP18 climate change projections.
- Proposed 2020 Model –
    - Baseline 2020 Model + Proposed Development and flood defence levels in Kent Project Site + Proposed Development levels in Essex Project Site + UKCP18 climate change projections.
- Ebbsfleet 2020 Model –
    - Ebbsfleet 2016 model + UKCP18 climate change projections.

3.6 Design Criteria

The Standard of Protection (SoP) for the Project Site will vary depending on the vulnerability use of the development plot within the Project Site area (see Figure 2-1, Figure 2-2 and Figure 2-3). The following criteria forms the basis of the flood management strategy:

- All development uses across the Project Site protected to the year 2070 as a minimum;
- More vulnerable uses (sleeping accommodation, safe refuge areas), highly vulnerable (telecommunications installations) and essential infrastructure (required to function and operate during a flood) protected for 100 years. Flood risk should be low during either an overtopping or breach of flood defence event. This category will be referred hereafter as More Vulnerable development;
- Less Vulnerable, water compatible and other essential infrastructure (not required to function and operate during a flood) protected for 60 years. Flood risk should be low during an overtopping of flood defence event but may remain at risk from flooding during a breach event. This category will be referred hereafter as Less Vulnerable development;
- Safe access and egress to and from buildings; and
- Formal flood defences to have a SoP for the 1 in 1000 year tidal event in the future.

Based on the available EA sea level rise projections (see

Table 2-7), the year 2125 has been selected to estimate the flood risk for the 100 year design life and 2090 for the 60 year design life.

The design flood event (DFE) has been identified as follows:

- Flood risk from the River Thames:
  - 1 in 200 year tidal overtopping flood event 2090 higher central climate change projection for Less Vulnerable development.
  - 1 in 200 year tidal overtopping or breach flood event 2125 upper end climate change projection for More Vulnerable development.

- Flood risk from the River Ebbsfleet:
  - 1 in 100 year fluvial flood event plus 70% allowance for climate change.

- Flood risk from surface water overland runoff in Kent Project Site:

  - No above ground flooding up to the 1 in 30 year + 40% allowance for climate change.
  - Buildings not to flood during the:
    - 1 in 100 year + 40% allowance for climate change rainfall event combined with Mean High Water Spring (MHWS) up to 2115; or
    - 1 in 1 year rainfall event combined with 1 in 200 year tidal flood event in 2090 higher central climate change projection.

- Flood risk from surface water overland runoff in Essex Project Site:
  - No above ground flooding up to the 1 in 30 year + 40% allowance for climate change
  - Buildings not to flood during the:
    - 1 in 100 year + 40% allowance for climate change rainfall event combined with 1 in 20 year tidal flood 2090 event higher central climate change projection; or,
    - 1 in 5 year +40% CC rainfall event combined with the 1 in 200 year tidal event for 2090 using the higher central climate change projection.

It is anticipated that the Baseline or Proposed 2020 Model may underestimate the potential river level in 2090 and 2125 if the Thames Estuary strategy includes a new barrier at Long Reach. This is because a new barrier at Long Reach is anticipated to increase river levels downstream at the Project Site post 2070 if in place.

Therefore, where applicable, development levels or secondary flood defences will be set at whichever is higher for either of the following:

- More Vulnerable uses:
  - 1 in 200 year 2125 upper end breach flood level + 300mm allowance for freeboard; or
  - 1 in 1000 year 2125 higher central overtopping or breach flood level.
- Less Vulnerable uses:
  - 1 in 200 year 2090 higher central overtopping flood level + 300mm allowance for freeboard; or
  - 1 in 1000 year 2090 higher central overtopping flood level.

The H++ model results will be used as a sensitivity check to understand the impact of flooding on the Project Site using the most conservative climate change projection.

4 Appraisal and management of flood risk – Kent Project Site (Main Resort)

4.1 Tidal flooding (overtopping and breach)

4.1.1 Baseline

The flood zone map shown in Figure 4-1 created using information from the EA shows that the Kent Project Site (Main Resort) straddles all three of the EA flood zones. It should be noted that there are two inconsistencies between the EA flood zones and the modelling results provided by the EA for this assessment.

1. The EA flood zones show only part of the Kent Project Site benefitting from flood defences. However, as is shown in Figure 4-2, the entire site currently benefits from flood defences; and,
2. The EA flood zones show land in the north of the Swanscombe Peninsula as being within Flood Zone 2, however this land is higher than the flood defence and other areas of the Swanscombe Peninsula and is unlikely to be in Flood Zone 2.

Without flood defences much of the lower land around Black Duck Marsh, Botany Marsh and South Pit within the Swanscombe Peninsula are at risk during a present day 1 in 200 year tidal flood event, considered a high risk.

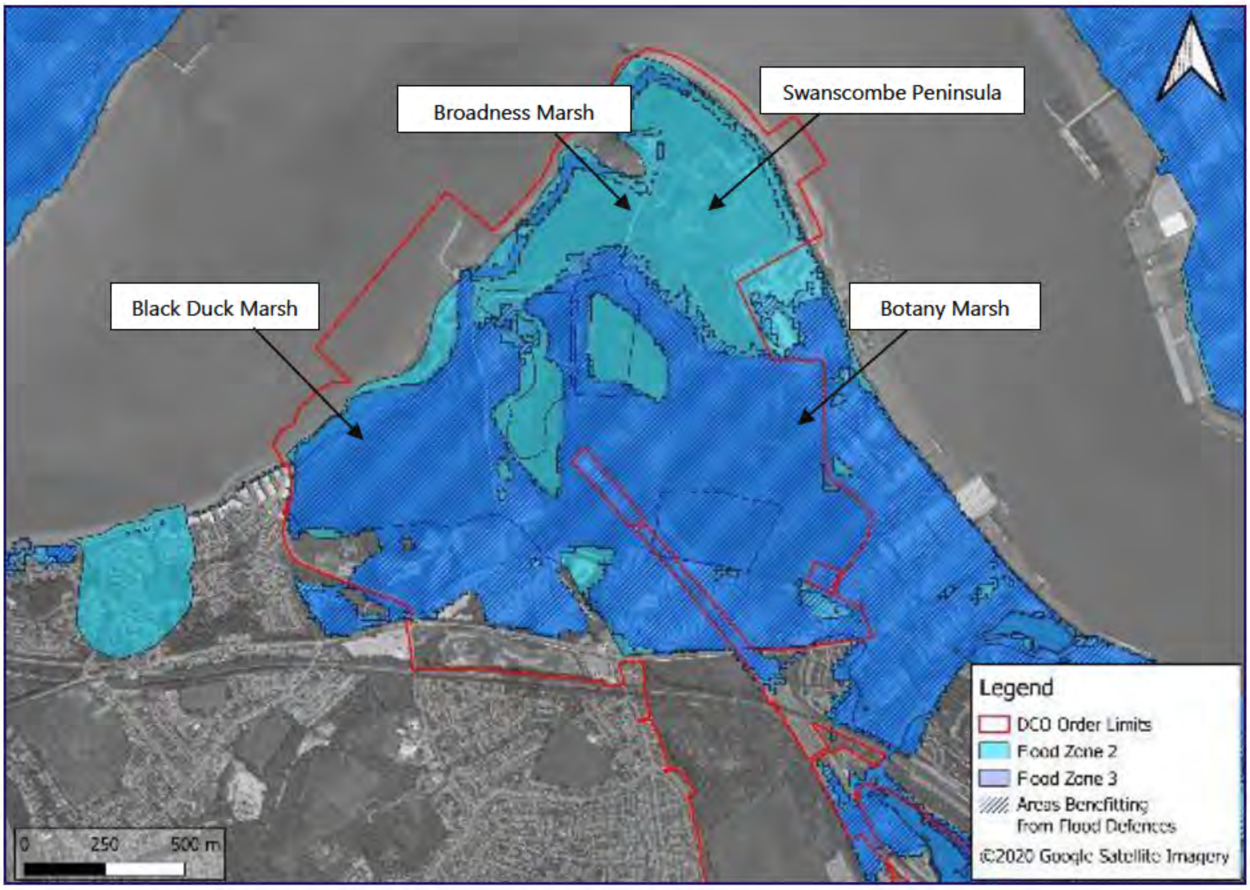

Figure 4-1: EA flood map showing Flood Zones 1, 2 and 3, illustrating fluvial and tidal flood risk to the Kent Project Site (Main Resort) if defences were not in place.

The Kent Project Site (Main Resort) benefits from existing flood defences. The flood defence crest elevations are variable around the site ranging between **6.31m AOD** and **8.8m AOD**. Flood defence types include flood walls, flood gates, high ground and embankments. Figure 4-3 shows the flood embankment along Black Duck Marsh. The spatial variability in crest levels and flood defence type is shown on Figure 4-2. In the flood risk information received from the Environment Agency on 01/05/2020 the current condition grade for defences in the Project Site area is 3 (fair), on a scale of 1 (very good) to 5 (very poor).

Figure 4-2: Kent Project Site (Main Resort) existing flood defence alignment, type and crest elevation as defined by the data supplied by the EA.

Figure 4-3: Kent Project Site (Main Resort) existing formal flood defences at Black Duck Marsh (photograph taken during site visit 28/07/20, looking southwest). Black Duck Marsh to the left side of photograph and the old flood defence embankment alignment on the right side.

Overtopping

The risk to the site is from overtopping of the formal flood defences on the west side and on the east side of the Swanscombe Peninsula. These overtopping locations are indicated in Figure 4-4 and Figure 4-5.

The Kent Project Site (Main Resort) is not at risk from overtopping of the existing western or eastern flood defences during the 1 in 200 year higher central climate change projection flood event in 2030.

Assuming no change to defence crest levels in the future, the Kent Project Site (Main Resort) is at risk from overtopping of the eastern flood defences in 2090 and both the eastern and western defences in 2125 during the 1 in 200 year higher central climate change projection flood event.

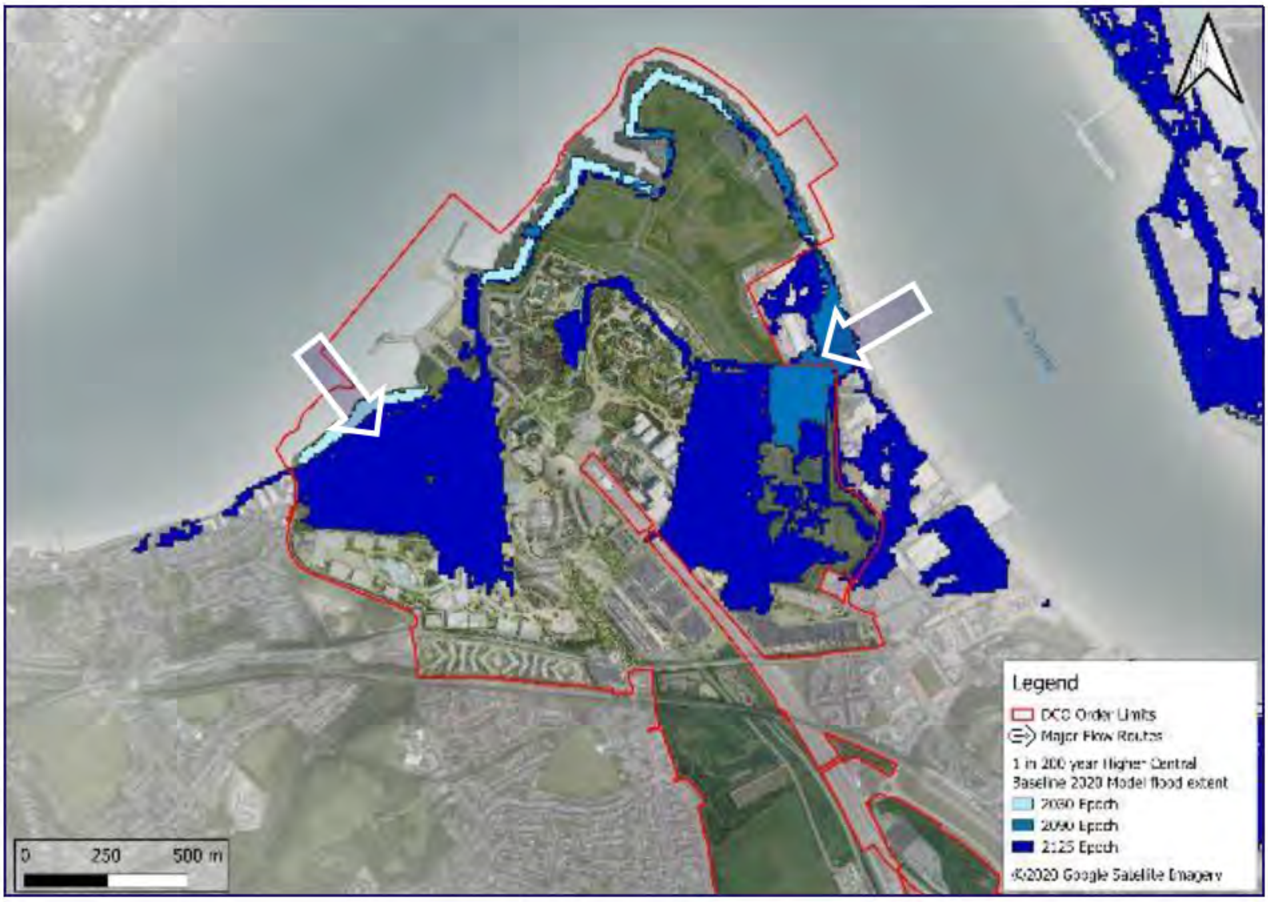

Figure 4-4: Kent Project Site (Main Resort) baseline overtopping flood extents for the 1 in 200 year return period event using the higher central climate change projections across different years, key flow paths indicated by the arrows.

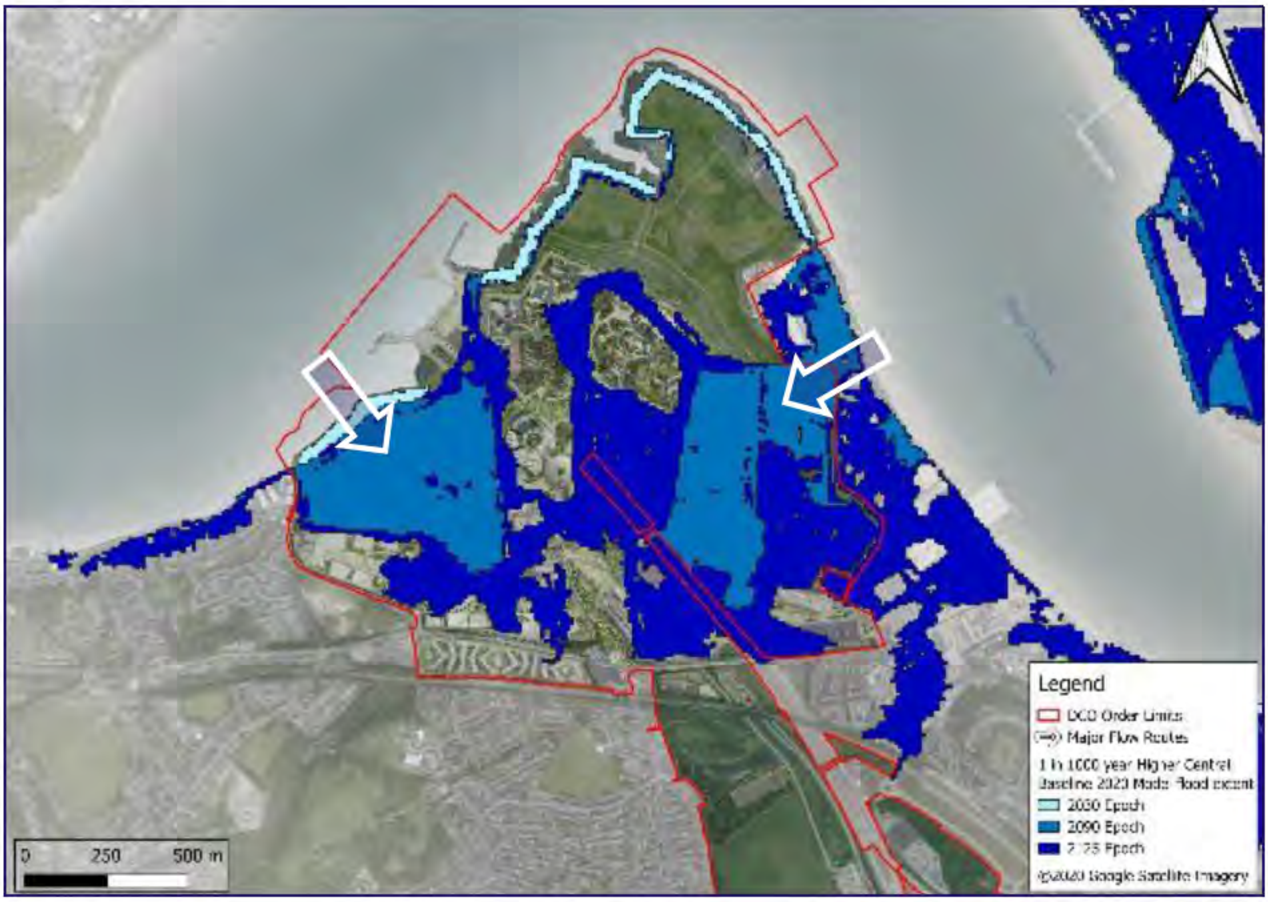

Figure 4-5: Kent Project Site (Main Resort) baseline overtopping flood extents for the 1 in 1000 year return period event using the higher central climate change projections across different years, key flow paths indicated by the arrows.

Breach

Figure 4-1 shows that much of the Kent Project Site (Main Resort) benefits from flood defences. Therefore, the removal of part of these defences in the form of a breach is a source of residual flood risk to the site, low probability but high impact.

Four different breach scenarios were tested across the Kent Project Site (Main Resort) as detailed in Appendix C. A breach in the defence along Black Duck Marsh has the greatest impact on onsite flood depths and extents. This is primarily due to the lower ground levels landward of the defence allowing floodwater to flow across the Kent Project Site (Main Resort) for a longer duration in the tidal cycle. The location of the breach as well as the flood extents for the 200 year and 1000 year model runs for various future epochs are shown on Figure 4-6 and Figure 4-7 respectively.

The breach details are shown in Table 4-1.

Table 4-1: Breach ID and design

Breach ID	Crest Level (m AOD)	Ground / Breach Level (m AOD)	Breach Width (m)
Breach 06	6.32	3.7	50

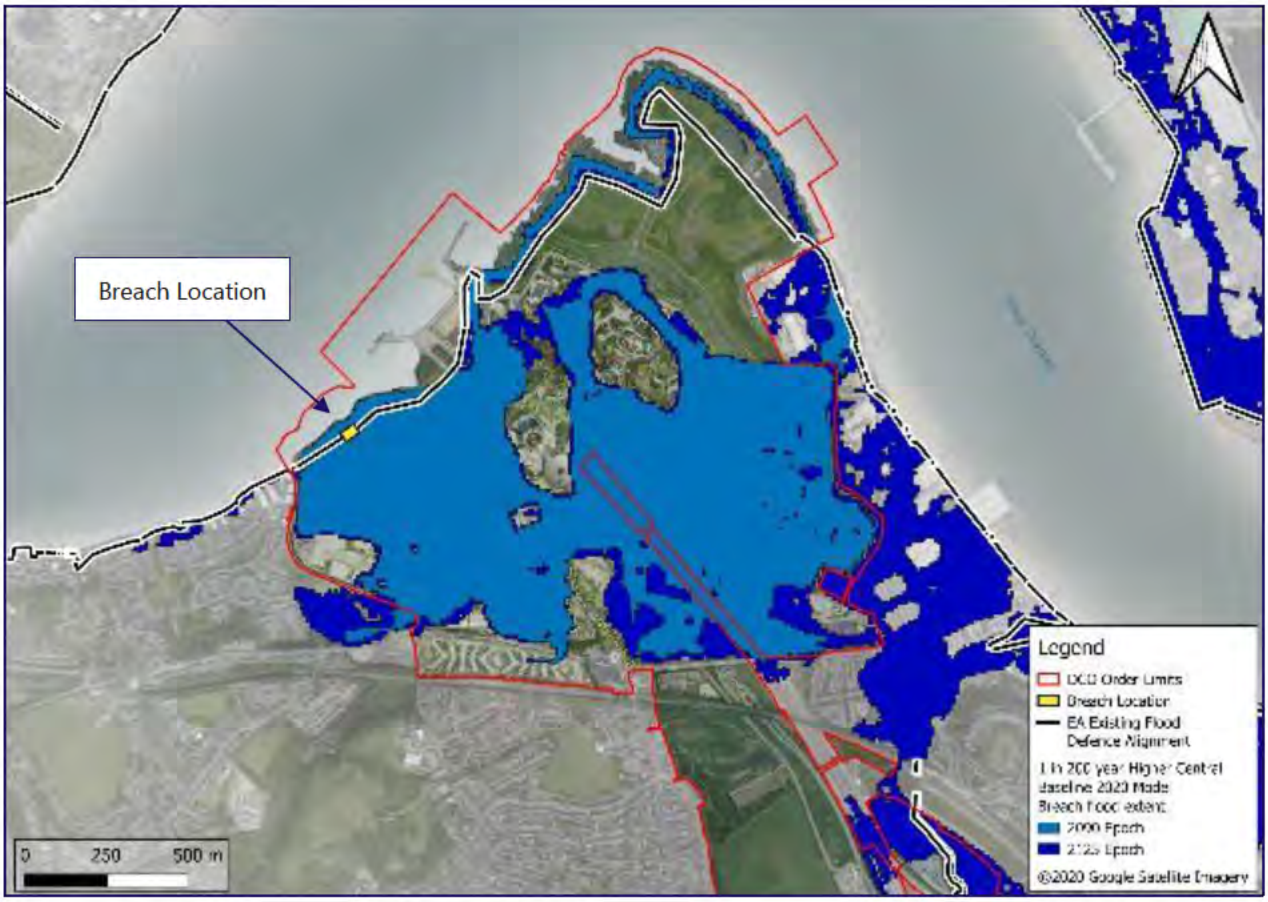

Figure 4-6: Kent Project Site (Main Resort) baseline breach flood extents for the 1 in 200 year return period event using the higher central climate change projections across different years.

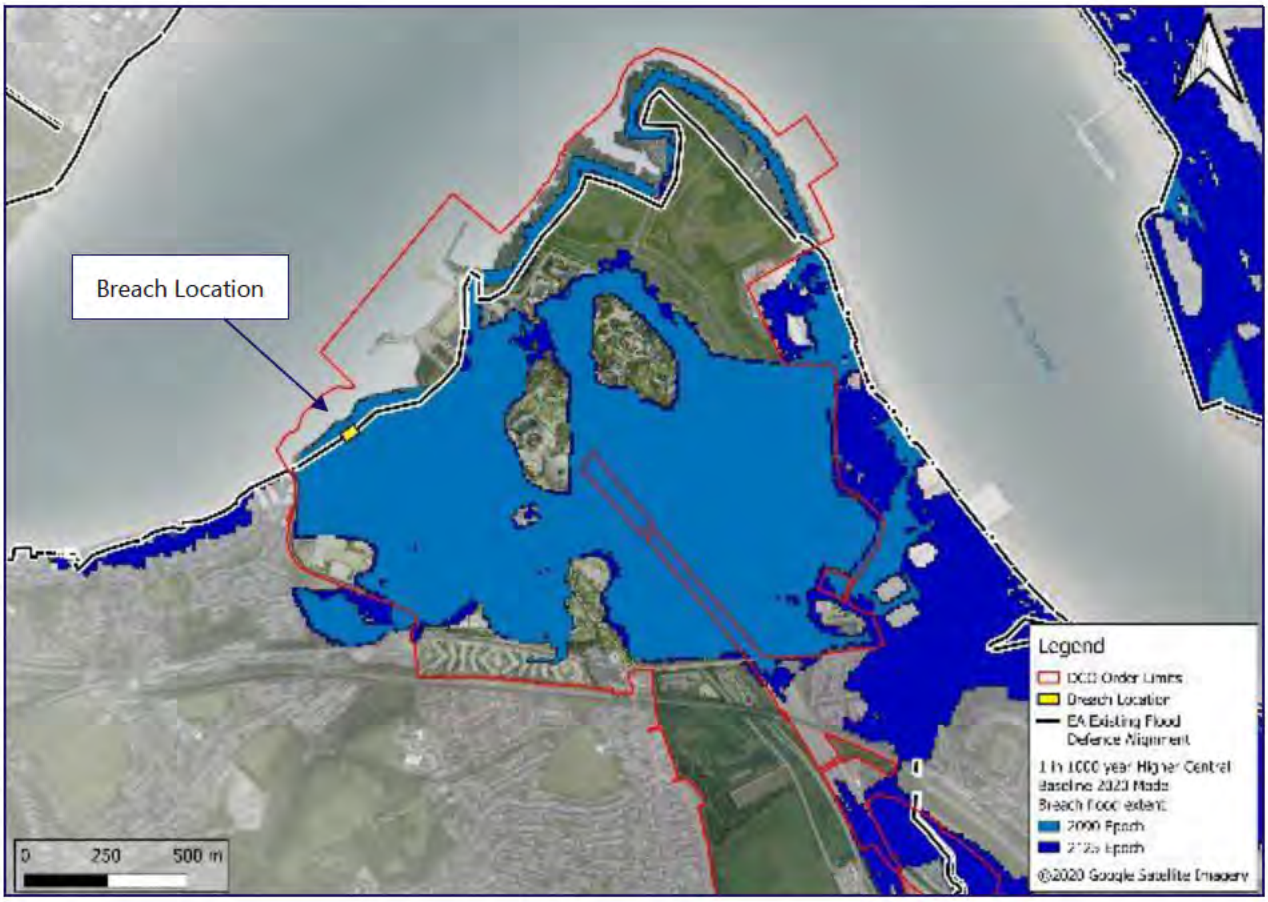

Figure 4-7: Kent Project Site (Main Resort) baseline breach flood extents for the 1 in 1000 year return period event using the higher central climate change projections across different years

<u>Flood Levels</u>

Flood Levels have been extracted from the Baseline 2020 Model results in order to assess how the Kent Project Site (Main Resort) performs in the baseline condition (no Proposed Development or changes to existing flood defences) and estimate the level of flood risk. Figure 4-8 shows the locations where the levels have been extracted from (including both in channel and the floodplain). The levels extracted are shown in Table 4-2.

Figure 4-8: London Resort Kent Project Site Baseline 2020 Model Results Sampling Locations

Table 4-2: Kent Project Site (Main Resort) estimated maximum flood levels from the Baseline 2020 Model (Note, a '-'indicates model not simulated for particular scenario) the spot level locations for the East and West Swanscombe Peninsula are indicated in Figure 4-8.

Year	Tidal Event	In channel (node 3.20/3.23)	West Swanscombe Peninsula		East Swanscombe Peninsula	
			Overtopping	Breach	Overtopping	Breach
Lowest existing flood defence crest level			6.31		6.32	
Current day	MHWS	3.33	-	-	-	-
	HAT	3.77	-	-	-	-
2090	1 in 200yr HC	6.15/6.3	0	5.59	1.44	3.4
	1 in 200yr UE	*6.65/6.54*	*3.08*	*5.89*	*2.34*	*4.12*
	1 in 1000yr HC	6.64/6.6	3.16	5.91	2.40	4.15
	1 in 1000yr UE	*6.9/6.75*	*3.61*	*6.18*	*2.65*	*4.76*
2100	1 in 200yr H++	7.2/7 2	6.54	*7.20*	6.57	*-6.39*
	1 in 1000yr H++	7.4/7.4	7.40	*7.32*	7.46	*7.23*
2125	MHWS	4.35	-	-	-	-
	HAT	4.79	-	-	-	-
	1 in 200yr HC	6.81/6.8	3.50	*6.21*	2.60	*4.74*
	1 in 200yr UE	7.1/7.0	5.10	*6.73*	4.32	*5.48*

	1 in 1000yr HC	6.95/6.9	4.74	6.45	3.56	5.51
	1 in 1000yr UE	7.20/7.14	*6.22*	*7.07*	*6.25*	*6.17*

4.1.2 Proposed mitigation strategy

The measures that have been proposed in order to mitigate the flood risk to the Kent Project Site (Main Resort) from tidal sources (overtopping and breach) fall into the following five categories:

1. Improve/Create new formal flood defences within the Kent Project Site (Main Resort) boundary;
2. Provide secondary flood defences;
3. Raise development levels and set finished floor levels;
4. Incorporate flood resilient measures; and
5. Establish a flood evacuation and management plan.

4.1.2.1 Formal Flood Defences

The Proposed Development requires realignment of the existing defences in the White's Jetty area. This is to make space for a new ferry terminal, setting down space for containers, logistic warehouses and operation of the area for visitors and staff to the Resort and marine transport access. If existing flood defences are removed/modified as part of Proposed Development, the EA stipulate that developers are required to create the new defences to the SoP required for the lifetime of the Proposed Development, which may differ to the existing SoP. The TE2100 Plan has been referred to when setting defence crest levels of the new defences.

It is the responsibility of the landowner to ensure that flood defences are maintained and free from obstruction to provide the standard of protection they were designed for. The assessment in the previous section indicates that parts of the existing flood defence within the Resort boundary are below the crest level required to provide adequate protection to this part of the River Thames between 2040 and 2070 as recommended in the TE2100 Plan. As such, the EA has permissive powers to make changes to the existing defences to provide the required SoP. Therefore, to minimise the disruption to the Resort once in operation, it is proposed that the existing defences are improved if required and raised at the onset of the Proposed Development. This is applicable to the flood defences adjacent to Black Duck Marsh.

In order to mitigate the flood risk to the Kent Project Site (Main Resort) from overtopping of the flood defences to the west of the Kent Project Site (Main Resort) the following is proposed:

- At Black Duck Marsh, increase the formal flood defence crest level along the existing alignment;
- At White's Jetty, replace the existing flood walls and flood gates with a flood embankment/raised ground levels along a new alignment to the landward side of the proposed jetty works;
- At the initial time of construction, the embankment defence crest levels will be set to a minimum of 7.00m AOD, which is the level required by the year 2070 under the EA TE2100 plan;
- After 2050, when the EA confirm the Thames Barrier Improvement works option, a review of the standard of protection for the Kent Project Site (Main Resort) and the levels required will be made;
- If the review indicates that additional standard of protection is required, this will be in place by 2070;
- The current worst-case scenario for the Project Site is the Thames Barrier Improvement Option 3.2 (See section 3.3.2), to develop a new Thames Barrier at Long Reach; and
- Allowances have been made in the design proposals for the future raising of the formal flood defence crest levels to 8.00m AOD for a passive flood defence solution. This is the level required for the period 2070 to 2170 by the EA TE2100 plan for Option 3.2 (see Figure 2-5).

Figure 4-9 below shows the locations for the proposed raising of the formal flood defences as well as the proposed new alignment for the defences at White's Jetty.

Figure 4-12 and Figure 4-14 show schematic cross sections of each defence and the spatial requirements based on current known information for the proposed future raising. The locations of these cross sections is shown on Figure 4-10 and Figure 4 -11.

Figure 4-9: Flood Risk Mitigation Kent Project Site (Main Resort) proposed works to the formal flood defences.

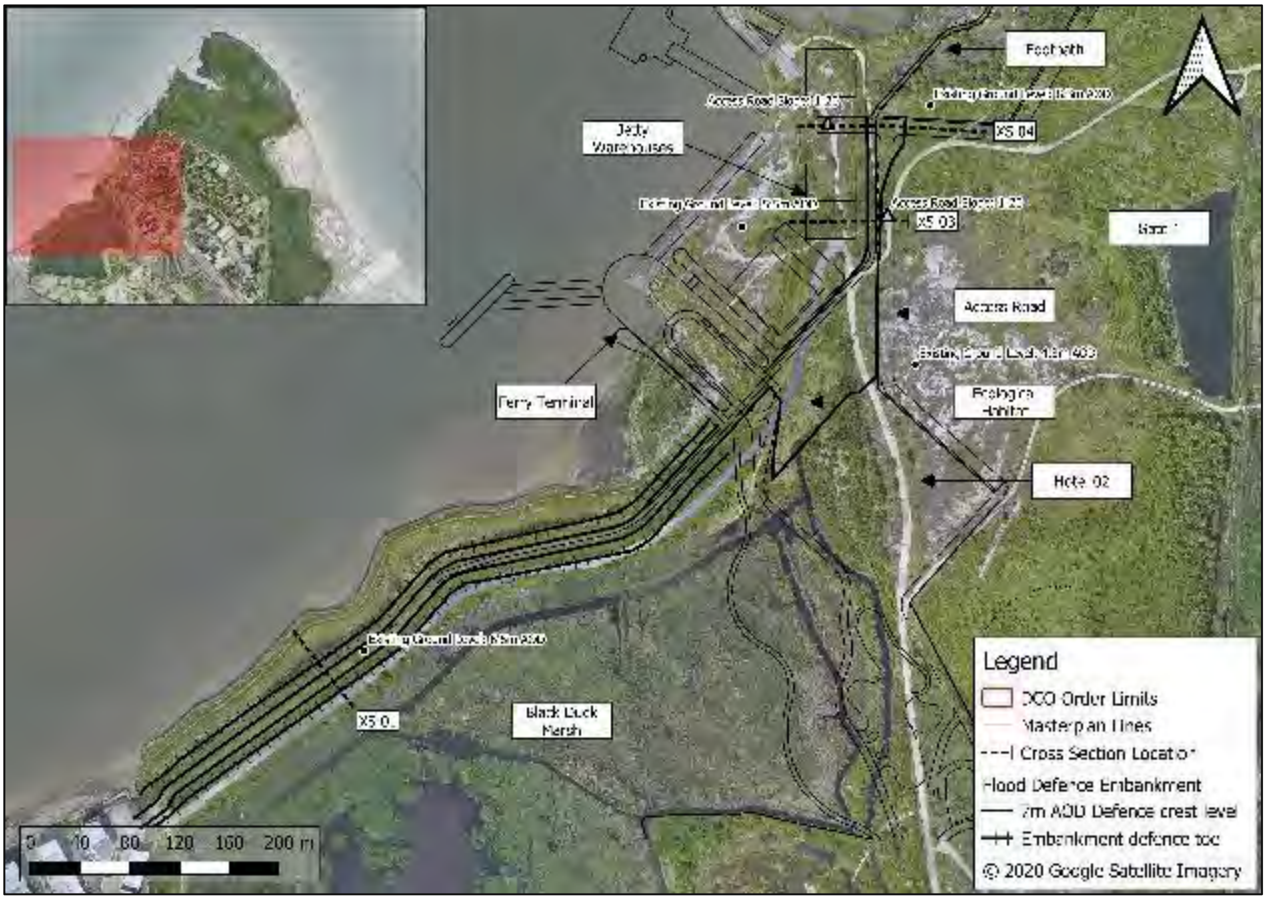

Figure 4-10: Spatial plan of showing indicative location of proposed flood defence crest, toe and raised land levels against existing satellite imagery. This is to achieve recommended TE2100 Plan flood defence SoP to 2070.

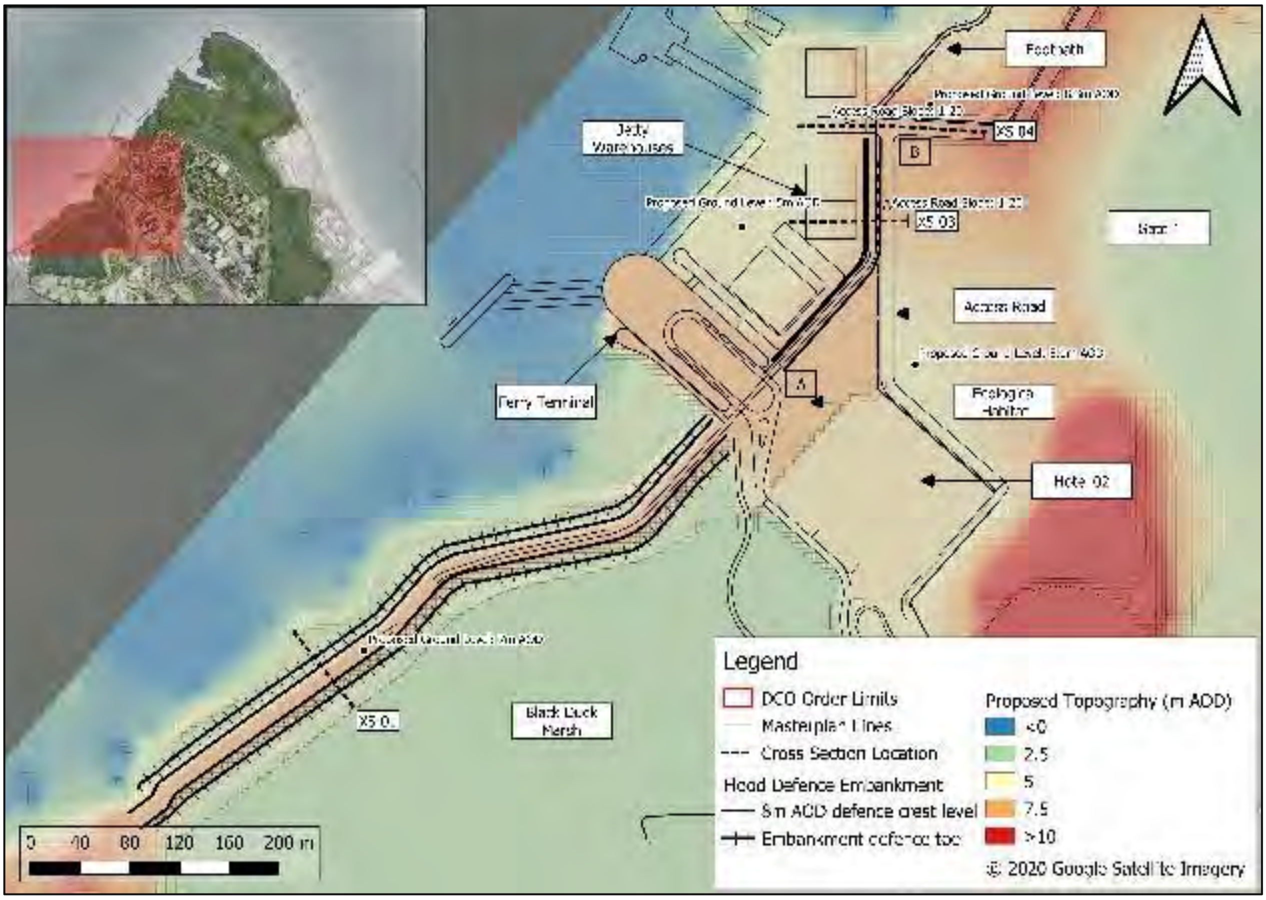

Figure 4 -11: Spatial plan of showing indicative location of proposed flood defence crest, toe and raised land levels against proposed topography. This is to achieve recommended TE2100 Plan flood defence SoP to 2125. At location A and B access roads that cross the embankment to access the Ferry Terminal and Whites Jetty respectively will be appropriately ramped up to meet the required crest level whilst maintaining the appropriate gradients.

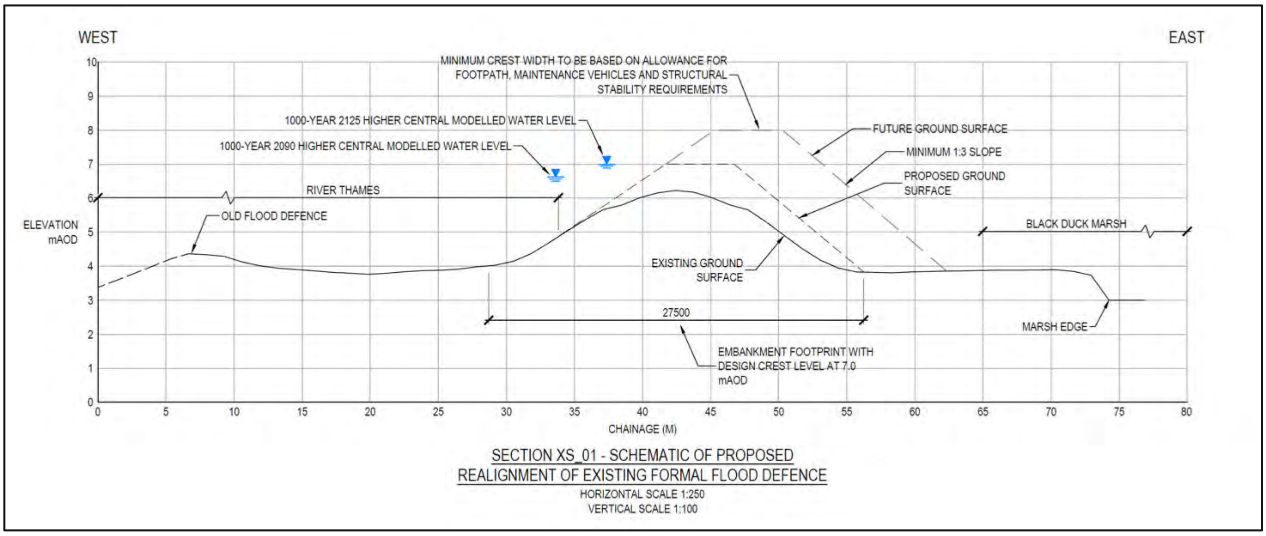

Figure 4-12: Black Duck Marsh cross section showing the proposed initial and phased defence crest level raising, cross section location shown on the plan in Figure 4 -11

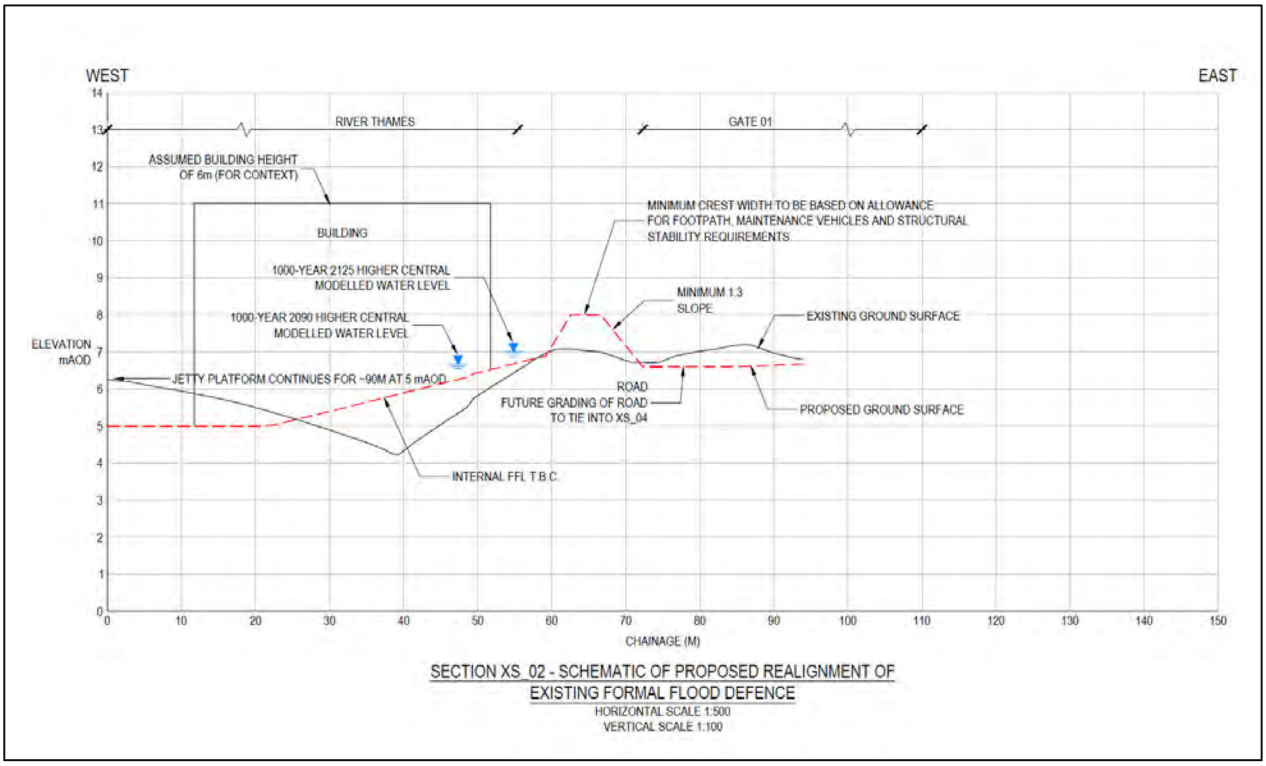

Figure 4-13: White's Jetty cross section showing the proposed initial and phased defence crest level raising, cross section location shown on the plan on Figure 4 -11.

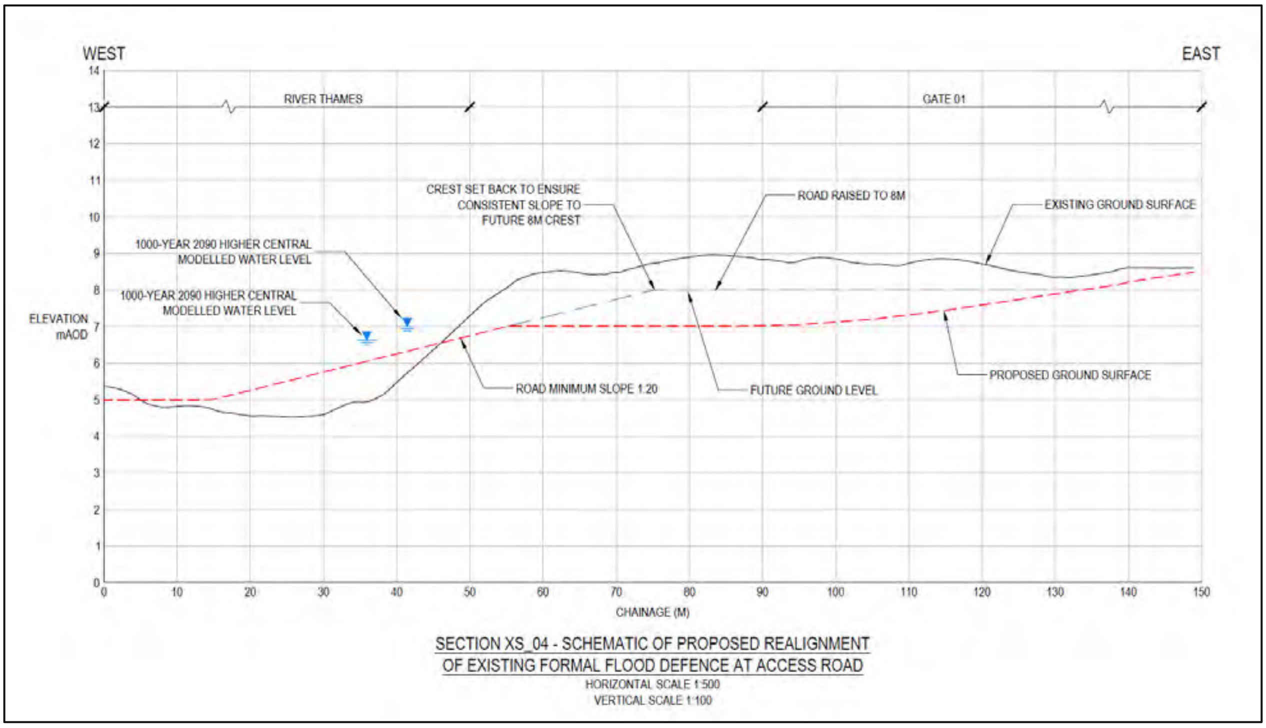

Figure 4-14: White's Jetty cross section showing the proposed initial and phased defence crest level raising, cross section location shown on the plan on Figure 4 -11.

In order to ensure the Kent Project Site (Main Resort) is at a low residual risk from a breach of the existing or new defences and that the design solutions will be appropriate for the design life, the following measures will be required in the next stage:

- Ground condition survey of existing embankment and high ground (specification to be agreed with the EA). This would be used to inform stability of the existing high ground, earth embankments and the viability and design requirements of proposed earth defence raising; and
- Slope stability analysis. This would be used to inform all modes of failure for the current and future scenarios including slip failure, bearing capacity failure, uplift and blow out, inter-partial friction soil stability for existing and new embankments.

In order to ensure the stability of slopes the Proposed Development will consider measures such as the use of gabion baskets, steel pilings and steel anchors to ensure that the failure of the flood defences is kept to a minimum. Further considerations required as part of the design include the following:

- Crest width and composition to be based on extreme water level to the crest of embankment (not design flood level);

- Below ground condition appropriate for fixing the embankment in place to reduce risk of movement under hydraulic loading and impact of seepage through or below the embankment;
- Construction of embankment undertaken in stages such that appropriate time for compaction is allowed for when determining final top level;
- Consideration of variable loads on top of the embankment from either pedestrians or vehicles crossing as part of the design load calculations;
- Appropriate embankment slopes allowing for safe crossing of vehicles if required (less steep than 1 in 20 slope for vehicles using for access); and
- Landscaping on and close to an embankment, incorporating appropriate species that allow maintenance and do not impact integrity of the embankment (such as tree roots).

As built drawings[17] of the existing flood defence along Black Duck Marsh indicates that raising of the embankment was undertaken over two to three phases with approximately 8 months in between each phase. It is likely this was to allow appropriate time for settlement and compaction of the material. Although, similar scale embankments are not proposed as part of the Proposed Development, similar phasing considerations will be required as part of the detailed design stage to ensure that appropriate allowance in the programme is made.

4.1.2.2 Secondary flood defences

The Proposed Development is at risk of overtopping in the future of the existing defences along the east side of the Swanscombe Peninsula which are outside the London Resort Order Limits.

Therefore, in order to mitigate the flood risk from overtopping of the formal flood defences to the east of the Kent Project Site (Main Resort), the following is proposed:

- A new secondary flood defence embankment along the east of the Proposed Development (the west of Botany Marsh);
- The defence crest level of the embankment will be set to 3.00m AOD (approximately 1m above proposed ground level), which is the level required by the year 2090 to ensure the Kent Project Site (Main Resort) is protected from the 1 in 200 year and 1000 year overtopping flood levels including freeboard. This

[17] Drawing 5691 / 1113, Swanscombe Peninsula Lengths 5/4 – 7 Section 2 Bell Wharf B.C.I. – Frontage 14 – Earth Bank Stage 2 Cross Sections, Southern Water Authority Kent River and Water Division Thames Tidal Flood Defences Private Front, February 1983.

would provide a SoP for both Less and More Vulnerable development categories; and

- If access points from the perimeter access road are required into Gate One the design levels will need to be modified such that vehicles can ramp up and over the secondary flood defence in order to maintain a passive flood defence.

Figure 4-15 shows the location for the secondary flood embankment along the east of the Proposed Development. The required crest level for the flood defence for tidal overtopping changes from requiring an embankment along the east edge of the Resort, to tying into raised ground levels along the north of the Resort where proposed levels are higher. However, the embankment also provides flood mitigation for potential high water levels in the proposed new wetland area during an extreme storm event. The embankment also acts as a visual barrier and separation between the perimeter road and the Gate One area. Figure 4-15 shows a schematic cross section of the secondary flood defence embankment. The location of the cross section is shown on Figure 4-15.

Figure 4-15: Flood Risk Mitigation Kent Project Site (Main Resort) secondary flood defence bund

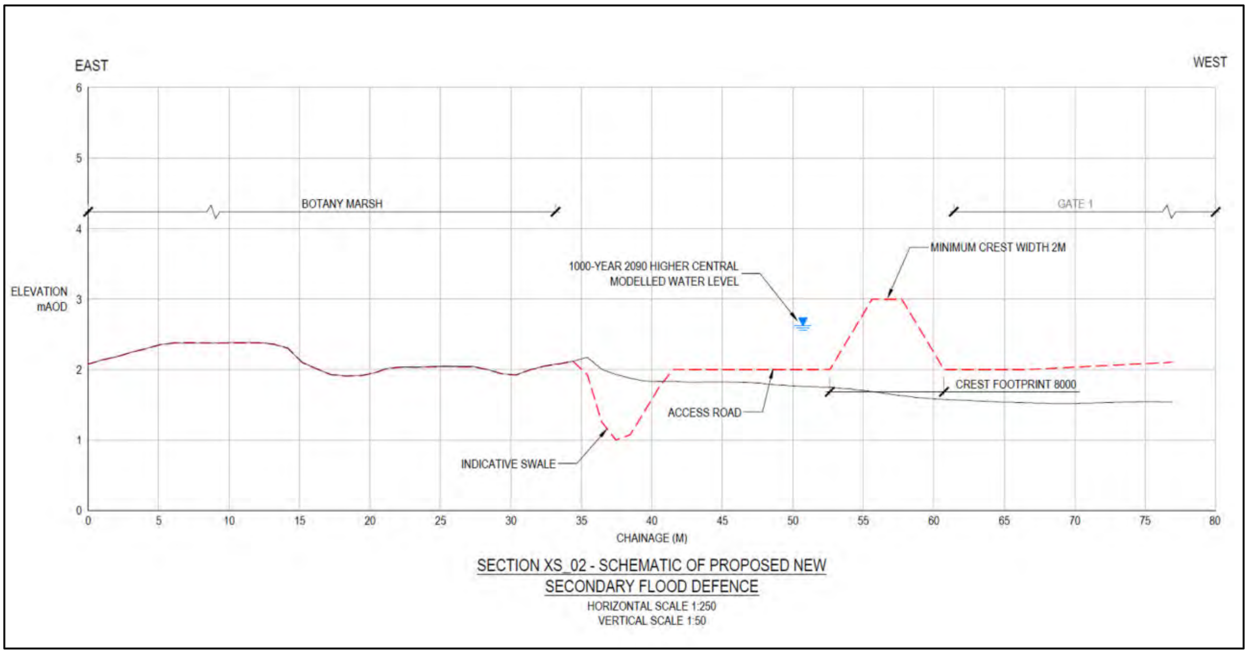

Figure 4-16: Cross section of the proposed secondary flood defence along the east of the Proposed Development, cross section location shown on Figure 4-15.

Figure 4 -17 and Figure 4-18 shows the residual flood risk from overtopping to the Kent Project Site (Main Resort) after the formal flood defence improvements are in place and the secondary bund mitigation measures are in place.

Figure 4 -17 shows the flood risk to the Kent Project Site (Main Resort) from the 200yr 2090 higher central overtopping event. The figure also shows the flood risk to the Kent Project Site (Main Resort) from the 1 in 200yr 2125 higher central overtopping event. This is based on no changes in the future to the formal flood defences to the east of the Kent Project Site (Main Resort) outside of the Order Limits, and therefore the risk shown would only occur if no improvements are made by others to the formal flood defences.

The figure shows the 1 in 200yr 2125 higher central event overtops the secondary bund and poses a risk to developments within the Gate One periphery and the back of house area to a depth of approximately 100mm.

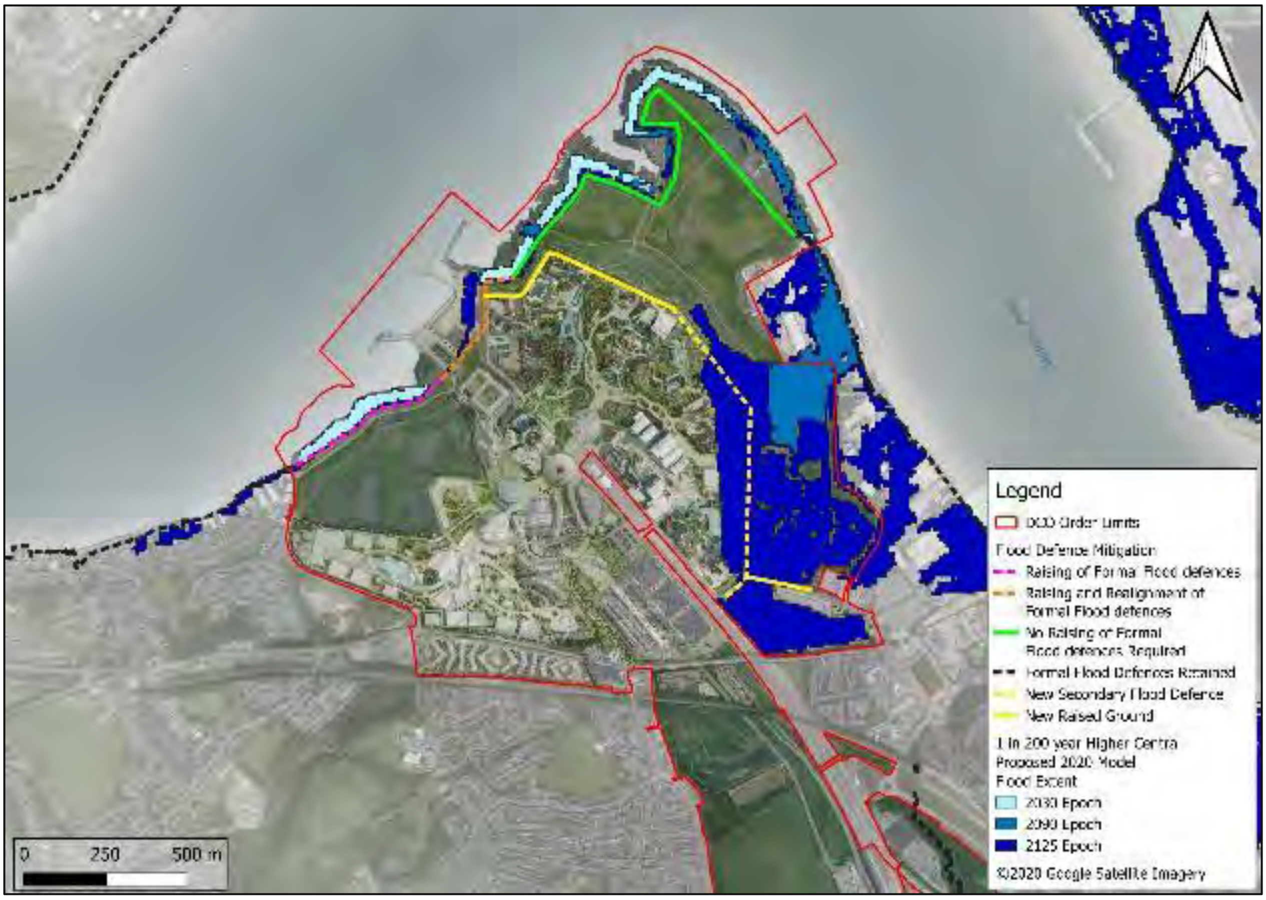

Figure 4 -17: London Resort Kent Project Site (Main Resort) overtopping flood risk 1 in 200 year for future years using the higher central climate change allowance (refer to Figure 4-15 for defence line style description).

Figure 4-18: Kent Project Site (Main Resort) post mitigation overtopping flood extents for the 1 in 1000 year return period event using the higher central climate change projections across different years (refer to Figure 4-15 for defence line style description)

Breach analysis has also been undertaken on the secondary flood defence to the east of the Swanscombe Peninsula. The breach analysis has been undertaken using the 1 in 1000 year event for the year 2090 using the higher central climate change projections. This event has been assessed rather than the 1 in 200 year event, as the flood level in Botany Marsh during this event has a greater hydraulic load to the secondary defence embankment than the DFE event (1 in 200 year 2090 higher central). The breach location was chosen based on where the direction of overtopping from the formal flood defence would have the greatest impact to the secondary bund.

Table 4-3 shows the details of the modelled breach in the secondary defensive bund and Figure 4-19 indicates the results of the breach event. As the image shows the ground level within Gate One is rising up soon after the bund and therefore a breach in the defences will not cause extensive flooding within the Gate One area.

Table 4-3: London Resort Kent Project Site (Main Resort) breach details for the secondary flood defence embankment

Breach ID	Crest Level (m AOD)	Ground / Breach Level (m AOD)	Breach Width (m)
Breach 21	3.00	2.0	50

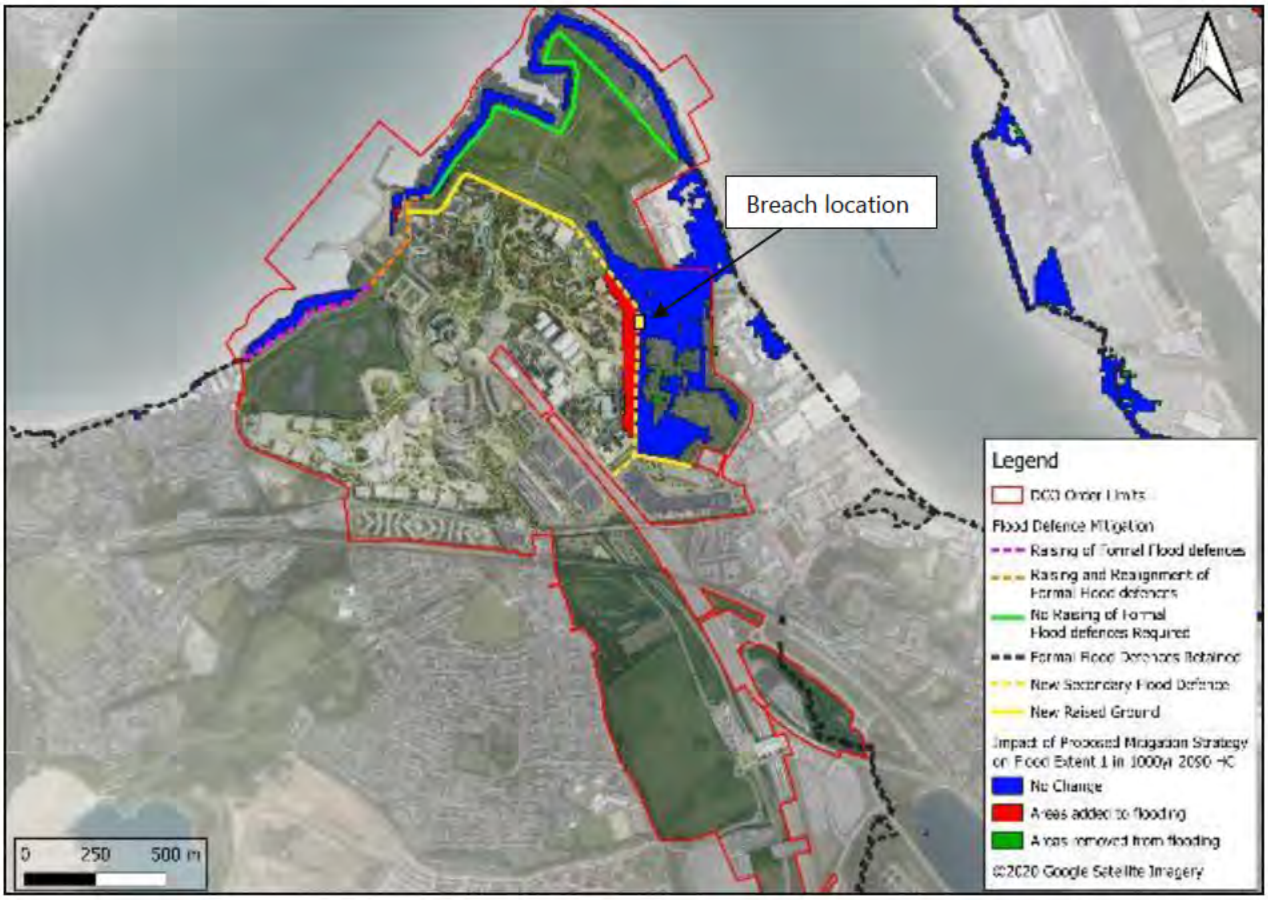

Figure 4-19: Kent Project Site (Main Resort) impact on the site of a breach in the secondary flood defences using the 1 in 1000 year event for the year 2090 using higher central climate change projection

4.1.2.3 Raise ground level and set finished floor level

With improvements made to the existing formal flood defences within the Kent Project Site (Main Resort) and the addition of a new secondary flood defence, there still remains a residual flood risk from the following:

- Overtopping of the secondary flood defence post 2090 if improvements to the existing formal flood defences along the east side of the peninsula are not made;
- Breach of the secondary flood defence; and
- Breach of the existing/improved formal flood defences.

An assessment of a breach in the formal flood defences either along the west or the east side of the Swanscombe Peninsula has been undertaken. Figure 4-20 shows the extent of flooding at the Kent Project Site (Main Resort) as a result of a breach in the formal flood defences at Black Duck Marsh during the 1 in 200-year event for 2125 using the upper end climate change projection. This breach location is considered to have the greatest impact across the Proposed Development in terms of flood levels and depths compared to other breach locations as well as from overtopping of flood defences. The breach scenario has therefore been used to inform the assessment. Details of the breach scenarios is provided in Appendix C.

This breach event has been used to determine the ground level/finished floor level required to ensure the flood risk to More Vulnerable development is low.

It is not proposed to raise the full resort development platform above the future overtopping or breach flood levels due to the following:

- Potential for displacement of flood volumes increasing flood risk to offsite area; and
- Prohibitive cost and programme implications on raising the full resort, approximately 120 ha.

Buildings developed as part of the Illustrative Proposed Masterplan (document reference LR-PL-APT-ILP-2.21.0) have instead been reviewed individually based on their flood risk vulnerability classification. The Proposed Development and the mitigation ground level/finished floor level required are indicated in Figure 4-20 and detailed further in Table 4-4. Table 4-4 presents the anticipated flood levels during the DFE for More Vulnerable proposed developments. This includes the More Vulnerable NPPF development category as well as the highly vulnerable and critical infrastructure (that must remain in operation during a flood). Where a room/space within a building is required to be at low risk from flooding but the full building platform/or key equipment are not raised, flood resistant measures will be included to prevent the ingress of floodwater into the space.

Table 4-4: More Vulnerable development uses and the estimated maximum water levels and depths (Proposed 2020 Model) – with recommended flood mitigation measures.

Proposed Development	Existing ground level (m AOD)	Proposed ground level (m AOD)	Residual – breach 2125 Water level (m AOD) (depth m)		Residual – breach H++ Water level (m AOD) (depth m)	Flood mitigation measure (levels includes minimum 300mm freeboard allowance)
			1:200yr UE	1:1000yr HC		
Hotel 01	3 – 5.7	3.00	5.8 (2.8)	5.7 (2.7)	5.48 (2.48)	Sleeping accommodation to be set above 6.1m AOD. Building flood resilient measures up to 6.1m AOD.
Hotel 02	2.2 – 6.4	5.50	6.9 (1.4)	6.7 (1.2)	6.56 (1.06)	Sleeping accommodation to be set above 7.2m AOD. Building flood resilient measures up to 7.2m AOD.
Hotel 03	2.2 – 6.7	5.00	6.9 (1.9)	6.6 (1.6)	6.51 (1.51)	Sleeping accommodation to be set above 7.2m AOD. Building flood resilient measures up to 7.2m AOD.
Hotel 04	3.2 – 20.6	6.00	7.0 (1.2)	6.7 (1.7)	6.56 (1.56)	Sleeping accommodation to be set above 7.3m AOD. Building flood resilient measures up to 7.3m AOD.
Telecommunication mast	4.3 – 4.7	8.00	6.9 (0)	6.8 (0)	(7.08) 0	Proposed ground level above DFE level. No mitigation required.
Related Housing	3.9 – 34.2	10.25	0	0	0	Proposed ground level above DFE level. No mitigation required.
Electricity Sub Station	1.4 – 20.0	7.28	0	0	0	Proposed ground level above DFE level. No mitigation required.
Back of House (South East)	1.4 – 12.3	4.00	5.2 (1.2)	5.0 (1.0)	5.39 (1.39)	Building flood resistant/resilient measures up to 5.5m AOD where required.
Bell Wharf warehouses with critical infrastructure	-4.11 – 8.35	5 - 7	6.9	7	7.13	Raise key equipment to above 7.2 m AOD or make building/equipment flood resistant.
Wastewater treatment facility	4.9 – 9.5	7.2	0	0	0	Proposed ground level above DFE level. No mitigation required. Protection to 8m AOD may be required in future. Flood resistant measures may be required for key operational items.

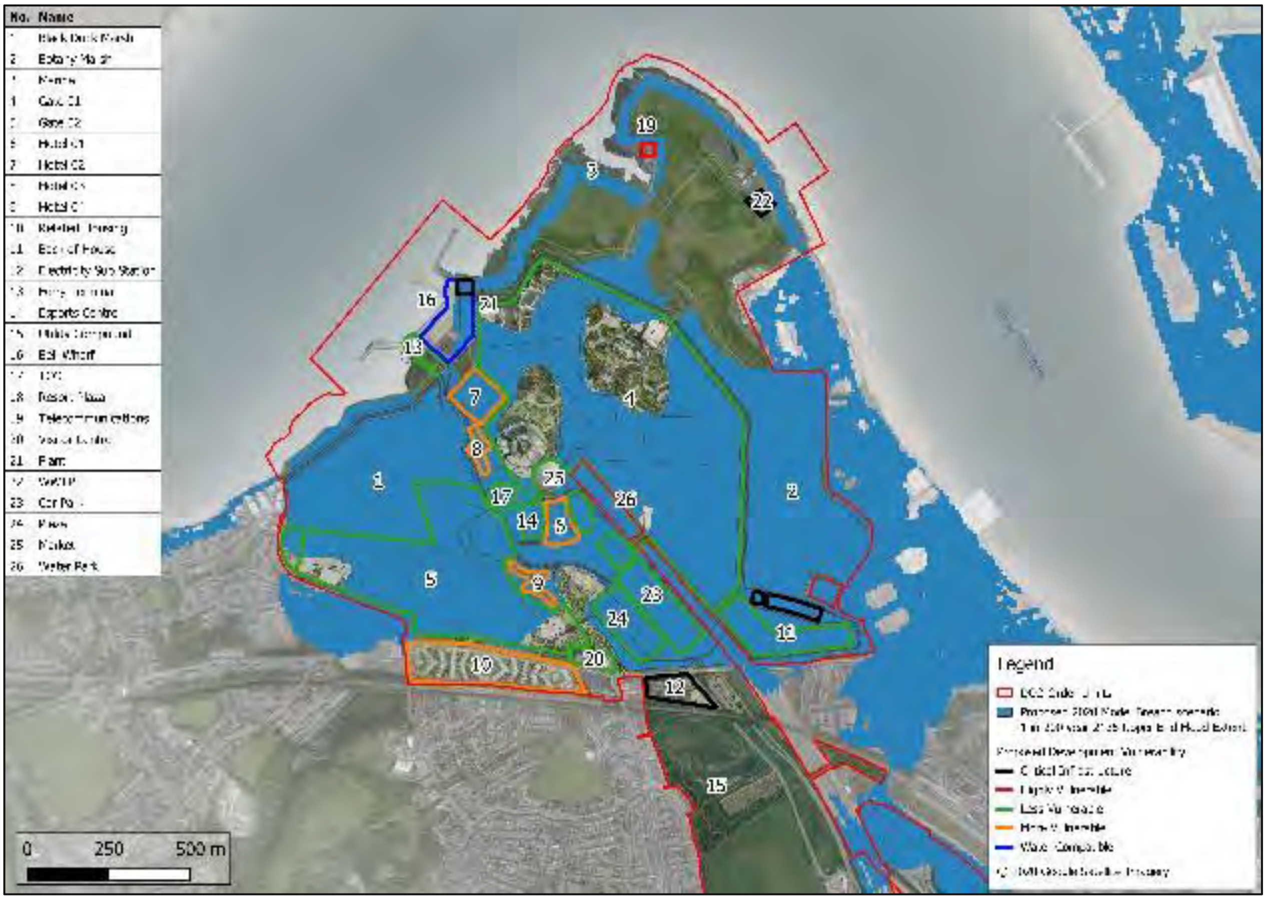

Figure 4-20: Kent Project Site (Main Resort) breach 1 in 200 year event 2125 epoch using the higher central climate change projection flood extent using baseline topography.

Based on certain areas/buildings of the Proposed Development being raised out of the flood extent and with others at a residual risk of flooding, the Kent Project Site (Main Resort) does not increase the flood extent to offsite areas as shown in Figure 4-21, including HS1 (for further details see Appendix C).

The impact of the proposed mitigation strategy on the extent of overtopping flooding for the 1 in 1000 and 1 in 200 year events at future epochs is shown in Figure 4-21, Figure 4-22 and Figure 4-23. It can be seen in these figures the approach of setting back the secondary flood defence to the western edge of Botany Marsh allows overtopping flood water to continue to use the marsh area as a storage area.

For the overtopping scenarios the mitigation strategy has also removed overtopping flood risk from the west through the improvement of the formal flood defences. In the modelling undertaken for return period events that occur beyond 2070 it is assumed that the formal flood defence has been raised in line with the mitigation strategy phased approach based on TE2100 flood defence levels.

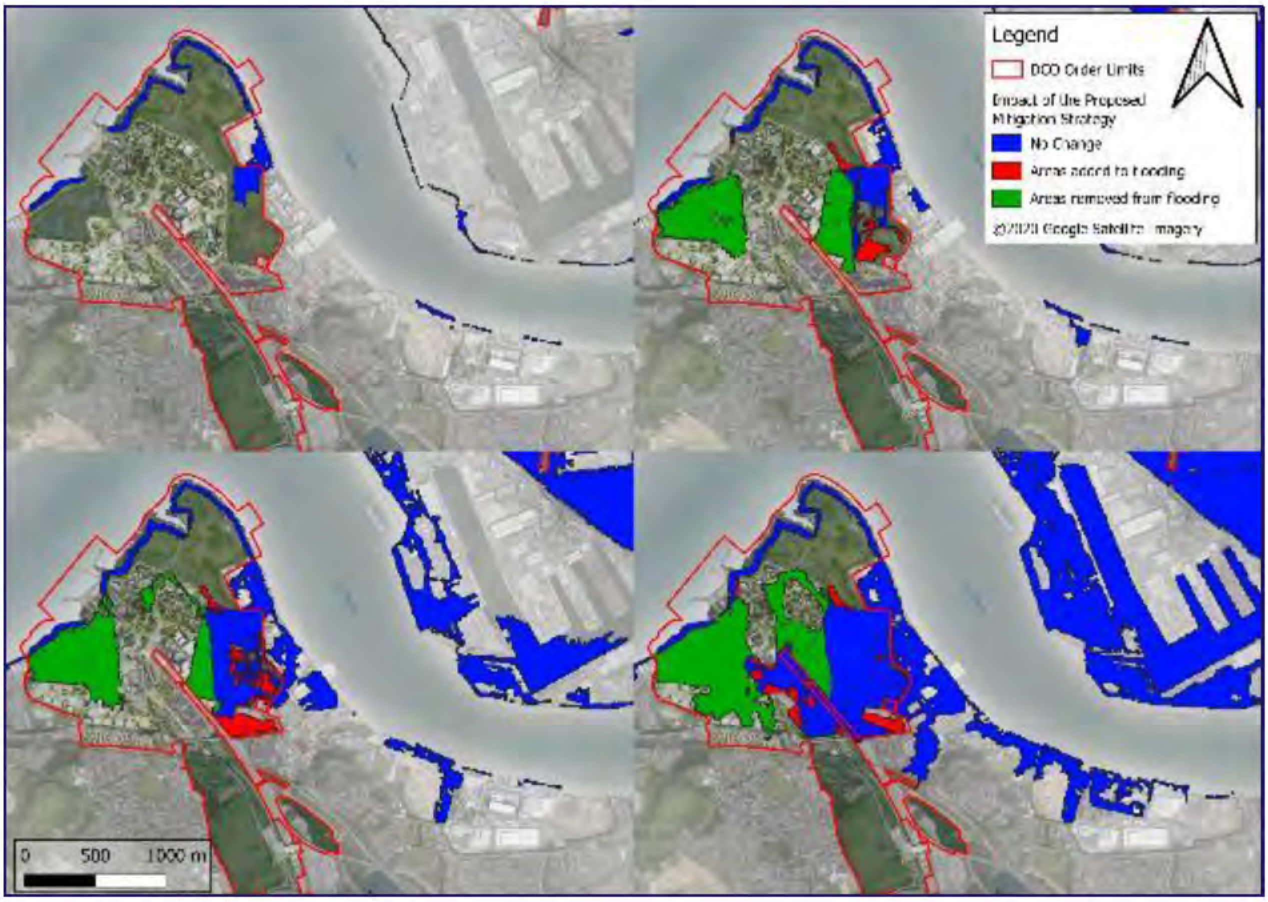

Figure 4-21: Kent Project Site (Main Resort) impact of the Proposed Development on overtopping flood extents for (top left) 1 in 200 year event in 2090 using the higher central climate change projection (top right) the 1 in 1000 year event in 2090 using the Higher Central climate change projection (bottom left) the 1 in 200 year event in 2125 using the higher central climate change projection (bottom right) the 1 in 1000 year event in 2125 using the higher central climate change projection

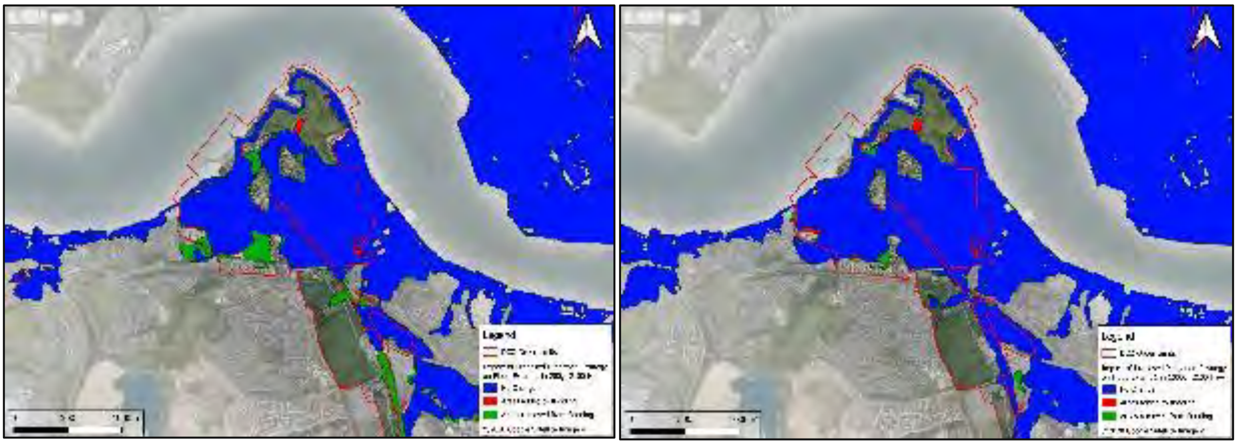

Figure 4-22: Kent Project Site (Main Resort) impact of the Proposed Development on overtopping flood extent for the (left) 1 in 200year 2100 H++ flood extent and (right) 1 in 1000year 2100 H++ Flood Extent

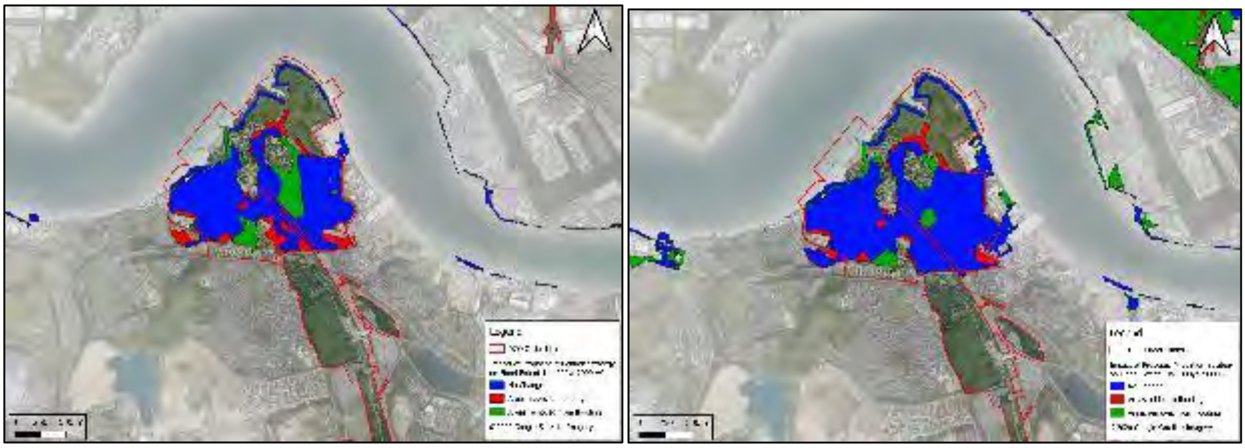

Figure 4-23: Kent Project Site (Main Resort) impact of the Proposed Development on the breach (Breach 06) flood extent for the (left) 1 in 200year 2090 Higher Central flood extent and (right) 1 in 1000year 2090 Higher Central flood extent

4.1.2.4 Incorporate flood resilient measures

The flood mitigation strategy for development uses classed as Less Vulnerable is to allow them to flood during a breach event and not to remove from the floodplain. However, to ensure the buildings can return and function soon after a flood event occurs, it is recommended that flood resilient measures are included in the building design. These may include measures such as the following:

- Water compatible internal walls;
- Water compatible flooring;
- Water compatible fittings;
- Sump and pump systems; and

- Raised electrics.

Table 4-5 shows the maximum DFE water level in 2090 from the Proposed 2020 Model and the anticipated flood levels in 2125 at the locations for Less Vulnerable proposed building developments. This includes the Less Vulnerable NPPF development categories as well as water compatible.

Table 4-5: Less Vulnerable development uses and the estimated maximum water levels and depths (Proposed 2020 Model) – with recommended flood mitigation measures.

Proposed Development	Existing ground level (m AOD)	Proposed ground level (m AOD)	Residual – breach Water level (m AOD) (depth m)					Flood mitigation measure (levels includes minimum 300mm freeboard allowance)
			2090		2100	2125		
			1:200yr HC	1:1000yr HC	1 in 200yr H++	1:200yr HC	1:1000yr HC	
'Conferention Centre'	2.5 – 7.2	3m Loading level 6m – GF level	5.2 (2.2)	5.7 (2.7)	6.2 (3.2)	5.82 (2.82)	5.9 (2.9)	Building flood resilient measures >5.7m AOD.
e-Sports Arena		3.00	5.2 (2.2)	5.7 (2.7)	6.1 (3.1)	5.50 (2.50)	5.9 (2.9)	Building flood resilient measures >5.7m AOD.
Market	3 – 5.7	3.00	4.7 (1.7)	5.2 (2.2)	5.5 (2.5)	5.27 (2.27)	5.6 (2.6)	Building flood resilient measures >5.2m AOD.
Gate One	0 - 14	4.00	*4.7 (0.7)*	*6.2 (2.2)*	*5.4 (1.4)*	*4.82 (0.82)*	5.5 (1.5)	Building flood resilient measures >6.2m AOD.
Gate Two	2 – 22.7	4.20	*5.9 (1.7)*	*5.2 (2.0)*	*6.6 (2.4)*	*6.26 (2.06)*	6.3 (2.1)	Building flood resilient measures >5.2m AOD.
Water Park	2.8 – 3.5	3.00	*4.7 (1.7)*	*5.2 (2.2)*	*5.4 (2.4)*	*5.23 (2.23)*	5.5 (2.5)	Building flood resilient measures >5.2m AOD.
Plaza	1 – 33.1	3.25	4.7 (1.45)	6.2 (2.95)	5.4 (2.15)	5.23 (1/98)	5.5 (2.25)	Building flood resilient measures >6.2m AOD.
Car Parks	0 – 22.7	3.25	4.7 (1.45)	5.2 (1.95)	5.4 (2.15)	5.23 (1.98)	5.5 (2.25)	Building flood resilient measures >5.2m AOD.
Visitor Centre	7.2 – 20.6	29.00	0	0	0	0	0	No mitigation required.
Bell Wharf warehouses	-4.11 – 8.35	5 - 7	6.2	6.5	7.1	6.67	7	Building flood resilient measures >6.5m AOD.
Ferry terminal	2.3 – 7.1	7.2 - 8	0	0	0	0	0	No mitigation required.

Back of House (south east)	1.4 – 12.3	3.00	3.4	4.5 (1.5)	5.4 (2.4)	4.29 (1.29)	5.5 (2.5)	Building flood resilient measures >4.5m AOD.

4.1.2.5 Establish a Flood Evacuation and Management Plan

Figure 4-24 illustrates the flood hazard to the Kent Project Site (Main Resort) during a 1 in 200 year 2125 upper end flood event. The figure indicates that during a breach event fast and deep water inundates the site quickly. As such, the impact of a breach inundation can happen quickly across the Kent Project Site (Main Resort) with little time for full evacuation.

A breach occurring during an extreme event will have a large impact on the Kent Project Site (Main Resort). However, such events generally come with prior-warning of several hours. Therefore, flood warning systems will be put in place and, in the case of a large storm event, it is anticipated that the Project Site will be closed to visitors. This may include measures such as signing up to the EA flood warning alert system and Met Office weather forecasts and disseminating information from the communications centre across the site using digital information boards or a Tannoy system. The proposed measures will be further developed as part of the wider Flood Evacuation and Management Plan in consultation with the local authority's emergency planners.

Hotels will include safe refuges and invacuation routes above the maximum breach level. The buildings will be designed to remain operational during a storm event.

For those development plots within the 1 in 200 year 2125 upper end breach maximum flood extent all sleeping accommodation (including hotels and residential areas) will be located on the first floor or above. There will be no private access to residential ground floor if the ground floor is lower than the design breach level.

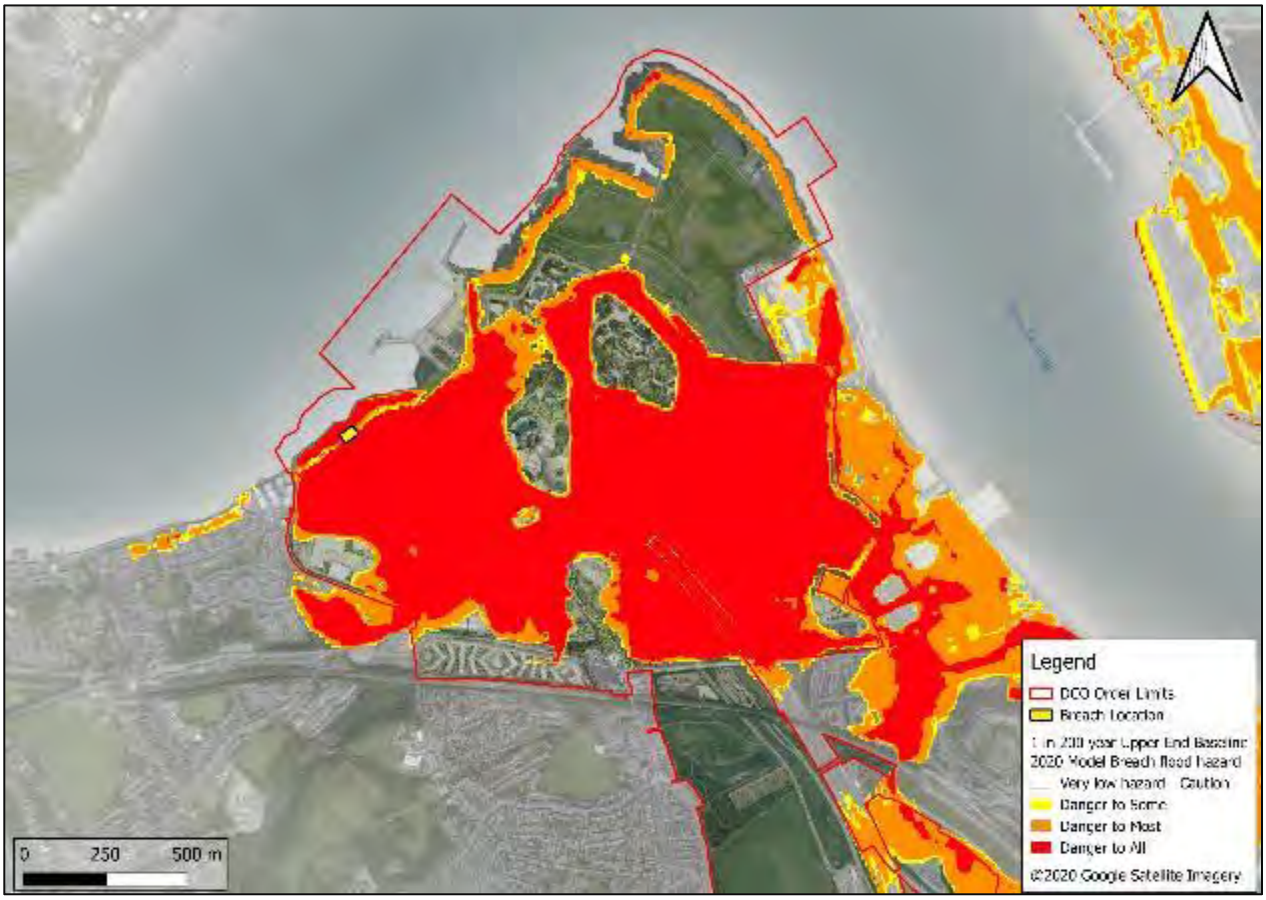

Figure 4-24: Kent Project Site (Main Resort) baseline breach flood hazard for the 1 in 200 year return period event using the upper end climate change projections

4.2 Fluvial flooding

The Kent Project Site (Main Resort) has an EA designated main river (referred to hereafter as the Swanscombe Channel) that runs from the south of the site in a northerly direction, ultimately draining into the River Thames using a combined gravity and pump driven outfall. The flows to the Swanscombe channel are understood to be mainly from Eastern Quarry abstraction discharge, the dewatering of HS1 and runoff from the surrounding catchment.

The gravity outlet is an approximately 320m long, 1.6m diameter culvert that discharges into the Thames to the north of White's Jetty. The recent CCTV survey (September 2020) and older CCTV information from the EA have indicated that the culvert is partly silted. Emergency discharge is also achieved via a pumped system operated by HS1, located to the north of the gravity culvert. This system is a 300mm diameter pipe.

There is a second EA designated main river that runs from the east of the site in a westerly direction to the same outflow. The flow is primarily overflow from Botany Marsh.

The arrangement of the EA designated main rivers are shown on Figure 4-25.

Figure 4-25: Kent Project Site (Main Resort) EA designated main rivers

The main rivers on the Kent Project Site (Main Resort) will be modified as part of the Proposed Development and therefore will be managed as part of the Surface Water Drainage Strategy (document reference 6.2.17.2). The appraisal and mitigation of risk from these water courses is discussed in more detail in Section 5.6.

4.3 Surface water and sewer flooding

4.3.1 Baseline

The EA surface water flood map, shown in Figure 4-26 for the Kent Project Site (Main Resort) indicates that the majority of the site is classified as having a low probability of surface water flooding (<0.1% chance in any given year). There are some areas with a high probability of surface water flooding (>3.3% chance in any given year), which correspond to localised depressions in the topography of the site. The localised depressions are particularly orientated around the Black Duck Marsh, Manor Road and Ebbsfleet International station.

Figure 4-26: EA flood map showing surface water modelled flood extent (Map data ©2015 Google, © Environment Agency copyright and/or database right 2014. All rights reserved. Some features of this map are based on digital spatial data from the Centre for Ecology & Hydrology, © NERC (CEH). Soils Data © Cranfield University (NSRI) and for the Controller of HMSO 2013)

4.3.2 Proposed mitigation strategy

The risks associated with surface water and sewer flooding have been considered with relation to the Proposed Development in the Surface Water Drainage Strategy (document reference 6.2.17.2) and which is summarised below in Section 4.6.

At the Kent Project Site (Main Resort) Southern Water have indicated that there is little capacity in the existing sewer system and therefore a new wastewater system is proposed including an onsite wastewater treatment works, for further details please see the Utilities Statement (document reference 7.6).

4.4 Groundwater flooding

4.4.1 Baseline

Groundwater flooding generally occurs in low-lying areas above permeable rock aquifers where the water table meets, and rises above, the ground surface.

The Kent Project Site (Main Resort) is generally underlain by Made Ground overlying Alluvium. The underlying solid geology comprises the Seaford Chalk Formation and Newhaven Chalk Formation. Superficial deposits of Head and Boyn Hill Gravel are shown to be present in the southern area (refer to ES Chapter Soils, hydrogeology and ground conditions document reference 6.2.18).

The Kent Thameside SFRA indicates that the much of the Kent Project Site (Main Resort) is within a groundwater risk area, see Figure 4-27. The Kent Thameside SFRA further comments that the Swanscombe Peninsula is a primary concern for the EA. If dewatering at Eastern Quarry is stopped it is estimated that the groundwater levels at the Eastern Quarry could recover to at least 5-8 m AOD, the River Ebbsfleet to start flowing again and potentially the low lying areas of the Swanscombe Peninsula (between 0 and 4m AOD) will be at greater risk of flooding due to the high connectivity through the chalk between the Eastern Quarry and the Swanscombe Peninsula, particularly through a drainage path at Knockhall. However, it is currently understood that there are no plans for abstraction at Eastern Quarry to cease in the near future.

At present, the Kent County Council Preliminary FRA locates the Kent Project Site (Main Resort) within an area shown to have a negligible risk of groundwater flooding, see Figure 4-28.

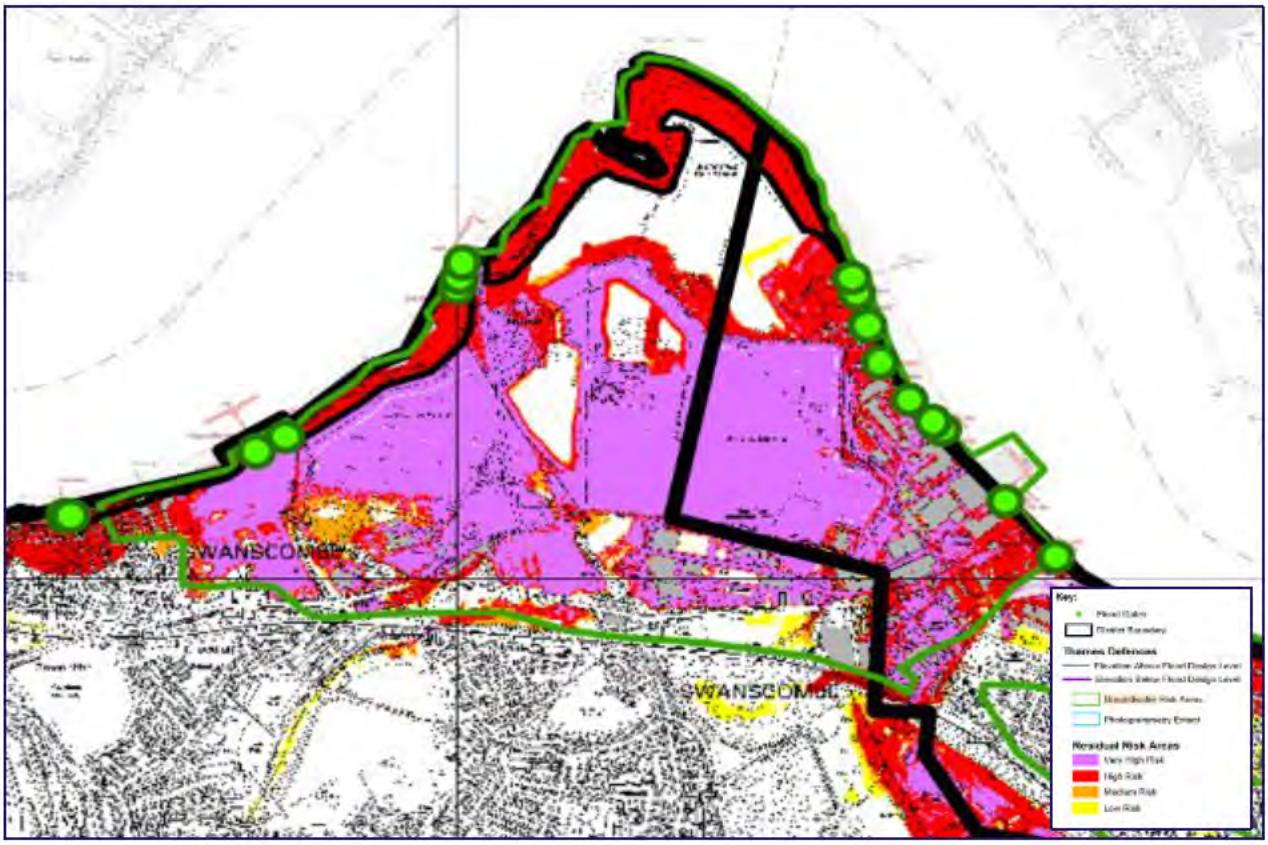

Figure 4-27: Kent Thameside SFRA Residual Flood Risk Map, including Groundwater Risk Areas [18]

[18] Kent Thameside Delivery Board: Strategic Flood Risk Assessment of Kent Thameside, JBA Consulting. December 2005.

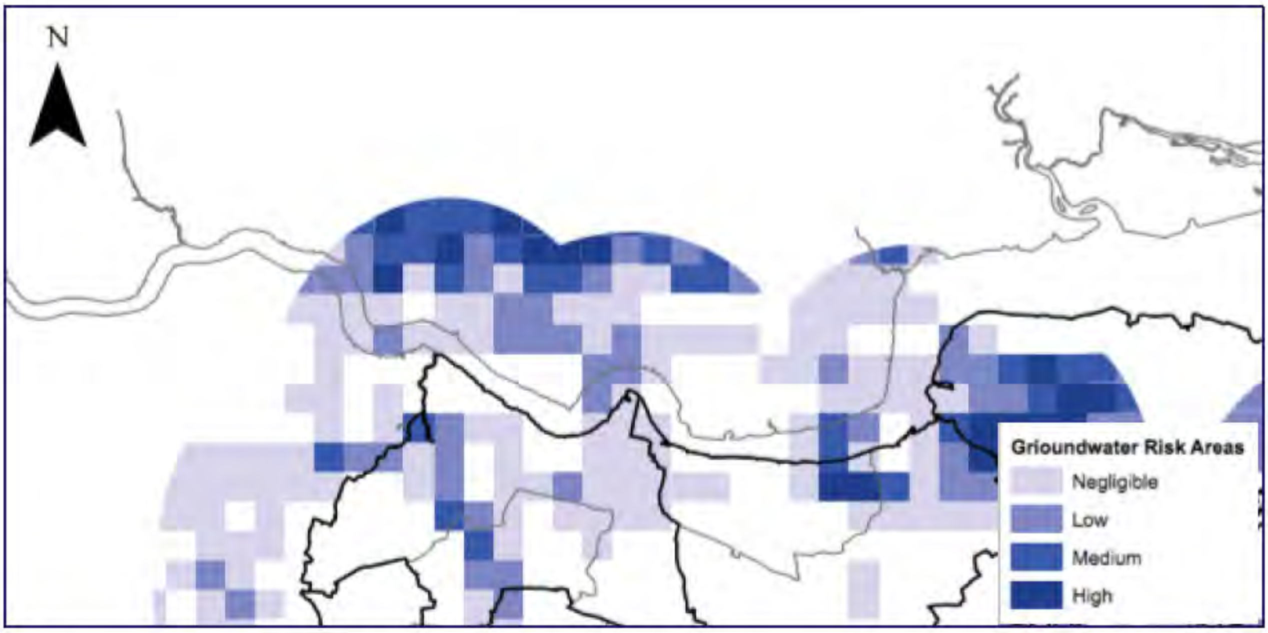

Figure 4-28: Kent County Council Groundwater Risk Areas (Kent county Council Preliminary Flood Risk Assessment – Main Report – Figure 6)

4.4.2 Proposed mitigation strategy

Post development, large areas of the Kent Project Site (Main Resort) will be capped with an impermeable layer to prevent mobilisation of contaminants through infiltration. There are no basement excavations proposed and as such it is considered that there is a *low* risk of groundwater flooding to the Proposed Development.

To minimise any risk from groundwater flooding during excavation of the Kent Project Site (Main Resort), cut levels should be limited to at least 0.5m above the groundwater level. Where this is not possible, dewatering and other groundwater control measures should be employed.

4.5 Flooding from artificial sources

Artificial sources of water include docks, canals, reservoirs, and lakes, where water is retained above natural ground level. Design failure at an artificial source of water has the potential to cause catastrophic damage to its surroundings due to the sudden release of large volumes of water. However, the likelihood of such a failure occurring is extremely low.

At the Kent Project Site (Main Resort) there are no artificial sources of flood risk and therefore the risk of flooding from artificial sources is considered to be *low*.

4.6 Surface Water Drainage Strategy

The Kent Project Site is predominantly an undeveloped area and is approximately 387.53 ha, from which the Main Resort is approximately 240 ha. The general topography is variable, with low-lying, undulating land across its central parts and some local mounds due to historical landfilling. The Kent Project Site (Main Resort) area has three managed marsh areas; Black Duck Marsh to the west, Botany Marsh to the east and Broadness Marsh to the north, which are currently drained via a series of manmade drainage ditches and culverts to the River Thames. A partially silted gravity culvert and the HS1 pumped culvert currently drain the majority of the Kent Project Site (Main Resort) area.

The proposals at the Kent Project Site (Main Resort) include Gates One and Two (Leisure Core), back of house facilities, Related Housing (staff accommodation) and infrastructure. Large areas are changing from permeable to impermeable.

The proposed drainage system will be designed for the 1 in 1-year storm event. Above ground flooding can occur only for events higher than the 1 in 30 year with 40% allowance for climate change (CC) in designated areas. Buildings will be protected up to the 1 in 100 year plus 40% CC design flood event and this has been tested against tide-locked conditions. The Proposed Development is designed for no flooding for up to the 1 in 1-year storm event combined with the 1 in 200 year tidal water level 2090 Higher Central allowance, and for up to the 1 in 100 year + 40% CC (up to 2115), combined with the Mean High Water Spring (MHWS). Sustainable Drainage Systems (SuDS) have been incorporated within the drainage network to provide benefit in terms of habitat creation and water quality.

Due to the Kent Project Site's (Main Resort) position abutting the River Thames, it is proposed that surface water runoff is discharged directly to the river. Some discrete and isolated areas of the Kent Project Site (Main Resort) to the south, such as the Related Housing (staff accommodation) and infrastructure compounds, are proposed to be drained via infiltration to the ground. These areas are considered to have good infiltration potential, low contamination levels and are the farthest away from the River Thames. As far as practical, a positive drainage system will be utilised within the development area to collect rainfall runoff from roofs and impermeable surfaces. The system will consist of open swales or piped gravity system if required. Pumping will be avoided and restricted to specific areas where the existing ground levels are very low around the HS1 tunnel. The surface water network will discharge to the two marsh areas on east and west of the site and a new constructed wetland proposed at the north of Gate One. Run-off from the access road will be collected via a perimeter swale, treated and discharged to the marshes/wetland. Finally, the surface water runoff will be discharged to River Thames, at unrestricted run-off rates, via new outfalls from the marshes and wetland area. The existing, silted gravity culvert and HS1 pumped culvert are not intended to be used and will be decommissioned, pending agreement with HS1. All outfalls will have second non-return valves. The marsh areas and wetland will act as attenuation areas during tide-locked conditions. The drainage strategy for Kent Project Site Main Resort is illustrated in Figure 4-29.

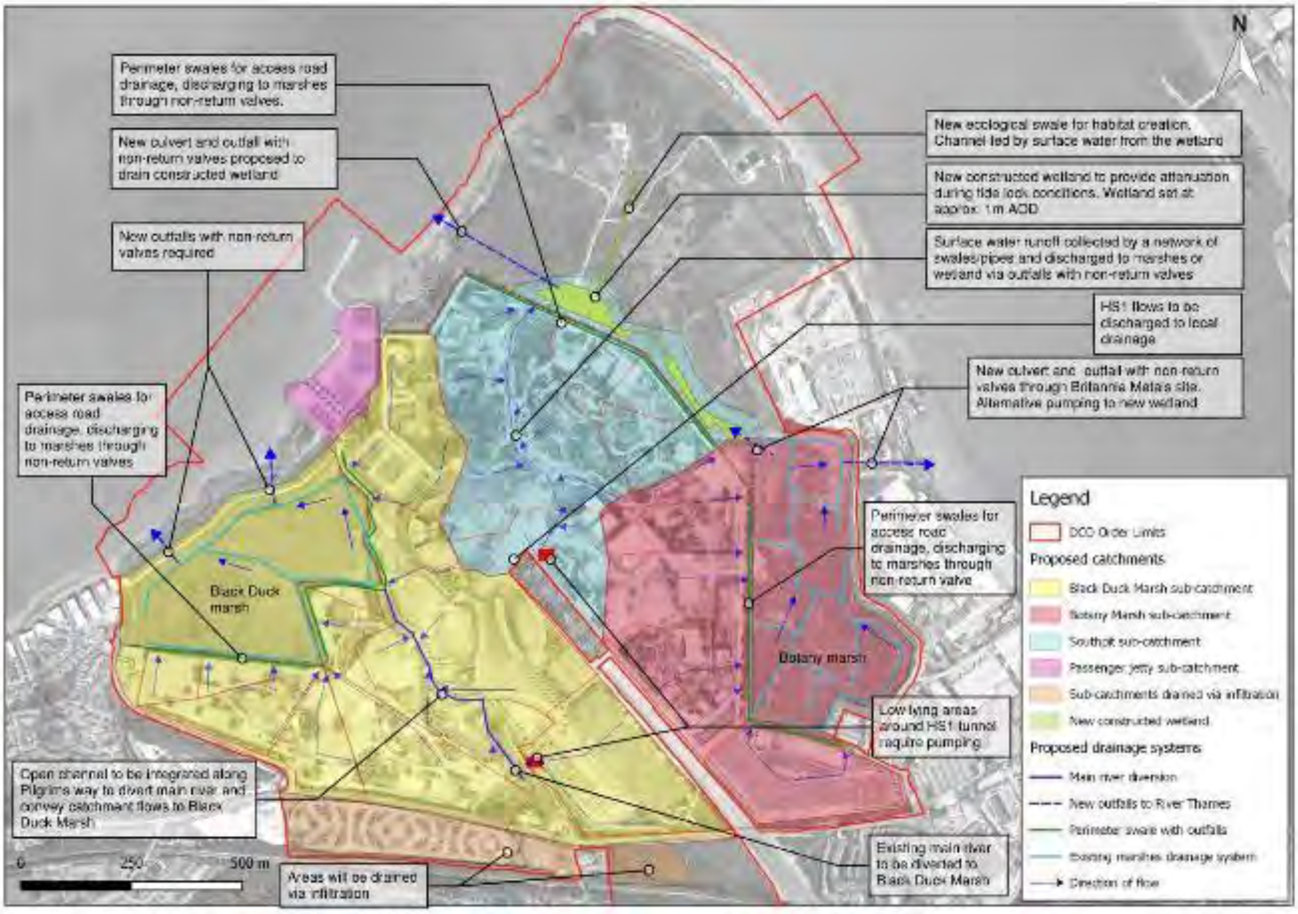

Figure 4-29: Proposed drainage strategy for Kent Project Site (Main Resort)

The additional volume of surface water runoff to the marshes is anticipated to create new habitat and provide ecological improvements under the Ecological Mitigation and Management Framework (Document Reference 6.2.12.3). Flexibility will be built into the design of the outfalls from the marshes allowing water levels within the marshes to be adjusted by increasing surface water outflows, as required. See the SWDS for further details (document reference 6.2.17.2).

4.7 Exception Test

In Section 2.2.1.3 of this report, the Related Housing, hotel units and critical infrastructure were identified as land used of a vulnerability classification that would require the Exception Test to be passed in order for the Proposed Development to be permitted within Flood Zone 3. To pass the Exception Test it must be demonstrated that:

- The Proposed Development provides wider sustainability benefits to the community that outweigh flood risk, informed by a strategic flood risk assessment where one has been prepared; and
- The Proposed Development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

The Swanscombe Peninsula is identified by the Kent Thameside SFRA as being under consideration as a 'mixed Major Development Site'.

The Proposed Development will positively serve the local communities and the Resort itself with new public areas offering a range of retail, commercial, dining and entertainment facilities connected to public spaces. The Proposed Development offers environmental enhancement through the provision of enhanced salt marsh areas between the flood defence alignment at the River Thames, and a new freshwater marsh area in the Broadness area to the north of Swanscombe Peninsula. It is therefore considered that the Proposed Development satisfies the environmental requirements of the Exception Test.

The Proposed Development includes increasing the standard of protection of the formal flood defences to 7.00m AOD, which is the level required by the year 2070 under the EA TE2100 Plan. Provisions are in place to improve the level of protection to 8.00m AOD by 2070 subject to a decision on the location of the new Thames Flood Barrier which is the level currently required by the year 2170 under the EA TE2100 Plan. To mitigate against the residual flood risk to the Kent Project Site (Main Resort) in the event of a breach, the proposed finished floor levels of the More Vulnerable land uses are set 300mm above the 1 in 200 year event in 2125 using the upper end climate change projection and the building is designed to be flood resilient up to this level. For the More Vulnerable land uses safe refuges and escape routes are set above the 1 in 200 year event in 2125 using the upper end climate change projection. As such it can be demonstrated that the Kent Project Site (Main Resort) will be safe from flood risk for its lifetime, in accordance with EA requirements and guidance and that the second part of the Exception Test is satisfied.

5 Appraisal and management of flood risk – Kent Project Site (Access Road)

5.1 Tidal flooding (overtopping and breach)

5.1.1 Baseline

The flood zone map produced by the EA shows that the Kent Project Site (Access Road) intersects all three of the EA flood zones. The Ebbsfleet Valley runs through the Order Limits and therefore some of the east is within the Fluvial Flood Zone 2 and Fluvial Flood Zone 3, as shown on Figure 5-1. The remainder of the Kent Project Site (Access Road) area is within Flood Zone 1. As a result the focus of the following analysis will be for the areas of the Order Limits that are within the Ebbsfleet Valley.

Flood Zone 3 is defined as an area with 1% or greater annual probability of river flooding, or a 0.5% or greater annual probability of flooding from the sea in any given year. According to the NPPF, the risk of flooding from rivers or the sea in Flood Zone 3 is classified as high.

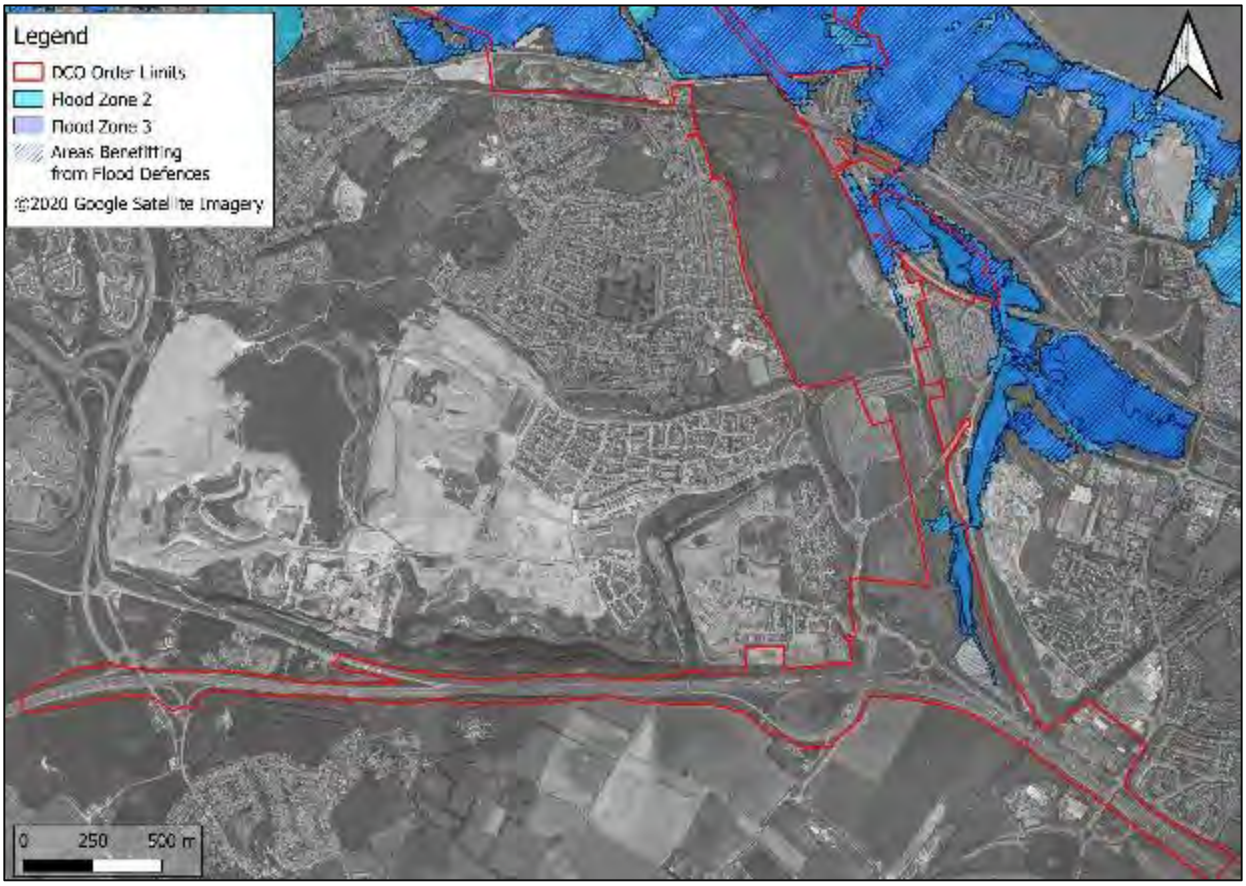

Figure 5-1: EA flood map showing Flood Zones 2 and 3, highlighting fluvial and tidal flood risk to the Kent Project Site (Access Road) (EA Product 4, 28/07/2020)

Sensitivity testing has been undertaken to understand the impact on modelled flood extents as a result of future sea level rise. The results indicate that flood extents do not increase except at Sawyer Lake which is located outside of the Order Limits, to the east. Flood depths within the River Ebbsfleet increase as a result of future sea level rise. Further details can be found in Appendix B.

5.2 Fluvial flooding

5.2.1 Baseline

The River Ebbsfleet runs through the Kent Project Site (Access Road). The River Ebbsfleet is a groundwater fed system that emerges at Springhead, located at National Grid Reference (NGR TQ6178372559) and flows north to the confluence of the water course with the River Thames beyond the northern edge of Robins Creek (NGR TQ6197074941).

The route the River Ebbsfleet takes (flowing south to north) is shown on Figure 5-2.

Figure 5-2: EA designated main rivers

Figure 5-3 shows the fluvial flood extents from the River Ebbsfleet 2016 hydraulic model for the River Ebbsfleet that affect the Kent Project Site (Access Road). There is out of bank flooding along much of the River Ebbsfleet Valley, however this flood plain remains within a narrow corridor. The extents show that climate change has a low impact on the flood extents of the River Ebbsfleet within the Order Limits. A partial area of the proposed Access Road intersects the flood extent and will therefore require flood mitigation measures to be put in place to ensure the risk to the road is minimised and that it does not increase the risk elsewhere.

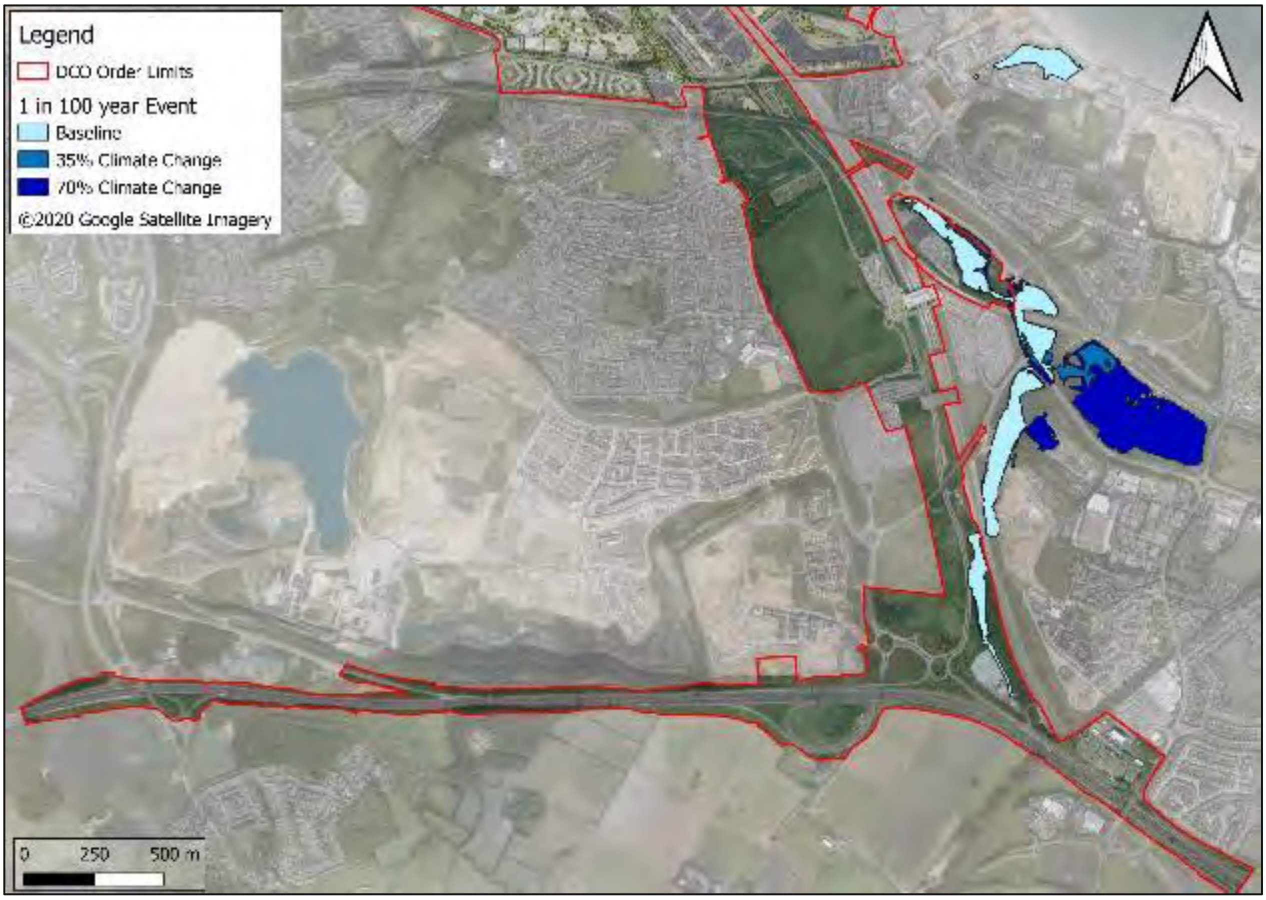

Figure 5-3: London Resort Kent Project Site (Access Road) fluvial flood extents

5.2.2 Proposed mitigation strategy

The following section has been prepared by WSP who are designing the Kent Project Site (Access Road) and have considered flood risk in relation to the access road.

The proposed highway alignment crosses a short section of the River Ebbsfleet floodplain.

To ensure a dry access route in the future, the level of the section of road that passes close to the River Ebbsfleet will be set above the following:

- 1 in 100 year event with 70% allowance for climate change for the epoch 2070 to 2115 (upper end) plus 300mm allowance for freeboard.

This level is estimated at 3.9mAOD (3.6mAOD + freeboard). See Appendix C for further details.

An assessment of the extent of the floodplain and of the extent of the proposed highway highlights that an area of approximately 0.126 ha is lost. The proposed highway embankment abutting the flood plain will incorporate retaining walls structures to ensure that the impact on the flood plain is minimised.

Compensatory storage will be provided 'levels for levels' in adjoining areas ensuring that flood risks are not increased.

Areas located directly upstream and downstream have been identified which can be locally lowered to ensure that the local flood plain storage is maintained.

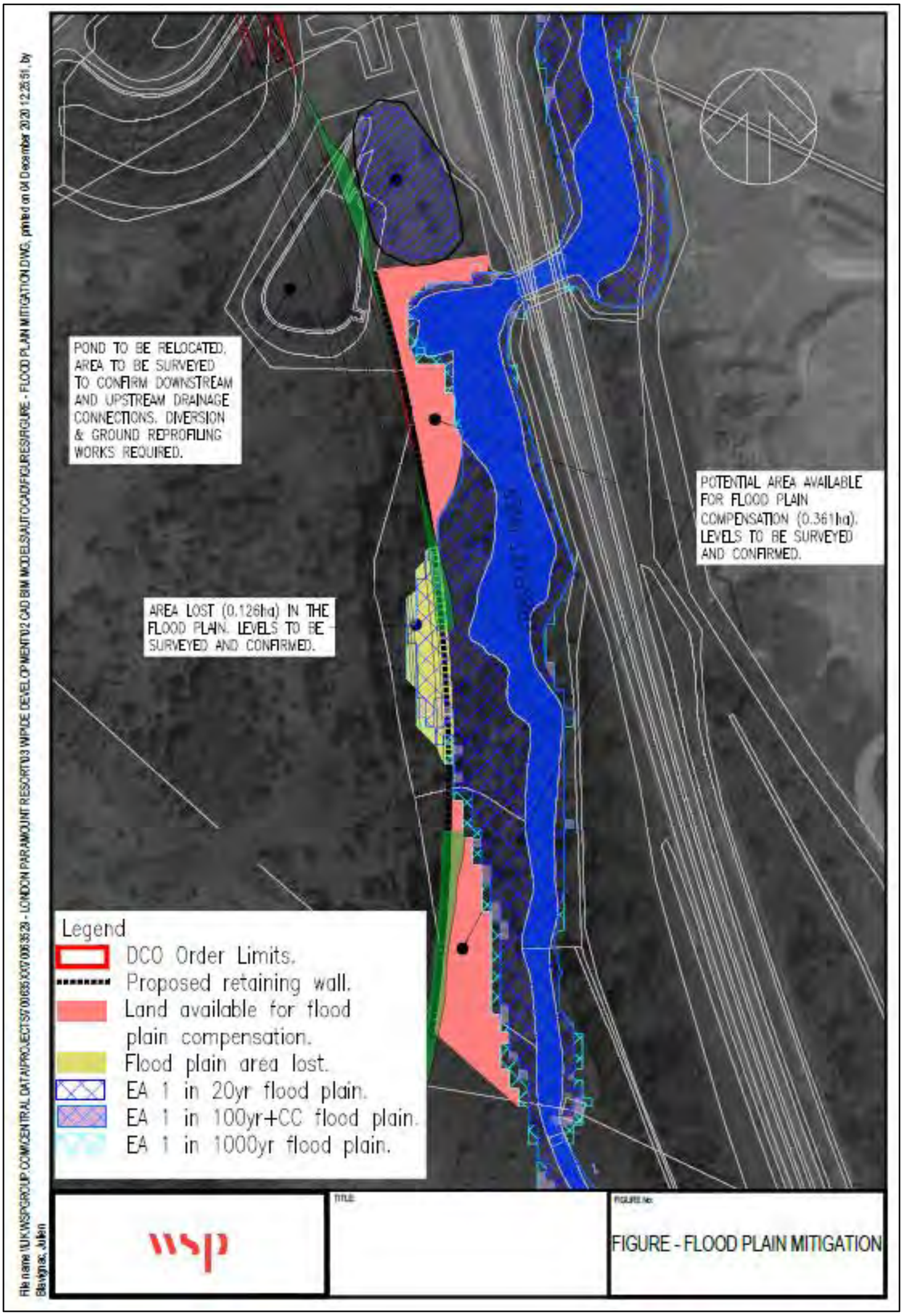

Figure 5-4: London Resort Kent Project Site (Access Road) fluvial flood plain mitigation

Figure 5-4 shows the fluvial flood extent that is lost due to the new highway alignment. Land has been identified directly upstream and downstream that may be able to provide compensatory flood plain storage but further investigation is required. Investigations are to include a detailed topographical survey of the watercourse embankments during the detailed design stage to inform a constraint review. If as a result of these investigations, the two areas are deemed unsuitable; further design options will be appraised, which may include relocating the road further to the west outside the floodplain.

5.3 Surface water and sewer flooding

5.3.1 Baseline

The EA surface water flood map, shown in Figure 5-5 for the Kent Project Site (Access Road) indicates that the majority of the site is classified as having a low probability of surface water flooding (<0.1% chance in any given year). There are some areas with a high probability of surface water flooding (>3.3% chance in any given year), which correspond to local depressions and roads in the topography of the Kent Project Site (Access Road). The localised depressions are particularly orientated around the Ebbsfleet International station, the Ebbsfleet River valley and Bamber Pit.

Figure 5-5: EA flood map showing surface water modelled flood extent (Map data ©2015 Google, © Environment Agency copyright and/or database right 2014. All rights reserved. Some features of this map are based on digital spatial data from the Centre for Ecology & Hydrology, © NERC (CEH). Soils Data © Cranfield University (NSRI) and for the Controller of HMSO 2013.)

5.3.2 Proposed mitigation strategy

The risks associated with surface water and sewer flooding have been considered with relation to the Proposed Development in the Surface Water Drainage Strategy (document reference 6.2.17.2) which is summarised below in Section 5.6 of this report.

5.4 Groundwater flooding

5.4.1 Baseline

Groundwater flooding generally occurs in low-lying areas above permeable rock aquifers where the water table meets and rises above the ground surface.

The Kent Project Site (Access Road) is underlain by Thanet Formation Bedrock along the A2 road and Lewes Nodular Chalk along the proposed new access road running north from the A2 along the Ebbsfleet valley. The area at greatest risk within the Kent Project Site (Access Road) is in the Ebbsfleet Valley. The River Ebbsfleet itself is groundwater fed and therefore the water table at the base of the valley is close to and in places above the ground level. The Kent County Council SFRA identifies the Ebbsfleet Valley as being at high risk from groundwater flooding, see Figure 5-6.

The Kent Thameside FRA indicates that should pumping cease at East Quarry, the flow rates in the River Ebbsfleet could increase and groundwater tables rise.

At present, however, the Kent County Council Preliminary FRA locates the Kent Project Site (Access Road) within an area shown to have a negligible risk of groundwater flooding, see Figure 5-7.

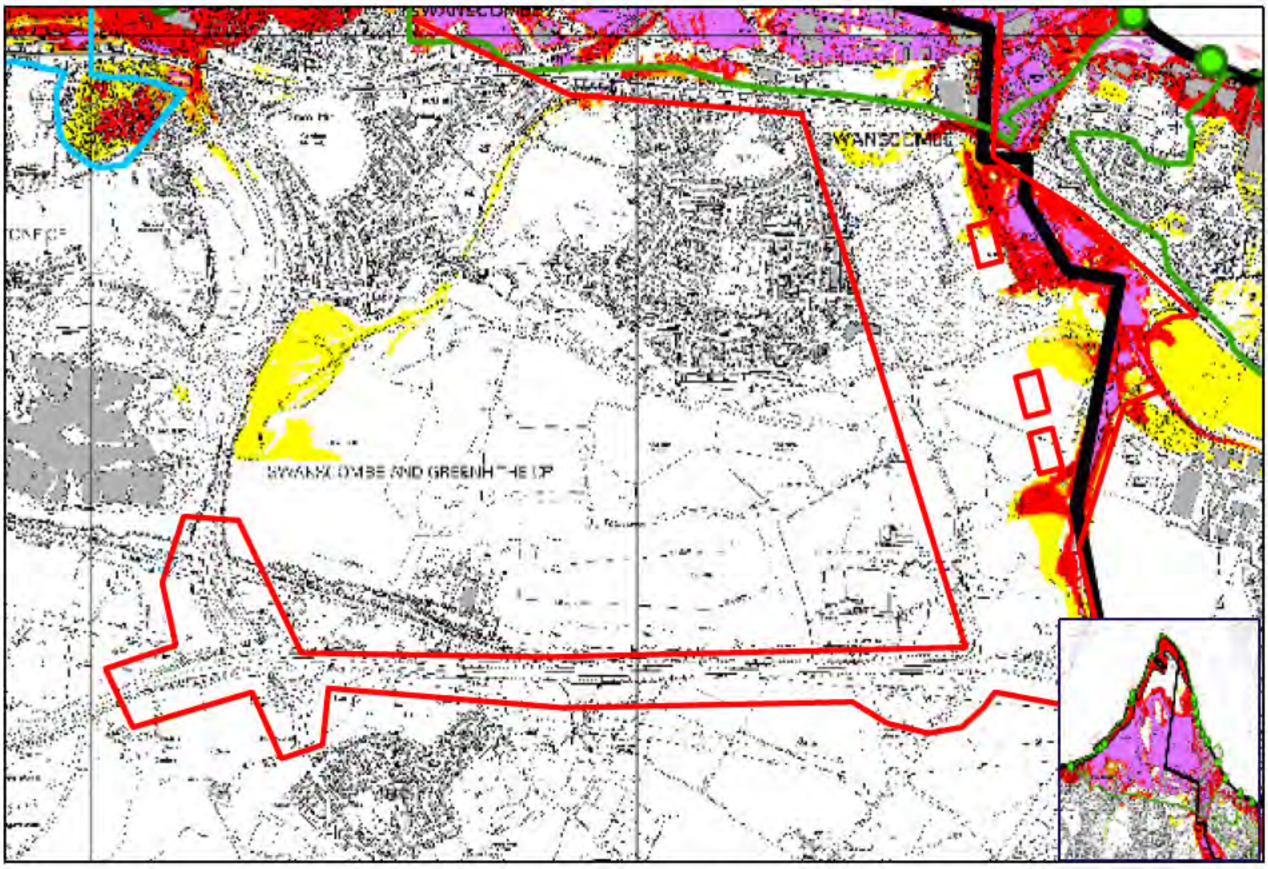

Figure 5-6: Kent Thameside SFRA Residual Flood Risk Map, including Groundwater Risk Areas

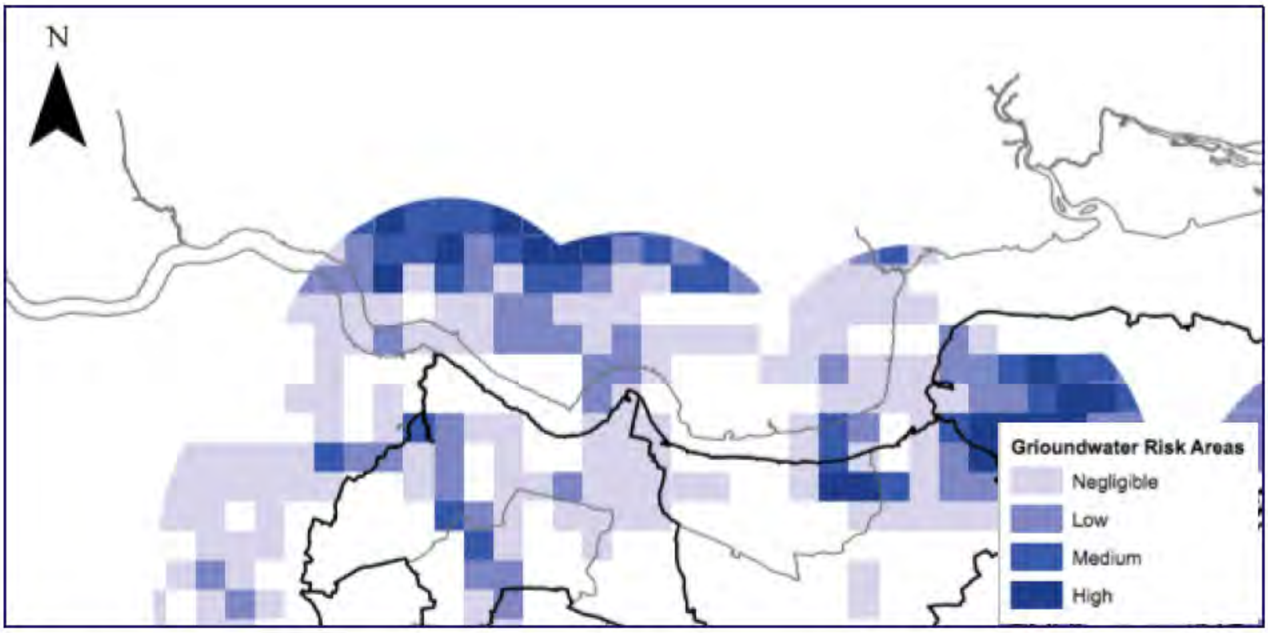

Figure 5-7: Kent County Council Groundwater Risk Areas (Kent County Council Preliminary Flood Risk Assessment - Main Report - Figure 6)

5.4.2 **Proposed mitigation strategy**

The Proposed Development within the Kent Project Site (Access Road) area is predominantly the Access Road which will not be impacted by groundwater. Other aspects of the Proposed Development are the utility compound and works around Ebbsfleet International station, both within the chalk of the Ebbsfleet Valley. These two developments are set above the valley bottom which will reduce the flood risk to the developments from groundwater. There are no basement excavations proposed and as a result the actual risk to the Proposed Development is considered to be *low*.

To minimise any risk from groundwater flooding during excavation of the Kent Project Site (Access Road), cut levels should be limited to at least 0.5m above the groundwater level. Where this is not possible, dewatering and other groundwater control measures should be employed.

5.5 Flooding from artificial sources

Artificial sources of water include docks, canals, reservoirs, and lakes, where water is retained above natural ground level. Design failure at an artificial source of water has the potential to cause catastrophic damage to its surroundings due to the sudden release of large volumes of water. However, the likelihood of such a failure occurring is extremely low.

At the Kent Project Site (Access Road) there are no artificial sources of flood risk in the vicinity and therefore the risk of flooding from artificial sources is considered to be *low*.

5.6 Surface Water Drainage Strategy

The following section has been prepared by WSP who considered the flood risk to the Kent Project Site (Access Road) as part of the masterplan design for the Access Road.

The Kent Project Site (Access Road) area is mainly undeveloped and includes land that were previously used for landfill activities and crosses existing infrastructures such as Ebbsfleet International Station's access road and railway tracks.

The general topography is variable, generally falling into north and east directions and some local mounds due to historical landfilling. The area includes ponds and a network of land drains, ditches and culverts. It is anticipated that the existing site ultimately drains to the Ebbsfleet River.

The proposals include an upgrade of the multi-roundabouts junction to the A2 (T), an upgrade of the south main access to Ebbsfleet International Station (A2260) and the construction of a main and secondary access roads for vehicles and infrastructure buildings.

The proposed drainage system will be designed for the 1 in 2-year storm event. Above ground flooding can occur only for events higher than the 1 in 30 year with 40% allowance for climate change in designated areas. The strategy is designed for no increase in flooding outside the development for the respective 1 in 2 year and 1 in 100 year + 40% Climate Change. SuDS have been incorporated within the drainage network to provide benefit in terms of habitat creation, biodiversity and water quality.

The drainage strategy for the Kent Project Site (Access Road) is to discharge by gravity through a network of attenuation ponds and underground storage to the Ebbsfleet River at greenfield runoff rates. Infiltration to the ground will be used where proven possible, pending further site investigation. Some sections of highway to the south will include standalone highway soakaways. A pumping station and associated storage will be required to drain the northern part of the proposed access road, where gravity drainage is not feasible.

Where existing ponds are impacted by the proposed access road, they are to be relocated on a like-for-like basis adjacent to its current location, to ensure no net loss of attenuation capacity and biodiversity.

See the Surface Water Drainage Strategy for further details (document reference 6.2.17.2).

5.7 Exception Test

In Section 3.2.1.3 of this report, the Proposed Development as part of the Access Road include Less Vulnerable Works at the Ebbsfleet International station and Critical Infrastructure at the Electricity Sub Station and along the Access Road. The Access Road intersects with the River Ebbsfleet Flood Zone 3b, functional floodplain and would require the Exception Test to be passed for the Proposed Development to be permitted within Flood Zone 3. To pass the Exception Test it must be demonstrated that:

- The Proposed Development provides wider sustainability benefits to the community that outweigh flood risk informed by a strategic flood risk assessment where one has been prepared; and
- The Proposed Development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

The Ebbsfleet Valley is identified by the Dartford Core Strategy as being an area of opportunity for increased development and as a means to improve access to the Swanscombe Peninsula.

The Proposed Development includes an Access Road to the Swanscombe Peninsula which will open up the area for increased footfall and custom. The dedicated Access Route will reduce the impact on existing local roads, reducing the impact on local residents and businesses. The Access Road also forms a connection point to the proposed electricity sub-station and utility compound. Therefore, access to these compounds is considered to be required at all times. This will be possible from the A2, along the Access Road, as parts of the A226 London Road becomes flooded during a breach scenario in a future extreme storm event.

As described in the previous section, the design of the Access Road ensures that it is safe to users of the road for a 100 year development life, whilst providing flood mitigation measures to ensure that risk of flooding is not increased to surrounding users and thus the exception test is satisfied.

6 Appraisal and management of food risk – Essex Project Site

6.1 Tidal flooding (overtopping and breach)

6.1.1 Baseline

The flood zone map produced by the EA shows that the Essex Project Site is entirely within Flood Zone 3 if undefended, as shown in Figure 6-1.

Flood Zone 3 is defined as an area with 1% or greater annual probability of river flooding, or a 0.5% or greater annual probability of flooding from the sea in any given year. According to the NPPF, the risk of flooding from rivers or the sea in Flood Zone 3 is classified as high.

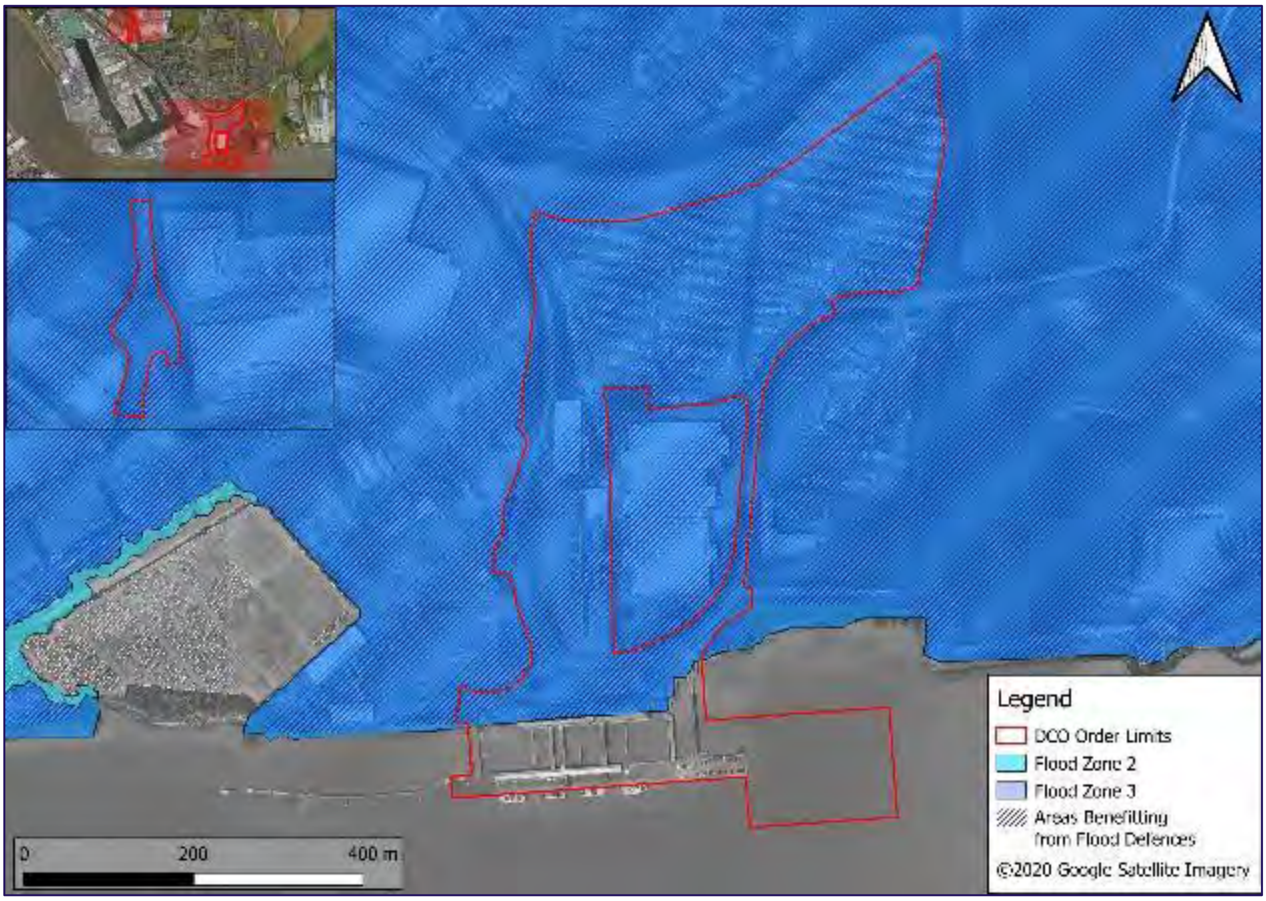

Figure 6-1: Essex Project Site EA Flood Zones

The Essex Project Site benefits from existing flood defences along the quay side, see Figure 6-2. Much of the flood defence extent within the Order Limits is a steel flood defence structure built inside the Tilbury Cruise Terminal (TCT) in the baggage hall and in the Riverside Station Buildings, along their northern walls. The total length is approximately 170m, including 11 flood gate openings. In the Baggage Hall, the steel structure is tied to the building's masonry wall. In the riverside station, the steel flood defence is a standalone steel structure supported by oblique steel props on the landward side and oblige steel ties on the riverward side.

To the east of the TCT the defences are steel plate sections bolted onto the southern face brickwork of the adjacent Tilbury Riverside Arts Activity Centre (TRAAC) with a mass concrete fill between the steel plate and the brickwork, see Figure 6-3. Those defences then run north east from the TRAAC toward the Order Limits consisting of steel box sections bolted to the original jetty deck, including a floodgate opening.

The flood defence crest elevations vary slightly from 6.45m AOD to 6.71m AOD.

Figure 6-2: Essex Project Site existing flood defence alignment, type and crest elevation.

Figure 6-3: London Resort Essex Project Site existing flood defences (photograph taken during site visit 28/07/20, looking west)

Overtopping

The existing defences provide a standard of protection to the Essex Project Site to the 1 in 1000 year event. However, for larger events and for future events there is risk of flooding as a result of the overtopping of the existing flood defences during tidal events. The risk to the Essex Project Site is from overtopping of the formal flood defences immediately in front but also from overland flow from the north east that results from the overtopping of offsite formal flood defences outside of the Order Limits to the east.

The Essex Project Site *is not* at risk from overtopping of the existing defences during the 1 in 200 year nor the 1 in 1000 year higher central climate change projection flood event for future epochs up to 2090.

Assuming no change to defence crest levels the Essex Project Site *is* at risk from overtopping of the formal flood defences during the 1 in 200 year and the 1 in 1000 year higher central climate change projection flood event in 2125.

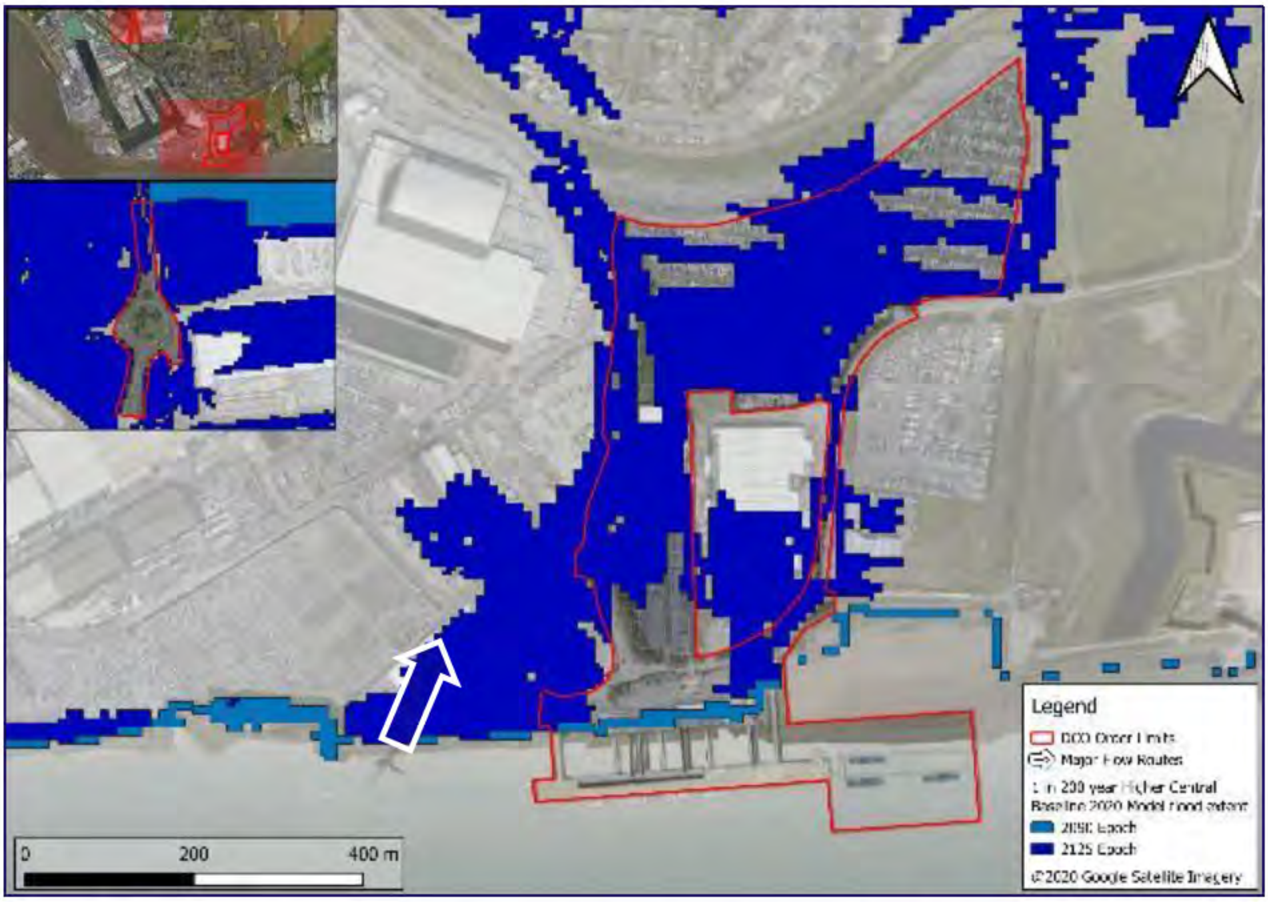

Figure 6-4: Key overtopping flow route into the Essex Project Site during the existing condition for the 1 in 200 year return period event using the higher central climate change projections across different years.

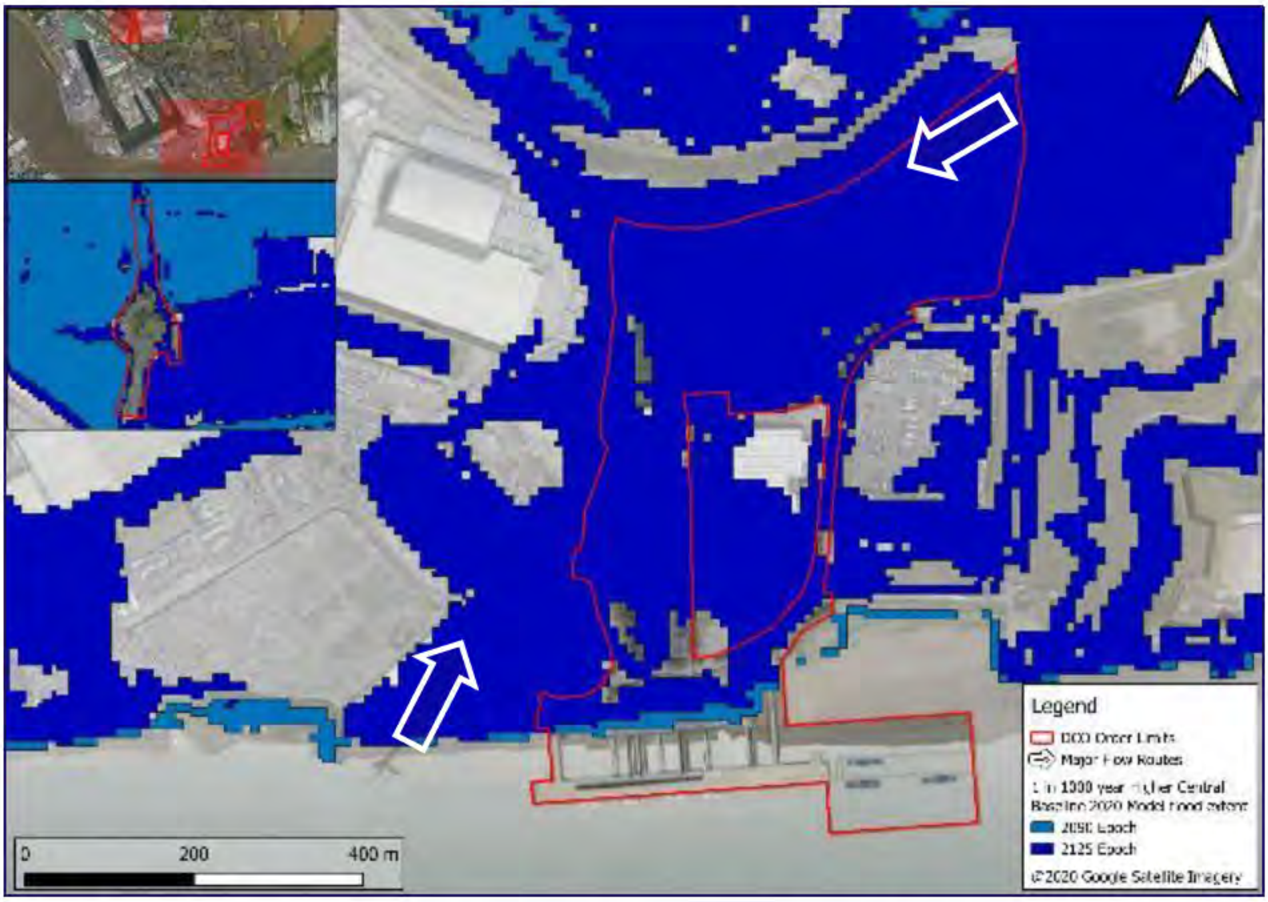

Figure 6-5: Key overtopping flow routes into the Essex Project Site during the existing condition for the 1 in 1000 year return period event using the higher central climate change projections across different years.

Breach

Figure 6-2 shows that much of the Essex Project Site benefits from flood defences. Therefore, the failure of part of these defences in the form of a breach is a source of flood risk.

The mechanism for a breach will vary depending on the location along the defence line. Immediately south of the proposed car park and plaza are the TCT buildings. During an extreme storm event the TCT buildings will flood which may cause structural damage before reaching the floodgates which may breach. To the east of the buildings a floodgate on the existing jetty within the Order Limits also has the potential to breach.

For the assessment, a breach location has been selected in the Tilbury formal flood defences that are within the Order Limits. This location has been selected on the following criteria:

1. Where the ground on the landward side of the flood defence is lowest; and

2. Where the Proposed Development is most likely to have the greatest impact on the flow path.

Figure 6-6 shows the location selected for the breach. This location is directly in front of the Proposed Development. The details of the breach are in Table 6-1.

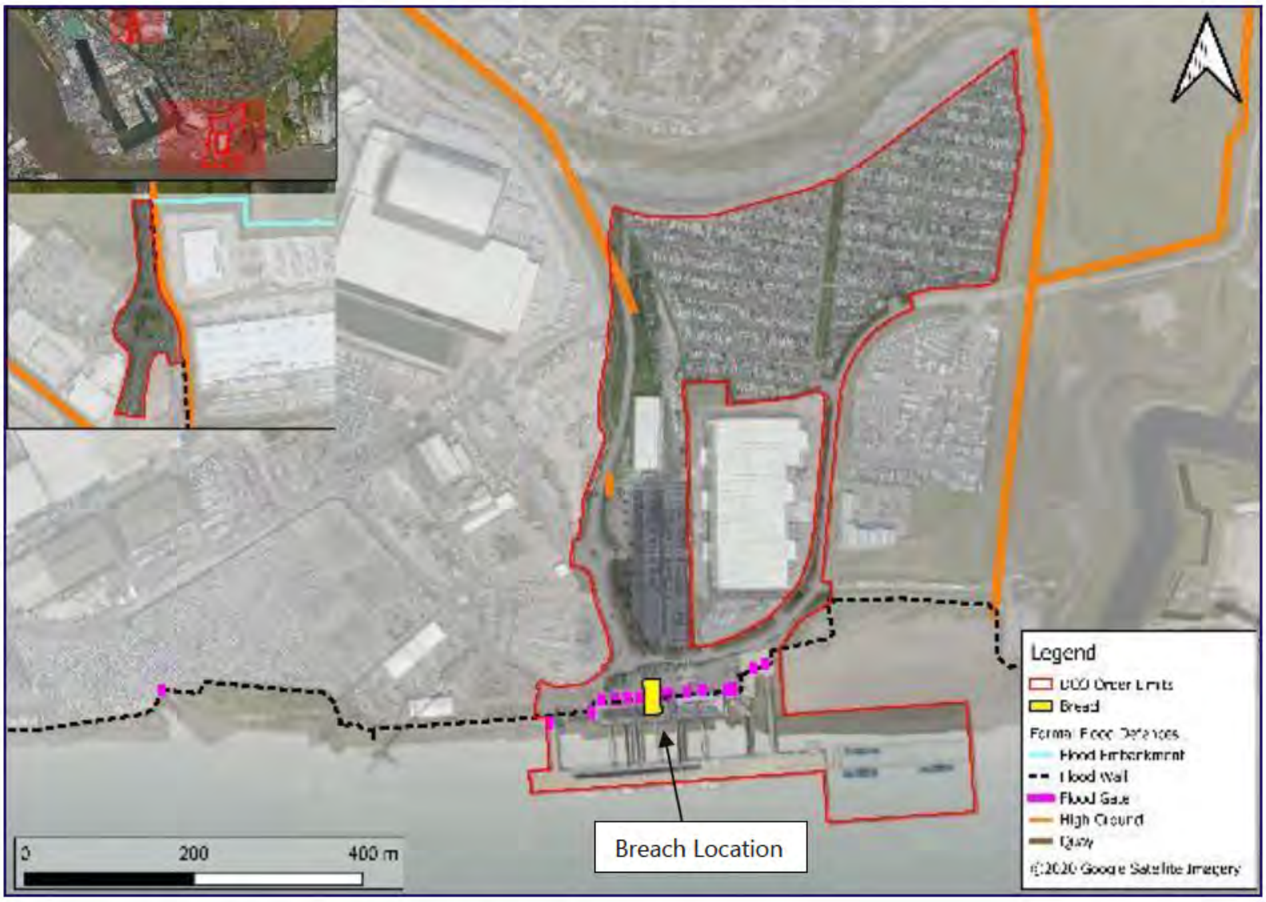

Figure 6-6: Essex Project Site breach location

Table 6-1: Breach ID and design

Breach ID	Crest Level	Ground/Breach Level (m AOD)	Breach Width (m)
Breach 22	6.63	4.04	20

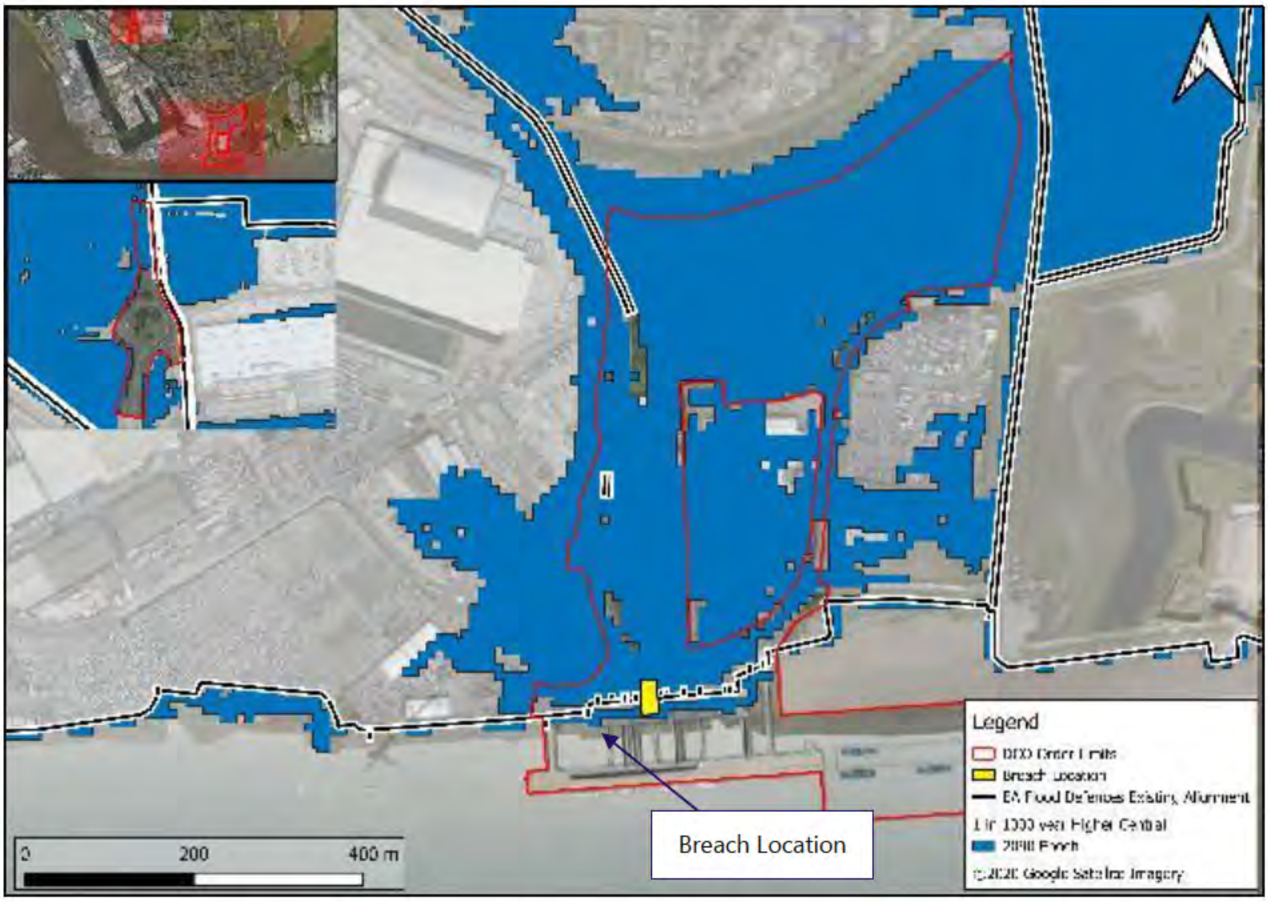

Figure 6-7: Essex Project Site baseline breach flood extent for the 1 in 1000 year return period event using the higher central climate change projections in 2090.

Flood levels

Flood Levels have been extracted from the Baseline 2020 Model Results in order to assess how the Essex Project Site performs in the baseline condition (no Proposed Development or changes to existing flood defences) and estimate the level of flood risk. Figure 6-8 shows the locations where the levels have been extracted from (including both in channel and the floodplain). The levels extracted are shown in Table 6-2.

Figure 6-8: Essex Project Site Baseline 2020 Model Results Sampling Locations

Table 6-2: Essex Project Site estimated maximum flood levels from the Baseline 2020 Model (Note, a '-'indicates model not simulated for particular scenario).

Year	Tidal Event	In Channel	Overtopping	Breach
Lowest existing flood defence crest level			6.45	
2090	1 in 200yr HC	6.20	0	2.98
	1 in 200yr UE	6.41	0	3.40
	1 in 1000yr HC	6.40	0	3.04
	1 in 1000yr UE	6.56	2.72	-
2100	1 in 200yr H++	7.10	4.10	-
	1 in 1000yr H++	7.40	5.30	-
2125	MHWS	-	-	-
	HAT	-	-	-
	1 in 200yr HC	6.60	2.82	-
	1 in 200yr UE	6.90	3.41	-
	1 in 1000yr HC	6.80	3.20	-
	1 in 1000yr UE	7.10	4.00	-

6.1.2 Proposed mitigation strategy

The measures that have been proposed in order to mitigate the flood risk to the Essex Project Site from tidal sources (overtopping and breach) fall into the following two categories:

1. Incorporate flood resilient measures; and

2. Establish a flood evacuation and management plan.

The baseline flood mapping shown in Figure 6-4 and Figure 6-5 indicate that the Essex Project Site is at risk from overtopping of the formal flood defences during the 1 in 200 year and the 1 in 1000 year higher central climate change projection flood event in 2125. Ground raising is not proposed in the Essex Project Site. However, the Proposed Development has been assessed in the Proposed 2020 model as a change in ground condition to represent the addition of the new buildings in the Site (see Appendix C for further details). Figure 6-9 indicates that the Proposed Development at the Essex Project Site has minimal increase in flood extent and depths compared to the baseline scenario. Localised increases of up to 90mm are observed in the locality of the Proposed Development, and approximately 15mm immediately to the north within the car park and Ferry Road. Figure 6-10 indicates that the Proposed Development locally increases flood extents to the east of the Order Limits approximately by 80mm during a breach scenario.

Figure 6-9 Essex Project Site change in Proposed 2020 model compared to Baseline 2020 model for overtopping flood extent in the 1 in 200 year event for 2125 higher central climate change projection

Figure 6-10 Essex Project Site change in Proposed 2020 model compared to Baseline 2020 model for Breach flood extent in the 1 in 200 year event for 2125 higher central climate change projection

To ensure that the Proposed Development does not increase the flood risk to sites outside the Order Limits, the multi-storey car park will be designed so that the ground level of the structure includes wide openings allowing floodwater to continue to flow into the space like it currently would. The ground floor construction material will be similar to that as existing, which would reduce any displacement of floodwater.

It is not proposed to alter the existing formal flood defences that are included within the Order Limits at the Essex Project Site.

However, as part of the future aspirations of the TE2100 Plan, the EA are currently investigating a realignment of the existing flood defences within the existing TCT buildings. Current drawings from the EA TE2100 Team entitled Tilbury Cruise Terminal Option 1 TEA-3F-00.00-DR-CI-00-000005 Rev P04 (January 2018) indicate a proposed realignment of defences along the southern side of Fort Road to the north of TCT buildings. The proposal is for an initial crest level of **6.9m AOD**, however consideration will be made for the fact that this crest level may require raising at a later date to **8.00m**

AOD. The design team will work closely with the EA as they develop their proposals for the new flood defences to ensure that an integrated approach to an effective solution can be made.

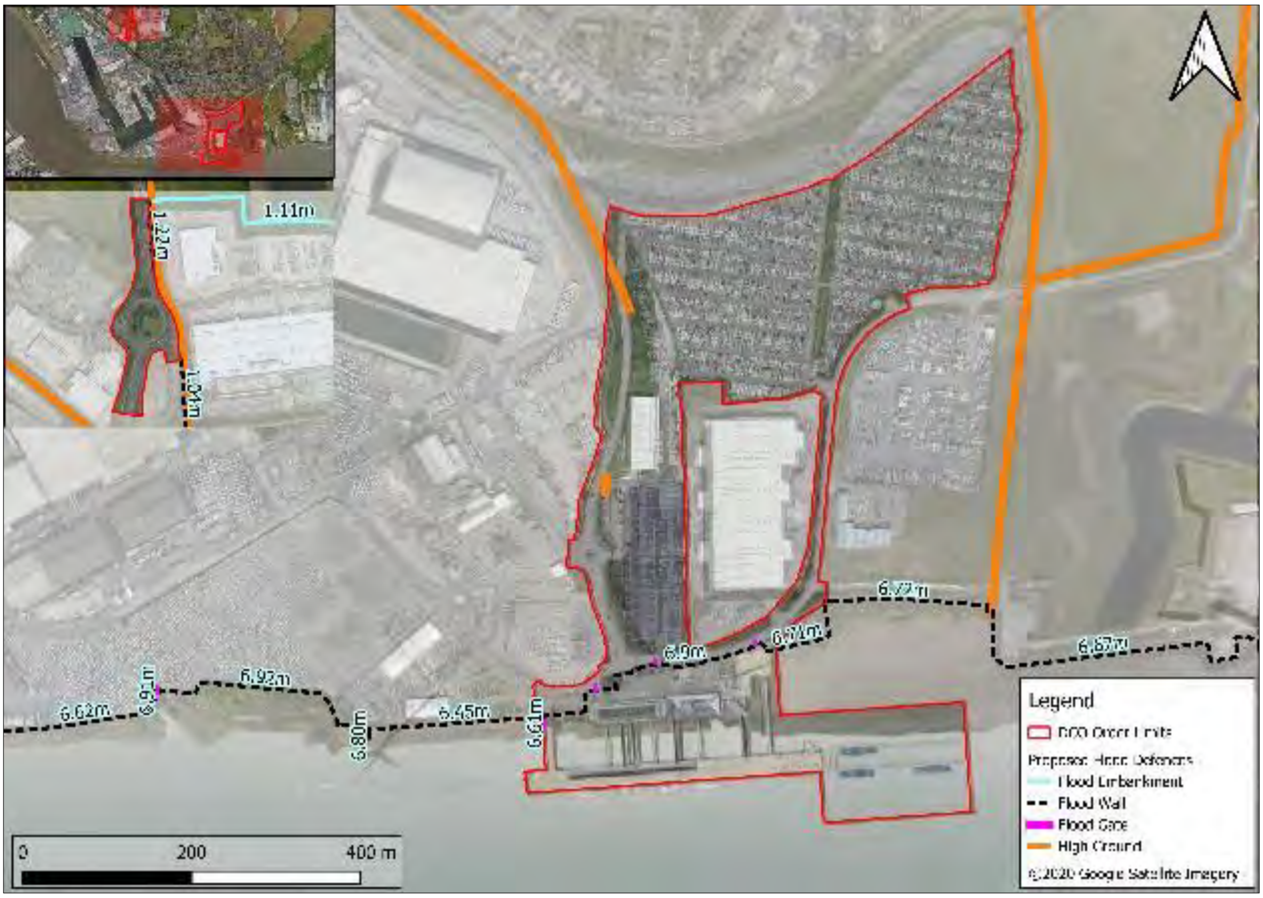

Figure 6-11: EA proposed flood defence alignment information taken from drawing TEA-3F-00.00-DR-CI-00-000005 Rev P04 (January 2018) Illustrative masterplan shown on imagery.

Any proposed refurbishment of the existing TCT buildings should be undertaken such that they do not impact the existing flood defence structure. Consideration will be made in the design that the EA will require access to inspect the existing defences and may require access to the Essex Project Site to improve the defences as outlined above.

6.1.2.1 Incorporate flood resilient measures

Table 4-4 shows the maximum DFE water level for the Proposed 2020 model at the Proposed Development at the Essex Project Site. Also included in the table is the proposed flood mitigation measures.

Table 6-3: Less Vulnerable development uses and the estimated maximum water levels and depths (Proposed 2020 Model) – with recommended flood mitigation measures.

Proposed Development	Existing ground level (m AOD)	Proposed ground level (m AOD)	Residual – breach Water level (m AOD) (depth m)						Flood mitigation measure
			2090		2100		2125		
			1:200yr HC	1:1000yr HC	1:200yr H++	1:1000yr H++	1:200yr HC	1:1000yr HC	
Cruise Terminal	4.1	4.1	5.1 (1)	5.2(1.1)	5.4 (1.32)	5.6 (1.5)	5.2 (1.1)	5.3 (1.2)	Building flood resilience measures up to 5.4m AOD.
Car Park	2.2 – 3.0	2.2 – 3.0	4.0 (1.8)	4.0 (1.8)	3.8 (1.6)	4.8 (2.6)	4.4 (2.2)	4.5 (2.3)	Building flood resilience measures up to 4.3m AOD.
Jetty	*N/A*	*N/A*	6.4	6.4	6.9	7.2	6.6	6.7	Building flood resilience measures up to 6.7m AOD.

The Proposed Development at the Essex Project Site is considered Less Vulnerable, or water compatible. The podium levels of the proposed multi-storey car park and passenger plaza are to remain at existing ground levels. To ensure that during a flood event, the risk to damage or cause for harm is kept as low as possible, appropriate mitigation measures will be put in place. This will include buildings with hard finishes such as in situ concrete and screed. Any bicycle area should have racks to secure the bikes and bollards put in appropriate areas if necessary, to ensure vehicles are not moved by floodwaters out of the vicinity of the multi-storey car park. Signage should be provided to warn users of the susceptibility to flooding and advise of routes to higher ground.

Minor works are proposed for modifying the existing road network. There is no intention to change road levels, instead the work will focus on traffic flow and road layout.

6.1.2.2 Establish a Flood Evacuation and Management Plan

Flood evacuation and management plans will be put in place to close the plaza to visitors during extreme weather warnings (the Resort will also be closed during this time). These procedures will be written as part of the detailed design stage, that will be coordinated with Tilbury Cruises and local authority emergency planners to ensure a coordinated response.

Figure 6-12 illustrates the flood hazard to the Essex Project Site during a 1 in 200-year 2125 overtopping Higher Central flood event and 1 in 200-year 2090 breach Higher Central event for both the Baseline 2020 model and the Proposed 2020 model. The flood hazard does not change at the Proposed Development or other areas compared to baseline scenario during future overtopping event in 2125. A localised increase from 'no hazard' to 'danger for some' is observed to the east of the Proposed Development in the industrial building immediately to the east as shown in Figure 6-12 during a breach scenario. The probability of a breach or failure in the defences is considered low.

As previously mentioned, the multi-storey car park will be designed so that the ground level of the structure includes wide openings allowing floodwater to continue to flow into the space like it currently would. This will reduce the potential impact to areas outside the Order Limit. However, to minimise the flood hazard to users, a Flood Evacuation and Management Plan is required to ensure flood warnings of a large storm event can be made.

Figure 6-12 indicates that during a breach event the fastest moving and deepest flood water moves away from the coast in a northerly direction. This follows the topography which slopes down away from the coastline. The flood hazard is lowest to the east. Therefore, flood evacuation routes will be established to the east of the Terminal building along Fort Road to allow any remaining visitors safe exit routes during a breach event.

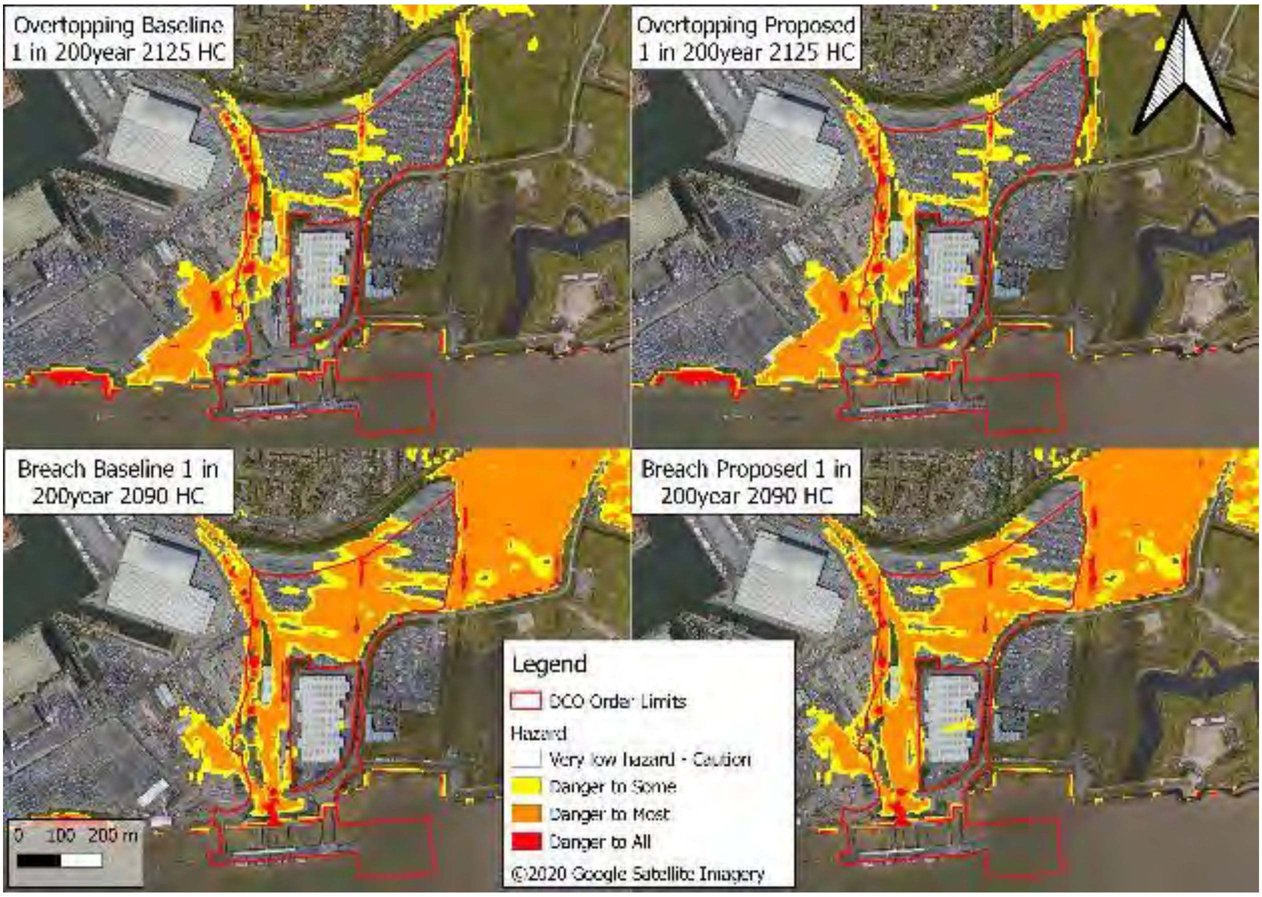

Figure 6-12: Essex Project Site 1 in 200 year overtopping and breach event (breach 22) 2090 using the higher central climate change allowance hazard flood map comparing Proposed 2020 model to Baseline 2020 model.

6.2 Fluvial flooding

6.2.1 Baseline

The Essex Project Site has two EA designated main rivers that run either through the Order Limits or in proximity to the Order Limits. Both run from north to south on the east and west sides of the Proposed Development.

The main river to the east of the Essex Project Site is known as Pincocks Trough. This river is fed by Chadwell Cross sewer and runs down the east of the Essex Project Site boundary. Pincocks Trough discharges into the River Thames at World's End Pumping Station, see Figure 7-11.

The main river to the west of the site is known as East Dock Sewer.

The rivers and the location of the rivers in relation to the Essex Project Site are indicated on Figure 6-13.

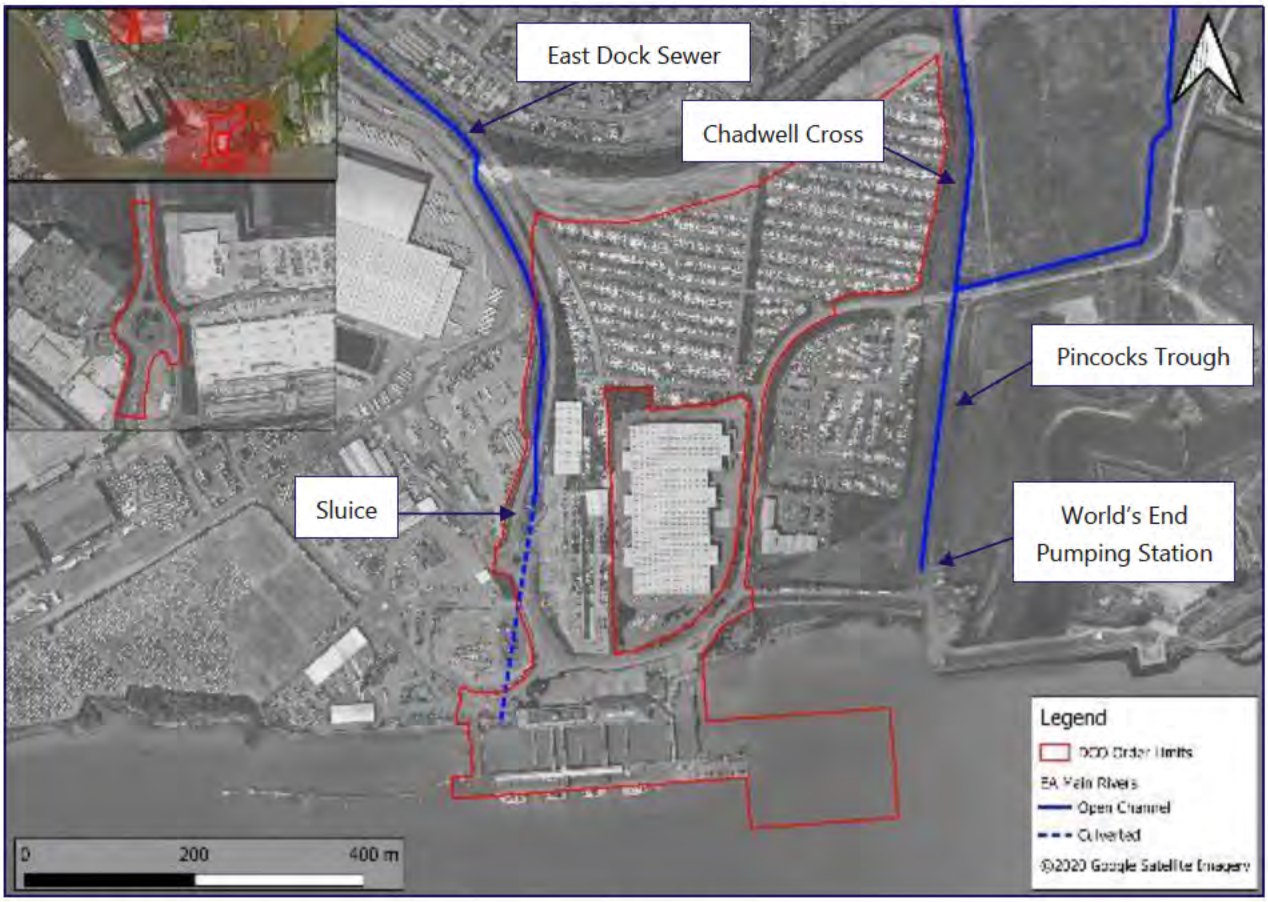

Figure 6-13: Essex Project Site EA designated main rivers

The EA has worked with ECC and Anglian Water (Partnership & Strategic Overview East Anglia: Essex, Norfolk & Suffolk) to develop the Tilbury Integrated Flood Strategy (2015) through modelling of different sources of flooding except tidal. These include surface water flooding for the 5%, 1% and 0.1% chance of flooding in any given year. Flood flow and level information from the above modelling have been provided as part of EA information provided and can be seen in Figure 6-14 and Table 6-4.

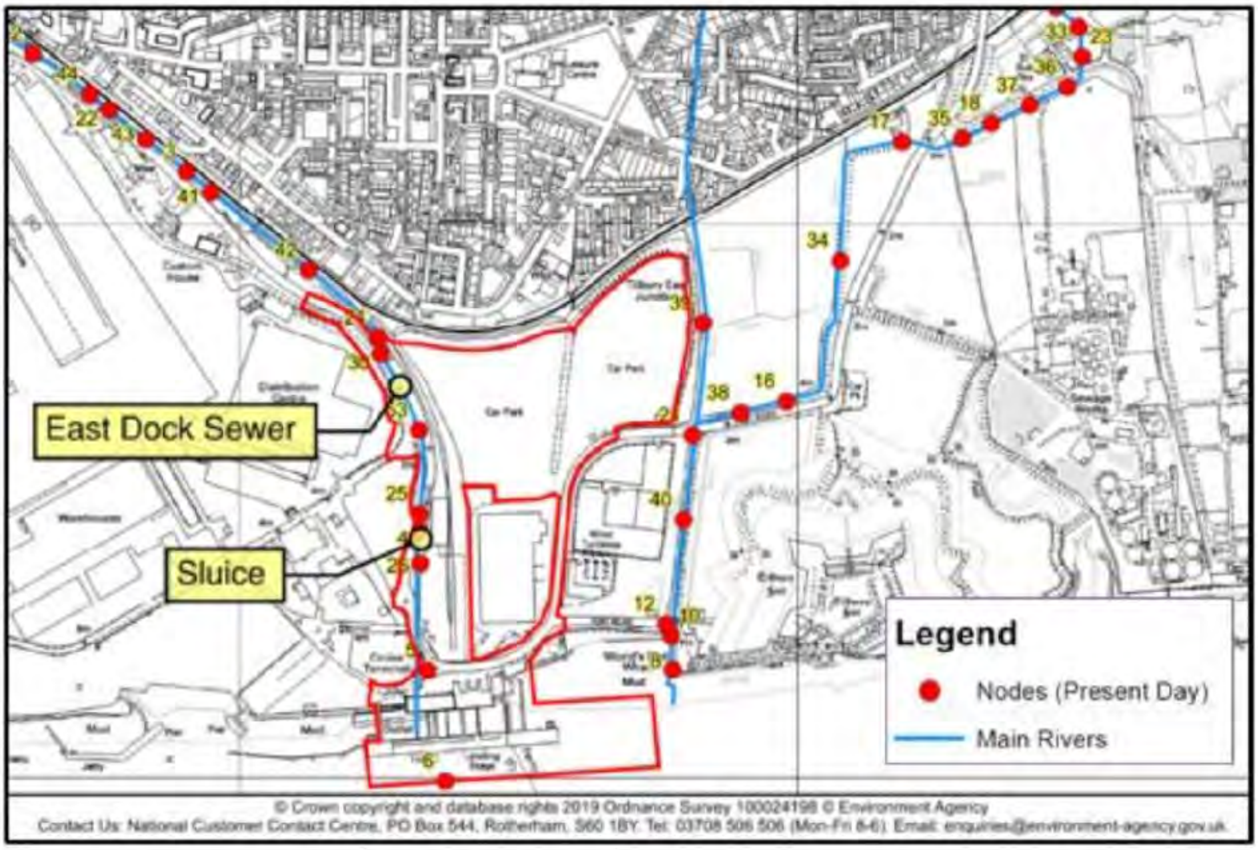

Figure 6-14: Tilbury Integrated Flood Strategy model nodes (adapted from EA Product 4, 28/07/2020)

Table 6-4: Flood levels near the development (m AOD)

Node	1 in 20yr	1 in 100yr	1 in 100yr +CC	1 in 1000yr
4	1.14	1.44	1.63	1.92

The resulting flood risk depths are shown in Figure 6-15. It is noted that the Essex Project Site is at some risk during the 1 in 100 year flood event plus climate change. The areas at flood risk are predominantly around the main rivers and a swale located within the new car storage area at the north.

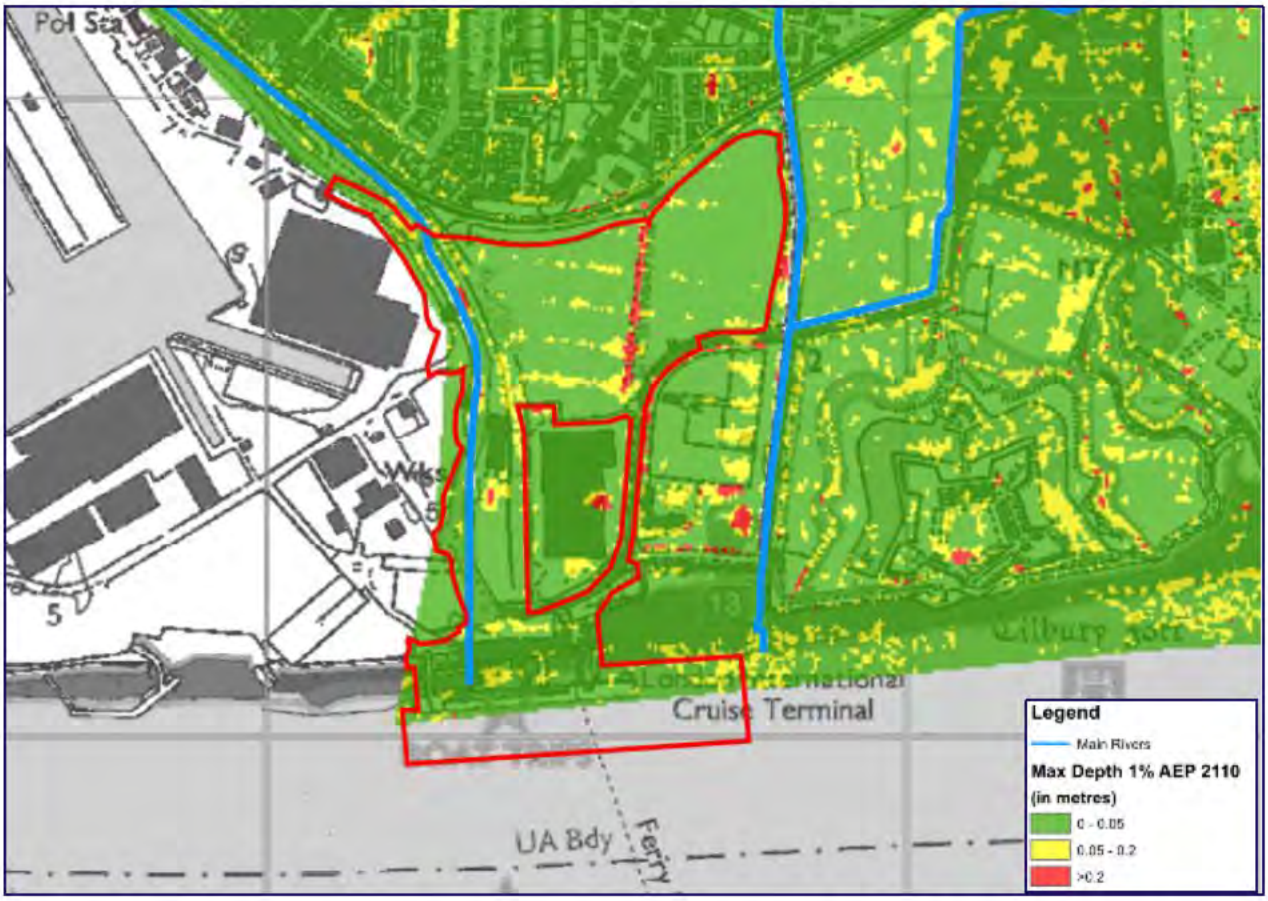

Figure 6-15: Tilbury Integrated Flood Strategy flood extents for the 1 in 100 year plus climate change (2110) (adapted from EA Product 4, 28/09/2020)

6.2.2 Proposed mitigation strategy

The Proposed Development at the Essex Project Site does not involve significant changes to the topography and the flow regime across the site. The anticipated impact on the fluvial flood plain is minimal and as such no mitigation strategy is required.

The processes within the stormwater systems and the drainage of the Essex Project Site into these water bodies is discussed in more detail in section 7.6 in this report.

6.3 Surface water and sewer flooding

6.3.1 Baseline

The EA surface water flood map, shown in Figure 6-16 for the Essex Project Site indicates that the majority of the site is classified as having a low probability of surface water flooding (<0.1% chance in any given year). There are some areas with a high probability of surface water flooding (>3.33% chance in any given year), which correspond to localised depressions in the topography and also to the drainage channel that runs along the western boundary. There is also higher probability of surface water flooding within the proposed Terminal Building.

Figure 6-16: EA flood map showing surface water modelled flood extent (Map data ©2015 Google, © Environment Agency copyright and/or database right 2014. All rights reserved. Some features of this map are based on digital spatial data from the Centre for Ecology & Hydrology, © NERC (CEH). Soils Data © Cranfield University (NSRI) and for the Controller of HMSO 2013.)

6.3.2 Proposed mitigation strategy

The risks associated with surface water and sewer flooding have been considered with relation to the Proposed Development in the Surface Water Drainage Strategy (document reference 6.2.17.2) which is summarised below in Section 6.6.

At the Essex Project Site there is capacity within the local sewer system for the site wastewater, it is therefore proposed that the site wastewater is connected to the existing sewer system to be treated at the Tilbury Water Recycling Centre as agreed with Anglian Water.

6.4 Groundwater flooding

The Essex Project Site is underlain by Chalk and has an associated high water table meaning that there is a risk of groundwater flooding. However, there have been no recorded cases of groundwater flooding. The Proposed Development at the Essex Project Site is Less Vulnerable. No basement levels are proposed.

To minimise any risk from groundwater flooding during excavation of the Essex Project Site, cut during construction will be limited to at least 0.5m above the groundwater level. Where this is not possible, dewatering and other groundwater control measures should be employed.

6.5 Flooding from artificial sources

Artificial sources of water include docks, canals, reservoirs, and lakes, where water is retained above natural ground level. Design failure at an artificial source of water has the potential to cause catastrophic damage to its surroundings due to the sudden release of large volumes of water. However, the likelihood of such a failure occurring is extremely low.

At the Essex Project Site there are two artificial sources of flood risk:

1. The Tilbury Flood Storage Area; and
2. Tilbury Docks.

The Tilbury Flood Storage Area (FSA) is operated as a category C reservoir with capacity to store surface water floodwaters during a 0.1% AEP (1 in 1000 year) event. In 2012 the EA ran a scheme to ensure that the FSA was compliant with matters of safety outlined by the Inspecting Engineer under the Reservoirs Act 1975. This involved the raising of embankments along sections of the eastern and western parts of the FSA to ensure that it can withstand a 0.1% (1 in 1000 year) Flood Event. The Area of the FSA is designated as functional floodplain (Flood Zone 3b) and therefore nearly all types of development are inappropriate at this location. The Essex Project Site is outside of the Tilbury FSA location, however part of the Essex Project Site is within the maximum extent of flooding from the FSA reservoir as seen in Figure 6-17.

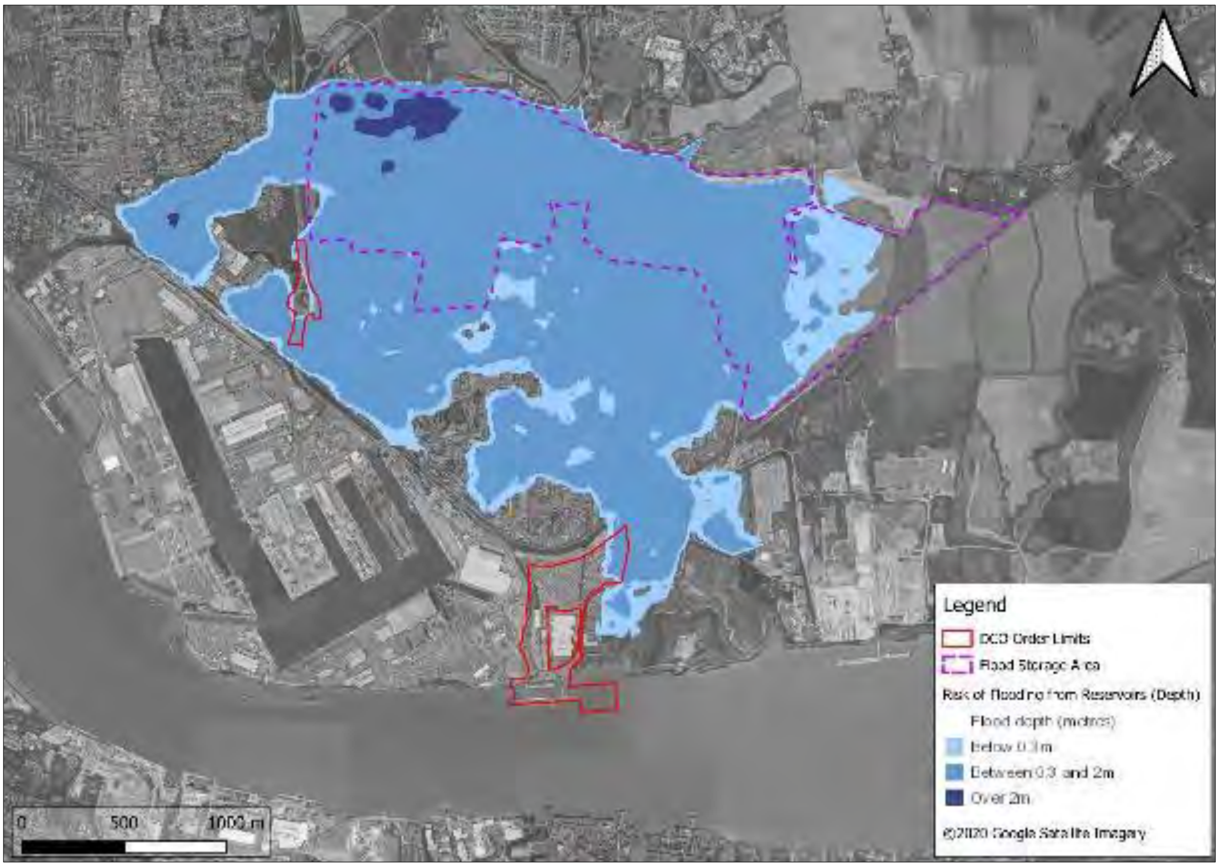

Figure 6-17: Essex Project Site Flood Risk from artificial sources (Map data ©2015 Google, © Environment Agency copyright and/or database right 2014. All rights reserved. Some features of this map are based on digital spatial data from the Centre for Ecology & Hydrology, © NERC (CEH). Soils Data © Cranfield University (NSRI) and for the Controller of HMSO 2013.)

Although part of the Essex Project Site is within the maximum extent of flooding from reservoirs, the areas with Proposed Development plots are not at risk and the EA advise[19] that this flood risk is *extremely low* due to the regular safety work undertaken at reservoirs to meet the requirements of the Reservoirs Act 1975. Therefore, no mitigation of this risk is considered to be required.

The Port of Tilbury is located in the south of Thurrock on a loop of the River Thames to the west of the Essex Project Site. Water levels at the docks are controlled by a series of lock gates and the water level is independent of water levels within the River Thames. There is a residual risk of a breach or failure of the lock gates during a tidal surge which could result in overtopping of the dock walls and flooding of the surrounding areas (see Figure 6-18).

[19]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/500922/Reservoir_safety_information_note.pdf

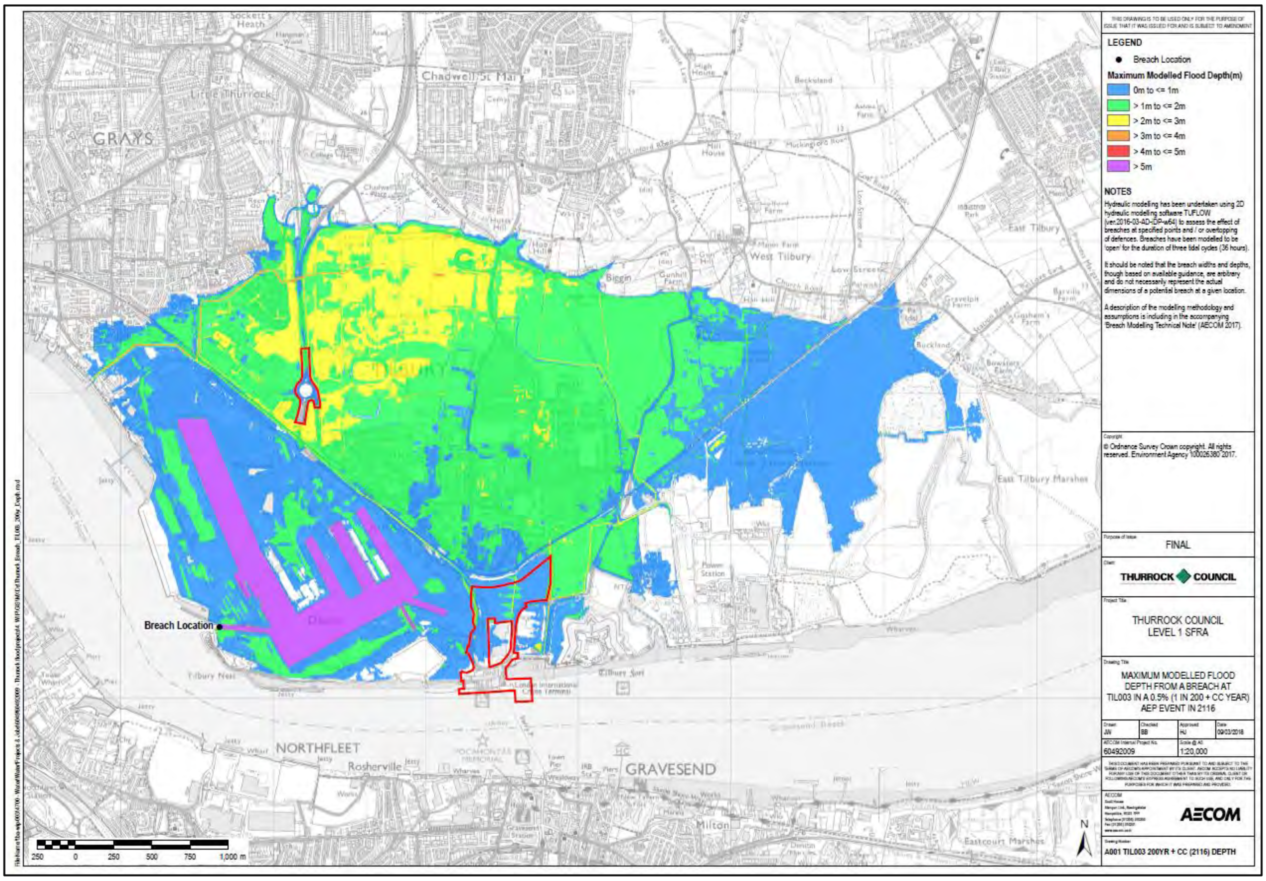

Figure 6-18: Essex Project Site flood risk from artificial sources: Tilbury Docks Breach[20]. DCO Limit shown in red.

The extent of flooding from a breach at the Tilbury Docks does intersect the Essex Project Site with water levels for the 1 in 200 year CC AEP event in 2115 causing depths generally less than 1m. However, the risk of flooding from the Tilbury Docks is residual and as with the risk of flooding from breach events, the risk to the Essex Project Site from this source is considered to be *low*. The land uses on the Essex Project Site are classified as Less Vulnerable to flooding.

Consideration of a breach at this location will be considered as part of the Flood Evacuation and Management Plan that will be undertaken in the next design stage.

[20] AECOM (June 2018) *'Thurrock Borough Council Level 1 Strategic Flood Risk Assessment' https://regs.thurrock.gov.uk/online-applications-skin/thurrock-strategic/sfra_201806/lptech-thurrock-sfra1-201806-v01.pdf (accessed on 02/07/2020)*

6.6 Surface Water Drainage Strategy

The Essex Project Site is currently used as parking / storage for new cars and is almost entirely impermeable. It is served by an existing surface water network managed by the Port of Tilbury (PoT). It connects to the main surface water channel (East Dock Sewer) that runs down from Tilbury, which has known issues of siltation and can cause flooding upstream in Tilbury. The channel discharges to River Thames.

The development proposals include the construction of a multi-storey car park and changes to the passenger area at the TCT.

The pipe network is designed for the 1 in 1-year storm event, with no above ground flooding for 1 in 30 + 40% CC. The surface water network is designed such that there is no risk of flooding to buildings for up to the 1 in 100 year +40% CC storm combined with 1 in 20 year (2090 Higher Central) tidal levels, and the 1 in 5 year + CC rainfall event combined with the 1 in 200 year + 40% CC tidal event.

The strategy proposes the construction of a new pipe to the River Thames for unrestricted surface water discharge. An existing PoT outfall is currently identified within the passenger area with unknown size, capacity or condition. Following investigations, if the outfall is considered appropriate for use, the new pipe will be connected to it. Alternatively, a new outfall will be constructed. The drainage system of the Essex Project Site will no longer discharge to the East Dock Sewer, which is known to cause flood risk issues, thereby reducing flood risk to other sites. Green/brown roofs at the multi-storey car park and permeable pavement at the visitor plaza are proposed, which will provide further value in terms of habitat, water quality and pollution control. Attenuation will be integrated near the multi-storey car park building and below the permeable pavement to accommodate surface water runoff during the tide-locked scenarios.

6.7 Exception Test

In Section 3.2.1.3, the proposed car park, plaza and the TCT are identified as Less Vulnerable and therefore not requiring an Exception Test to be passed in order for the Proposed Development to be permitted within Flood Zone 3.

Therefore, the Essex Project Site has been made resilient for the 1 in 200 year event in 2090 using the upper end climate change projection. Safe refuge and escape routes will be considered as part of the Flood Evacuation and Management Plan undertaken in the next stage of design.

7 EA feedback and responses

To inform the masterplanning process as the Resort progresses, consultation has been undertaken with the EA to ensure the design solutions capture site specific information and that as the main statutory consultee for flood risk, any concerns or requirements are fully addressed in the FRA.

Table 7-1 below summarises the main topics raised by the EA with information on how these aspects have been addressed in the FRA. Responses to feedback from all stakeholders has been provided in document reference 6.2.17.5.

Table 7-1 Summary of responses to EA comments received during consultation

Topic	EA Comment (summarised)	Project Consideration
Development lifetime	It is understood that the development in its entirety (both Kent and Essex Project Sites) will be present in 2070 and later due to no confirmed decommission date for the Resort.	Although a decommission date has not been confirmed, flood mitigation measures have been proposed to ensure the more vulnerable land uses have protection for the next 100 years. However, buildings for less vulnerable uses are designed to flood after a 60 year development life but will include resilient measures to reduce the impact of flooding and enable them to return back to normal as quickly as possible.
	The NPPF climate change H++ scenario should be discussed in the FRA and treated as a sensitivity test to ensure the Proposed Development can be adapted to large-scale climate change over its lifetime.	H++ scenario has been considered in the assessment. See Sections 4.1.1 and 6.1.1.
	Sleeping accommodation should be set above the modelled breach flood levels and robust site flood plans in place. The adoption of 100 year design life should be used.	The recommended measures have been included in the strategy as described in Sections 4.1.2.3 and 4.1.2.5.
	The overtopping and mitigation for it should be based on a 100-year lifetime for the Proposed Development. The ability to raise all the buildings	Consideration between providing additional protection to the Project Site development and the impact to offsite areas has been made through

Topic	EA Comment (summarised)	Project Consideration
	further to reduce their risk of flooding should be considered.	assessing different flood mitigation scenarios. The current proposals have minimal impact on flood risk to offsite areas. Further description provided in Section 4.1.2.3.
	The 1 in 200 year tidal flood event higher central climate change projection is acceptable as the design flood event for the Essex Project Site, considered 'less vulnerable' and used as the basis for designing safe access, escape routes and places of refuge. However, for 'more vulnerable' it is stipulated that 'higher central' and 'upper end' allowances should be used (for example hotels on the Kent Project Site).	Description of the different vulnerability uses and how they have been assessed is provided in Section 3.6.
TE2100	In order to manage the impacts of climate change, the TE2100 plan has identified three reaches for a future Thames Barrier: at Woolwich, in its existing location, at Long Reach, or at Tilbury. As part of breach modelling to support the FRA, impacts of a future barrier must be considered. The FRA must demonstrate that there is a workable solution for the probable worst case flood scenario.	The assessment considers the 1 in 1000 year event as well as the DFE of 1 in 200 year to make allowance for a barrier located at Long Reach, considered to have the worse impact on water levels at the Project Site. Further design considerations provided in Section 3.6.
	The Baseline 2020 Model used for the assessment appears sufficiently conservative for the Upper End allowance for sea level rise in the year 2125 but may not be for Higher Central, based on water levels at Node 3.38.	The EA sea level rise guidance indicates that the Higher Central sea level rise estimates based on UKCP18 are lower than sea level rise estimates from UKCP09, whereas Upper End levels are higher (shown in Table 2-6 and Table 2-7). Node 3.38 is located at the mouth of the estuary where the tidal curve is input into the model. At the Project Site, however, water levels are higher in both the Higher Central and Upper End scenarios compared to TE2100

Topic	EA Comment (summarised)	Project Consideration
		water levels at the same location. Therefore, it is considered that the adjustments made in the Baseline and Proposed 2020 models are suitable for use in this assessment when allowing for UKCP18 climate change projections.
	The future crest level should address the worst case future Thames Barrier option, and should therefore be set at 8m AOD for the Kent Project Site. The standard of protection that must be adopted for the tidal defences is 1 in 1000 years taking account of future climate change.	The TE2100 Plan which adopts a SoP of 1 in 1000 year has been used to guide setting of formal flood defence crest levels. This includes a future crest level of 8m AOD to be incorporated into the design.
	Date of completion for the Extreme Water Level modelling is not known, however it should be reviewed when becomes available.	Updates to the TE2100 Plan will be referred to if available at detailed design stage to ensure the flood risk management strategy is still applicable.
	The effects of climate change on the tidal flood defences should be provided for appropriate design of new or works to existing flood defences.	The effects of climate change based on the latest UKCP18 projections have been included in the assessment and used to inform the flood mitigation strategy.
	As the development is within the Thames Estuary and its defences can benefit others, the SoP for the defences should be considered to be 1: 1000yr unless the TE2100 policy states differently.	The TE2100 Plan has been used to inform the assessment which indicates SoP is 1 in 1000 year event.
Breach	The 1 in 200 year breach event should be considered, as well as the 1 in 1000 year. The breach design level should be used to inform the FRA if the developer requires the development to remain operational, and/or resilience levels required in order to return to operational as quickly and safely as possible. This information and flood	Both events have been assessed. Details can be found in Section 4.1.2.

Topic	EA Comment (summarised)	Project Consideration
	depths, paints the picture of flood risk for emergency planners. This should also be updated in the conclusion.	
	More localised ground raising to prevent or reduce flooding to all the buildings might be possible during a breach event.	Consideration between providing additional protection to the Project Site and the impact to offsite areas has been made through assessing different flood mitigation scenarios. The current proposals have minimal impact on flood risk to offsite areas. Further description provided in Section 4.1.2.3.
	How will the risk of the secondary flood defence failing during possible overtopping be mitigated? Spillway features could be an option.	Impact of a breach in the secondary flood defence is considered to be minimal. Further description provided in Section 4.1.2.2.
Kent Project Site - Marshes	Understanding of baseline condition of the existing marshes need to be made to understand impact on flood risk, drainage and ecology.	Consideration of the flood risk and management of the marshes has been captured in the Surface Water Drainage Strategy (document reference 6.2.17.2 and Flood Risk Appendix 17.2).
Kent Project Site - HS1	Minimising flood risk to HS1 should be considered as part of design.	HS1 currently discharges to the Swanscombe channel in the centre of the Kent Project Site. Management and redesign of the existing channel and ditch network at the site is captured in the Surface Water Drainage Strategy (document reference 6.2.17.2 and Flood Risk Appendix 17.2)).
Kent Project Site - Flood defences	Flood defences reduce but do not remove the risk of flooding. Therefore, breach modelling for both new and existing flood defences should be undertaken.	Breach modelling has been undertaken for both existing and proposed new flood defences as described in Sections 4.1.1 and 4.1.2 respectively.
	The flood defences and areas of high ground should be assessed to establish their residual life and stability	Ground investigations will be undertaken in the next stage of the Proposed Development. This will be

Topic	EA Comment (summarised)	Project Consideration
	over the development lifetime including the impacts of sea level rise.	used to assess the condition of the existing defences to better understand any mitigation works required.
	As the detailed design for Gate One and Gate Two will not form part of the DCO application, the spatial extent of the constraint outlines should be made clear, along with the offsets to the river, and flood defences including future crest raising. This should also include the transition for high ground to earth flood defence.	Spatial considerations for proposed and future raising has been described and illustrated in Sections 4.1.2.1 and 4.1.2.2. The current proposals and strategy illustrate the proposed alignment and spatial requirements for the proposed flood defences based on the current information available, including minimising steep slopes for safe maintenance and minimising hard engineered structures. Ground investigations and detailed analyses will be required in the next stage to better ascertain the foundations and fill material required to ensure stability of the flood defences to the crest level. Consultation with the EA will be undertaken to derive the Ground Investigation specification before works are undertaken. Allowances have been made in the design proposals to allow for amendments in proposed ground levels without having an impact on the overall masterplan layout. These works will be undertaken at the earliest stage to ensure that appropriate lead times are allowed for in the construction programme. These requirements are noted in Section 4.1.2.1.
	At this stage in the process the principle of the method of defence raising needs to be proven to be workable, with the space provided. If the earth flood defences are to be raised in phases to reduce the risk of slip failures by allowing time for drainage and inter-partial friction to improve this may require more than two stages of raising and take several years to complete. Even though the defences will be raised in a staged approach, LRCH will need to confirm that the foundations will support a future raising to 8mAOD from the start which should be supported by sufficient site investigations and structural calculations.	
	Site investigations to confirm the feasibility of the flood defence raising needs to be undertaken prior to design stage and sent to the EA for review. Consultation on the design of the site investigations before being undertaken would also be required.	

Topic	EA Comment (summarised)	Project Consideration
	The credible worst case spatial footprint of primary flood defences including with future raising needs to be established. Sufficient space of inspection and maintenance will also be required.	
	The alignment of the defences now and in the future should be shown in plan with plenty of offset measurements to the nearest possible built structures based upon the constraints outlines. Cross sections would also help to illustrate this.	
	Built development close to the tidal defences and fluvial watercourses should allow for wide vegetation buffer strips to provide space for future works to minimise potential need for bank hardening and for the benefit of wildlife.	
	Supporting evidence is required for how raising the flood defences to the TE2100 future levels for the Proposed Development lifetime will be made. This should include the type of defence raising, how raising will be approached (i.e. raised in one go or phases) and evidence that the current foundations/ground conditions can support this raising along with results from site investigations and structural calculations.	
	Trees and larger vegetation should be located away from the toe of a flood defence as if they are too close they could adversely impact the structural integrity of the flood defence.	
	Zoomed in plans and cross sections are needed around the tidal flood defences to better understand	

Topic	EA Comment (summarised)	Project Consideration
	distances between buildings and the defences.	
	It is not clear how it will be ensured that sufficient funds will be available to undertake the future defence raising when required.	It is envisaged that discussions regarding funding requirements will be undertaken during the DCO examination period and agreed wording to be incorporated into the DCO Protective Provisions.
River Ebbsfleet	There has long been an aspiration from a local group to open up Robin's Creek to the River Thames for vessels movements. If the flood wall was to be retreated landward of the Creek to facilitate this it could reduce the storage in the River Ebbsfleet. This can be seen as a possible in combination effect when considered with the Access Road works.	Noted. Blockage scenarios have been undertaken to better understand localised impact at the site. No further changes to include possible future changes at Robin's Creek has been undertaken at this stage.
Essex Project Site - flood risk	SFRA flood information used old climate change projection so should not be relied upon. However, the Thurrock 2018 SFRA should be referred to for a sensitivity test for any breach modelling.	The SFRA breach modelling results have been referred to when considering the flood mitigation required at the Essex Project Site for managing flood evacuation. Further details provided in Section 6.1.2.
	Flood risk from the Integrated Urban Drainage model should be referred to (considers fluvial and surface water combined). Any land raising for roads or works within the fluvial floodplain require compensatory storage for any loss of fluvial floodplain.	Reference to the results from the IUD model have been provided in Section 6.2. No land raising is proposed as part of the Proposed Development.
	LiDAR data should be used with care when identifying defence crest levels and ground levels due to recent development works north of the River Thames.	LiDAR 2019 data has been used within the Proposed 2020 Model as no additional topographic data was available for the Essex Project Site. However, it is considered that the LiDAR is suitable for estimating flood depths at the Essex Project Site and to inform the hazard risk to the site.

Topic	EA Comment (summarised)	Project Consideration
	Overtopping of the existing flood defences is required as part of the assessment.	Flood risk from overtopping has been assessed and results presented in Table 6-2.
	Defences on the Essex Project Site provide and must continue to provide a 1 in 1000yr SoP.	Changes to the existing flood defences are not proposed. Care will be required during refurbishment of the Tilbury Cruise Terminal building as to not impact the structure of the existing defences. The proposals will allow space for future flood defence works if undertaken by others.
	Consideration of impact of flood waters in the Terminal Cruise Terminal buildings on structural integrity and breach, as well as breach in the floodgate to the east of the building should be made.	The location for a breach has been based on existing ground levels and approximately centre of the Essex Project Site in order to ascertain the greatest flood impact at the site. Further description and results has been provided in Section 6.1.2.2.
	The 1 in 1000 yr 2090 higher central climate change projection flood event should be used for emergency planning purposes. The H++ should be used as a sensitivity test.	Both events have been assessed in the Proposed 2020 Model and results presented in Table 6-2.

8 Summary and conclusions

This FRA has been prepared to support the DCO application for the London Resort. This FRA has been undertaken in accordance with the NPPF. This FRA includes contributions from WSP who have assessed the flood risk to the Kent Project Site (Access Road).

The Proposed Development is a leisure focussed mixed use development, consisting of commercial, community, and educational facilities, as well as approximately 500 residential units and transport links. The proposed development uses include *essential infrastructure*, *highly vulnerable, more vulnerable, less vulnerable* and *water compatible* developments.

An assessment of the risk with flooding from the following sources has been carried out:

- Rivers (fluvial) and sea (tidal);
- Surface water and sewers;
- Groundwater; and
- Artificial sources.

The Proposed Development is situated in Flood Zone 3, with some areas in Flood Zone 2 and Flood Zone 1. Both the Kent and Essex Project Sites benefit from flood defences with a tidal flood defence range between 6.21m AOD and 8.8m AOD for the Kent Project Site and between 6.45m AOD and 6.71m AOD for the Essex Project Site. Both the Kent and Essex Project Sites are located downstream of the Thames Tidal Barrier.

At the Kent Project Site, the Proposed Development includes changes to the existing river defences along Black Duck Marsh and at Whites Jetty. The changes will be phased. Initially, the defences will be set to a flood defence level of 7.0m AOD, which is the level required by the year 2070 under the EA Thames Estuary 2100 (TE2100) Plan. A review will be undertaken after 2050 which will take into account a pending decision on the improved Thames Barrier location. Allowances have been made in the design for a potential future improvement of the defence crest levels to 8m AOD which is the level currently required by the year 2170 under the EA TE2100 plan considering the worst case Thames barrier scenario.

At the Kent Project Site, the Proposed Development also includes a new secondary flood embankment along the east side of the Proposed Development which will provide protection to the Kent Project Site (Main Resort) for the 1 in 200 year event up to 2090 using the higher central climate change projection.

With consideration of the improvements to the defences the overall fluvial and tidal flood risk is considered to be *low*.

At the Essex Project Site, the Proposed Development does not include changes to the formal flood defences. The Proposed Development at the Essex Project Site is considered to be *Less Vulnerable*. The defences at the Essex Project Site do not overtop during the 1 in 200 year 2090 future epoch using the higher central climate change projections. Therefore, the flood risk to the Essex Project Site is considered to be *low*.

There is a residual risk of a breach in the defences at both the Kent and Essex Project Sites. In the event of a breach, there is a risk that the lower lying areas of the Project Site are flooded. At both sites, it is also proposed that at both the Kent Project Site and the Essex Project Site the *less vulnerable* developments are made resilient up to the 1 in 200 year 2090 breach water level considering the higher central climate change projection, and that the finished floor level of *more vulnerable* developments and any *critical infrastructure* that require operation during the breach event be set above the 1 in 200 year 2125 beach water level considering the upper end climate change projection. The probability of a breach in defences is considered to be *low*.

At the Kent Project Site (Access Road) there is a risk of fluvial flooding to the Proposed Development from the River Ebbsfleet. The proposed design includes flood mitigation measures that include ensuring that the minimum affected road level is above the 1 in 100 year fluvial flood event level plus 70% allowance for climate change, considering the 2125 future epoch tidal levels using the upper end tidal climate change projections plus 300mm freeboard. The mitigation measures also include compensatory storage for 0.13 ha of flood plain that is lost.

The Surface Water Drainage Strategy (document reference 6.2.17.2), proposes to discharge surface water from the Kent Project Site (Access Road) developments by gravity through a network of attenuation ponds and underground storage to the Ebbsfleet River at greenfield runoff rates.

It is concluded that with the proposed flood risk management strategy in place the flood risk to the Proposed Development is *low* both today and in the future. Analysis of the modelling undertaken as part of this FRA has indicated that the inclusion of the masterplan proposals including the flood risk management measures has no adverse impacts to flood extents and depths in surrounding areas.

The measures proposed at the Kent Project Site (Main Resort) have the additional benefit of improving the standard of protection of the River Thames formal flood defences to 2125 benefitting not only the Proposed Development but neighbouring developments as well. Furthermore, the Proposed Development includes replacing manual flood gates with a passive flood defence embankment reducing the residual risk of failure and increasing resilience to future uncertainties.

At the Essex Project Site the Surface Water Drainage Strategy (document reference 6.2.17.2) has the additional benefit of reducing the flow into the East Dock Sewer, which is currently near capacity. The reduced flow into this channel reduces the risk of the system being overwhelmed during a storm event in the future. The Essex Project Site surface water will be discharged directly into the River Thames via a new independent system for the Proposed Development.

APPENDIX A – NPPF Tables

Table 1: Flood Zones

These Flood Zones refer to the probability of river and sea flooding, ignoring the presence of defences. They are shown on the Environment Agency's Flood Map for Planning (Rivers and Sea), available on the Environment Agency's web site, as indicated in the table below.

Flood Zone	Definition
Zone 1 Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)
Zone 2 Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map)
Zone 3a High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding.(Land shown in dark blue on the Flood Map)
Zone 3b The 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. (Not separately distinguished from Zone 3a on the Flood Map)

Table 2: Flood risk vulnerability classification

Essential infrastructure

- Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk.
- Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood.
- Wind turbines.

Highly vulnerable

- Police and ambulance stations; fire stations and command centres; telecommunications installations required to be operational during flooding.
- Emergency dispersal points.
- Basement dwellings.
- Caravans, mobile homes and park homes intended for permanent residential use.
- Installations requiring hazardous substances consent. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as 'Essential Infrastructure').

More vulnerable

- Hospitals
- Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels.
- Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels.
- Non–residential uses for health services, nurseries and educational establishments.
- Landfill* and sites used for waste management facilities for hazardous waste.
- Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.

Less vulnerable

- Police, ambulance and fire stations which are not required to be operational during flooding.
- Buildings used for shops; financial, professional and other services; restaurants, cafes and hot food takeaways; offices; general industry, storage and distribution; non-residential institutions not included in the 'more vulnerable' class; and assembly and leisure.
- Land and buildings used for agriculture and forestry.
- Waste treatment (except landfill* and hazardous waste facilities).
- Minerals working and processing (except for sand and gravel working).
- Water treatment works which do not need to remain operational during times of flood.
- Sewage treatment works, if adequate measures to control pollution and manage sewage during flooding events are in place.

Water-compatible development

- Flood control infrastructure.
- Water transmission infrastructure and pumping stations.
- Sewage transmission infrastructure and pumping stations.
- Sand and gravel working.
- Docks, marinas and wharves.
- Navigation facilities.
- Ministry of Defence defence installations.
- Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location.
- Water-based recreation (excluding sleeping accommodation).
- Lifeguard and coastguard stations.
- Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms.
- Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

" * " Landfill is as defined in Schedule 10 of the Environmental Permitting (England and Wales) Regulations 2010.

Paragraph: 066 Reference ID: 7-066-20140306

Revision date: 06 03 2014

Table 3: Flood risk vulnerability and flood zone 'compatibility'

Flood Zones	Flood Risk Vulnerability Classification				
	Essential infrastructure	Highly vulnerable	More vulnerable	Less vulnerable	Water compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a †	Exception Test required †	✗	Exception Test required	✓	✓
Zone 3b *	Exception Test required *	✗	✗	✗	✓*

Key:

✓ Development is appropriate

✗ Development should not be permitted.

Notes to table 3:

- This table does not show the application of the Sequential Test which should be applied first to guide development to Flood Zone 1, then Zone 2, and then Zone 3; nor does it reflect the need to avoid flood risk from sources other than rivers and the sea;
- The Sequential and Exception Tests do not need to be applied to minor developments and changes of use, except for a change of use to a caravan, camping or chalet site, or to a mobile home or park home site;
- Some developments may contain different elements of vulnerability and the highest vulnerability category should be used, unless the development is considered in its component parts.

† In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

" * " In Flood Zone 3b (functional floodplain) essential infrastructure that has to be there and has passed the Exception Test, and water-compatible uses, should be designed and constructed to:

- remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows and not increase flood risk elsewhere.

Paragraph: 067 Reference ID: 7-067-20140306

Revision date: 06 03 2014

Table 1: peak river flow allowances by river basin district (based on a 1961 to 1990 baseline)

River basin district	Allowance category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Northumbria	H++	20%	35%	65%
	Upper end	20%	30%	50%
	Higher central	15%	20%	25%
	Central	10%	15%	20%
Humber	H++	20%	35%	65%
	Upper end	20%	30%	50%
	Higher central	15%	20%	30%
	Central	10%	15%	20%
Anglian	H++	25%	40%	80%
	Upper end	25%	35%	65%
	Higher central	15%	20%	35%
	Central	10%	15%	25%
South east	H++	30%	60%	120%
	Upper end	25%	50%	105%
	Higher central	15%	30%	45%
	Central	10%	20%	35%

Thames	H++	25%	40%	80%
	Upper end	25%	35%	70%
	Higher central	15%	25%	35%
	Central	10%	15%	25%
South west	H++	25%	50%	105%
	Upper end	25%	40%	85%
	Higher central	20%	30%	40%
	Central	10%	20%	30%
Severn	H++	25%	45%	90%
	Upper end	25%	40%	70%
	Higher central	15%	25%	35%
	Central	10%	20%	25%
Dee	H++	20%	30%	60%
	Upper end	20%	30%	45%
	Higher central	15%	20%	25%
	Central	10%	15%	20%
North west	H++	25%	45%	95%
	Upper end	20%	35%	70%
	Higher central	20%	30%	35%
	Central	15%	25%	30%

Solway	H++	25%	45%	95%
	Upper end	20%	30%	60%
	Higher central	15%	25%	30%
	Central	10%	20%	25%
Tweed	H++	20%	35%	75%
	Upper end	20%	25%	45%
	Higher central	15%	20%	25%
	Central	10%	15%	20%

Table 3: sea level allowances by river basin district for each epoch in mm per year (based on a 1981 to 2000 baseline) – the total sea level rise for each epoch is in brackets

Area of England	Allowance	2000 to 2035 (mm)	2036 to 2065 (mm)	2066 to 2095 (mm)	2096 to 2125 (mm)	Cumulative rise 2000 to 2125 (metres)
Anglian	Higher central	5.8 (203)	8.7 (261)	11.6 (348)	13 (390)	1.20
Anglian	Upper end	7 (245)	11.3 (339)	15.8 (474)	18.1 (543)	1.60
South east	Higher central	5.7 (200)	8.7 (261)	11.6 (348)	13.1 (393)	1.20
South east	Upper end	6.9 (242)	11.3 (339)	15.8 (474)	18.2 (546)	1.60
South west	Higher central	5.8 (203)	8.8 (264)	11.7 (351)	13.1 (393)	1.21
South west	Upper end	7 (245)	11.4 (342)	16 (480)	18.4 (552)	1.62
Northumbria	Higher central	4.6 (161)	7.5 (225)	10.1 (303)	11.2 (336)	1.03
Northumbria	Upper end	5.8 (203)	10 (300)	14.3 (429)	16.5 (495)	1.43
Humber	Higher central	5.5 (193)	8.4 (252)	11.1 (333)	12.4 (372)	1.15
Humber	Upper end	6.7 (235)	11 (330)	15.3 (459)	17.6 (528)	1.55
North west	Higher central	4.5 (158)	7.3 (219)	10 (300)	11.2 (336)	1.01
North west	Upper end	5.7 (200)	9.9 (297)	14.2 (426)	16.3 (489)	1.41

APPENDIX B – Meeting Minutes

creating a better place

Mr Karl Craddick
Savills (L and P) Ltd
Wessex House Priors Walk
WIMBORNE
Dorset
BH21 1PB

Our ref: KT/2020/127150/01-L01
Your ref: Environment Agency

Date: 13 July 2020

Flood Risk Modelling Approach Report and associated Meeting Minutes

London Resort

Thank you for sending through the Flood Risk Modelling Approach and meeting minutes following our flood risk catch up on 23 June 2020. We have reviewed the information within these documents and have the following comments to make.

Our comments below have been aligned with relevant points from the meeting minutes for ease of reference.

General advice

1.3 – Philip Spearman's role is: Flood & Coastal Risk Management Senior Advisor - East Anglia, Thames Estuary Asset Management 2100 Programme (TEAM2100)

3.3 – It is not clear what is meant by the proposed and mitigation model in the meeting minutes.

3.5 – What does the applicant see as the lifetime of the development? That is not the same as the design life.

3.7 – Environment Agency East Anglia Area do not have any other model for the Thames Estuary than the TE2100 model itself, and have no familiarity with the NKM model.

3.8 – The Thames Estuary 2100 team are updating the existing model of the estuary to support to 10 year Review of the Plan. This will include a revised set of extreme water levels and will review future defence crest levels in due course. It will also include the UKCP18 for sea level rise. The TE2100 Plan outlines different options for a future Thames barrier location. Should a barrier be moved downstream, the closest location to this site is Long Reach, Purfleet. Should Long Reach, Purfleet be progressed, a decision is required by 2050 for a barrier to then be built and operational by 2070.

3.10 – We are unable to provide the draft Thames Estuary modelling data as it has not been agreed and signed off internally. This must have been a misunderstanding.

Phil Spearman can act as point of contact for TEAM2100 programme links to the Tilbury Cruise Terminal but may not be most suitable contact for model data. Please forward any required information or queries to Karolina Allu who will distribute.

3.11 – The alternative approach suggested was not to apply various sensitivity tests; but much more simply to add additional freeboard to the defence crest levels and raise the in-channel water levels by an additional amount using engineering judgement for a credible worst case. Then to present the uncertainty in the FRA with results for both the current levels and the additional allowance / credible worst case. The development could then be adjusted to suit at the designed design stage. We believe the complex factoring BH propose will add value.

3.12 – 600mm is the wrong freeboard value for the future crest levels based on the existing TE2100 modelling. In this part of the estuary the currently adopted freeboard is 700mm.

3.13 – The TE2100 modelled in-channel water levels do not include freeboard but the future defence crest levels include 700mm of freeboard along this section of the estuary.

3.14 – We will check the data response and confirm.

4.7 – Visual inspections may be useful but are not sufficient. Ground investigation, slope stability modelling and intrusive testing of hard defence structures will be required to demonstrate the condition, stability and remaining lifetime of the flood defences. That is needed for the structures that are to remain as well as for new work. Vehicle loading is one factor but the impacts of sea level rise on the integrity of the embankments and hard structures also needs to be assessed. We do not know if all the defences will remain stable with sea level rise.

4.11 – Can the staff village be set at a level where it is not at risk in the event of a breach?

4.12 – We do not yet have the results from the modelling or the finished floor levels to establish that the proposal for the staff village is appropriate.

We recommended BH to look into the possibility of replication the approach of modelling a breach every 20 or 50 metres.

4.14 – We did ask for the drone data although we cannot guarantee that it can be used to determine the breach locations.

4.16 – We described the technique of raising earth flood embankments in stages that was used as part of the past embankment raising works. That is one approach to reduce the risk of a slip failure before settlement and drained conditions improves inter-particle friction. There are other approaches.

5.3 – We expect residual risk (breach) sites to be assessed against 1 in 200-year and 1 in 1000-year levels with allowance for climate change.

5.4 – To add more detail: The existing tidal defence line is a steel flood defence structure built inside the Tilbury Cruise Terminal in the Baggage Hall and in the Riverside Station buildings, along their northern walls. The total length is approximately 170m, including 11 floodgate openings. In the Baggage Hall, the steel structure is tied to the building's masonry wall. In the Riverside Station, the steel flood defence is a standalone steel structure, supported by oblique steel props on the landward side and oblique steel ties on the riverward side. Any changes to these existing buildings will need to take this into account.

5.6 – The FRA should use the TE2100 as a base level (2005) and add the UKCP18 climate change allowances. FFL/design level would be used to inform the FRA if the developer requires the development to remain operational, and/or resilience levels required in order to return to operational as quickly and safely as possible. The level of temporary safe refuges could also be dependent on the breach modelling.

5.8 – The breach analysis will be used to inform and confirm that any new road/buildings will not bisect a flood cell, changing the flow path of the breached flood water, which could increase the flood hazard elsewhere.

6.2 – The 1000+cc should be modelled as part of the new modelling if tis is currently unknown.

6.3 – We are currently investigating a realignment of the existing flood defences within the existing Tilbury Cruise Terminal building (section 5.4 above).

6.4 – We indicated that there needed to be consideration of proposed timing of the two schemes and benefits the tidal defence works bring to proposed development now and into the future.

8.2 – KCC will only be concerned over parts of the ditches that are not Main River. It is not clear form the record if the BH are only referring to main river sections.

8.4 – We can request further details on this but are unsure what data we hold.

8.6 – We stated that the culvert may not be structurally sound and also the outfall may need remediation work. The culvert and outfall should be brought into good repair if it is to be re-used, and be replaced if necessary. During the meeting the development team confirmed that the existing culvert would be replaced as part of the development if that is required, and said that an additional culvert for surface water discharge to the River Thames might be needed.

9.1 – It is understood that the project team are unsure of proposals at this time for any land raising for roads or any works within a fluvial floodplain. The requirement for compensatory storage for any loss of fluvial floodplain should be investigated.

Tide locking

There is a reference to Tide Locking at the end of the Flood Risk Strategy. The tide lock scenarios require further discussion, and it is not clear how sea level rise is being considered.

Defences

We note a general lack of familiarity with the Tilbury Site. The closest Breach Location from the Thurrock SFRA is unlikely to be suitable for use in assessing the impact of a breach of the tidal defences on the proposed development.

We also note the lack of use of the TE2100 Thames Estuary Model as this guides policy throughout the estuary.

It is advised that the project team take care to familiarise themselves with the defences and local flooding issues at the Tilbury Site. A meeting is arranged for Tuesday 14 July to discuss this further.

Please do not hesitate to contact me if you require further details.

Yours sincerely,

Mrs Karolina Allu
Planning Advisor

[redacted]

Minutes

Subject	London Resort – Flood Risk Discussion	Job no	0042936
Place	MS Teams	Date	23 June 2020
Present	Karolina Allu (KA) - EA Lucy Hayward (LH) - EA David Gauntlett (DGa) - EA Nicole Lupton (NL) - EA Phillip Spearman (PS) – EA Robert Williams (RW) - EA Dale Gutsell (DG) - EA Christine Cambrook (CC) - BH Harry Mansfield (HM) - BH Nilani Venn (NV) - BH	Apologies	-
Distribution	As above		

Objective of meeting: Discussion regarding the principles of the Flood Risk Mitigation Strategy for the London Resort project.

Item		Action
1.0	**Introduction**	
1.1	CC introduced her role and BH colleagues: CC – Project Leader for London Resort project in BH. Coordinator for all the different disciplines. NV – overseeing the different water elements of the project and leading on the flood risk element. HM – supporting NV on the flood risk element of the project.	
1.2	KA introduced her role and EA colleagues: KA – Project Manager at the EA based in Kent office RW – Flood & coastal risk mang. Officer in the Partnerships & Strategic Overview Team, Kent, South East Area LH – Flood & coastal risk mang. Officer in the Partnerships & Strategic Overview Team, Essex, East Anglia Area NL- Flood & coastal risk mang. Officer in the Partnerships & Strategic Overview Team, Essex, East Anglia Area DGa – Asset Management Team, East Anglia DG - Asset Management Team, East Anglia	
1.3	PS introduced himself as part of the TE2100 team.	
1.4	NV gave an introduction to the project, masterplan proposals and the two main sites, the Main Resort in Kent area and the parking and ferry terminal at Tilbury, in the Thurrock, Essex area.	

2.0 Overview of Existing flood risk	
2.1 NV presented flood extents for the existing tidal risk of flooding to the Main Resort. Based on the latest flood model data available (North Kent Coastal Model, 2018), site is at a low risk from current day 1 in 200 year and 1 in 1000 year tidal flood events.	
2.2 The site is at risk in the future 1 in 1000 year flood event due to overtopping of existing defences on the east peninsular, just south of the red line boundary, and minor overtopping on the west along the current earth embankment.	
3.0 Assessing tidal flood risk – Main Resort	
3.1 NV indicated that BH will use the North Kent Coast (NKC) 2018 Model supplied to us from the EA recently. This model will be updated with drone topographic data currently being flown for the Main Resort site.	
3.2 The model will also be updated with updated tidal curves to capture the recent (Dec 2019) EA climate change guidance.	
3.3 The proposed and mitigation model will include proposed development levels and the proposed flood defence and mitigation measures.	
3.4 A model will also be set up to assess the residual risk. This will be through looking at breach scenarios. Previously one breach location was selected on the east and one on the west side of the peninsula. It is proposed to retain these same two locations for this study.	
3.5 NV indicated that the previously agreed (in 2014/15) requirements for setting the flood defence levels were based on the 1 in 1000 year tidal flood level + climate change for a 60 year design life + 600mm freeboard.	
3.6 NV indicated that we have contacted both the EA and TE2100 teams and there are no currently completed studies that incorporate the latest climate change guidance in their modelling. Therefore, it was proposed to scale the tidal curve that is in the NKC 2018 model based on the latest sea level rise bandings set out in the EA Dec 2019 CC guidance, although this would not take into account any changes in tidal curve shape due to changes such as storm surge.	
3.7 PS pointed out that by manually scaling the curve just gives the still water level and does not take into account other factors.	
3.8 PS indicated that TE2100 team are currently undertaking their own modelling that looks at possible Thames tide barrier locations. A number of barrier locations are being modelled; the location likely to have the most significant impact on water levels at the project site is Long Reach. It is considered that this barrier will be in place by 2084 and therefore should be considered in the London Resort project. Their modelling includes the latest CC guidance. EA to share information on the barrier options and assumed timing.	PS
3.9 BH, EA and TE2100 agreed that the current timescales of the different modelling projects means that it is unlikely that results of these studies will be available in time for the DCO.	
3.10 However, it was agreed that the draft TE2100 model files and tidal curves were provided to BH to incorporate in their modelling in the first instance as there is more confidence in the draft curves than the methodology in scaling. PS said to write an email to him requesting this data and they will	BH/PS

provide it. It will then be the case that the final outcome of the TE2100 project will be incorporated into the proposals during detailed design stage.	
[Post Meeting Note: BH sent request to PS, RW and KA on 29/06/20]	
3.11 RW indicated an alternative approach to scaling is to take existing tidal curve and apply various sensitivity tests.	
3.12 RW queried where the 600mm freeboard allowance came from and indicated that there are also recommendations by the EA for 700mm elsewhere. RW indicated it may be best to get a better understanding of the risk in the area before defining a set freeboard allowance number, as it is normally assessed on a case by case situation by allowing for uncertainty.	
3.13 Post meeting note – does the TE2100 modelling not already include an allowance for freeboard?	EA
3.14 RW indicated that recently some incorrect EA data have been issued out and requested to see the data received by BH to check whether it is the relevant data.	PS/BH/RW
[Post Meeting Note: BH sent request to RW, PS and KA on 29/06/20]	
4.0 Flood risk mitigation – Main Resort	
4.1 NV indicated that it is currently proposed to realign the existing flood defence embankment so that it continues behind the jetty area forming a continuous defence line tying into existing high ground levels in the north. To protect the proposed buildings in this area, they will be set at the defence level. The existing wall and flood gates will be removed.	
4.2 RW indicated that this seems appropriate. If the low loader vehicles struggle with the access ramp over the embankment, then longer path may be needed where they cross the crest at a different location.	
4.3 NV indicated that two options are being considered for flood defence alignment around Black Duck Marsh: raising existing defences or following the development plot edge around the east of the marsh to double up as a security bund. This second option would result in flooding of the marsh and pedestrian right-of-way path in the future. EA were happy for both options to be investigated.	
4.4 EA indicated that further discussions are likely to be required with the EA Fisheries & Biodiversity team regarding the management of the marsh and changes in freshwater to saltwater. BH are arranging a meeting with the landscape architect, ecologist and EA biodiversity team.	BH/EA
4.5 NV indicated that the EA defence information indicates that there is a short section of flood wall that may need to be raised that is currently outside the red line boundary. RW agreed that raising this additional length is sensible and suggested the red line is amended in this location to allow for the raising.	
4.6 RW indicated that the EA favour raising of development levels to provide flood mitigation compared to defences as it is more robust.	
4.7 RW indicated that a condition survey of the existing defences that will remain should be undertaken. The defences should be visually assessed for any signs of failure, slips etc.	

4.8 As part of the design for raising of the defences, slope stability assessment for the proposed vehicle loading should be undertaken as the defence was unlikely to have previously been designed for the same use.

4.9 NV indicated that on the east side of the development high ground levels form the existing defence along the north and north east of the peninsula. Where defences change to a wall with flood gates this is outside of the red line boundary. As such, it is not proposed to raise the existing defences but instead to potentially raise the development level in Botany Marsh above the future flood level.

4.10 RW indicated that raising land levels is a good strategy.

4.11 NV presented the results of the breach analysis undertaken as part of the project in 2014/2015 which considered one breach on the west and one on the east side of the peninsula. The staff village may be at risk from flood water from a breach flowing through the tunnel entrance (through the chalk spine that the A226 passes over). The tunnel isn't currently in the model and would be included in any future modelling. However, it can be seen that only the access route into that area would be at risk. The residential buildings will be set at ground level or above which is higher than the access route. Safe access can be found from where the road ramps up to the existing Craylands Lane.

4.12 RW indicated that the proposal for the staff village appears appropriate. He also indicated that a study undertaken in 2017 looked at breaches every 20m or 50m of the existing defences (depending whether a hard or soft defence). This gave an understanding of the complete risk of the existing defences, although did not get results which indicated which breach had the greatest impact at a particular flooded model cell. BH indicated that their modelling software differs to that used for the successive breach analysis.

4.13 As breach scenarios are not solely used to identify the risk from a defence in poor condition, the EA indicated that assessment of new defences should also be considered.

4.14 RW indicated that it may be possible to review the topographic data that is currently being flown to have a better idea of where the flow routes that may have the greatest impact are to help determine an appropriate breach location for further assessment.

4.15 EA indicated that although asset inspections are undertaken, they are not responsible for maintenance and not much maintenance is known to have occurred in this location. The liability for maintenance sits with the landowner. The EA have permissive powers to maintain a flood defence if needed if it is considered to have an impact on people. However, it does not take away the responsibility of the landowner.

4.16 The EA indicated that there may be a risk of slip failures during embankment raising, given the ground conditions on site. Therefore, it is recommended to raise in stages where after each subsequent stage a waiting period occurs to allow the ground to consolidate before raising the next part. This also benefits ecology. A slip circle method failure analysis (geotechnical analysis) would be required as part of the design. This would also consider sea level rise and loading for different vehicles in the future.

5.0 Assessing tidal flood risk – Tilbury Site	
5.1 NV indicated that the proposals at this location are to create a new building for coach and vehicle parking, a new entrance area with facilities for passengers, and an extension to the ferry jetty to allow passengers to be picked up by Thames Clippers and taken to the Main Resort. There are no current plans for changes within the wider car park area, or the surrounding road network. Improvement works to a near by junction may be required to increase vehicle capacity.	
5.2 NV indicated that the site is not at risk from an existing or future 1 in 200year tidal event or current day 1 in 1000year event.	
5.3 The EA stated that the 1 in 200year event is irrelevant in this location as sites should be assessed against the 1 in 1000year event.	
5.4 EA indicated that the existing flood defences currently run along the edge of Tilbury and the Thames as a wall. The wall is integrated in the back of the cruise buildings (steel A frame sections grouted to northern face of building) with flood gates at appropriate points for access to the buildings. Any changes to these existing buildings will need to take this into account.	
5.5 NV presented breach analysis undertaken for the SFRA Level 1 2018 study. This identified the site at risk from a breach located to the east of the site.	
5.6 NL pointed out that the SFRA uses the old climate change allowances and therefore, a breach analysis is required for the project. This would be not to set design levels for a new building but to inform the Flood Evacuation and Management Plan based on the hazard from the assessment. This will have implications on the operational performance.	
5.7 EA recommended working with the LA emergency planners when developing the Flood Management and Evacuation Plan.	
5.8 The EA confirmed that a breach analysis will also be required to assess whether any proposals displace flood water elsewhere putting other areas at risk, such as through raising road levels.	
5.9 The EA suggested looking at a breach analysis as part of BH modelling work from one of the flood gates within our red line boundary.	
5.10 LH suggested confirming with the Lead Local Flood Authority as to the vulnerability classification of the proposals for the FRA – e.g. less vulnerable or essential infrastructure.	
5.11 BH are to email KA with data request previously sent to EA as it was unlikely it included the Anglian Region.	BH/KA
[Post Meeting Note: BH sent request to KA, LH and NL on 29/06/20]	
6.0 Flood risk mitigation – Tilbury Site	
6.1 NV indicated that there are no flood mitigation proposals at the site due to site only requiring a new multi-storey car park. Existing ground levels are approximately 2mAOD, so there is no desire to raise existing ground levels.	
6.2 NV indicated the existing defences are currently appropriate for the site. However, the future flood risk for a 1 in 1000year event is currently not known as the flood modelling hasn't been undertaken.	
6.3 EA indicated that the existing flood walls would not be able to be raised along the current alignment. In order to protect the area from future flood risk, a realignment of the defence wall is being investigated by the EA. This	

	follows the alignment of the road immediately to the north of the cruise buildings.	
6.4	The EA indicated that two factors need to be considered for the new flood defences: the timescale for delivery; and the sizing of the defences.	
6.5	Discussions will be required between BH and the EA with regard to the current defence proposals to ensure there is no conflict in design. BH should set up another call with DGa and DG to find out further details.	BH/DGa/DG
6.6	Although BH indicated that the defences would be assessed for the design life of the site (to 2084), the EA indicated that understanding of how raising in the future will be achieved needs to be provided.	
6.7	The EA indicated that the intake to a gravity outfall sluice is located to the west of the proposed building. Due to its condition, it will be sensitive to construction in that area. The culvert outfall discharges to the Thames to the west of the cruise terminal.	
7.0	**Assessing and mitigating fluvial flood risk – Access Road**	
7.1	NV presented the existing 1 in 100yr+CC and 1 in 1000yr flood extents as provided in the River Ebbsfleet model recently provided by the EA. Main increase is observed in the existing lake.	
7.2	NV indicated that the proposals in this area are not confirmed. Modifications to existing junction and roads may be required to improve access to the site and are currently being developed.	
7.3	RW indicated that the River Ebbsfleet is a groundwater fed river which can be difficult to estimate behaviour and therefore flood extents.	
7.4	RW indicated any built environment may be at risk. If any land raising is made in this area, flood compensation would be need to be looked into which may have implications on the red line boundary if keeping within the site boundary.	
8.0	**Assessing and mitigating fluvial flood risk – Main Resort**	
8.1	NV indicated that it was not proposed to model the fluvial flood risk from the main ditch that runs south to north in the Main Resort due to it being developed. It is proposed to divert the ditch either to the east or west to convey the existing flow rates and discharge to the Thames. Taking into account tidelock scenarios.	
8.2	RW indicated it is likely that the LLFA will need to be met to discuss the requirements of the ditch and the stormwater drainage strategy. RW has previously worked with Neil Clarke in KCC.	
8.3	BH are to arrange a meeting with KCC and invite RW.	BH/RW
8.4	NV asked the EA whether there are any known sources of discharge into the ditch. RW was not sure although he was aware of HS1 discharge and that eastern quarry have applied for a permit to increase their discharge. This would be to the main ditch until March 2022 and then into the Thames. RW can provide further details on this.	RW
8.5	RW indicated that the culvert believed to discharge the main ditch to the north of the jetty is blocked and a survey to understand conveyance capacity has not been possible. CC indicated that Lafarge have looked into clearing the culvert but it is currently costly to remove the hazardous waste and they could not obtain a permit.	

Minutes taken by: Nilani Venn

8.6	RW indicated that the culvert outfall itself may need attention and this should be considered if re-using the existing culvert.	
8.7	RW indicated that the ditch network will need to be modelled as part of application to demonstrate that the proposed storm drainage system works. This is mainly due to concerns regarding the substantial increase in overland runoff due to increased impermeable area and prevention of infiltration.	
9.0	**Assessing and mitigating fluvial flood risk – Tilbury Site**	
9.1	LH queried whether the fluvial flood extents at the Tilbury site have been reviewed which BH responded with not to date.	
9.2	LH highlighted that conveyance is critical in the two main rivers in this location and it cannot take any more discharge.	
9.3	BH said they will look into the main rivers at this location and will request the data from the EA via KA. *[Post Meeting Note: BH sent request to KA, LH and NL on 29/06/20]*	BH/KA
10.0	**Next Steps**	
10.1	RW queried what the Statement of Common Ground is. BH indicated that it is their intention to have the principles of the FRA agreed with the EA ahead of the DCO application.	
10.2	BH asked the EA if they are happy to have further meetings and review the FRA ahead of planning, to which they agreed.	
10.3	Biodiversity and achieving net gain as part of the proposals was flagged by the EA as a potential risk to the project. BH acknowledged this is known and a meeting with the EA is required.	
10.4	CC and KA are to agree the format of the next meetings scheduled. This will include topics covering water quality, contamination, marine works, ecology and stormwater. Future meetings may need to be split for the north and south teams.	CC/KA
10.5	RW queried whether the topo data being obtained can be passed to him for his own review of the site. BH indicated they will look into this.	BH

The minutes detailed herein reflect the author's recollection of the discussions held during the meeting detailed above. If you feel that these minutes are inaccurate; proposed additions, corrections and/or comments must be submitted to the author in writing within five working days of the date of these minutes. If no written responses are received within this period, these minutes will be deemed the official record of the meeting.

Minutes taken by: Nilani Venn

BURO HAPPOLD

Minutes

Subject	London Resort - EA Meeting	Job no	0042936
Place	Via Teams	Date	04 August 2020
Present	*Environment Agency* Karolina Allu Robert Williams *Kent County Council* Bronwyn Buntine *BuroHappold* Christine Cambrook Nilani Venn Harry Mansfield Elijah Greene Rodoula Gregoriou David Palmer *WSP* Steve Dellow	Apologies	None
Distribution	As present plus internal project teams.		

Objective of meeting: To update the EA and KCC on progress to date on flood risk and surface water drainage, and to receive feedback and confirmation of approach.

Item	Action
1.0 Introductions	
1.1 All present introduced themselves and their role on the project.	
2.0 Flood Risk	
2.1 HM talked through prepared slides on flood risk and hydraulic modelling for the Swanscombe Peninsula. The slides focussed on Tidal Flood Risk. A copy of the slide deck is provided alongside these minutes. The key Points made were:	
2.2 Formal flood defence crest levels will been set based on the TE2100 current guidance (2015). This is a 7.0mAOD defence crest level (freeboard included) for the period up to 2070. Beyond 2070 the crest level is dependent upon a decision for the improvement of the Thames Barrier. TE Option 1.4 involves the improvement of the Thames Barrier in situ, the guidance indicates that this would require crest levels of 7.5mAOD for the period between 2070 and 2120. TE Option 3.2 involves a new Thames barrier to be constructed at Long Reach, the guidance indicates that this would require crest levels of 7.00mAOD for the period between 2070 and 2170. Some of the flood levels quoted here are incorrect. Please see section 2.29 which has the correct values.	

2.3 A staggered approach is proposed, to raise the defences to 7.0mAOD in the first instance, with a scheduled review post 2050 to identify improvements required subject to the decision of the Thames barrier improvements (2050 is the anticipated date by TE2100 team for the final decision on preferred option to be made).

2.4 In the meeting held with the EA on the 23rd June '20 it was raised that updates to the TE2100 modelling is currently being undertaken to include the UKCP18 data as well as modelling the different tidal and flood defence options for the Thames. After the meeting the EA confirmed that draft modelling data could not be shared with BH at this time as EA internal sign off had not been made. In the EA response dated 13th July '20 RW suggested that applying '*additional amount using engineering judgement for a credible worst case*' to allow for the additional increase in water level should be undertaken in lieu of the updated TE2100 levels.

2.5 To make an allowance for sea level rise based on the latest climate change guidance, BH have undertaken modelling for assessing flood risk at the site by using the most appropriate currently available model for the site which is the North Kent Coast Model (2018). This has been updated by BH to modify the tidal curve boundary using the recommended methodology provided in the latest EA climate change guidance to allow for UKCP18 sea level rise. This is referred to hereafter as the BH Baseline model. The BH Baseline model has been run using a number of different storm events, using both the Higher Central and Upper End Climate Change Projection scenarios to give a broad understanding of the flood risk to allow for the uncertainty in flood levels at this stage. This is in accordance with the methodology presented to the EA at meeting of 23rd June '20.

2.6 RW advised that there are issues with both the TE2100 and the TE Breach Assessment 2018 model based in ICM (infoworks). The TE Breach model includes continuous breaches whereas the hydrology is currently being updated in the TE2100 model. Buro Happold will continue to use the North Kent Coast 2018 model, as discussed and agreed.

2.7 The EA is not able to advise when the latest updated TE2100 modelling will be available and it is unlikely that it will be ready for use until sometime after the DCO submission.

2.8 RW advised that the project team should continue to develop the scheme design on the basis of data available. The EA would like this design development tested against the new TE2100 model once it becomes available. It was agreed that the scheme would be re-evaluated against the new modelling when that becomes available, which is likely to be in 2021.

Overtopping Flood Management Strategy

2.9 BH have simulated the BH Baseline model for the 1 in 200 year and 1 in 1000year events for 2040, 2070, 2090 and 2125.

2.10 HM presented the modelling results and mitigation proposal for overtopping of the current flood defences. Overtopping occurs on the western and eastern sides of the peninsula. Overtopping does not occur to the north due to levels, as this area is primarily high ground.

2.11 The proposed mitigation for overtopping of the western flood defences is to raise the formal flood defence bund along the edge of Black Duck Marsh along its current alignment and to tie into existing high ground to the SW of the site.

2.12 The section of existing flood defences (currently flood wall and flood gates) in the location of the jetty area, will be removed and a new embankment running along the landward side of the jetty BoH area will be created tying into the Black Duck Marsh embankment to the SW and into higher ground to the NE.

2.13 The site is not at risk from overtopping of the eastern flood defences during the 1 in 200yr HC 2070 flood event.

2.14 In 2090 the site is at risk from overtopping during a 1 in 200yr HC flood event. The proposed solution for overtopping of the eastern flood defences could be the construction of a new bund along the eastern edge of the resort boundary, which provides a secondary flood defence specific to the site. The bund crest level would be set at the 1 in 200year HC 2090 level + 300mm freeboard.

2.15 Modelling was undertaken to ascertain whether the bund should be located on the east or west side of Botany Marsh (raise existing embankment on east side or create a new embankment on west side).

2.16 The modelling demonstrated that by locating the bund on the west side this would allow the storage of flood water in Botany Marsh, preventing displacement of floodwater to offsite areas, therefore not increasing the flood risk to any properties outside the site during the design flood event.

2.17 RW queried if the project can raise the existing formal flood defences along the eastern edge of the Swanscombe Peninsular, to reduce this future overtopping. DP confirmed that this is outside the project boundary and the project will not be raising these defences.

2.18 RW queried if creating a new bund in the west side of Botany Marsh eventually will increase flood risk elsewhere. HM explained that the analysis has considered four scenarios: the 1 in 200 year, 1 in 1000 year 2090 higher central and upper end scenarios, and the flood extent elsewhere is not increased.

2.19 There was discussion around the potential risk to the project if the modelling data (river levels) change at a later date, and the flood risk off-site is seen to increase. The conclusion reached was that when the model or inputs change at a later date, the future baseline modelling would also need to be assessed. The project team can only base their designs on the models and data that are currently available.

2.20 EG noted that the northern constructed wetland/Swanscombe marsh regeneration works option currently being proposed, will provide additional storage capacity and is subject to further modelling.

2.21 There was discussion about the future raising of this bund, and the future raising of the formal flood defence on the river edge. It was reiterated that while this bund could be raised in the future, it is a secondary line of defence to protect the project and not a formal flood defence. The formal tidal flood defence along the river front would need to be raised in the future to provide protection to the wider site area.

Breach Flood Management Strategy

2.22 HM explained the breach modelling undertaken, whereby the worst case of 4 breach locations has been used to inform mitigations required within the project boundary.

2.23 The strategy for the site is to allow less vulnerable uses to flood during a breach event but that a resilient approach to design is made.

2.24 More vulnerable uses, such as sleeping accommodation (staff area and hotels), and some critical infrastructure for the resort operation, are proposed to be set above the breach flood level for the 1:200 year HC event in 2125, plus a 300mm freeboard. Due to the current uncertainties regarding the future flood levels, we will also assess the impact from other storm events.

2.25 RW reiterated that the project should consider a 100 year life, as the project includes residential (staff accommodation) and hotels, and as no agreed decommissioning date is in place. The reason for the 100-year lifetime was due to the long operational life of other Theme Parks in the UK and the lack of an agreed decommissioning date.

2.26 RW queried if a continuous breach modelling approach had been considered, as per previous discussions. HM responded that it has not, for the previously discussed reasons. However, the modelling undertaken indicates that the breach locations impact the site in the same way – as water floods into the marsh areas and from there into the project site. The northern part of the site has little impact from a breach due to the high ground. The locations chosen on the west and east sides were based on where the existing ground level is low and therefore would have the greatest impact.

2.27 HM explained that in the event of an extreme storm event, flood warnings will ensure that the resort is closed to visitors and the site would be unoccupied with the exception of staff village and hotels. Sleeping accommodation will be located on the first floor or above (not on ground floor levels). The buildings would be provided with safe invacuation locations. The project will identify a detailed Flood Warning and Evac/Invacuation Plan, post DCO submission. It is anticipated that this will be a planning condition. Flood warnings may not be much help in the event of a breach of the defences because the defences are so close to the operational site.

2.28 RW queried if a breach in the project secondary bund will be considered. HM confirmed this can be modelled if required by the EA. It was stated by BH that a breach in the secondary defence bund would be modelled.

Approach for future raising of formal flood defences

2.29 BH indicated that the TE2100 guidance requires different flood defence crest levels depending on the tidal barrier option the EA take forward in the future. The current 2015 TE2100 guidance indicates that to provide protection during a 0.1%AEP event defence crest levels should be set at as follows:

- 7.0mAOD to provide protection up to 2070.
- 8.0mAOD to provide protection between 2070 to 2170 if the preferred option for Long Reach tidal barrier (Option 3.2) is chosen.
- 7.5mAOD to provide protection between 2070 and 2120, and then further raising to 8.0mAOD between 2120 to 2170 if refurbishment of existing Thames barrier along with improved defences (Option 1.4) is taken forward.

2.30 Due to uncertainties of the tidal barrier option being taken forward, BH proposed that the strategy will be to set the formal flood defence level at 7.0mAOD with consideration in the design that allows future raising of defences to be made at around 2050 when confirmation of the tidal barrier option is confirmed.	
2.31 RW noted that a strategy for future raising of flood defences, that can be delivered without undue cost and difficulty, needs to be demonstrated as part of the DCO. Any solution should be considered in both technical and planning terms. BH stated that future embankment raising could be very difficult.	
2.32 RW noted that the condition of retained defences needs to be verified and survey and calculations undertaken to confirm ongoing performance. He noted there are a number of ways earth embankments can become destabilised due to rising water levels. CC responded that this is understood however this would be addressed at the detailed design stage. Site investigations and surveys being left to the post planning stage will be too late to prove that workable solution exists to defence raising to 7.0 m AOD and later to 8.0 m AOD.	
2.33 EG noted there is significant technical complexity around the jetty area in achieving the 8.0mAOD defence level, and that a flood gate is being considered as an option in this area. RW responded that the EA are working to remove flood gates where possible and he cannot see why the EA would accept it in this instance. Following discussion, it was agreed the project team would work to develop a solution that does not rely on a flood gate, however if this is not possible it would be required to robustly demonstrate to the EA that no other solution exists for this area. The EA cannot guarantee acceptance of a flood gate if one is proposed.	
3.0 Surface Water Drainage – Peninsula	
3.1 RG talked through the slides prepared on existing and proposed surface water drainage for the Swanscombe Peninsula site. Slides are provided alongside these minutes. Key points made were:	
3.2 Water in the marsh areas appears to be standing water, flow has not been observed during the site visits. Outfall locations are as shown on the plans.	
3.3 Further investigation is required in relation to Botany Marsh, no outfalls have been observed but there may be one to the eastern peninsula edge running beneath the industrial sites.	
3.4 CCTV survey is being procured to confirm details of inflows and outfalls.	
3.5 The *main river* and some of the additional water channels will be diverted as part of the works. Water flows from off-site will be diverted (e.g. from HS1 / Eastern Quarry). Information on drainage consents has been requested from the EA. EA to update on availability of information.	EA
3.6 Unrestricted discharge to the river is proposed, with the surface water drainage network to be designed for tidelock scenarios.	
3.7 BB and RW confirmed that unrestricted discharge to river is acceptable. *(Post-meeting note – the tidelock scenarios have now been confirmed with KCC and are shown below:*	

	River Water Levels		
Rainfall Event	No restriction (low tide)	MHWS	1:200 year water level 2090
1:1 year	x	x	x
1:30 year	x	x	
1:100 year + climate change	x	x	

3.8 RW noted that scour protection at outfalls must be considered to prevent any damage to structures or foreshore.

3.9 Surface water catchments are proposed that discharge water via a perimeter swale into the marshes on the east and west of the resort. The catchment areas of the proposed catchments have increased compared to baseline conditions. Additional flow to these marshes is beneficial ecologically. Flow regime is being developed in collaboration with EDP (ecologists).

3.10 A new constructed wetland (northern constructed wetland) is currently being proposed to the north of the resort, as a possible SQID for capturing surface water flows and providing SuDS treatment prior to discharge to the River Thames.

3.11 Velocity control will be provided at the outfalls into the marshes.

3.12 RG noted that the drone survey data shows the marsh areas as relatively flat and the extensive vegetation reduces the usefulness of this data in confirming catchments. The drone composite DTM is being updated as per the onsite measurements taken by EG with an allowance for the vegetations effect on capacity.

3.13 BB raised the topic of the level of inundation acceptable to the marsh habitats, and the potential need for a mechanism by which the water levels in the marsh can be reduced after a flood event.

3.14 EG noted that the existing outlet at Black Duck marsh should mitigate against prolonged inundation/will be upgraded to do so. The proposed northern constructed wetland/Swanscombe marsh regeneration works will mitigate against prolonged inundation of Botany marsh.

3.15 BB noted that KCC would usually require attenuated surface water volumes to be located outside an area of flood risk. NV indicated that storage provisions are being considered for tidelock scenarios, as the general strategy is to discharge unrestricted to the Thames. An assessment will be made to ensure the capacity of the marshes would be able to withstand both a potential future overtopping flood event and a tidelock scenario that prevents surface water from being discharged into the Thames.

3.16 BB noted that prolonged inundation of the marshes may have impact on the ecology which also needs to be considered.

3.17 KA noted that a joint discussion on management of the marsh habitats, with the EA and Natural England, and EDP would be beneficial. *(Post-meeting note – set up for 24.08.20)*

Minutes taken by: Christine Cambrook

3.18 RW questioned if the project would be modelling the drainage system. DP confirmed the approach will be to undertake catchment analysis, with flows incorporated into a model to ensure proposed system has capacity for the tidelock scenarios, but detailed drainage network design will not be undertaken for the DCO submission. In the absence of network modelling it will be necessary to prove that the culverts and outfalls will have sufficient capacity. The lack of modelling may require a more precautionary approach to demonstrate that.

3.19 BB noted that the highway drainage on Manor Way is known to be problematic, due to a pumped system that fails. BB to provide further information. *(Post-meeting note, information and relevant contact at KCC provided).*

3.20 RW noted that the marsh outfalls should incorporate gates at strategic points to allow surface water to be retained within the marsh or drained from the marshes should it be desirable in the future. The installation of level control structures was agreed by BH.

3.21 RW noted that the EA would oppose culverting of the existing watercourses, and where diverted, prefer soft banks. More information is required on the diverted channel routes. The project team will maximise the opportunities for open, soft channels but it is inevitable that some open watercourses will need to be culverted. The EA need to see details of proposed channel diversions, bank treatment and any culverting as soon as possible.

3.22 BB noted that land drainage consents will be required for the ordinary watercourses, and that sufficient offset for access and maintenance is required for the retained watercourses.

3.23 BB expressed positivity around the proposed perimeter swale and noted that sufficient width must be included in the scheme for this, as often swales are removed later due to space take. Cross sections and plans with dimensions would help better understand that this is the case. RG and EG confirmed the spatial allowance currently in the masterplan for the swale and edge conditions as ~10m.

3.24 RW noted the (previously discussed) poor condition of the culvert from the *main river* to the Thames and enquired as to the proposals for this. EG advised that it is likely to become redundant based on the revised surface water drainage strategy, but this is yet to be confirmed.

4.0 Surface Water Drainage - Access Road

4.1 SD gave an overview of the surface water drainage proposals for the access road. Key points noted were:

4.2 The road will be a private road, with private drainage, though it will be designed to adoptable standards.

4.3 The highways drainage will be designed to have capacity for the 1 in 30 year event. A sensitivity test will be undertaken to assess the impact during a 1 in 100 year exceedance event.

4.4 Surface water will discharge to two existing ponds. One towards the north and one towards the south. Levels are to be confirmed as to whether the drainage gradients will meet these two ponds as the road is relatively flat. Consideration of whether additional outfall location is to be determined.

Ownership of the ponds was discussed, understood to be Ebbsfleet Development Corporation (EDC).

4.5 BB noted the access road drainage should be discussed with EDC, as KCC have seen development proposals for parcels close to the access road and sufficient capacity needs to be ensured.

4.6 BB noted the water quality challenges will be significant for the highway drainage. There is a preference for natural systems.

4.7 EG noted that the existing ground conditions need to be investigated as contaminated landfill may be present near the northern pond/proposed surface water outlet.

The minutes detailed herein reflect the author's recollection of the discussions held during the meeting detailed above. If you feel that these minutes are inaccurate; proposed additions, corrections and/or comments must be submitted to the author in writing within five working days of the date of these minutes. If no written responses are received within this period, these minutes will be deemed the official record of the meeting.

APPENDIX C – Hydraulic Modelling Report

BURO HAPPOLD

London Resort

Hydraulic Modelling Report

0042936

18 December 2020

Revision 0000

Revision	Description	Issued by	Date	Checked
00	Appendix B to Flood Risk Assessment (Appendix 17.1 of ES Chapter 17 Water Resources and Flood Risk)	HM	18/12/2020	NV

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author	**Harry Mansfield**
date	**18/12/2020**
approved	**Nilani Venn**
signature	[redacted]
date	**18/12/2020**

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Glossary

Term	Definition
Annual Exceedance Probability (AEP)	The probability that a storm event will be exceeded in any given year.
Actual Risk	The risk that has been estimated based on the quantitative assessment of the performance capability of the existing flood defences.
Attenuation	A method to reduce a flood peak to prevent flooding, often utilising temporary storage, but increasing the duration of the flow.
Design Flood Level	This is the level of flooding that flood defences or mitigation measures are designed against.
Flood Defence	A natural or man-made infrastructure used to prevent certain areas from inundation from flooding and/or the provision of flood warning systems.
Floodplain	Area of land adjacent to a water course which water flows or is stored during a flood event, or would otherwise be flooded in the absence of flood defences.
Flood Resilience	Improving flood resistance, e.g. reducing the risk of properties against flooding events.
Flood Risk	The level of risk to personal safety and damage to property resulting from flooding due to the frequency or likelihood of flood events.
Flood Risk Assessment (FRA)	An assessment of the flood risks to the Proposed Development over its expected lifetime and the possible flood risks to the surrounding areas, assessing flood flows, flood storage capacity and runoff.
Flood Warning Systems (FWS)	A system by which to warm the public of the potential of imminent flooding. This is typically linked to a flood forecasting system.
Fluvial Flooding	Flooding resulting from an exceedance event in a river or watercourse.
Groundwater	Water present within underground strata known as aquifers.
Impermeable Surface	A surface that does not permit the infiltration of water and, therefore, generates surface water runoff during periods of rainfall.
Inundation	Flooding of land with water
Mitigation	Actions taken to reduce either the probability of flooding or the consequences of flooding or a combination of the two.
Permeability	The measures of ease with which a fluid can flow through a porous medium.
DCO Order Limits	Boundary drawn to indicate the site area on which the planning application is based.
Refuge	Area for shelter / protection during flood events.
Residual Risk	The risk that remains after risk management and mitigation measures have been implemented.
Resilience	The degree to which an asset or development can recover from a flooding event.
Return Period	The average frequency of a specified condition. An 'n' year event is one that occurs on average over the long term, once every 'n' years.
Risk	Risk is the probability that an event will occur and the impact (or consequences) associated with that event.
Runoff	Water flow over surfaces to the drainage system. Runoff occurs when rainfall exceeds the rate of permeability of a surface.
Strategic Flood Risk Assessment (SFRA)	An SFRA is the assessment and 'categorisation' of flood risk on an area-wide basis in accordance with the NPPF, usually carried out by the Local Planning Authority.
Surface Water Flooding	Surface water flooding occurs when the volume of water is unable to filtrate through the ground or enter drainage systems, and therefore runs quickly off land and results in localised flooding. This type of flooding is usually associated with intense rainfall.
Sustainable Drainage Systems (SuDS)	SuDS are used as a strategy to manage surface water in a sustainable manner or least damaging solution through management practices and physical structures.

Abbreviations

Term	Definition
AEP	Annual Exceedance Probability
DCO	Development Consent Order
EA	Environment Agency
ECC	Essex County Council
EDC	Ebbsfleet Development Corporation
FRA	Flood Risk Assessment
FWS	Flood Warning Systems
DFE	Design Flood Event
DEM	Digital Elevation Model
DFE	Design Flood Event
DSM	Digital Surface Model
DTM	Digital Terrain Model
GBC	Gravesham Borough Council
ha	Hectare
HC	Higher Central
HS1	High Speed 1
H++	H Plus Plus (Climate Change scenario)
KCC	Kent County Council
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
LPA	Local Planning Authority
m AOD	metres Above Ordnance Datum
NPPF	National Planning Policy Framework
NSIP	National Significant Infrastructure Project
PPG	Planning Practice Guidance
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage Systems
SWDS	Surface Water Drainage Strategy
SWMP	Surface Water Management Plan
TC	Thurrock Council
TE2100	Thames Estuary 2100
UE	Upper End
UKCP09	United Kingdom Climate Projection 2009
UKCP18	United Kingdom Climate Projection 2018

1 Introduction

1.1 Background

This Hydraulic Modelling Report has been prepared as an appendix to the Flood Risk Assessment (FRA) (Document Reference 6.2.17.1) prepared by Buro Happold to support the Development Consent Order (DCO) application for the London Resort, hereafter referred to as the 'Project Site'.

The purpose of this report is to detail the hydraulic modelling information that was made available to Buro Happold for the FRA, the work undertaken to update the available models for the Proposed Development and the analysis of the results that contributed to the conclusions reached in the FRA.

1.2 Proposed Development

The Proposed Development is located across the north and south bank of the River Thames. For clarity, the section of the Project Site that is to the south of the River Thames is referred to in this report as the Kent Project Site and that to the north of the river is identified as the Essex Project Site. They are not contiguous. Figure 1-1 illustrates those areas.

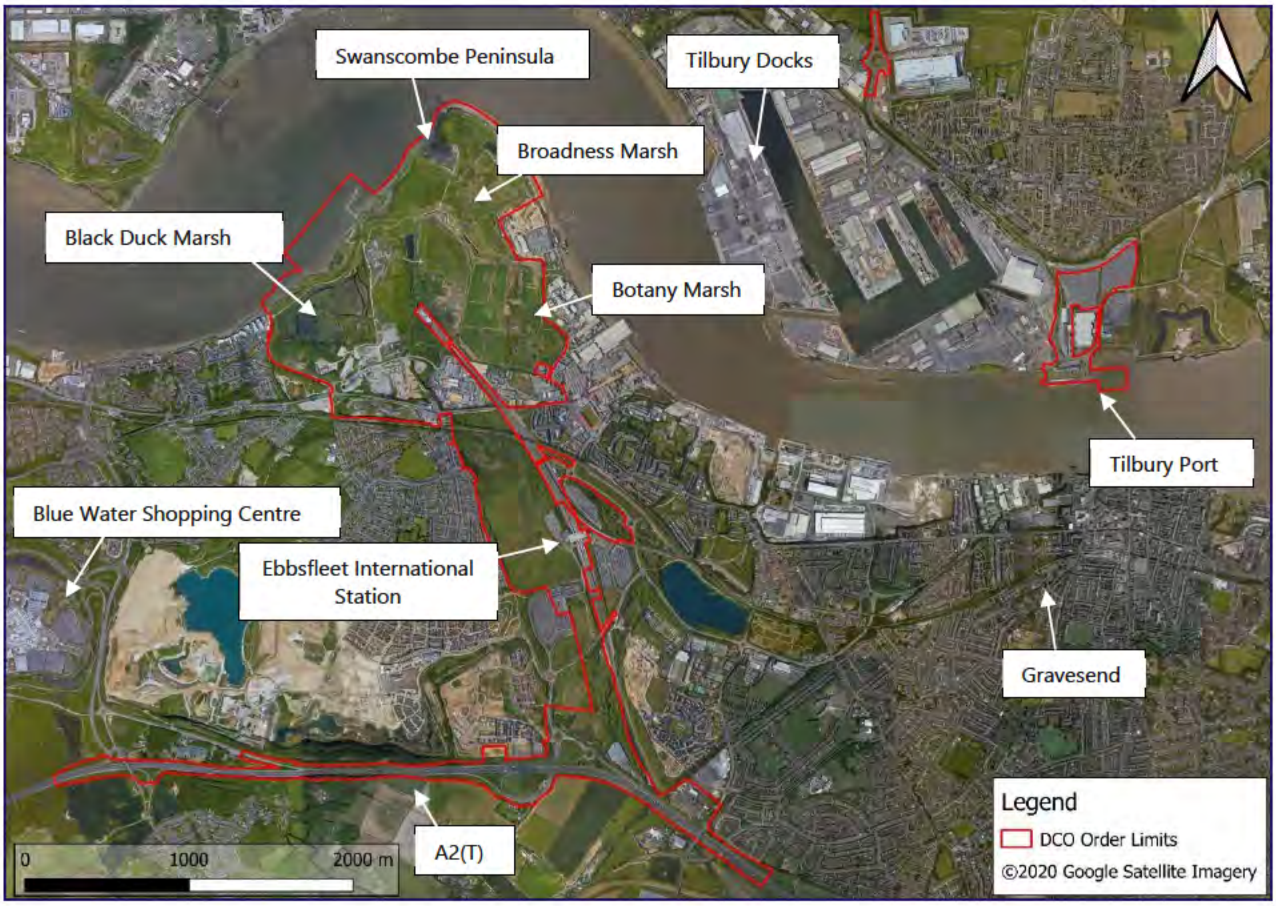

Figure 1-1: Order Limits shown in red and key places identified.

The section of the Project Site that is to the south of the River Thames is split into two further areas for the purpose of this assessment. The three areas referred to within the assessment are as follows and shown in Figure 1-2.

1. Kent Project Site (the Main Resort);
2. Kent Project Site (the Access Road); and,
3. Essex Project Site.

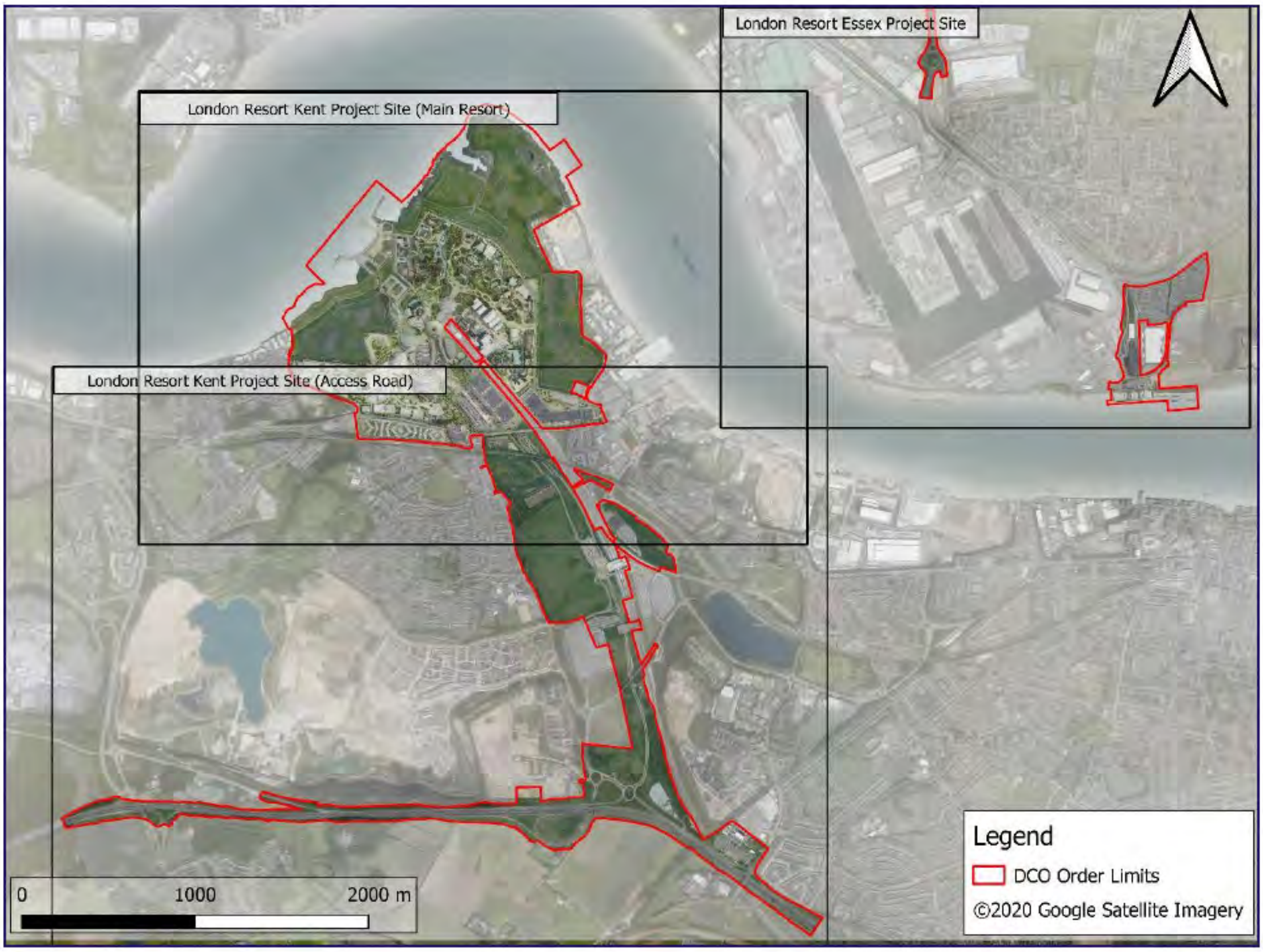

Figure 1-2: The London Resort Project Site areas.

1.3 Flood Risk

The flood risk to the project considered in this report includes:

- Tidal flooding from the River Thames as a result of the overtopping or the breach of the Thames flood defences; and,
- Fluvial flooding from the River Ebbsfleet as a result of the overtopping of the Ebbsfleet River banks.

2 Tidal flood risk approach and available information

2.1 Approach

Hydraulic Modelling has been undertaken to assess the impact during an extreme tidal flood event during the lifetime of the Proposed Development based on two key scenarios:

i) The defended scenario, in which the existing flood defences are in place and perform as designed; and,

ii) The breach scenario, in which there is a failure of the flood defences, a breach event.

For this assessment four hydraulic flood models were built:

1. **Baseline 2020 Defended:** The defended model with the baseline condition at the Project Site;
2. **Proposed 2020 Defended:** The defended model with the Proposed Development;
3. **Baseline 2020 Breach:** The breach model with the baseline condition at the Project Site; and,
4. **Proposed 2020 Breach:** The breach model with the Proposed Development.

These four models have been adapted from the Environment Agency (EA) supplied North Kent Coast 2018 Defended model. Details of the key aspects of these models are below, and the information received from the EA.

The Baseline 2020 modelling results together with information received from the Thames Estuary 2100 (TE2100) team to develop a flood risk mitigation strategy for the Project Site that are tested in the Proposed 2020 model.

2.2 Available models

There are three EA hydraulic models relevant to the London Resort Project Site for tidal flood risk. The models are summarised in Table 2-1.

Table 2-1: Available hydraulic models

Model name	Date	Model applicability	Limitation
TE2100 (referred hereafter as TE2100 model)	2005 (TE2100 plan published 2015)	1D ISIS model used to generate in channel extreme water levels to guide flood defence criteria. Includes Thames Estuary Tidal Curve at Southend as a downstream Boundary and a fixed flow at Kingston as the upstream Boundary.	Uses outdated climate change projections. No 2D (floodplain) Domain.
Thames Estuary Breach Assessment (referred hereafter as TEBA18 model)	2018	1D-2D ICM model used to generate a single maximum flood extent, depth, hazard and velocity output that takes into consideration all possible breach scenarios for the area between the Thames Barrier and Gravesend and Linford.	Uses outdated climate change projections. Modelled in ICM. Breach only model.
North Kent Coast Model (referred hereafter as NKC18 model)	2018	1D-2D ISIS-TUFLOW EA model of tidal flood risk along the North Kent Coastline, from Erith in the west to Seasalter in the east. Includes existing flood defences using information from the National Flood and Coastal Defence Database (NFCDD).	Uses outdated climate change projections. 2D (floodplain) Domain only on south side of river.

Of the three hydraulic models, the TE2100 model is a 1D only model that is the reference material for the 1D representation of the Thames Estuary in all three models. Both the TEBA18 model and the NKC18 model use variations of the TE2100 model as the baseline for the in channel 1D model representation and represent the Kent Coast in the 2D Domain. None of the models use the latest UKCP18 climate change guidance (published by EA in December 2019, updated July 2020).

The NKC18 model has been selected to support the representation of the baseline model for the London Resort due to the inherent versatility of a model designed to represent both defended and breach scenarios.

Modifications have been made to NKC18 model so that it more accurately represents the baseline at the Project Site and to be used for the proposed condition. The section below describes background information on the model, and the amendments made.

2.3 The North Kent Coast 2018 Model

The EA supplied three versions of the NKC18 hydraulic model to Buro Happold in May 2020:

i) The defended model;

ii) The undefended model; and,

iii) The breach model.

For this modelling assessment the defended model and the breach model were required (it should be noted that the breach model referred to here is not the TEBA 2018 model referred to above). The full details of these model builds are documented in the North Kent Coast Model Updates report[1]. The key details are in Table 2-2 and a visualisation of the model is shown in Figure 2-1.

Table 2-2: North Kent Coast Model details

Name	Build date	1D node count	2D cell size	2D cell count	2D domain area	Model run time (hh:mm:ss)
North Kent Coast 2018	2018	110	10m	690,770	68,900,000m^2	6:53:05

[1] JBA, January 2019; *'North Kent Coast Model Updates'*

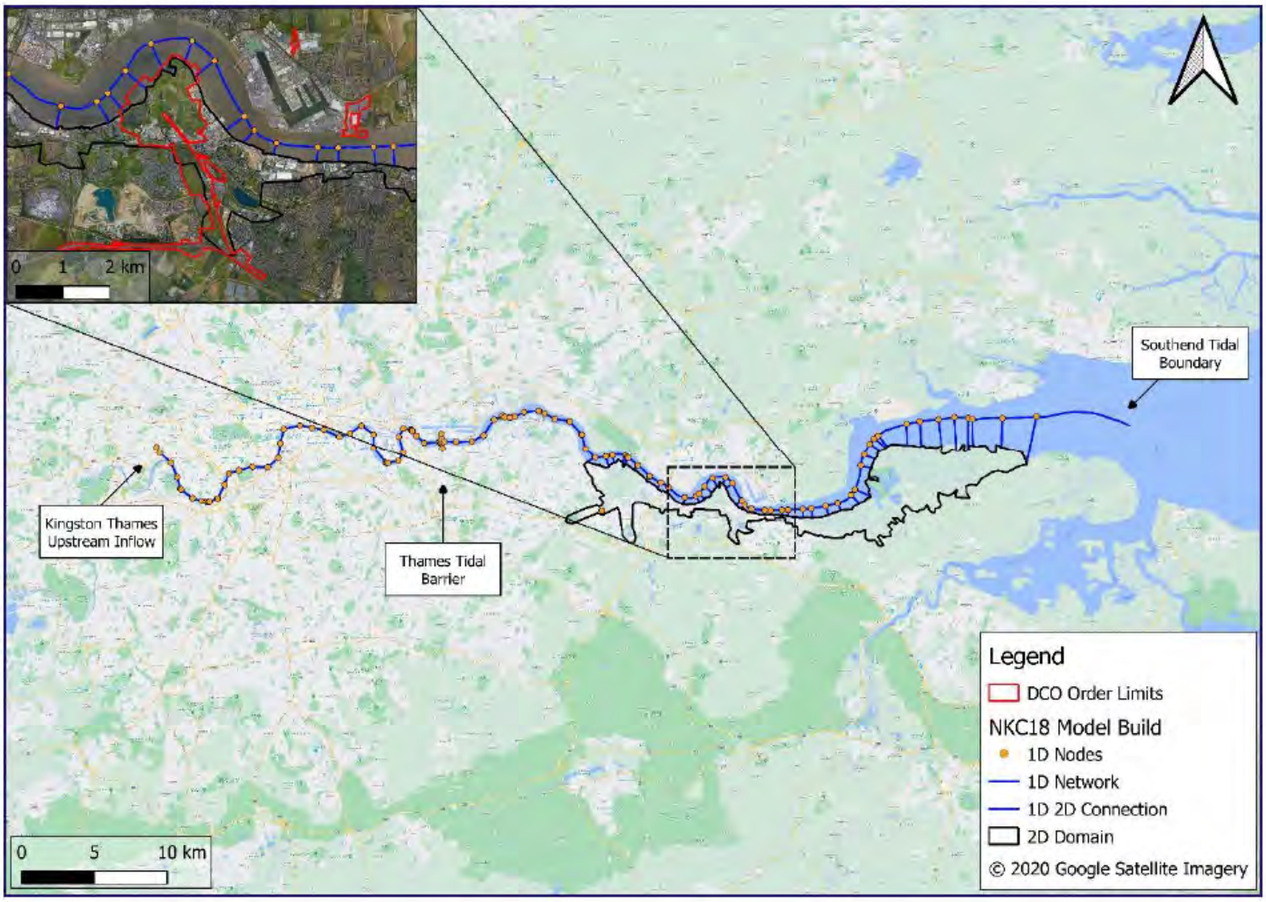

Figure 2-1: NKC18 model build

2.4 TE2100 guidance

Where the flood mitigation strategy includes alterations to the existing flood defences along the River Thames, the defence crest levels will be set not by the hydraulic modelling but instead by the TE2100 (2015) Design Water Levels and Future Crest Levels guidance[2].

Table 2-3 is an extract from the guidance. This guidance informs users on the recommended crest levels for the formal Thames Flood defences and is based on the in channel, 1D TE2100 modelling. The guidance is influenced by the proposed improvement to the Thames Flood Barrier scheduled to take place in 2070.

It is understood that currently there are three leading options for enhancing the flood barrier on the Thames:

- The first, referred to as Option 1.4, proposes to improve the Barrier at its current location with improved flood defences downstream.
- The second, referred to as Option 3.1, is for a new Thames Flood Barrier, located at Tilbury, approximately 2.5km downstream of the site; and,
- The third, referred to as Option 3.2, is for a new Thames Flood Barrier, located at Long Reach, approximately 5 kilometres upstream of the Site.

[2] Thames Estuary 2100: Improvements to the Flood Risk Management System (2015). Environment Agency.

Of the three, Option 1.4 and Option 3.2 will require an increase in the defence crest level at the site in the year 2070 or later, however option 3.2 being downstream of the site will not require defence crest raising in the year 2070 or later.

The London Resort Kent Project Site is located between model nodes 3.20 and 3.23 (see Figure 2-2). The Essex Project Site is located at model node 3.25.

The current TE2100 guidance defines that the formal flood defences require a minimum crest level of 7.00mAOD in order to provide the minimum level of protection to the site until 2070. Beyond 2070, in order to provide the same level of protection for the worst case scenario, the formal flood defences at the site will be required to be raised to 8.00mAOD. This level is based on Option 3.2 (a barrier at Long Reach) which would have the greatest impact on flood levels at the Site.

Table 2-3: Defence levels downriver of the Thames Barrier, extract from the 2015 TE2100 guidance (LB is left bank and RB is right bank). Values shown in bold relate to the Project area.

Defence Levels downriver of Barrier		Existing defence levels (2009)		Options 1.4* & 3.2**		Option 1.4		Option 1.4		Option 3.2	
				Defence levels required in 2040		Defence levels required in 2070		Defence levels required in 2120		Defence levels required in 2070	
				(for period 2040 to 2070)		(for period 2070 to 2120)		(for period 2120 to 2170)		(for period 2070 to 2170)	
Location	**Node**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**	**LB**	**RB**
Darent	3.20	6.85	6.28	7.00	**7.00**	7.50	**7.50**	8.00	**8.00**	8.50	**8.00**
	3.21	6.90	7.05	7.00	**7.00**	7.50	**7.50**	8.00	**8.00**	8.50	**8.00**
	3.22	6.85	7.05	7.00	**7.00**	7.50	**7.50**	7.90	**7.90**	8.00	**8.00**
	3.23	6.85	6.75	7.00	**7.00**	7.50	**7.50**	7.90	**7.90**	8.00	**8.00**
	3.24	6.50	6.73	6.90	6.90	7.40	7.40	7.90	7.90	8.00	8.00
Tilbury	3.25	6.95	6.87	6.90	**6.90**	7.40	**7.40**	7.90	**7.90**	8.00	**8.00**

**Option 1.4 includes the improvement of the Thames Barrier at its current location.*
***Option 3.2 includes the construction of a new Thames Barrier at Long Reach.*

Figure 2-2: Thames Estuary modelling key 1D node locations.

2.5 Required standard of protection

The Standard of Protection (SoP) required by the Project Site underpins the level of mitigation required and guides the hydraulic modelling process.

The SoP for the Project Site will vary depending on the vulnerability use of the development plot within the Project Site area. The following criteria forms the basis of the flood management strategy:

- All development uses across the Project Site protected to the year 2070 as a minimum;
- More vulnerable uses (sleeping accommodation, safe refuge areas), highly vulnerable (telecommunications installations) and essential infrastructure (required to function and operate during a flood) protected for 100 years. Flood risk should be low during either an overtopping or breach of flood defence event. This category will be referred hereafter as More Vulnerable development;
- Less Vulnerable, water compatible and other essential infrastructure (not required to function and operate during a flood) protected for 60 years. Flood risk should be low during an overtopping of flood defence event but may remain at risk from flooding during a breach event. This category will be referred hereafter as Less Vulnerable development;
- Safe access and egress to and from buildings; and
- Formal flood defences to have a SoP for the 1 in 1000 year tidal event in the future.

Based on the available EA sea level rise projections the year 2125 has been selected to estimate the flood risk for the 100 year design life and 2090 for the 60 year design life.

The design flood event (DFE) has been identified as follows:

- Flood risk from the River Thames:

- 1 in 200 year tidal overtopping flood event 2090 higher central climate change projection for Less Vulnerable development.
- 1 in 200 year tidal overtopping or breach flood event 2125 upper end climate change projection for More Vulnerable development.

It is anticipated that the Baseline or Proposed 2020 Model may underestimate the potential river level in 2090 and 2125 if the Thames Estuary strategy includes a new barrier at Long Reach. This is because a new barrier at Long Reach is anticipated to increase river levels downstream at the Project Site post 2070 if in place.

Therefore, where applicable, development levels or secondary flood defences will be set at whichever is higher for either of the following:

- More Vulnerable uses:
  - 1 in 200 year 2125 upper end breach flood level + 300mm allowance for freeboard; or
  - 1 in 1000 year 2125 higher central overtopping or breach flood level.
- Less Vulnerable uses:
  - 1 in 200 year 2090 higher central overtopping flood level + 300mm allowance for freeboard; or
  - 1 in 1000 year 2090 higher central overtopping flood level.

The H++ model results will be used as a sensitivity check to understand the impact of flooding on the Project Site using the most conservative climate change projection.

2.6 Vulnerability classification for the Proposed Development

The land uses identified for the Proposed Development and their vulnerability classification are given below in Table 2-4. The following sections indicate the risk associated for the different land uses from the different sources of flooding.

Table 2-4: Proposed Development vulnerability Kent Project Site (Main Resort)

Item of Proposed Development	Vulnerability Classification
Hotels	More Vulnerable
'Conferention Centre'	Less Vulnerable
e-Sports Arena	Less Vulnerable
Market	Less Vulnerable
Gate One	Less Vulnerable
Gate Two	Less Vulnerable
Plaza	Less Vulnerable
Car Parks	Less Vulnerable
Visitor Centre	Less Vulnerable
Bell Wharf warehouses	Less Vulnerable
Bell Wharf warehouses with critical infrastructure	Essential Infrastructure

Item of Proposed Development	Vulnerability Classification
Ferry Terminal	Less Vulnerable
Telecommunication Mast	Highly Vulnerable
Related Housing	More Vulnerable
Waste Water Treatment Plan	Essential Infrastructure
Back of House East	Less Vulnerable
Back of House West	Less Vulnerable
Electricity Sub Station	Essential Infrastructure

Figure 2-3 Proposed Development components of the Kent Project Site (Main Resort) and their vulnerability classifications

Table 2-5: Proposed Development vulnerability Kent Project Site (Access Road)

Item of Proposed Development	Vulnerability Classification
London Resort Access Road	Essential Infrastructure
Utility Compound	Essential Infrastructure

Figure 2-4: Proposed Development components of the Kent Project Site (Access Road) and their vulnerability classifications.

Table 2-6: Proposed Development vulnerability Essex Project Site

Item of Proposed Development	Vulnerability Classification
Car Park	Less Vulnerable
Passenger plaza	Less Vulnerable
Jetty	Water Compatible

Figure 2-5 Proposed development components of the Essex Project Site and their vulnerability classifications

3 Tidal flood risk (overtopping and breach) baseline 2020 model

3.1 Introduction

The North Kent Coast 2018 model has been identified from the models supplied by the EA for this project as being the best fit for the modelling tasks required for this report. In order to gain an understanding of the tidal flood risk to the Project Site in the existing condition for both the present day storm events and for the designated future events some alterations are required to the North Kent Coast 2018 model.

These alterations are outlined in the section below.

3.2 Baseline 2020 model

The NKC18 model was updated to provide a more up to date baseline model by including the following:

i) Drone survey of the Kent Project Site undertaken in June 2020;

ii) 2D coverage on the north side of the Thames in the location of the Essex Project Site;

These updates are discussed in more detail below, the final updated baseline model is hereafter referred to as the Baseline 2020 Model.

The hydrology used in the NKC18 hydraulic model, as well as the updates that were required to it are another essential component of the London Resort hydraulic modelling approach. These items are discussed in detail in Section 3.3.

3.2.1 Updates to the floodplain topography

As part of the London Resort Project an aerial survey was commissioned to provide updated surface elevation data. The aerial survey was carried out using an eBee X RTK fixed-wing survey grade drone. The survey was undertaken for the Kent Project Site (Main Resort) and the Kent Project Site (Access Road). The survey does not include the Essex Project Site.

The specification for the product is as follows:

- Camera Model Name: SenseFly/AeriaX_18.5_6000x4000 (RGB)
- Sensor: 20MP SODA RGB Camera
- Positioning: Real Time Kinematic (RTK)
- GCPs: Yes – As checkpoints
- Output Coordinate System: OSGB36/OSTN15
- 2D Outputs: Nadir Orthomosaic in GeoTIFF output format and Google times export in .kml and .html
- 2.5D Outputs: Nadir DSM and DTM in GeoTIFF formats
- 3D Outputs: Point cloud in .las output format and Contour Lines in .shp, .dxf format.
- Processed on 2020-06-18 07:50:24

Figure 3-1 below is a snapshot of the 3D reality Mesh of the survey carried out of the Kent Project Site.

Figure 3-1: 3D Reality mesh produced by Angell Surveys Ltd

A composite ground model has been produced using information from the original DSM, and stockpile areas merged with data from the DTM processed data. The information in the DSM, the DTM, and the Composite model have been resampled into cell sizes of 1.0m, 2m, and 5m.

Level adjustments were made to the marsh land areas. Discrepancies between the DSM and DTM identified errors in the survey technology's ability to denote ground elevations in areas of water and dense vegetation. Modifications were made to the marsh areas using surrounding reference points within the model and comparisons with the LiDAR data previously used in the model.

The resulting surface shown in Figure 3-2 was used within the hydraulic model overlaying the filtered 1m LiDAR used in the NKC18 model.

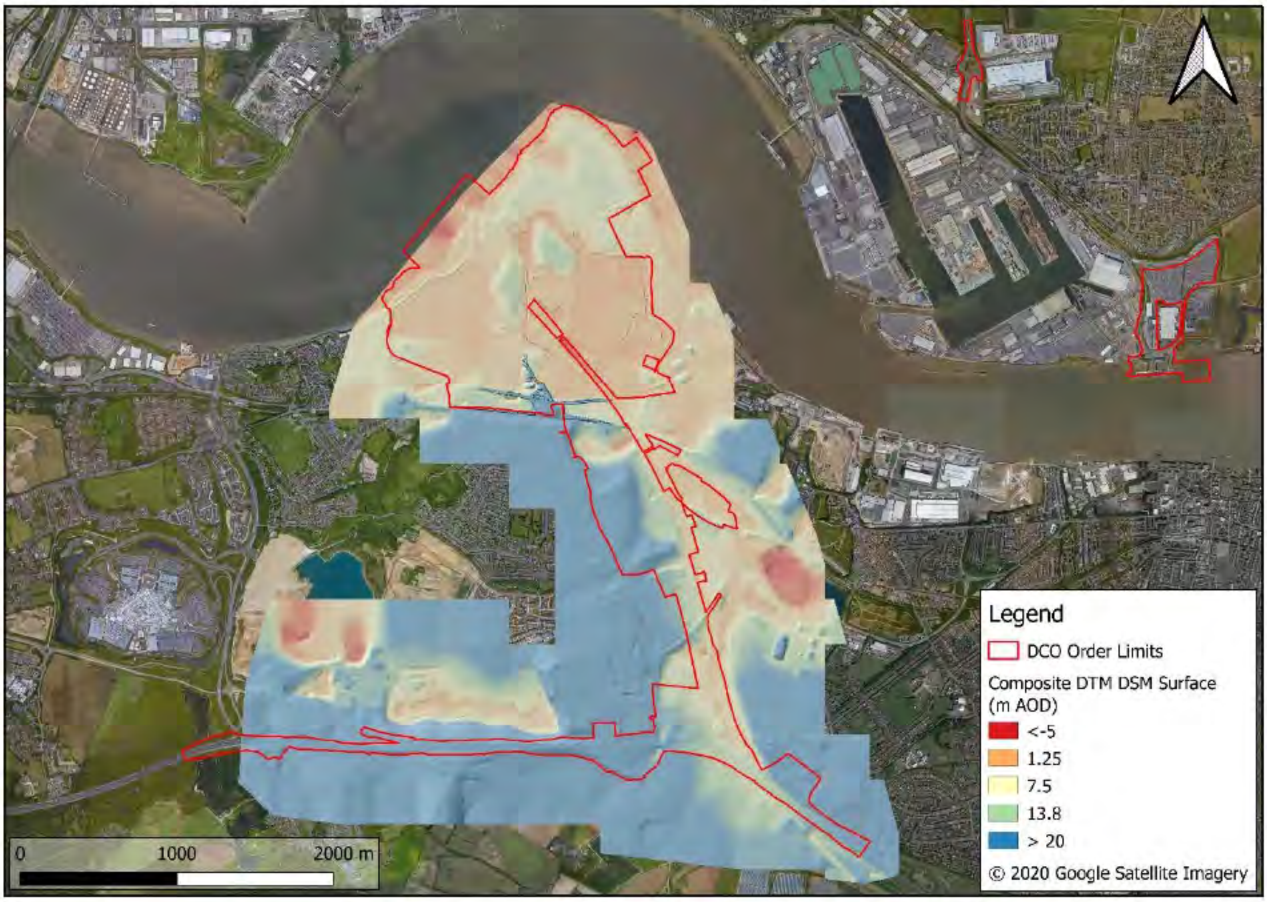

Figure 3-2: Composite DTM and DSM surface elevations used in the Baseline 2020 model.

3.2.2 Updates to the model domain

The NKC18 model includes a 2D domain on the right bank (south side) of the River Thames. For the Baseline 2020 model a second domain was added to the model to represent the left bank (north side) of the River Thames to include the London Resort Essex Project Site.

As the topography of the area is mostly flat the additional 2D domain area extends beyond the Order Limits. Table 3-1 details the Baseline 2020 model build as compared to the NKC18 model built, Figure 3-3 illustrates the model build.

Table 3-1: Baseline 2020 model build, as compared to the NKC18 model build

Name	Build date	1D node count	2D cell size	2D cell count	2D domain area	Model run time (hh:mm:ss)
North Kent Coast 2018	2018	110	10m	690,770	68,900,000m^2	6:53:05
Baseline 2020	2020	110	10m	980,448	97,900,000m2	16:26:58

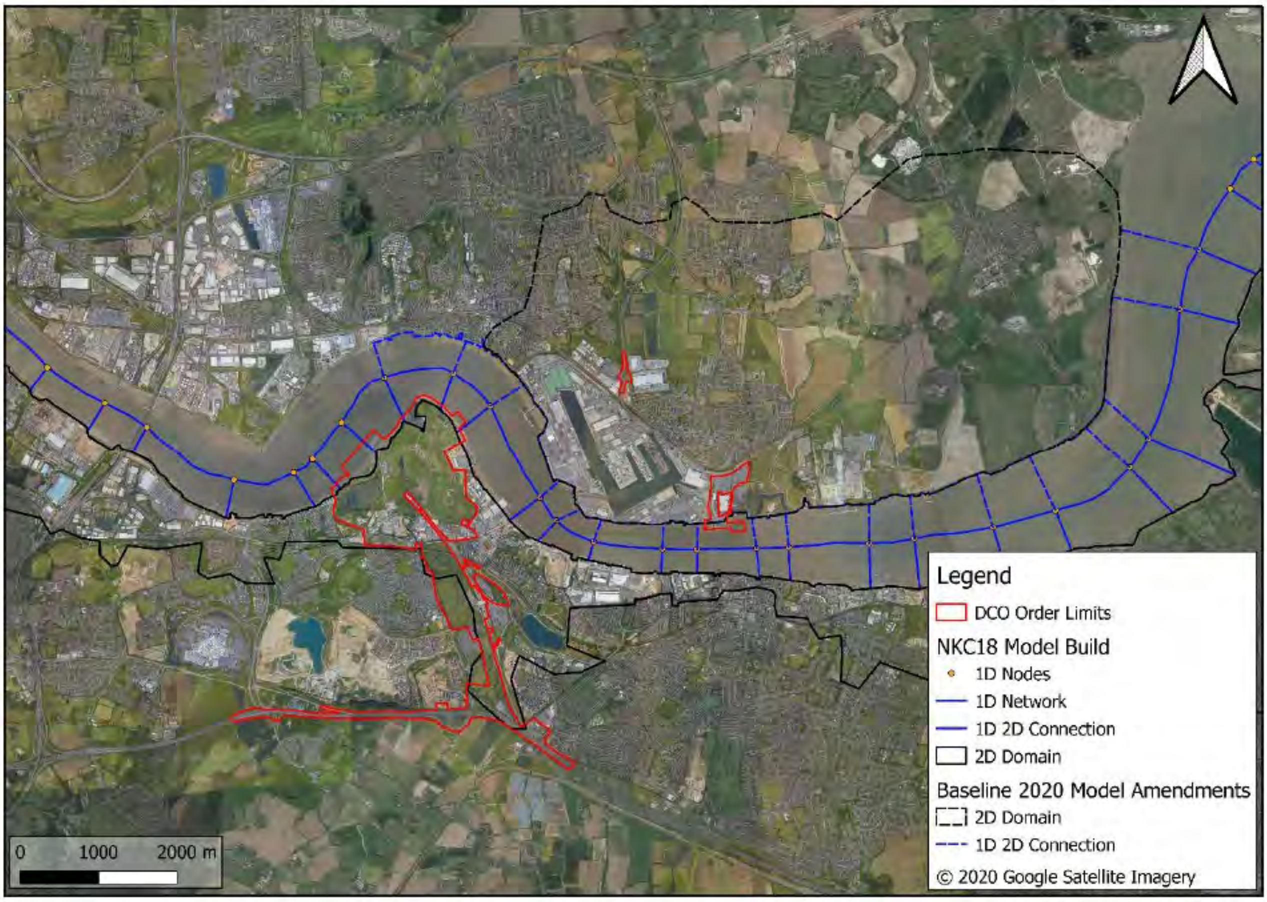

Figure 3-3: Baseline 2020 model build

The Baseline 2020 2D model domain north of the River Thames utilises the following:

- Flood plain roughness utilises OS MasterMap (2014) data to identify the land use types, and then applies the same mannings n roughness values used in the NKC18 model.
- Flood plain topography is derived from downloaded 2019 EA 1m DTM.
- Formal flood defence crest levels have been included using the EA provided *Spatial Defence Attributes* shapefile.

3.2.3 Breach design

Four breach locations were assessed in the existing Thames flood defences for the Kent Project Site. Four breaches in the formal flood defence alignment and one breach in the proposed secondary flood defence alignment, shown in Figure 3-4. The breach details are provided in Table 3-2. Two of the breaches in the formal flood defences are taken directly from the breaches analysed in the NKC18 model. The remaining three breaches were designed to test further locations for the Baseline 2020 and Proposed 2020 models.

Figure 3-4: Kent Project Site (Main Resort) breach locations

Table 3-2: Kent Project Site breach details

Breach ID	Crest level (m AOD)	Ground\Breach level (m AOD)	Breach width (m)	Defence type	Origin	Location
Breach 03	6.68	4.8	20	Wall	NKC18	Outside the Order Limits to the east.
Breach 06	6.32	3.7	50	Embankment	NKC18	Inside the Order Limits to the west along Black Duck Marsh.
Breach 09	6.50	4.3	20	Wall	BH2020	Outside the Order Limits to the east.
Breach 10	6.32	4.1	50	Embankment	BH2020	Inside the Order Limits to the west along Black Duck Marsh.

At the Essex Project Site a single breach location is used in the flood wall directly in front of the Proposed Development. The breach location is shown in Figure 3-5. The details of the breach are in Table 3-2.

Figure 3-5: Essex Project Site breach location

Table 3-3: Essex Project Site Breach Details

Breach ID	Crest level (m AOD)	Ground\Breach level (m AOD)	Breach width (m)	Defence type	Origin	Location
Breach 22	6.63	4.04	20	Wall	BH2020	Inside the Order Limits within the Ferry Cruise Terminal, directly in front of the Essex Proposed Development.

3.3 Hydrology

The NKC18 model has three inflow locations: two QTBDY units and one HTBDY as shown on Figure 3-6 and detailed in Table 3-4.

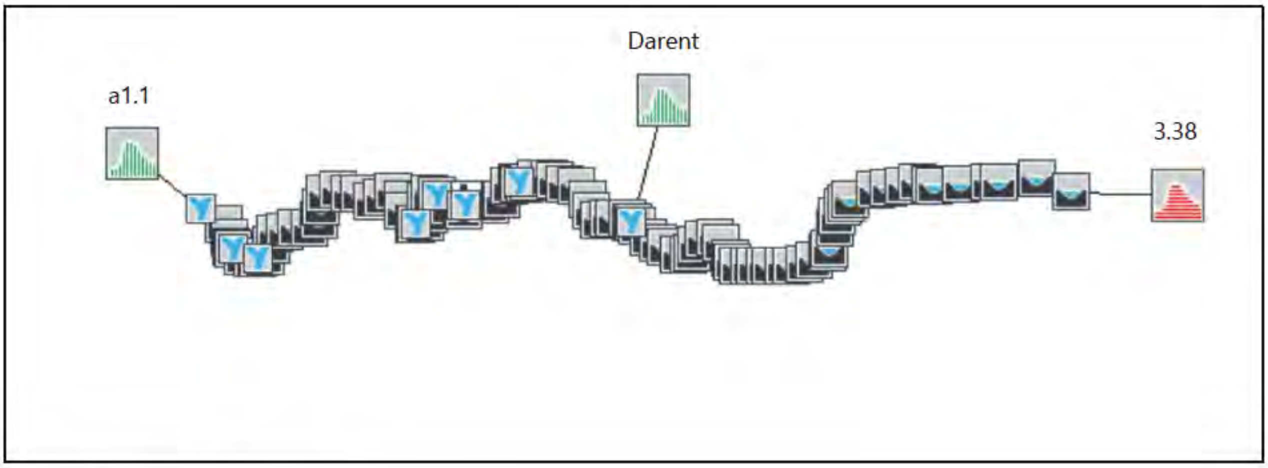

Figure 3-6: NKC18 model hydrology

Table 3-4: Details of the NKC18 1D inflow locations

1D Node ID	Name	Type	Description
a1.1	Hydrograph at Kingston	QTBDY (Flow over time)	Fixed single inflow of 60m^3/s at the upstream extend of the model on the River Thames to represent the fluvial flow at Kingston.
Darent	Darent	QTBDY (Flow over time)	Unused inflow at Darent.
3.38	Southend Tidal	HTBDY (Head over time)	Variable tidal boundary applied at the Thames estuary, close to Southend-on-Sea to the north and Allhollows to the south.

Details of the derivation of the tidal boundary and the storm surge shape can be found within the NKC18 documentation[3]. In the NKC18 model, tidal boundaries for the following return periods are provided for the "present day" scenarios: 20%, 5%, 3.33%, 2%, 1.33%, 0.5%, 0.1%. The NKC18 model also provides tidal curves for future epochs, however the tidal curves were not based on the latest climate change projections for sea level rise.

The latest climate change projections are the UK Climate Projections 2018 (UKCP18). Table 3-6 shows the guidance for sea level rise for the Higher Central and the Upper End projections. The Higher Central projections are those that are surpassed by only 30% of projection scenarios. The Upper End Projections are those that are surpassed by only 5% of projection scenarios. Table 3-5 shows the previous UKCP09 sea level rise (used in the NKC18 model) and Table 3-6 shows the current sea level rise guidance. Table 3-7 shows the guidance for sea level rise for the H++ scenario. The H++ scenarios are climate change projections designed to explore the high-end plausible future sea level rise should sea level rise exceed model predictions.

Table 3-5: EA sea level rise guidance (mm/year) based on UKCP09 climate change projections

UKCP09					
Area of England	**Allowance**	**1990 to 2025**	**2026 to 2055**	**2056 to 2085**	**2086 to 2115**
South East	-	4	8.5	12	15

[3] JBA, January 2019; *'North Kent Coast Model Updates'*

Table 3-6: EA sea level rise guidance (mm/year) based on UKCP18 climate change projections

UKCP18					
Area of England	**Allowance**	**2000 to 2035**	**2036 to 2065**	**2066 to 2095**	**2096 to 2125**
South East	Higher Central	5.7	8.7	11.6	13.1
South East	Upper End	6.9	11.3	15.8	18.2

Table 3-7: EA sea level rise guidance for H++ scenario based on UKCP18 climate change projections

Allowance category	Total sea level rise to 2100
H++ scenario	1.9m

In order to adapt the NKC18 model tidal hydrographs for use in the Baseline 2020 model and the Proposed 2020 model this process was followed for each of the 0.5% and the 0.1% tidal curves:

i) Select a desired future epoch;

ii) Select whether to use the Higher Central or Upper End projections;

iii) Select the desired storm period (0.5% or 0.1%);

iv) Calculate the peak water level for node 3.38 for the desired epoch using the TE2100 2005 extreme water level as a baseline and add the appropriate sea level rise allowance (from Table 3-6);

v) Normalise the NKC18 tidal curve for the selected storm return period;

vi) Scale the normalised curve to the peak water level calculated in step 4; and,

vii) Apply to the hydraulic model.

The process is slightly different for the H++ model scenarios. H++ projections are limited to 2100, and so the future epoch selected in step 1 is 2100 and the sea level rise added to the TE2100 2005 extreme water level identified in step 4 is a single increase of 1.9m.

Figure 3-7 shows a comparison of the tidal curves at Southend (node 3.38). The graph shows the increase in the peak values as a result of using the latest climate change guidance. Table 3-8 provides a comparison of flood levels collected from available data and from the Baseline 2020 and Proposed 2020 models.

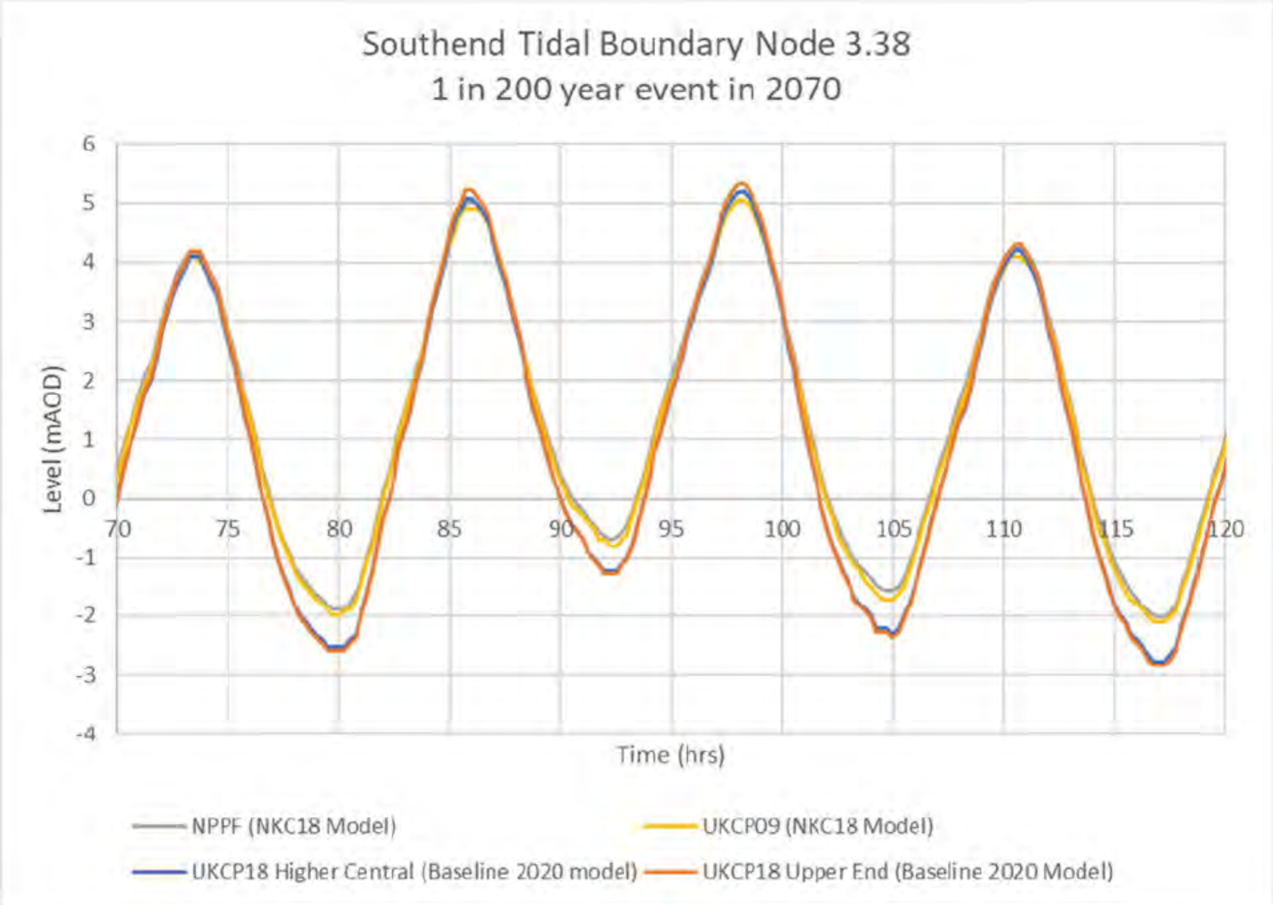

Figure 3-7: Southend downstream tidal boundary (node 3.38) tidal curve comparison for the 1 in 200 year storm event for 2070, comparing the climate change projections

Table 3-8: Comparison of in channel Extreme Water Levels from the available hydraulic models for the 1 in 1000 year river levels. Dashes indicate where data is not available.

TE2100 2015 Plan (EA)										
Node	**2005**	**2016**	**2040**	**2070**	**2090**	**2100**	**2115**	**2120**	**2125**	**2170**
3.20	5.9	-	6.11	6.27	-	6.58	-	6.76	-	7.22
3.25	5.81	-	6.02	6.17	-	6.47	-	6.67	-	7.19
3.38	5.03	-	6.24	5.55	-	5.95	-	6.25	-	7.00
Thames Estuary Breach Model 2018 Model (EA)										
Node	**2005**	**2016**	**2040**	**2070**	**2090**	**2100**	**2115**	**2120**	**2125**	**2170**
3.20	-	-	-	-	-	-	6.68	-	-	-
3.25	-	-	-	-	-	-	6.61	-	-	-
3.38	-	-	-	-	-	-	6.18	-	-	-
North Kent Coast 2018 Model (EA)										
Node	**2005**	**2016**	**2040**	**2070**	**2090**	**2100**	**2115**	**2120**	**2125**	**2170**
3.20	-	6.01	-	-	-	-	-	-	-	-
3.25	-	5.72	-	-	-	-	-	-	-	-
3.38	-	5.13	-	-	-	-	-	-	-	-

Baseline 2020 Model (Upper End) - Existing defences										
Node	**2005**	**2016**	**2040**	**2070**	**2090**	**2100**	**2115**	**2120**	**2125**	**2170**
3.20	-	-	6.21	-	6.90	-	-	-	7.24	-
3.25	-	-	5.9	-	6.59	-	-	-	7.15	-
3.38	-	-	5.31	-	5.99	-	-	-	6.61	-
Baseline 2020 Model (Higher Central) - Existing defences										
Node	**2005**	**2016**	**2040**	**2070**	**2090**	**2100**	**2115**	**2120**	**2125**	**2170**
3.20	-	-	6.17	-	6.71	-	-	-	7.05	-
3.25	-	-	5.86	-	6.38	-	-	-	6.75	-
3.38	-	-	5.26	-	5.77	-	-	-	6.22	-

3.4 Model runs

The following model runs were undertaken in order to understand the hydraulic characteristics of the London Resort Project Site at selected future epochs during selected climate projections.

Table 3-9: Model run scenarios, scenario event combinations that are highlighted in yellow have been run and used for this project.

Future Epoch		**2090**				**2100**		**2125**			
Return Period Event		**1 in 200yr**		**1 in 1000yr**		**1 in 200yr**	**1 in 1000yr**	**1 in 200yr**		**1 in 1000yr**	
Climate Change Projections		**HC**	**UE**	**HC**	**UE**	**H++**	**H++**	**HC**	**UE**	**HC**	**UE**
Model Name	**Scenario**										
Baseline 2020	Defended										
	Breach 03	X	X		X	X	X	X	X	X	X
	Breach 06										
	Breach 09	X	X		X	X	X	X	X	X	X
	Breach 10	X	X		X	X	X	X	X	X	X
	Breach 22		X		X	X	X	X	X	X	X

3.5 Results

3.5.1 Overtopping

Kent Project Site

At the Kent Project Site, the modelling results for the Baseline 2020 model indicate that the existing flood defences to the east of the Order Limits overtop during the 1 in 200 year 2090 scenario and the existing flood defences within the Order Limits to the west overtop during the 1 in 200 year 2125 scenario, both during the higher central climate change projection. Figure 3-8 shows the flood extents for the select scenarios. The flood extents for the 1 in 200 year 2125 higher central model run scenario do not connect across the centre of the Kent Project Site (Main Resort).

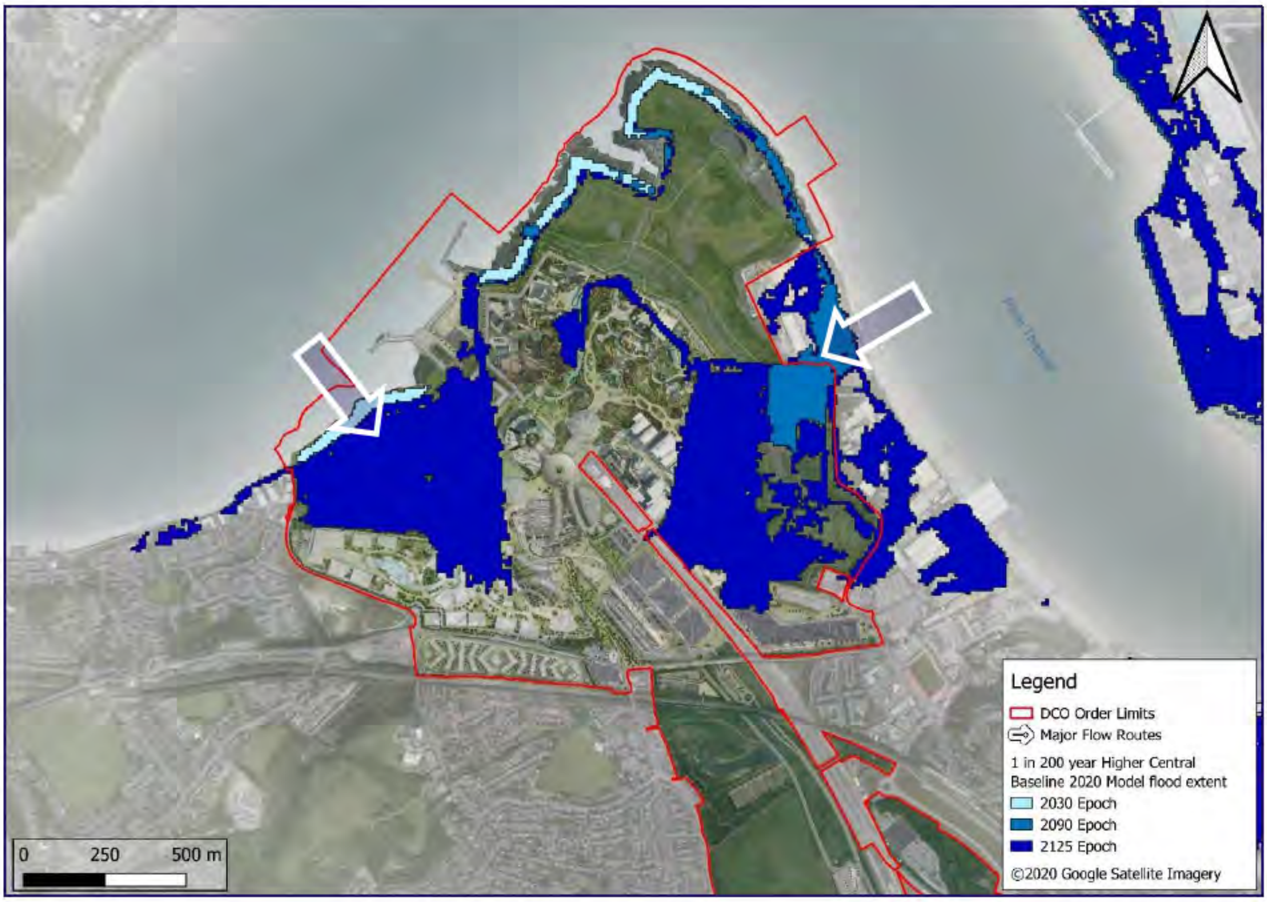

Figure 3-8: Kent Project Site (Main Resort) baseline overtopping flood extents for the 1 in 200 year return period event using the higher central climate change projections across different years, key flow paths indicated by the arrows.

The 1 in 1000 year event overtops both the eastern and western flood defences in the 2090 scenario, during the higher central climate change projection, as shown in Figure 3-9. Differing to the 1 in 200 year scenarios, in the 1 in 1000 year storm scenario the flood extents from the east and the west of the Kent Project Site (Main Resort) connect across the centre. The connection is narrow, reflecting the higher topography at that location and the natural narrowing that results from the proximity of the higher ground in the north of the Swanscombe Peninsula and the chalk spine to the south.

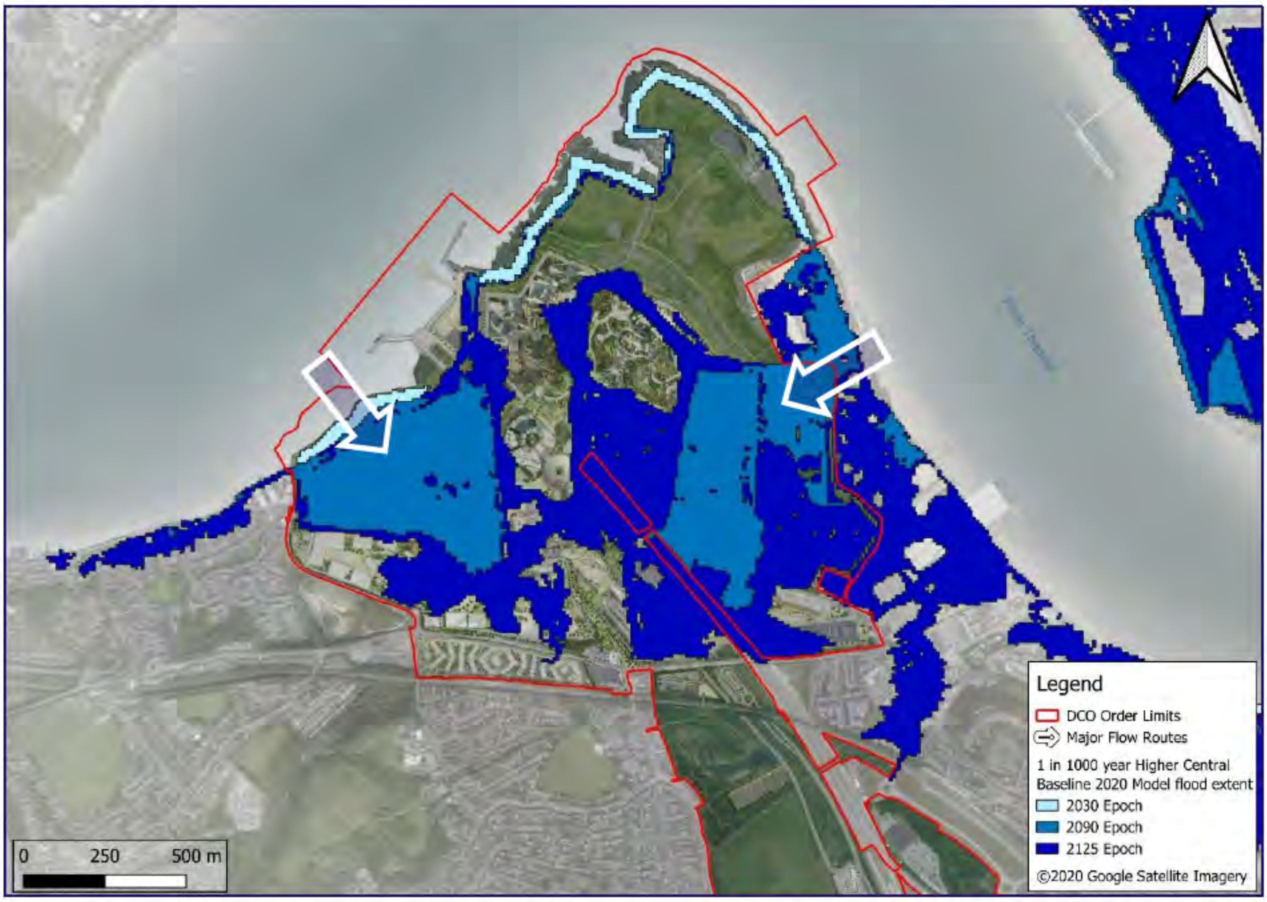

Figure 3-9: Kent Project Site (Main Resort) baseline overtopping flood extents for the 1 in 1000 year return period event using the higher central climate change projections across different years, key flow paths indicated by the arrows.

Both flow routes from the east and the west of the Kent Project Site (Main Resort) enter the marsh areas first before flooding the centre of the Kent Project Site (Main Resort).

Figure 3-10 shows four timesteps taken out of the TUFLOW hydraulic modelling results. The images show flood depth overlain by the flow velocity vector arrows. These four timesteps are the moments of initial overtopping of the eastern formal flood defences and the progress of the flood water into the Kent Project Site (Main Resort). The initial overtopping occurs at location A at the flood wall amongst the industrial developments outside of the Order Limits to the north east of Botany Marsh. Flows move south west across the industrial development and into Botany Marsh at location B. From the Marsh area flows move directly east into the Proposed Development area. From the initial overtopping to the flow entering the Proposed Development area is approximately 1 hour.

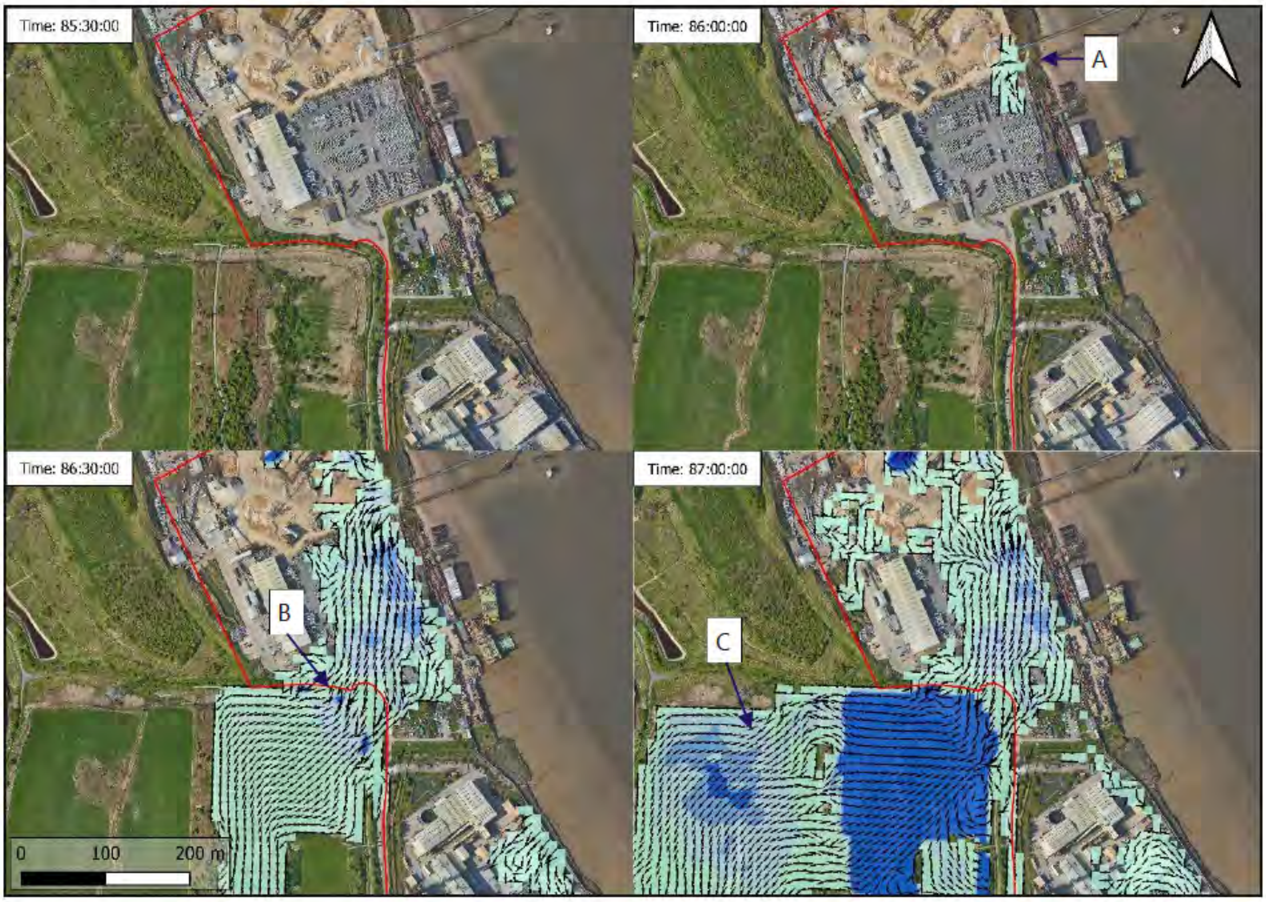

Figure 3-10: Kent Project Site Baseline 2020 overtopping flow routes from the east of the Kent Project Site (Main Resort) for the 1 in 200 year 2125 higher central scenario

Figure 3-11 shows the same four timesteps for the overtopping flow route in the west of the Kent Project Site (Main Resort). The image shows that the flood defences on this side of the peninsula overtops at a later timestep than at the east of the peninsula. Unlike at the east, the overtopping of the western defences occurs at a number of locations broadly simultaneously (A, B, C). Flood water is immediately within the Order Limits and fills the Black Duck Marsh area. From the marsh area flood water enters the centre of the Kent Project Site (Main Resort) via a topographical narrowing at location E. Location D highlights a secondary more minor overtopping that occurs to the north of the marsh area at the Jetty, flowing south into the marsh area to combine with the major flow route.

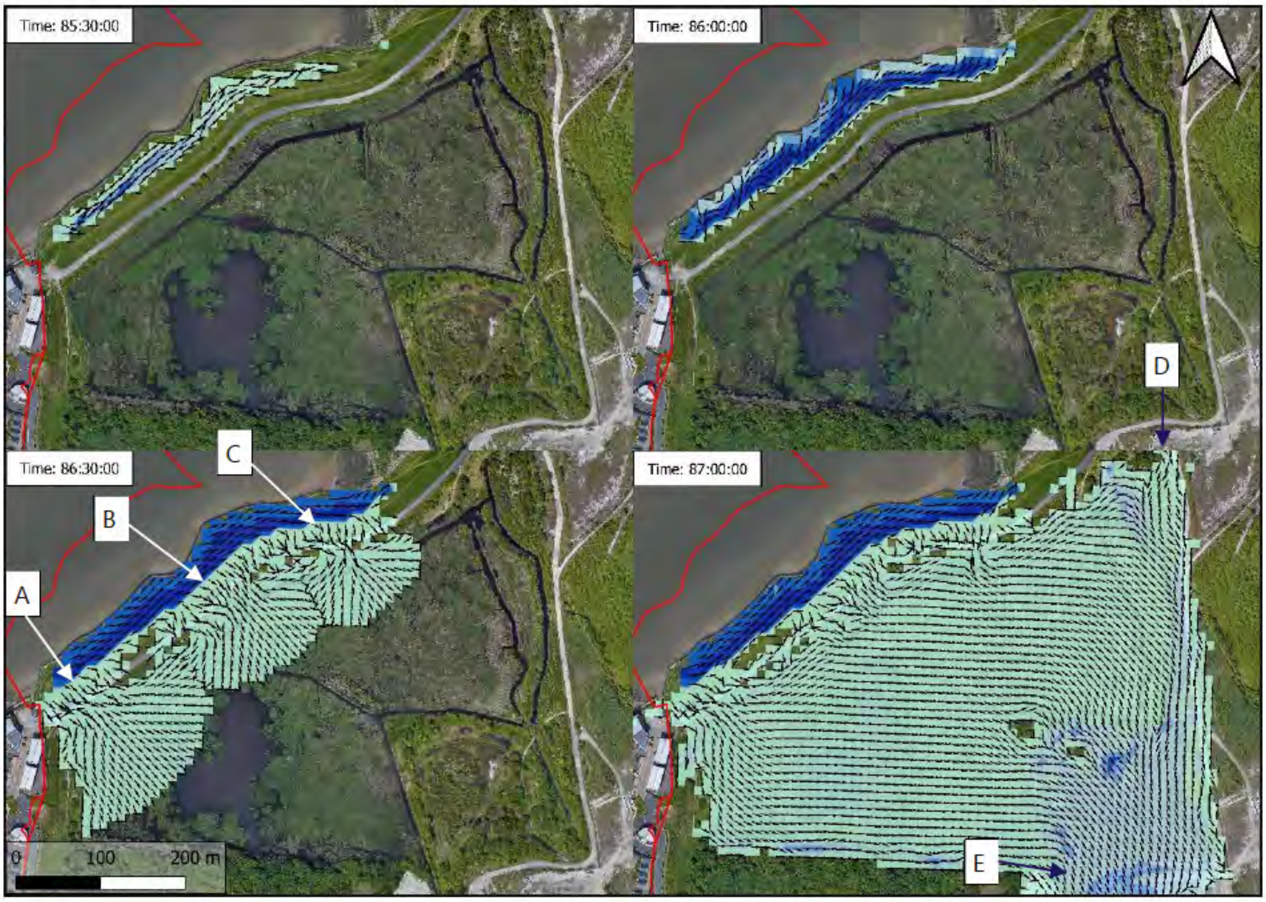

Figure 3-11: Kent Project Site Baseline 2020 overtopping flow routes from the west of the Kent Project Site (Main Resort) for the 1 in 200 year 2125 higher central scenario

Figure 3-12 shows the Baseline 2020 model flood hazard for the Kent Project Site (Main Resort) as a result of overtopping of the flood defences. The results show that for each event shown results in increased hazard on the Proposed Development. The highest hazard are around the marsh areas and where flow enters the Proposed Development.

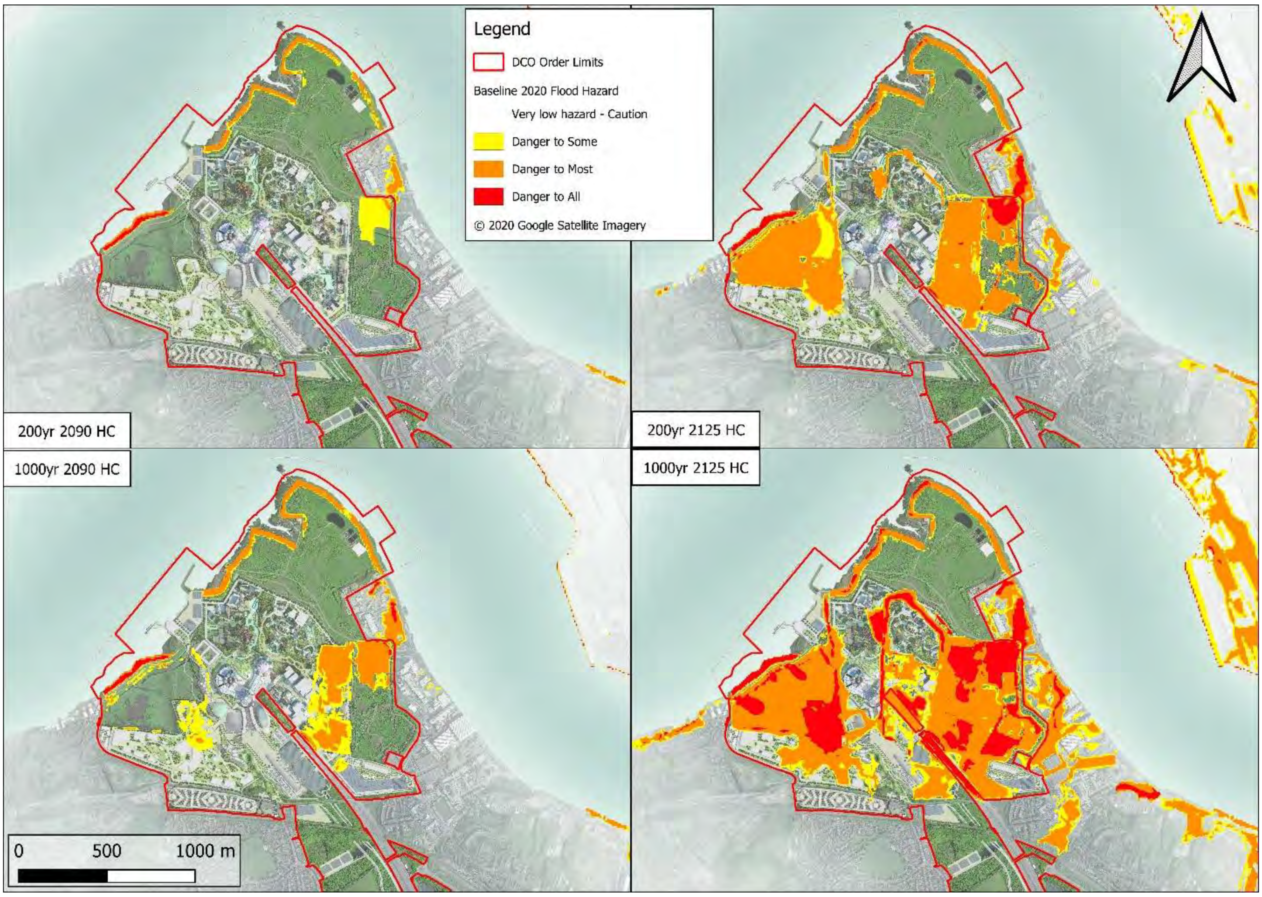

Figure 3-12: Kent Project Site (main resort) baseline overtopping hazard for the 1 in 200 year and the 1 in 1000 year 2090 and 2125 future epochs using the higher central sea level rise projections

Essex Project Site

At the Essex Project Site, the modelling results for the Baseline 2020 model indicate that the 1 in 200 year 2090 event using the higher central climate change projections does not cause overtopping of the formal flood defences near to the Essex Project Site and therefore overtopping does not cause flood risk to the Essex Project Site for this event. For the 1 in 200 year 2125 event using the higher central climate change projections the existing flood defences within the Order Limits to the south and immediately outside of the Order Limits to the south west result in flooding on the Essex Project Site. Figure 3-13 shows the flood extents for the select scenarios and the key overtopping flow path.

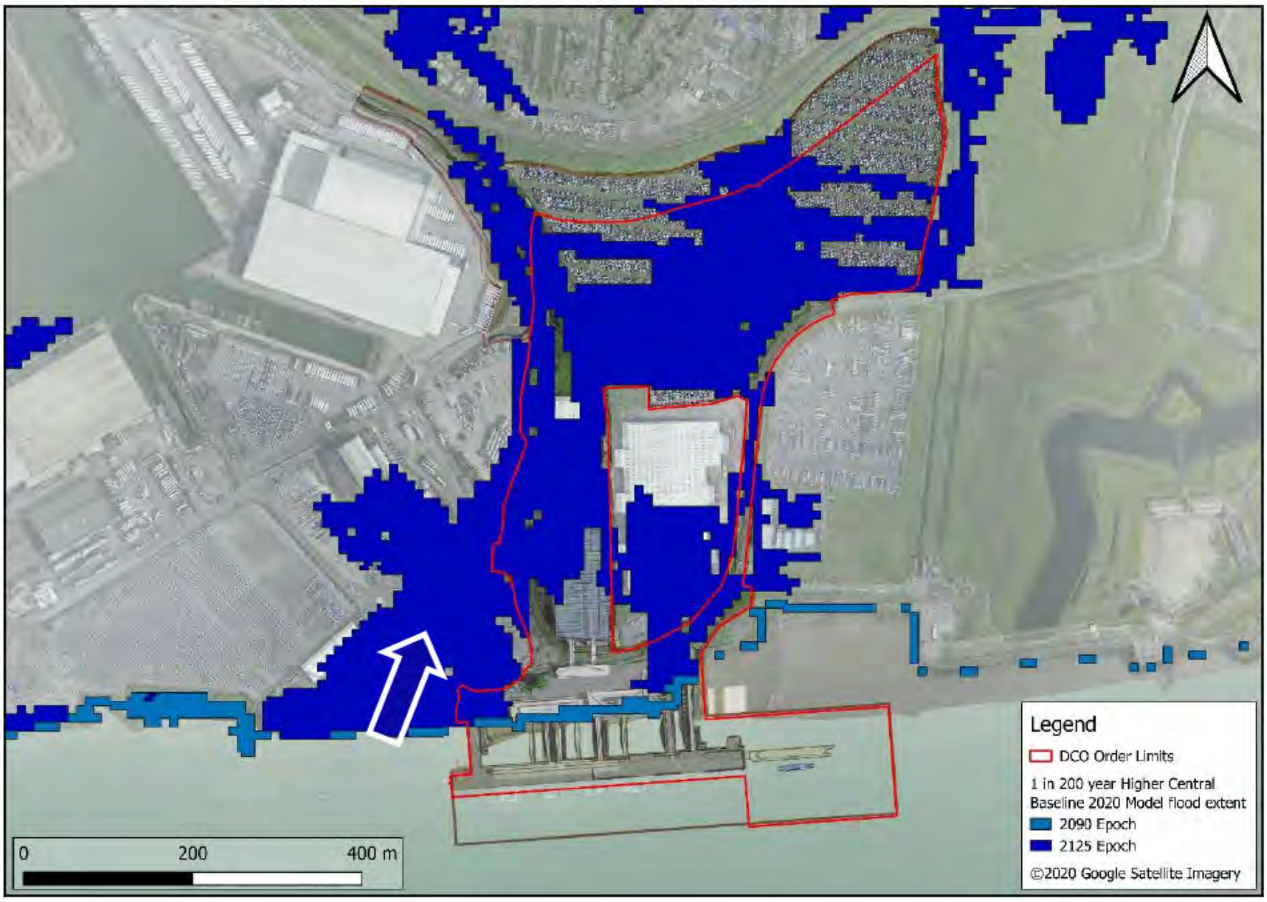

Figure 3-13: Essex Project Site baseline overtopping flood extents for the 1 in 200 year return period event using the higher central climate change projections across different years, key flow paths indicated by the arrow.

The 1 in 1000 year 2090 event using the higher central climate change projection also does not overtop the formal flood defences near to the Essex Project Site and therefore overtopping does not cause flood risk to the Essex Project Site for this event. For the 1 in 200 year 2125 event using the higher central climate change projections the existing flood defences within the Order Limits to the south and immediately outside of the Order Limits to the south west resulting in flooding on the Essex Project Site. Figure 3-14 shows the flood extents for the select scenarios and the key overtopping flow path. For the 1 in 1000 year 2125 event there is also a contribution from overland flow from the north east that causes ponding in the Essex Project Site, this is the result of overtopping of the formal flood defences to the east of the Essex Project site.

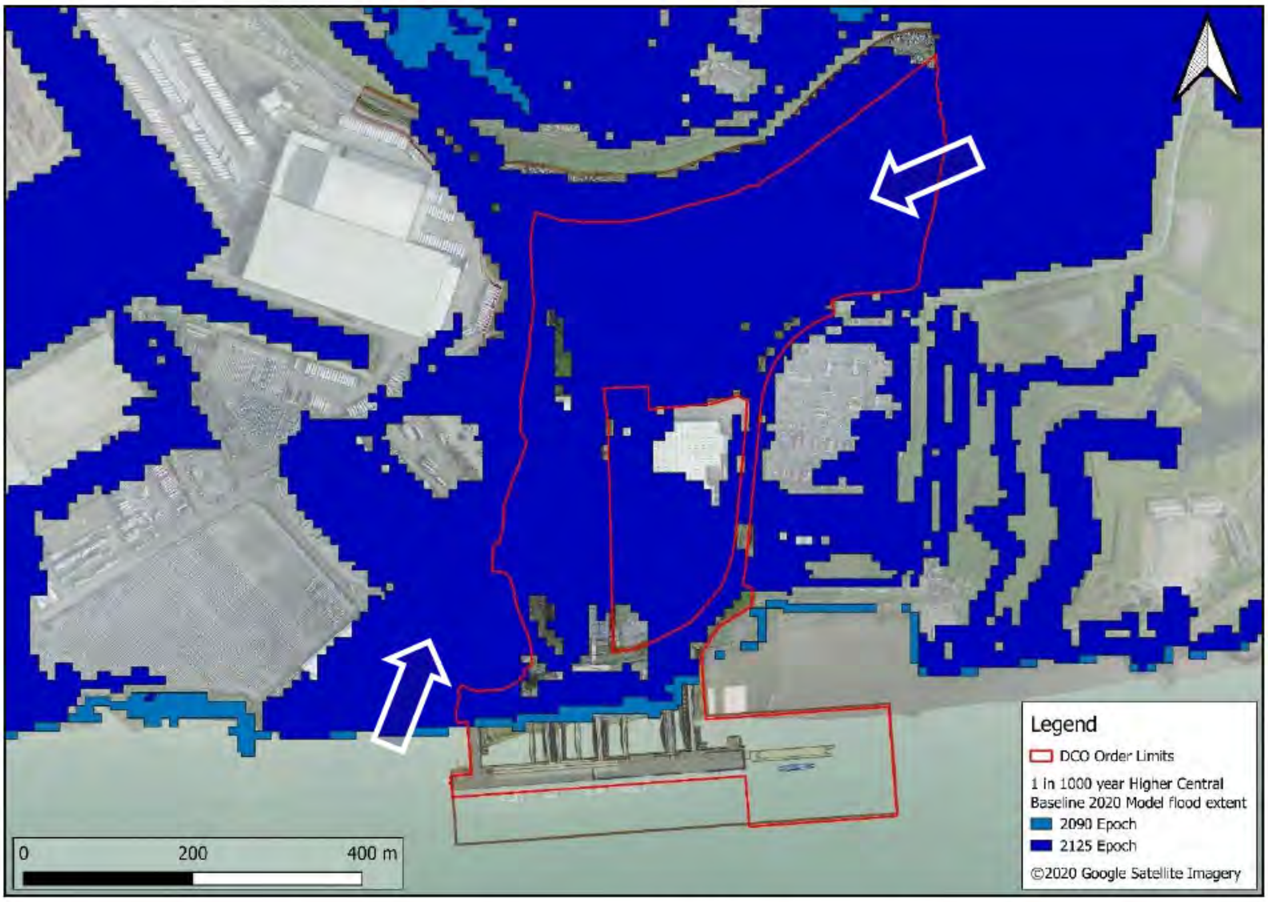

Figure 3-14: Essex Project Site baseline overtopping flood extents for the 1 in 1000 year return period event using the higher central climate change projections across different years, key flow paths indicated by the arrows.

Figure 3-15 shows four timesteps taken out of the TUFLOW hydraulic modelling results. The images show flood depth overlain by the flow velocity arrow vectors. These four timesteps are the moments of initial overtopping of the southern formal flood defences and the progress of the water into the Essex Project Site. The greatest extent of the formal flood defences that are overtopping are to the south west of the Essex Project Site (Location A) there is a secondary location of overtopping to the south / south east of the Essex Project Site (Location B). The flood water flows in a northerly direction following the topography as it slopes down away from the flood defences. These flow routes approximately follow the two EA designated main risers that run along the east (Location D) and the west (Location C) of the Essex Project Site, and the flood water eventually pools in the existing surface car park to the north (Location E).

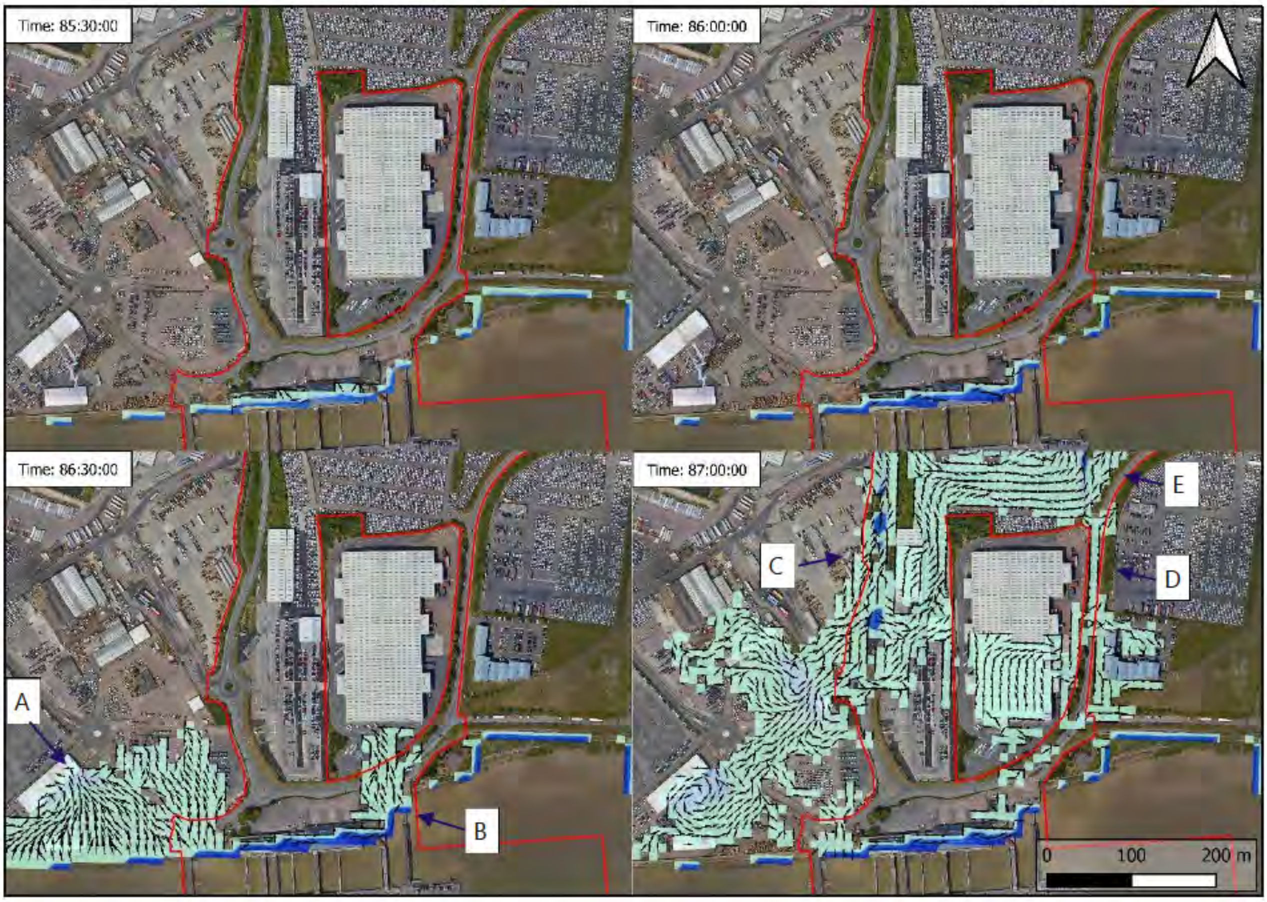

Figure 3-15: Essex Project Site Baseline 2020 overtopping flow routes from the south of the site for the 1 in 200 year 2125 higher central scenario

Figure 3-16 shows the Baseline 2020 model flood hazard for the Essex Project Site as a result of overtopping of the flood defences. The results show that for each of the 2125 future epoch events the event results in an increased hazard on the Essex Project Site. The hazard is greatest between the location of the overtopping and away from the defences where flooding pools within the Order Limits. There is less hazard by the flood defences where ground levels are higher.

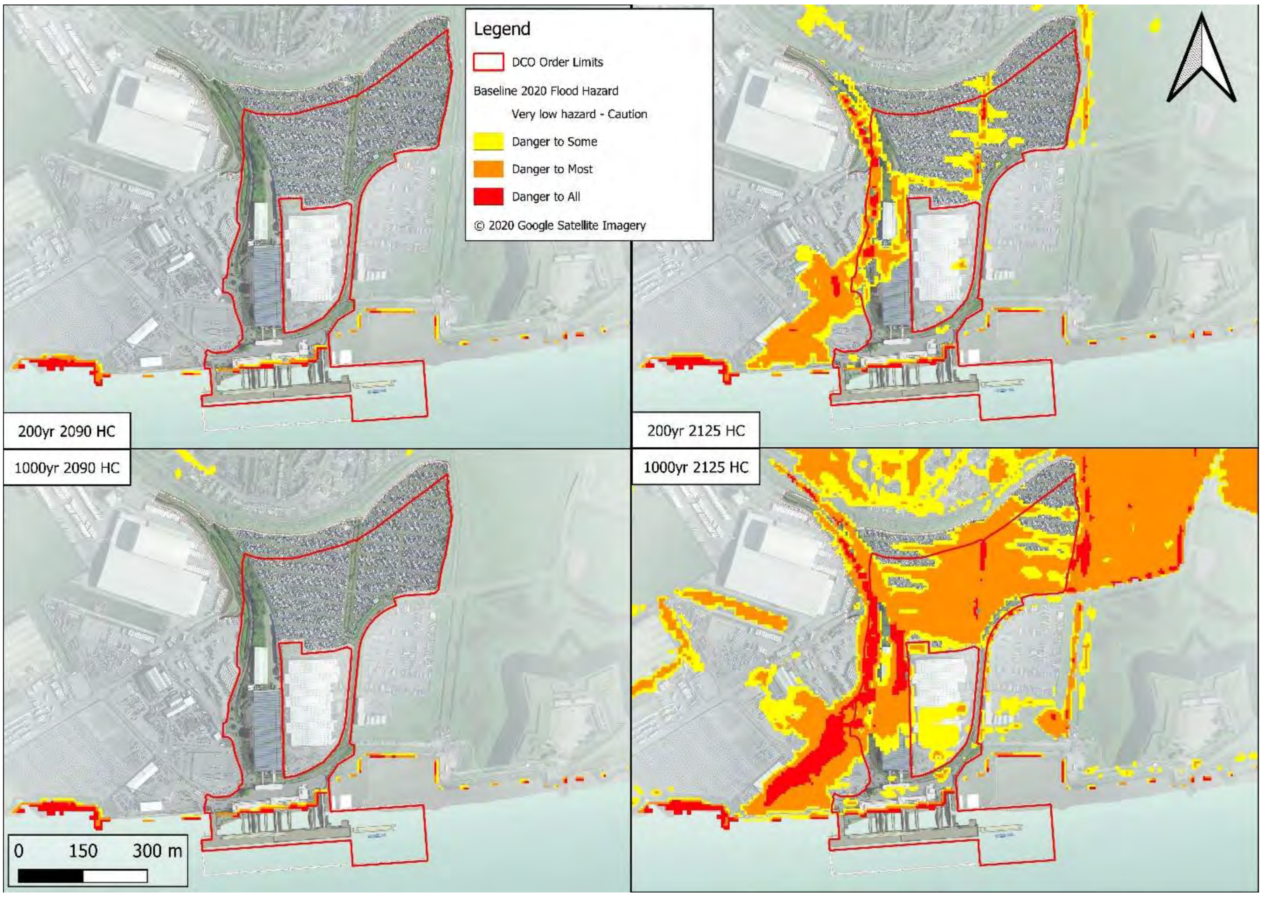

Figure 3-16: Essex Project Site baseline overtopping hazard for the 1 in 200 year and the 1 in 1000 year 2090 and 2125 future epochs using the higher central sea level rise projections

3.5.2 Breach

Kent Project Site

At the Kent Project Site (Main Resort) 4 breach locations have been reviewed in the existing defences. The breaches are within the formal flood defence line to determine the residual risk to the Kent Project Site (Main Resort) if the protection provided by the formal flood defences is removed.

The breaches have been reviewed to identify which has the greatest impact on the Kent Project Site (Main Resort) in terms of flood extent and flood depth. Figure 3-17 shows the analysis of the breach locations for the 1 in 1000-year 2090 event using the higher central climate change projections. Of the four breach events reviewed it is Breach 06 that has the greatest extent over the Kent Project Site (Main Resort).

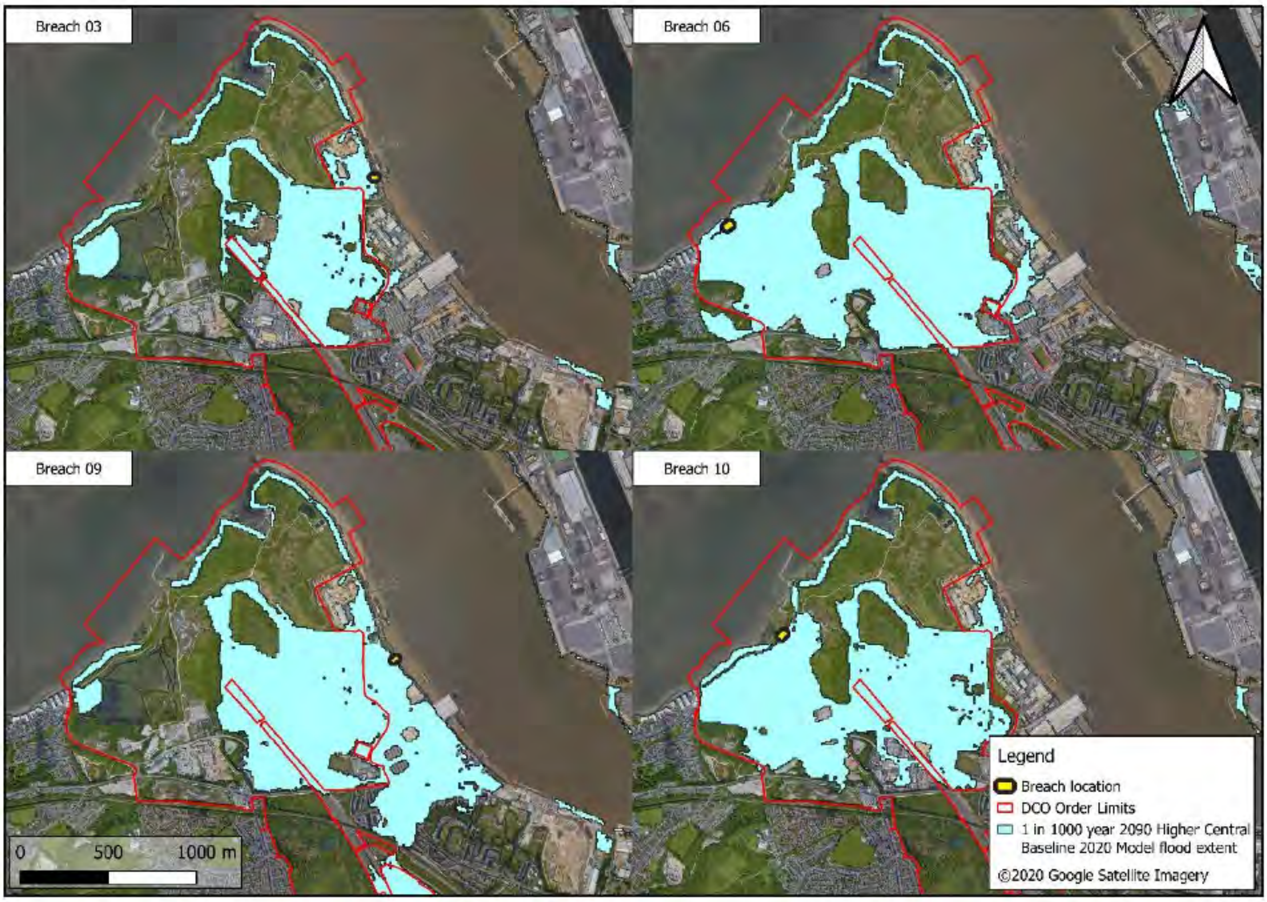

Figure 3-17: Breach analysis at the Kent Project Site (Main Resort)

Figure 3-18 shows a comparison of the water levels across the Kent Project Site (Main resort) for each of the breach scenarios in the Baseline 2020 model for the 1 in 1000 year 2090 storm event using the higher central climate change projections. The data shows that Breach 06 has the greatest impact on flood water level on both the east and the west side of the Kent Project Site (Main Resort).

ID	Breach 03 (m AOD)	Breach 06 (m AOD)	Breach 09 (m AOD)	Breach 10 (m AOD)
1	3	5.91	0	5.28
2	3.24	4.25	3.82	3.08
3	3.24	4.25	3.82	3.08
4	3.08	4.25	3.82	3.62
5	0	0	0	0
6	0	0	0	0

Figure 3-18: Breach analysis water level comparison for the 1 in 1000 year 2090 event, using the higher central climate change projection

Figure 3-19 and Figure 3-20 show the breach flood extents for the breach 06 using the baseline model under different return period event conditions. These images show that during all events the breach flooding crosses the Kent Project Site (Main Resort) from west to east flooding both the Black Duck Marsh and the Botany Marsh as well as a much of the centre of the Kent Project Site. The flood extent is bounded in the north by the high ground at the land fill locations, and is bounded in the south by the chalk spine.

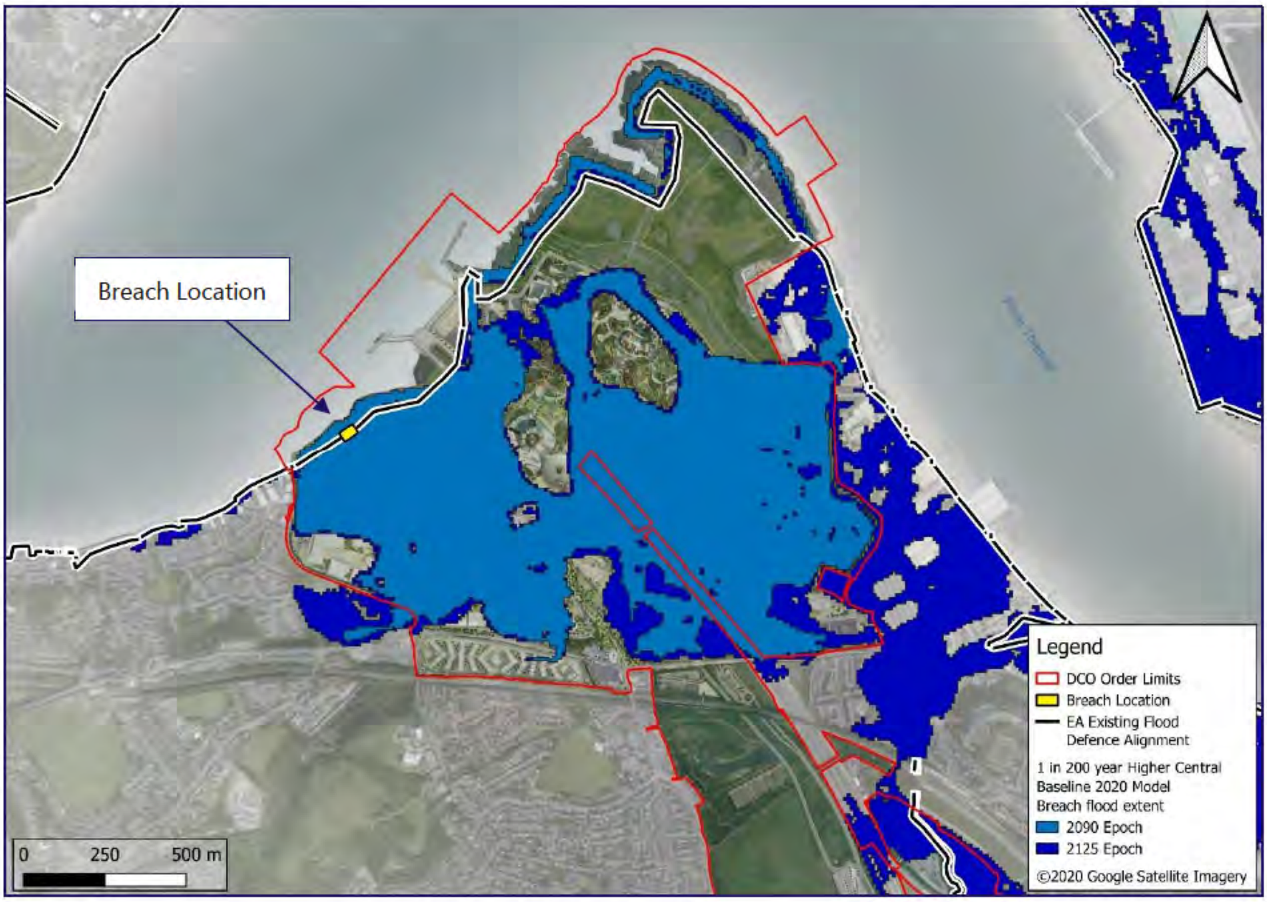

Figure 3-19: Kent Project Site (Main Resort) baseline breach flood extents for the 1 in 200 year return period event using the higher central climate change projections across different years.

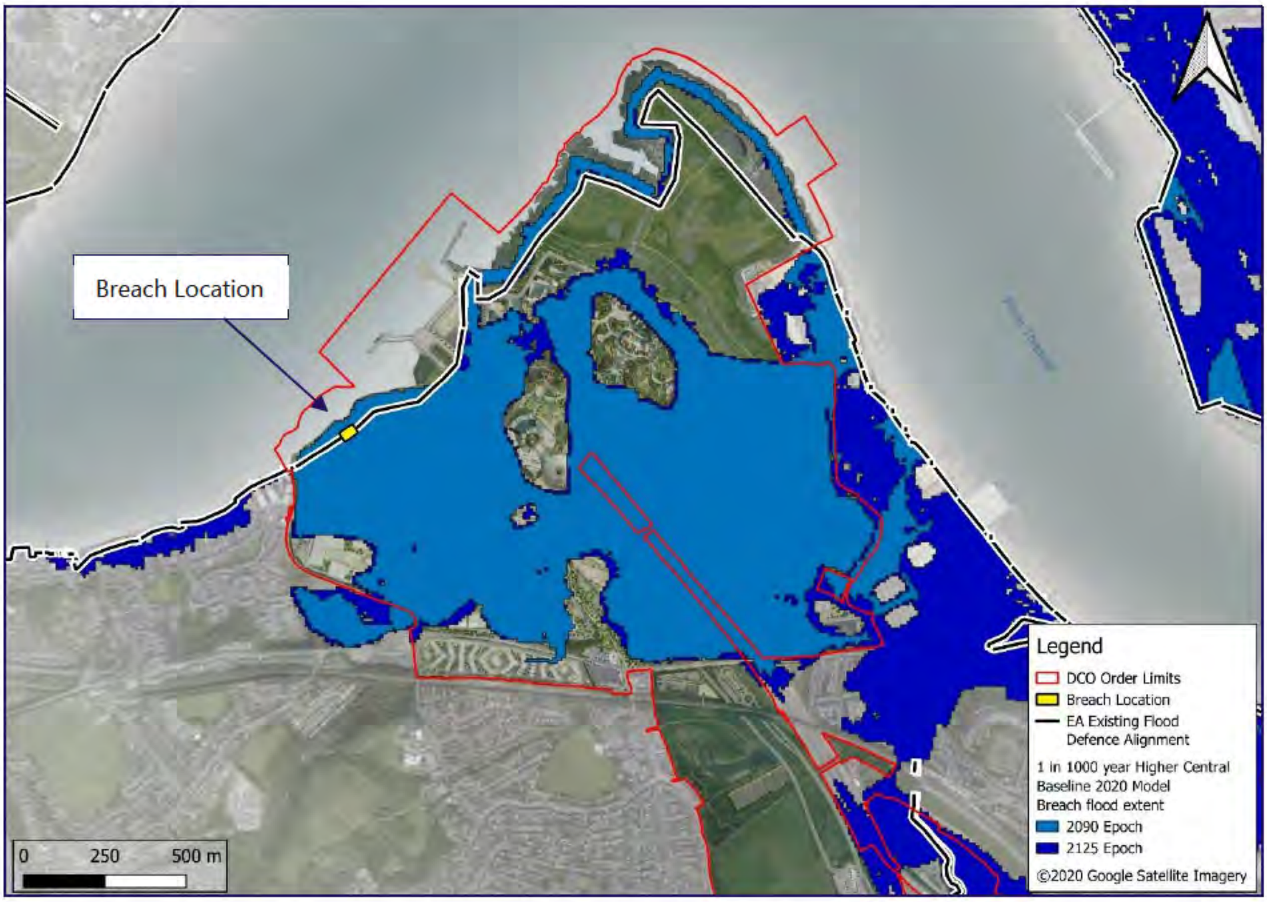

Figure 3-20: Kent Project Site (Main Resort) baseline breach flood extents for the 1 in 1000 year return period event using the higher central climate change projections across different years.

Figure 3-21 shows the Baseline 2020 model flood hazard for the Kent Project Site (Main Resort) as a result of a breach in the flood defences at Breach 06. The results show that for each event shown results in increased hazard on the Proposed Development. The highest hazard are around the marsh areas and where flow enters the Proposed Development.

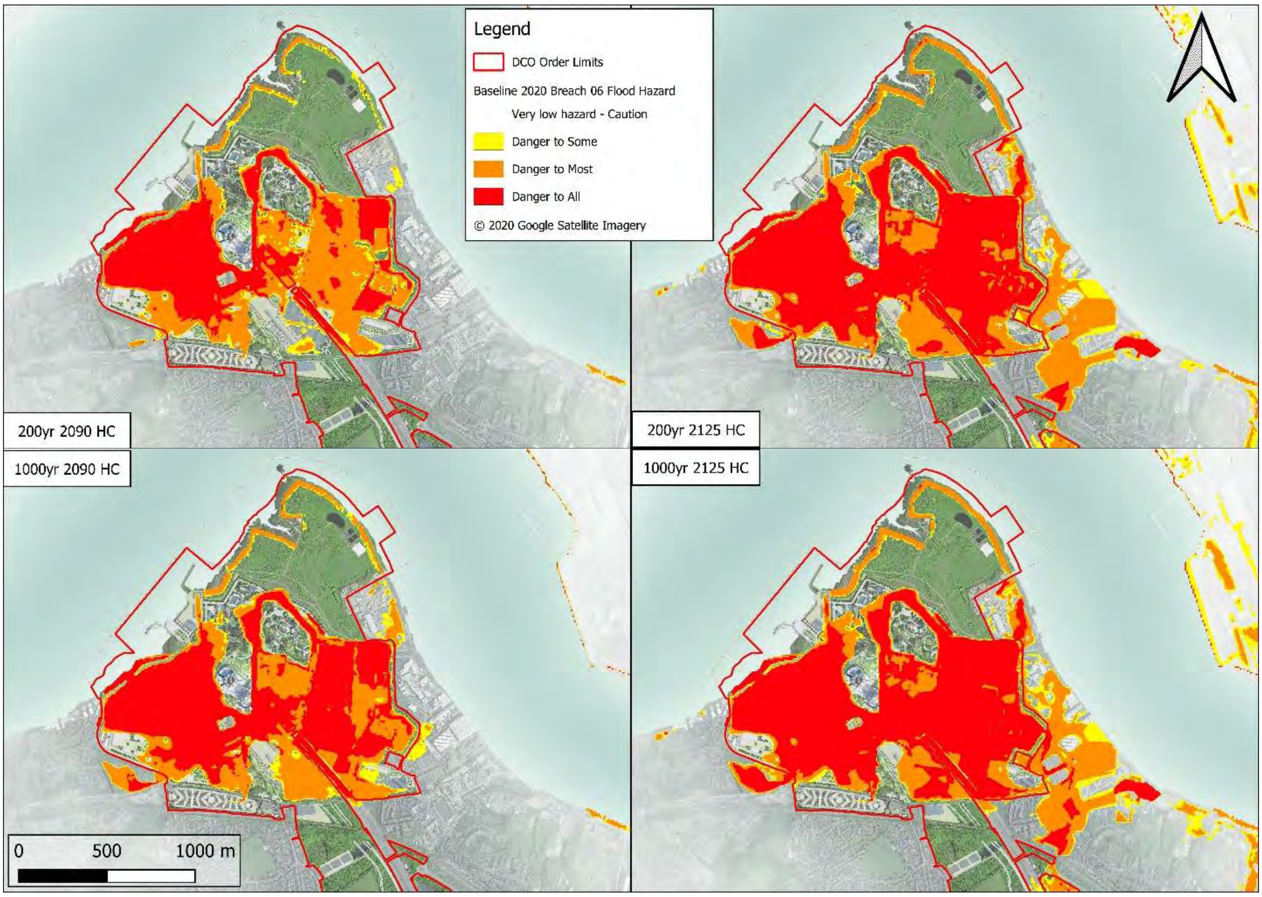

Figure 3-21: Kent Project Site (Main Resort) baseline breach hazard for the 1 in 200 year and the 1 in 1000 year 2090 and 2125 future epochs using the higher central sea level rise projections

Essex Project Site

At the Essex Project Site a single breach location has been tested. This breach location is located in the formal flood defences at the centre of the formal flood defences that are within the existing Tilbury Terminal Cruise Buildings. Figure 3-22 shows the breach flood extent at the Essex Project Site in the Baseline 2020 model during the 1 in 1000 year 2090 event using the higher central climate change projection. Due to the location of the breach event and the topography of the Essex Project Site the majority of the Order Limits are inundated.

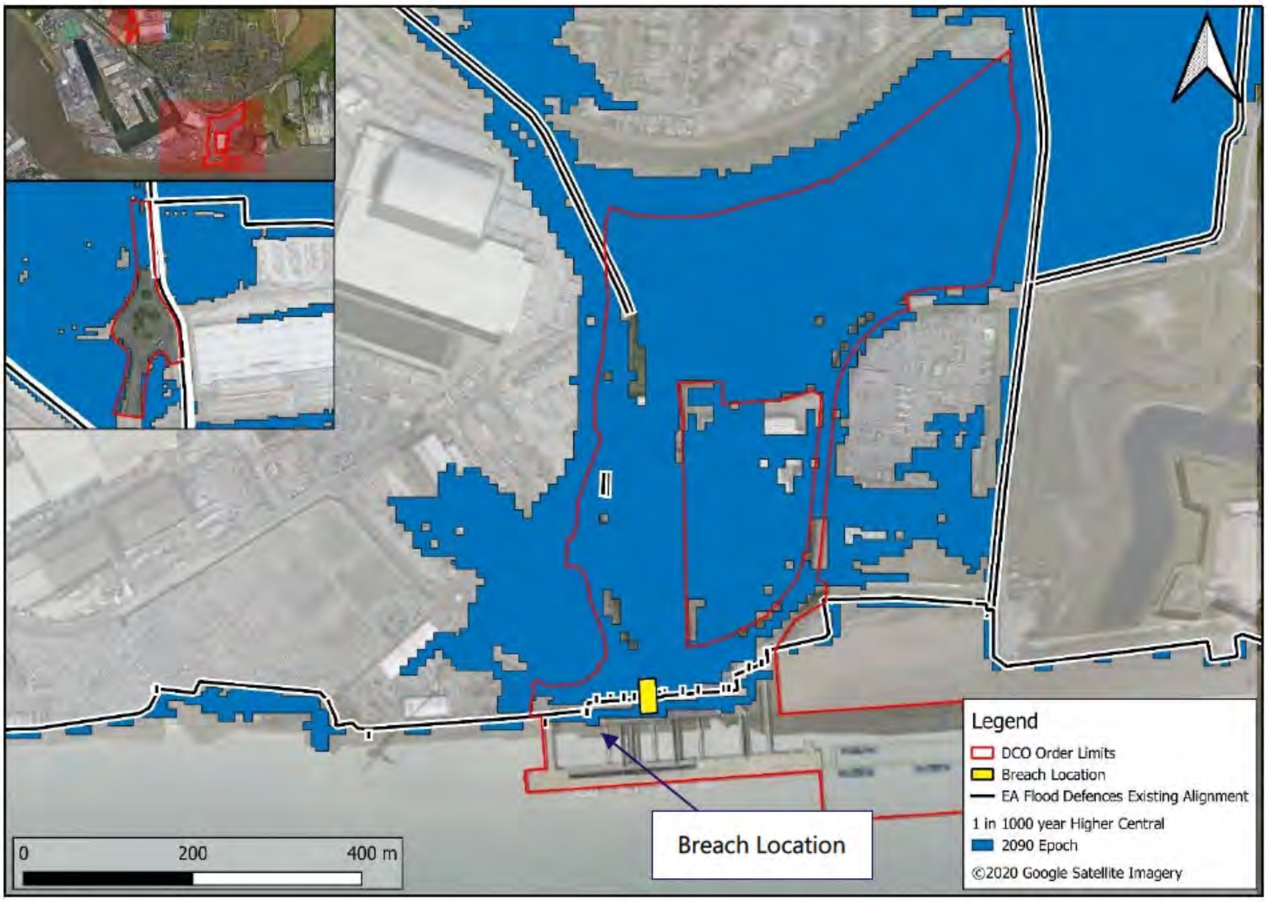

Figure 3-22: Essex Project Site baseline breach flood extent for the 1 in 1000 year return period event using the higher central climate change projections in 2090.

Figure 3-23 shows the Breach flood extent maps taken from the Thurrock SFRA. The flood maps are for 2116 and therefore the flooded extent is greater. However it can be seen that the flood extents follow a similar pattern, particularly the flood extent originating from a breach in the Tilbury Dock to the east of the Essex Project Site. Flood water can be seen to move away from the coastline into the lower ground in land.

Figure 3-23: Essex Project Site Thurrock SFRA breach hazard maps for comparison[4]

Figure 3-24 shows the Baseline 2020 model flood hazard for the Essex Project Site as a result of a breach in the flood defences at Breach 22. The results show that for each event shown results in increased hazard on the Proposed Development particularly along the main flow path from the breach into the lower land away from the flood defences.

[4] Thurrock Level 1 Strategic Flood Risk Assessment (SFRA), June 2018 https://regs.thurrock.gov.uk/online-applications-skin/thurrock-strategic/sfra_201806/lptech-thurrock-sfra1-201806-appendixc7-v01.pdf

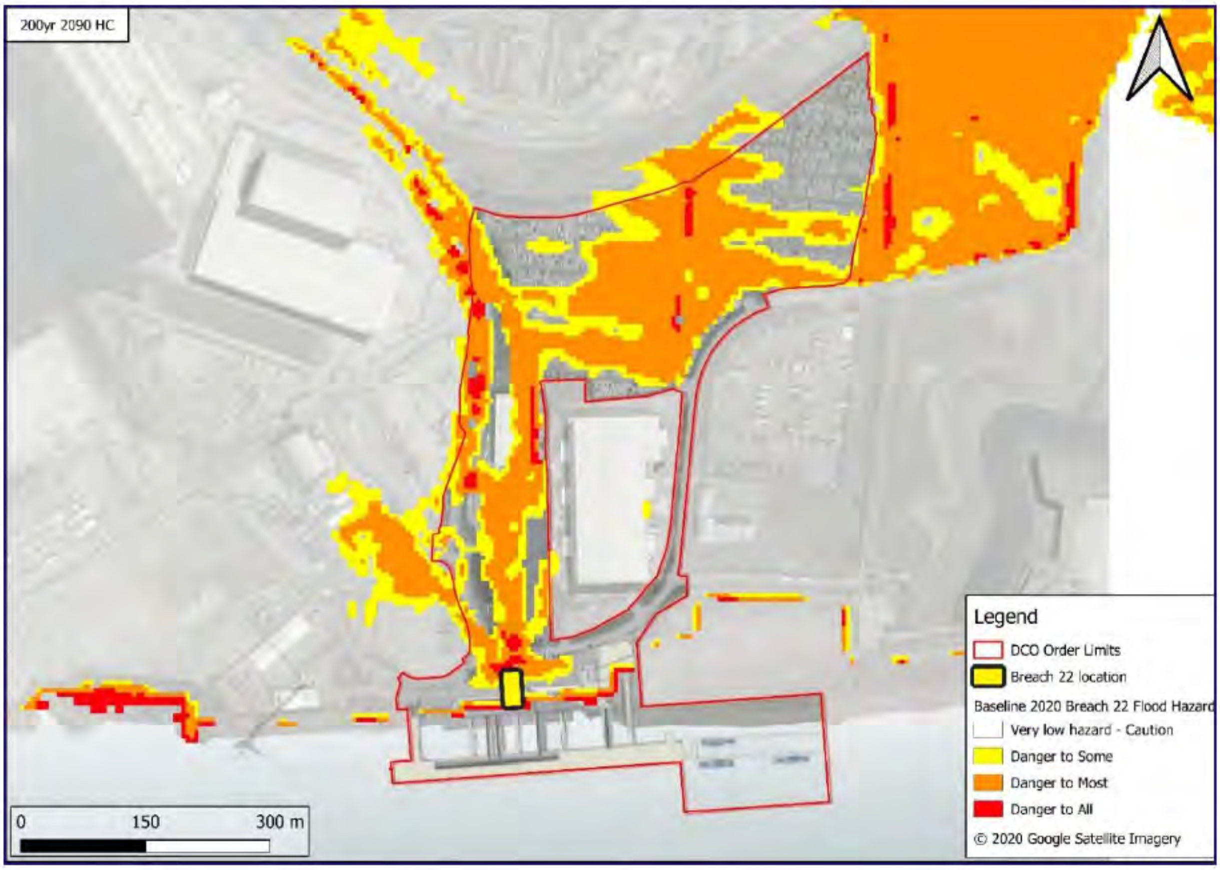

Figure 3-24: Essex Project Site baseline breach hazard for the 1 in 200 year 2090 future epoch using the higher central sea level rise projection

3.6 Conclusion

As a result of the modelling undertaken and in reference to the TE2100 guidance material the following mitigation strategy has been put together that will be tested in the Proposed 2020 model.

At the Kent Project Site:

i) Improve the Formal Flood defences;

ii) Add a secondary flood defence along the east side of the proposed development (the west side of botany marsh);

iii) Defining More Vulnerable development levels; and

iv) Defining Less Vulnerable development levels and resiliency.

At the Essex Project Site:

i) Defining Less Vulnerable development levels and resiliency.

The Proposed 2020 model developed in the next section tests the efficacy of the proposals and generates the information to set the More Vulnerable and Less Vulnerable levels.

4 Tidal flood risk (overtopping and breach) proposed 2020 model

4.1 Introduction

The Proposed 2020 model was developed in order to assess the impact of the Proposed Development on the flood mechanism in order to identify any flood mitigation measures required. The key changes are as follows:

i) Surface Topography – The existing topography was replaced by the proposed masterplan topography for the Kent Project Site; and,

ii) Surface Roughness – The existing OS Map roughness was replaced by estimated proposed roughness for the proposed Kent Project Site and Essex Project Site land uses.

4.2 Proposed 2020 model

4.2.1 Improvements to the flood defences

The Proposed Development includes the improvements of the Formal Flood Defences along the Black Duck Marsh and at Whites Jetty Area. For the proposed of this modelling the levels have been set along these areas at 8m AOD. At Black Duck Marsh this has been represented by using a Zline in Tuflow 2D domain running along the existing alignment setting the crest to 8m AOD. At White Jetty this has been represented by removing the existing flood defences and running a new line of the flood defences using a Zline in Tuflow 2D domain along the landward side of the Whites Jetty, as shown in

Figure 4-1.

Figure 4-1: Flood Risk Mitigation Kent Project Site (Main Resort) proposed works to the formal flood defences.

To mitigate against the overtopping flood risk from the east of the Kent Project Site a secondary flood defence is proposed. This flood defence will be set to 3.00m AOD which provides a protection against the 1 in 200 year and 1 in 1000 year overtopping levels for 2090 using the higher central climate change projections. Figure 4-2 shows the alignment of this new bund.

Figure 4-2: Flood Risk Mitigation Kent Project Site (Main Resort) secondary flood defence bund

4.2.2 Updates to the floodplain topography

A Proposed Surface DEM was generated to represent the topography of the Kent Project Site post development. This includes the podium levels of the built environment as well as any structural flood retention walls and flood defences that are part of the mitigation strategy.

The proposed topography is shown in Figure 4-3 and the change in topography is shown in Figure 4-4.

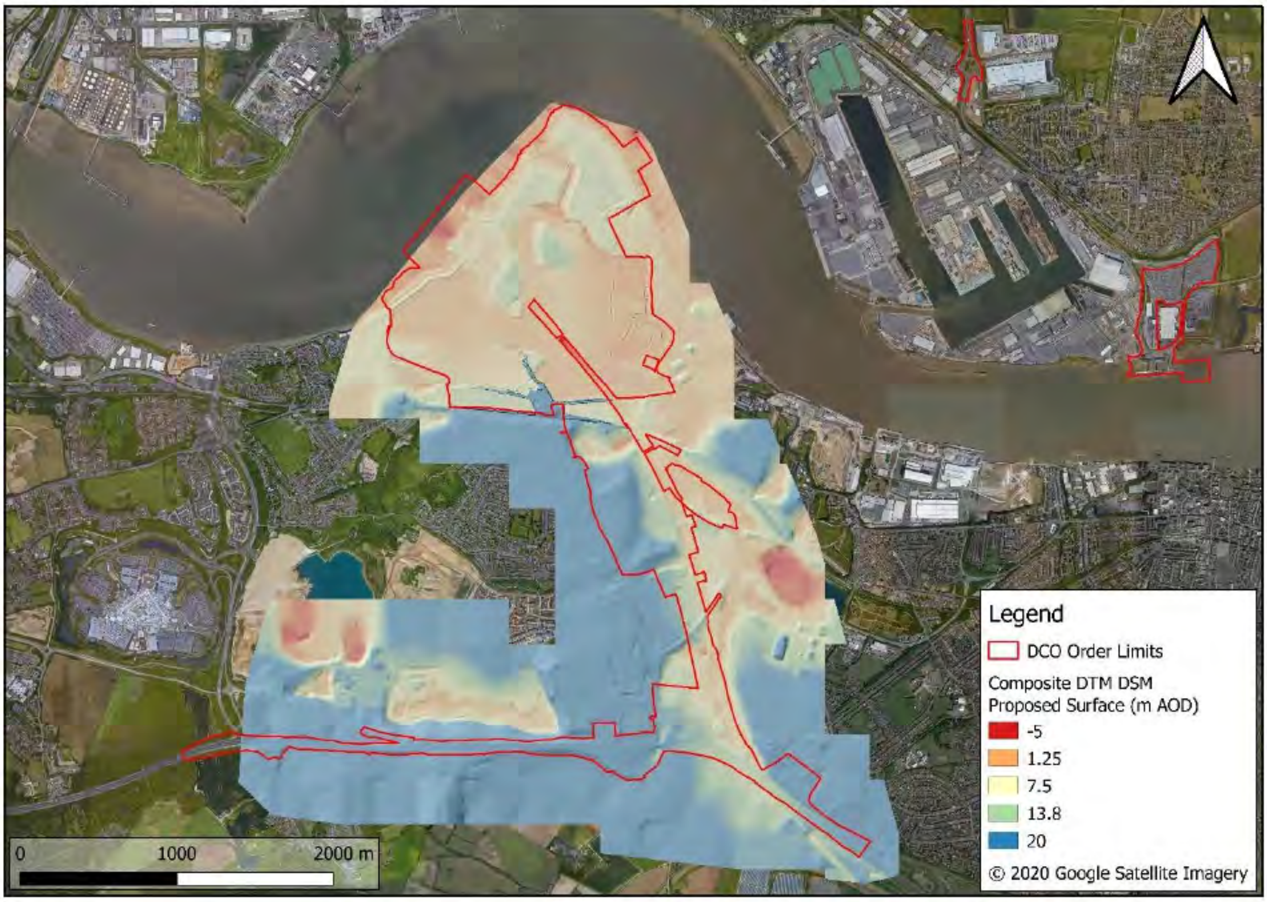

Figure 4-3: Composite DTM and DSM Proposed 2020 model surface elevations

Figure 4-4: Change in topography

4.2.3 Updates to the flood plain roughness

In order to represent the Proposed Development the land use in the Baseline 2020 hydraulic model was updated. Figure 4-5 shows the land use change for the Kent Project Site (Main Resort) and Figure 4-6 shows the land use change for the Essex Project Site. Table 4-1 details the land uses used to represent the proposed development and the manning's n values used.

Table 4-1: Roughness details

Land Use ID	Description	Mannings n Roughness
5	Building	0.300
16	General Surface (Manmade)	0.020
17	Unclassified	0.040

Figure 4-5: Changes to the Baseline 2020 model land use to represent the Proposed Development

Figure 4-6: Changes to the Baseline 2020 model land use to represent the Proposed Development

4.2.4 Breach design

The four breach locations at the Kent Project Site that were reviewed in the baseline model have been maintained in shape, size and location within the Proposed 2020 model. The Proposed 2020 model also includes a further breach within the new secondary bund location to the east of the site along botany marsh.

Figure 4-7: Kent Project Site (Main Resort) breach locations

Table 4-2: Kent Project Site breach details

Breach ID	Crest level (m AOD)	Ground\Breach level (m AOD)	Breach width (m)	Defence type	Origin	Location
Breach 03	6.68	4.8	20	Wall	NKC18	Outside the Order Limits to the east.
Breach 06	6.32	3.7	50	Embankment	NKC18	Inside the Order Limits to the west along Black Duck Marsh.
Breach 09	6.50	4.3	20	Wall	BH2020	Outside the Order Limits to the east.
Breach 10	6.32	4.1	50	Embankment	BH2020	Inside the Order Limits to the west along Black Duck Marsh.
Breach 21	3.00	2.0	50	Embankment	BH2020	Inside the Order Limits to the west of Botany Marsh along Gate 1 boundary.

Table 4-3: Essex Project Site additional breach details

Breach ID	Crest level (m AOD)	Ground\Breach level (m AOD)	Breach width (m)	Defence type	Origin	Location
Breach 22	6.63	4.04	20	Wall	BH2020	Inside the Order Limits within the Ferry Cruise Terminal, directly in front of the Essex Proposed Development.

At the Essex Project Site there is no change to the breach used.

4.3 Hydrology

No change to the model hydrology for the Proposed 2020 model analysis.

4.4 Model runs

The following model runs were considered for the Proposed 2020 model.

Table 4-4: Model runs considered for the Proposed 2020 model

Future Epoch		2090				2100		2125			
Return Period Event		1 in 200yr		1 in 1000yr		1 in 200yr	1 in 1000yr	1 in 200yr		1 in 1000yr	
Climate Change Projections		HC	UE	HC	UE	H++	H++	HC	UE	HC	UE
Model Name	Scenario										
Proposed 2020	Defended										
	Breach 06										
	Breach 09	X	X	X		X	X	X	X	X	X
	Breach 21	X	X		X	X	X	X	X	X	X
	Breach 22				X	X			X		X

4.5 Results

4.5.1 Overtopping

Kent Project Site

At the Kent Project Site, the modelling results for the Proposed 2020 model indicates that the proposed flood defences to the west of the Kent Project Site within the Order Limits do not overtop during the 1 in 200 year storm event in either of the 2090 nor the 2125 future epochs, using the higher central climate change projections. Figure 4-8 shows the flood extents for the select scenarios. The majority of the flood extents within the Order Limits are kept within Botany Marsh.

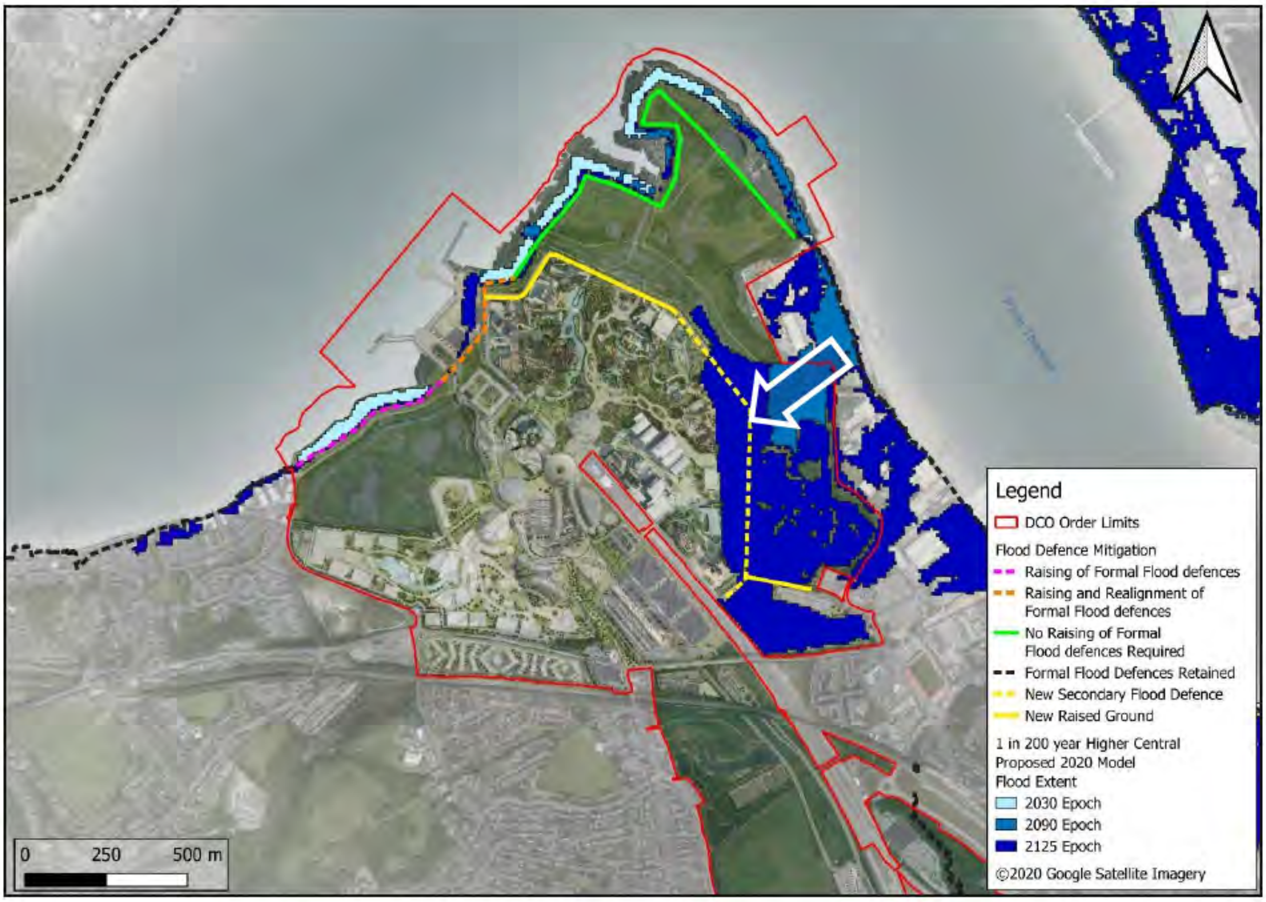

Figure 4-8: Kent Project Site (Main Resort) proposed overtopping flood extents for the 1 in 200 year return period event using the higher central climate change projections across different years, key flow paths indicated by the arrows

The Proposed 2020 Model results for the 1 in 1000 year storm event are similar. The proposed improvements to the formal flood defences prevent the overtopping of the western formal flood defences at Black Duck Marsh in both the 2090 and the 2125 future epochs, using the higher central climate change projection. As with the 1 in 200 year event the formal flood defences to the east of the Order Limits do over top, however the secondary flood defence along the western edge of Botany Marsh retains much of the flood water within the Marsh. The flood extent of the 1 in 1000 year 2090 event using the higher central climate change projections are entirely restricted to Botany Marsh. The 1 in 1000 year 2125 event using the higher central climate change projections overtop the secondary bund and flood a strip along the border of Gate 1, the back of house and the centre of the Proposed Development.

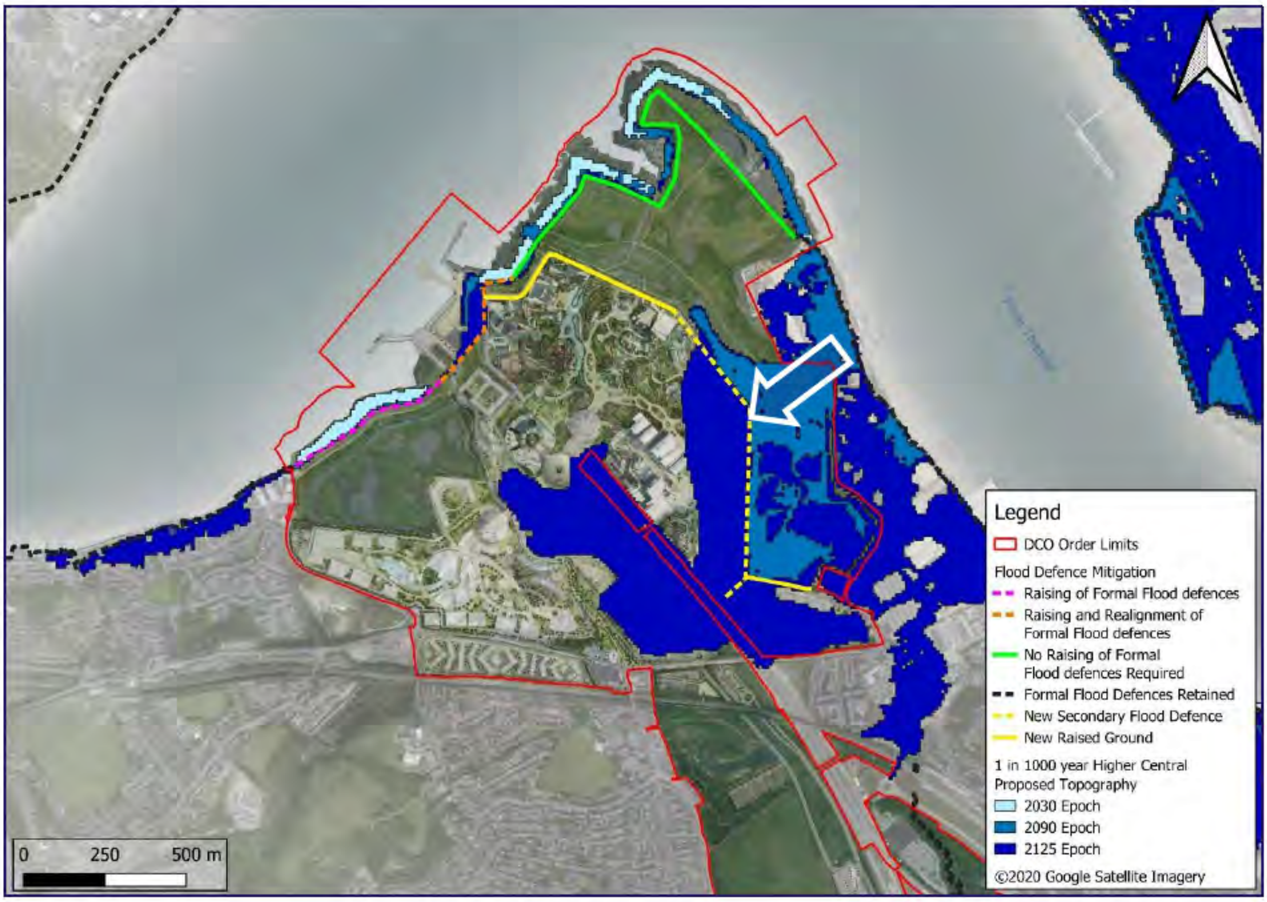

Figure 4-9: Kent Project Site (Main Resort) proposed overtopping flood extents for the 1 in 1000 year return period event using the higher central climate change projections across different years, key flow paths indicated by the arrows

The impact of the Proposed Development on each of the selected scenarios are shown in Figure 4-10. These figures show increases in the flood extent as red, reductions in the flood extent as green and no change to the flood extent as blue. The images show that there is no increase offsite at the Kent Project Site (Main Resort) for these scenarios as a result of including the Proposed Development in the hydraulic model.

The images also show the flood mitigation strategy working as intended in order to prevent the overtopping of the western formal flood defences for both events up to the 2125 future epoch, and to remove flood risk from the east of the Kent Project Site (Main Resort) up to the 2090 future epoch.

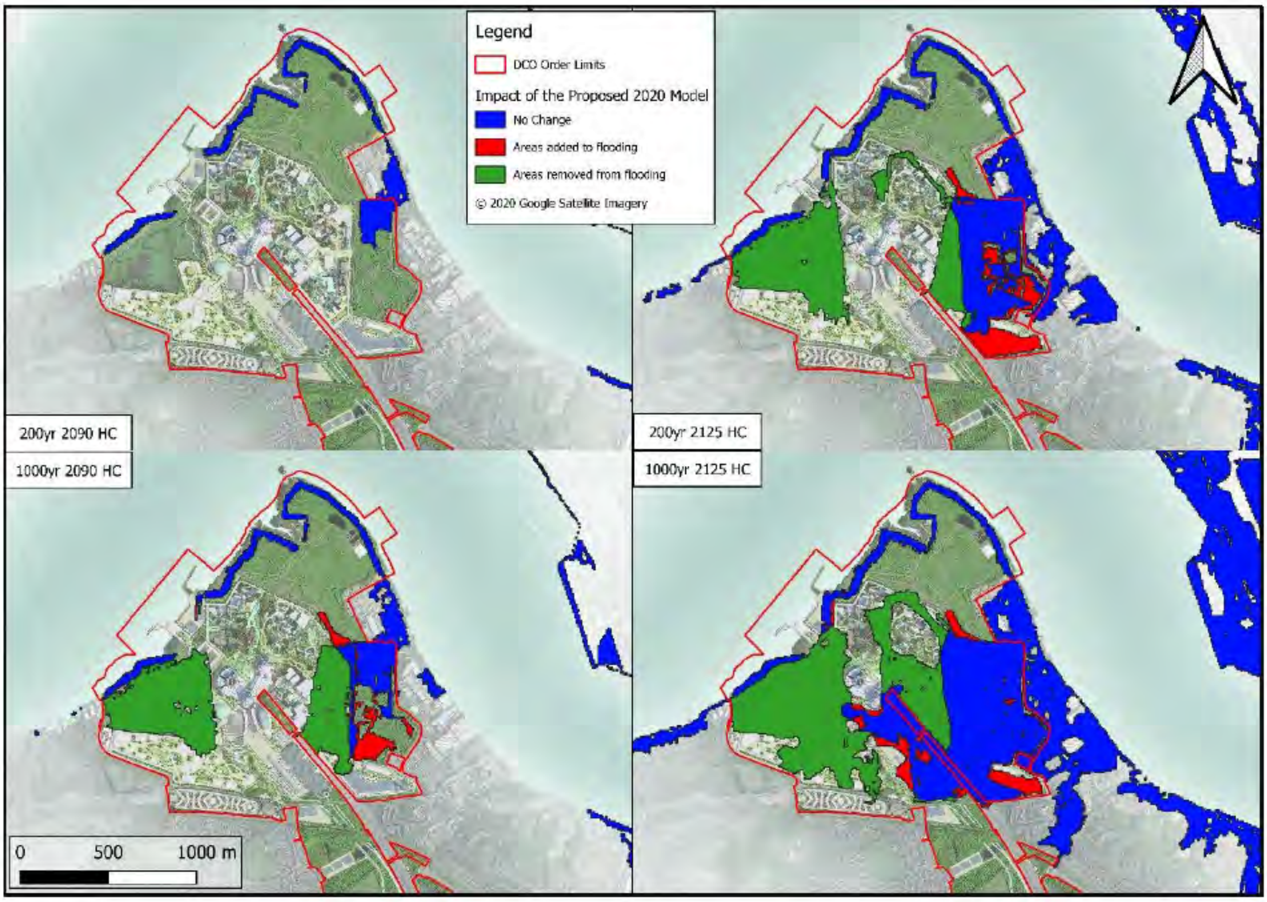

Figure 4-10: The impact of the Proposed 2020 model on the Baseline 2020 model when considering the overtopping higher central scenarios

At the High Speed 1 (HS1) line the inclusion of the Proposed Development has removed the risk to the tunnel from overtopping in the 1 in 200 year 2125 future epoch event, as well as the 1 in 1000 year 2090 future epoch event using the higher central climate change projections. The Proposed Development does not remove the risk to the HS1 for the 1 in 1000 year 2125 future epoch event. Figure 4-11 and Figure 4-12 shows the impact of the Proposed Development on flood levels at the HS1 line. Figure 4-11 shows the risk to the HS1 line for the 1 in 200 year 2125 future epoch event removed. Figure 4-12 shows the risk to the HS1 line for the 1 in 1000 year 2125 future epoch event reduced.

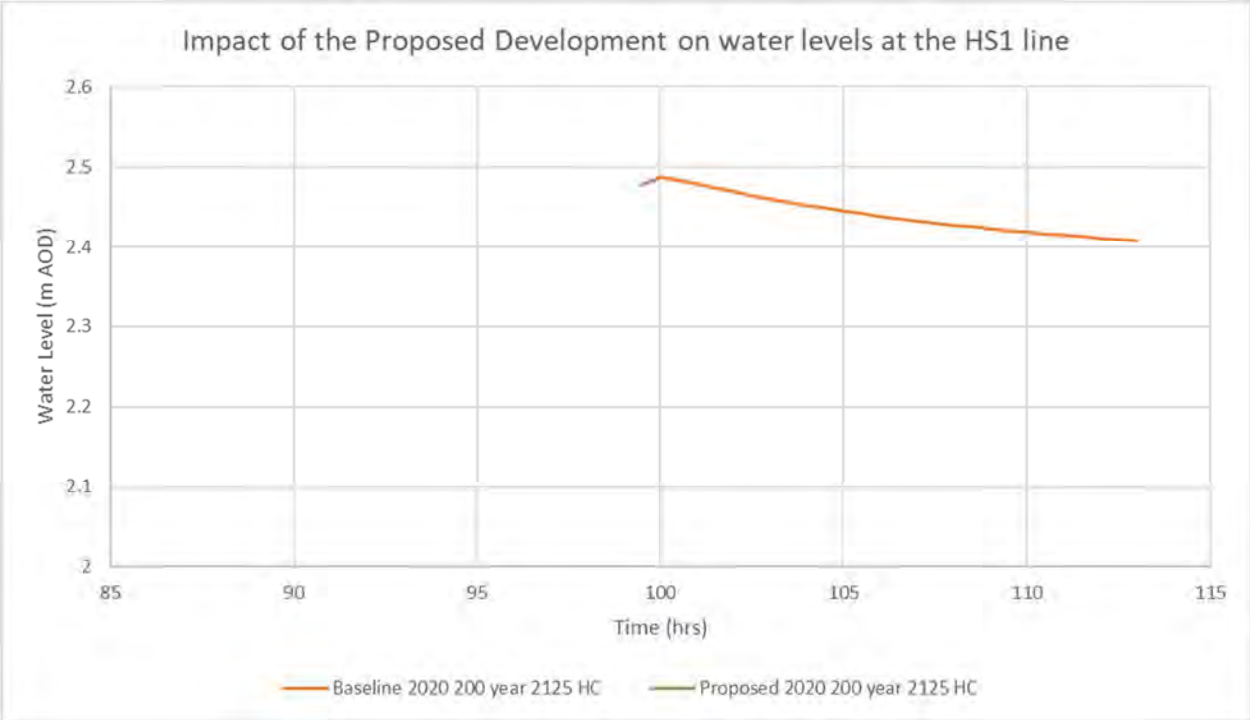

Figure 4-11: Impact of the Proposed Development on water levels at the HS1 line for the 1 in 200 year 2125 future epoch higher central event

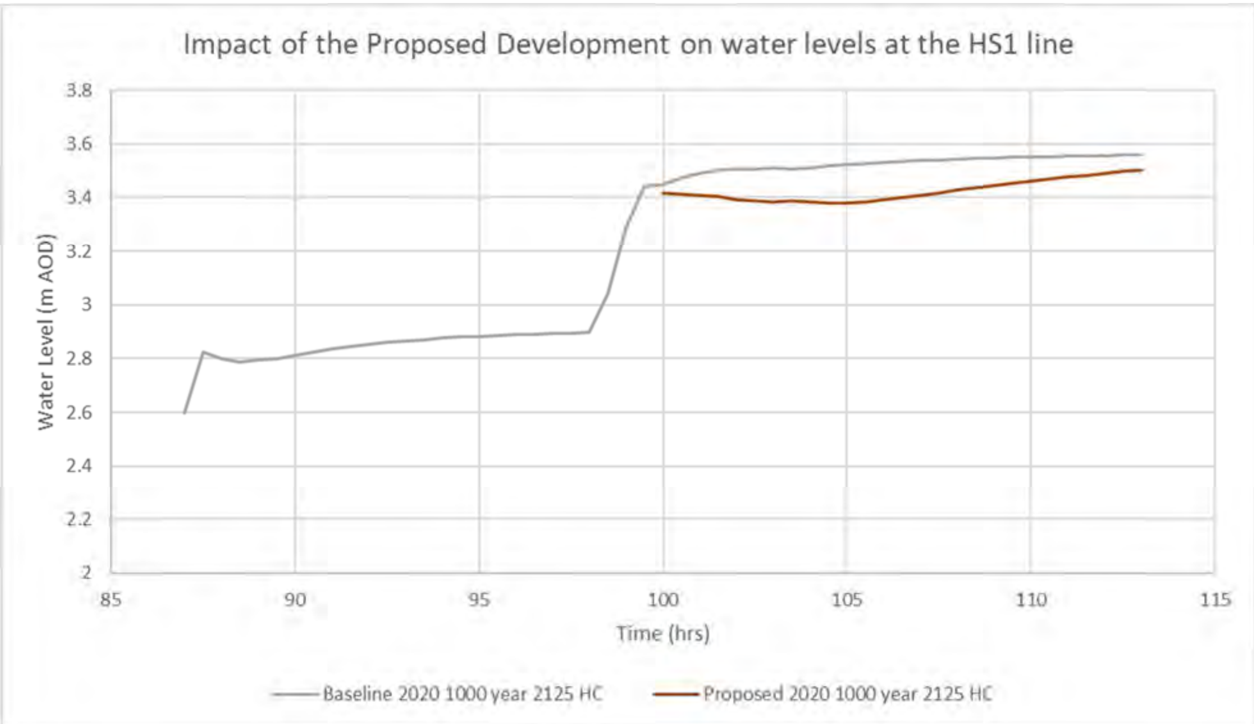

Figure 4-12: Impact of the Proposed Development on water levels at the HS1 line for the 1 in 100 year 2125 future epoch higher central event

Figure 4-13 shows the Proposed 2020 model flood hazard for the Kent Project Site (Main Resort) as a result of overtopping of the flood defences. The results show that for each event shown results in increased hazard on the Proposed Development. The highest hazard is around the marsh areas and where flow enters the Proposed Defences. As a result of the Proposed Development there is lower hazard within the Order Limits.

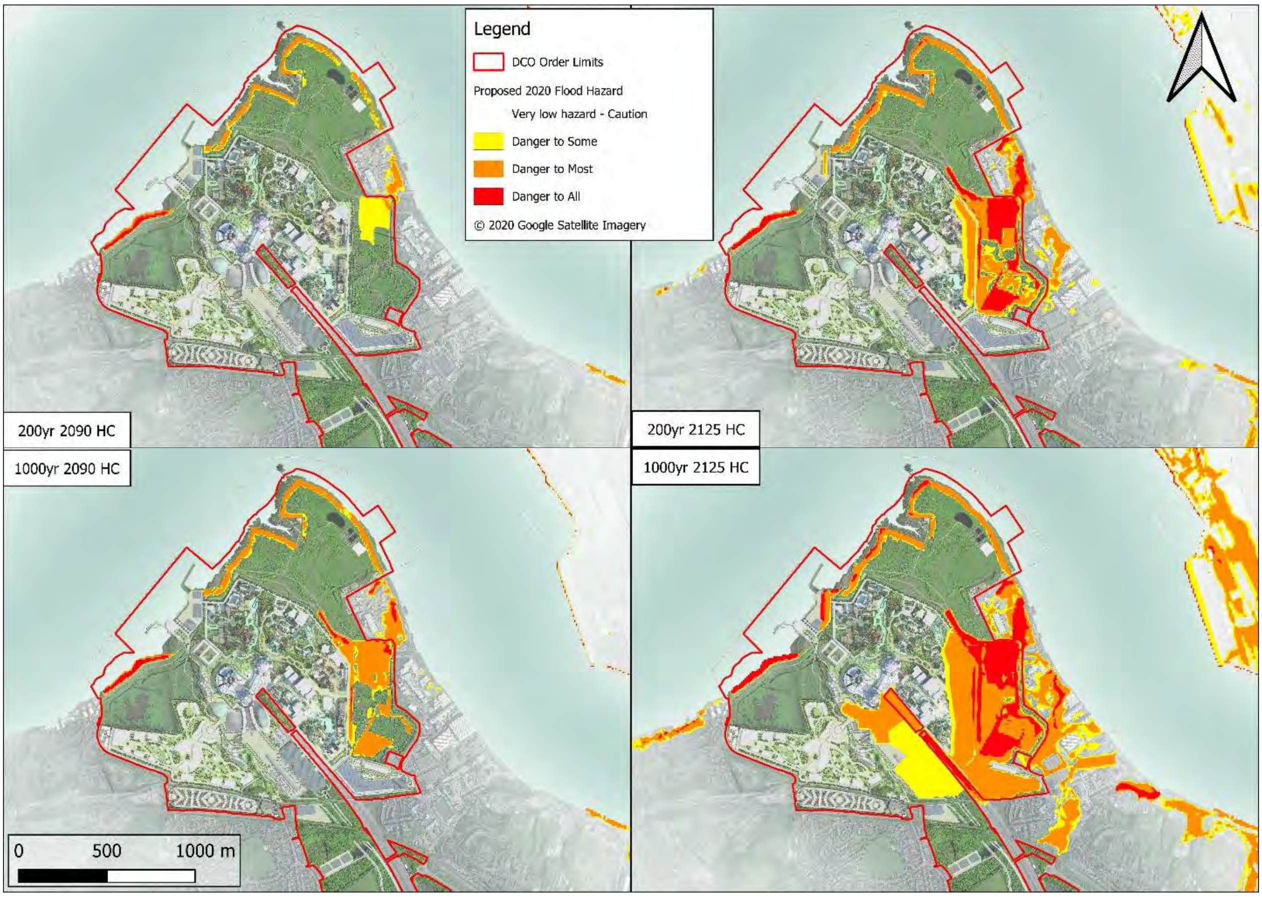

Figure 4-13: Kent Project Site (main resort) proposed overtopping hazard for the 1 in 200 year and the 1 in 1000 year 2090 and 2125 future epochs using the higher central sea level rise projections

Essex Project Site

At the Essex Project Site there is no change to the proposed Thames flood defences, therefore the flow routes in the Proposed 2020 model are the same as in the Baseline 2020 model. However, the flow routes through the Essex Project Site are altered slightly by changes to the built environment within the project boundary.

Figure 4-14 shows the impact of the Proposed 2020 model on the flood extents. By representing the Proposed Development as 'Buildings' manning's n roughness value, it can be seen that there is an increase to the flood extent as a result of the inclusion of the Proposed Development. The main changes are primarily seen along the drainage channel in the northwest and in the industrial area immediately adjacent to the Essex Project Site. However, these increases do not affect residential areas.

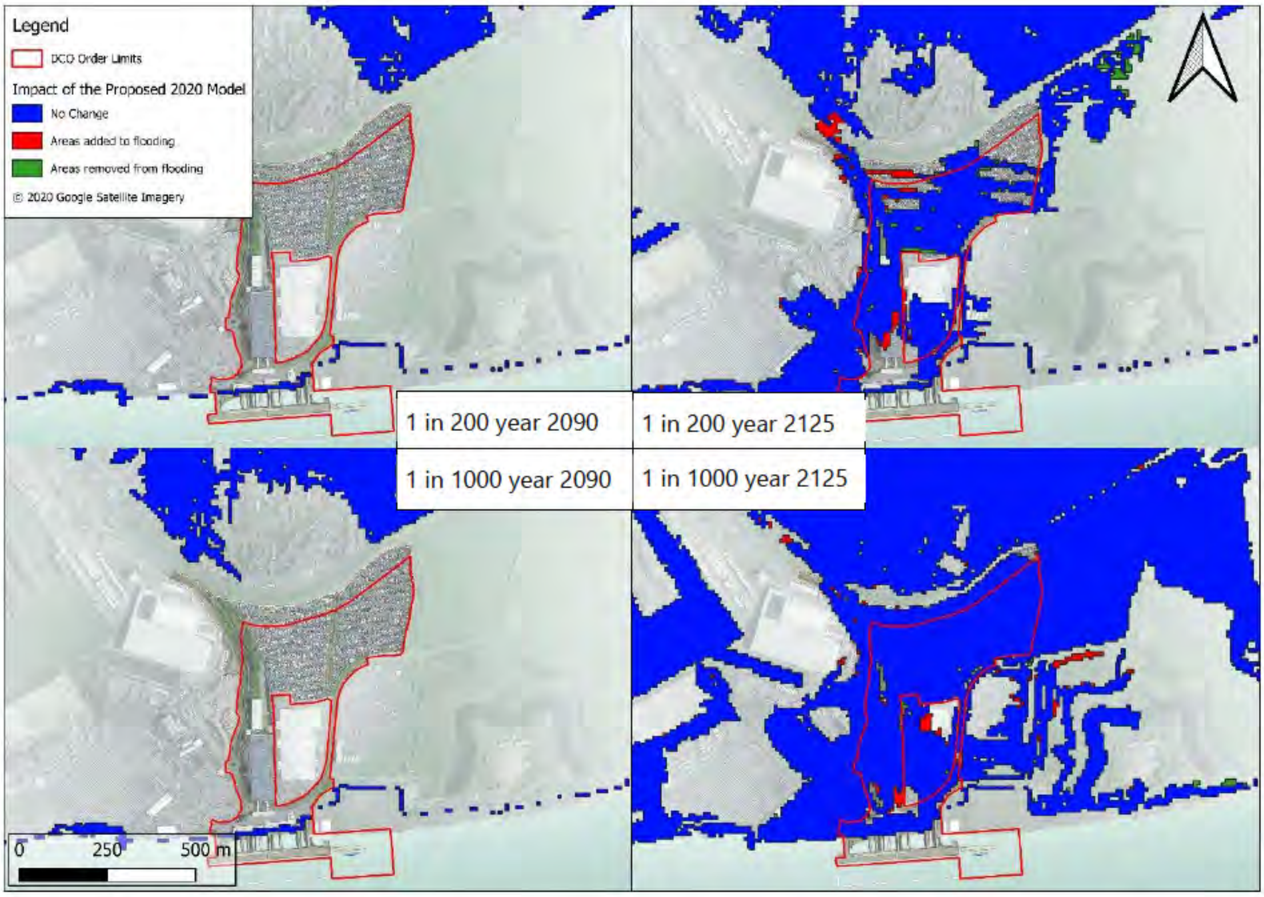

Figure 4-14: The impact of the Proposed 2020 model to the Baseline 2020 model when considering the overtopping higher central scenarios

The Proposed Development at the Essex Project Site was then represented in the flood model with a change in manning's n value. The Site in the Baseline 2020 model represents the Site with a value of 0.02. The Buildings value is 0.3 used to represent floodwater being able to pass into buildings through vents or gaps in doorways, allowing water to permeate into the building, although in general reduces the flow of water across the building footprint.

Guidance taken from a report on selecting manning's value[5], suggests that where flow may be obstructed, a value of 0.05 should be added to the baseline value to account for obstructions greater than 50% of the flow area. As such, a value of 0.07 was tested in the Proposed 2020 model to represent a building with wide openings to prevent a restriction in the flow of water, which would be possible for a multi-storey car park.

Figure 4-15 indicates the change in results in the Proposed 2020 model with a manning's value of 0.07 compared to the Baseline 2020 model. The results indicate that localised changes in flood level are observed in the location of the multi-storey car park with increases in levels up to approximately 90mm and 1mm - 15mm in the north west corner of the Order Limits, in the existing car park and Ferry Road. It is not clear whether the change in levels observed are directly related to the Proposed Development or within the modelling error tolerance of the model. No changes in extent or levels are observed north of the railway line.

[5] G. J. Arcement Jr and V. R Schneider, Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains, US Geological Survey Water-Supply Paper 2339, 1989.

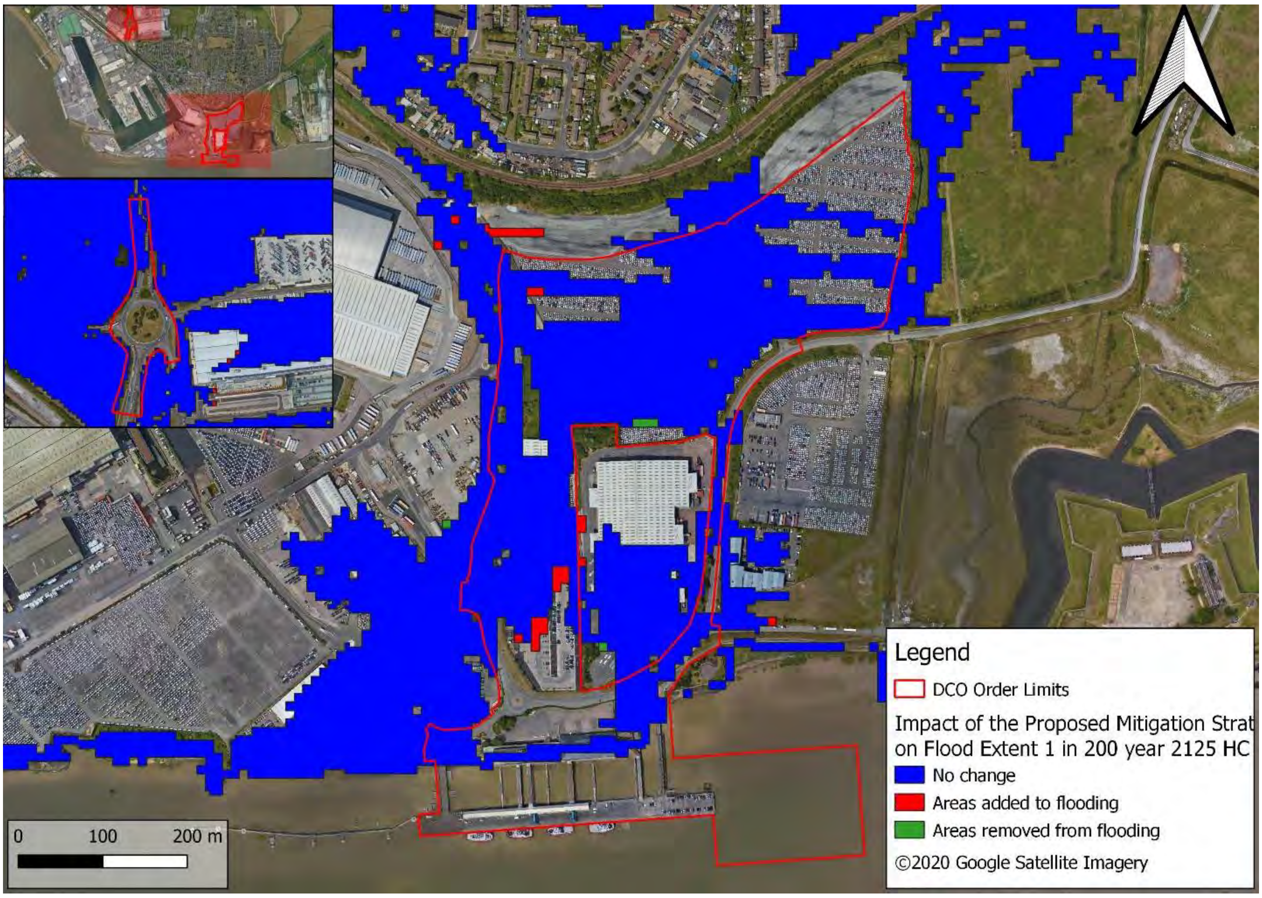

Figure 4-15 Essex Project Site change in Proposed 2020 model compared to Baseline 2020 model for overtopping flood extent in the 1 in 200 year event for 2125 higher central climate change projection with manning's roughness value for obstructions greater than 50% of flow area.

Figure 4-16 shows the Proposed 2020 model flood hazard for the Essex Project Site as a result of overtopping of the flood defences during different future epochs based on the Building's manning's roughness value of 0.3. Figure 4-17 illustrates the Proposed 2020 model with a manning's n value of 0.07 compared to Baseline 2020 model for the overtopping 1 in 200 year event in 2125 with higher central climate change projection. The Proposed Model results show that in 2125 there is a primarily a Danger to Most hazard within the Project Site during an overtopping of the formal defences. The hazard risk is not increased within or outside of the Site due to the Proposed Development when the building is kept primarily open for floodwater to continue to flow through the structure.

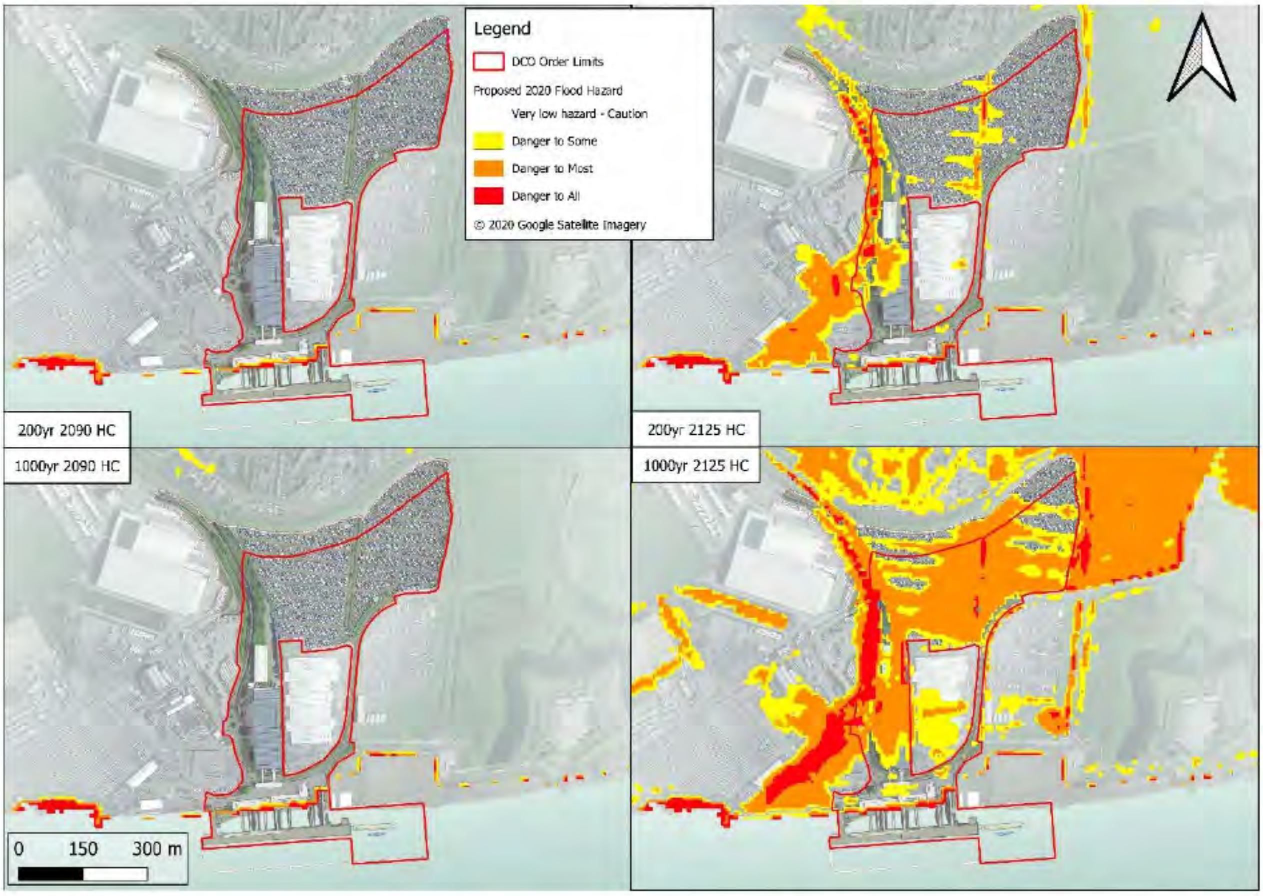

Figure 4-16: Essex Project Site Proposed 2020 model overtopping hazard for the 1 in 200 year and the 1 in 1000 year 2090 and 2125 future epochs using the higher central sea level rise projections based on 'Buildings' manning's roughness value

Figure 4-17 Essex Project Site 1 in 200 year Proposed 2020 model compared to Baseline 2020 model during overtopping 2090 using the higher central climate change allowance hazard flood map based on the obstruction greater than 50% manning's roughness value

4.5.2 Breach

Kent Project Site

At the Kent Project Site (Main Resort) analysis of the Proposed 2020 model breach results as compared to the Baseline 2020 model results has been undertaken. Figure 4-18 shows the results of this analysis. The Proposed 2020 model results in changes to the flood extents in each of the return periods reviewed. The increases to the flood extent are within the Order Limits. There are also some decreases to the flood extent that occurs both inside and outside of the Order Limits.

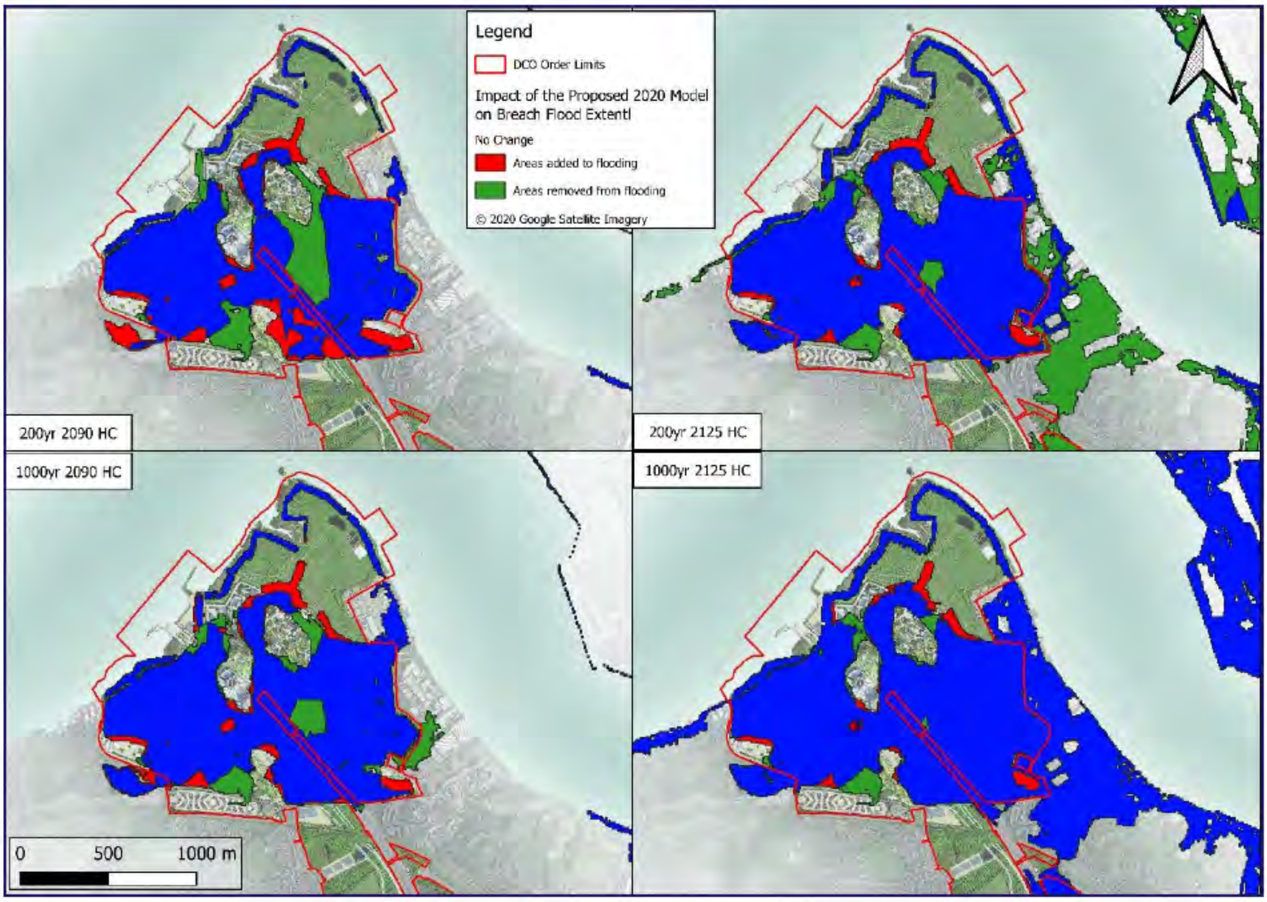

Figure 4-18: The impact of the Proposed 2020 model to the Baseline 2020 model when considering the Breach 06 higher central scenarios

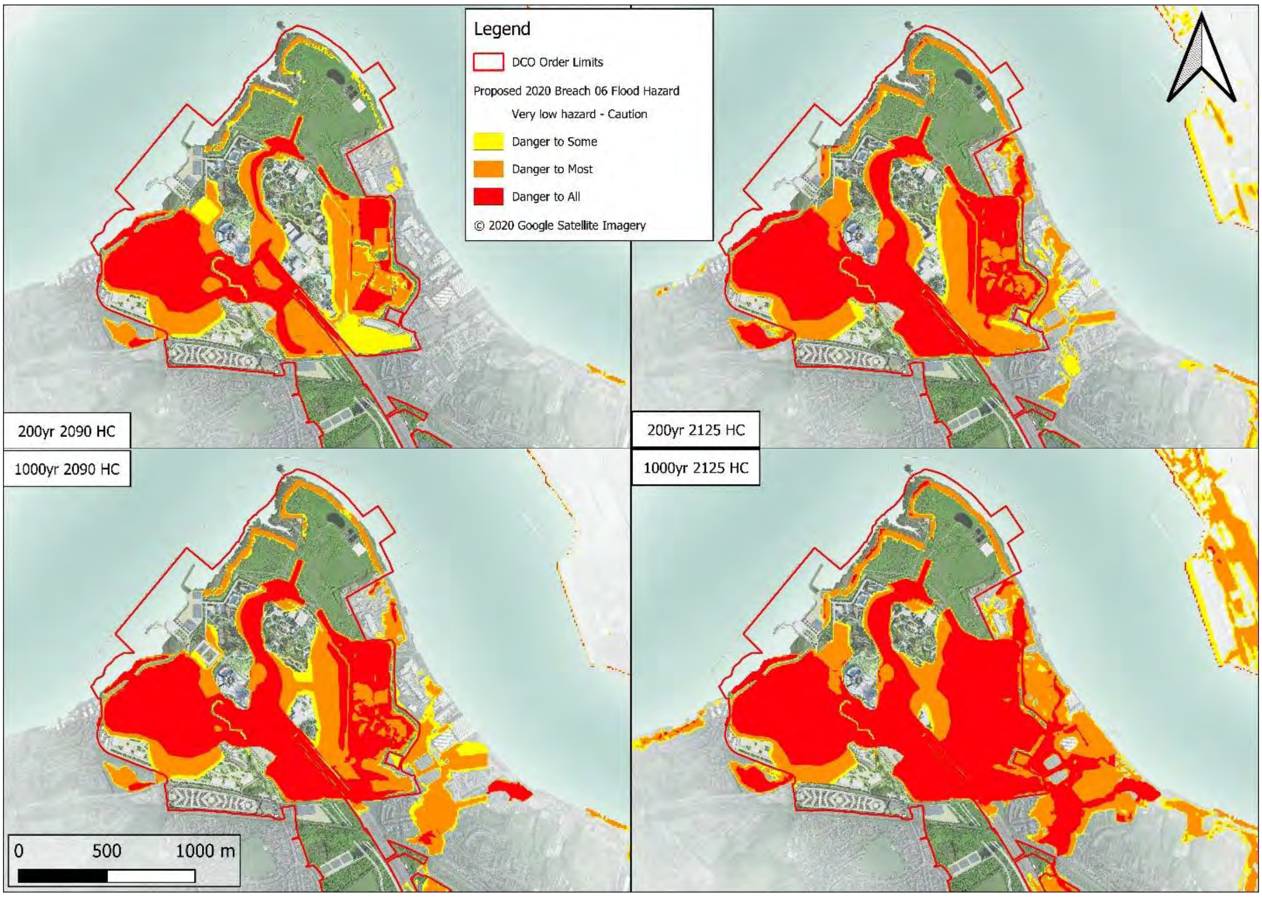

Figure 4-19: Proposed 2020 Essex Project Site flood hazard Breach 06 model results higher central sea level projection

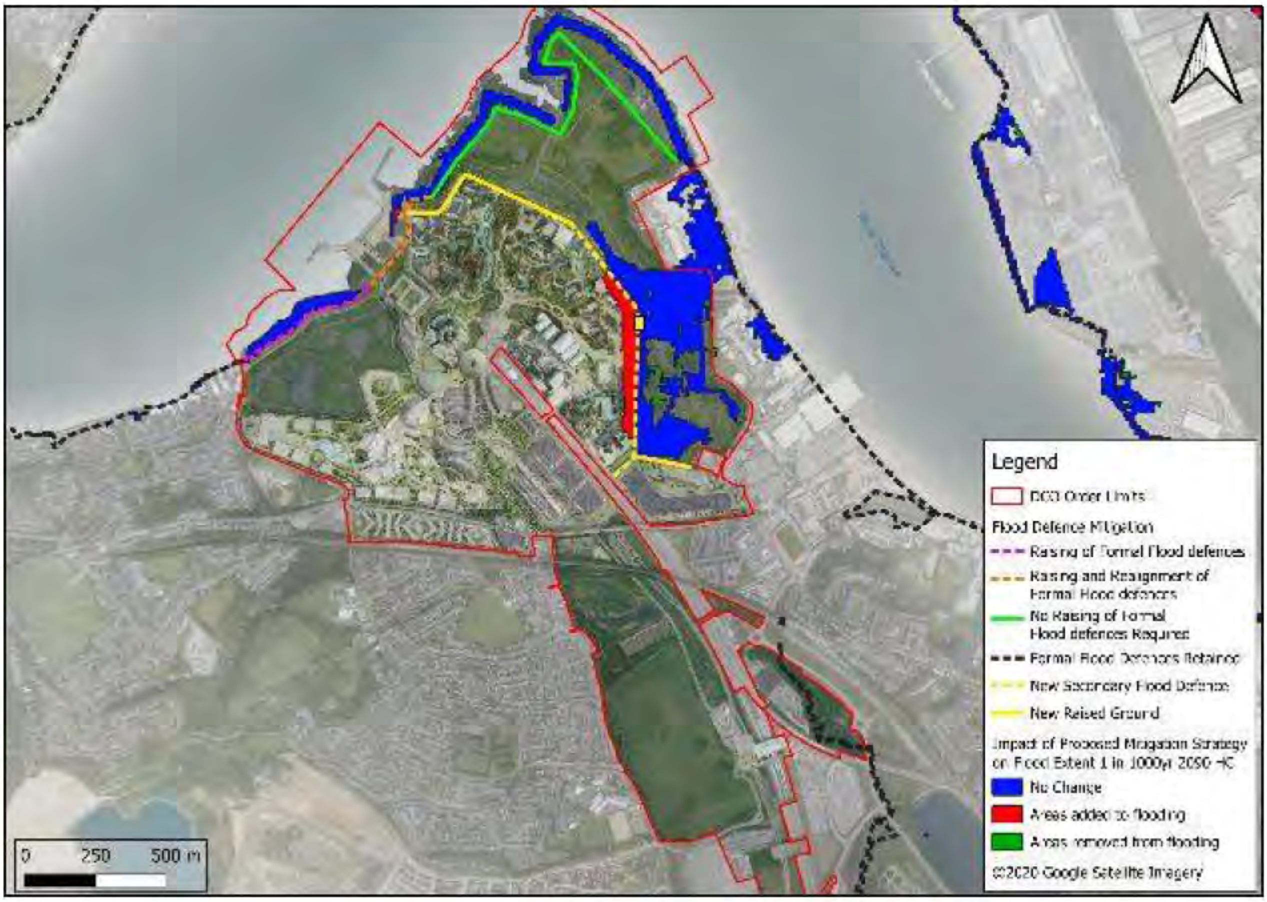

Figure 4-20: Breach 21 in the new secondary flood defence, 1 in 1000 year 2090 higher central climate change projections

Essex Project Site

At the Essex project the same analysis has been undertaken using the 1 in 200 year event for 2090. The impact of the Proposed Development can be seen in Figure 4-21 below. The image shows that the inclusion of the Proposed Development in the model has resulted in a change in the flow routes in the breach 22 model run. This causes a slight increase in the flood extent to the east and to the west of the Essex Project Site. However, the increases in the flood extent do not include any residential areas. The increases are predominantly restricted to local car parks, green areas and some industrial land.

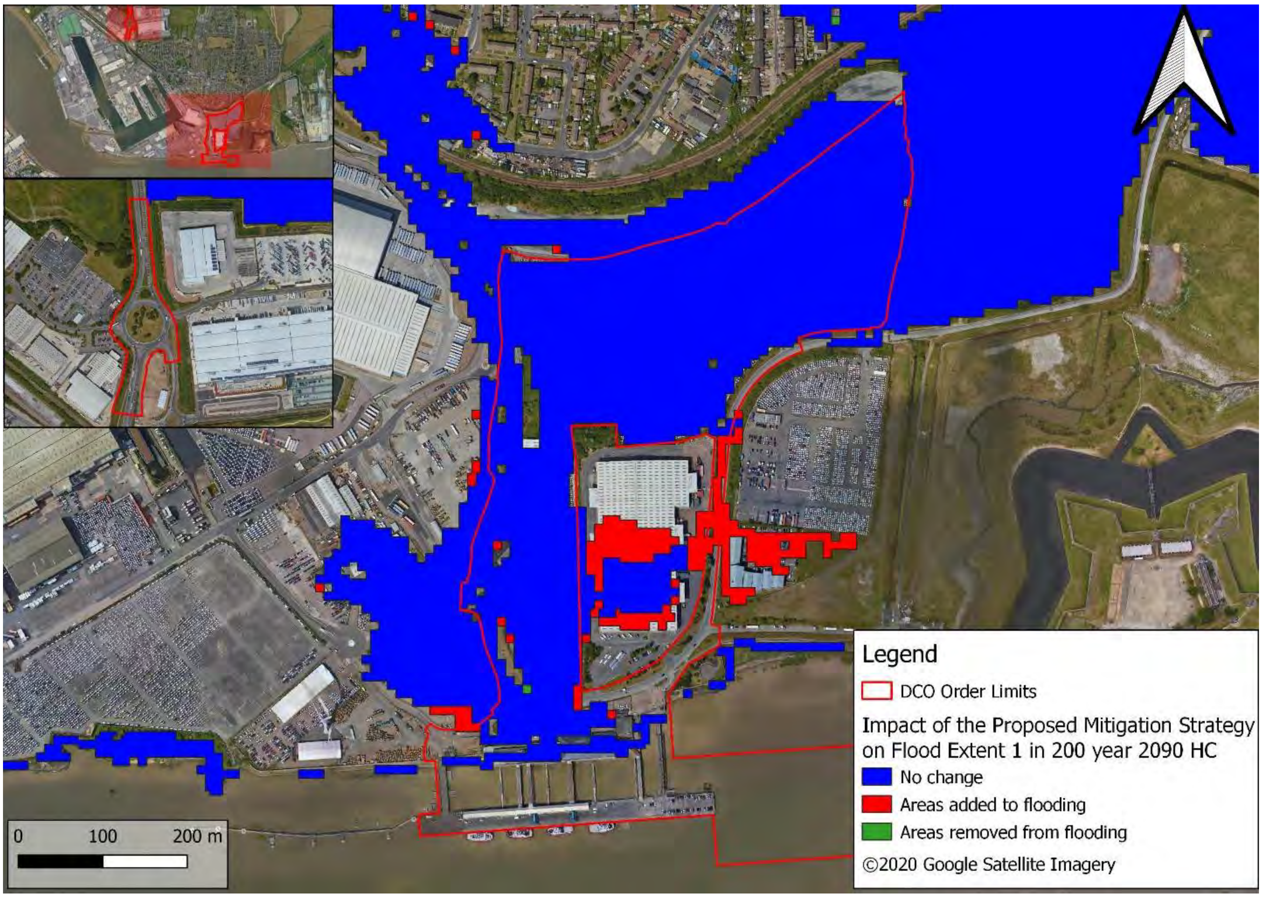

Figure 4-21: The impact of the Proposed 2020 model to the Baseline 2020 model when considering the Breach 22 1 in 200 year 2090 higher central scenario

Figure 4-22 shows the Proposed 2020 model compared to Baseline 2020 model flood hazard for the Essex Project Site as a result of a breach in the flood defences at Breach 22. The results are based on a manning's value for an obstruction greater than 50%. The results show that the Proposed Development does not increase the flood hazard to areas within or outside the Order Limits. Areas classified as Danger to All are observed immediately downstream of the breach location and parts of Ferry Road as it runs north towards the railway line. The safest access route from the Site is along Fort Road in an easterly direction.

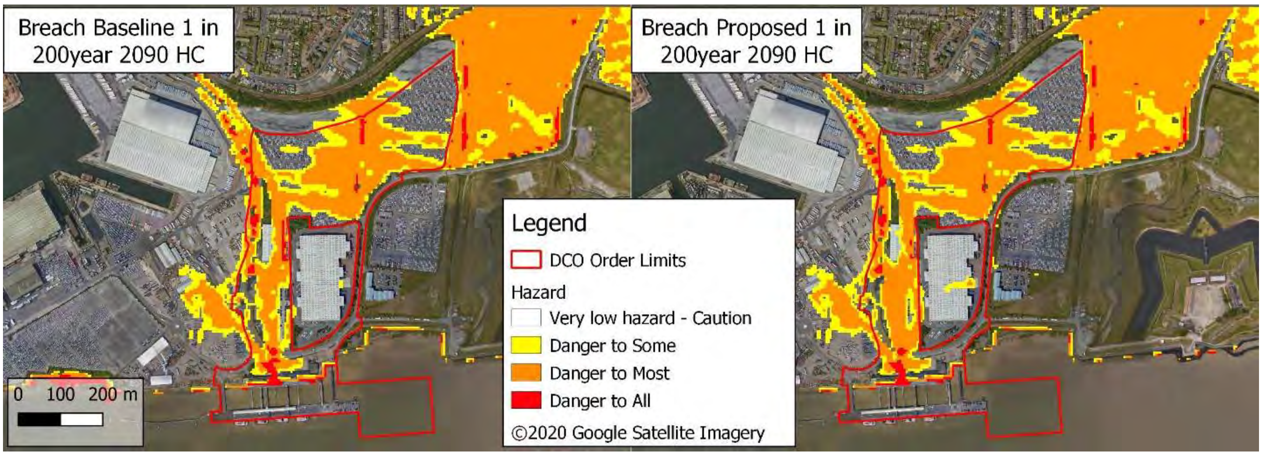

Figure 4-22: Essex Project Site Proposed 2020 model and Baseline 202 model during a breach hazard for the 1 in 200 year 2090 future epoch using the higher central sea level rise projection

5 Fluvial Flood Risk Ebbsfleet

5.1 Approach

The London Resort (Access Road) includes the River Ebbsfleet fluvial system. The River Ebbsfleet is a groundwater fed system that flows north from Springhead by the A2, through part of the Order Limits and into the River Thames at Robins Creek. Hydraulic Modelling was used in order to determine the level of risk to the Proposed Development and to provide the necessary data for flood mitigation proposals.

A single model was used to represent the baseline condition under a number of future scenarios.

5.2 The Ebbsfleet 2016 model

The Ebbsfleet 2016 model was provided by the EA for use in this analysis. The details of the model can be seen in Table 5-1 and a visualisation of the model is shown in Figure 5-1.

Table 5-1: Ebbsfleet 2016 model specifications

Name	Build date	1D node count	2D cell size	2D cell count	2D domain area	Model run time (hh:mm:ss)
Ebbsfleet 2016	2016	168	4m	107,272	1,707,141	01:24:02

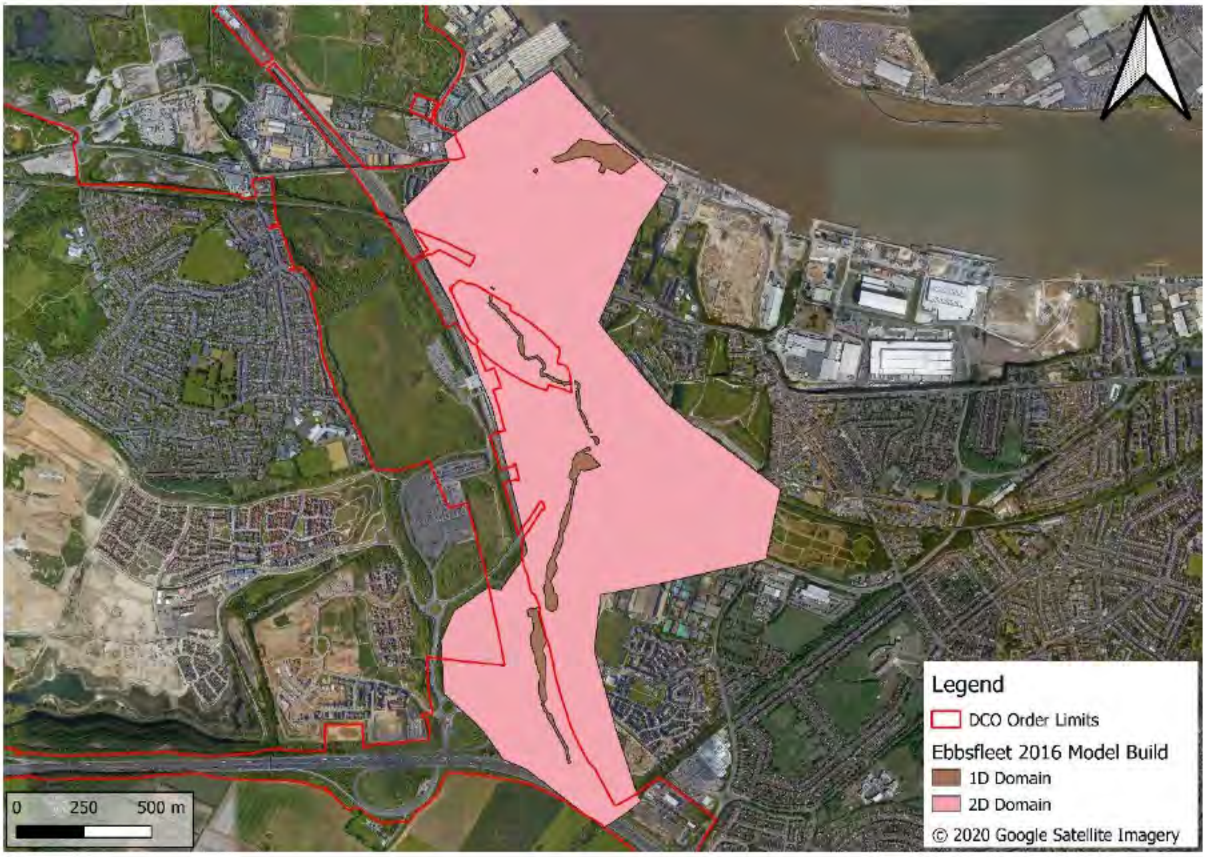

Figure 5-1: Ebbsfleet 2016 Model Build

5.3 Model runs

The following model runs were undertaken in order to understand the hydraulic characteristics of the London Resort Project Site at selected future epochs during selected storm intensities. The 1 in 25 and the 1 in 100 year runs were provided with the model. The future epoch 1 in 100 year model runs were developed and run as part of this analysis. The procedure is described below.

Table 5-2: Ebbsfleet Hydraulic Modelling Runs

Return Period Event	Climate Change	Future Epoch	Sea Level Rise
1 in 20 year	-	-	-
1 in 100 year	-	-	-
1 in 100 year	35%	2125	Higher Central
1 in 100 year	70%	2125	Upper End

5.4 Hydrology

The Ebbsfleet 2016 model has 5 inflow locations: three QTBDY units and two HTBDY units as shown on Figure 5-2 and detailed in Table 5-3.

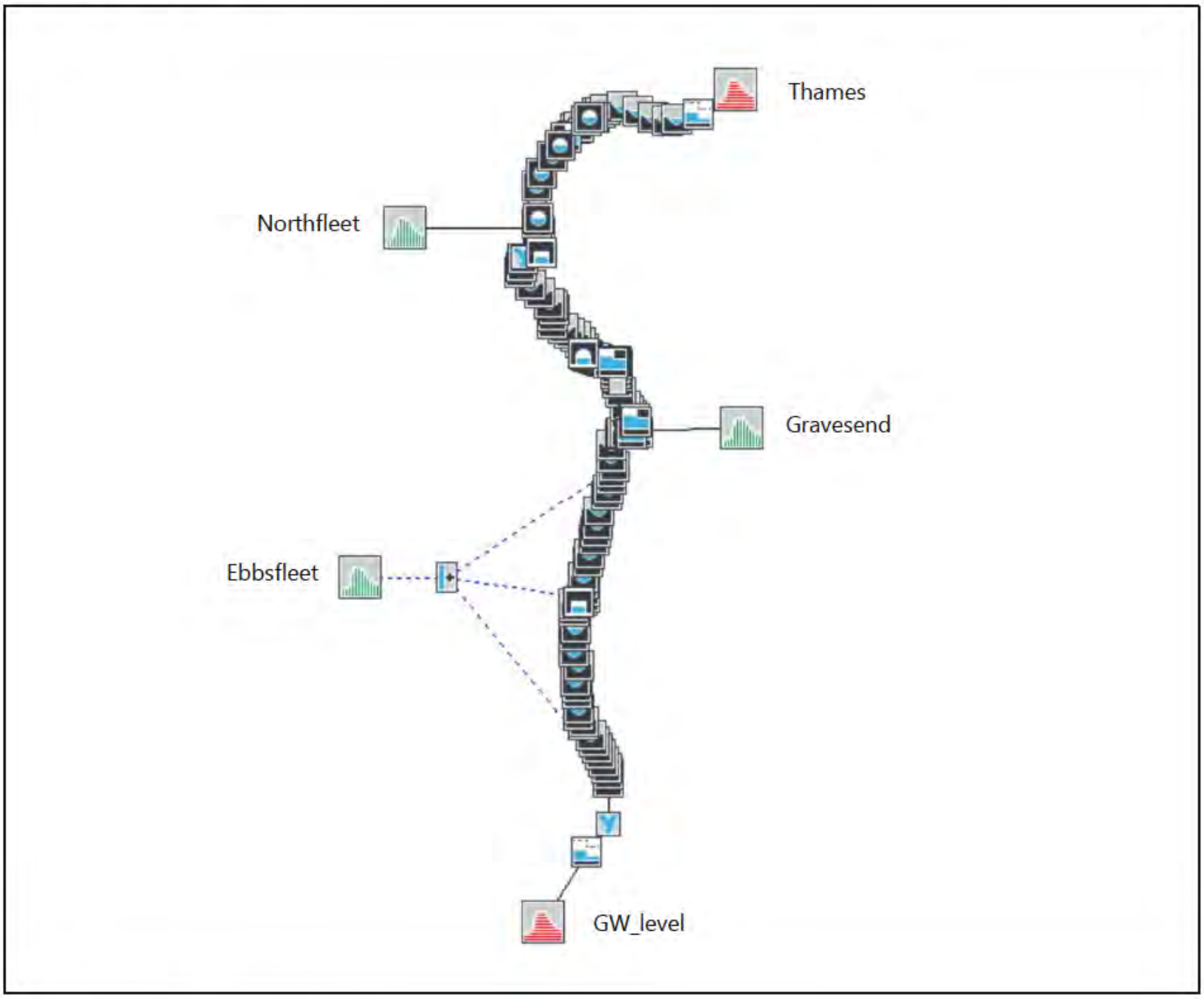

Figure 5-2: Ebbsfleet 2016 model hydrology

Table 5-3: Details of the Ebbsfleet 2016 1D inflow locations

ID	Description	Type	Comment
GW_level	40 Year groundwater event, as calculated using Norfolk probability method	HTBDY	A head time boundary representing a large groundwater catchment to the south of Springhead.
Ebbsfleet	-	QTBDY	A flow time boundary representing runoff from 2.76km² of the Upper Ebbsfleet, covering the springhead area.
Gravesend	-	QTBDY	A flow time boundary representing run off from 5.86km² of Gravesend West, covering the Northfleet Area.
Northfleet	-	QTBDY	A flow time boundary representing runoff from 2.19km² of Northfleet, covering the Swanscombe Area.

Thames	HAT @ Tilbury	HTBDY	The highest astronomical time (HAT) for the River Thames at Robins Creek as applied in 2005. The peak tidal curve is 3.98mAOD.

Details of the derivation of the inflows and further information on the groundwater analysis for the catchment to springhead can be found within the Ebbsfleet 2016 model documentation[6]. In the Ebbsfleet 2016 inflows are provided for the following return period storm events: 50%, 20%, 3.33%, 2%, 1%, 0.5%, 0.1%. The Ebbsfleet 2016 model also provides the following climate change scenarios: 1%plus25%CC, 1%plus35%CC, 1%plus70%CC.

The Ebbsfleet model does not provide any scenarios taking into account future sea level rise. Two tidal scenarios were added as part of this project that consider the impact of climate change: the 2125 epoch using the higher central sea level rise predictions, and the 2125 epoch using the upper end sea level rise predictions. The latest sea level rise guidance is shown Table 5-4.

Table 5-4: UKCP18 Sea level rise guidance (mm/year)

UKCP18					
Area of England	**Allowance**	**2000 to 2035**	**2036 to 2065**	**2066 to 2095**	**2096 to 2125**
South East	Higher Central	5.7	8.7	11.6	13.1
South East	Upper End	6.9	11.3	15.8	18.2

The appropriate sea level rise was added to the Tilbury HAT tidal boundary in order to generate the future epoch tidal levels as shown in Figure 5-3. The maximum tidal level for the 2125 higher central projection scenario is 4.70mAOD. The maximum tidal level for the 2125 upper end projection scenario is 5.47mAOD.

[6] Flood Map Improvements: Ebbsfleet, Modelling Report. March 2015. Environment Agency (Capita URS)

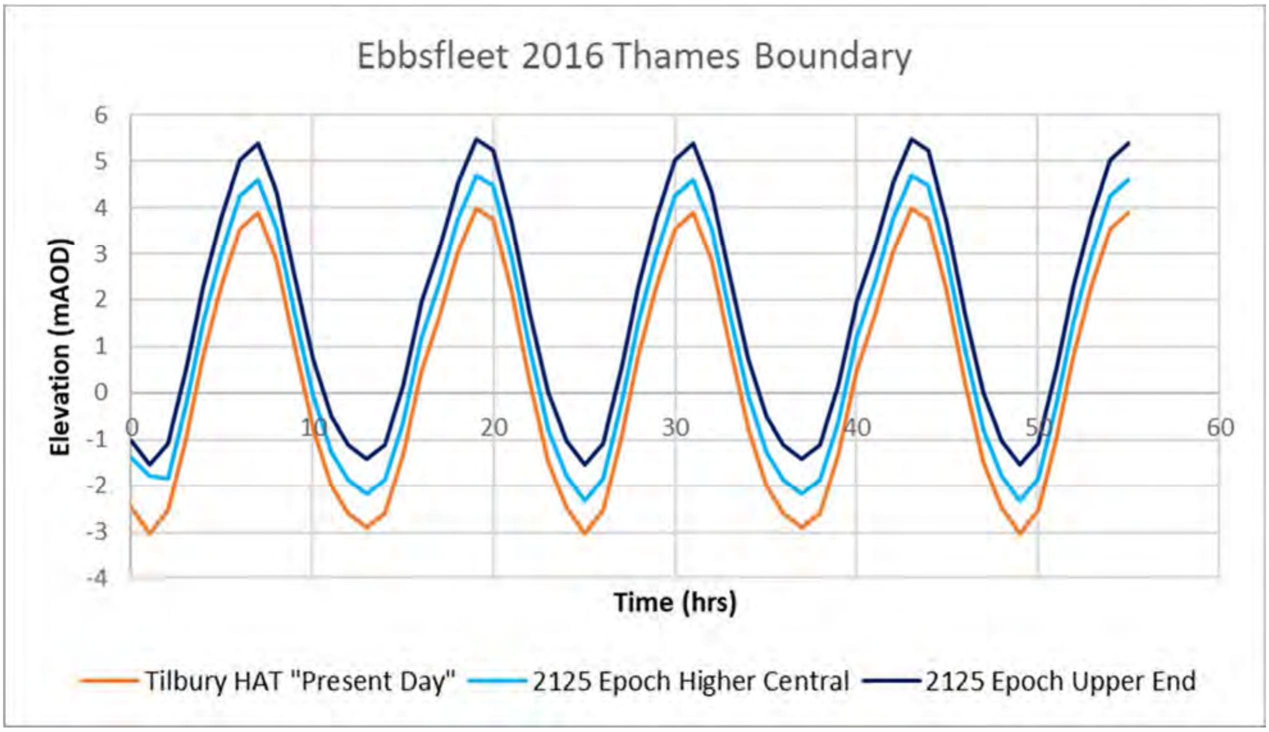

Figure 5-3: Ebbsfleet 2016 Thames Boundary future epochs

5.5 Analysis

The baseline model results are shown below. It can be seen that there is little variety in extent between the events considered. The main location where the extent changes significantly is around Sawyers Lake and to the south of Sawyers Lake, both locations are outside of the Order Limits.

Figure 5-4: Ebbsfleet 2016 model results extents for the 1 in 20 year return period event (left) and the 1 in 100 year return period event (right)

Figure 5-5: Ebbsfleet 2016 model results extents for the 1 in 100 year return period event with 35% climate change 2125 future epoch using higher central sea level rise projections (left) and 1 in 100 year return period event plus 70% climate change 2125 future epoch using Upper End sea level rise projections (right)

There are two locations where the Ebbsfleet flood extent covers parts of the Order Limits. These locations are reviewed more closely in the image below. The maximum water levels for the spot checks indicated are shown in Table 5-5. This information is provided to WSP for the design of the Access Road and development within this area of the Order Limits.

Table 5-5: Maximum water level at each of the spot check locations within the Order Limits

Node ID	1 in 20 year	1 in 100 year	1 in 100 year plus 35% CC 2125 HC	1 in 100 year plus 70% CC 2125 UE
Spot Check 1	3.03	3.22	3.45	3.56
Spot Check 2	3.08	3.25	3.47	3.59

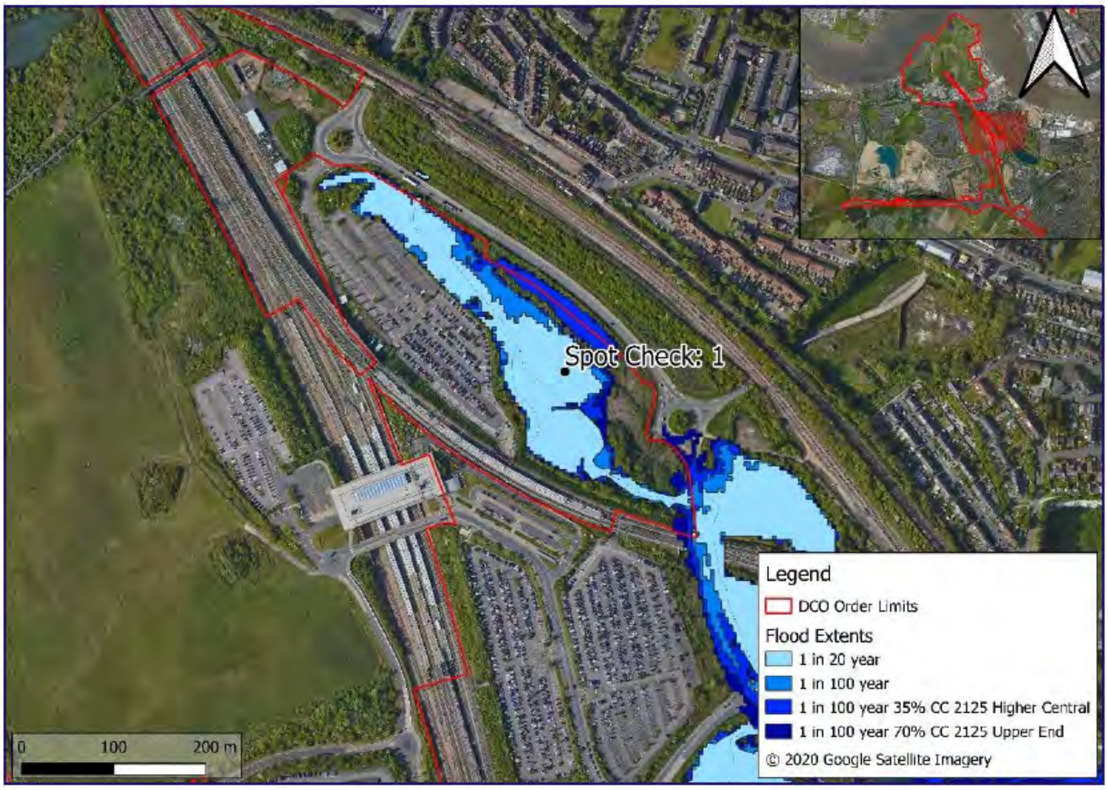

Figure 5-6: Ebbsfleet 2016 model flood result extents within the Order Limits

Figure 5-7: Ebbsfleet 2016 model flood result extents within the Order Limits

6 Conclusion

6.1 Summary

The London Resort Proposed Development is at risk at both the Kent Project Site (Main Resort) and the Essex Project Site from the overtopping and breach of the Thames Flood defences.

Overtopping flood risk at the Kent Project Site (Main Resort) enter the Order Limits from both the east and the west via the two marsh areas. This flooding occurs in events greater than the 1 in 200 year 2090 future epoch using the higher central climate change projections. Breach flood risk to the Kent Project Site (Main Resort) has been identified to be greatest when the breach is in the flood defences at Black Duck Marsh along the western edge of the Proposed Development. A breach in the flood defences at this location causes significant flood risk to the Kent Project Site (Main Resort) at relatively low return period storm events.

The Proposed Development reduces the flood risk to the Kent Project Site (Main Resort) by preventing overtopping of the flood defences to the west of the Swanscombe peninsula along Black Duck Marsh and by restricting to a degree flooding from the east of the Swanscombe peninsula to Botany Marsh. With the Proposed Development in place the flood risk to the Kent Project Site (Main Resort) is only present for the 1 in 1000 year 2125 future epoch event using the higher central climate change and any event greater than this. The Proposed Development has a reduced impact on the flood risk to the Kent Project Site (Main Resort) from a breach in the flood defences. However, in both the breach and the overtopping scenarios the Proposed Development does not increase flood risk to offsite locations.

Overtopping flood risk at the Essex Project Site overtops the flood defences south west of the Order Limits. The Essex Project Site is subject to flooding for events greater than the 1 in 200 year event 2125 future epoch using the higher central climate change projections. At the Essex Project Site there is no change to the flood risk with the Proposed Development in place. Analysis of the overtopping results and the breach results indicate that there is some increase in offsite flood extents and depths as a result of the Proposed Development if the buildings are constructed as traditional fully enclosed structures. However, if large openings are allowed for in the structures, allowing floodwater to flow through as it would currently, only negligible changes in flood levels and extents are obsereved in areas outside of the Order Limits, and localised changes at the Proposed Development.

The London Resort Proposed Development is also at risk at the Kent Project Site (Access Road) from fluvial flood events in the Ebbsfleet Valley. Analysis of the Ebbsfleet 2016 model results have provided flood extents and maximum water levels that are generated in the Order Limits as a result of both present day and future epoch storm scenarios. The data generated by this model of the scale of the flood risk posed to the Proposed Development by the River Ebbsfleet was provided to WSP for inclusion in the Access Road Design, to ensure flood risk to the Site and elsewhere is minimised.

6.2 Conclusion

This hydraulic modelling report has been prepared as an appendix to the Flood Risk Assessment (FRA) prepared by Buro Happold to support the Development Consent Order (DCO) application for the London Resort.

The results and analysis in this report indicates that the Proposed Development improves the flood resilience of the Kent Project Site (Main Resort) from overtopping scenarios up to 2125 without causing an increase in the flood extents offsite. The Proposed Development does not change the flow paths across the Kent Project Site (Main Resort) in the breach scenario and therefore does not result in any offsite changes in extent for the breach scenarios.

At the Essex Project Site with appropriate design of the Proposed Development, flood extent and depths are not increase in offsite areas and the risk to the development is also low.

At the Kent Project Site (Access Road) The Order Limits are impacted by the flood extents for the River Ebbsfleet Fluvial system. The information is used to design and support the Kent Project Site (Access Road) development.

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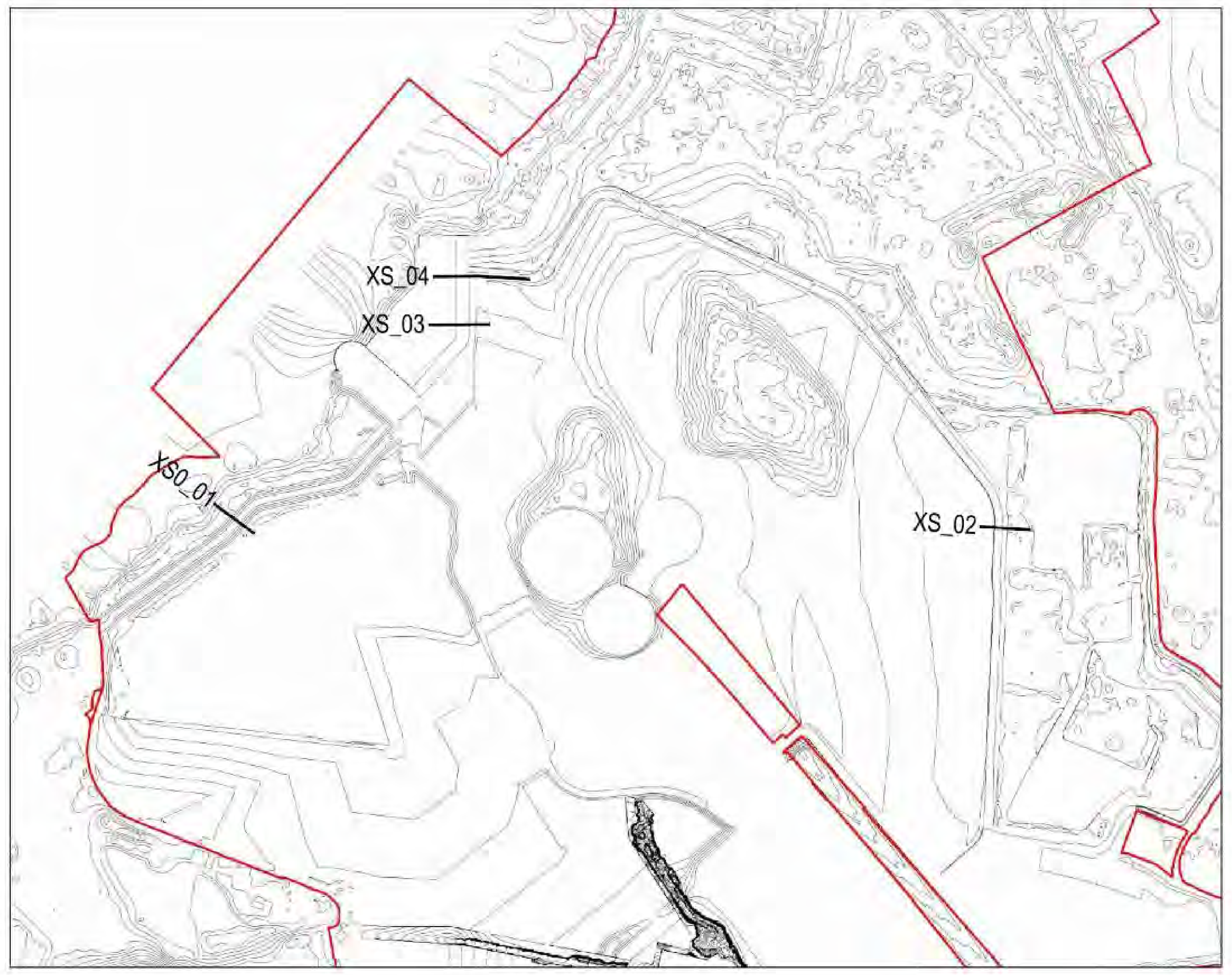
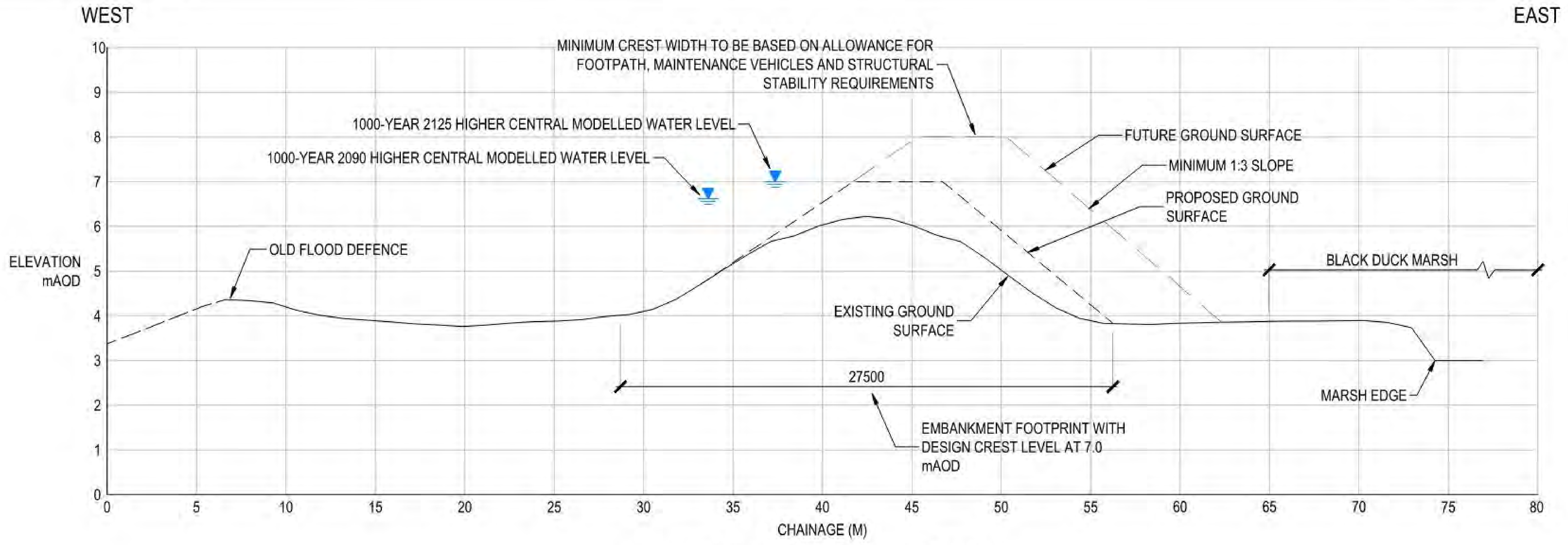
APPENDIX D – Flood Defence Schematic Drawings

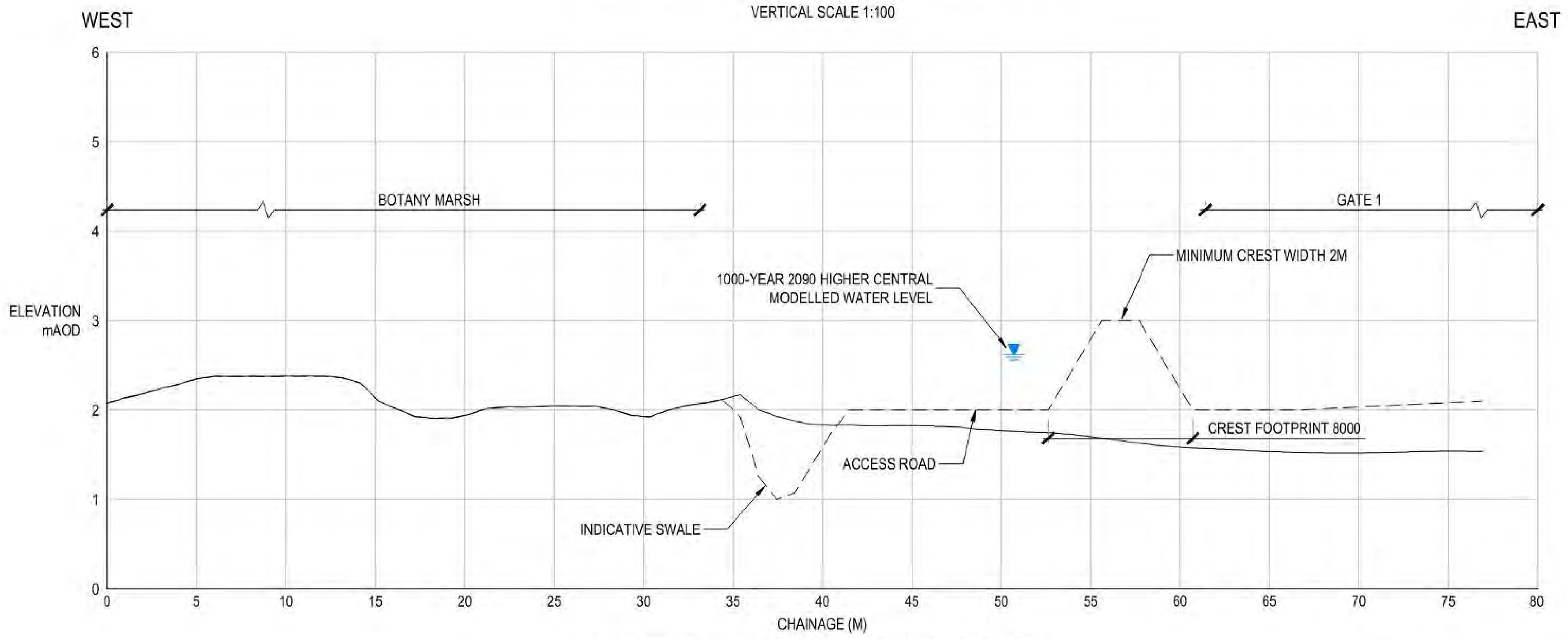
FOR CONSULTATION PURPOSES



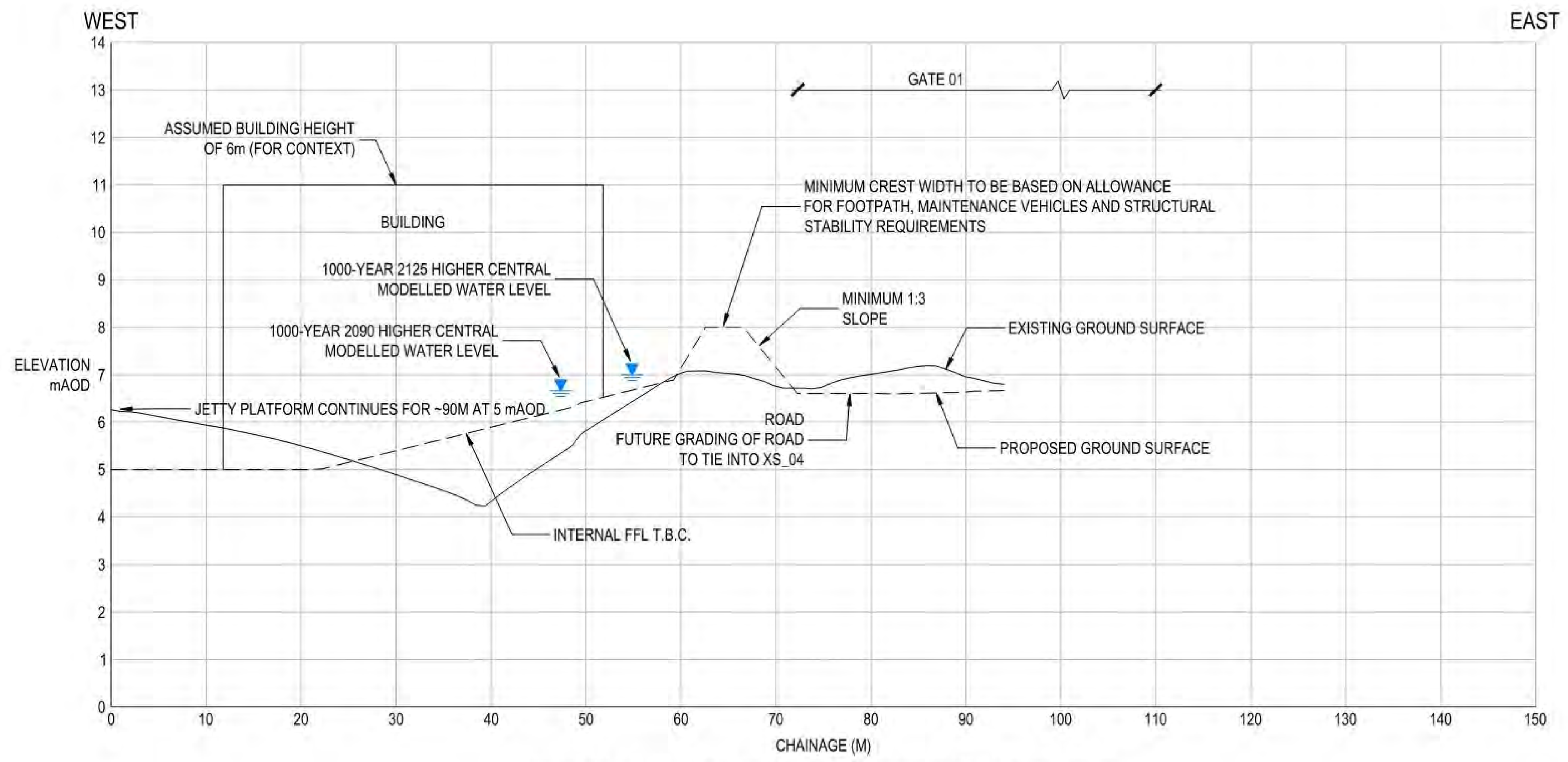
REF. DRAWING NO.S LR-DS-BUR-DCP-174.0 & LR-DS-BUR-DCP-174.1



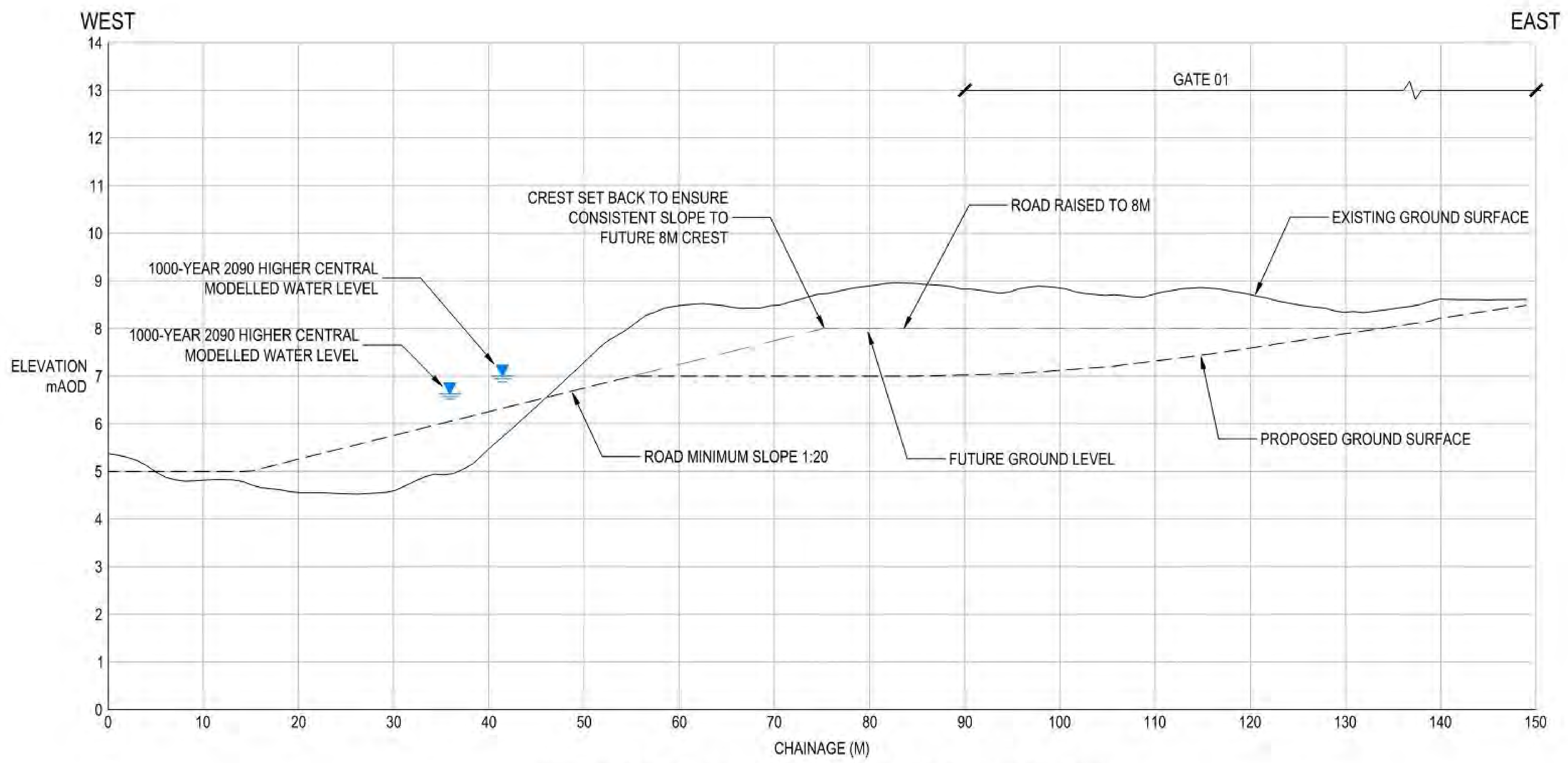
SECTION XS_01 - SCHEMATIC OF PROPOSED REALIGNMENT OF EXISTING FORMAL FLOOD DEFENCE
HORIZONTAL SCALE 1:250
VERTICAL SCALE 1:100



SECTION XS_02 - SCHEMATIC OF PROPOSED NEW SECONDARY FLOOD DEFENCE
HORIZONTAL SCALE 1:250
VERTICAL SCALE 1:50



SECTION XS_03 - SCHEMATIC OF PROPOSED REALIGNMENT OF EXISTING FORMAL FLOOD DEFENCE
HORIZONTAL SCALE 1:500
VERTICAL SCALE 1:100



SECTION XS_04 - SCHEMATIC OF PROPOSED REALIGNMENT OF EXISTING FORMAL FLOOD DEFENCE AT ACCESS ROAD
HORIZONTAL SCALE 1:500
VERTICAL SCALE 1:100

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Project | Project No.

Rev	Reason for Issue	Date	Drw | Chk
P01	Information	04.11.20	NG | HM

THE LONDON RESORT DEVELOPMENT CONSENT ORDER

Schematic Cross Sections of Proposed Flood Defences

Sheet 1 of 1

Application Number
BC080001

Drawing Reference

Scale | Sheet: | Revision

APPENDIX E – High Resolution Images

BURO HAPPOLD

London Resort

Flood Risk Assessment – Appendix E High Resolution Figures

[Category]

24 December 2020

Revision 00

Revision	Description	Issued by	Date	Checked
00	Issue for DCO Submission	HM	24/12/20	BUR/LRCH

https://burohappold.sharepoint.com/sites/042936/Shared Documents/F34 Water/03 Reports/201218_FINAL_ES_CHAPTER-APPENDICES/Appendix 17.1 - FRA/SS-High Res and Word/FRA/201208 HM 0042936 The London Resort - Stage II Flood Risk Assessment 00 - High Res Figures.docx

Client name [Company]

[Author]

1 Introduction

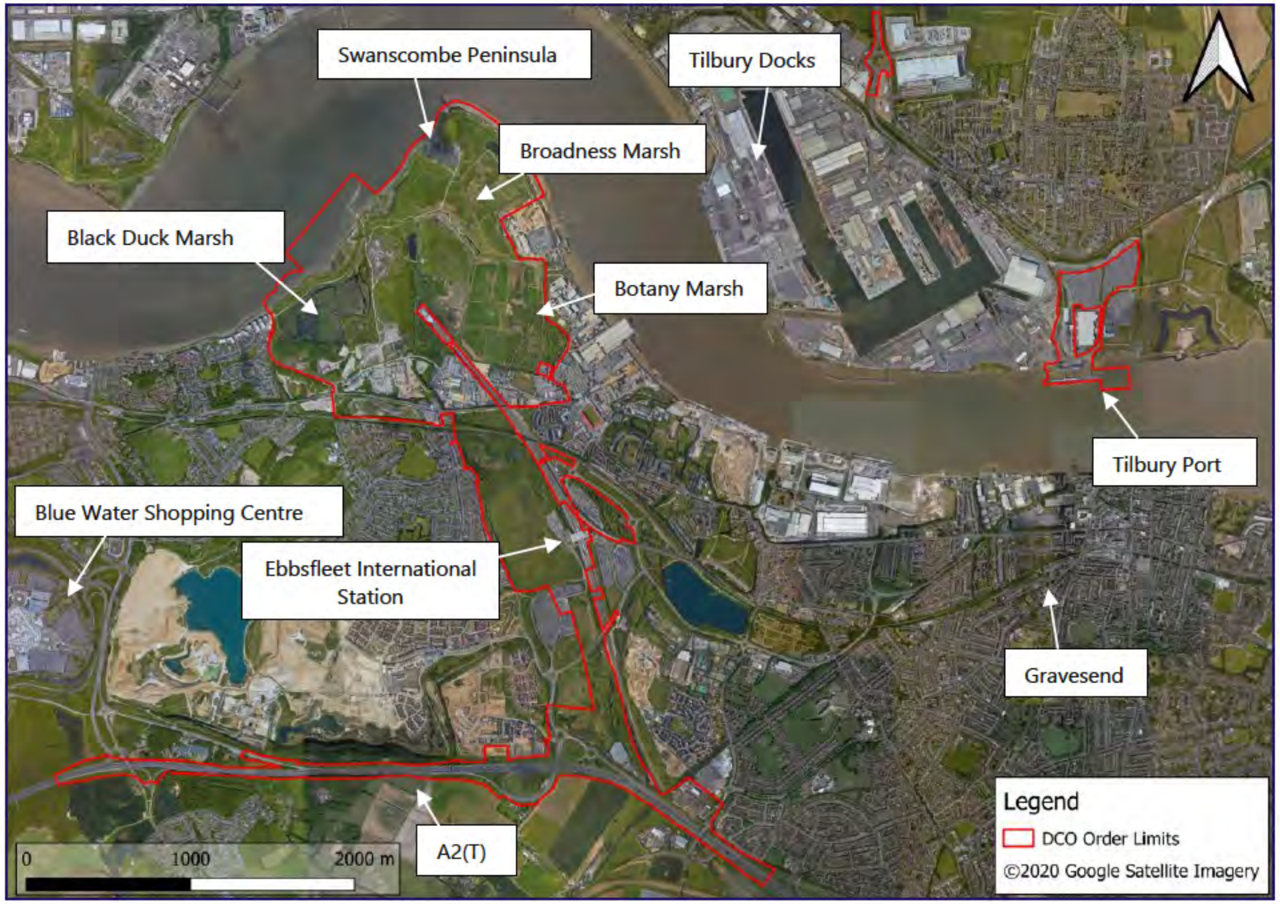


Figure 1-1: DCO Order Limits shown in red and key places identified.

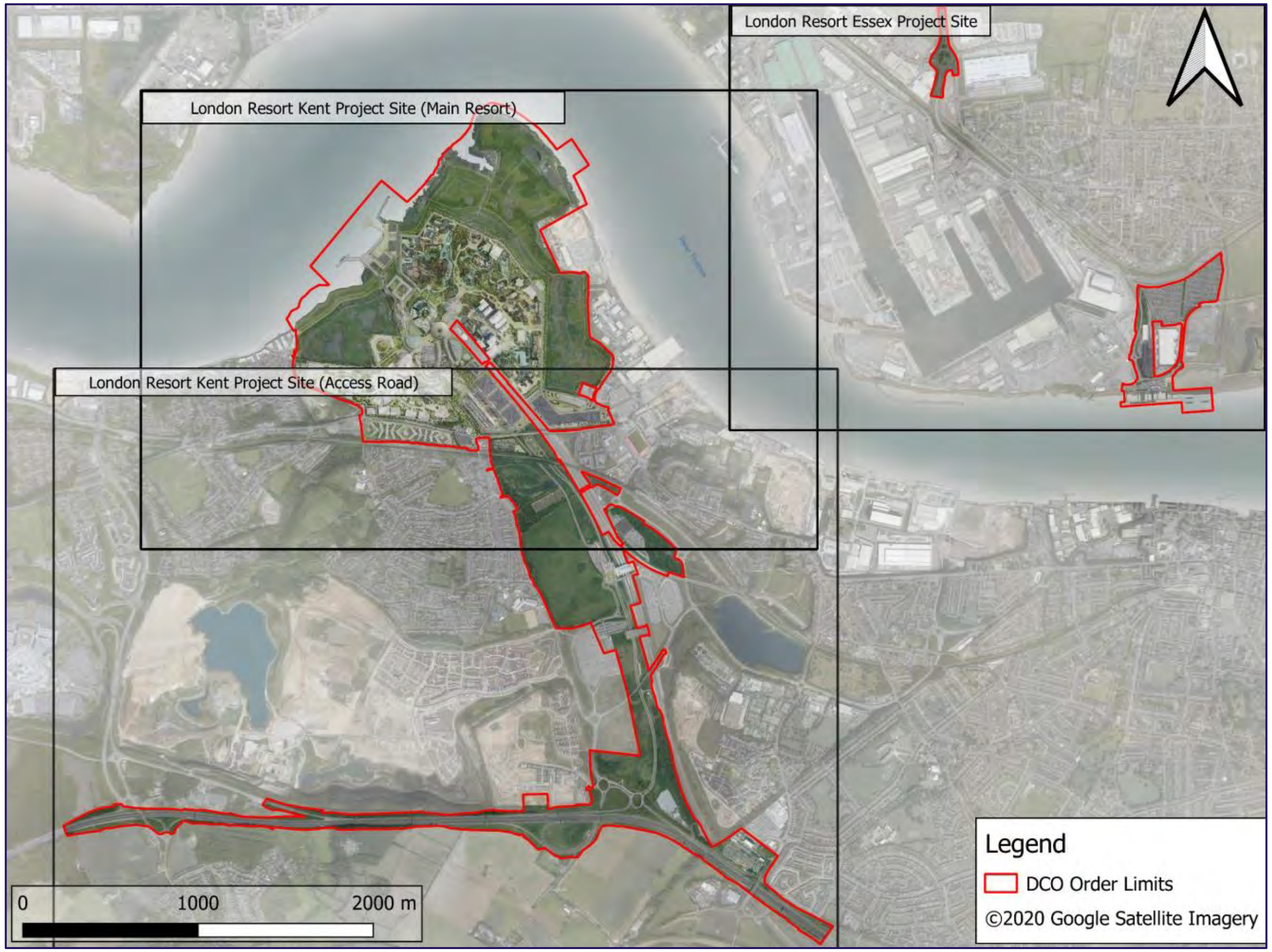


Figure 1-2: The London Resort Project Site

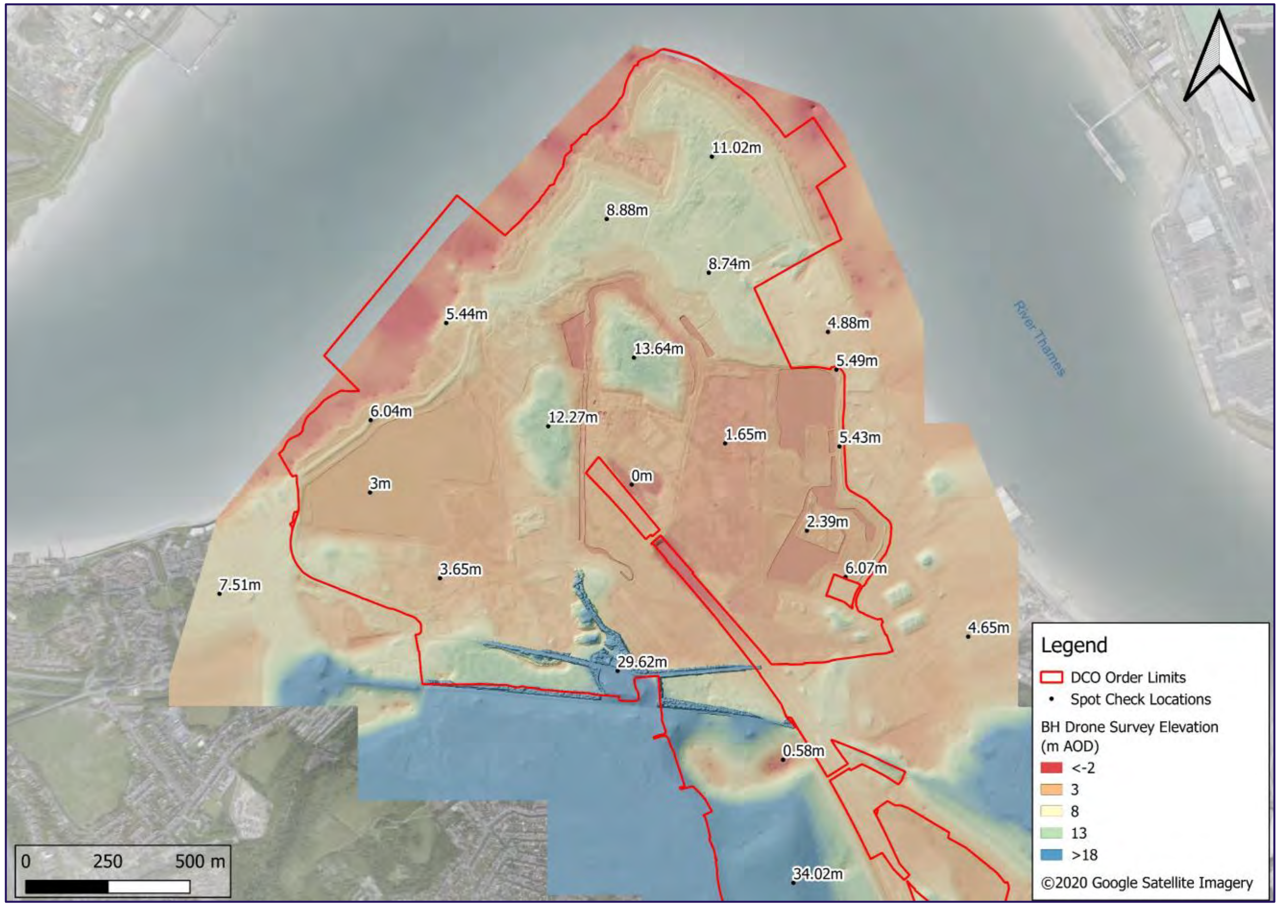


Figure 1-3: Existing flood defence alignment and crest levels for the Kent Project Site (Main Resort) taken from EA data with spot elevations from topographic survey flown July 2020.

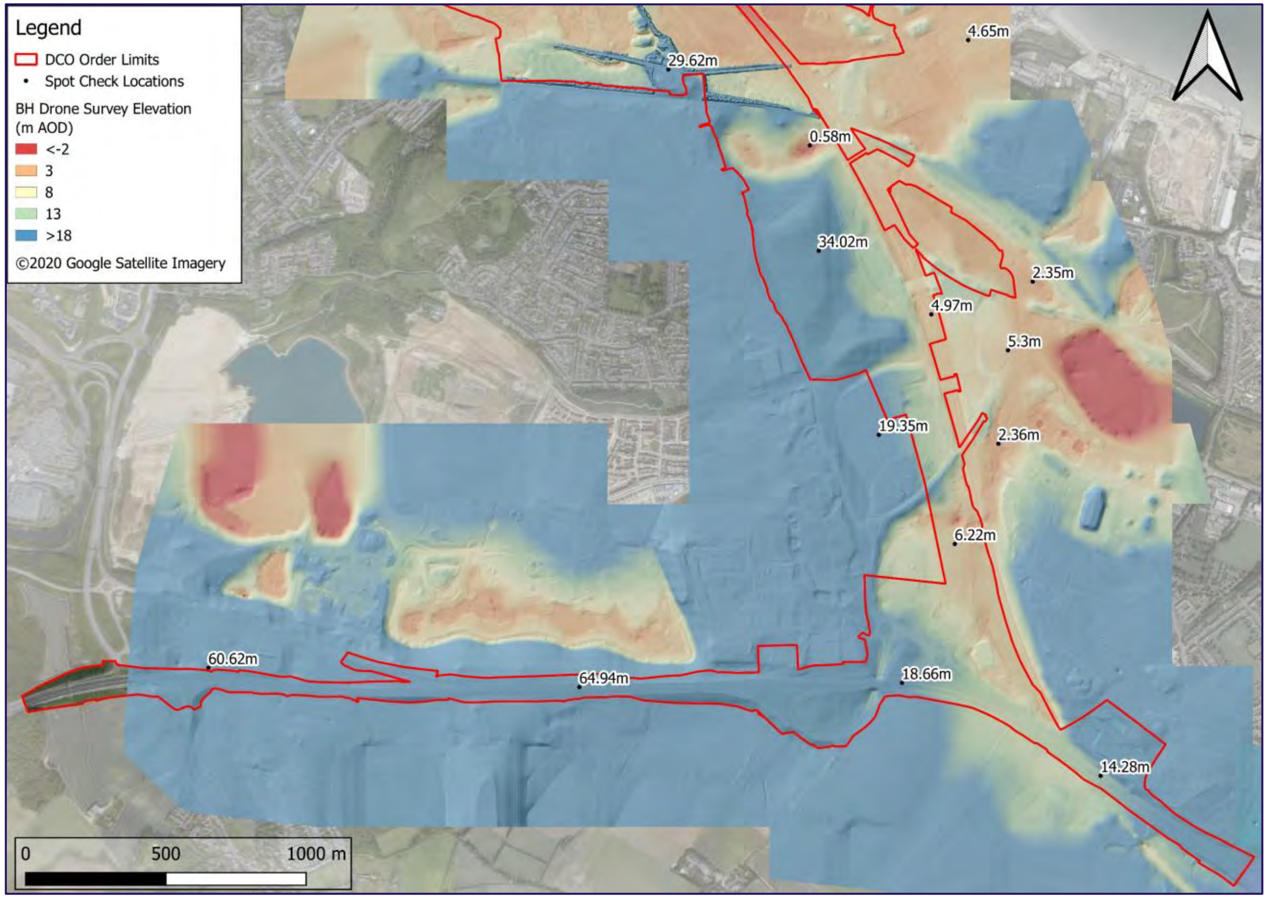


Figure 1-4: Existing flood defence alignment and crest levels for the Kent Project Site (Access Road) taken from EA data with spot elevations from topographic survey flown July 2020.

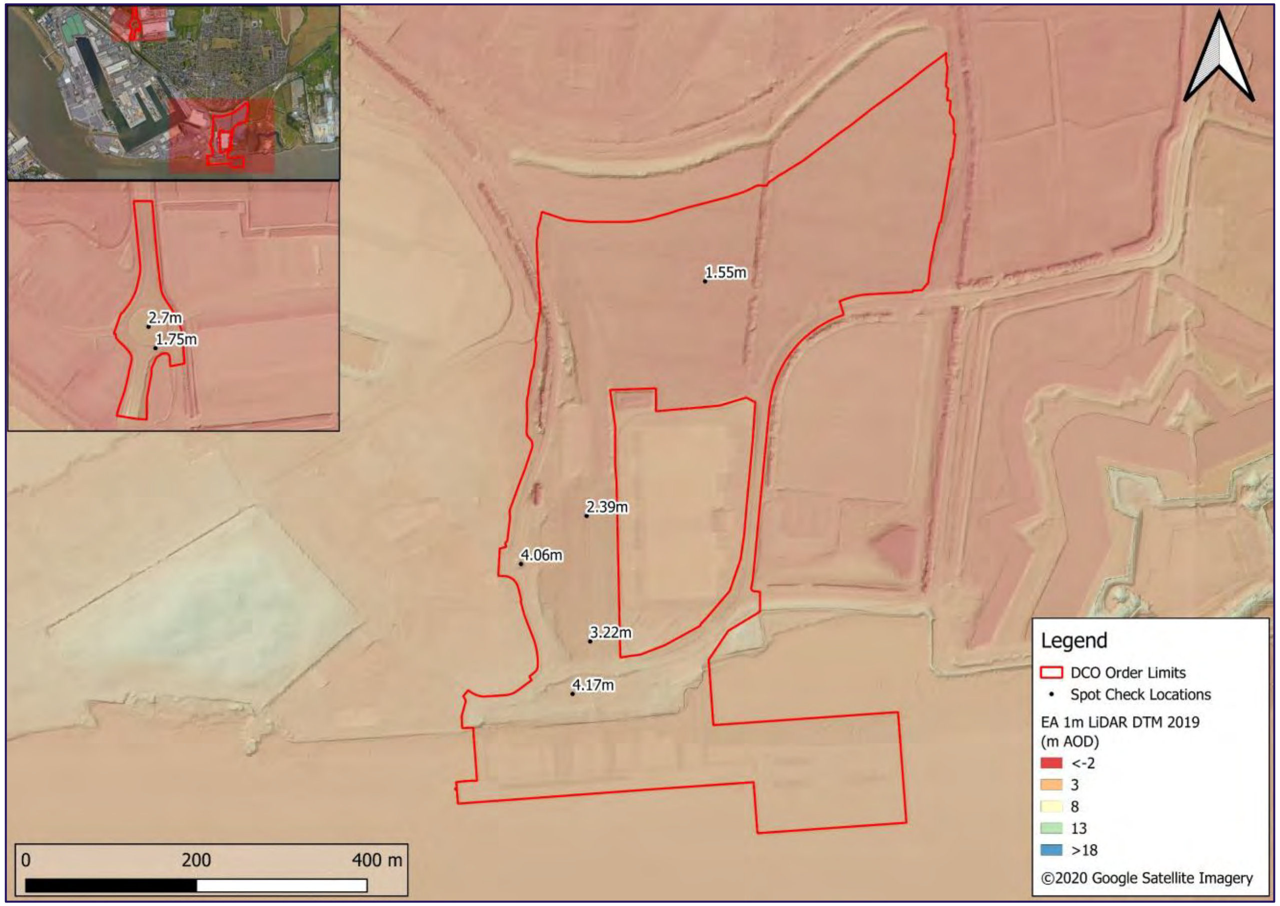


Figure 1-5: Existing flood defence alignment and crest levels taken from EA data and spot elevations of existing land levels taken from 1m LiDAR 2019 for the Essex Project Site.

2 Planning Context

Figure 2-1 Proposed Development components of the Kent Project Site (Main Resort) and their vulnerability classifications

Figure 2-2: Proposed Development components of the Kent Project Site (Access Road) and their vulnerability classifications.

Figure 2-3 Proposed development components of the Essex Project Site and their vulnerability classifications

Figure 2-4: Thames Estuary modelling key 1D node locations

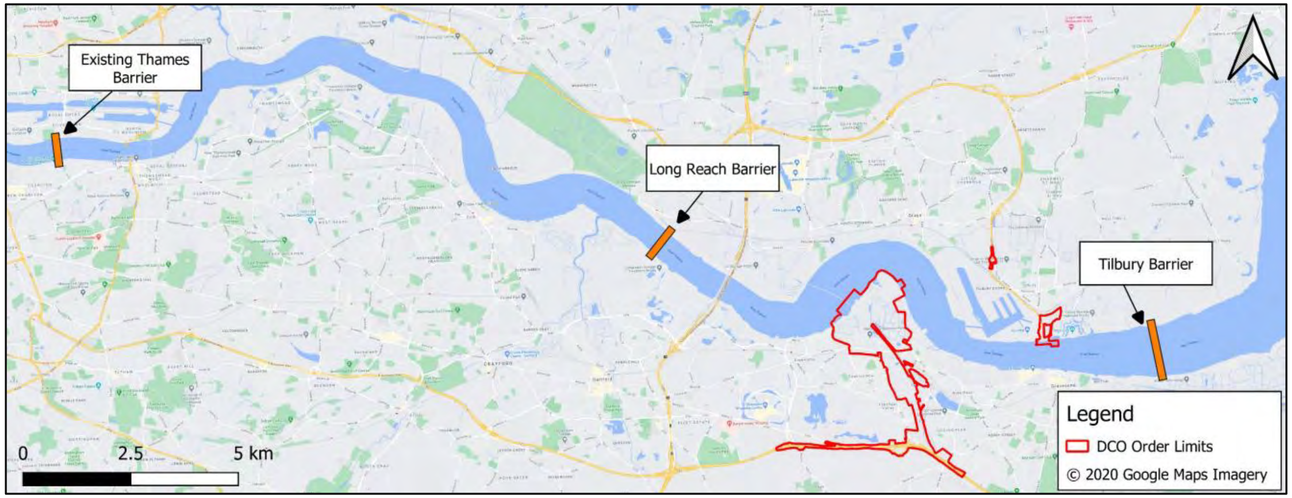


Figure 2-5: TE2100 proposed Thames Barrier improvement locations (Existing Barrier is Option 1.4; Tilbury Barrier is Option 3.1; Long Reach Barrier is Option 3.2)

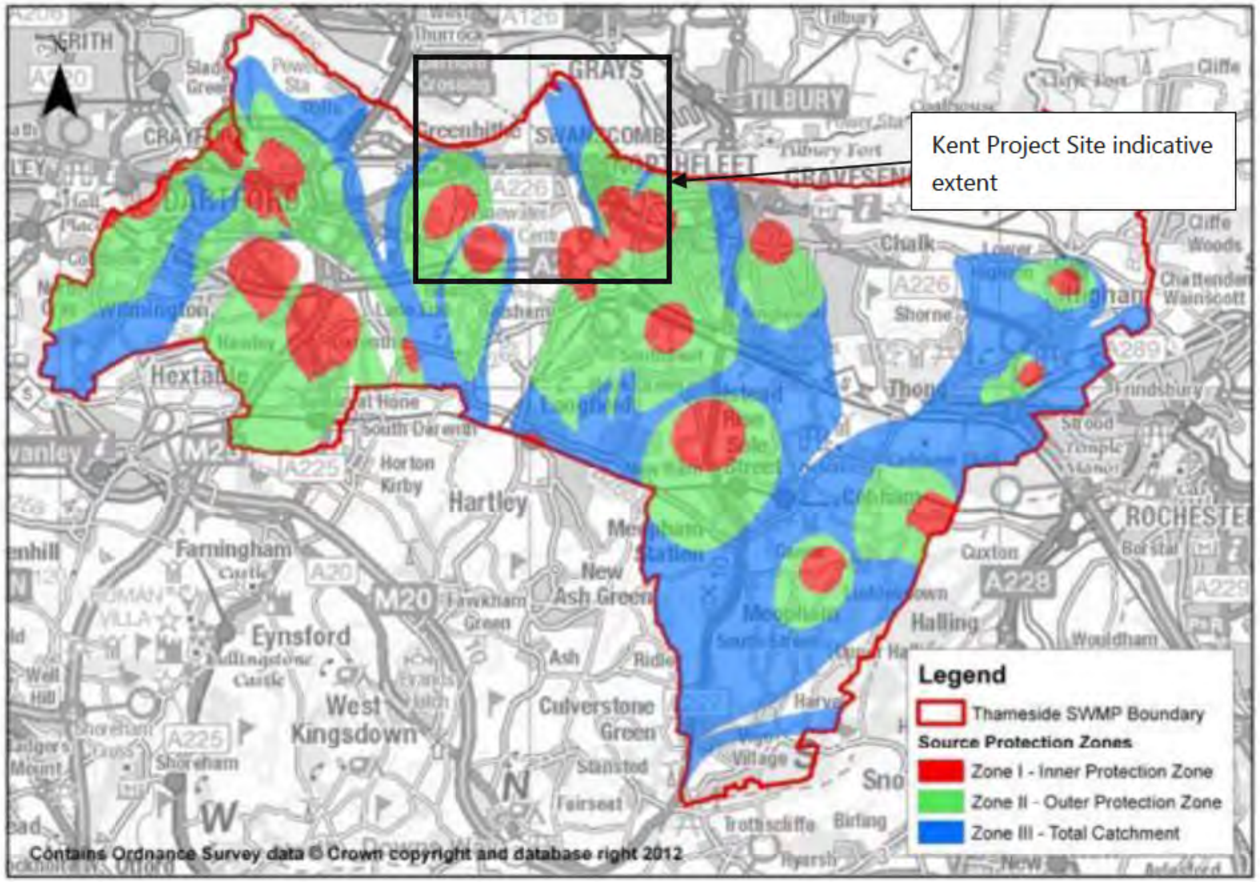
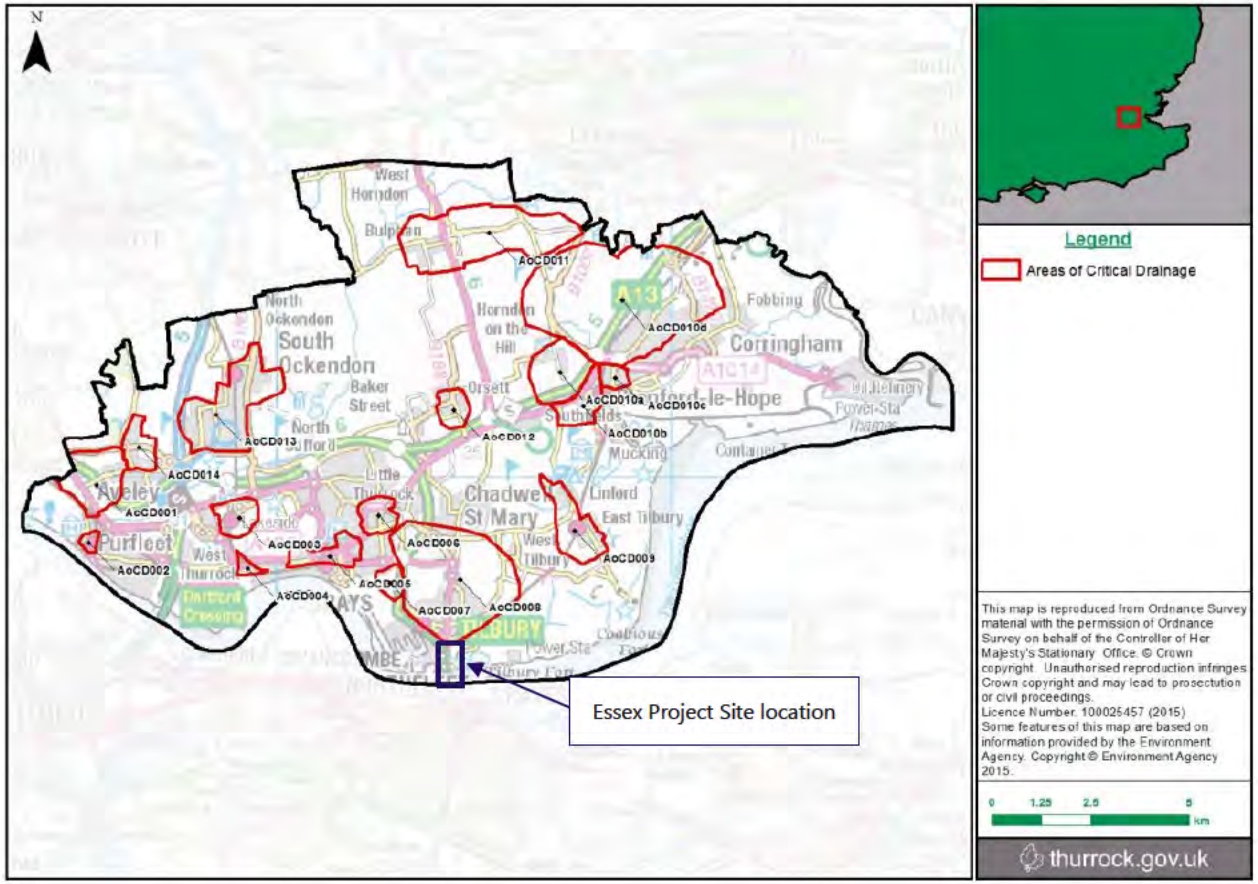


Figure 2-6: Kent Groundwater Protection Zones (adapted from an image in the Kent County Council SWMP (12/10/2020)

Figure 2-7: Thurrock Council Areas of Critical Drainage (Thurrock Local Flood Risk Management Strategy, Thurrock Council, December 2015)



3 Appraisal and Management of Flood Risk – Kent Project Site (Main Resort)

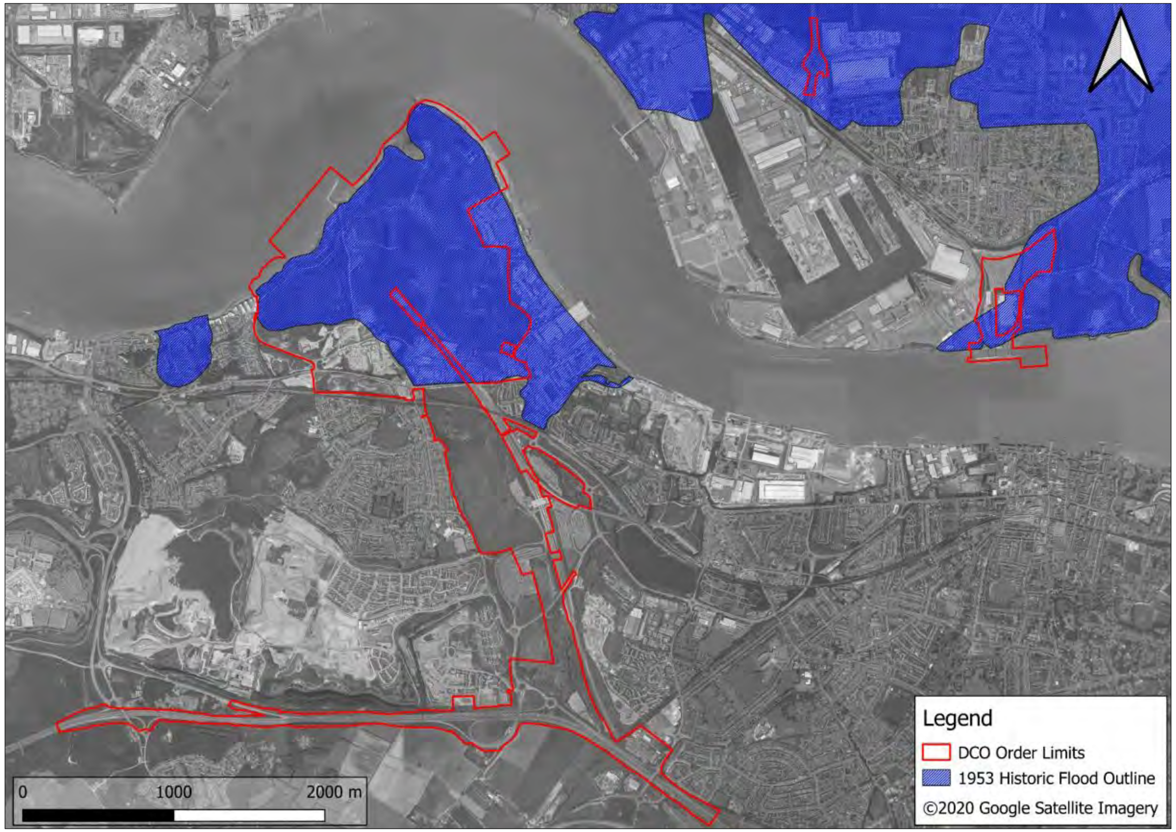


Figure 3-1: Historic Flood Map (1953) downloaded from data.gov.uk[1] (accessed on 24/06/2020).

[1] https://data.gov.uk/dataset/76292bec-7d8b-43e8-9c98-02734fd89c81/historic-flood-map

4 Appraisal and management of flood risk – Kent Project Site (Access Road)

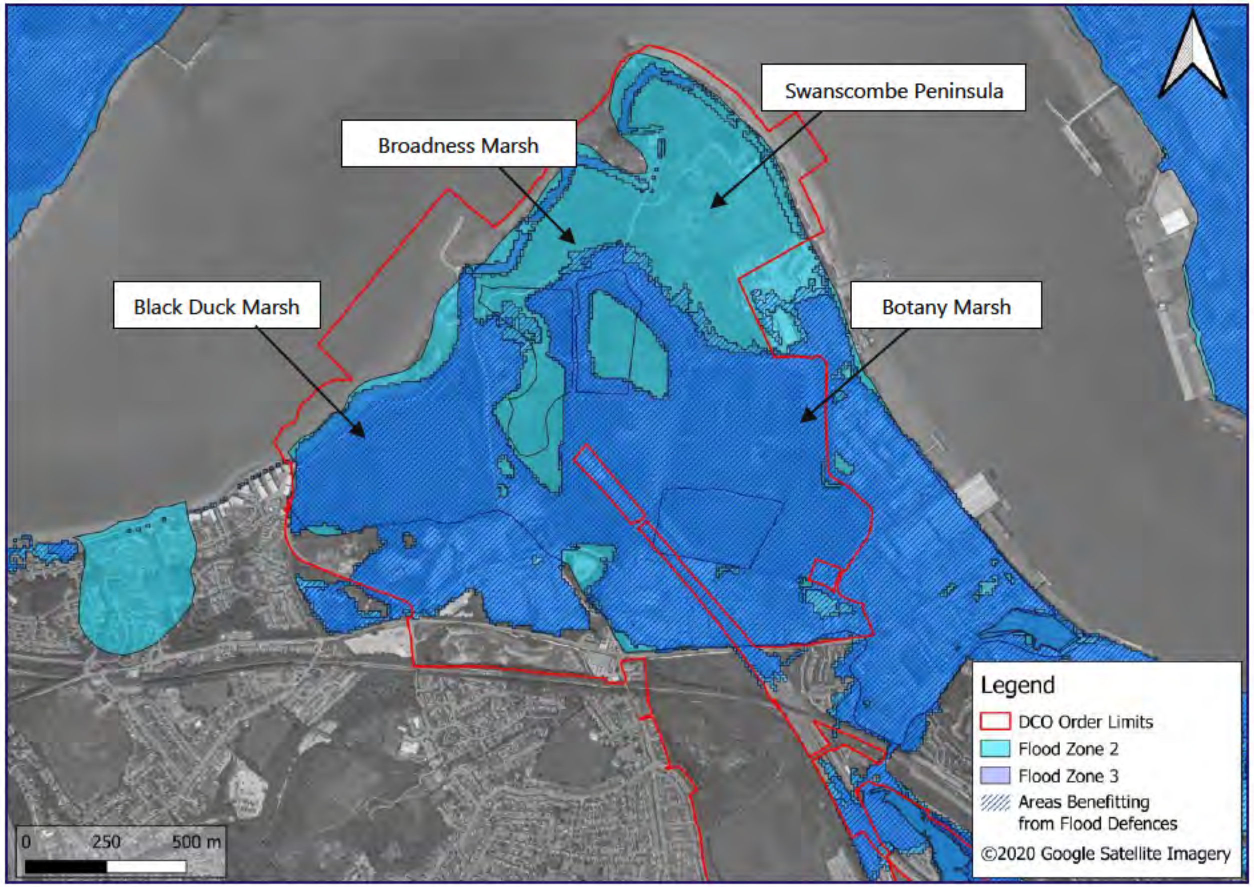


Figure 4-1: EA flood map showing Flood Zones 1, 2 and 3, illustrating fluvial and tidal flood risk to the Kent Project Site (Main Resort) if defences were not in place.

Figure 4-2: Kent Project Site (Main Resort) existing flood defence alignment, type and crest elevation as defined by the data supplied by the EA.

Figure 4-3: Kent Project Site (Main Resort) existing formal flood defences at Black Duck Marsh (photograph taken during site visit 28/07/20, looking southwest). Black Duck Marsh to the left side of photograph and the old flood defence embankment alignment on the right side.

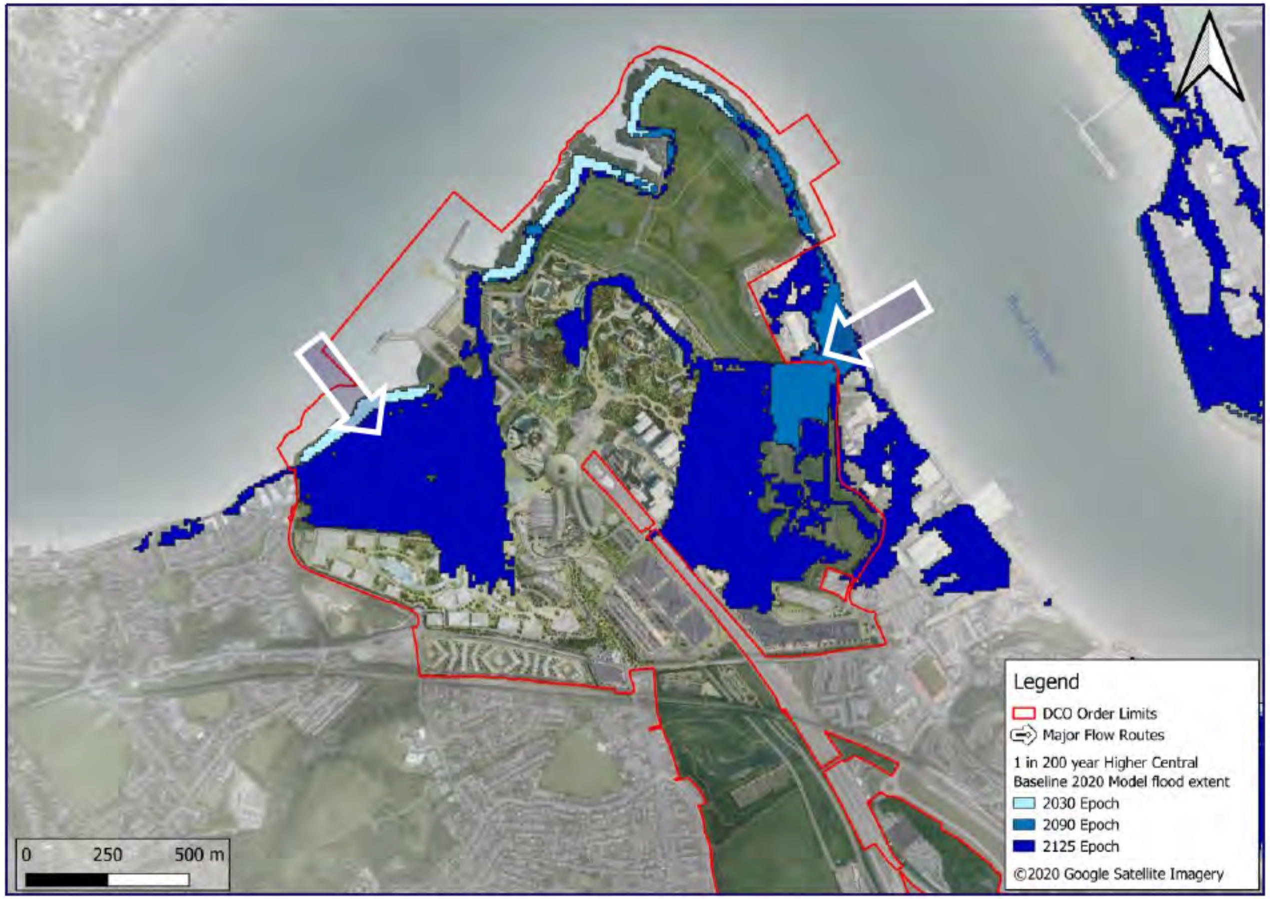


Figure 4-4: Kent Project Site (Main Resort) baseline overtopping flood extents for the 1 in 200 year return period event using the higher central climate change projections across different years, key flow paths indicated by the arrows.

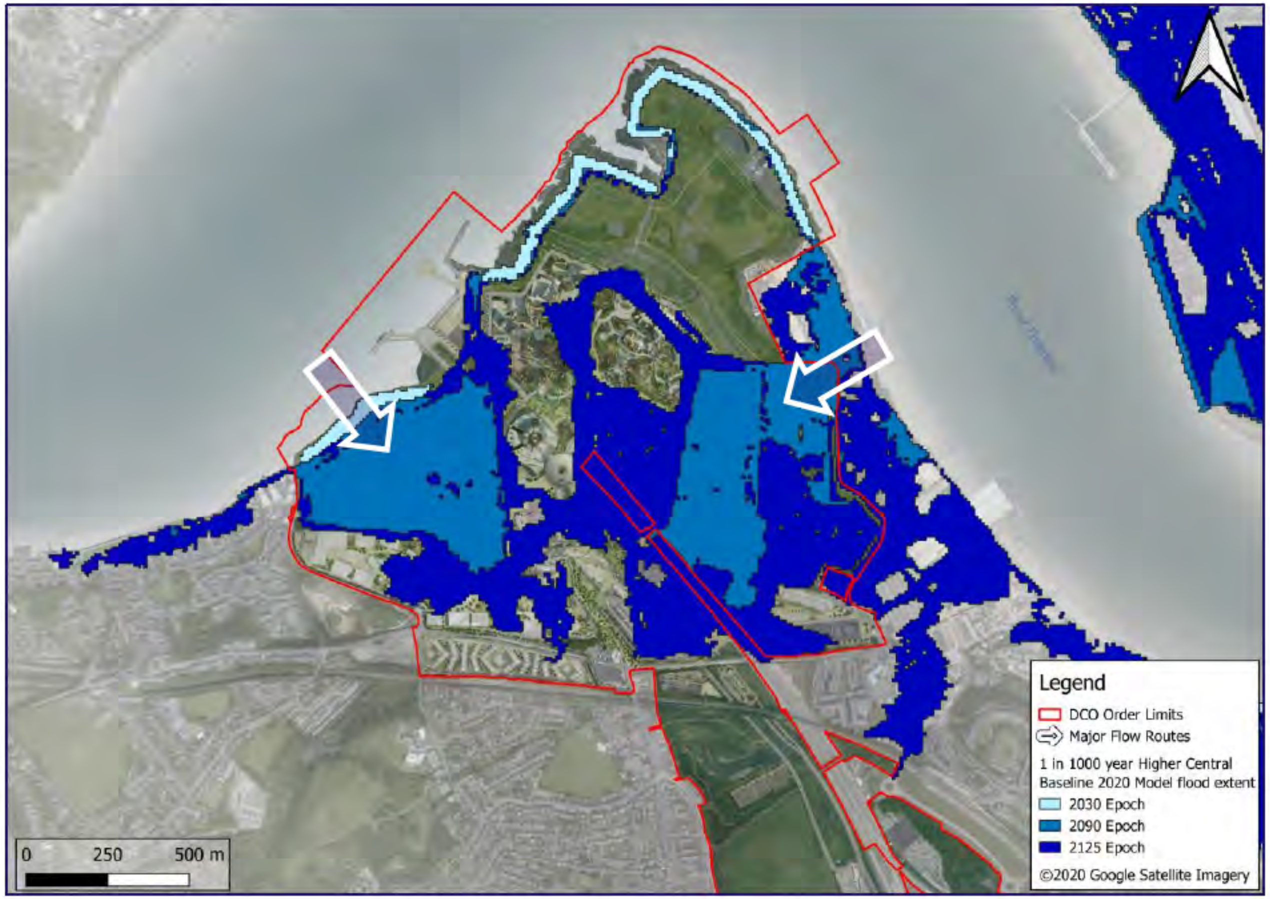


Figure 4-5: Kent Project Site (Main Resort) baseline overtopping flood extents for the 1 in 1000 year return period event using the higher central climate change projections across different years, key flow paths indicated by the arrows.

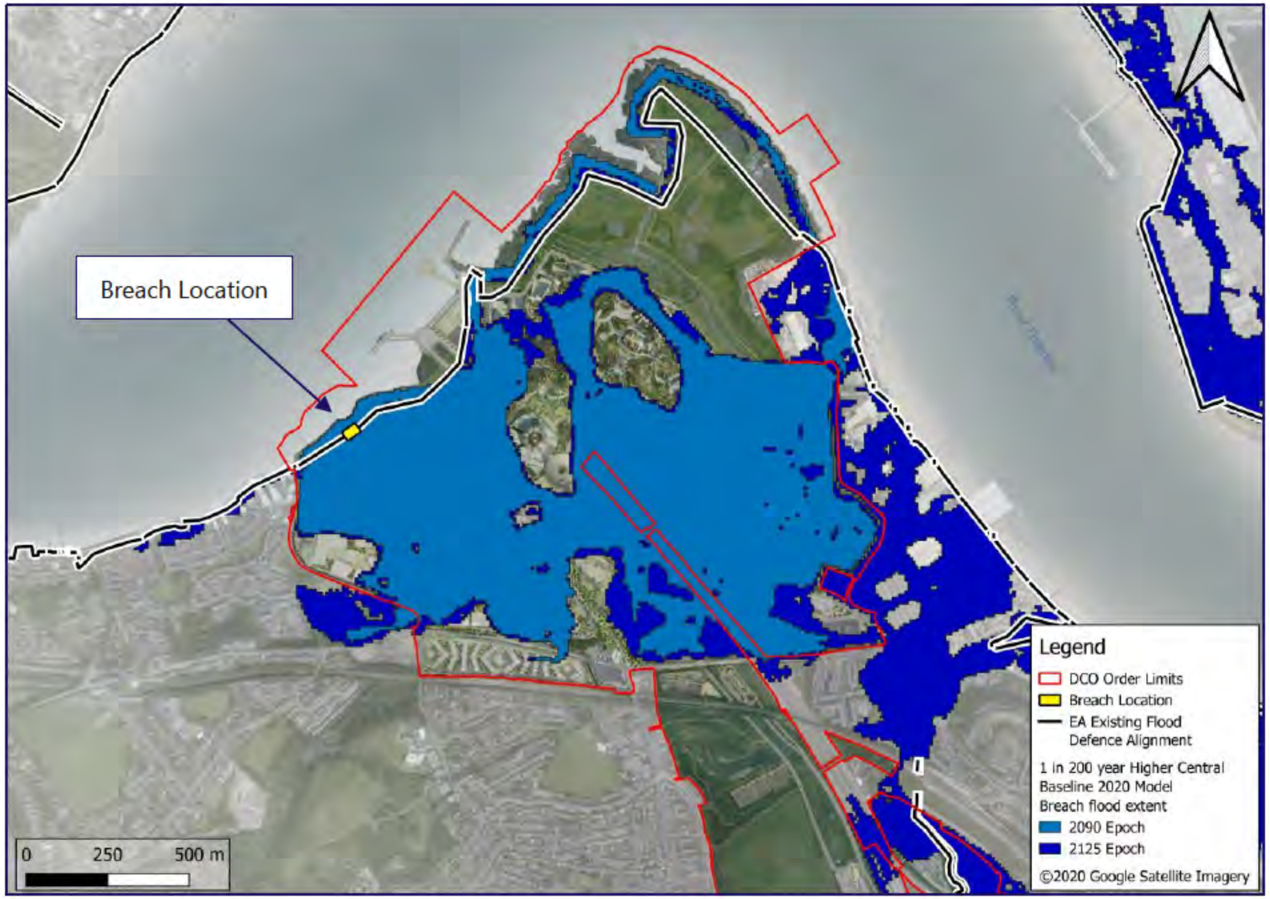


Figure 4-6: Kent Project Site (Main Resort) baseline breach flood extents for the 1 in 200 year return period event using the higher central climate change projections across different years.

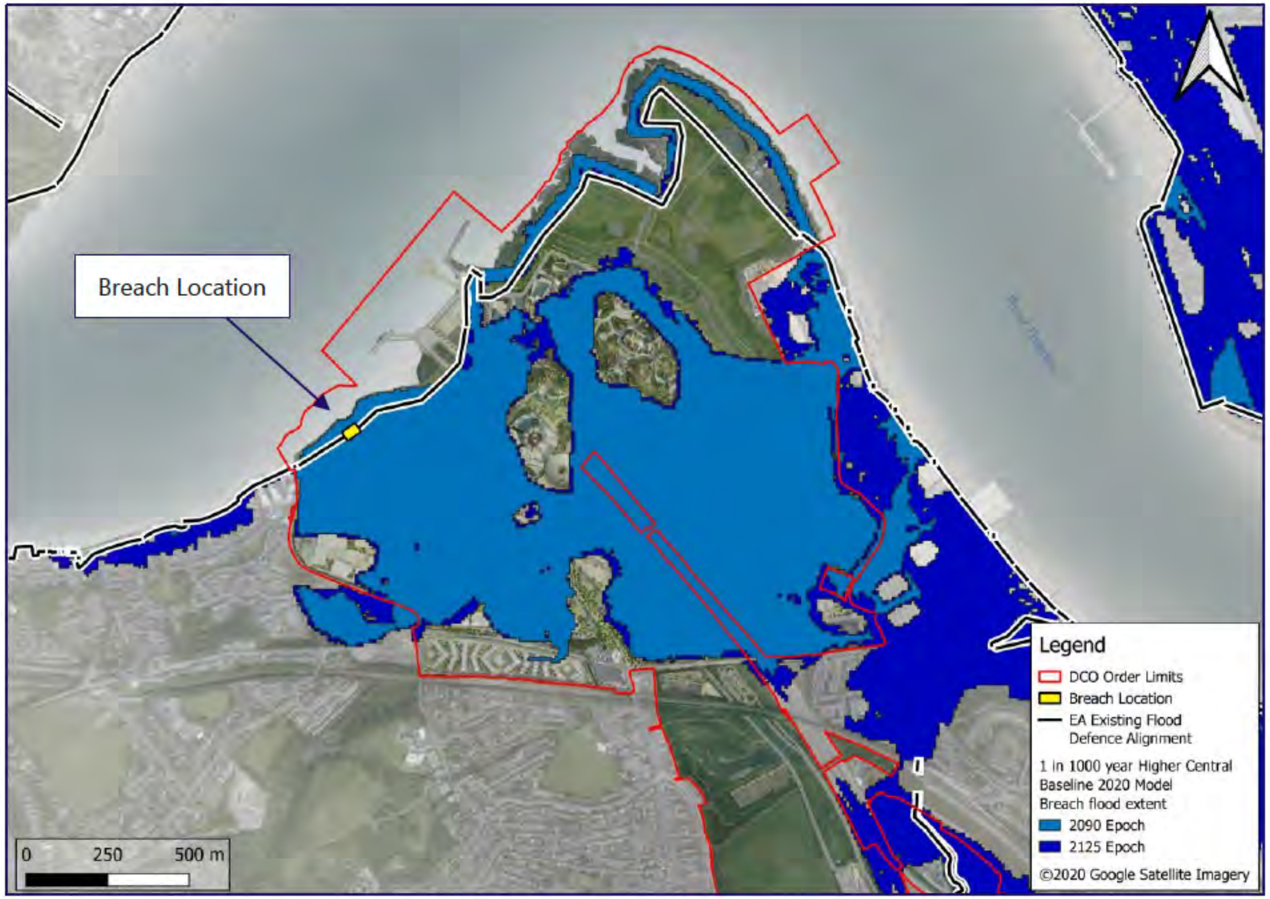


Figure 4-7: Kent Project Site (Main Resort) baseline breach flood extents for the 1 in 1000 year return period event using the higher central climate change projections across different years

Figure 4-8: London Resort Kent Project Site Baseline 2020 Model Results Sampling Locations

Figure 4-9: Flood Risk Mitigation Kent Project Site (Main Resort) proposed works to the formal flood defences.

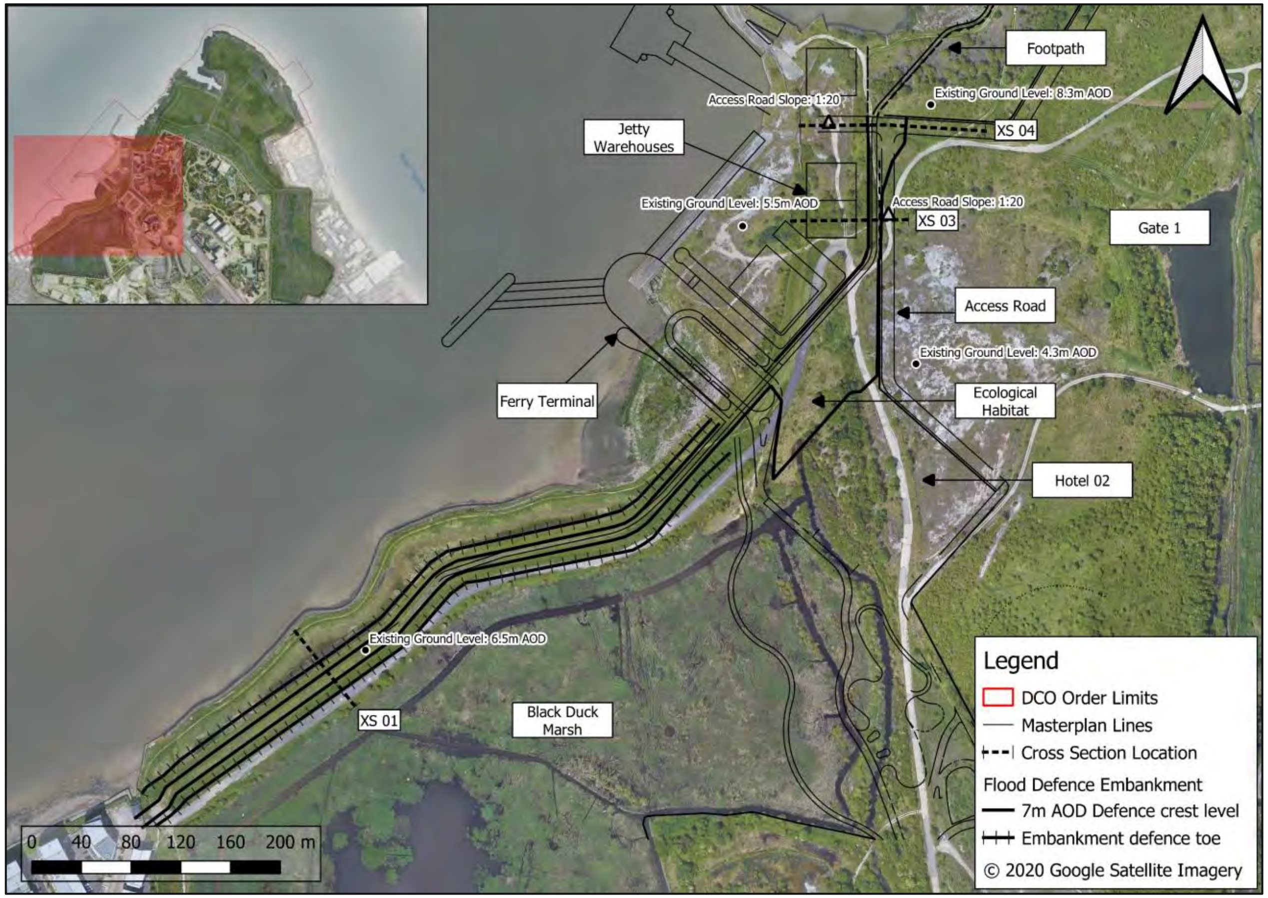


Figure 4-10 Spatial plan of showing indicative location of proposed flood defence crest, toe and raised land levels against existing satellite imagery. This is to achieve recommended TE2100 Plan flood defence SoP to 2070.

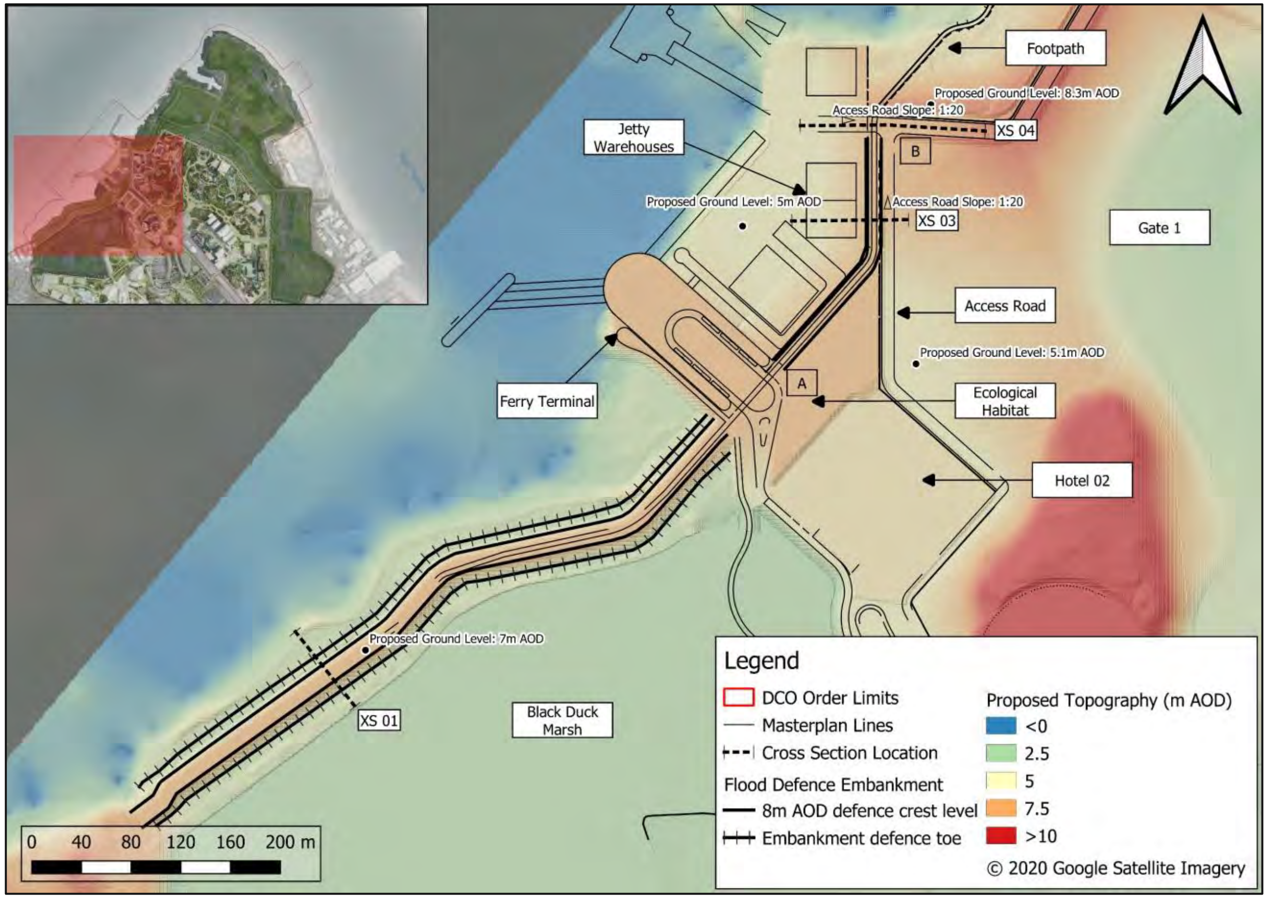


Figure 4-11 Spatial plan of showing indicative location of proposed flood defence crest, toe and raised land levels against proposed topography. This is to achieve recommended TE2100 Plan flood defence SoP to 2125. At location A and B access roads that cross the embankment to access the Ferry Terminal and Whites Jetty respectively will be appropriately ramped up to meet the required crest level whilst maintaining the appropriate gradients.

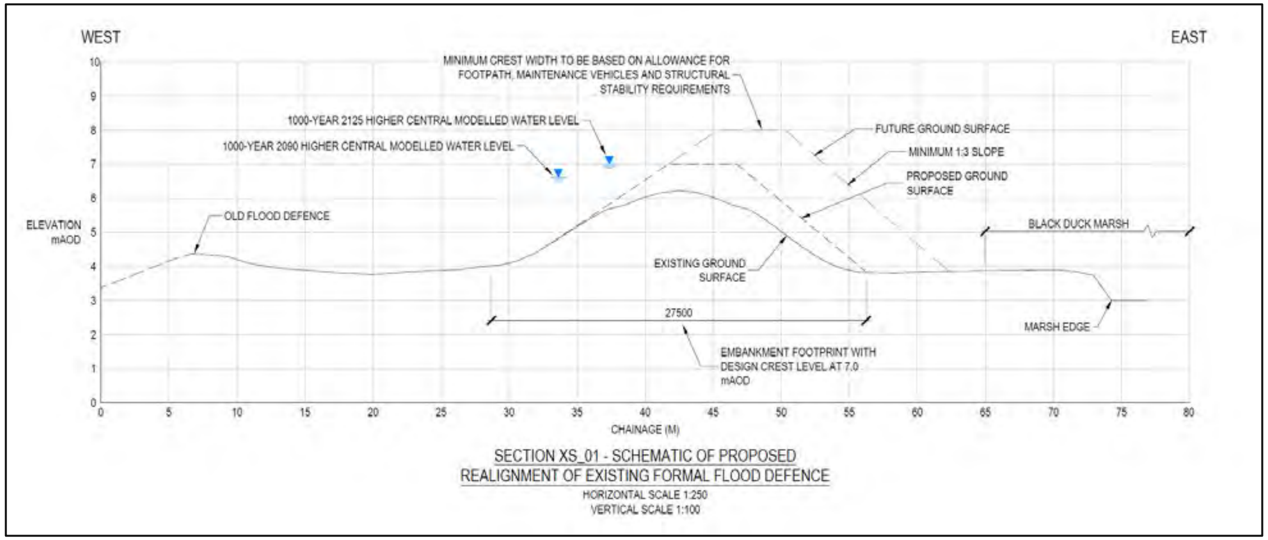


Figure 4-12: Black Duck Marsh cross section showing the proposed initial and phased defence crest level raising

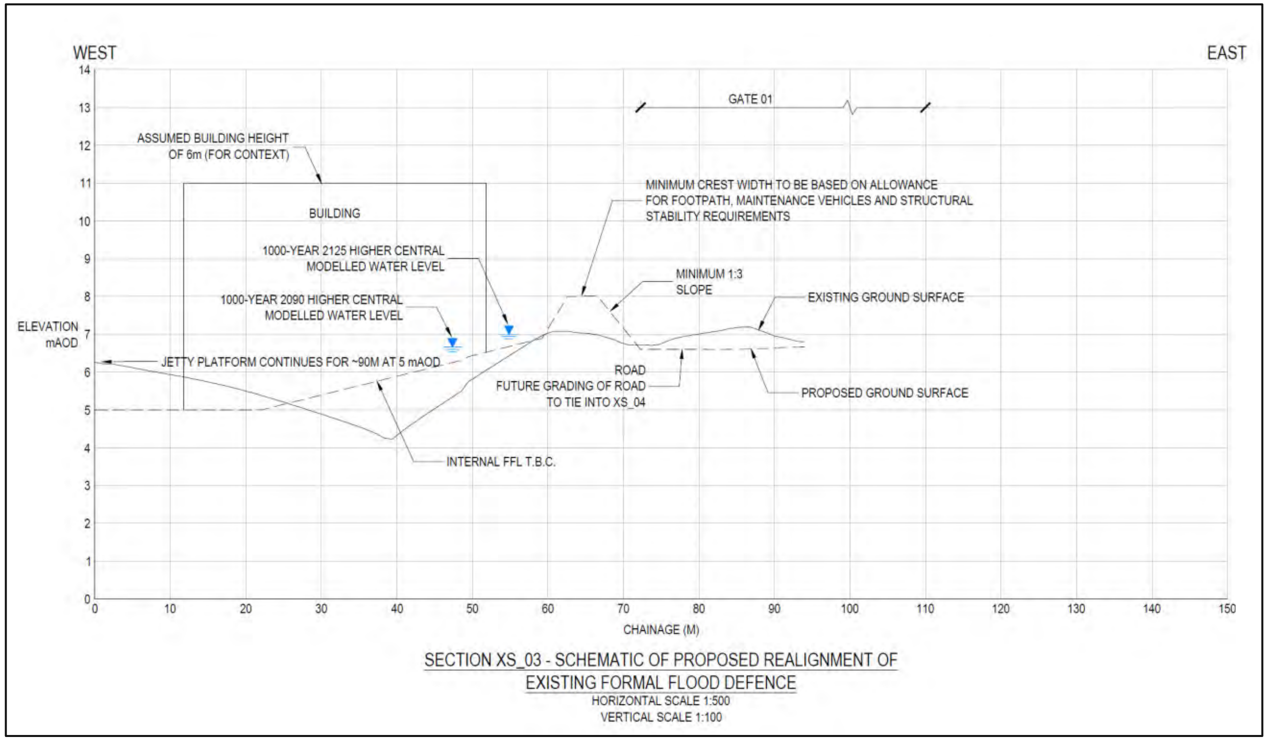


Figure 4-13: Whites Jetty cross section showing the proposed initial and phased defence crest level raising

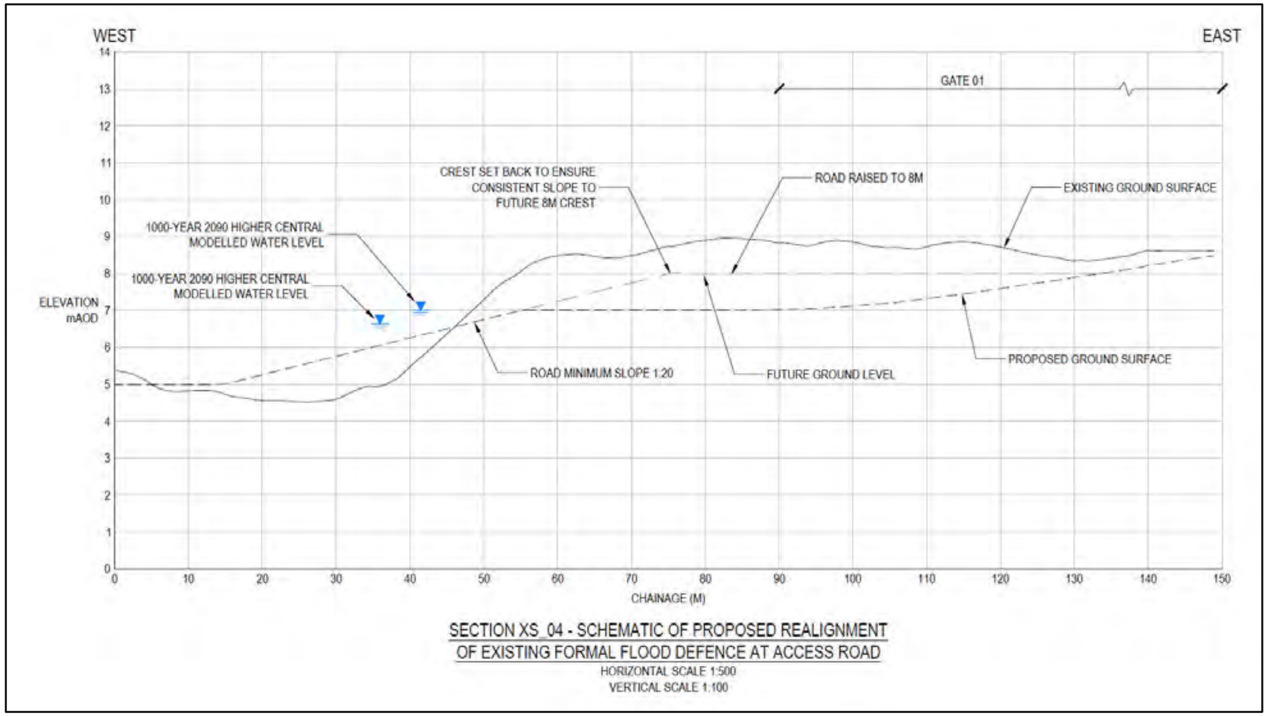


Figure 4-14: Whites Jetty cross section showing the proposed initial and phased defence crest level raising

Figure 4-15: Flood Risk Mitigation Kent Project Site (Main Resort) secondary flood defence bund

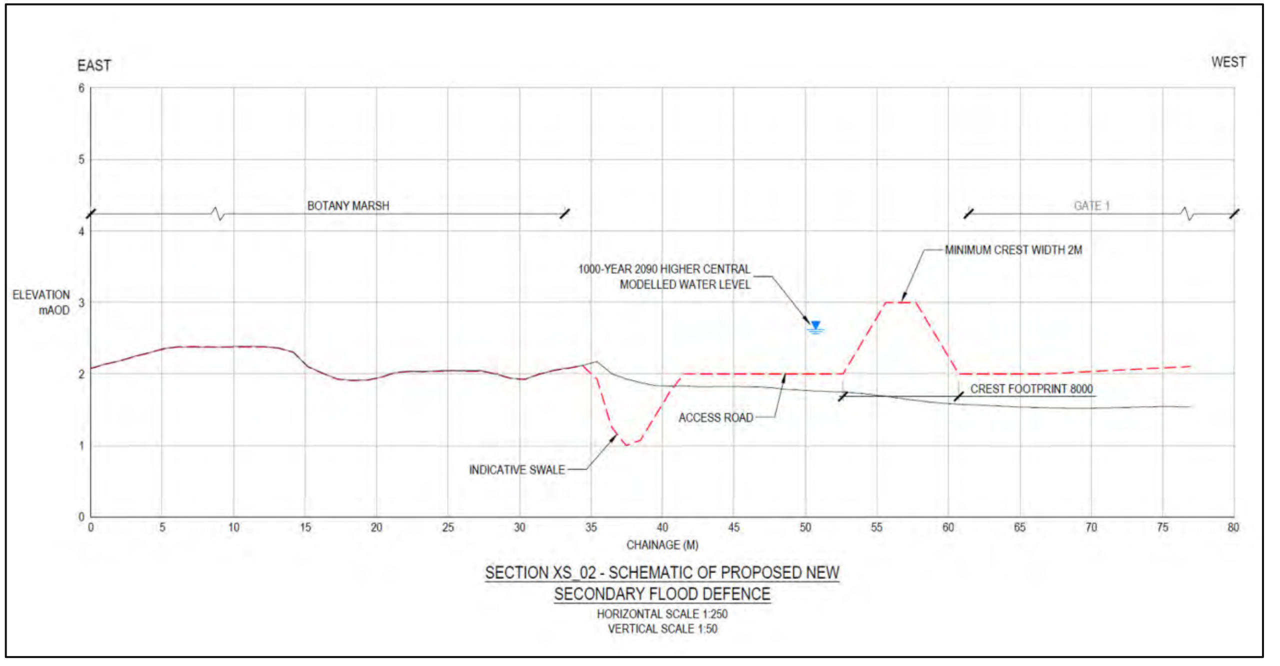


Figure 4-16: Cross section of the proposed secondary flood defence along the east of the Proposed Development

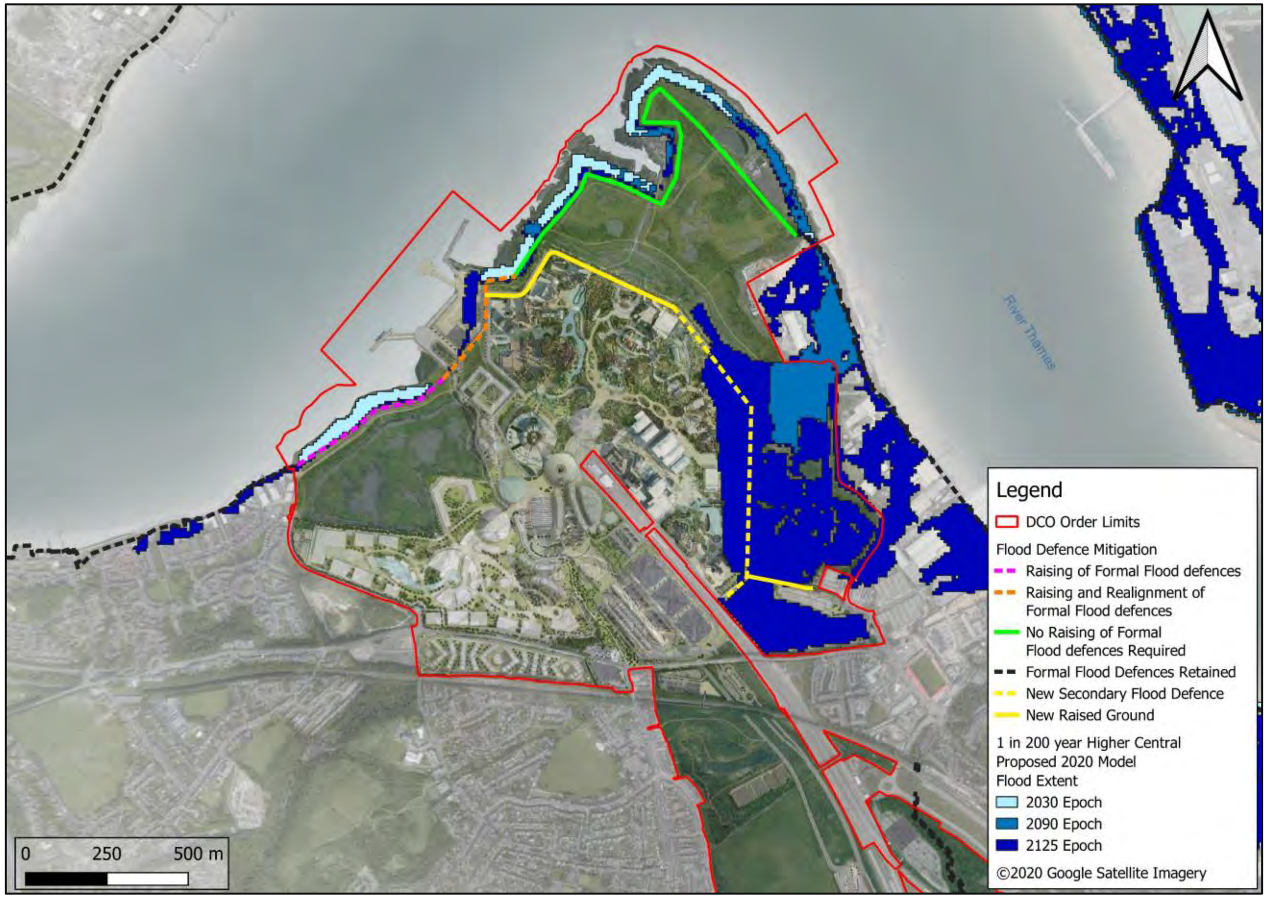


Figure 4-17: London Resort Kent Project Site (Main Resort) overtopping flood risk 1 in 200 year for future years using the higher central climate change allowance (refer to Figure 4-15 for defence line style description).

Figure 4-18: Kent Project Site (Main Resort) post mitigation overtopping flood extents for the 1 in 1000 year return period event using the higher central climate change projections across different years (refer to Figure 4-15 for defence line style description)

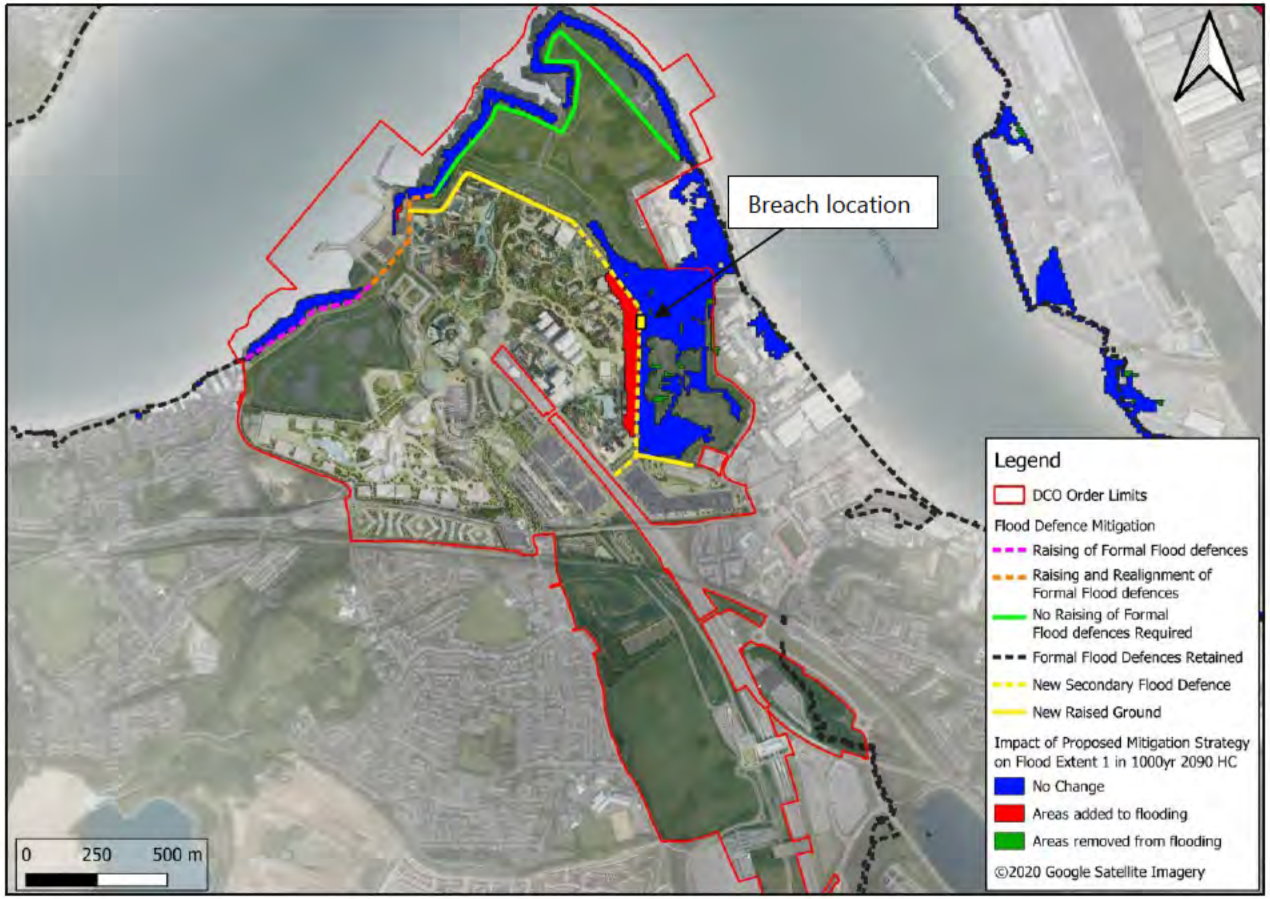


Figure 4-19: Kent Project Site (Main Resort) impact on the site of a breach in the secondary flood defences using the 1 in 1000 year event for the year 2090 using higher central climate change projection

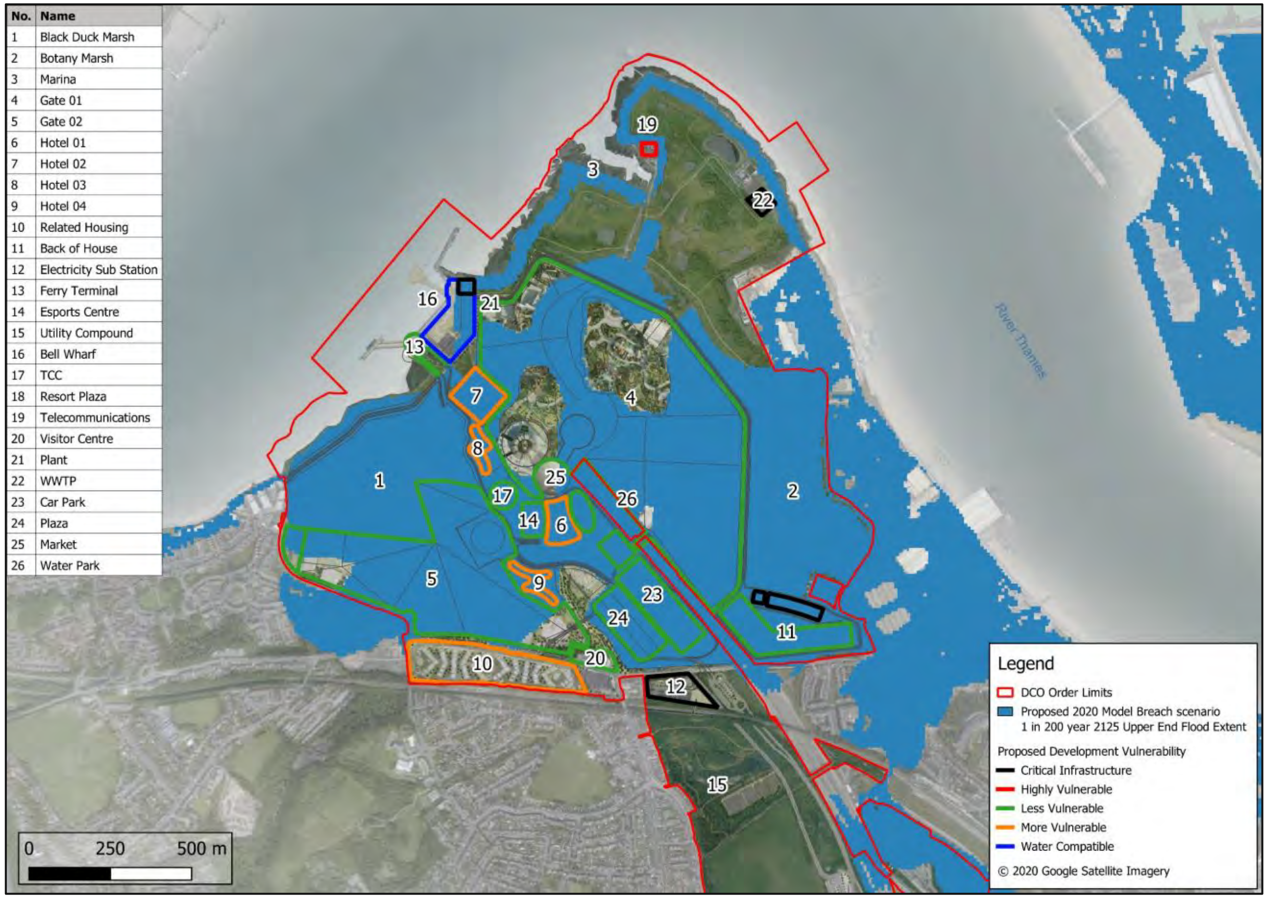


Figure 4-20: Kent Project Site (Main Resort) breach 1 in 200 year event 2125 epoch using the higher central climate change projection flood extent using baseline topography.

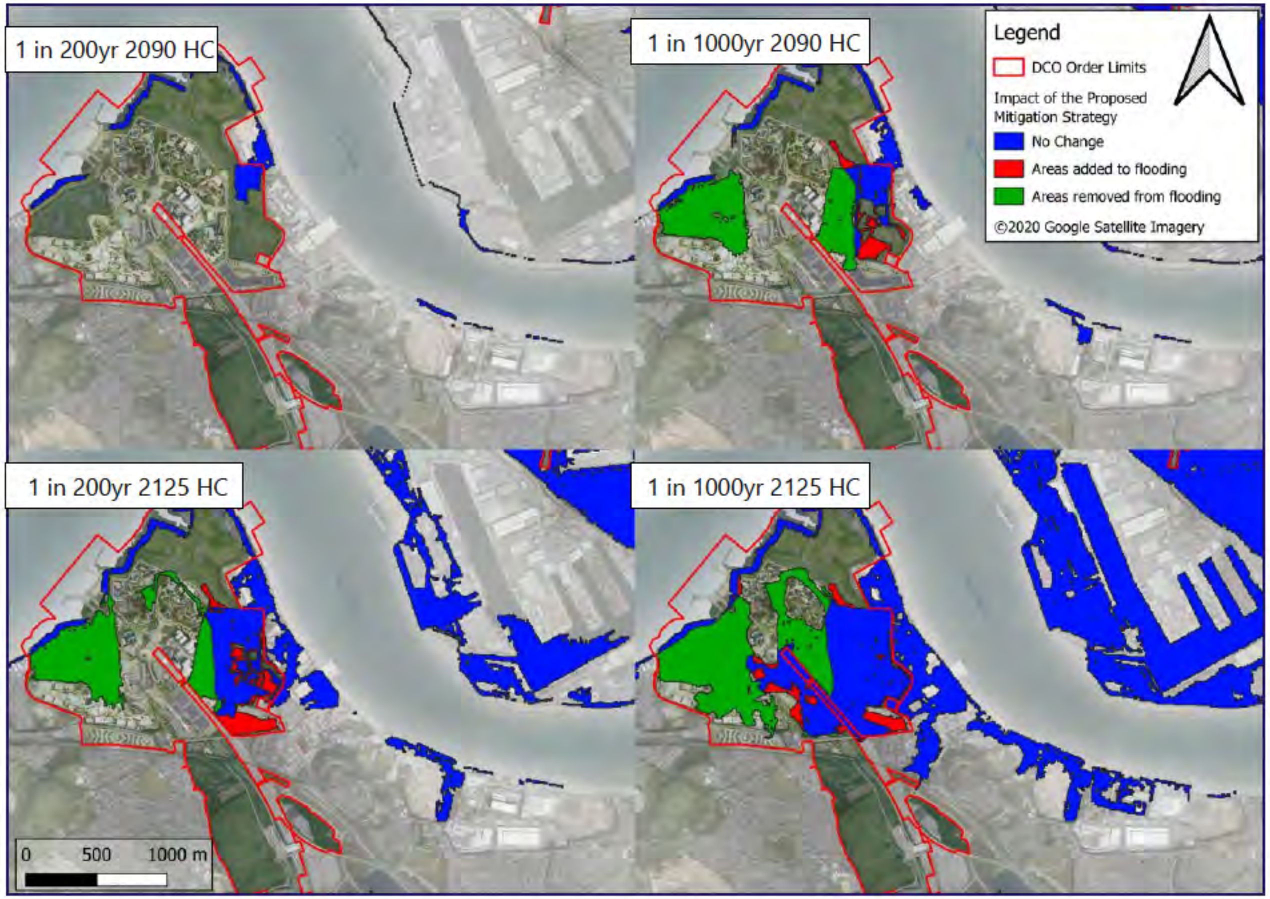


Figure 4-21: Kent Project Site (Main Resort) impact of the Proposed Development on overtopping flood extents for (top left) 1 in 200 year event in 2090 using the higher central climate change projection (top right) the 1 in 1000 year event in 2090 using the Higher Central climate change projection (bottom left) the 1 in 200 year event in 2125 using the higher central climate change projection (bottom right) the 1 in 1000 year event in 2125 using the higher central climate change projection

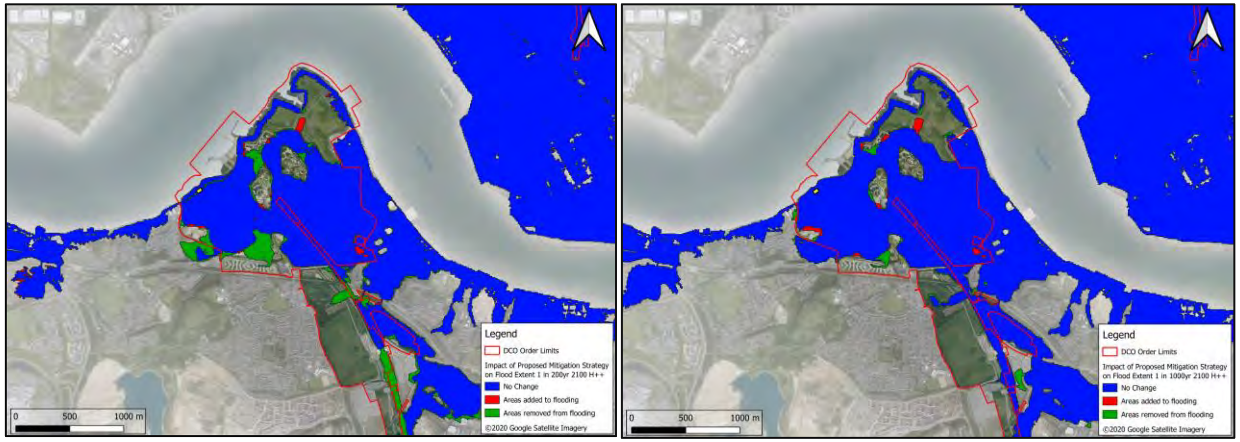


Figure 4-22: Kent Project Site (Main Resort) impact of the Proposed Development on overtopping flood extent for the (left) 1 in 200year 2100 H++ flood extent and (right) 1 in 1000year 2100 H++ Flood Extent

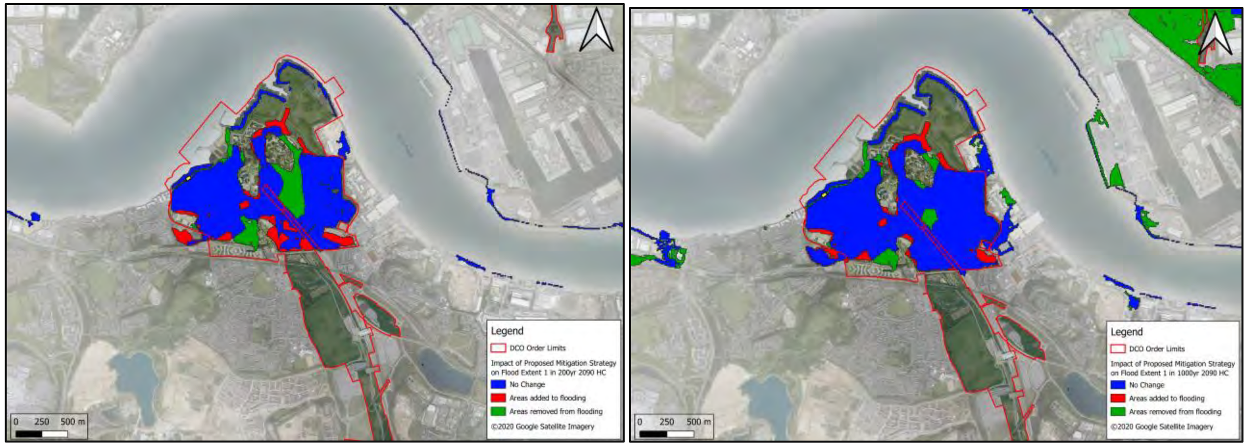


Figure 4-23: Kent Project Site (Main Resort) impact of the Proposed Development on the breach (Breach 06) flood extent for the (left) 1 in 200year 2090 Higher Central flood extent and (right) 1 in 1000year 2090 Higher Central flood extent

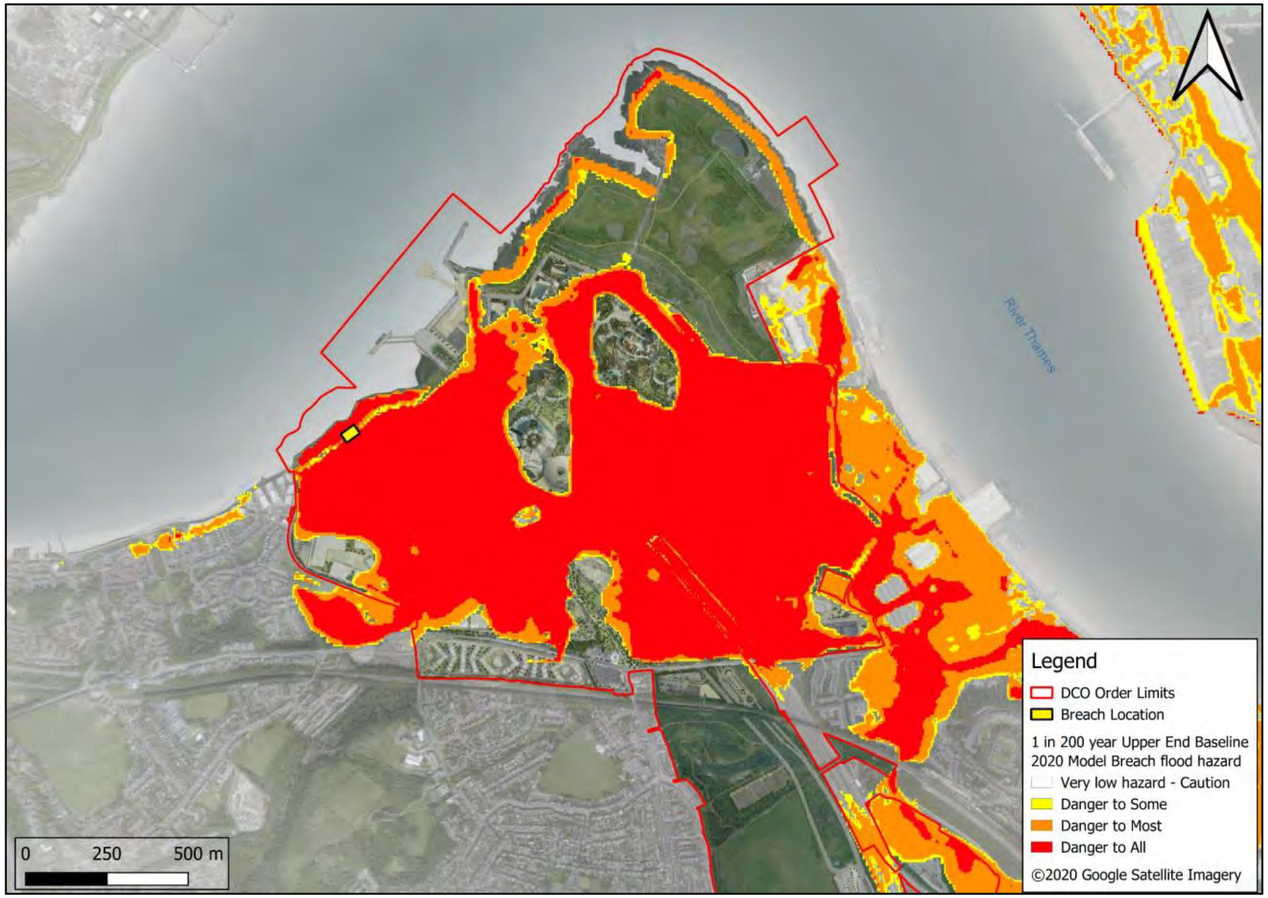


Figure 4-24: Kent Project Site (Main Resort) baseline breach flood hazard for the 1 in 200 year return period event using the upper end climate change projections

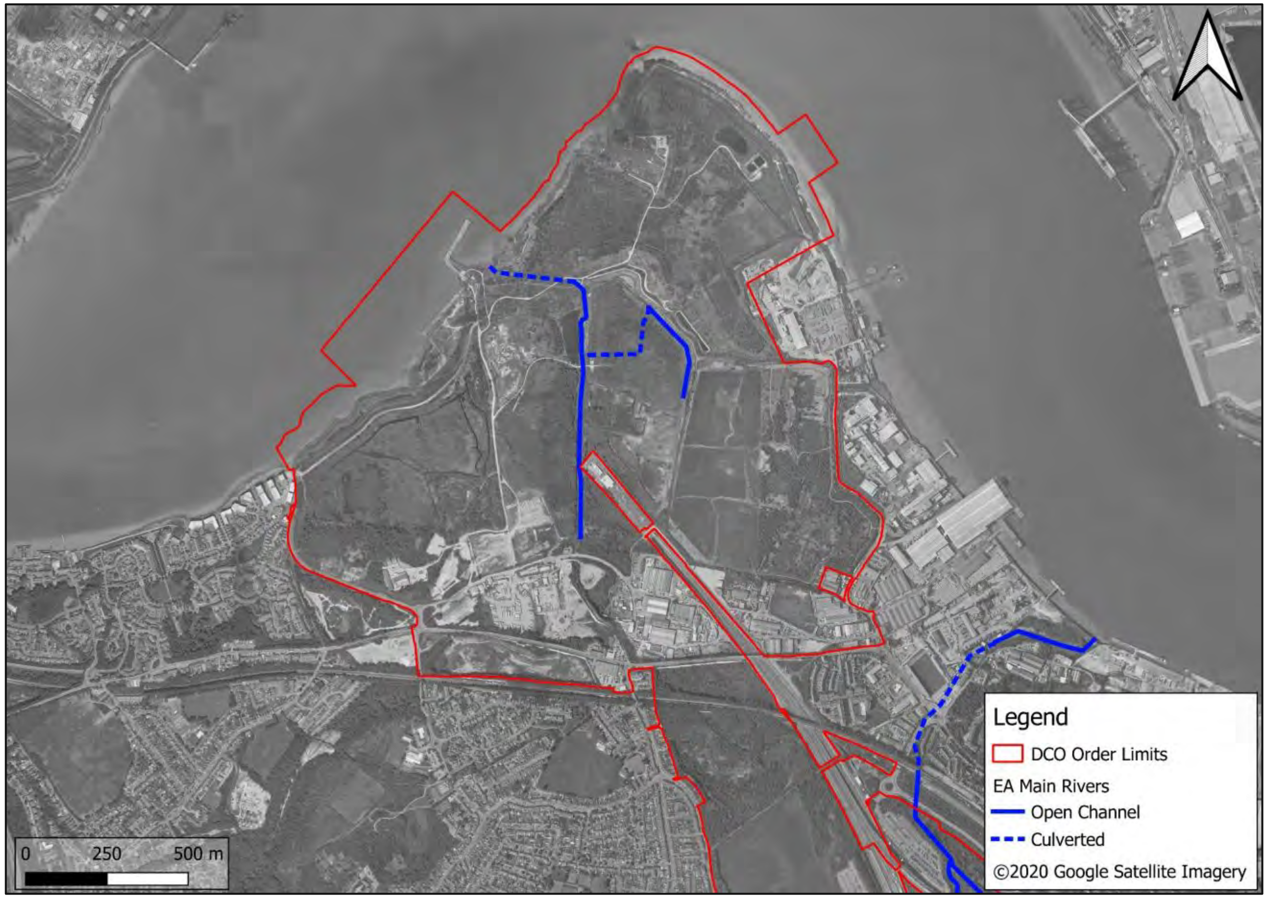


Figure 4-25: Kent Project Site (Main Resort) EA designated main rivers

Figure 4-26: EA flood map showing surface water modelled flood extent (Map data ©2015 Google, © Environment Agency copyright and/or database right 2014. All rights reserved. Some features of this map are based on digital spatial data from the Centre for Ecology & Hydrology, © NERC (CEH). Soils Data © Cranfield University (NSRI) and for the Controller of HMSO 2013)

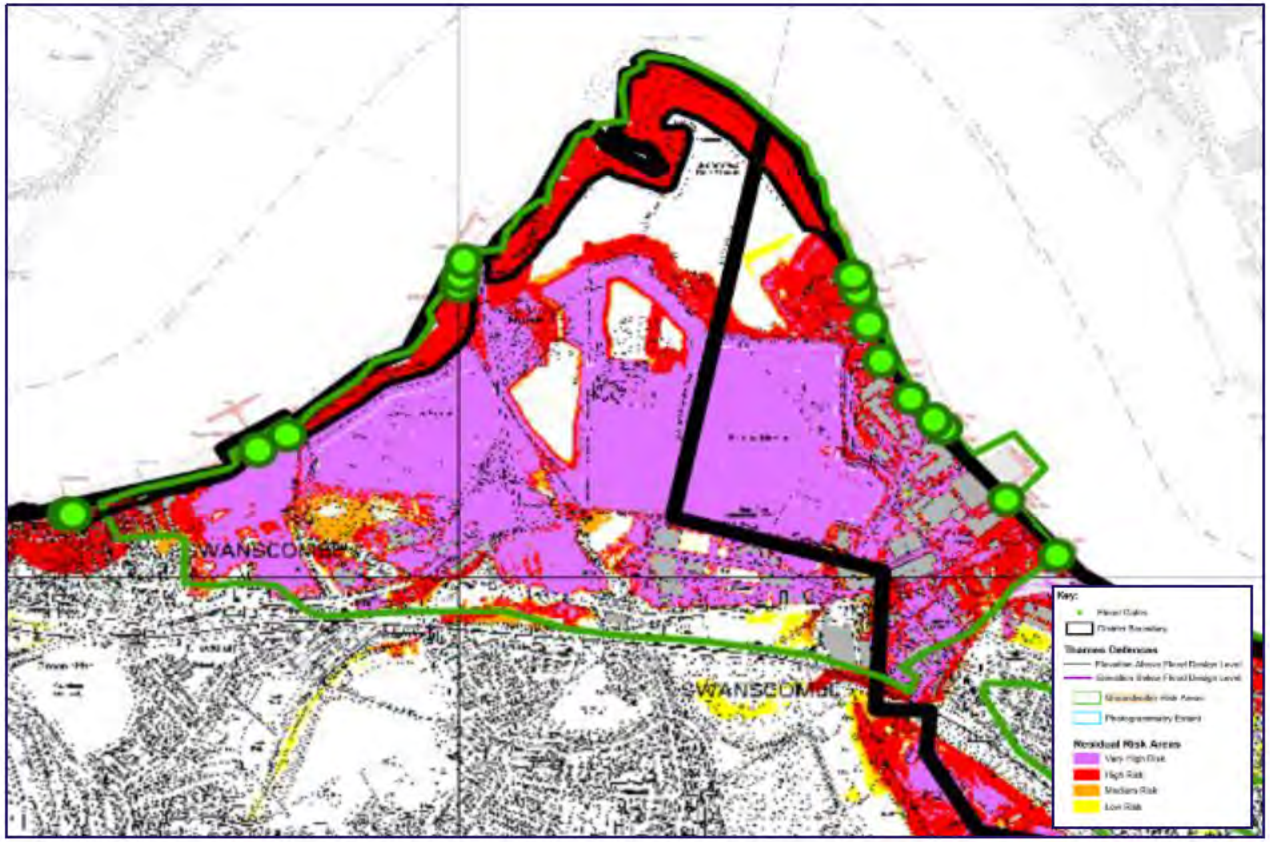


Figure 4-27: Kent Thameside SFRA Residual Flood Risk Map, including Groundwater Risk Areas [2]

[2] Kent Thameside Delivery Board: Strategic Flood Risk Assessment of Kent Thameside, JBA Consulting. December 2005.

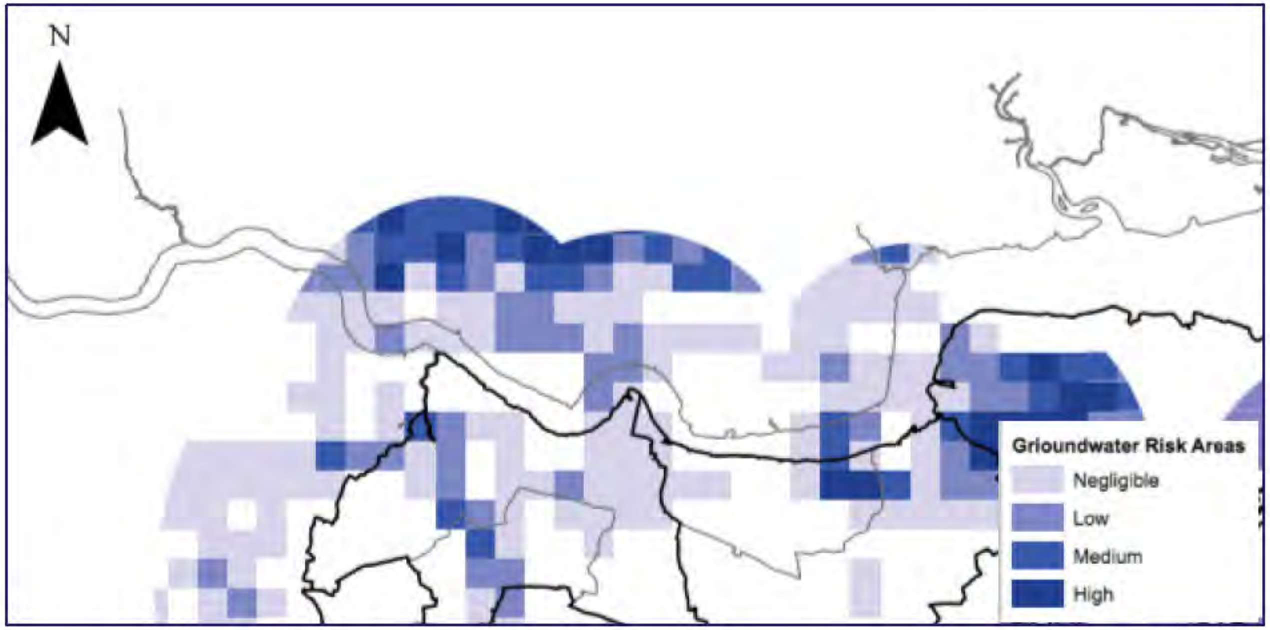


Figure 4-28: Kent County Council Groundwater Risk Areas (Kent county Council Preliminary Flood Risk Assessment – Main Report – Figure 6)

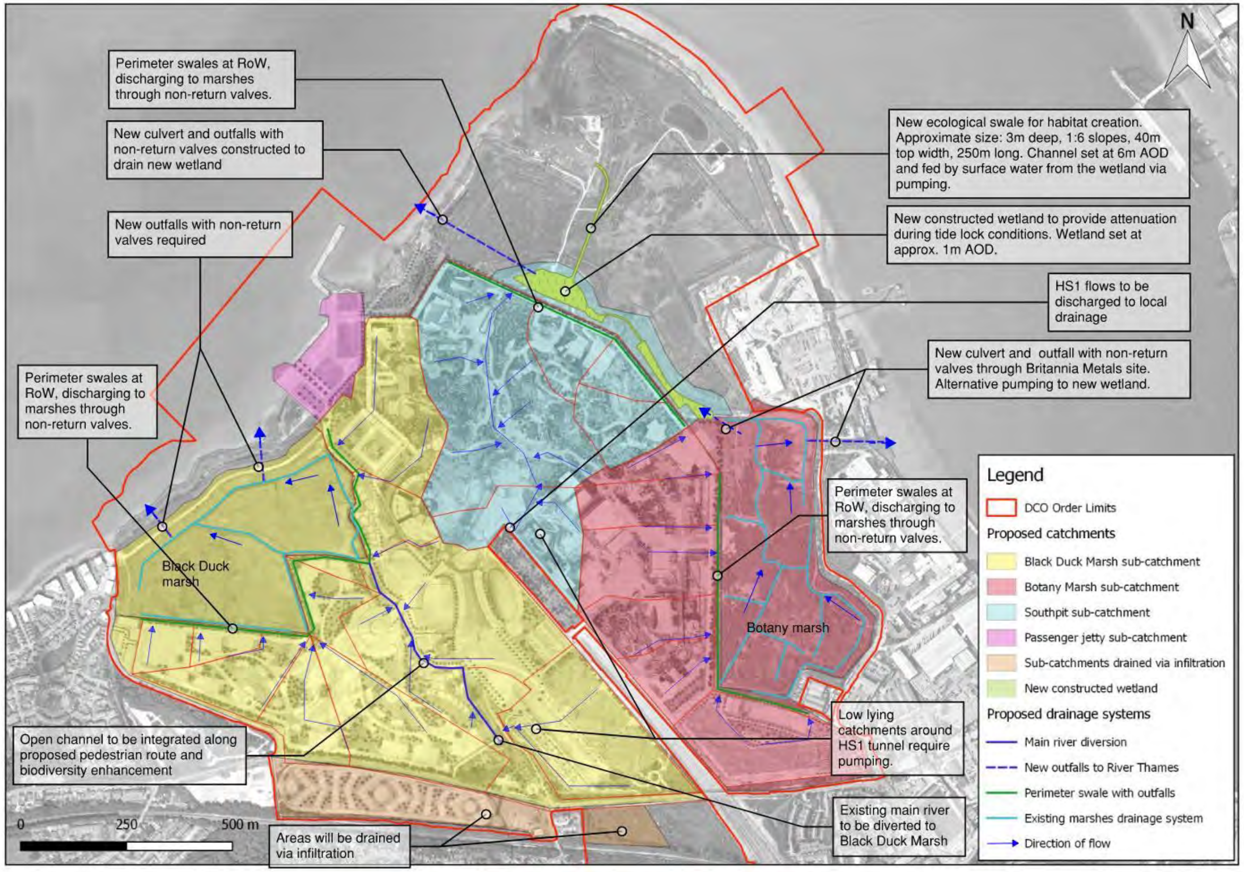


Figure 4-29: Proposed drainage strategy for Kent Project Site (Main Resort)

5 Appraisal and management of flood risk Essex Prokect Site

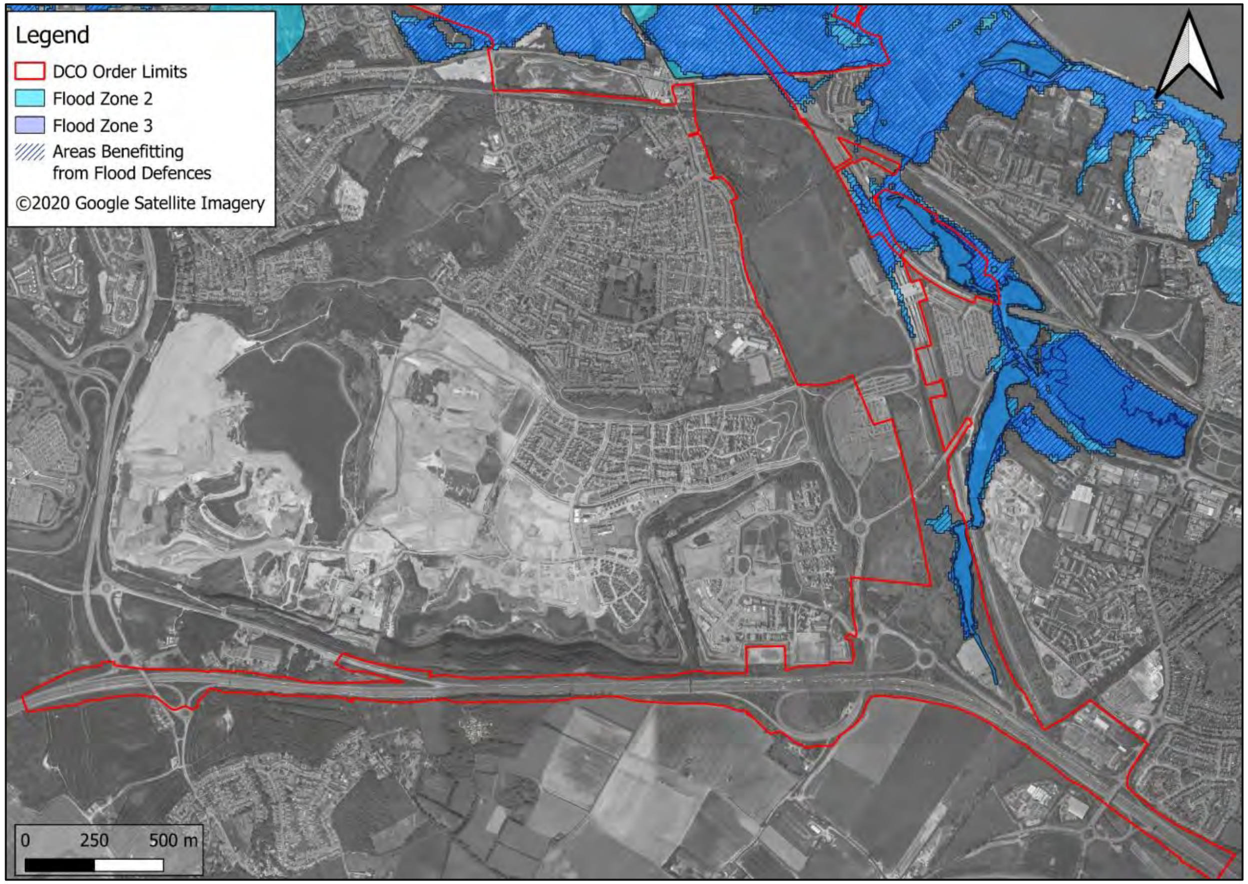


Figure 5-1: EA flood map showing Flood Zones 2 and 3, highlighting fluvial and tidal flood risk to the Kent Project Site (Access Road) (EA Product 4, 28/07/2020)

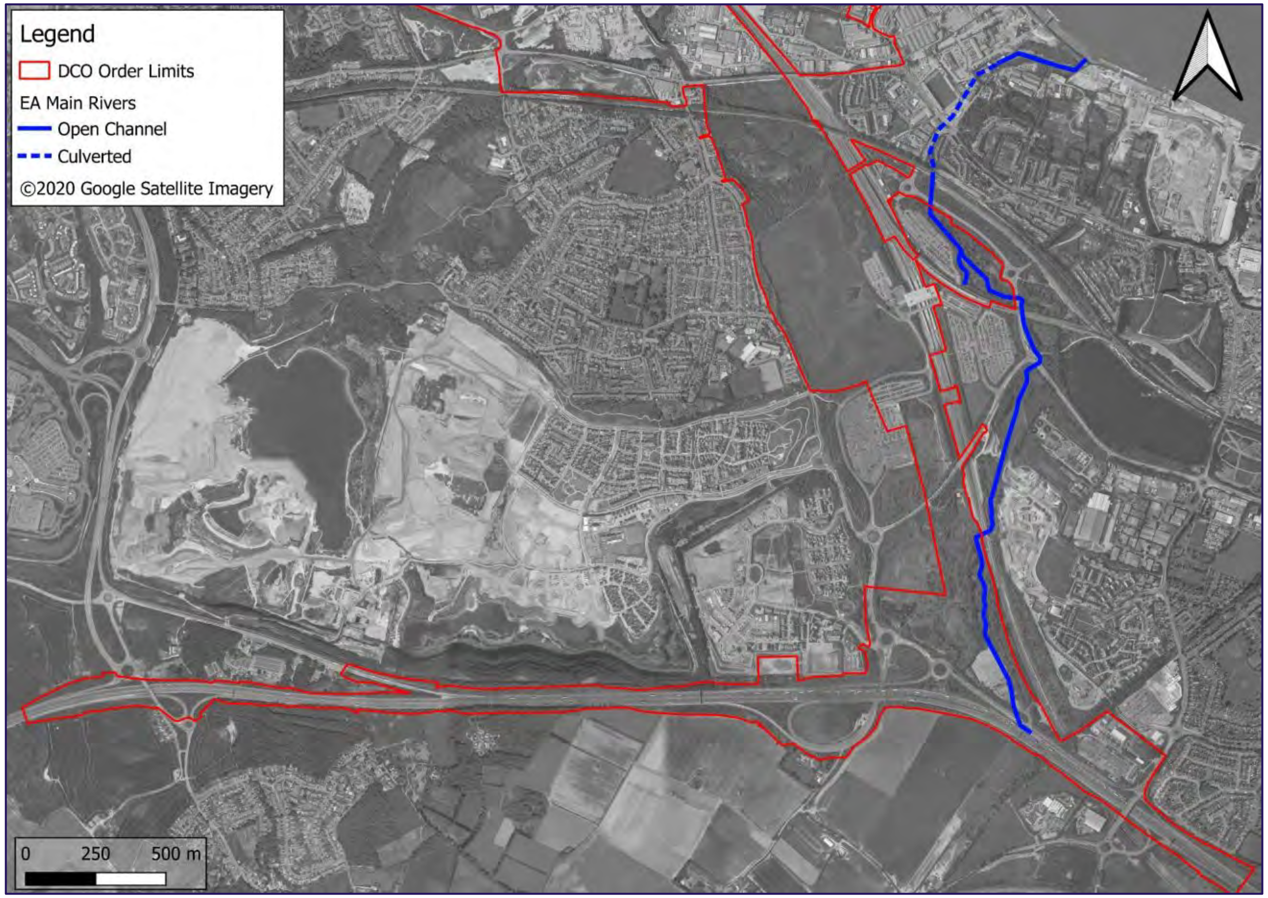


Figure 5-2: EA designated main rivers

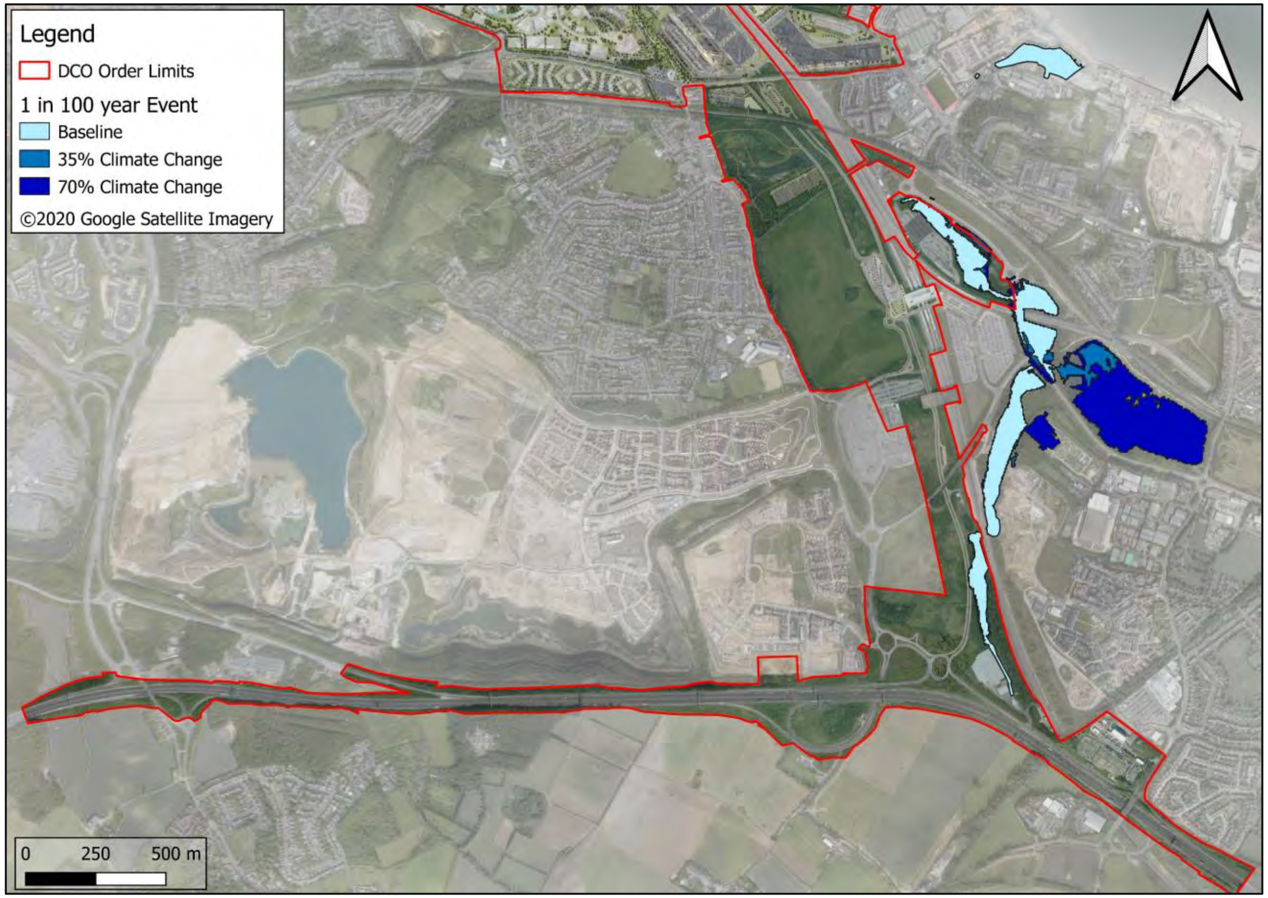


Figure 5-3: London Resort Kent Project Site (Access Road) fluvial flood extents

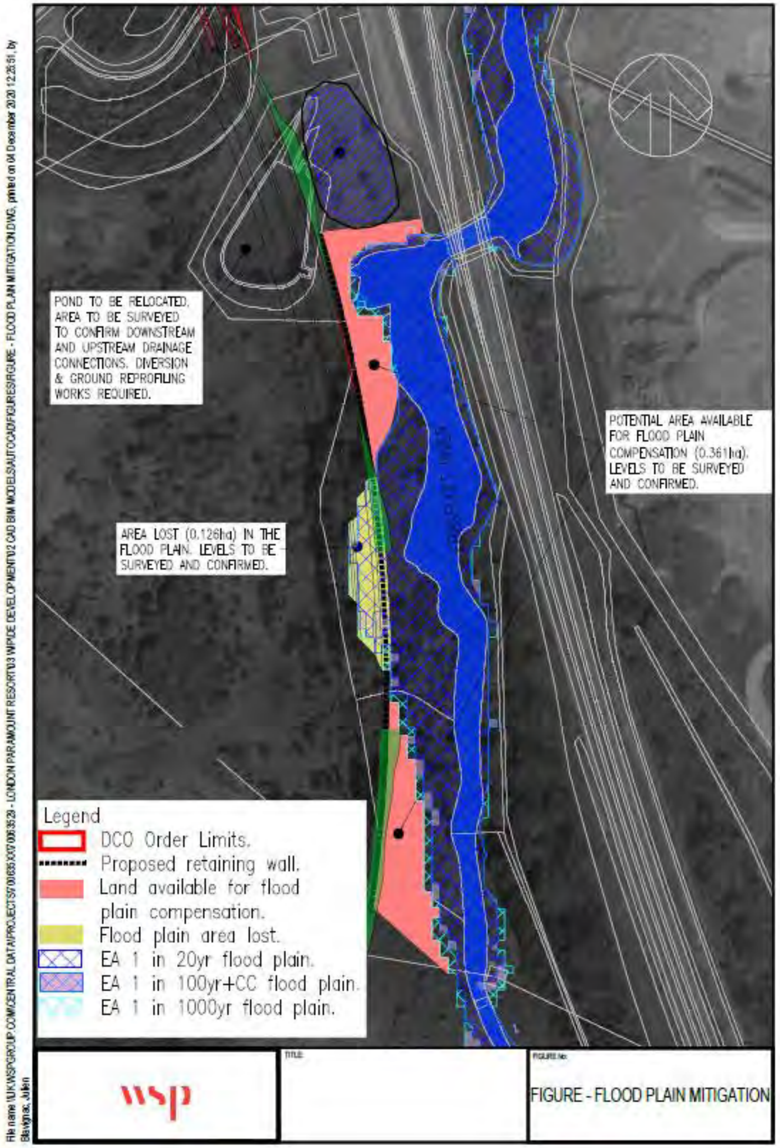


Figure 5-4: London Resort Kent Project Site (Access Road) fluvial flood plain mitigation

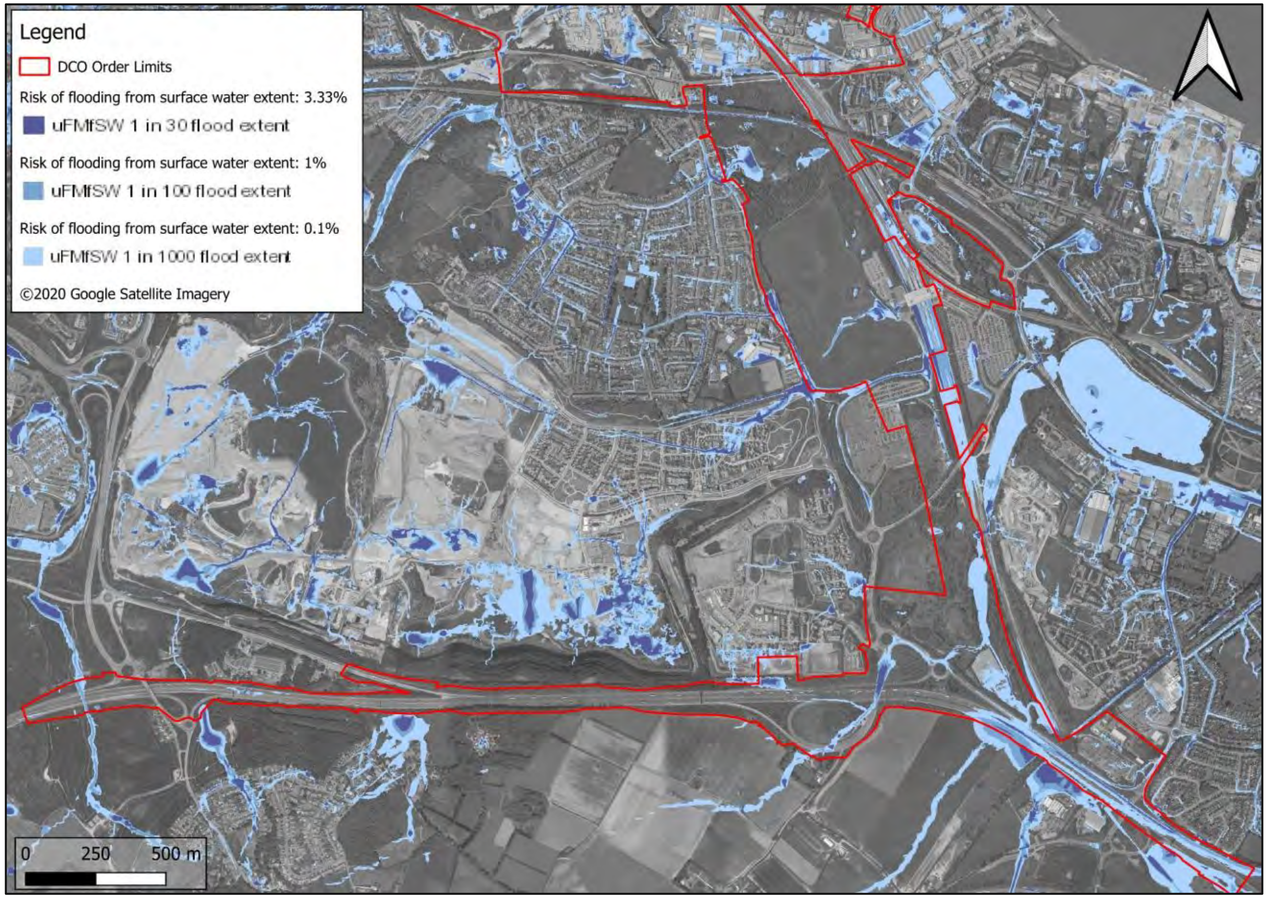


Figure 5-5: EA flood map showing surface water modelled flood extent (Map data ©2015 Google, © Environment Agency copyright and/or database right 2014. All rights reserved. Some features of this map are based on digital spatial data from the Centre for Ecology & Hydrology, © NERC (CEH). Soils Data © Cranfield University (NSRI) and for the Controller of HMSO 2013.)

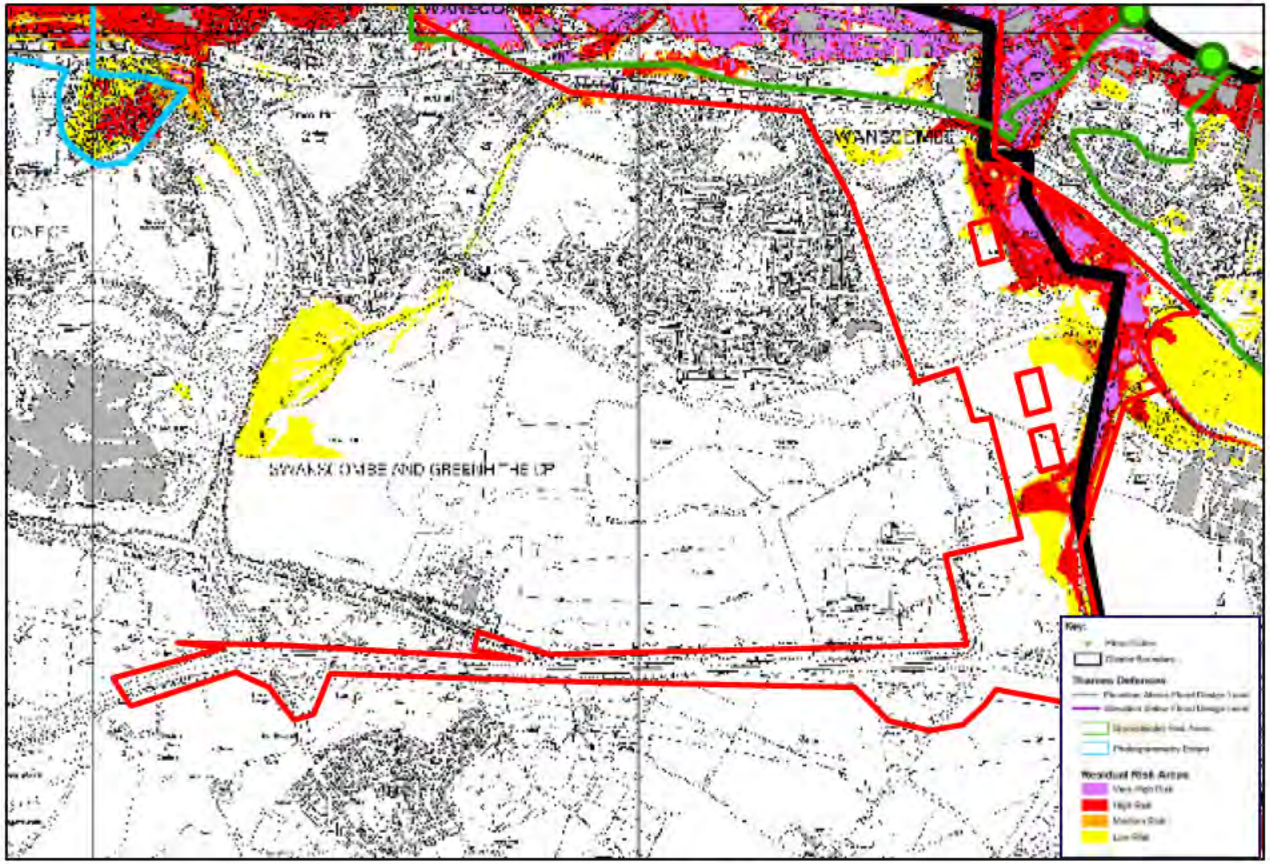


Figure 5-6: Kent Thameside SFRA Residual Flood Risk Map, including Groundwater Risk Areas

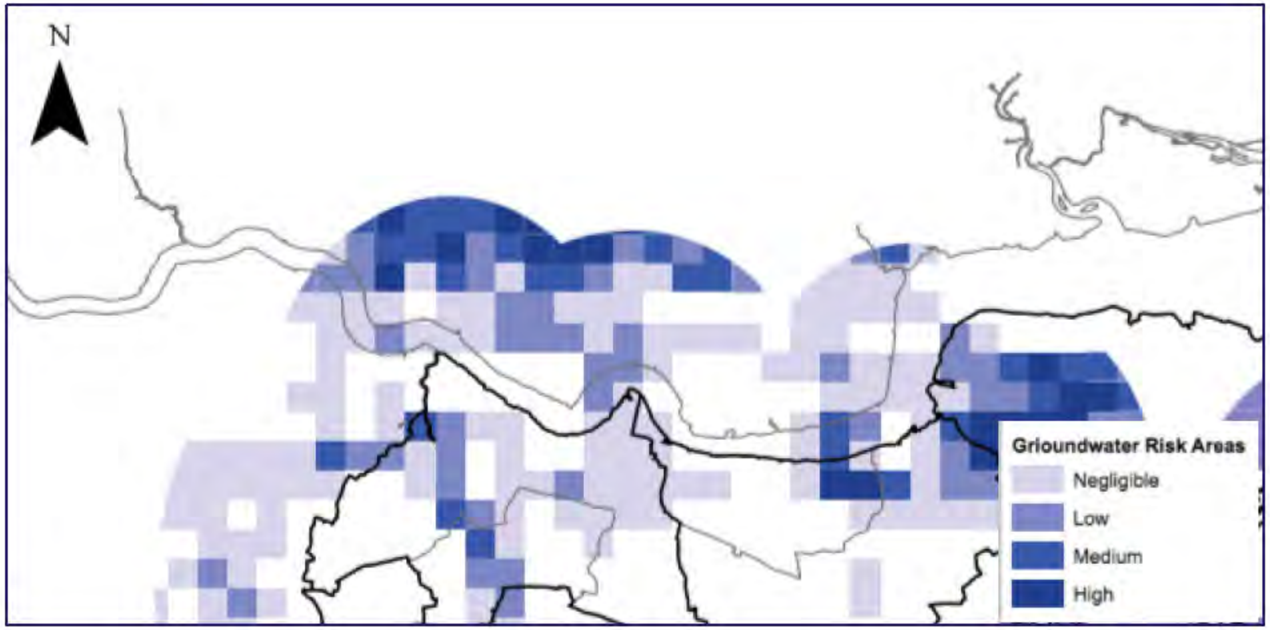


Figure 5-7: Kent County Council Groundwater Risk Areas (Kent County Council Preliminary Flood Risk Assessment - Main Report - Figure 6)

6 Stakeholder Feedback and responses

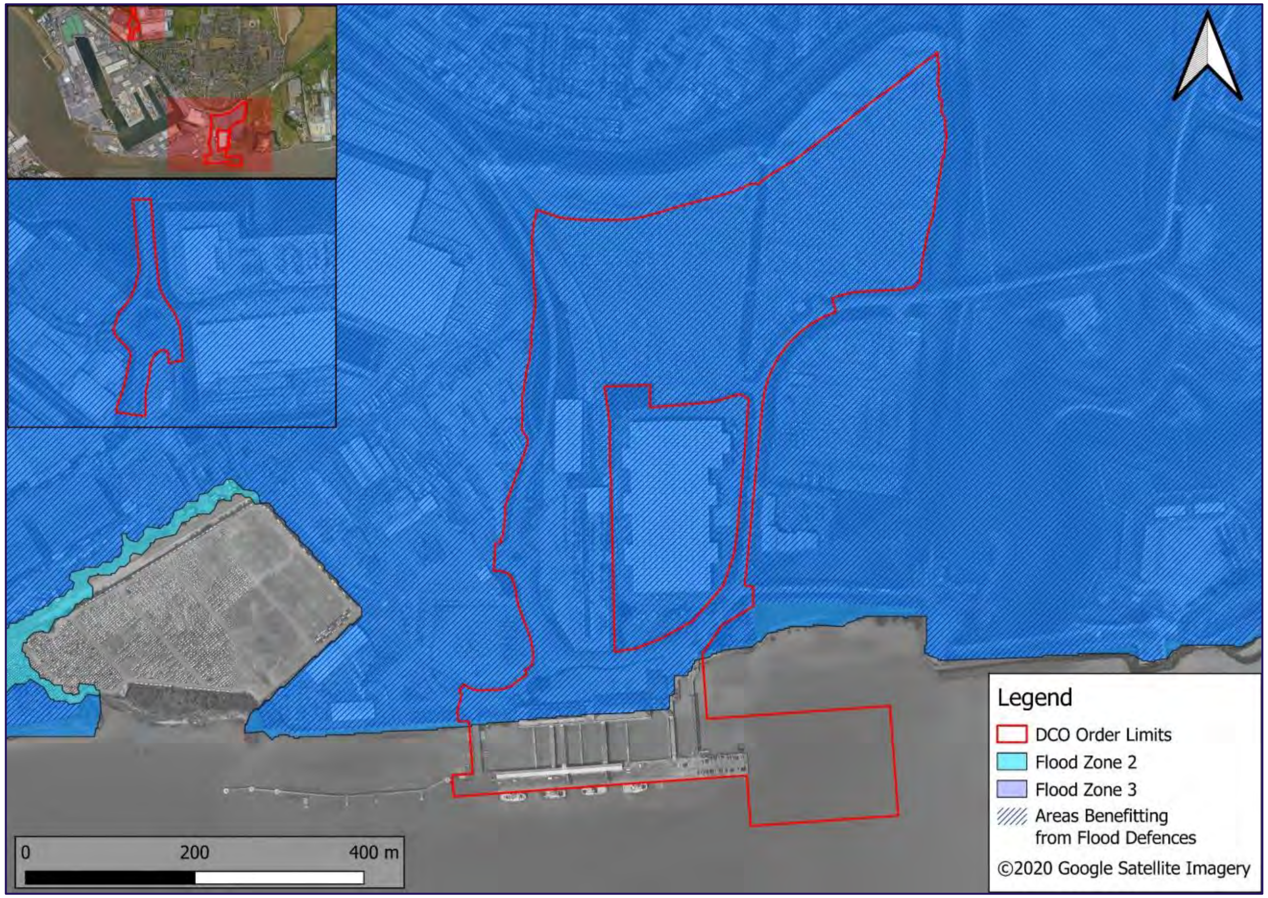


Figure 6-1: Essex Project Site EA Flood Zones

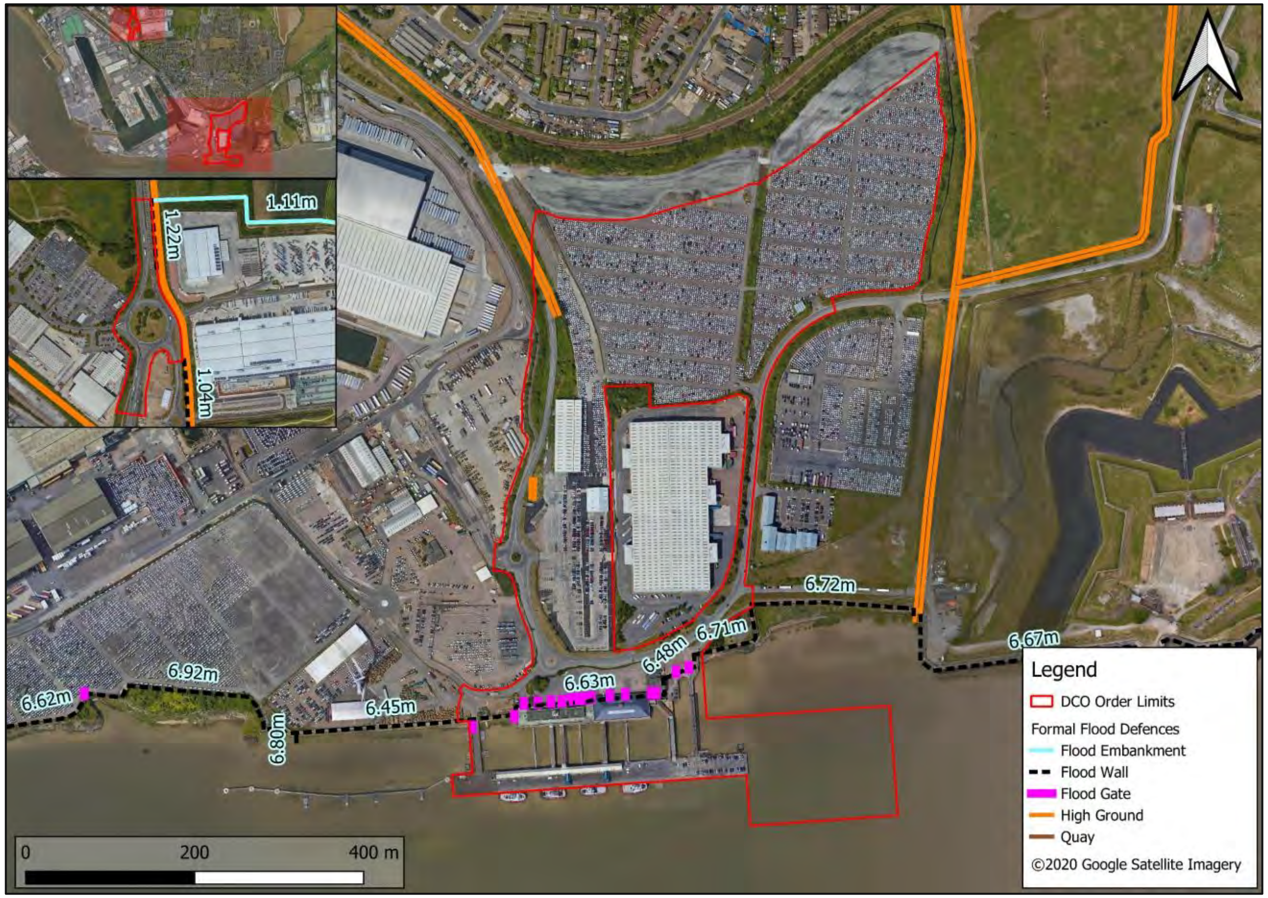


Figure 6-2: Essex Project Site existing flood defence alignment, type and crest elevation.

Figure 6-3: London Resort Essex Project Site existing flood defences (photograph taken during site visit 28/07/20, looking west)

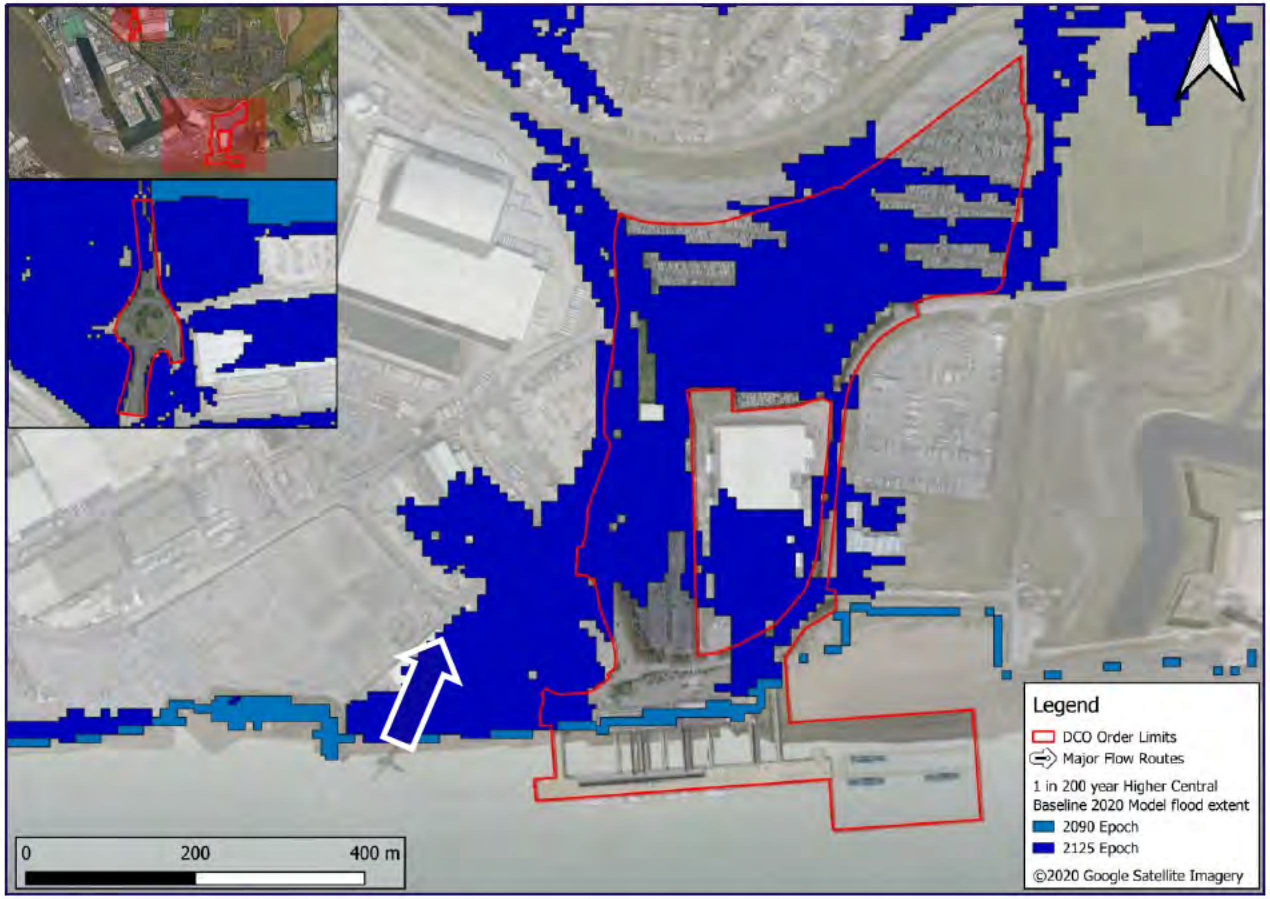


Figure 6-4: Key overtopping flow route into the Essex Project Site during the existing condition for the 1 in 200 year return period event using the higher central climate change projections across different years.

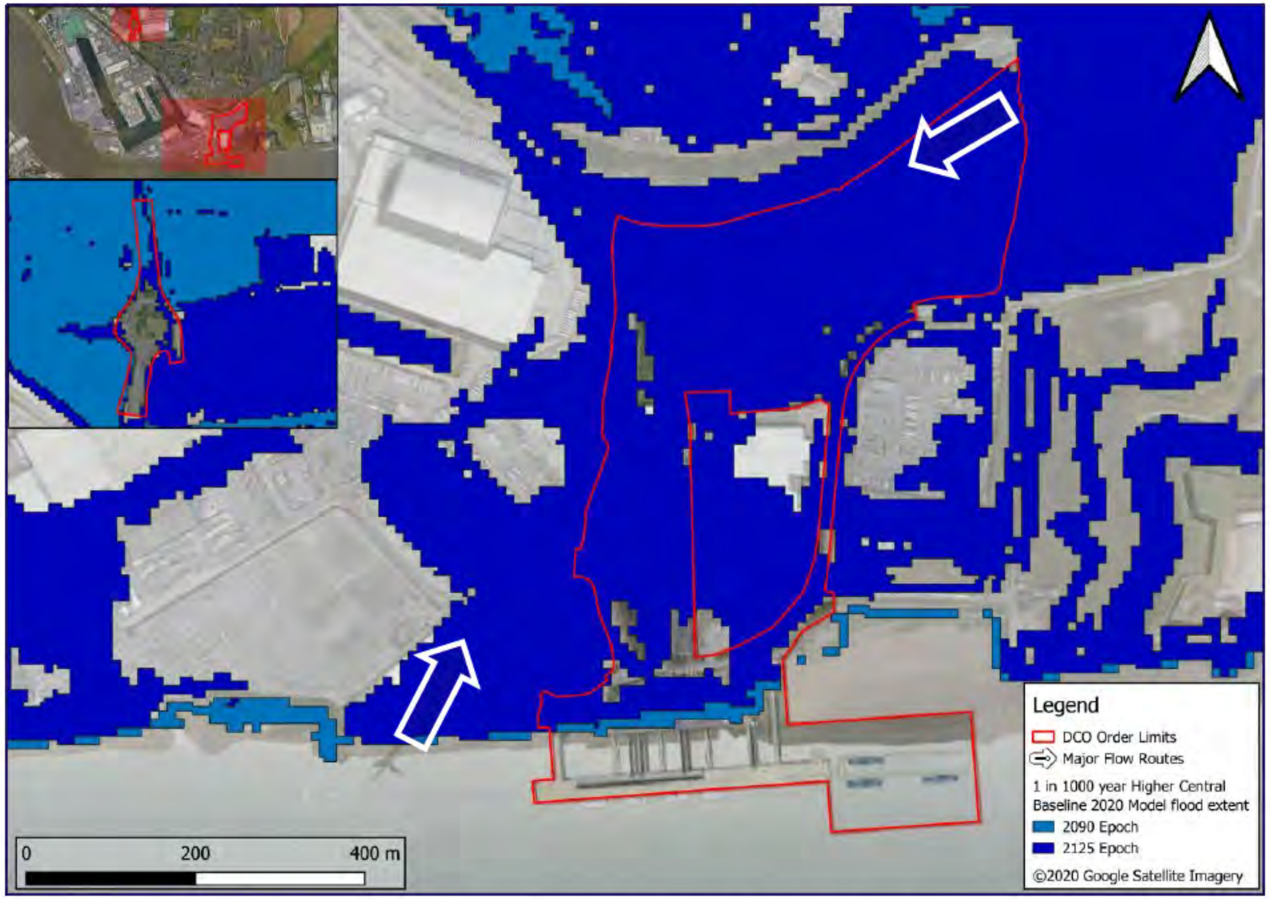


Figure 6-5: Key overtopping flow routes into the Essex Project Site during the existing condition for the 1 in 1000 year return period event using the higher central climate change projections across different years.

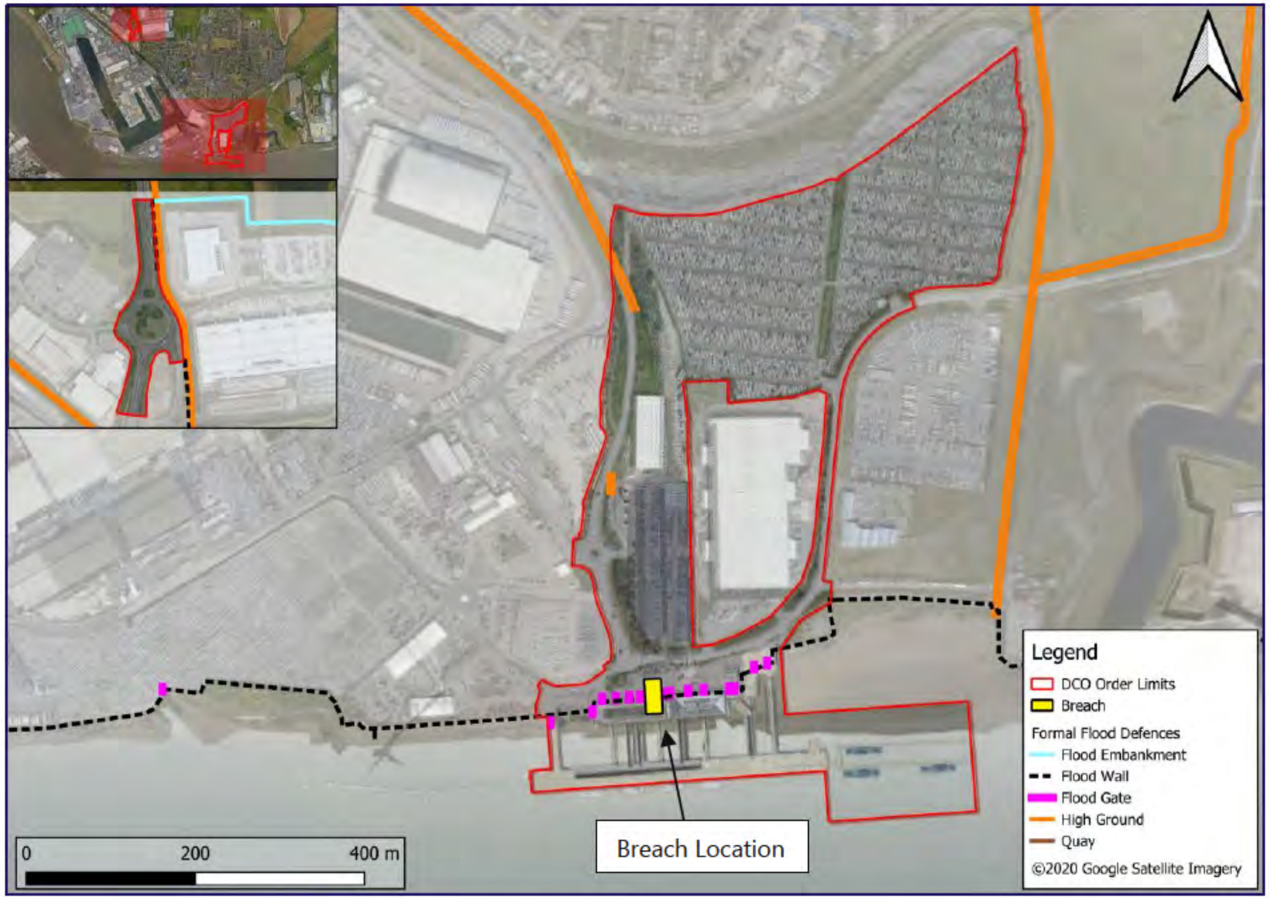


Figure 6-6: Essex Project Site breach location

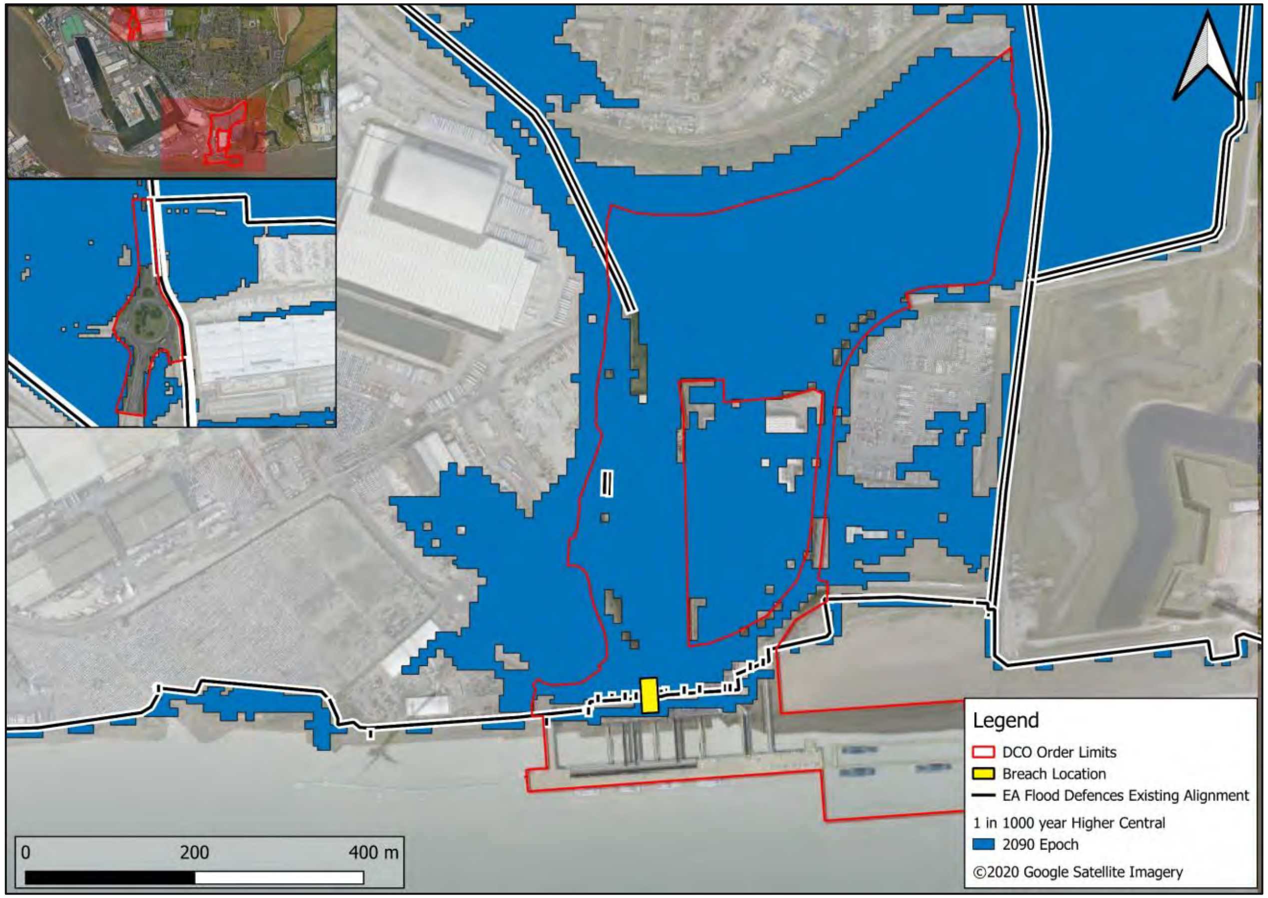


Figure 6-7: Essex Project Site baseline breach flood extent for the 1 in 1000 year return period event using the higher central climate change projections in 2090.

Figure 6-8: Essex Project Site Baseline 2020 Model Results Sampling Locations

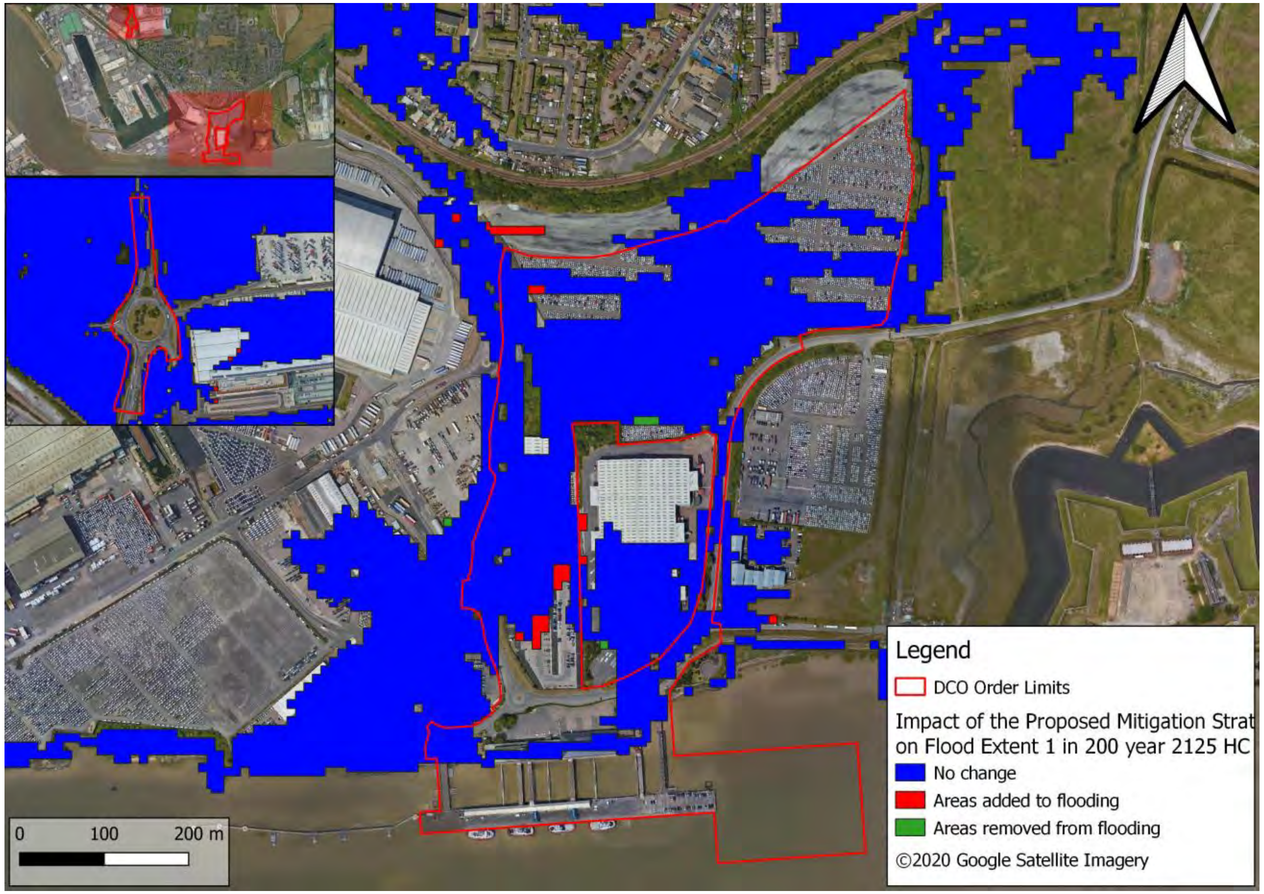


Figure 6-9 Essex Project Site change in Proposed 2020 model compared to Baseline 2020 model for overtopping flood extent in the 1 in 200 year event for 2125 higher central climate change projection

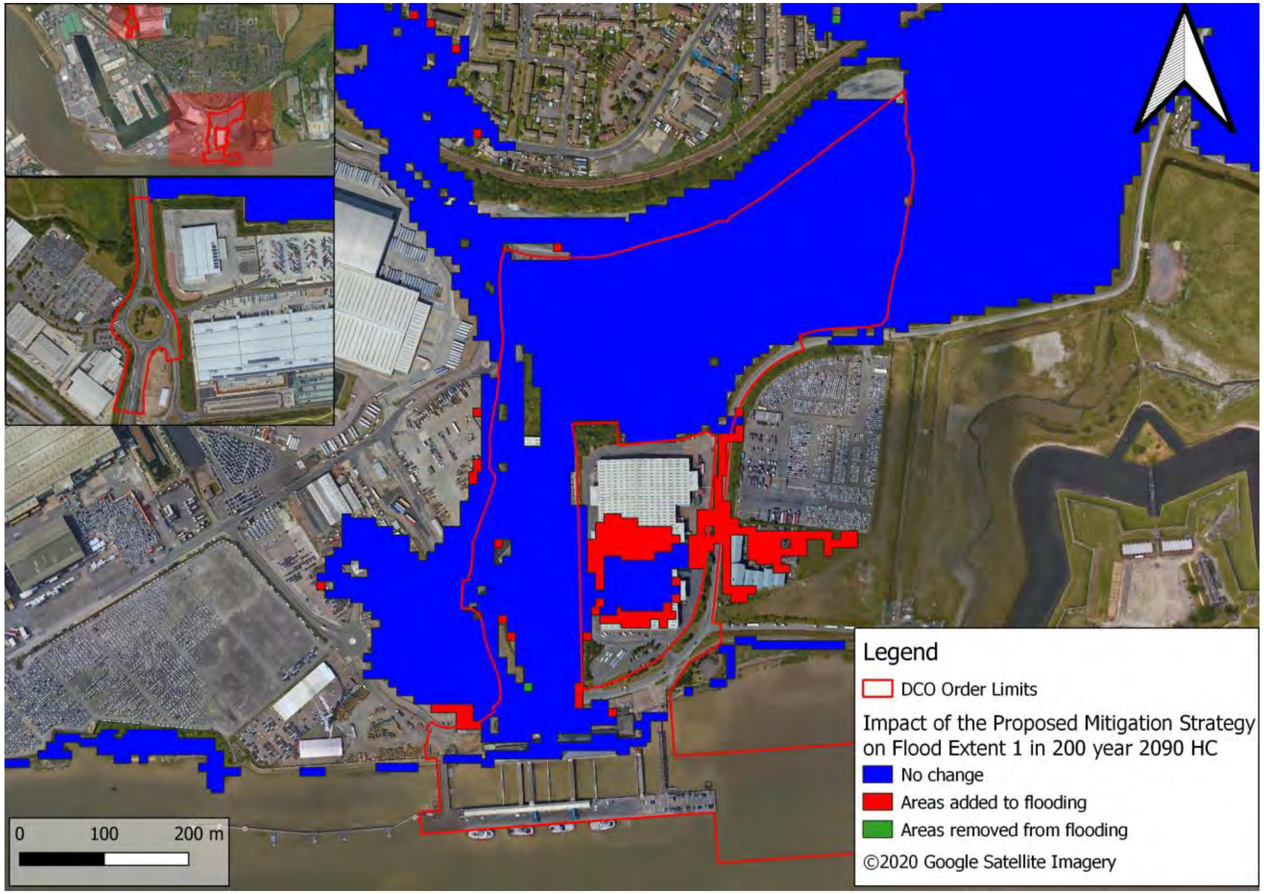


Figure 6-10 Essex Project Site change in Proposed 2020 model compared to Baseline 2020 model for Breach flood extent in the 1 in 200 year event for 2125 higher central climate change projection

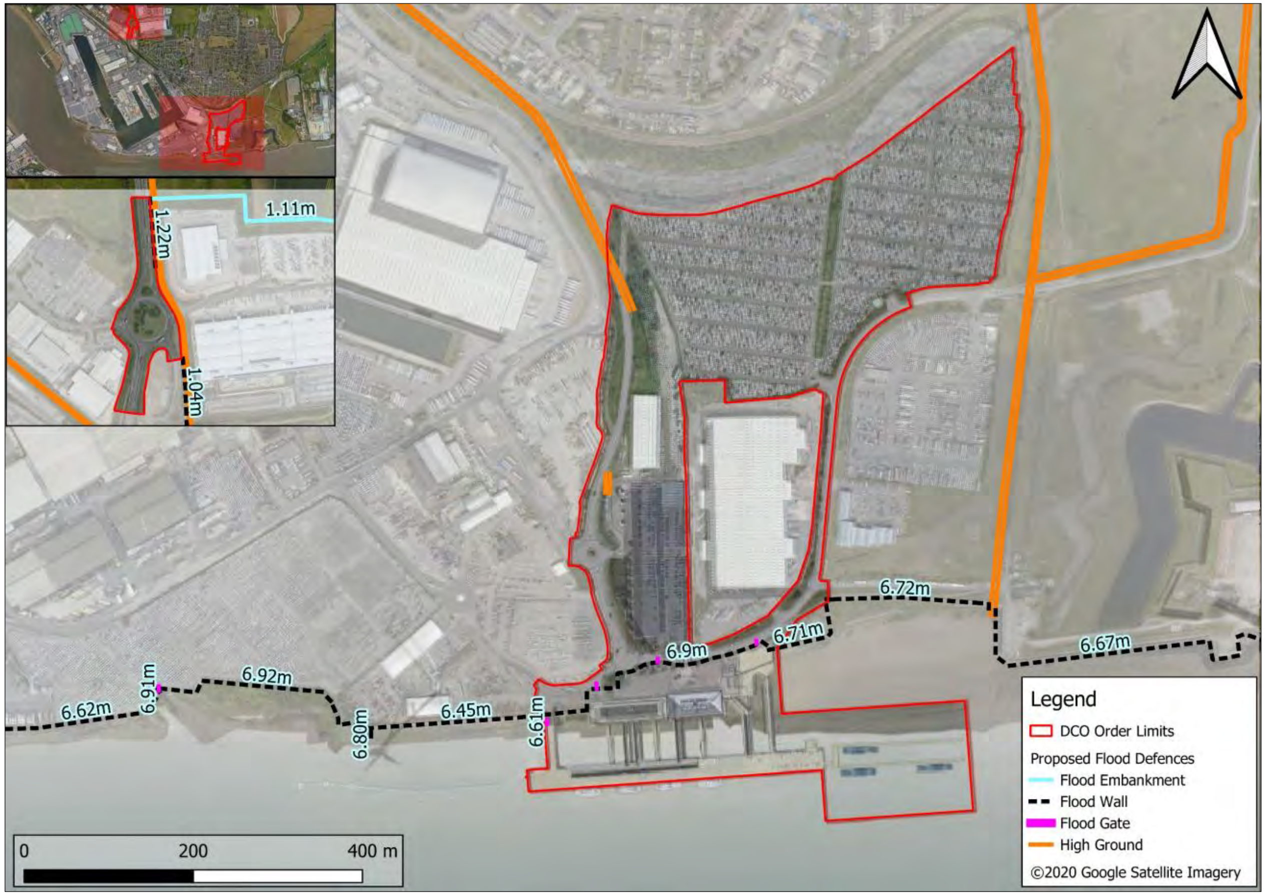


Figure 6-11: EA proposed flood defence alignment information taken from drawing TEA-3F-00.00-DR-CI-00-000005 Rev P04 (January 2018) Illustrative masterplan shown on imagery.

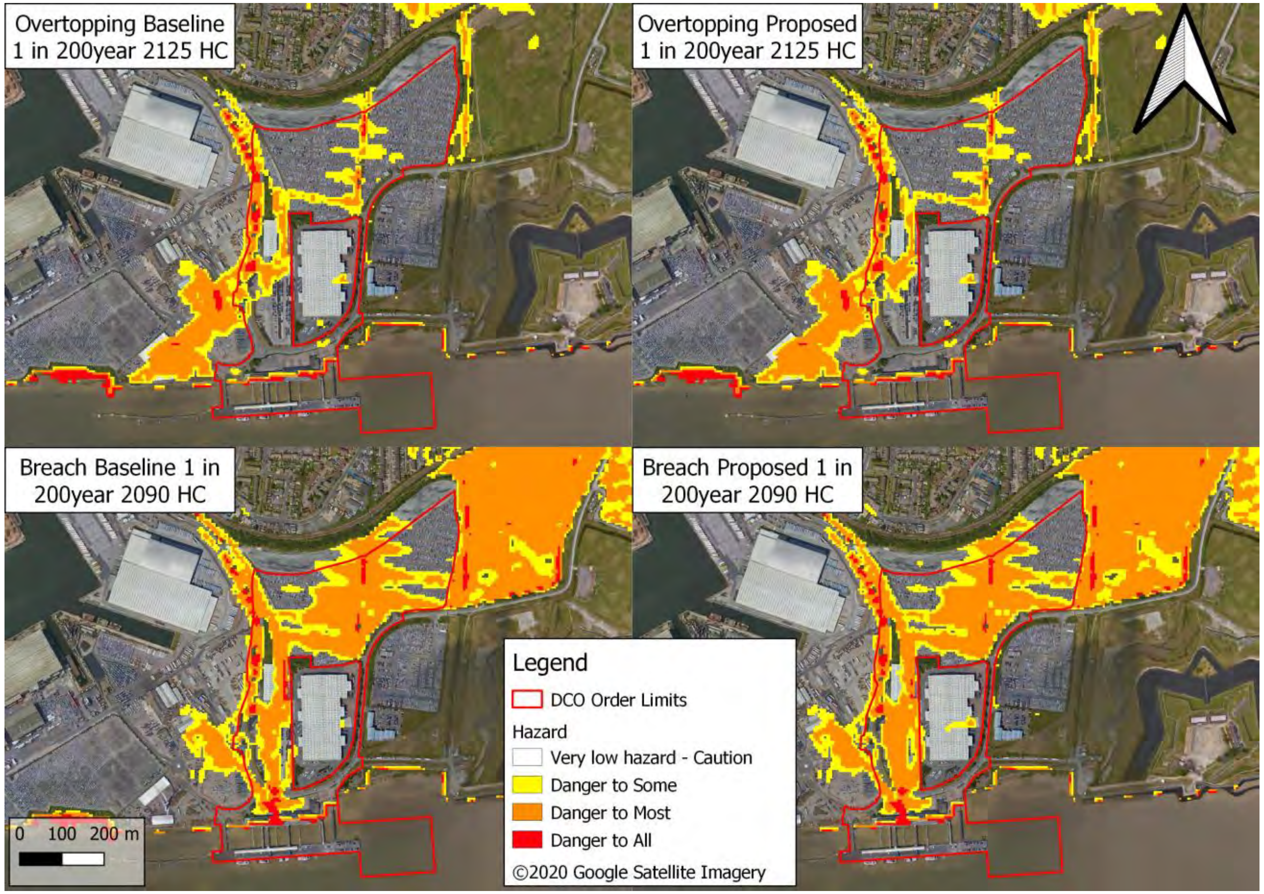


Figure 6-12: Essex Project Site 1 in 1000 year Breach event (breach 22) 2090 using the higher central climate change allowance hazard flood map

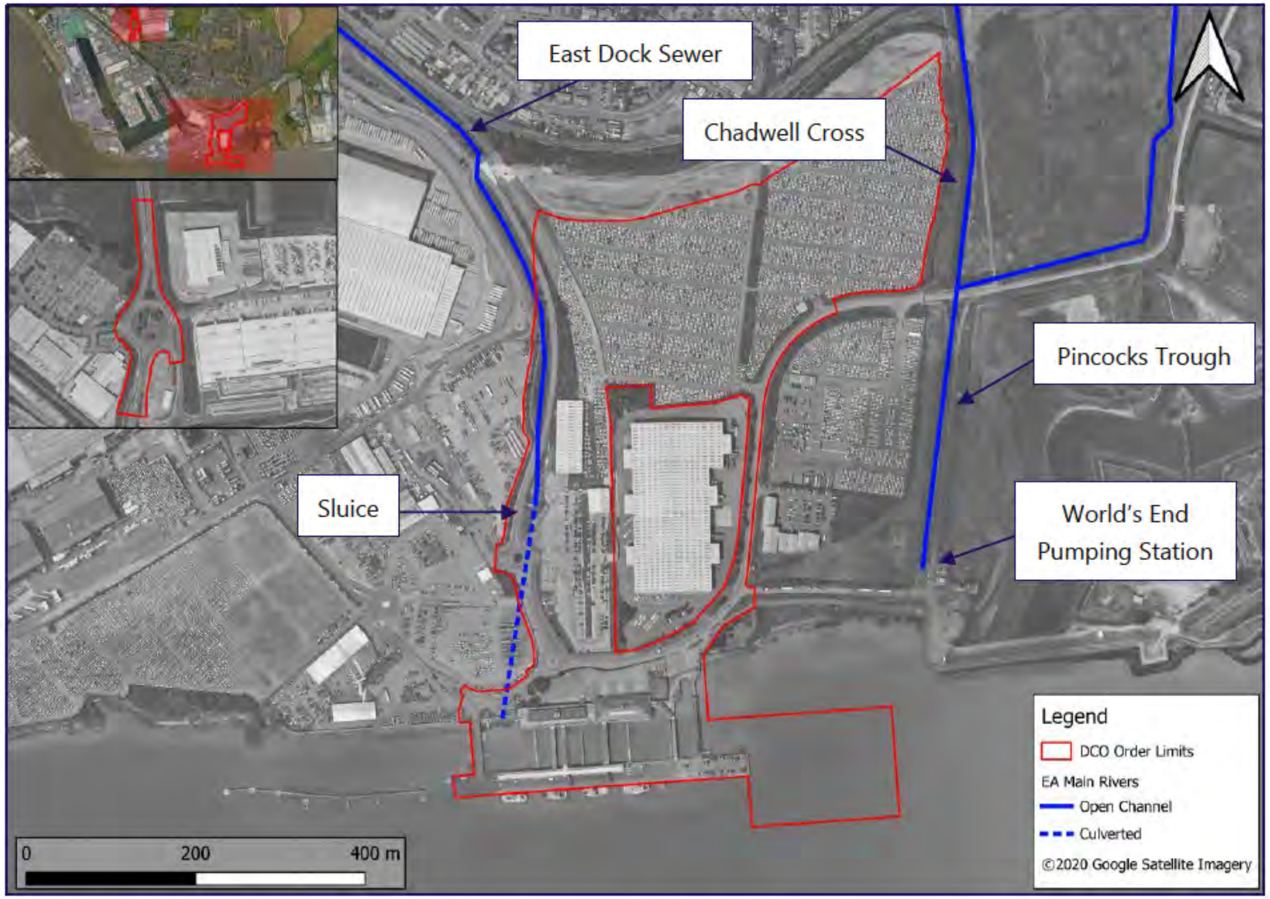


Figure 6-13: Essex Project Site EA designated main rivers

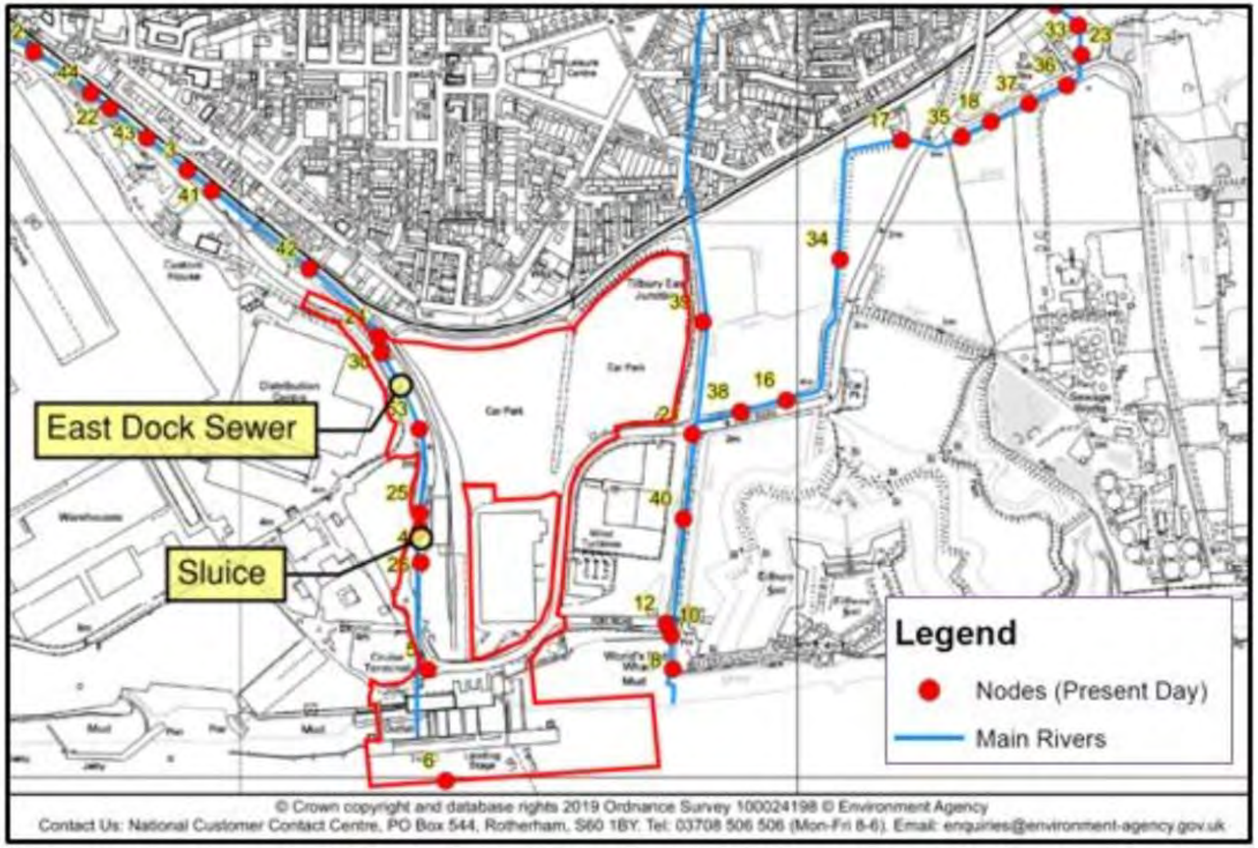


Figure 6-14: Tilbury Integrated Flood Strategy model nodes (adapted from EA Product 4, 28/07/2020)

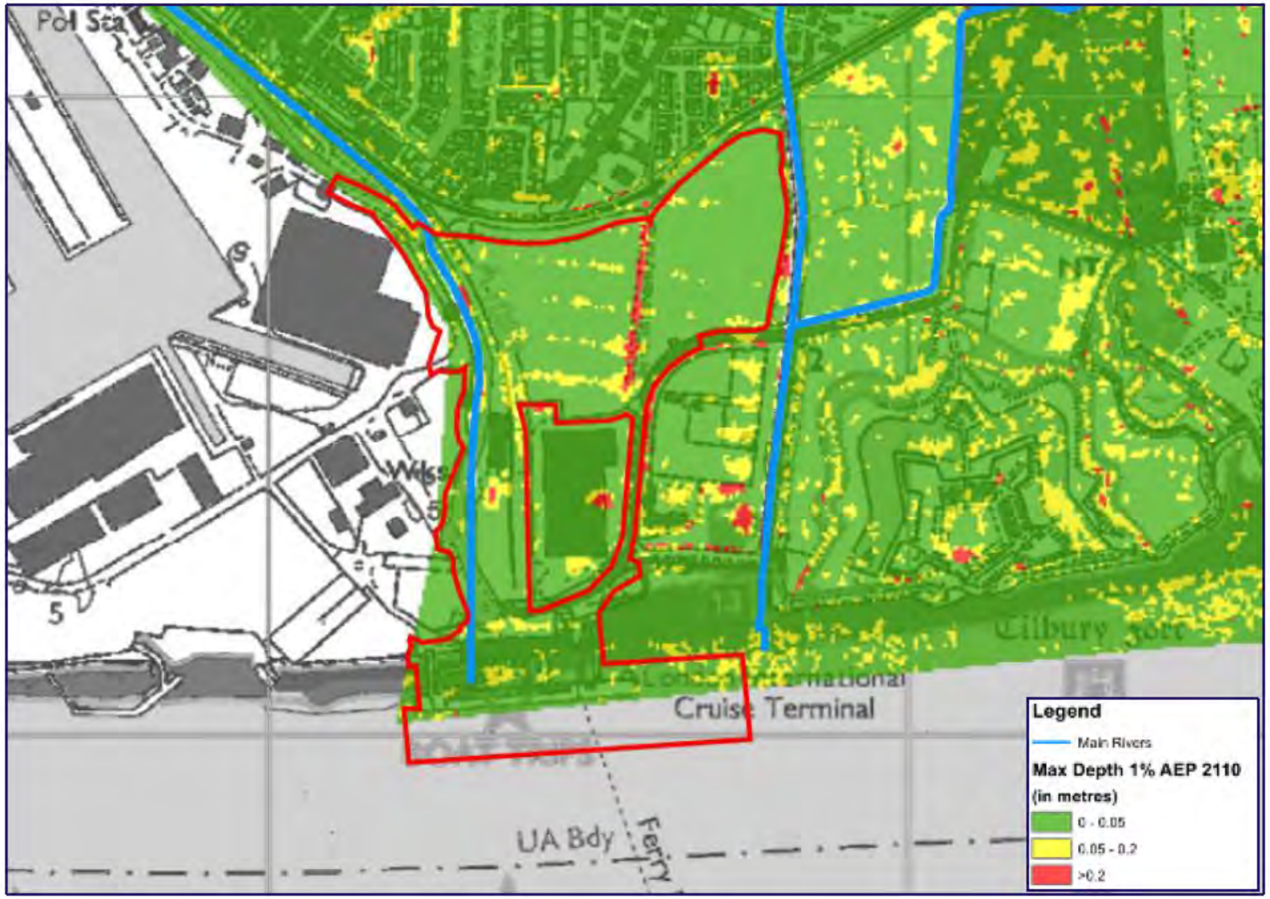


Figure 6-15: Tilbury Integrated Flood Strategy flood extents for the 1 in 100 year plus climate change (2110) (adapted from EA Product 4, 28/09/2020)

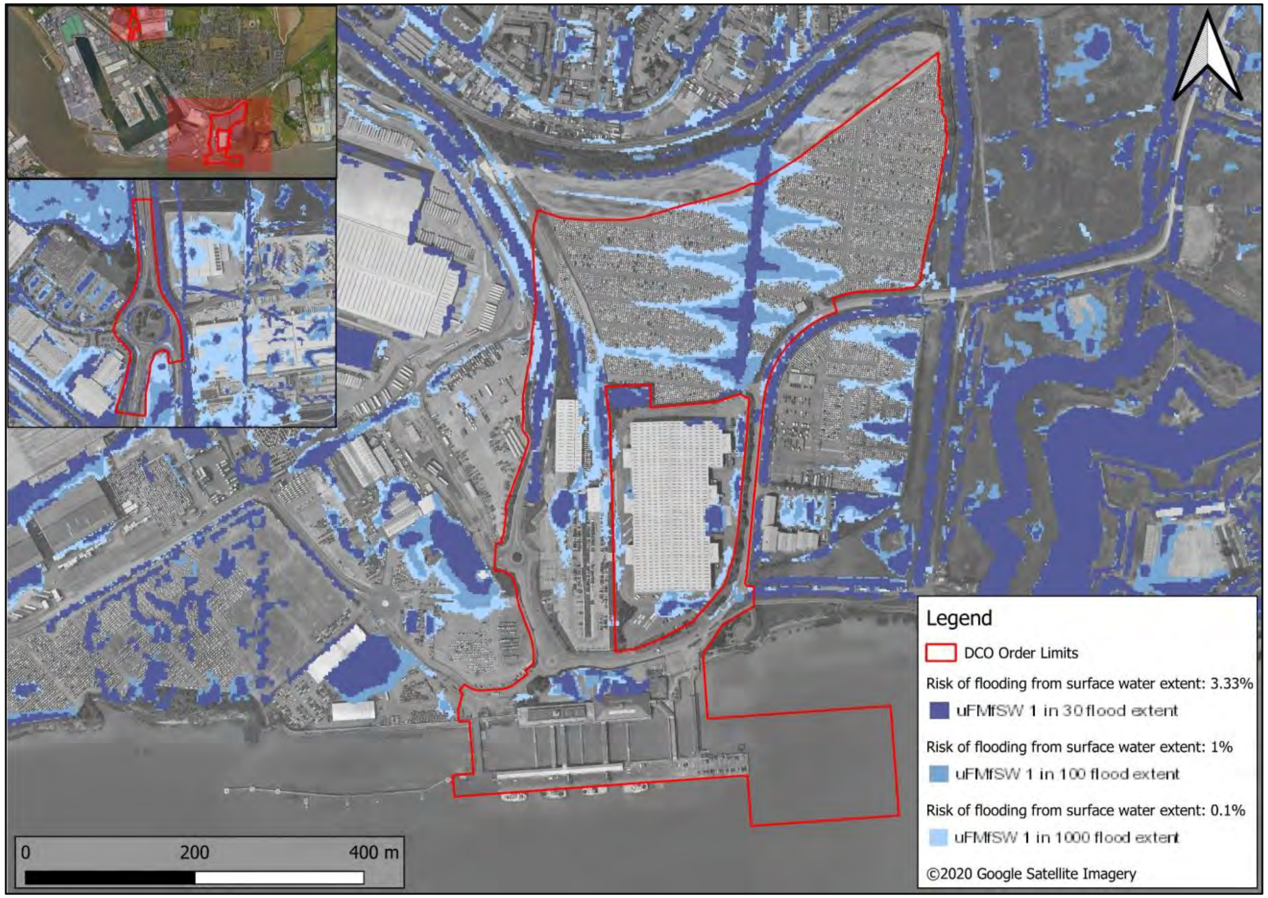


Figure 6-16: EA flood map showing surface water modelled flood extent (Map data ©2015 Google, © Environment Agency copyright and/or database right 2014. All rights reserved. Some features of this map are based on digital spatial data from the Centre for Ecology & Hydrology, © NERC (CEH). Soils Data © Cranfield University (NSRI) and for the Controller of HMSO 2013.)

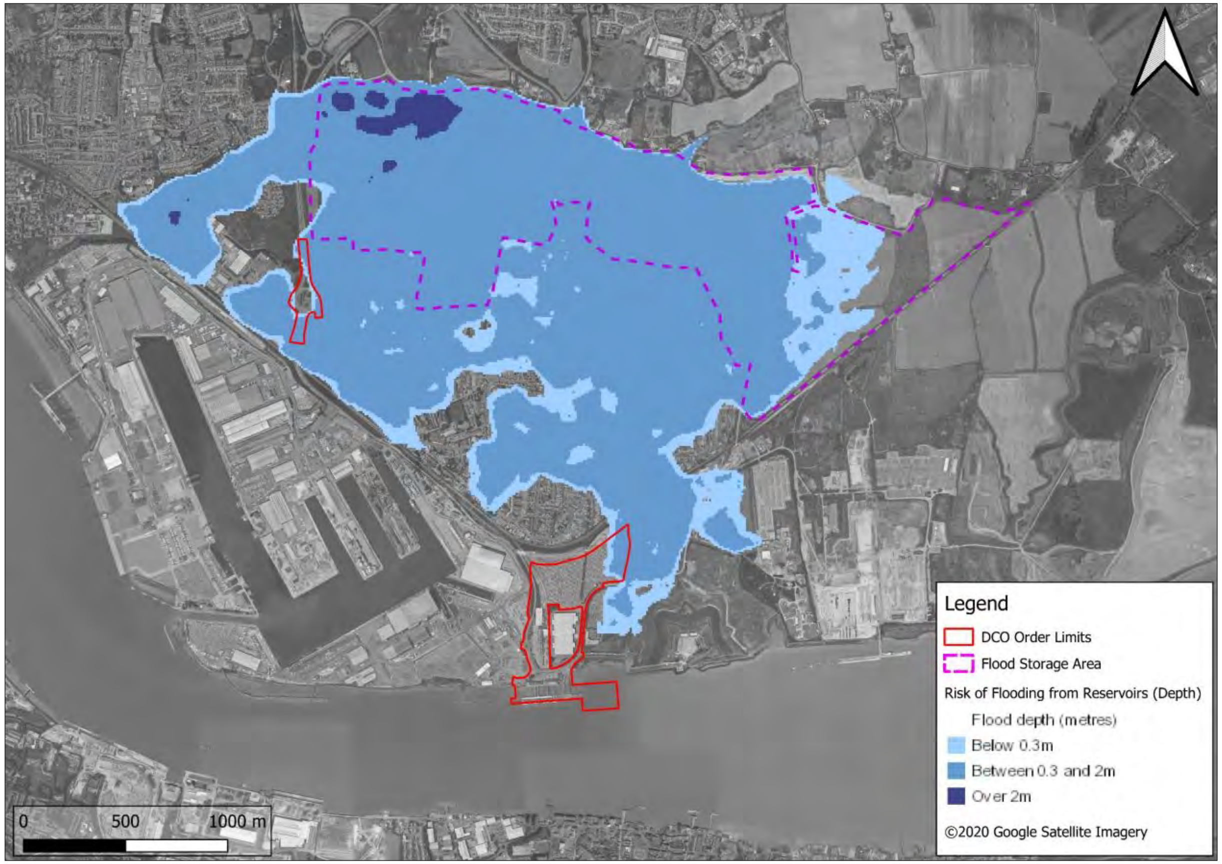


Figure 6-17: Essex Project Site Flood Risk from artificial sources (Map data ©2015 Google, © Environment Agency copyright and/or database right 2014. All rights reserved. Some features of this map are based on digital spatial data from the Centre for Ecology & Hydrology, © NERC (CEH). Soils Data © Cranfield University (NSRI) and for the Controller of HMSO 2013.)

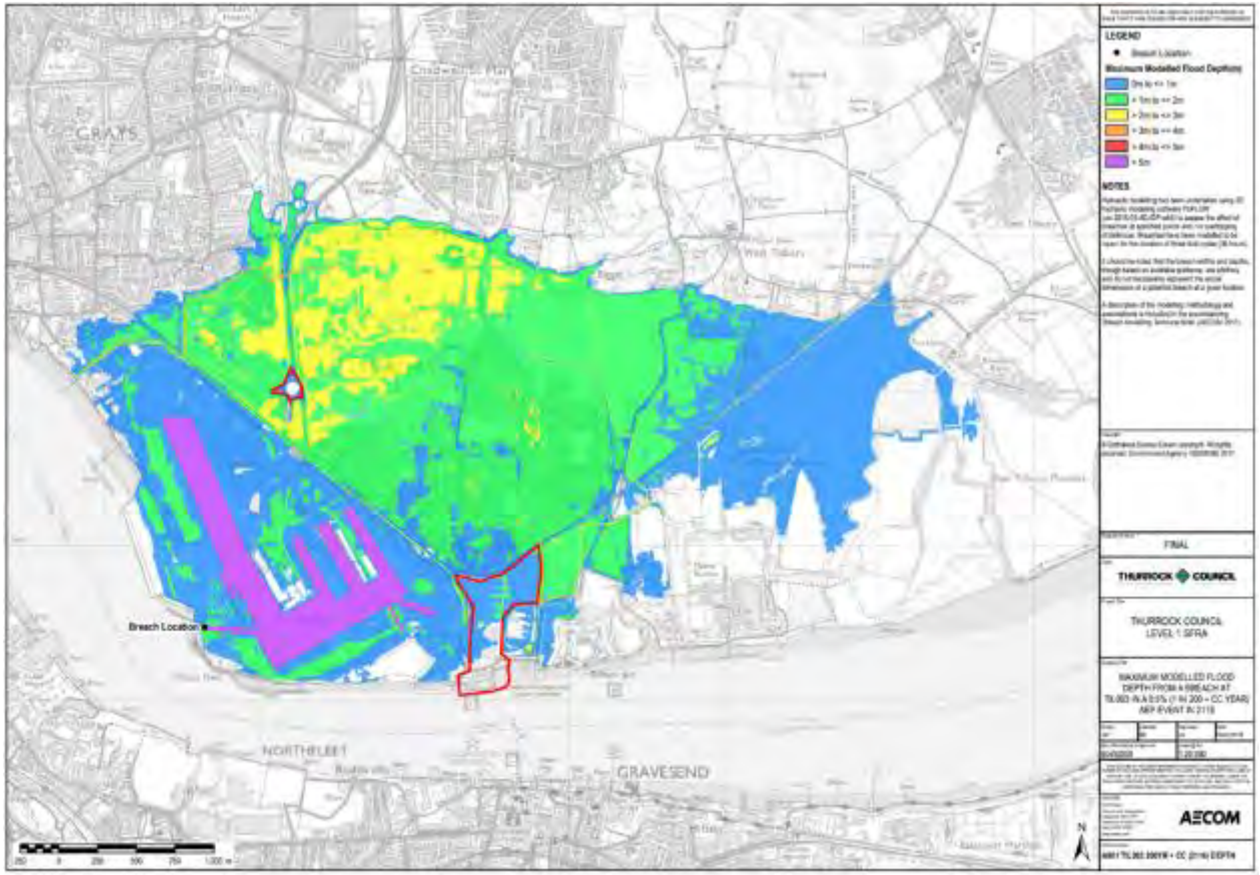


Figure 6-18: Essex Project Site flood risk from artificial sources: Tilbury Docks Breach[3]. DCO Order Limit shown in red.

[3] AECOM (June 2018) *'Thurrock Borough Council Level 1 Strategic Flood Risk Assessment' https://regs.thurrock.gov.uk/online-applications-skin/thurrock-strategic/sfra_201806/lptech-thurrock-sfra1-201806-v01.pdf (accessed on 02/07/2020)*