Appendix 9A: Flood Risk Assessment
Part 1 - FRA

Flood Risk Assessment

Humber Zero

Phillips 66 and VPI Immingham

February 2023

Delivering a better world

Quality information

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Revision History

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1. Introduction

1.1 Commission

AECOM Limited (AECOM) has been commissioned by Phillips 66 and VPI Immingham (known as 'the Applicants' hereafter) to produce a Flood Risk Assessment (FRA) to support planning applications for the proposed Post Combustion Carbon Capture (PCC) developments located at VPI Immingham Combined Heat and Power (CHP) Plant and the Phillips 66 Humber Refinery (the 'Proposed Developments'). The Proposed VPI Development comprises a PCC retrofit to two gas turbines (GT1 and GT2) and two auxiliary gas boilers at the CHP Plant (post code location DN40 3DZ). The Proposed Phillips 66 Development comprises a PCC retrofit to the Fluid Catalytic Cracker (FCC) stack at the Humber Refinery (post code location DN40 3DW).

1.2 Background

The Proposed Development Sites (the Sites) lie 1.6 km north of Immingham and 1.4 km west of the Humber Estuary. The Sites are located within the North Lincolnshire Council administrative boundary, in the ward of Ferry.

The National Planning Policy Framework 2022 (NPPF)[1] and associated Flood Risk and Coastal Change Planning Practice Guidance (PPG)[2] specify that any new development located within an area susceptible to flooding from local sources and/or located within Flood Zone 1 and greater than 1 hectare (ha), or located in Flood Zone 2 or 3, should be supported by a site-specific FRA. The FRA should demonstrate how these flood risks will be managed so that the development remains safe throughout its lifetime, taking into account the vulnerability of the Proposed Development and the potential impact of climate change on flood risk.

1.2.1 Phillips 66 Site

The Philips 66 Site is largely within the operational Humber Refinery. The main PCC plant, including the compression facilities, will be in the north-west corner of the Humber Refinery. This area is currently used for open storage. Two buildings in this area are to be demolished and the existing uses will be relocated to other parts of the Refinery.

The route of the proposed CO_2 pipeline connecting the Phillips 66 PCC plant and compression facilities to the CO_2 gathering network (provided by others) follows an existing utilities corridor along the northern boundary of the Refinery (known as Avenue A) with several above ground pipes on racks. The existing utilities will be retained and will not be affected by the Proposed Phillips 66 Development. The CO_2 pipeline will then cross the Phillips 66 railway sidings and part of the Network Rail operated railway line between Grimsby, Immingham and Ulceby, using an existing pipeline crossing. On the north side of the railway line, the CO_2 pipeline will turn south-east to a tie-in with the proposed CO_2 gathering network (Humber Low Carbon Pipelines and/or Viking CCS) for transmission to a storage facility under the North Sea.

Electricity supply and signal cables will also be required along the same route as the CO_2 pipeline.

1.2.2 VPI Site

The VPI Site is located partly within the operational VPI Immingham CHP Plant site. The PCC plant will require various connections to the CHP Plant (for example to divert flue gas into the PCC plant, and for the supply of electricity and steam) and is likely to use some of the existing facilities with the CHP Plant (such as the control room).

The area for the VPI PCC plant is located immediately to the south of the CHP Plant and comprises grassland and scrub with an open ditch west to east running through the centre, areas of hardstanding and existing below ground utilities. The northern part of this area (closest to the CHP Plant) was previously used for construction laydown during the construction of the CHP Plant.

[1] National Planning Policy Framework (NPPF) 2022. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/6000/2115548.pdf. Retrieved: 08/11/22
[2] Planning Practice Guidance (PPG) 2022. Accessed: https://www.gov.uk/guidance/flood-risk-and-coastal-change. Retrieved: 08/11/22

1.3 Scope of Report

The aim of this study is to undertake a FRA that is appropriate to the nature and scale of the Proposed Developments. The FRA determines flood risk posed to the Sites and arising as a result of the Proposed Developments and recommends suitable mitigation measures where required.

The objectives of this report are to:

- Consult with the Environment Agency, North Lincolnshire Council (in their role as Lead Local Flood Authority (LLFA)), and North East Lindsey Internal Drainage Board (IDB) (via the Witham IDB) in relation to flood risk and their requirements for management of any risk (data consultation responses are presented as **Annex A**);
- Collect and review existing information relating to flood risk posed to the Proposed Development Sites from all sources (including tidal, fluvial, surface water, groundwater, artificial sources and sewer and drainage infrastructure);
- Assess the flood risk to and from the Proposed Developments in accordance with the NPPF and the associated PPG, taking into account climate change; and
- Outline any mitigating measures needed to ensure the Proposed Developments and their users will be safe for the lifetime of the developments.

1.4 Data Sources

The baseline conditions for the Sites have been established through a desk study using publicly available information. The FRA is based on the best available flood risk information available at the time of writing. Data has been obtained from online Environment Agency resources and other publicly available external sources.

Data collected and used to inform this assessment is summarised in **Table 1.1**.

Table 1.1 Sources of Data Reviewed

Purpose	Data Source	Comments
Identification of Hydrological Features	1: 10,000 Ordnance Survey (OS) mapping[3]	Identifies the position of the Sites, local hydrological features, and riparian owners.
Historical Land Use and Hydrological Features	Historic OS maps dating back from 1842- Present[4]	Identifies historical land use change and hydrological features over the last 176 years.
Identification of Existing Flood Risk	Environment Agency Flood Map for Planning (FMfP) (online[5] and reproduced in Plate 5.2 and Plate 5.8)	Identifies fluvial/ tidal inundation extents.
	Environment Agency Long Term Flood Risk Maps (online[6] and reproduced in Plate 5.6 and Plate 5.12)	Identification of flood risk from surface water and reservoirs.
	Environment Agency Flood Inundation Mapping[7]	Provides information on the risk of flooding from reservoirs (artificial sources).
	Environment Agency Groundwater Conditions Map[8]	Identification of groundwater designations through geology.
	Grimsby and Ancholme: Catchment Flood Management Plan[9]	Assesses flood risk across the North Lincolnshire Council boundary area. Includes flood risk from fluvial/ tidal, sewers, overland flow and groundwater.

[3] Ordnance Survey. Accessed: https://explore.osmaps.com/. Retrieved: 08/11/22
[4] Ordnance Survey. Maps from 1857-1986. Accessed: http://www.oldmapsonline.org/. Retrieved: 08/11/22
[5] Environment Agency. Flood Risk for Planning. Available at: https://flood-map-for-planning.service.gov.uk/. Retrieved: 08/11/22
[6] Environment Agency. Flood Risk from Surface Water Available at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?map=SurfaceWater. Retrieved: 08/11/22
[7] Environment Agency. Flood Risk from Reservoirs. Available at: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?map=Reservoirs. Retrieved: 08/11/22
[8] Environment Agency. Groundwater. Available at: http://magic.defra.gov.uk/MagicMap.aspx. Retrieved: 08/11/22
[9] Environment Agency (2009). Grimsby and Ancholme: Catchment Flood Management Plan. Accessed:: https://www.gov.uk/government/publications/grimsby-and-ancholme-catchment-flood-management-plan. Retrieved: 08/11/22

Purpose	Data Source	Comments
	North Lincolnshire Council Preliminary Flood Risk Assessment (PFRA)[10] North Lincolnshire Council Strategic Flood Risk Assessment (SFRA) – 2022[11] North Lincolnshire Council Local Flood Risk Management Strategy (2016) (LFRMS)[12] Consultation with Environment Agency, North Lincolnshire Council and North East Lindsey IDB. (Annex A)	
	British Geological Survey (BGS) records[13] Environmental Statement (ES) Chapter 10: Geology, Hydrogeology and Land Contamination (ES Volume I)[14]	Provides details of geology and hydrogeology in the vicinity of the Sites.
Identification of Historical Flooding	North Lincolnshire SFRA[11] North Lincolnshire PFRA[10] Consultation with Environment Agency, North East Lincolnshire Council and North East Lindsey IDB (Annex A) DEFRA Data Service Platform[15] and reproduced in Plate 5.1 and Plate 5.7	Provides details of historical flooding.
Details of the Proposed Developments	Layout Plans (Annex B) Humber Zero FEL 2	Provides the indicative layouts of the Proposed Developments.
	Humber Zero VPI-Immingham Post-Combustion Carbon Capture Project FEED Flood Risk Assessment[16]	Details for the ditch diversion and surface water management information for the VPI Site.
	Preliminary Drainage Calculations[17]	Surface water drainage calculations for the Phillips 66 Site
	Ditch Diversion Plan (Annex D)	Shows location and design parameters for the proposed diversion of South Killingholme Drain.

[10] North Lincolnshire Council Preliminary Flood Risk Assessment (PFRA). Accessed: https://webarchive.nationalarchives.gov.uk/ukgwa/20140328094437/http:/www.environment-agency.gov.uk/research/planning/135526.aspx. Retrieved: 08/11/22
[11] North Lincolnshire Council (2022). Strategic Flood Risk Assessment (SFRA). Accessed: https://www.northlincs.gov.uk/planning-and-environment/planning-policy-monitoring-and-information/#1590668927619-985ee698-b5b5. Retrieved: 08/11/22
[12] North Lincolnshire Council (2016). Local Flood Risk Management Strategy. Accessed: https://www.northlincs.gov.uk/community-advice-and-support/flooding-and-other-emergencies/#1604922292125-82ee4b59-6f57. Retrieved: 08/11/22
[13] British Geological Survey (BGS) records. Accessed: https://www.bgs.ac.uk/map-viewers/geology-of-britain-viewer/. Retrieved: 08/11/22
[14] AECOM (2023) ES Vol I Chapter 10: Geology, Hydrogeology and LandContamination. Retrieved: 08/11/22
[15] DEFRA. Data Services Platform. Available at: https://environment.data.gov.uk/. Retrieved: 08/11/22
[16] Worley (2022) Humber Zero VPI-Immingham Post-Combustion Carbon Capture Project FEED Flood Risk Assessment
[17] Worley (2022) 60-PY13-02 Humber Zero FEL 2 Preliminary Drainage Calculations Rev A – 15/12/2022

2. Site Information

2.1 Site Location and Context

The Sites are located 1.6 km north of Immingham near South Killingholme. The boundaries for the Sites are shown on **Plate 2.1** below.

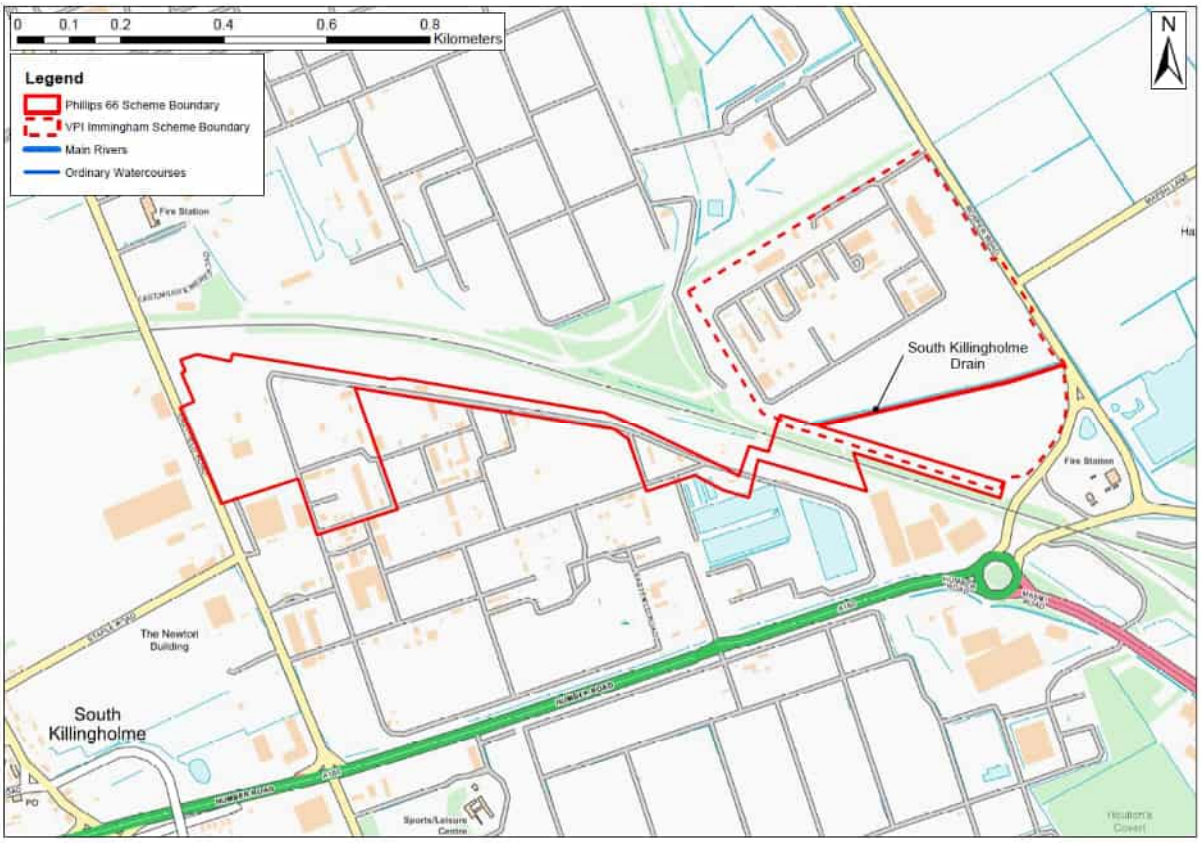

Plate 2.1: Site Location Plan for the Proposed Phillips 66 and VPI Immingham Developments

2.1.1 Phillips 66 Site

The Phillips 66 Site is centred on National Grid Reference (NGR) TA 16029 16662 and lies adjacent to the River Humber (Humber Estuary). Access is gained via Eastfield Road (via A160).

2.1.2 VPI Site

The VPI Site is centred on National Grid Reference (NGR) TA 16851 17255 and lies adjacent to the River Humber (Humber Estuary). Access is gained via Rosper Road (via A160).

2.2 Local Water Features

2.2.1 Phillips 66 Site

The following local water features have been identified within or close proximity to the Phillips 66 Site through the inspection of OS 1:10,000 mapping[3]:

- Tidal River: The Humber Estuary (River Humber) originates at Trent Falls, by the confluence of the tidally influenced rivers Ouse and Trent and flows south-east into the North Sea;
- Main River: North Beck Drain is approximately 4.8 km south-east from the Phillips 66 Site and has flood defences;
- Ordinary Watercourses: North East Lindsey IDB are operational within the area and have flood risk management responsibilities over South Killingholme Drain, divided into two respective watercourses,

Watercourse 9A and Watercourse 9. Watercourse 9A lies partly within the westernmost part of the Phillips 66 Site;

- A series of unnamed land drains run parallel with the Humber Refinery boundary and the area surrounding the Phillips 66 Site is drained via a network of small land drainage ditches that convey surface water from the surrounding greenfield areas located between the Humber Refinery and the Humber Estuary; and
- Lagoons associated with the water treatment facility within the Humber Refinery.

2.2.2 VPI Site

The following local water features have been identified within or close proximity to the VPI 66 Site through the inspection of OS 1:10,000 mapping[3]:

- Tidal River: The Humber Estuary (River Humber) originates at Trent Falls, by the confluence of the tidally influenced rivers Ouse and Trent and flows south-east into the North Sea.
- Main River: Stallingborough North Beck Drain is approximately 4.8 km south-east from the VPI Site boundary and has flood defences.
- Ordinary Watercourses: North East Lindsey IDB are operational within the area and have flood risk management responsibilities over South Killingholme Drain, divided into two respective watercourses, Watercourse 9A and Watercourse 9. Watercourse 9A crosses the VPI Site.
- Rosper Road Pools, an artificial flood relief reservoir, is located approximately 50 m to the east of the VPI Site, east of Rosper Road.

2.3 Historical Land Use and Water Features

2.3.1 Phillips 66 Site

Historical OS mapping[4] dating from 1887 to the present day was reviewed. The earliest known mapping shows undeveloped agricultural land prior to the development of the Humber Refinery in 1966. The local water features mentioned above in **Section 2.2.1** are not present on these maps (excluding the River Humber).

2.3.2 VPI Site

Historical OS mapping[4] dating from 1887 to the present day was reviewed. The earliest known mapping shows undeveloped agricultural land prior to the development of the CHP Plant in 2004. The local water features mentioned above in **Section 2.2.2** are not present on these maps (excluding the River Humber).

2.4 Topography

OS mapping and LiDAR Digital Terrain Model (DTM) of 1m grid resolution, obtained from the DEFRA Data Services Platform[15], was reviewed (presented in **Plate 2.2**). Please note that there is a data anomaly within the dataset, and therefore levels within the area marked in light grey are assumed to be similar to the surrounding areas.

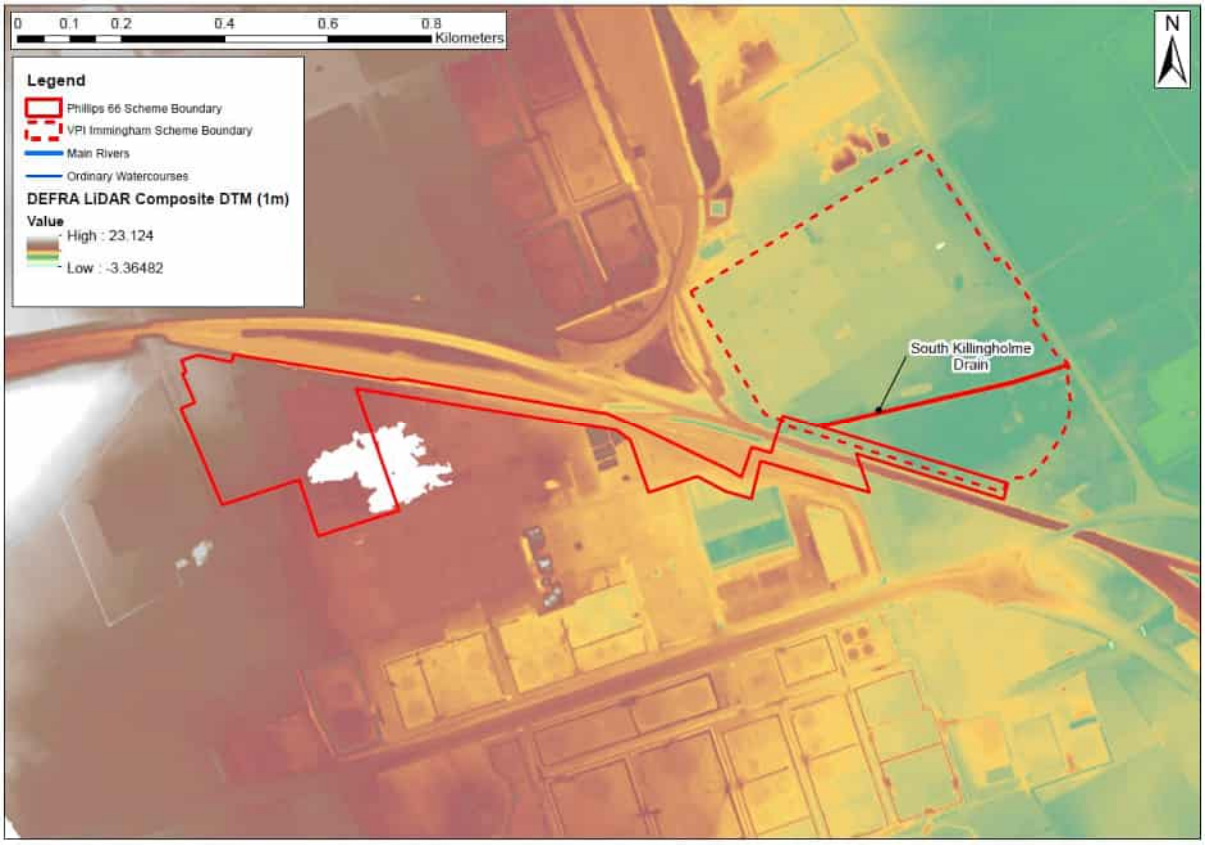

Plate 2.2: Site Topography for the Phillips 66 and VPI Immingham Developments

2.4.1 Phillips 66 Site

The Phillips 66 Site falls from north-west to south-east, with a high point of 13.24 m AOD in the north-west corner of the Phillips 66 Site (the proposed location of the main PCC plant) and a low point of 2.93 m AOD in the eastern section of the Phillips 66 Site, adjacent to the railway.

2.4.2 VPI Site

The VPI Site falls from north-west to south-east, with a high point of 5.02 mAOD in the north-west corner of the VPI Site and a low point of 2.76 mAOD in the south-eastern corner of the VPI Site.

2.5 Geology and Hydrogeology

2.5.1 Phillips 66

ES Chapter 10: Geology, Hydrogeology and Land Contamination (ES Volume I)[14] indicates that Devensian – Diamicton superficial deposits and Burnham Chalk Formation bedrock underlies the Phillips 66 Site.

The Environment Agency groundwater mapping[8] indicates that the Phillips 66 Site falls within Source Protection Zone III (SPZ). Groundwater SPZs monitor the risk of contamination from any activities that may cause pollution to the surrounding area. This is described in more detail in **Section 5.1.5**.

2.5.2 VPI Site

ES Chapter 10: Geology, Hydrogeology and Land Contamination (ES Volume I)[14] indicates that Devensian – Diamicton superficial deposits and Burnham Chalk Formation bedrock underlies the Proposed Development Site.

The Environment Agency groundwater mapping[8] indicates that the Proposed Development Site falls within SPZ III. Groundwater SPZs monitor the risk of contamination from any activities that may cause pollution to the surrounding area. This is described in more detail in **Section 5.2.5**.

2.6 The Proposed Developments

As described in Section 1.1, the first phase of the Humber Zero project comprises the Proposed VPI Development and the Proposed Phillips 66 Development.

The Proposed Developments are necessarily located adjacent to the existing activities that are to be decarbonised (namely the Humber Refinery FCC and the VPI Immingham CHP Plant), but they are also well situated to connect into either the Viking CCS CO_2 gathering network and/or the Humber Low Carbon Pipelines CO_2 gathering network for transport to storage sites under the North Sea. Development Consent Order applications for both of these CO_2 gathering networks are being progressed by Harbour Energy and National Grid respectively and are due to be submitted in early 2023.

The water, steam and power required for the Proposed Developments will be supplied from existing Humber Refinery systems and the VPI Immingham CHP Plant. The PCC facilities will be designed for up to 95% CO_2 capture during steady state operation. It is intended that CO_2 will be exported at high pressure via an interface to a CO_2 gathering network adjacent to the Sites.

2.6.1 Philips 66 Development

The Proposed Phillips 66 Development will comprise a PCC plant and associated facilities for the Fluid Catalytic Cracker (FCC) at the Humber Refinery.

The Proposed Phillips 66 Development will include the following components:

- FCC flue gas waste heat exchanger for energy recovery;
- ducting (including ducting over an existing internal access road) to connect the FCC unit to the Phillips 66 PCC plant;
- flue gas pre-treatment using Selective Catalytic Reduction (SCR), a wet gas scrubber and wet electrostatic precipitator with associated air-cooled heat exchangers;
- one PCC unit with associated quencher, blower, absorber, stack, stripper/ regenerator, thermal reclaimer unit and air-cooled heat exchangers/ fin fans;
- low pressure and high pressure CO_2 vent stacks for use during start up, shut down and emergencies only;
- CO_2 compression facility with associated air-cooled heat exchangers/ fin fans;
- oxygen removal and dehydration facilities;
- CO_2 metering and a pipeline connecting the PCC plant and compression facilities to the CO_2 gathering network interface, including a pipeline crossing of the Phillips 66 railway sidings and Network Rail railway line;
- on-site electrical substation;
- caustic, solvent and other chemical offloading and storage facilities;
- utilities (including chillers, steam generator and air compressors)
- internal access roads;
- surface water and foul water drainage systems;
- construction and maintenance laydown areas; and
- a new site access from Eastfield Road.

Plans showing the layouts of the Proposed Development are presented as Annex B.

2.6.2 VPI Development

The Proposed VPI Development will include the following components:

- ducting to connect GT1, GT2 and the auxiliary boilers to the VPI PCC plant;
- two PCC units (or 'trains'), each with associated blower, direct contact cooler, absorber, stack, stripper/ regenerator, thermal reclaimer unit and air-cooled heat exchangers;
- a CO_2 vent stack for use during start up, shut down and emergencies only;
- CO_2 compression facility with associated air-cooled heat exchangers;
- oxygen removal and dehydration facilities;

- CO_2 metering and a pipeline connecting the PCC plant and compression facilities to the CO_2 gathering network interface;
- up to four on-site electrical substations;
- caustic, solvent and other chemical offloading and storage facilities;
- utilities (including chillers, steam generator, hydrogen package and air compressors)
- internal access roads;
- surface water drainage system
- realignment of the existing ditch (South Killingholme Drain) within the VPI Site;
- construction and maintenance laydown areas; and
- a new site access from Rosper Road.

Plans showing the layouts of the Proposed Development are presented as **Annex B**.

3. Planning Policy and Guidance

3.1 Overview

The Section below considers the planning policies and guidance that are of relevance to the Proposed Developments with regards to flood risk.

3.2 National Planning Policy Context

3.2.1 National Planning Policy Context

Section 12 of the 2022 updated NPPF is supported by the 2022 Flood Risk and Coastal Change Planning Practice Guidance (PPG), which both advise on how the planning process can take account of risks associated with flooding.

The NPPF and PPG must be taken into account in the preparation of local and neighbourhood plans and are a material consideration in planning decisions. It constitutes guidance for LPA and decision-takers, both in drawing up plans and as a material consideration in determining applications.

As such, for new development applications, the following should be applied:

- the Sequential Test;
- the Exception Test, if necessary;
- safeguarding land from development that is required for current and future flood management; and
- seeking opportunities to facilitate the relocation of existing development, including housing, to more sustainable locations if climate change is expected to increase flood risk.

The NPPF states that when determining planning applications, LPA should ensure that flood risk is not increased elsewhere. Where appropriate, applications should be supported by a site-specific FRA. Development should only be allowed in areas at risk of flooding where, in light of this assessment (and the Sequential and Exception tests, as applicable), it can be demonstrated that:

- within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;
- the development is appropriately flood resistant and resilient;
- it incorporates Sustainable Drainage (SuDS), unless there is clear evidence that this would be inappropriate;
- any residual risk can be safely managed; and
- safe access and escape routes are included where appropriate, as part of an agreed emergency plan.

Major developments should incorporate SuDS unless there is clear evidence that this would be inappropriate. The systems used should:

- take account of advice from the Lead Local Flood Authority;
- have appropriate proposed minimum operational standards;
- have maintenance arrangements in place to ensure an acceptable standard of operation for the lifetime of the development; and
- where possible, provide multifunctional benefits.

All sources of flooding should be considered in order to steer development at the planning stage to areas at the lowest risk of flooding in order to satisfy the Sequential Test. This includes assessing the risk of flooding from Main Rivers and the Sea. The predicted flood risk from these sources is shown on the Environment Agency's Fluvial and Coastal Map, also known as the Flood Map for Planning (FMfP), which outlines three main zones of risk. These are described in **Table 3.1**.

Table 3.1 Environment Agency Flood Zone Definitions

Flood Zone	Definition	Risk of flooding
Flood Zone 1	Land that has a low probability of flooding (less than 1 in 1,000 annual probability of river or sea flooding (<0.1%))	Low
Flood Zone 2	Land that has a medium probability of flooding (between 1 in 100 and 1 in 1,000 annual probability of river flooding (0.1-1%), or between 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.1-0.5%)	Medium
Flood Zone 3a	Land that has a high probability of flooding (1 in 100 year or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%)	High
Flood Zone 3b (Functional Floodplain)	This zone comprises land where water has to flow or be stored in times of flood. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. Functional floodplain will normally comprise: • land having a 3.3% or greater annual probability of flooding, with any existing flood risk management infrastructure operating effectively; or • land that is designed to flood (such as a flood attenuation scheme), even if it would only flood in more extreme events (such as 0.1% annual probability of flooding). Please note, this zone is not usually included within the FMfP and is calculated where necessary during detailed hydraulic modelling.	Very High

Source: Planning Practice Guidance (2022)

3.2.2 The Sequential and Exception Tests

The overall aim of the Sequential Test is to steer new development to areas defined as a low flood risk, such as Flood Zone 1. Where there are no reasonably available sites in Flood Zone 1 areas, LPA allocating land in Local Plans or determining planning applications for development at any particular location should take into account the flood risk vulnerability of land uses and consider reasonably available sites in Flood Zone 2 areas, applying the Exception Test if required. Only where there are no reasonably available sites in Flood Zone 1 or 2 areas should the suitability of sites in Flood Zone 3 be considered, taking into account the flood risk vulnerability of land uses and applying the Exception Test if required.

For the Exception Test to be passed, the following points must be satisfied:

- It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk.
- A site-specific FRA must demonstrate that 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.
- It must be demonstrated whether the development can reduce flood risk overall, through the provisions or new or improved flood defences or improved drainage.

All elements of the test will have to be passed for development to be allocated or permitted.

3.2.3 Development and Flood Risk Vulnerability

The NPPF defines what development is considered suitable within each Flood Zone based upon the level of vulnerability of the development. This is shown in **Table 3.2**. Given that the Proposed Developments includes utility infrastructure for electricity supply, it is anticipated that the Development Sites will need to remain operational in times of a flood event. As such, the vulnerability classifications suggest the Proposed Developments are considered to be *'essential utility infrastructure, including infrastructure for electricity supply including generation, storage and distribution systems'* which is classified as 'Essential Infrastructure'.

Table 3.2 Flood Risk Vulnerability and Flood Zone Compatibility

Flood Risk Vulnerability Classification	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone 1	✓	✓	✓	✓	✓
Flood Zone 2	✓	✓	Exception test required	✓	✓
Flood Zone 3a	Exception test required	✓	×	Exception test required	✓
Flood Zone 3b (Functional Floodplain)	Exception test required	✓	×	×	×

Key
✓ Development is appropriate.
× Development should not be permitted

Based on the classification shown in **Table 3.2**, the construction of Essential Infrastructure is permitted in Flood Zones 1 and 2, with the requirement for an Exception Test for developments in Flood Zone 3. The Environment Agency Flood Map for Planning (FMfP) (**Plate 5.2** and **Plate 5.8**) indicates the main PCC plant and majority of the CO_2 pipeline of the Proposed Phillips 66 Development are located in Flood Zone 1, and therefore the Sequential Test is passed for these aspects of the Proposed Developments.

Part of the proposed Phillips 66 CO_2 pipeline and the existing access track along South Killingholme Drain (included in the Phillips 66 Site for access only) and the entire Proposed VPI Development are located in Flood Zone 3. The Proposed Developments will contribute towards the local plan aim to reduce North Lincolnshire's carbon footprint and the UK target to reduce carbon emissions by at least 100% by 2050, as such the Proposed Developments satisfy the requirements of the Exception Test, which this FRA will later demonstrate.

3.3 Local Planning Policy

3.3.1 North Lincolnshire Core Strategy

The North Lincolnshire Core Strategy was adopted in June 2011[18] and sets out the long-term vision for North Lincolnshire and provides a blueprint for managing growth and development in the area up to 2026.

The relevant flood risk sections and policies are summarised in **Table 3.3.**

Table 3.3 Relevant Core Strategy Policies

Section/Policy Number	Sub-section	Summary
Section 11: Environment and Resources	11.16	The Government in the Climate Change Act 2008 has set a UK target of reducing carbon emissions by at least 100% by 2050 and by at least 40% by 2020.
	11.18	The Council has signed the Nottingham Declaration on Climate Change that required it to develop a Climate Change Action Plan.
	11.21	North Lincolnshire has a history of providing power including combined heat and power and providing fuel sources for the area and elsewhere. Where non-renewable resources such as oil, gas and coal continue to be used it will be essential to use the best available clean technologies and abatement measures, including developing carbon capture methods, to help reduce carbon emissions.
	11.25	The risk of coastal and river flooding will increase as a result of the predicted effects of climate change, including rising sea level and

[18] North Lincolnshire Council (2011) Core Strategy. Accessed: https://www.northlincs.gov.uk/planning-and-environment/planning-policy-local-development-framework. Retrieved: 08/11/22

Section/Policy Number	Sub-section	Summary
		increased rainfall. To achieve a programme of sustainable development North Lincolnshire will need to adapt to this situation, in agreement with the Environment Agency, by taking steps to defend existing properties and direct new sustainable growth to areas with little or no risk of flooding. However, North Lincolnshire has a significant amount of land within zone 3, where in part, for wider sustainable reasons, development will have to be located.
	11.29	The Catchment Flood Management Plan (CFMP's) for Grimsby and Ancholme, and the Draft CFMP for the Trent are higher-level strategic flood management plans that cover parts of North Lincolnshire. These include a broad set of policies for the river catchment areas.
	11.30	All development will be measured against a risk-based approach to flooding involving Sequential and Exception testing. The Sequential Test looks to steer new development away from areas at risk of flooding wherever possible. To pass the Sequential Test, anyone proposing development in areas at risk of flooding will need to show that reasonably available, acceptable sites are unsustainable in other ways in lower flood risk zones. If the Sequential Test is passed, the Exception Test may be necessary, depending on the vulnerability of the development and the level of flood risk. The Exception Test seeks to ensure that development: • Provides benefits to the community that outweigh the risks of flooding • Is located on previously developed land where possible; and • Is safe and does not increase the risk to others.
	11.31	Once these tests have been passed, all development proposals in areas considered at risk of flooding will require a detailed FRA
CS 18 Sustainable Resources Use and Climate Change		The council will actively promote development that utilises natural resources as efficiently and sustainably as possible. This will include: • Requiring the use of Sustainable Urban Drainage Systems (SuDS) where practicable. • Supporting the necessary improvement of flood defences and surface water infrastructure required against the actions of climate change and preventing development in high flood risk areas wherever practicable and possible.
CS19 Flood Risk		The council will support development proposals that avoid areas of current or future flood risk, and which do not increase the risk of flooding elsewhere. This will involve a risk based sequential approach to determine the suitability of land for development that uses the principle of locating development, where possible, on land that has a lower flood risk, and relates land use to its vulnerability to flood. Development in areas of high flood risk will only be permitted where it meets the following prerequisites: 1. It can be demonstrated that the development provides wider sustainability benefits to the community and the area that outweigh flood risk. 2. The development should be on previously used land. If not, there must be no reasonable alternative developable sites on previously developed land. 3. A flood risk assessment has demonstrated that the development will be safe, without increasing flood risk elsewhere by integrating water management methods into development. Development within the Lincolnshire Lakes area will comply with the flood management principals set out in the Western Scunthorpe Urban Extension Exception Test Strategy. Any further flood management proposals will have to be agreed by both the council and the Environment Agency during the process of the Lincolnshire Lakes Area Action Plan. Development proposals in flood risk areas which come forward in the remainder of North Lincolnshire shall be guided by the Strategic Flood Risk Assessment for North Lincolnshire and North East Lincolnshire. This will ensure that proposals include

Section/Policy Number	Sub-section	Summary
		site specific flood risk assessments which take into account strategic flood management objectives and properly apply the Sequential and, where necessary, Exception Tests. In addition, development will be required, wherever practicable, to incorporate SUDS to manage surface water drainage. The Council will also seek to reduce the increase in flood risk due to climate change through measures to reduce carbon dioxide emissions.

Source: < https://www.northlincs.gov.uk/planning-and-environment/planning-policy-local-development-framework>

3.4 Other Relevant Policy and Guidance

3.4.1 Humber Flood Risk Management Strategy

The Humber Flood Risk Management Strategy[19] sets out the Environment Agency's vision for managing the risk of flooding from the Humber Estuary to respond to climate change and sea level rise. The Strategy sets out the Environment Agency's general approach to managing the estuary's flood defences.

The Sites are situated on the border of Flood Area 23b Killingholme Marshes and Flood Area 24 Immingham to West Grimsby in the Humber FRMS, where defences will be improved as necessary to protect people, businesses and nationally important industry from tidal flooding. Defences will be improved near North Killingholme and Stallingborough within the next five years. This particular section of the coastline is not covered by the 'Flamborough Head to Gibraltar Point' Shoreline Management Plan, which starts at the Port of Immingham.

3.4.2 Humber Flood Risk Management Plan

The Humber Flood Risk Management Plan[20], published in December 2022, focuses on the more significant areas of flooding and describes the risk of flooding now and in the future within the Humber River Basin District. The plan will help to:

- identify measures (actions) that will reduce the likelihood and consequences of flooding.
- improve resilience, which is the capacity of people and places to plan for, better protect, respond to, and to recover from flooding and coastal change, while informing the delivery of existing flood programmes.
- work in partnership to explore wider resilience measures. These include nature based solutions, property flood resilience and sustainable drainage systems.
- plan and adapt to a changing climate through developing longer-term, adaptive approaches.

In many cases the measures (actions) in the plans will help contribute to wider benefits for local places including climate mitigation and adaptation, nature recovery as well as integrated water management.

The Sites are located within the Immingham Rivers and the Sea Flood Risk Area and identifies the main flood risk within the area as tidal flooding.

The FRMP states '*A project is being developed to better protect the town of Immingham. This is being led by North East Lincolnshire Council in collaboration with the Environment Agency, North East Lindsey IDB and Anglian Water. This is expected to be delivered in phases between 2021 and 2027. The tidal outfall at Habrough Marsh Drain will be improved first. Further improvements expected to follow include surface water, land drainage and the sewerage network.*

3.4.3 Humber 2100+ Strategy

The Humber 2100+ Strategy[21], which is a partnership project including 12 local authorities, is redefining the strategic approach to managing tidal risk on the Humber. It will identify the most sustainable, credible and cost-effective approach to managing tidal flooding over the next 100 years, considering predicted sea level rise and climate change.

[19] Environment Agency (2008) Humber Flood Risk Management Strategy. Accessed: https://www.gov.uk/government/publications/humber-flood-risk-management-strategy. Retrieved: 08/11/22
[20] Environment Agency (2022) Humber River Basin District Flood Risk Management Plan 2021 to 2027. December 2022
[21] Humber 2100+ Strategy. Accessed: https://consult.environment-agency.gov.uk/humber/strategyreview/. Retrieved: 16/01/23

The conclusions of the Humber 2100+ project will set the future direction of defence needs around the whole estuary, including around Killingholme and Immingham.

3.4.4 Grimsby and Ancholme Catchment Flood Management Plan (CFMP)

In 2009, a CFMP was produced by the Environment Agency for the Grimsby and Ancholme catchment[9] addressing the scale and extent of flooding both now and in the future and setting policies for managing flood risk. In the area considered in relation to the Proposed Developments (Sub-area 4 Immingham, Grimsby and Buck Beck), the CFMP addresses the risk posed by the tidal risk from the Humber Estuary, tide locking of local watercourses and the pumping of drainage channels.

The vision and preferred management policy for the sub-area is Policy option 4: Areas of low, moderate or high flood risk where the Environment Agency are already managing the flood risk effectively but where further actions may be taken to keep pace with climate change.

3.4.5 North East Lindsey Drainage Board Byelaws

IDBs operate in the low-lying fen and valley areas, maintaining pumping stations and drainage channels to ensure that people are safe, and the risk of flooding is greatly reduced. The North East Lindsey Drainage Board ('the IDB') extends to an area of 11,250 hectares which is formed predominantly of the coastal strip extending from the Humber bridge southwards to Grimsby.

The North East Lindsey Drainage Board Byelaws and Land Drainage Act 1991 allow the IDB to take action to ensure that free flow of water is unrestricted.

Watercourses maintained by the IDB are cleaned out annually and it is important that access is preserved for machinery to enable this work to be undertaken. The IDB's Byelaws prevent the erection of any building, structure (whether temporary or permanent) or planting of trees/ shrubs etc. within nine metres either side of an IDB maintained watercourse irrespective of any planning permission without the consent of the IDB. The IDB's consent will also be required to undertake works such as:

- works in, over, under or within nine metres of an IDB maintained watercourse;
- installation of a culvert, weir or other like obstruction within any watercourse; and
- any works that increase the flow of surface water or treated foul effluent to any watercourse within the IDB's district.

3.4.6 North Lincolnshire Council Local Flood Risk Management Strategy (LFRMS)

As a LLFA, North Lincolnshire Council has a responsibility to develop a LFRMS[12] which sets out a clear plan for future flood risk management in the region, ensuring people, businesses, communities and other risk management authorities have an active role in how flood risk is managed.

The LFRMS sets out how the Council intends to manage local flood risks, as well as contribute to management from non-local sources, and to engage and inform residents on their own responsibilities and enable them to contribute to the management of flood risk.

3.4.6.1 North Lincolnshire Strategic Flood Risk Assessment (SFRA)

North Lincolnshire Council Level 1 SFRA[11] was published in 2012 to support the assessment of development sites in relation to flood risk. The SFRA was completed in consultation with the Environment Agency and North East Lindsey IDB to provide information on the probability of flooding. The report also takes into account the impacts of climate change.

It is intended that the SFRA will be used by North Lincolnshire Council's planning and building control department to inform the application of the Sequential Test when allocating land or determining applications, in line with the NPPF.

The SFRA locates the Sites within the Eastern Coastal Area where the main source of flooding is a combination of large waves and high-water levels in the Humber Estuary. A more detailed assessment has been undertaken as part of the SFRA for Flood Compartment 1T3 – Immingham and North Killingholme (which the Sites are located within) which indicates the South Killingholme area is liable to flooding should a breach of the flood defences occur.

4. Climate Change

The NPPF requires site specific FRA accompanying planning applications to assess the risk of all sources of flooding to and from the development and to demonstrate how these flood risk will be managed so that the development remains safe throughout its lifetime, taking climate change into account.

The Environment Agency's guidance (last updated in May 2022)[22] indicates that climate change is likely to result in increase to:

- peak river flows;
- peak rainfall intensity;
- sea level rise; and
- wave height and offshore wind speed.

4.1 Tidal Climate Change Allowances

The Proposed Developments lie within the Humber River Basin District. Annual sea level allowances for the Humber River Basin District are presented in **Table 4.1**. These allowances are based upon the UK Climate Projections 2018 (UKCP18) and account for slow land movement due to 'glacial isostatic adjustment' from the release of pressure at the end of the last ice age. The northern part of the UK is slowly rising, and the southern part is slowly sinking.

Table 4.1: Annual Sea level allowances for the Humber River Basin District for each epoch

Allowance Category	'2020s' (2000 to 2035)	'2050s' (2036 to 2065)	'2080s' (2066 to 2095)	'2100s' (2096 to 2125)	Cumulative rise 2000 to 2125
Upper End	6.7 mm	11 mm	15.3 mm	17.6 mm	1.55 m
Higher Central	5.5 mm	8.4 mm	11.1 mm	12.4 mm	1.15 m

Source: Flood Risk Assessments: climate change allowances[22]

The lifetime of the Proposed Developments is approximately 25 years (from 2027). Based on projections in Table 4.1, the following sea level allowances should be assessed:

- Higher Central: 0.22 m; and
- Upper End: 0.28 m.

4.2 Offshore Wind Speed and Extreme Wave Height Allowance

Wave heights may change because of:

- increased water depths; and
- changes to the frequency, duration and severity of storms.

The climate change allowances for the English coast are presented in **Table 4.2**.

Table 4.2: Offshore Winds Speed and Extreme Wave Height Allowance for the English Coast

Allowance Category	Total potential change anticipated for '2020s' (2000 to 2055)	Total potential change anticipated for '2080s' (2056 to 2125)
Offshore wind speed allowance	5%	10%
Offshore wind speed sensitivity test	10%	10%
Extreme wave height allowance	5%	10%
Extreme wave height sensitivity test	10%	10%

[22] Environment Agency (2022). Flood Risk Assessments: climate change allowances. Accessed: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances. Retrieved: 08/11/22

Allowance Category	Total potential change anticipated for '2020s' (2000 to 2055)	Total potential change anticipated for '2080s' (2056 to 2125)

Source: Flood Risk Assessments: climate change allowances[22]

Given that the Proposed Developments are not located adjacent to the sea, wind speed and extreme wave height are not considered further in this assessment.

4.3 Peak River Flow Allowances

The peak river flow allowances show the anticipated changes to peak flow by management catchment. The range of climate change allowances are based on percentiles. A percentile is a measure used in statistics to describe the proportion of possible scenarios that fall below an allowance level. The 50th percentile is the point at which half of the possible scenario for peak flows fall below it and half fall above it.

- Central allowance is based on the 50th percentile.
- Higher central is based on the 70th percentile.
- Upper end is based on the 90th percentile.

The Proposed Developments lie within the Humber River Basin District and the Louth, Grimsby and Ancholme Management Catchment. **Table 4.3** shows the climate change allowances for the catchment.

Table 4.3: Peak River Flow Allowance for the Louth, Grimsby and Ancholme Management Catchment

Allowance Category	Total potential change anticipated for '2020s' (2015 to 2039)	Total potential change anticipated for '2050s' (2040 to 2069)	Total potential change anticipated for '2080s' (2070 to 2115)
Upper End	21%	19%	33%
Higher Central	9%	5%	12%
Central	4%	-1%	4%

Source: Flood Risk Assessments: climate change allowances[22]

4.3.1 Peak River Flow Allowances for Different Assessments

To determine which peak river flow allowance is appropriate for the type of development, the flood risk vulnerability classification, flood zone and the lifetime of the Proposed Development is considered. **Table 4.4** summarises the peak river flow allowances for the different flood risk vulnerability classifications for each flood zone.

Table 4.4: Environment Agency Climate Change Allowances to apply based upon the Flood Zone and Development Land Use Vulnerability

	Water Compatible	Less Vulnerable	More Vulnerable	Highly Vulnerable	Essential Infrastructure
Flood Zone 1	CA	CA	CA	CA	CA
Flood Zone 2	CA	CA	CA	CA	HCA
Flood Zone 3a	CA	CA	CA	X	HCA
Flood Zone 3b	CA	X	X	X	HCA

CA = Central Allowance; HCA = Higher Central Allowance; X = Development not permitted

4.3.1.1 Phillips 66 Site

Given the Phillips 66 Development is located in Flood Zones 1, 2 and 3 and is considered 'Essential Infrastructure', the Higher Central allowance should be assessed.

4.3.1.2 VPI Site

Given the Proposed VPI Development is located in Flood Zones 2 and 3 and is considered 'Essential Infrastructure', the Higher Central Allowance should be assessed.

4.4 Peak Rainfall Intensity Allowance

Increased rainfall affects river levels and land and urban drainage systems. **Table 4.5** shows anticipated changes in extreme rainfall intensity in the Louth, Grimsby and Ancholme Management Catchment.

Table 4.5. Peak Rainfall Intensity Allowance for the Louth, Ancholme and Grimsby Management Catchment

Parameter	Allowance	Total potential change anticipated for '2050s'	Total potential change anticipated for '2070s'
1% annual exceedance rainfall event (2070 – 2115)	Upper End	40%	40%
	Central	20%	25%
3.3% annual exceedance rainfall event (2070 – 2115)	Upper End	35%	35%
	Central	20%	25%

Source: Flood Risk Assessments: climate change allowances[22]

Information provided by Worley, presented as Appendix 9C Drainage Strategies (ES Volume II), provides further information on proposed surface water management at the Phillips 66 and VPI Sites, including allowance for climate change over the lifetime of the developments.

4.5 Climate Change Allowances for the Proposed Developments

The lifetime of the Proposed Developments is approximately 25 years from 2027, therefore, the peak climate change allowances for the lifetime of the Proposed Developments should be assessed appropriately as shown in **Table 4.6**.

Table 4.6. Peak Climate Change Allowances for the Proposed Developments

Proposed Phillips 66 and VPI Developments	
River Basin District	Humber
Management Catchment	Grimsby and Ancholme
Flood Zone	Tidal - Flood Zones 1, 2 and 3
Flood Risk Vulnerability Classification	Essential Infrastructure
Lifetime of Development	25 years (from 2027 to 2052)
Tidal Climate Change Allowance	Sea Level Rise Upper End (0.28m)
	Sea Level Rise Higher Central (0.22m)
Fluvial Climate Change Allowance	2080's Higher Central (12%)
Peak Rainfall Intensity Allowance*	1% AEP 2070s Central (25%) 3% AEP 2070s Central (25%)

* The lifetime of the Proposed Developments (the design life) is 25 years (2050s epoch), however, in terms of climate change an additional peak rainfall intensity allowance has been added to take a conservative approach, assuming that the Proposed Developments could continue to operate beyond their design life. On this basis, the climate change allowance factor considered has been 25%. This value corresponds to the central allowance of the 2070s epoch.

5. Flood Risk to the Development

The NPPF requires the effects of all sources of flood risk to and from a development are considered within a FRA. The FRA should demonstrate how identified risks should be managed so that the development remains safe throughout its lifetime, taking into account climate change.

This review was undertaken using publicly available information to assess the flood risk at the Sites.

5.1 Phillips 66 Site

5.1.1 Historical Flooding

Environment Agency records, presented in **Plate 5.1**, indicate that the Phillips 66 Site has not flooded previously from tidal sources. However, surface water flooding occurred at the Refinery outfall and associated holding ponds (No.1 and No.2) which feed into the ditches on Rosper Road via the South Killingholme Drain. It is likely this flooding occurred as a consequence of exceedance flow from the site drainage systems during this high return period rainfall event.

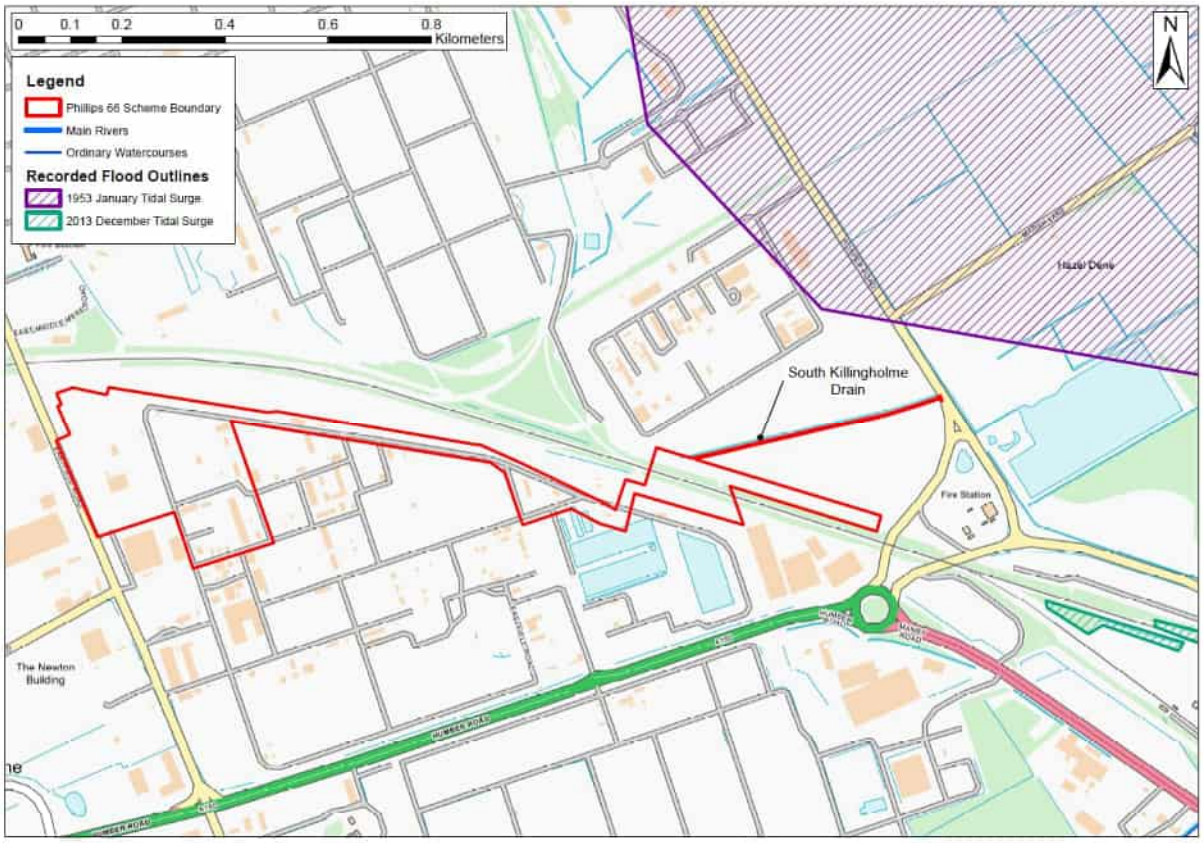

Plate 5.1: Environment Agency Historic Flood Map for Phillips 66 Site

5.1.2 Flooding from Tidal Sources

Tidal flooding occurs during extreme high tide and/ or storm surge events which may cause wave overtopping or the unlikely event of a breaching scenario of existing tidal defences. High water levels within tidally influenced estuaries and rivers may also contribute to tidal flooding.

The Phillips 66 development site is located approximately 1.4 km from the tidal River Humber, which originates at Trent Falls and flows in a south-easterly direction into the North Sea.

A review of the Environment Agency FMfP (shown in **Plate 5.2**) illustrates that the main Phillips 66 PCC plant and the majority of the CO_2 pipeline will be located in Flood Zone 1, land assessed as having a less than 0.1% AEP of fluvial or tidal flooding (1 in 1000-year return period) in any year. The proposed CO_2 pipeline to the north-east of the Network Rail railway line (and the existing access track along South Killingholme Drain included in the Phillips 66 Site for access only) are to be located predominantly within Flood Zone 3, land assessed as having a greater

than 0.5% AEP (1 in 200-year return period) but marginally infringes upon Flood Zone 2, land assessed as having between a 0.1% AEP (1 in 1000-year return period).

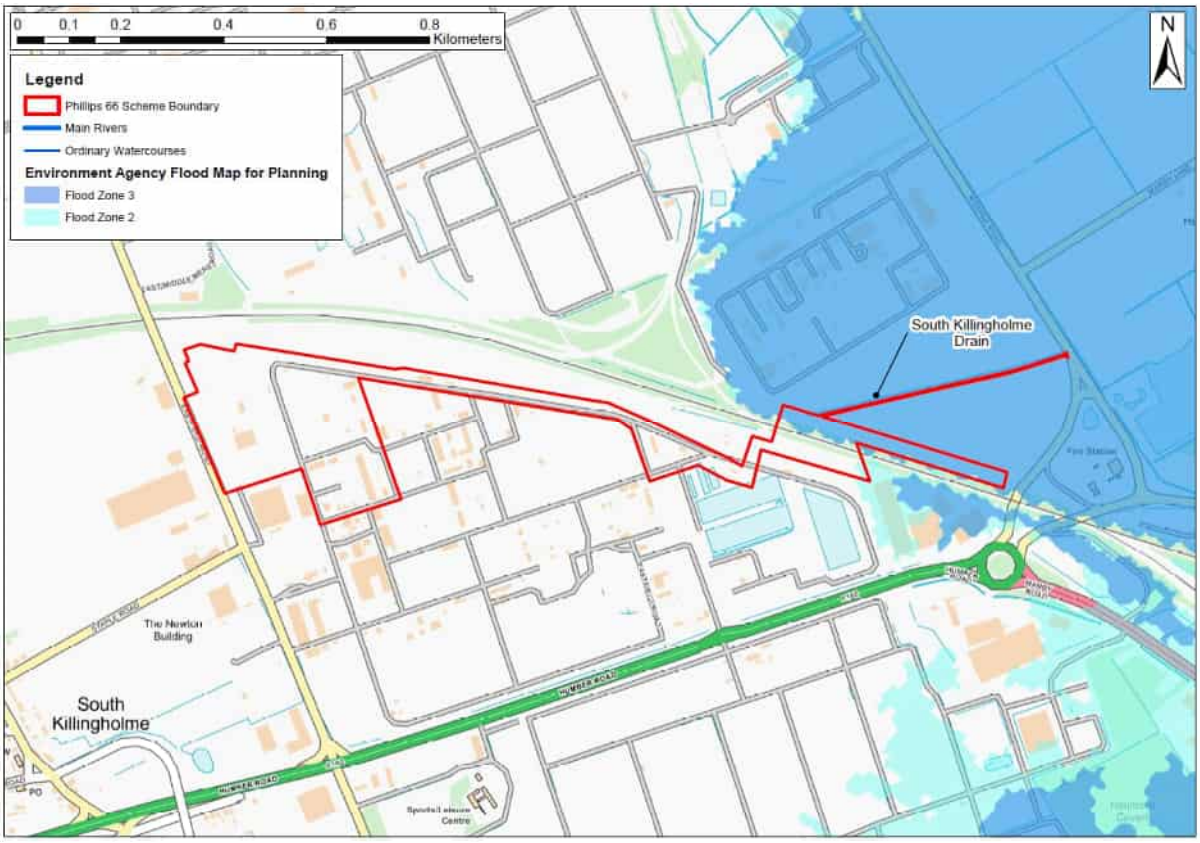

Plate 5.2: Environment Agency Flood Map for Planning Phillips 66 Development Site

5.1.2.1 Extreme Water Levels

Extreme still tidal water level data was provided by the Environment Agency with a baseline of 2021 for the present-day scenario. The extreme still water levels for 2046 and 2071 include projected climate change, accounting for sea level rise and fluvial flow uplifts, in line with the UKCP18 allowances (**Annex A**). This dataset is considered to be the most up-to-date and appropriate for this review and is presented in **Table 5.1**.

Table 5.1 Predicted extreme water levels for South Killingholme

		Extreme Still Water Level (mAOD)	
Year	Annual Exceedance Probability (%)	Higher Central	Upper End Allowance
2021	50%	4.32	4.33
	10%	4.58	4.59
	2%	4.86	4.87
	1%	4.99	5.00
	0.5%	5.15	5.16
	0.1%	5.47	5.48
2046	50%	4.50	4.54
	10%	4.75	4.79
	2%	5.04	5.08
	1%	5.16	5.21
	0.5%	5.32	5.54
	0.1%	5.63	5.67
2071	50%	4.73	4.86
	10%	4.99	5.11
	2%	5.27	5.39
	1%	5.40	5.51

	0.5%	5.54	5.82
	0.1%	5.84	5.95

In Section 4.1, the sea level allowances for the Phillips 66 Site for the year 2052, based on the Environment Agency Flood Risk Assessment: Climate Change Allowances guidance[22] were calculated as 0.22 m (Higher Central) and 0.28 m (Upper End). The data in Table 5.1 indicates that for the Higher Central allowance, sea levels are predicted to rise by 0.17 m for 2046 and by 0.41 m for 2071, therefore the calculated 0.22 m sea level rise for 2052 is considered feasible. For the Upper End allowance, sea levels are predicted to rise by 0.21 m for 2046 and by 0.51 m for 2071, therefore the calculated 0.28 m sea level rise for 2052 is considered feasible.

Given the Proposed Phillips 66 Development is classed as 'Essential Infrastructure', with a lifetime of 25 years (from 2027), the 0.5% AEP (1 in 200 year return period) flood event and higher central allowance must be assessed. As such, for the year 2052 the extreme still water level at South Killingholme is predicted to be **5.37 mAOD** (hereafter referred to as the 'critical flood level'). This still water level is derived by adding the calculated sea level allowance, 0.22 m, to the 2021 (baseline) 0.5% AEP still water level of 5.15 m AOD (**Table 5.1**).

5.1.2.2 Flood Defences

The Environment Agency has confirmed that tidal defences, consisting of earth embankments and concrete floodwalls protect the Phillips 66 Site. The Environment Agency owns, inspects and maintains these defences and advises that the defences are in fair condition and reduce the risk of flooding (at the defence) up to the 0.5% AEP (1 in 200-year return period) flood event. A review of the Environment Agency Asset Management Database[23] indicates that the flood defences (located along the coastline at South Killingholme) range in crest height from 5.96 m AOD to 6.35 m AOD.

5.1.2.3 Breach of Defences

The Environment Agency has provided breach location and associated breach hazard maps from the Northern Area Tidal Hazard Mapping Study. The Northern Area Tidal Hazard Mapping study involved a modelled representation of tidal breaches along the east coast and the south bank of the Humber Estuary, with breaches in the hard defences set at 20 m wide and the defences assumed to breach down to the ground level behind the defence. The defences were raised within the model to create reservoir cells, ensuring that the most precautionary volumes of water were driven through the breach opening.

The breach modelling was based on the Still Water Tidal Levels from the Northern Area Tidal Model Analysis 2006 including the 0.5% AEP and 0.1% AEP flood events for the current year (based on 2006 modelling outputs) and 2115. The breach locations nearest the Phillips 66 Site are located on the frontage at South Killingholme and East Halton. The Hazard Classification Methodology used is based on Flood Risk Assessment Guidance for New Development known as FD2320/TR213[24], presented in Error! Reference source not found..

Table 5.2 Flood Hazard Classification

Flood Hazard	Classification
Low	**Caution** - Flood zone with shallow flowing water or deep standing water
Moderate	**Dangerous for some** (i.e. Children) – Danger: Flood zone with deep or fast flowing water
Significant	**Dangerous for most people** – Danger: Flood zone with deep fast flowing water
Extreme	**Dangerous for all** – Extreme Danger: Flood zone with deep fast flowing water

The 2006 0.5% AEP breach scenario is considered most appropriate for this assessment and the associated hazard map is presented in **Plate 5.3**. The hazard map indicates that part of the proposed Phillips 66 CO_2 pipeline (and the existing access track along South Killingholme Drain) are located within a 'Moderate', 'Significant' or 'Extreme' hazard area with a maximum water depth of 1.6 m and a maximum water velocity of 1.5-2.5 m/s.

[23] Environment Agency Asset Management Database. Available at: https://environment.data.gov.uk/asset-management/index.html. Retrieved: 03/11/2022
[24] DEFRA (2021) Flood Risk Guidance for New Development. Accessed: https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/flood-risk-assessment-guidance-for-new-development. Retrieved: 08/11/22

In line with guidance from the SFRA[11], to determine the breach flood level and advise the level for any critical electrical equipment (see **Section 7.1.1.1** for further details), the 0.1% 2115 breach scenario is assessed (presented in **Plate 5.4**). By comparison of the hazard outlines with LiDAR levels the 0.1% AEP 2115 breach scenario flood level is estimated to be 6.3 m AOD (refer to **Annex E**).

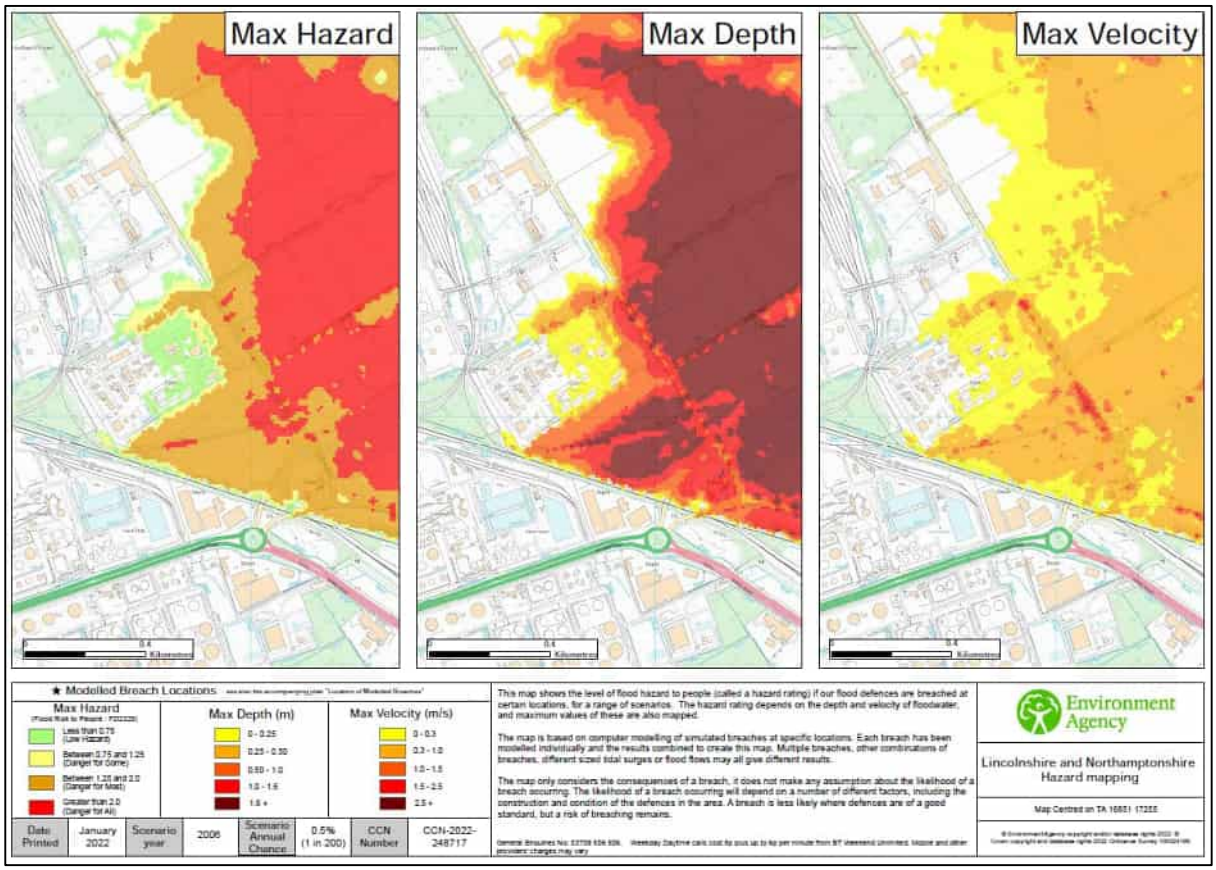

Plate 5.3: Environment Agency Modelled Breach Hazard Map for 0.5% AEP 2006 Scenario

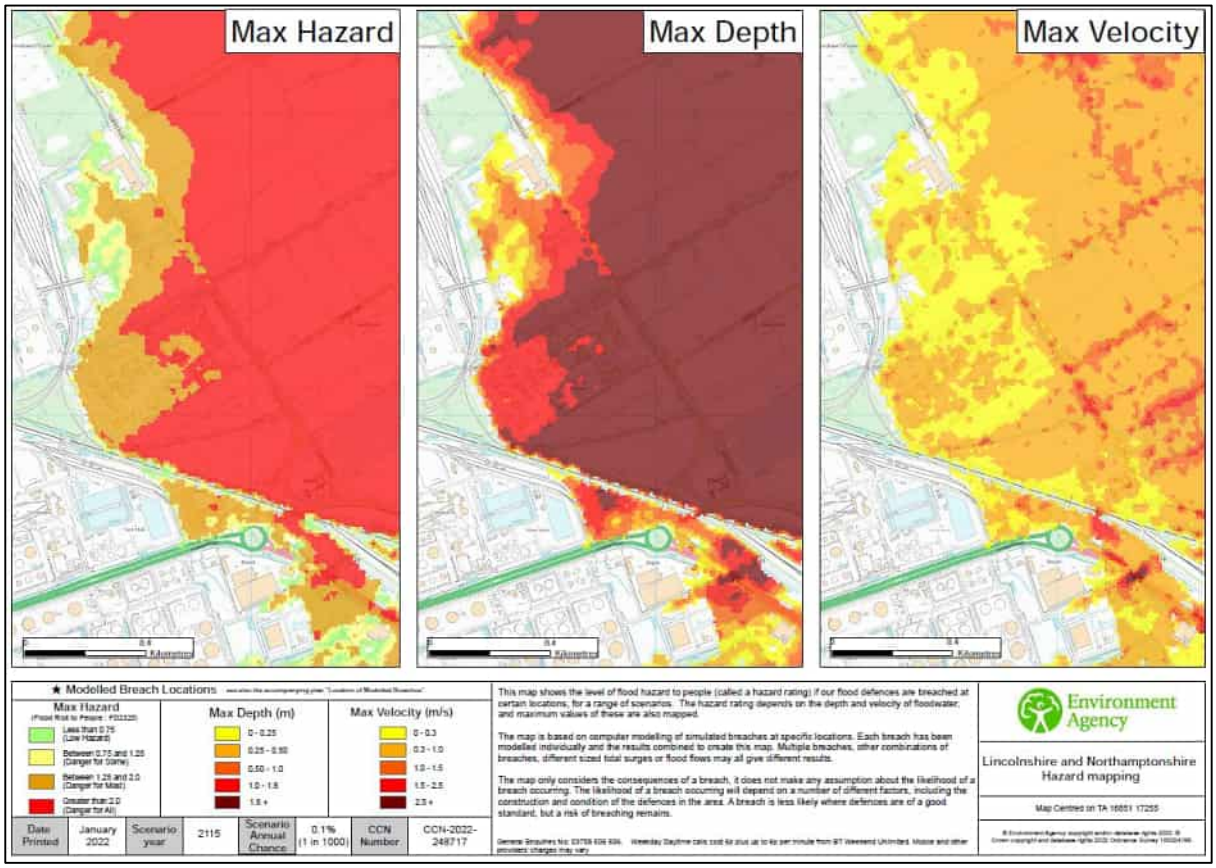

Plate 5.4: Environment Agency Modelled Breach Hazard Map for 0.1% AEP 2115 Scenario

The 2115 hazard map (**Plate 5.4**) indicates that part of the proposed Phillips 66 CO2 pipeline (and the existing access track along South Killingholme Drain) remain located within a 'Moderate', 'Significant' or 'Extreme' hazard area with water depths in excess of 1.6 m and a maximum water velocity of 1.5-2.5 m/s.

Although a breach of the flood defences would represent a significant hazard (i.e. the consequence), given the routine inspections and maintenance of the flood defences by the Environment Agency, the likelihood of breach occurring is low. The NPPF requires that plans and mitigation are put in place to manage the risks should breach occur. Mitigation measures for the Proposed Phillips 66 Development are outlined in **Section 7.1.1**.

5.1.2.4 Overtopping of Flood Defences

The Northern Area Tidal Mapping Study also involved the modelled representation of tidal overtopping along the east coast and the south bank of the Humber Estuary. The Environment Agency has confirmed that the Site is not affected by overtopping of the defences during the 2006 0.5% AEP overtopping scenario, (See the associated hazard mapping in **Annex A**).

The Phillips 66 Site is affected in the 2115 0.1% AEP overtopping scenario and the associated hazard map is presented in **Plate 5.5**. The hazard map indicates that part of the proposed Phillips 66 CO_2 pipeline (and the existing access track along South Killingholme Drain) are located within a 'Moderate', 'Significant' or 'Extreme' hazard area with water depths in excess of 1.6 m and a maximum water velocity of 1.5-2.5 m/s.

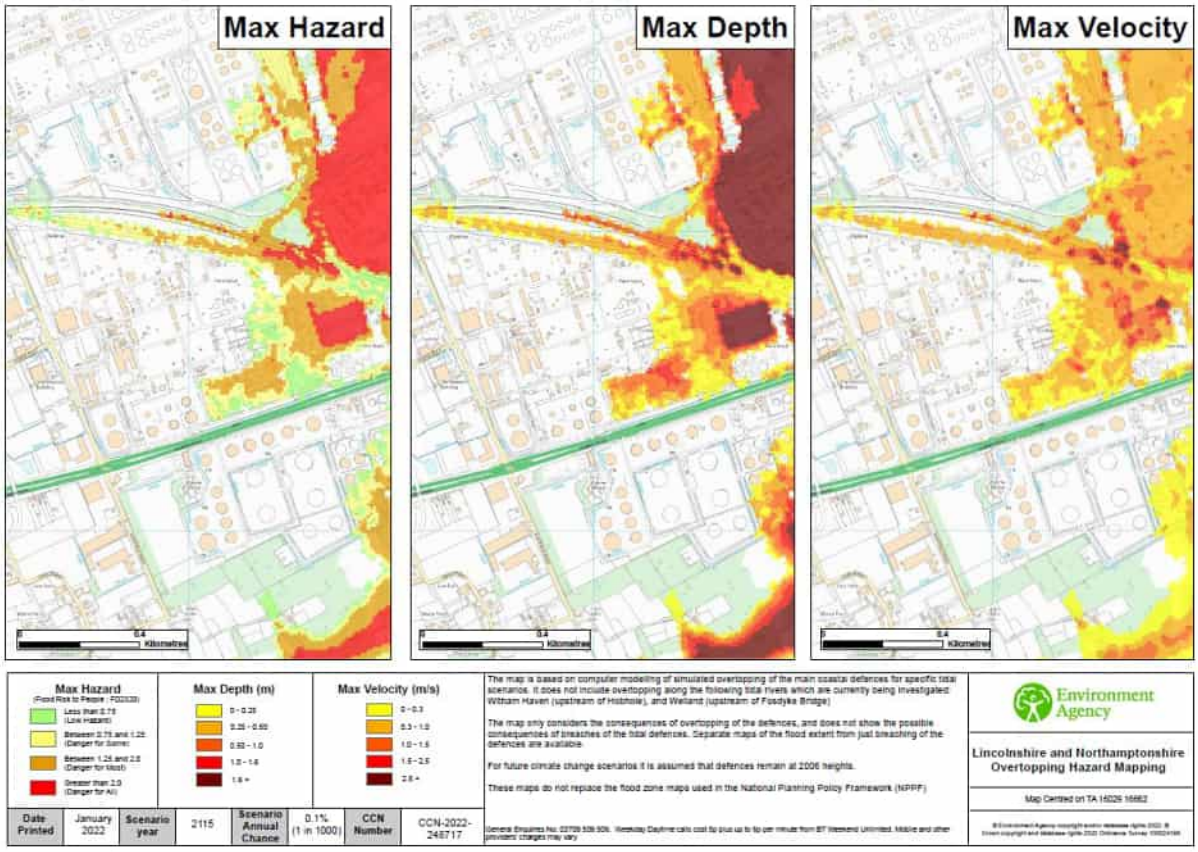

Plate 5.5: Environment Agency Modelled Overtopping Hazard Map for 0.1% AEP 2115 Scenario

Although the overtopping of the flood defences would represent a significant hazard (i.e. the consequence), the likelihood of overtopping occurring is low . The NPPF requires that plans and mitigation are put in place to manage the risks should overtopping occur. Mitigation measures for the Proposed Phillips 66 Development are outlined in **Section 7.1.1**.

5.1.2.5 Summary of Flood Risk from Tidal Sources (Phillips 66 Site)

This risk of tidal flooding over the lifetime of the Philips 66 development is considered to be low, given that the flood defences are approximately 0.59m higher than the critical flood level of 5.37 mAOD (including an allowance for sea level rise). Over the lifetime of the development, should a breach in defences or overtopping occur, parts of the development site that lie below 6.3m AOD may be inundated.

5.1.3 Fluvial Sources

Fluvial flooding occurs when the capacity of a river is exceeded either due to high flows from the catchment draining into the river or a combination of high flows and high tides, which causes raised water levels due to backwater effects.

5.1.3.1 Main River

The Phillips 66 Site is not considered to be at risk of flooding from fluvial main rivers.

5.1.3.2 Ordinary Watercourses

Ordinary Watercourses include every river, stream, brook, cut, dike/ dyke and sluice which do not form part of a Main River network. Where applicable, the Riparian Owner, IDB or LLFA have a lead responsibility for managing the risk of flooding from ordinary watercourses. North East Lindsey IDB are operational within the area and have flood risk management responsibilities over South Killingholme Drain.

There is no national mapping of the predicted flood extents associated with the identified Ordinary Watercourses and land drains available within the development site boundary and no additional hydraulic modelling has been undertaken for the catchment by the Environment Agency, NELC or North East Lindsey IDB. For small catchments it is possible to use the Environment Agency Risk of Flooding from Surface Water (RoFSW) flood

map[6] extents as a proxy (**Plate 5.6**) to understand flood risk from the Ordinary Watercourses and land drainage channels.

South Killingholme Drain

The North East Lindsey IDB divide the South Killingholme Drain into two respective watercourses, Watercourse 9A and Watercourse 9. Watercourse 9A crosses the VPI Site (and is located partly within the westernmost part of the Phillips 66 Site) and Watercourse 9 runs parallel with Rosper Road.

A review of the RoFSW mapping identifies areas of flooding out of bank during the 1% AEP event upstream of the railway culvert as the South Killingholme Drain leaves the wider Phillips 66 Site towards the southeast corner. Flood extents can be seen to increase for the 0.1% AEP event; however, the extent remains local to the watercourse and does not cause the proposed Phillips 66 PCC development area to flood.

High levels within the tidally influenced watercourses are a potential flood risk to the area due to associated tide-locking when high tides prevent these watercourses discharging into the Humber Estuary. Flood risk from this source remains a residual risk over the lifetime of the development. However, mitigation measures included on the Site for the tidal breach scenario are sufficient should flooding occur.

Un-named Land Drains

A series of unnamed land drains run parallel with the Humber Refinery boundary and the area surrounding the Phillips 66 Site is drained via a network of small land drainage ditches that convey surface water from the surrounding greenfield areas located between the Humber Refinery and the Humber Estuary.

A review of the RoFSW mapping identifies areas of flooding out of bank during the 1% AEP event on land between the Phillips 66 Site and the railway to the north. Mapping indicates that this flooding is not extensive and remains below 300 mm in depth. The flood extent does not infringe into the proposed PCC development area, instead remaining within the corridor of land along the railway line.

Climate Change

Climate change must be taken into account when considering flooding from fluvial sources. This is usually represented by an increase in peak river flows (**Table 4.3**). In the Louth, Grimsby and Ancholme Catchment, peak river flows are expected to increase by 12% in the 2080's epoch.

Based on the RoFSW maps, the risk of flooding from Ordinary Watercourses and the un-named land drains will remain low over the lifetime of the development.

5.1.3.3 Summary of Flood Risk from Fluvial Sources (Phillips 66 Site)

The risk of fluvial flooding over the lifetime of the Proposed Phillips 66 Development is considered to be low, given that the development is not located in proximity to any main rivers. There is a residual risk of flooding from ordinary watercourses and un-named drains in the event that they become tide-locked, however, the mitigation proposed for tidal sources is considered to be sufficient.

5.1.4 Surface Water (Overland Flow)

Surface water flooding is caused by overland flow that results from rainfall that fails to drain into the ground through infiltration, instead of travelling over the ground surface. This can be exacerbated where the permeability of the ground is low due to the type of soil (such as clayey soils) and geology or land use including urban developments with impermeable surfaces.

The Environment Agency RoFSW maps[6] indicate areas at risk from surface water flooding when rainwater does not drain away through the normal drainage systems or soak into the ground, but instead lies on or flows over the ground. The RoFSW flood map for the Phillips 66 development site is shown in **Plate 5.6** below. As defined by the Environment Agency, the following levels of surface water flood risk can be classified as defined in **Table 5.3**.

Table 5.3: Definition of risk from surface water flooding

Risk of flooding	Definition
Very Low	Each year, the area has a chance of flooding of less than 1 in 1,000 (0.1% AEP)
Low	Each year, the area has a chance of flooding of between 1 in 1,000 (0.1%AEP) and 1 in 100 (1% AEP)

Risk of flooding	Definition
Medium	Each year, the area has a chance of flooding of between 1 in 100 (1%AEP) and 1 in 30 (3.3% AEP)
High	Each year, the area has a chance of flooding of greater than 1 in 30 (3.3% AEP)

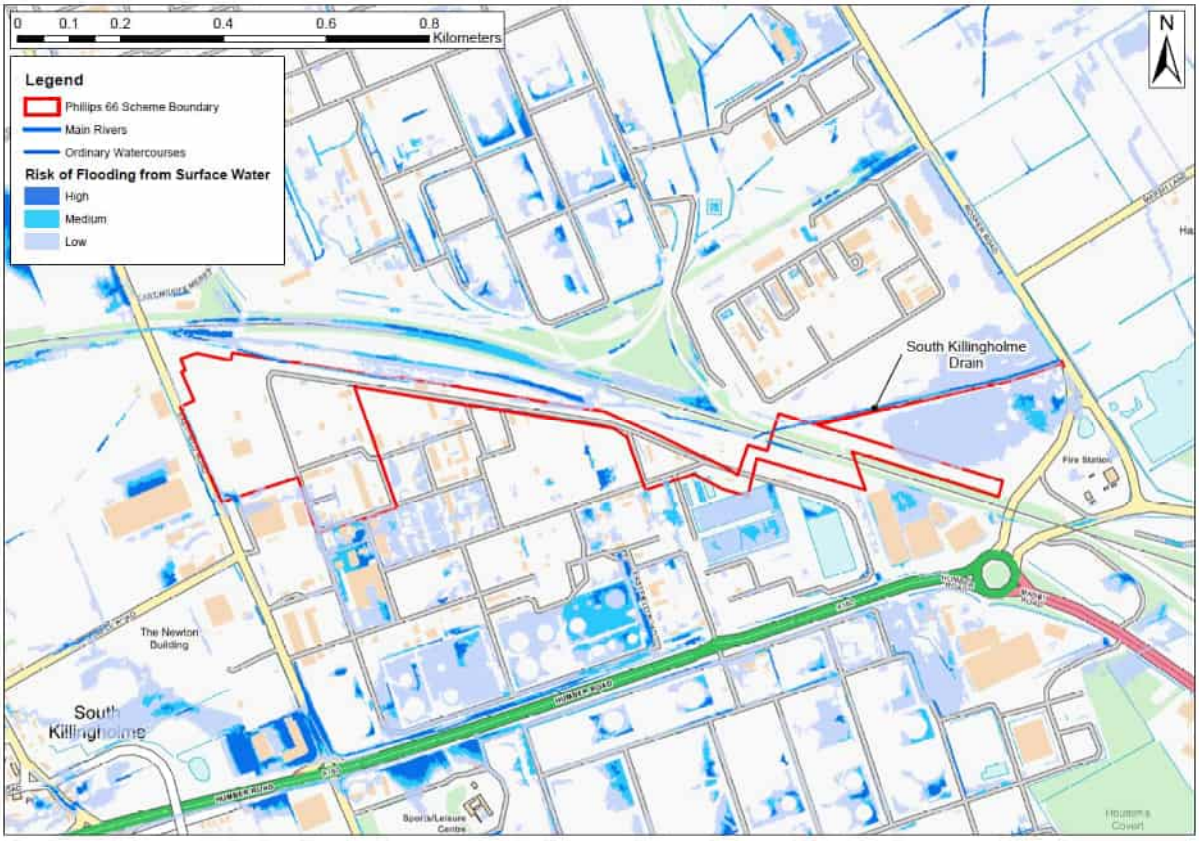

Plate 5.6: Environment Agency Risk of Flooding from Surface Water Map for Phillips 66 Site

Following a review of the Environment Agency RoFSW dataset, it is concluded that the majority of the Phillips 66 Site is shown to be at 'very low' risk of surface water flooding. There are isolated areas of the Phillips 66 Site at 'low', 'medium' and 'high' risk of surface water flooding, reflecting areas of low topography during higher return period events and the flood extents associated with South Killingholme Drain and the railway culvert. Flood depths are predicted to remain below 900 mm. The risk of flooding from surface water is therefore considered to be low and will be addressed by the drainage strategy.

Climate change must be taken into account when considering surface water runoff generated by development sites. This is usually represented by increasing peak rainfall intensities (**Table 4.5**). An increase in rainfall intensity will result in an increase in runoff rates and volumes from the Phillips 66 Site, exacerbated by increased areas of impermeable surface associated with the Proposed Phillips 66 Development.

Using the 'Low' risk surface water flood extent as a proxy for the impacts of climate change, the risk of flooding does not significantly increase across the Phillips 66 Site.

Information provided by Worley, presented as Appendix 9C Drainage Strategy (ES Volume II), provides further information on proposed surface water management at the Phillips 66 Site, including allowance for climate change.

The risk of surface water flooding over the lifetime of the Proposed Phillips 66 Development will therefore remain low.

5.1.5 Groundwater Sources

Groundwater flooding can occur when groundwater levels exceed ground surface levels as a result of periods of sustained high rainfall. The underlying geology has a major influence on where this type of flooding takes place; it

is most likely to occur in low-lying areas underlain by permeable rocks (aquifers) where the water table is more likely to be at shallow depth.

5.1.5.1 Geology and Hydrogeology

The 1:50,000 British Geology Survey (BGS) Map of Britain indicates that the Phillips 66 Site is mapped on superficial deposits of Devensian-Diamicton Deposits, comprising clay and silt. The bedrock geology mapped underlying the development site comprises Burnham Chalk Formation, a principal aquifer according to the DEFRA Aquifer Designation Map[8], suggesting there could be permeable layers indicative of elevated groundwater levels within the surrounding area.

5.1.5.2 Groundwater Levels

Groundwater levels tend to get re-charged during the winter and high groundwater levels can cause flooding as the water table rises. The rise in water table levels can be very slow, dependant on rainfall patterns and groundwater flooding can be long lasting (weeks or months). Borehole records from the British Geological Survey indicated groundwater strikes between 7.01 m and 9.5 m below ground level within the Phillips 66 Site boundary. As these are simply water strikes during drilling and not long-term monitoring records they may overestimate the depth to the water table.

Should localised groundwater emergence occur it is considered this can easily be dealt with by the use of a small pump and would not increase flood risk from groundwater sources to the area during or after the construction process.

5.1.5.3 Groundwater Flooding

The North Lincolnshire Council PFRA[10] states "*Generally the risk of flooding from groundwater is in the coastal areas from Immingham to Humberston, i.e. the lower lying parts of the floodplain*" (page 22).

Groundwater levels tend to get re-charged during the winter and high groundwater levels can cause flooding as the water table rises. This rise in water table levels can be very slow, dependent on rainfall patterns. There is no reference to groundwater flooding events in in the North Lincolnshire SFRA for the Eastern Coastal Area where the Phillips 66 Site is located. There are no historical flood records for groundwater flooding within the Phillips 66 Site or the wider South Killingholme area.

The direct impact of climate change on groundwater resources is dictated by the changes in rainfall intensity and soil infiltration. During drier seasons, there may be reductions in groundwater recharge that may cause a long-term decline in groundwater storage. Alternatively, groundwater recharge may be stabilised or even increased by frequent and prolonged periods of rainfall.

As a precautionary measure, any below ground elements associated with the Proposed Phillips 66 Development should be designed in such a way as to withstand any upward hydraulic pressures in the event that groundwater levels rise as a result of climate change. Assuming this is the case, any anticipated increase in groundwater levels, as a result of climate change will unlikely increase the risk of groundwater flooding to the Proposed Phillips 66 Development.

5.1.5.4 Groundwater Flooding

Given the limited information available and potential for high groundwater levels below the Phillips 66 Site, the risk from groundwater flooding is considered to be medium and the following mitigation measures are recommended:

- All below ground elements should be designed to withstand any upward hydraulic pressure.

5.1.6 Sewer and Drainage Infrastructure Flooding

The Phillips 66 Site is currently drained via an Oily Water Sewer and a Surface Water Drainage System. The Oily Water Sewer drains to the on-site effluent treatment plant where water is treated and transferred to No.1 Holding Pond located in the south-east corner of the wider Phillips 66 Site.

The surface water drainage system collects surface water runoff from roads, roofs, etc and passes through a tilted plate interceptor before the system is split so the majority of flow passes through the effluent treatment plant. Any exceedance flow bypasses the treatment plant and is held in No.2 Holding Pond to the south-east corner of the wider Phillips 66 Site.

The outlet of No.1 Holding Pond combined with the outlet from No.2 holding pond passes through Induced Air Floatation before being discharged at the refinery outfall into the South Killingholme Drain.

There are no historical records of sewer flooding in the area local to the Phillips 66 Site noted within the SFRA, however, exceedance flows from the holding ponds has previously occurred resulting in flooding to the area local to the tanks locations.

The proposed Phillips 66 PCC plant area is located remote from the holding pond area; however, a small section of the pipeline corridor passes in close proximity to the ponds and the exceedance storage area.

The drainage network within the Phillips 66 Site is a managed system and the risk of flooding from drainage sources is considered a low risk.

5.1.7 Flood Risk from Canal Systems

A review of the Canal and River Network Mapping from the Canal and River Trust[25] shows there are no canals within the vicinity of the Phillips 66 Site . Given the distance between the Phillips 66 Site and canal infrastructure, the risk of flooding from canal systems is negligible and is not considered further in this assessment.

5.1.8 Flood Risk from Reservoirs

The Environment Agency's flood map showing 'Risk of Flooding from Reservoirs' indicates that the Phillips 66 Site is not located in an area at risk of flooding from reservoirs.

Raised storage lagoons (No.3 Pond and the Alkaline storage lagoon) are raised above existing ground levels in the south-east corner of the wider Phillips 66 Site. Should either of these features fail associated flooding would remain local to the area and shallow in depth.

5.2 VPI Development Site

5.2.1 Historical Flooding

Environment Agency records, presented in **Plate 5.7**, indicate that part of the VPI Site flooded during the tidal surge in 1953. In addition, anecdotal evidence (**Annex C**) shows that in 2007 surface water flooding occurred at the VPI CHP Site (which was owned and operated by ConocoPhillips at the time) and along Rosper Road.

[25] Canal and River Trust. Available at: https://canalrivertrust.org.uk/enjoy-the-waterways/canal-and-river-network. Retrieved: 16/01/2023

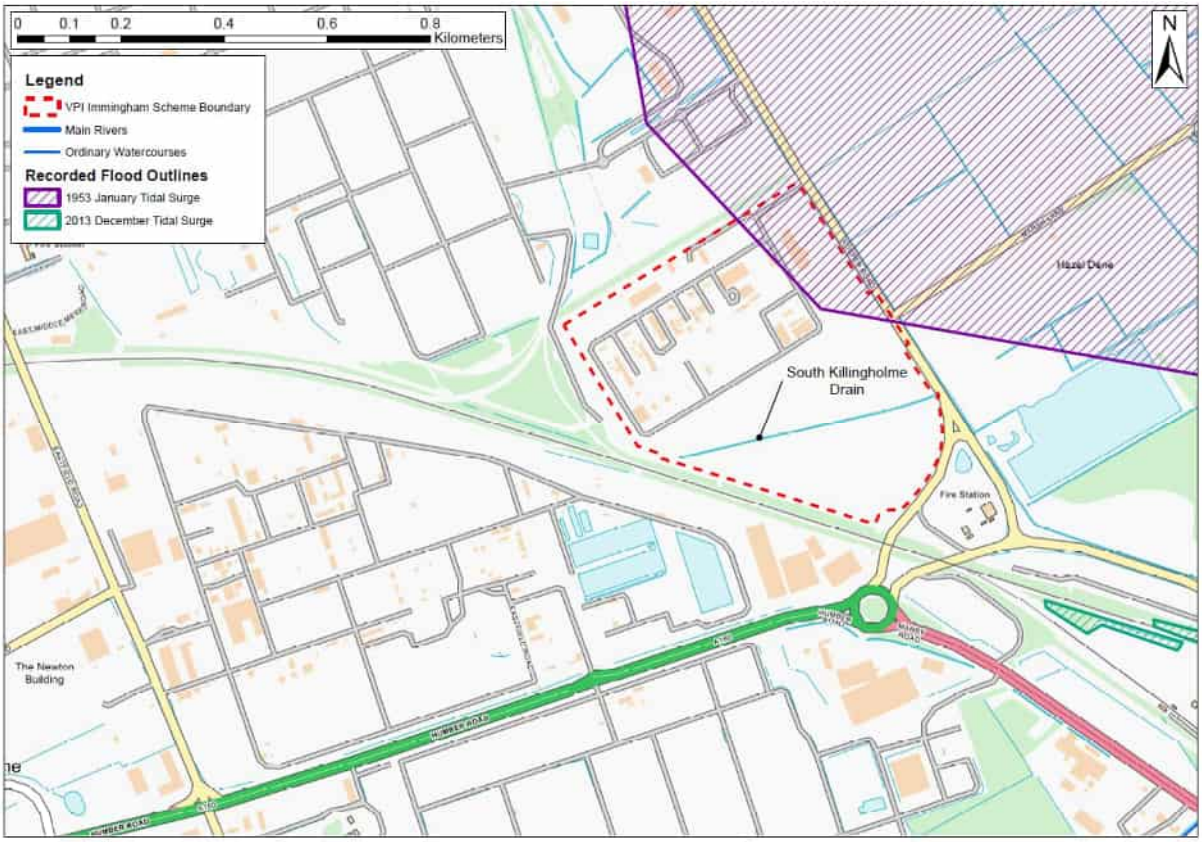

Plate 5.7: Environment Agency Historic Flood Map for VPI Site

5.2.2 Flooding from Tidal Sources

Tidal flooding occurs during extreme high tide and/ or storm surge events which may cause wave overtopping or the unlikely event of a breaching scenario of existing tidal defences. High water levels within tidally influenced estuaries and rivers may also contribute to tidal flooding.

The VPI Site is located approximately 1.4 km from the tidal River Humber, which originates at Trent Falls and flows in a south-easterly direction into the North Sea.

A review of the Environment Agency FMfP (shown in **Plate 5.8**) illustrates that the entire VPI Site is located in Flood Zone 3, land assessed as having a greater than 0.5% AEP (1 in 200-year return period).

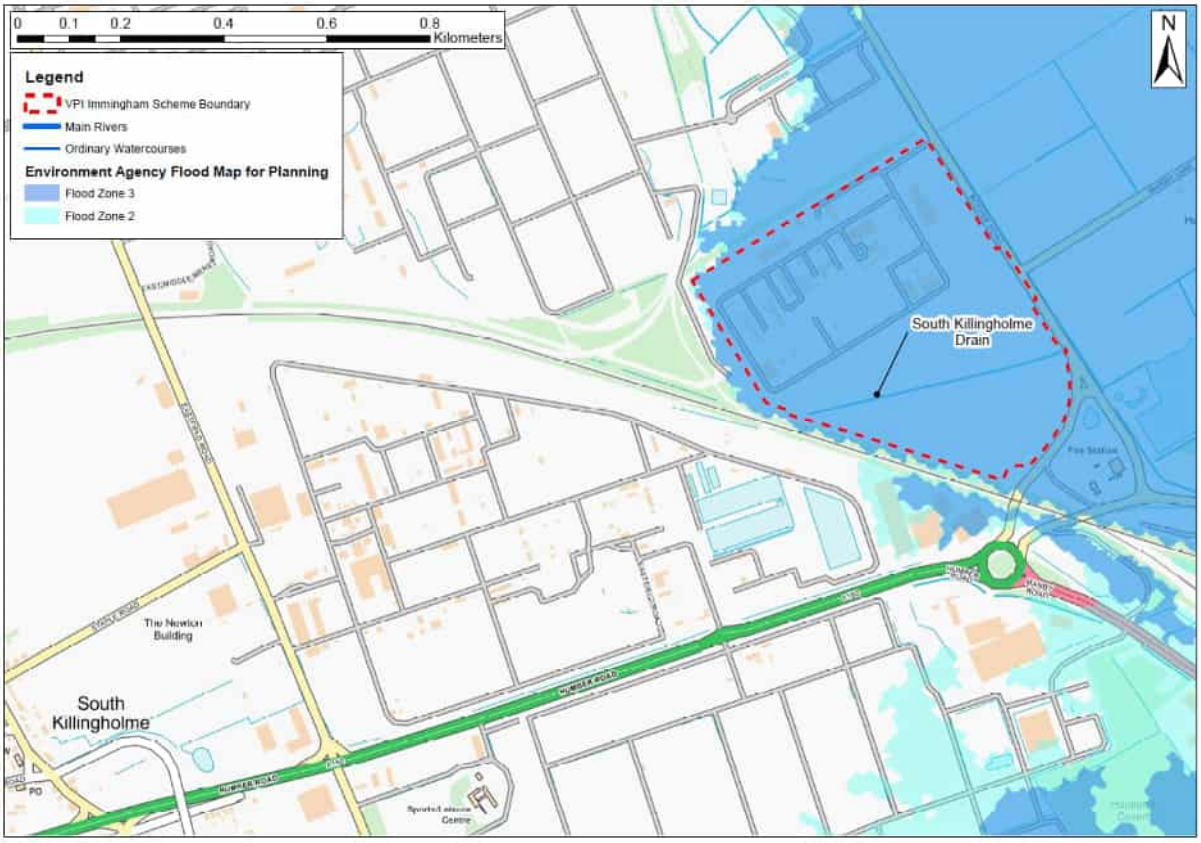

Plate 5.8: Environment Agency Flood Map for Planning VPI Site

5.2.2.1 Extreme Water Levels

Extreme still tidal water level data was provided by the Environment Agency with a baseline of 2021 for the present-day scenario. The extreme still water levels for 2046 and 2071 include projected climate change, accounting for sea level rise and fluvial flow uplifts, in line with the UKCP18 allowances (**Annex A**). This dataset is considered to be the most up-to-date and appropriate for this review and is presented in **Table 5.4**.

Table 5.4 Predicted extreme water levels for South Killingholme

		Extreme Still Water Level (mAOD)	
Year	**Annual Exceedance Probability (%)**	**Higher Central**	**Upper End Allowance**
2021	50%	4.32	4.33
	10%	4.58	4.59
	2%	4.86	4.87
	1%	4.99	5.00
	0.5%	5.15	5.16
	0.1%	5.47	5.48
2046	50%	4.50	4.54
	10%	4.75	4.79
	2%	5.04	5.08
	1%	5.16	5.21
	0.5%	5.32	5.54
	0.1%	5.63	5.67
2071	50%	4.73	4.86
	10%	4.99	5.11
	2%	5.27	5.39
	1%	5.40	5.51
	0.5%	5.54	5.82
	0.1%	5.84	5.95

In Section 4.1, the sea level allowances for the Proposed VPI Development for the year 2052, based on the Environment Agency Flood Risk Assessment: Climate Change Allowances guidance[22] were calculated as 0.22 m (Higher Central) and 0.28 m (Upper End). The data in **Table 5.4**Table 5.1 indicates that for the Higher Central allowance, sea levels are predicted to rise by 0.17 m for 2046 and by 0.41 m for 2071, therefore the calculated 0.22 m sea level rise for 2052 is considered feasible. For the Upper End allowance, sea levels are predicted to rise by 0.21 m for 2046 and by 0.51 m for 2071, therefore the calculated 0.28 m sea level rise for 2052 is considered feasible.

Given the Proposed VPI Development is classed as 'Essential Infrastructure', with a lifetime of 25 years (from 2027), the 0.5% AEP (1 in 200 year return period) flood event and higher central allowance must be assessed. As such, for the year 2052 the extreme still water level at South Killingholme is predicted to be 5.37 m AOD (hereafter referred to as the 'critical flood level'). This still water level is derived by adding the calculated sea level allowance, 0.22 m, to the 2021 (baseline) 0.5% AEP still water level of 5.15 m AOD (**Table 5.4**).

5.2.2.2 Flood Defences

The Environment Agency has confirmed that tidal defences, consisting of earth embankments and concrete floodwalls protect the VPI Site. The Environment Agency owns, inspects and maintains these defences and advises that the defences are in fair condition and reduce the risk of flooding (at the defence) up to the 0.5% AEP (1 in 200-year return period) flood event. A review of the Environment Agency Asset Management Database[23] indicates that the flood defences (located along the coastline at South Killingholme) range in crest height from 5.96 m AOD to 6.35 m AOD.

5.2.2.3 Breach of Defences

The Environment Agency has provided breach location and associated breach hazard maps from the Northern Area Tidal Hazard Mapping Study. The Northern Area Tidal Hazard Mapping study involved a modelled representation of tidal breaches along the east coast and the south bank of the Humber Estuary, with breaches in the hard defences set at 20 m wide and the defences assumed to breach down to the ground level behind the defence. The defences were raised within the model to create reservoir cells, ensuring that the most precautionary volumes of water were driven through the breach opening.

The breach modelling was based on the Still Water Tidal Levels from the Northern Area Tidal Model Analysis 2006 including the 0.5% AEP and 0.1% AEP flood events for the current year (based on 2006 modelling outputs) and 2115. The breach locations nearest the VPI Site are located on the frontage at South Killingholme and East Halton. The Hazard Classification Methodology used is based on Flood Risk Assessment Guidance for New Development known as FD2320/TR213[24], presented in **Table 5.5**.

Table 5.5 Flood Hazard Classification

Flood Hazard	Classification
Low	**Caution** - Flood zone with shallow flowing water or deep standing water
Moderate	**Dangerous for some** (i.e. Children) – Danger: Flood zone with deep or fast flowing water
Significant	**Dangerous for most people** – Danger: Flood zone with deep fast flowing water
Extreme	**Dangerous for all** – Extreme Danger: Flood zone with deep fast flowing water

The 2006 0.5% AEP breach scenario is considered most appropriate for this assessment and the associated hazard map is presented in **Plate 5.9**. The hazard map indicates that the entire VPI Site is located within a 'Moderate', 'Significant' or 'Extreme' hazard area with a small area to the north-east with flood depths in excess of 1.6 m and a maximum water velocity of 1.5-2.5 m/s. In line with guidance from the SFRA[11], to determine the breach flood level and advise the level for critical electrical equipment (see **Section** Error! Reference source not found. for further details), the 0.1% AEP 2115 breach scenario is assessed (presented in **Plate 5.10Plate 5.4**). By comparison of the hazard outlines with LiDAR levels the 0.1% AEP 2115 breach scenario flood level is estimated to be 6.3 m AOD (refer to **Annex E**).

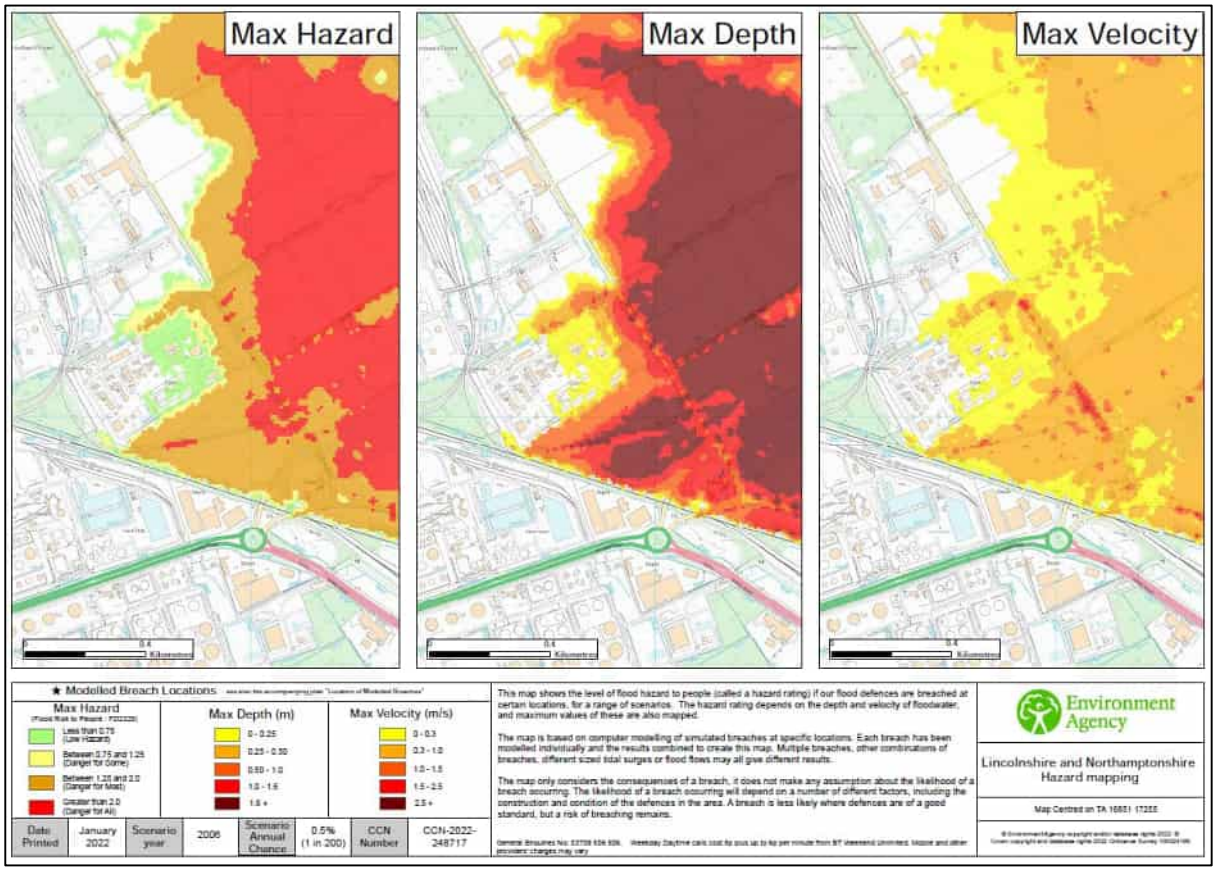

Plate 5.9: Environment Agency Modelled Breach Hazard Map for 0.5% AEP 2006 Scenario

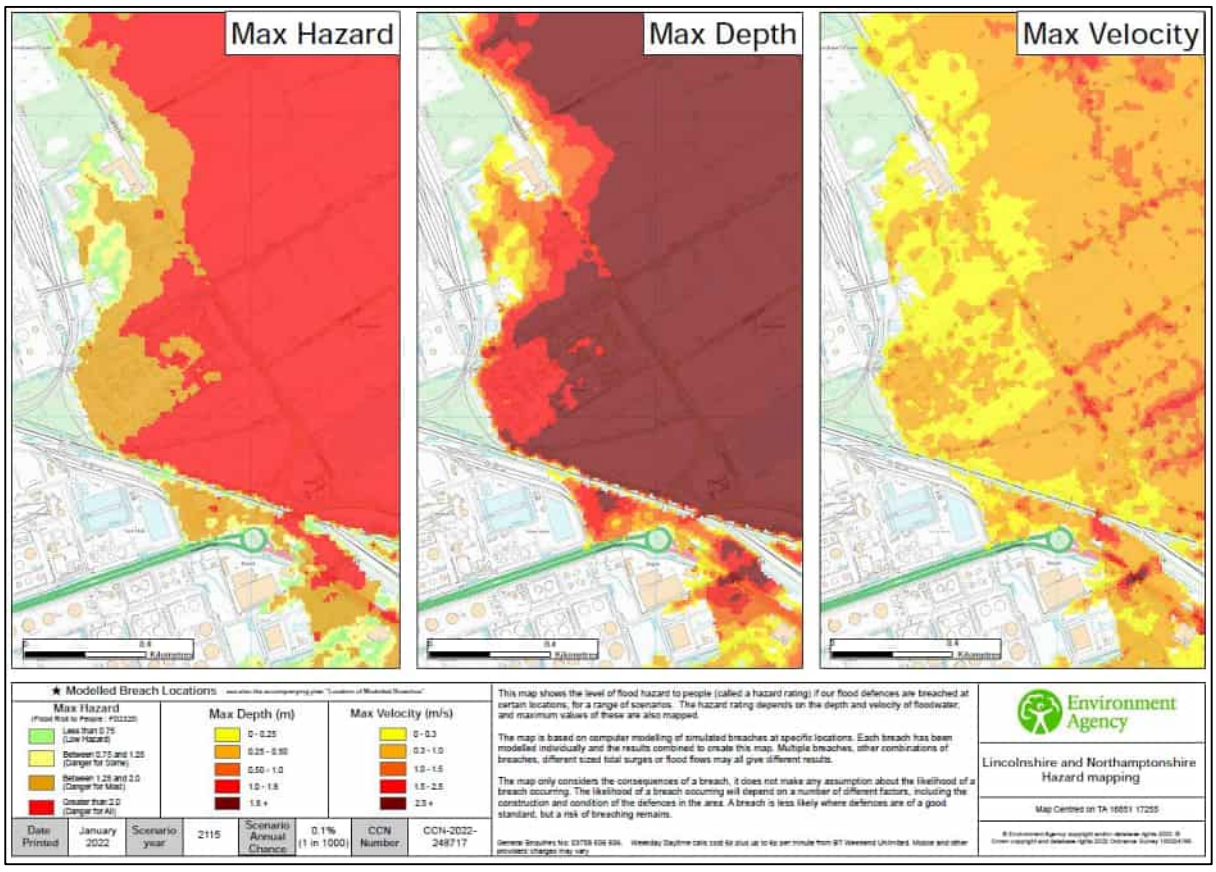

Plate 5.10: Environment Agency Modelled Breach Hazard Map for 0.1% AEP 2115 Scenario

The hazard map indicates that the entire VPI Site is located within a 'Moderate', 'Significant' or 'Extreme' hazard area with flood depths over the majority of the VPI Site area in excess of 1.6 m and a maximum water velocity of 1.5-2.5 m/s.

Although a breach of the flood defences would represent a significant hazard (i.e., the consequence), given the routine inspections and maintenance of the flood defences by the Environment Agency, the likelihood of breach occurring is low. The NPPF requires that plans and mitigation and put in place to manage the risks should breach occur. Mitigation measures for the Proposed VPI Development are outlined in **Section** Error! Reference source not found..

5.2.2.4 Overtopping of Flood Defences

The Northern Area Tidal Mapping Study also involved the modelled representation of tidal overtopping along the east coast and the south bank of the Humber Estuary. The Environment Agency has confirmed that the VPI Site is not affected by overtopping of the defences in 2006 0.5% AEP overtopping scenario (the current scenario),

The VPI Site is affected in the 2115 0.1% AEP overtopping scenario and the associated hazard map is presented in **Plate 5.11: Environment Agency Modelled Overtopping Hazard Map for 0.1% AEP 2115 Scenario**. The hazard map indicates that the entire Proposed VPI Development is located within an 'Extreme' hazard area with a maximum water depth of greater than 1.6 m and a maximum water velocity of 1.5-2.5 m/s.

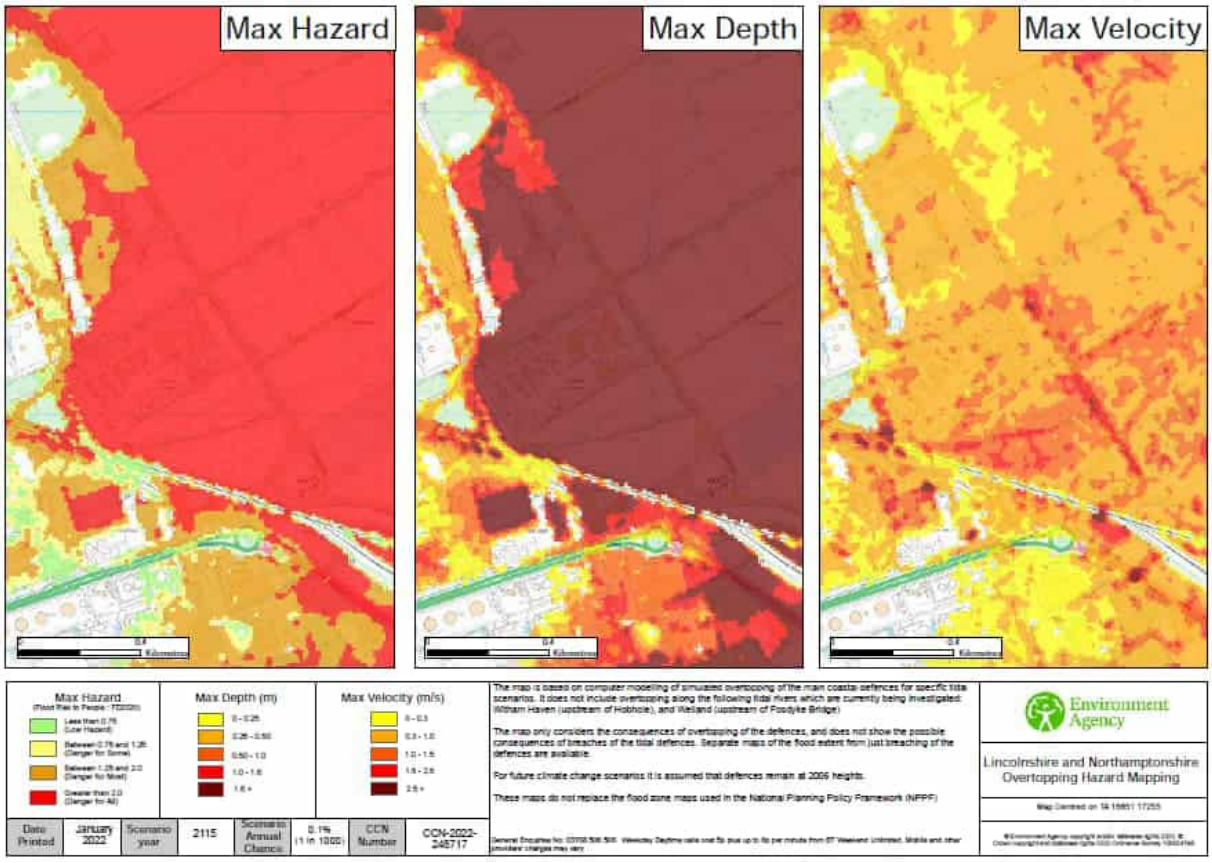

Plate 5.11: Environment Agency Modelled Overtopping Hazard Map for 0.1% AEP 2115 Scenario

Although the overtopping of the flood defences would represent a significant hazard (i.e. the consequence), the likelihood of overtopping occurring is low . The NPPF requires that plans and mitigation are put in place to manage the risks should overtopping occur. Mitigation measures for the VPI Development are outlined in **Section 7**.

5.2.2.5 Summary of Flood Risk from Tidal Sources (VPI Site)

This risk of tidal flooding over the lifetime of the Proposed VPI Development is considered to be low, given that the flood defences are approximately 0.59 m higher than the critical flood level of 5.37 m AOD (including an allowance for sea level rise). Should a breach in defences occur, parts of the development site that lie below 6.3 mAOD may be inundated.

5.2.3 Fluvial Sources

Fluvial flooding occurs when the capacity of a river is exceeded either due to high flows from the catchment draining into the river or a combination of high flows and high tides, which causes raised water levels due to backwater effects.

5.2.3.1 Main River

The VPI Site is not considered to be at risk of flooding from fluvial main rivers.

5.2.3.2 Ordinary Watercourses

Ordinary Watercourses include every river, stream, brook, cut, dike/ dyke and sluice which do not form part of a Main River network. Where applicable, the Riparian Owner, IDB or LLFA have a lead responsibility for managing the risk of flooding from ordinary watercourses. North East Lindsey IDB are operational within the area and have flood risk management responsibilities over South Killingholme Drain.

South Killingholme Drain

The IDB divide South Killingholme Drain into two respective watercourses, Watercourse 9A and Watercourse 9. Watercourse 9A crosses the VPI Site and Watercourse 9 runs parallel with Rosper Road. High levels within the tidally influenced watercourses are a potential flood risk to the area due to associated tide-locking when high tides prevent these watercourses discharging into the Humber Estuary.

There is no national mapping of the predicted flood extents associated with these Ordinary Watercourses and land drains available within the development site boundary. It is possible to use the Environment Agency RoFSW flood map (**Plate 5.12**) as a proxy to understand flood risk from the Ordinary Watercourses and land drainage channels.

A review of this dataset indicates there is no out of bank flooding along the drain during the 1% AEP event. During the 0.1% AEP event flood water extends out from South Killingholme Drain across the Site to the north and south with flood depths between 300 mm and 900 mm. The risk of flooding to the VPI Site from these extents is assessed as low and the mitigation proposed for tidal sources is considered to be sufficient.

Climate Change

Climate change must be taken into account when considering flooding from fluvial sources. This is usually represented by an increase in peak river flows (**Table 4.3**). In the Louth, Grimsby and Ancholme Catchment, peak river flows are expected to increase by 12% in the 2080's epoch.

South Killingholme Drain will be diverted as part of the Proposed VPI Development. The drain, which currently crosses the proposed development area, will be diverted along the southern boundary of the VPI Site. The diversion will tie in with the current culverted sections where the drain enters the VPI Site from the west (from the Phillips 66 Site and under the railway) and where the drain leaves the VPI Site (to the east beneath Rosper Road.

The diversion design provides a slightly longer channel with an increase in capacity above that currently provided by the South Killingholme Drain therefore the risk of flooding over the lifetime of the Proposed VPI Development will remain low. Further information for the diversion of South Killlingholme Drain within the VPI Site boundary is provided in **Section 6.2.2**, **Section 7.6** and **Annex E**.

5.2.3.3 Summary of Flood Risk from Fluvial Sources (VPI Site)

The risk of fluvial flooding over the lifetime of the Proposed VPI Development is considered to be low, given that the development is not located in proximity to any main rivers. There is a residual risk of flooding from ordinary watercourses in the event that they become tide-locked, however the mitigation proposed for tidal sources is considered to be sufficient.

5.2.4 Surface Water (Overland Flow)

Surface water flooding is caused by overland flow that results from rainfall that fails to drain into the ground through infiltration, instead of travelling over the ground surface. This can be exacerbated where the permeability of the ground is low due to the type of soil (such as clayey soils) and geology or land use including urban developments with impermeable surfaces.

The Environment Agency RoFSW maps[6] indicate areas at risk from surface water flooding when rainwater does not drain away through the normal drainage systems or soak into the ground, but instead lies on or flows over the ground. The RoFSW flood map for the VPI Site is shown in **Plate 5.12** below. As defined by the Environment Agency, the following levels of surface water flood risk can be classified as defined in

Table 5.6.

Table 5.6: Definition of risk from surface water flooding

Risk of flooding	Definition
Very Low	Each year, the area has a chance of flooding of less than 1 in 1,000 (0.1% AEP)
Low	Each year, the area has a chance of flooding of between 1 in 1,000 (0.1%) and 1 in 100 (1% AEP)
Medium	Each year, the area has a chance of flooding of between 1 in 100 (1%) and 1 in 30 (3.3% AEP)
High	Each year, the area has a chance of flooding of greater than 1 in 30 (3.3% AEP)

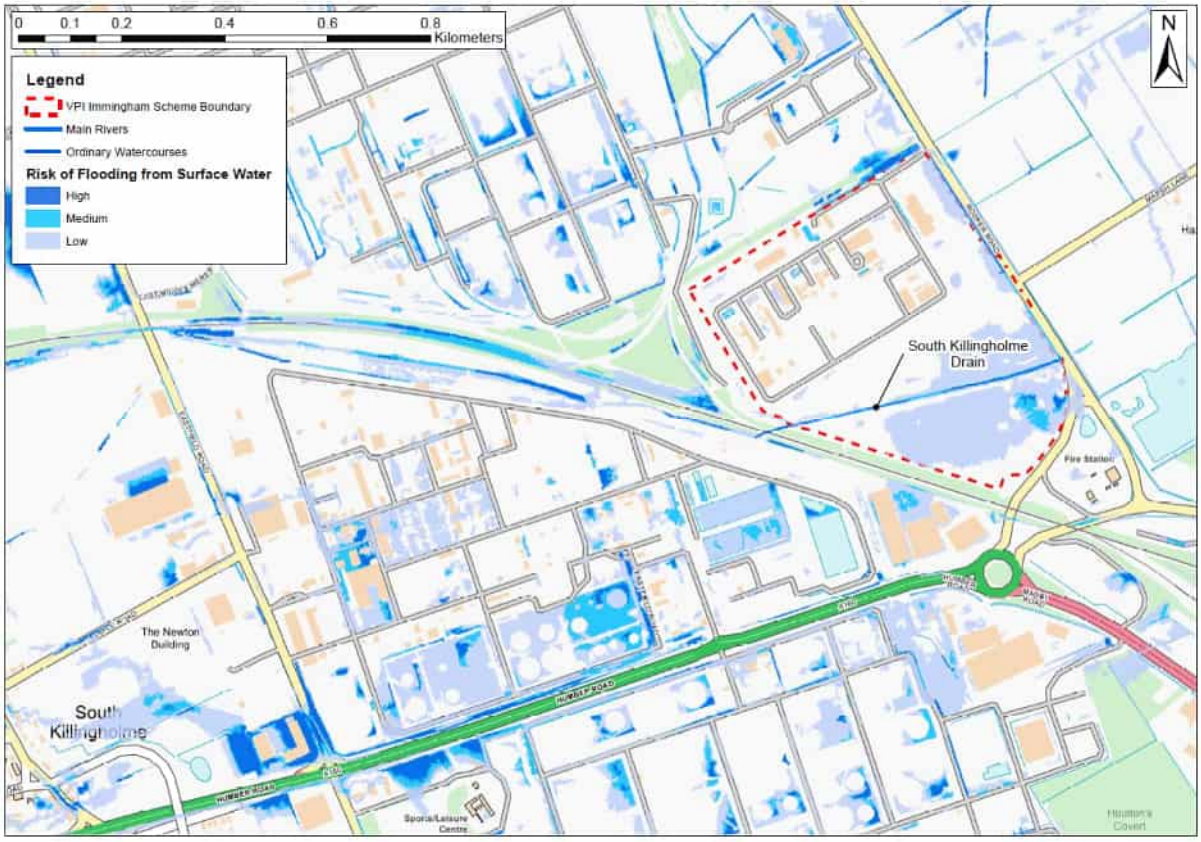

Plate 5.12: Environment Agency Risk of Flooding from Surface Water Map for VPI Site

Following a review of the Environment Agency RoFSW dataset, it is concluded that the majority of the VPI Site is shown to be at 'very low' risk of surface water flooding. There are isolated areas of the VPI Site at 'low', 'medium' and 'high' risk of surface water flooding, reflecting areas of low topography during higher return period events and the flood extents associated with South Killingholme Drain. Flood depths are predicted to remain below 900 mm. The risk of flooding from surface water is therefore considered to be low.

Climate change must be taken into account when considering surface water runoff generated by development sites. This is usually represented by increasing peak rainfall intensities (**Table 4.5**). An increase in rainfall intensity will result in an increase in runoff rates and volumes from the Proposed VPI Development, exacerbated by increased areas of impermeable surface associated with the Proposed VPI Development.

Using the 'Low' risk surface water flood extent as a proxy for the impacts of climate change, the risk of flooding to the VPI Site can be seen to increase along the corridor of the existing drain. As part of the development, it is

proposed to divert the Killingholme Drain to the southern area of the Site (see **Section 6.2.2**, **Section 7.6** and **Annex E** for further details), The proposed ditch diversion is slightly longer than the current drain therefore provides more capacity for flows within the channel.

Information provided by Worley, presented as Appendix 9C Drainage Strategies (ES Volume II), provides further information on proposed surface water management at the VPI Site, including allowance for climate change over the lifetime of the development. With the proposed management of surface water, including an allowance for climate change in combination with the diversion of the South Killingholme Drain, the risk of surface water flooding remains low over the lifetime of the Proposed VPI Development.

5.2.5 Groundwater Sources

Groundwater flooding can occur when groundwater levels exceed ground surface levels as a result of periods of sustained high rainfall. The underlying geology has a major influence on where this type of flooding takes place; it is most likely to occur in low-lying areas underlain by permeable rocks (aquifers) where the water table is more likely to be at shallow depth.

5.2.5.1 Geology and Hydrogeology

The 1:50,000 British Geology Survey (BGS) Map of Britain indicates that the development site is mapped on superficial deposits of Devensian-Diamicton Deposits, comprising clay and silt. The bedrock geology mapped underlying the development site comprises Burnham Chalk Formation, a principal aquifer according to the DEFRA Aquifer Designation Map[8], suggesting there could be permeable layers indicative of elevated groundwater levels within the surrounding area.

5.2.5.2 Groundwater Levels

Groundwater levels tend to get re-charged during the winter and high groundwater levels can cause flooding as the water table rises. The rise in water table levels can be very slow, dependant on rainfall patterns and groundwater flooding can be long lasting (weeks or months). Borehole records from the British Geological Survey indicates groundwater strikes between 12.80 m and 18 m below ground level within the VPI Site boundary. As these are simply water strikes during drilling and not long-term monitoring records, they may overestimate the depth to the water table.

Should localised groundwater emergence occur it is considered this can easily be dealt with by the use of pumps and would not increase flood risk from groundwater sources to the area during or after the construction process.

5.2.5.3 Groundwater Flooding

The North Lincolnshire Council PFRA[10] states "*Generally the risk of flooding from groundwater is in the coastal areas from Immingham to Humberston, i.e. the lower lying parts of the floodplain*" (page 22).

Groundwater levels tend to get re-charged during the winter and high groundwater levels can cause flooding as the water table rises. This rise in water table levels can be very slow, dependent on rainfall patterns. There is no reference to groundwater flooding events in in the North Lincolnshire SFRA for the Eastern Coastal Area where the Post Combustion Carbon Capture project is located. There are no historical flood records for groundwater flooding within the VPI Site or the wider South Killingholme area.

The direct impact of climate change on groundwater resources is dictated by the changes in rainfall intensity and soil infiltration. During direr seasons, there may be reductions in groundwater recharge that may cause a long-term decline in groundwater storage. Alternatively, groundwater recharge may be stabilised or even increased by frequent and prolonged periods of rainfall. As a precautionary measure, any below ground elements associated with the Proposed VPI Development should be designed in such a way as to withstand any upward hydraulic pressures in the event that groundwater levels rise as a result of climate change. Assuming this is the case, any anticipated increase in groundwater levels, as a result of climate change will unlikely increase the risk of groundwater flooding to the Proposed VPI Development.

5.2.5.4 Groundwater Flooding

Given the limited information available and potential for high groundwater levels below the development site, the risk from groundwater flooding is considered to be medium and the following mitigation measures are recommended:

- All below ground elements should be designed to withstand any upward hydraulic pressure.

5.2.6 Sewers and Drainage Infrastructure

The VPI Site currently comprises undeveloped brownfield land with the South Killingholme Drain running through the area of the new VPI plant development. There is no formal drainage infrastructure (surface water or foul) within the VPI Site boundary therefore drainage occurs via natural processes (i.e., infiltration to ground).

Topographic survey indicates that land to the north of the drain within the VPI Site boundary drains south to the South Killingholme Drain whilst land to the south of the watercourse drains to the south and south-east towards Humber Road.

There are no historical records of sewer flooding in the area local to the VPI Site and given the VPI Site drains naturally the risk of flooding from sewers and drainage infrastructure is low.

5.2.7 Flood Risk from Canal Systems

A review of the Canal and River Network Mapping from the Canal and River Trust[25] shows there are no canals within the vicinity of the development site. Given the distance between the development site and canal infrastructure, the risk of flooding from canal systems is negligible and is not considered further in this assessment.

5.2.8 Flood Risk from Reservoirs

The Environment Agency's flood map showing 'Risk of Flooding from Reservoirs' indicates that the VPI Site is not located in an area identified to be at risk of flooding from reservoirs.

6. Impacts of the Development on Flood Risk

This section aims to assess the risk of all sources of flooding from the Proposed Developments, and to demonstrate how these flood risks will be managed.

6.1 Proposed Phillips 66 Development

6.1.1 Impact on Tidal Flooding

It is proposed that ground levels are raised in the area of the proposed Phillips 66 PCC plant area to provide a development platform, however as this area of Phillips Site is located in Flood Zone 1 and is not located within the 2115 breach flood extent (refer to **Section 5.1.2.3**) the Proposed Phillips 66 Development does not have the potential to alter flood flow paths should a breach event occur. No ground raising is proposed along the pipeline corridor.

The risk of flooding from tidal sources remains low over the lifetime of the Phillips 66 Development. The pipeline corridor to the southeast of the Phillips 66 Site remains within the tidal flood breach area, however flood resistance and resilience measures will be built into the design of the pipeline to minimise the impacts of flood risk over its lifetime. See **Section 7** for further details.

6.1.2 Surface Water Runoff Generation and Overland Flow

The Proposed Phillips 66 Development will lead to an increase in the area of impermeable surface associated with the creation of the carbon capture plant. As a result, the amount and rate of surface water generated by the Phillips 66 Site will increase, which left unmitigated could increase the risk of surface water flooding to surrounding areas.

However, the Proposed Phillips 66 Development will include a new surface water drainage network which will tie into the Humber Refinery's existing 'Clean' surface water (CSW) drainage system., Attenuation will be provided within the pipework of the drainage system before feeding into the Effluent Treatment Plant and within the existing Humber Refinery No.1 and No.2 holding ponds), prior to discharge into the South Killingholme Drain. Exceedance flows from the holding ponds will be stored within the wider Phillips 66 Site as the current scenario with no flows off site. .

Further details regarding both the foul and surface water drainage strategy for the Phillips 66 Site have been provided by Worley and are presented in Appendix 9C (ES Volume II).

There are no prominent surface water flow paths predicted on the Phillips 66 Site in accordance with the RoFSW dataset and as such, the impact of the Proposed Phillips 66 Development on surface water flood risk to other areas is therefore considered to be low and no further mitigation above that stipulated above is required.

6.1.3 Groundwater Flooding

With the exception of foundations and drainage infrastructure no other underground structures are proposed therefore the risk of flooding from groundwater will remain a medium risk.

6.2 Proposed VPI Development

6.2.1 Impact on Tidal Flooding

It is proposed that ground levels are raised across the VPI Site (by a maximum of 1 m in places) to provide a development platform. The development platform level of 4.9 m AOD allows the platform to tie in with ground levels along the southern boundary of the VPI Immingham CHP Site.

Raising ground levels has the potential to displace flood water, increasing flood risk to areas off site, including adjacent developments. The VPI Site is at residual risk of flooding should a breach of the flood defences occur. The breach hazard flood extent (See **Plate 5.9**) is constrained by the railway line during a 0.5% AEP breach event with limited flooding beyond the railway line to the west and south. During a 0.1% AEP flood event the area of breach extent does not increase and neither does the hazard classification, flood depths or flood velocities. Based on this information it is unlikely that the area of ground raising within the VPI Site will impact the risk of flooding to off-site areas.

6.2.2 The risk of flooding from tidal sources remains low over the lifetime of the Proposed VPI Development. Impact on Fluvial Flooding

South Killingholme Drain is required to be diverted as part of the Proposed VPI Development. It will be diverted along the southern boundary of the VPI Site during the construction phase. The final design incorporates diverting the drain along the southern boundary of the VPI Site in a combination of an open channel, with a culverted section along the western section where the watercourse runs parallel to the existing Phillips 66 pipe band. The existing culverted section starts in the lagoons on Phillips 66 site and runs under the rail lines.

The diverted drain will tie into the existing channel near the western boundary where the watercourse emerges from under the Network Rail railway and the eastern end before a culvert under Rosper Road. The diversion will involve making the channel slightly longer, however maintaining a similar slope, cross-section and depth. This can be achieved within the space allowed within the layout of the Proposed VPI Development for the diversion. The design will provide a slight increase in capacity over the existing drain to prevent increased flood risk upstream and downstream.

Further details regarding the watercourse diversion have been provided by Worley and are presented in **Annex D**.

Surface water runoff generated on new impermeable surfacing will be manged via a new surface water drainage system which includes an attenuation pond and a restricted greenfield discharge to the South Killingholme Drain.

Based on this information the risk of flooding from fluvial sources will remain low as a consequence of the VPI Site being developed.

6.2.3 Surface Water Runoff Generation and Overland Flow

The Proposed VPI Development will lead to an increase in the area of impermeable surface associated with the creation of the carbon capture plant. As a result, the amount and rate of surface water generated by the VPI Site will increase, which left unmitigated could increase the risk of surface water flooding to surrounding areas.

Following development, surface water is proposed to discharge to South Killingholme Drain at the current VPI storm discharge to a new outfall to the South Killingholme Drain immediately upstream of Rosper Road via an attenuation pond and class 1 oil separator.

Surface water discharged from the Proposed VPI Development will be restricted to the greenfield runoff rate, via the attenuation pond with sufficient storage for climate change over the lifetime of the development.

Other SuDS techniques such as swales, permeable paving and soakaways, to attenuate flow from the VPI Site and maximise infiltration (where appropriate), may be considered at the detailed design stage.

Further details regarding the drainage strategy for the Site have been provided by Worley and are presented in Appendix 9C (ES Volume II).

6.2.4 Groundwater Flooding

With the exception of foundations and drainage infrastructure no other underground structures are proposed therefore the risk of flooding from groundwater will remain a medium risk.

7. Flood Risk Management Measures

The following mitigation measures will be included in the Proposed Developments to reduce the risk of flooding during extreme events and residual risks should also be considered. These measures will help to reduce the impact of a flood event should it occur.

7.1 Development Levels

There are three specific levels that must be considered for developments at risk of flooding:

- finished floor levels;
- advisory levels for critical plant/ equipment; and
- safe refuge level for personnel.

Section 7.1.1 and Section 7.1.2 below sets out the development levels proposed for the Phillips 66 Site and VPI Site respectively.

7.1.1 Proposed Phillips 66 Development

7.1.1.1 Finished Floor Levels

The Environment Agency recommend that any new buildings should raise Finished Floor Levels (FFLs) as high as practicable and, if these will be below the predicted flood depth (referring to the relevant Environment Agency 2115 0.5 % AEP tidal breach map), suitable flood resistance/ resilience measures identified.

As the main development area within the Phillips 66 Site is located in Flood Zone 1 and is not located within the 2115 flood hazard breach extent, finished floor levels will be raised 300 mm above the surrounding ground level, where practical.

7.1.1.2 Advisory Levels for Critical Plant

The minimum installation level for critical plant and machinery should be considered. The PPG classifies the development as 'essential infrastructure' and as such the North East Lincolnshire SFRA states "*essential infrastructure should remain operation at times of flood. The flood risk assessment should demonstrate that development will remain operational in case of a breach in the defences during a 0.1% event (2115 scenario). Critical equipment should be above this flood depth shown on the tidal hazard mapping for this scenario.*".

There are no advisory levels for critical plant/ equipment stated in planning policy, however the Environment Agency advise that critical plant/ equipment (to be defined by Phillips 66), should be raised and secured above the expected 0.1% AEP climate change breach scenario floodwater level where it is practicable to do so.

Development defined as critical infrastructure for the Proposed Phillips 66 Development will be located at existing ground level for operational reasons therefore flood resilience and resistance measures will be put in place (e.g. raised plinths, watertight housing bunding where practicable etc), as with other critical infrastructure within the wider refinery site.

Items of critical plant for which spares can be kept on the Phillips Site will be identified, and storage of those items on Site will be implemented to reduce the potential recovery time in the event of a major flood event.

7.1.1.3 Safe Refuge

In the event that flooding occurs with such speed that personnel on the Phillips 66 Site are not able to evacuate, the PPG requires safe refuge to be provided within the Phillips 66 Site. This allows any individuals on the Phillips 66 Site to wait safely until the flooding subsides or rescue can be affected.

As the main development area within the Phillips 66 Site is located in Flood Zone 1 and is not located within the 2115 flood hazard breach extent a place of safe refuge will not be required. The 2115 breach hazard mapping (**Plate 5.9** and **Plate 5.10**) clearly shows that access and egress to the Phillips 66 Site, along Eastfield Road, remains clear of flood water during the 2115 breach flood events.

7.1.2 Proposed VPI Development

7.1.2.1 Finished Floor Levels

The Environment Agency recommend that any new buildings should raise Finished Floor Levels (FFLs) as high as practicable and, if these will be below the predicted flood depth (referring to the relevant Environment Agency 2115 0.5 % AEP tidal breach map), suitable flood resistance/ resilience measures identified.

Finished floor levels for the VPI Site will not be raised and [redacted] will remain below the 2115 0.5% AEP breach water level. In line with Environment Agency guidance flood resistant and resilient measures will be incorporated into the building design, as outlined below.

7.1.2.2 Advisory Levels for Critical Plant

The minimum installation level for critical plant and machinery should be considered. The PPG classifies the development as 'essential infrastructure' and as such the North East Lincolnshire SFRA states "*essential infrastructure should remain operational at times of flood. The flood risk assessment should demonstrate that development will remain operational in case of a breach in the defences during a 0.1% event (2115 scenario). Critical equipment should be above this flood depth shown on the tidal hazard mapping for this scenario*."

There are no advisory levels for critical plant/ equipment stated in planning policy, however the Environment Agency advise that critical plant/ equipment (to be defined by VPI), should be raised and secured above the expected 0.1% AEP climate change breach scenario floodwater level where it is practicable to do so.

Development defined as critical infrastructure for the Proposed VPI Development will be located at existing ground level for operational reasons therefore flood resilience and resistance measures will be put in place (see Section 7.2) (where practicable), as with other critical infrastructure within the VPI Immingham CHP Site.

7.1.2.3 Safe Refuge

In the event that flooding occurs with such speed that personnel on the VPI Site are not able to evacuate, safe refuge will be provided onsite. This will allow any individuals on the VPI Site to wait safely until the flooding subsides or rescue can be affected.

Safe refuge, located above 6.3 m AOD i.e. the flood level corresponding to the 0.1% AEP breach flood event with climate change allowance, is anticipated to be provided in the existing CHP Plant administration building. Provision for disabled persons to reach these areas should also be considered as part of the design.

7.2 Flood Resistant and Resilient Design

CIRIA Report C688 'Flood Resilience and Resistance for Critical Infrastructure'[26], states that "*Flood resilience involves designing an infrastructure asset or adapting an existing infrastructure asset so that although it comes into contact with floodwater during floods, no permanent damage is caused, structural integrity is maintained and, if operational disruption does occur, normal operation can resume rapidly after a flood has receded.*

Flood resistance involves designing an infrastructure asset or adapting and existing infrastructure asset so that floodwater is excluded during flood events and normal operation can continue with no disruption occurring to the essential services the asset provides".

7.2.1 Proposed Phillips 66 Development

The main development area within the Phillips 66 Site is located within Flood Zone 1 and is not within the 2115 breach flood extent. However, the CO_2 pipeline to the north-east of the Network Rail railway line will be located within the 2115 breach flood extent. The following methods of flood resistant and resilient construction will be included in the design to mitigate extreme flood events:

- pipelines and storage tanks designed to withstand the water pressures associated with high return period event flooding;
- tanks/pipelines securely tethered in such a way to ensure the infrastructure remains secure should flooding occur;

[26] CIRIA. (2010). Report C688 'Flood Resilience and Resistance for Critical Infrastructure. Available at: https://www.ciria.org/Resources/Free_publications/Flood_resilience.aspx

- electrical supply entering the Proposed Phillips 66 Development from height and down to required connections;
- flood proofing including the use of water resistant coatings, use of galvanised and stainless steel fixings and raising electrical sockets and switches; and
- any below ground infrastructure must be designed to withstand hydrostatic pressures and built with flood resilient materials.

7.2.2 Proposed VPI Development

The following methods of flood resistant and resilient construction will be included in the design of the Proposed VPI Development:

- pipelines and storage tanks designed to withstand the water pressures associated with high return period event flooding;
- tanks securely tethered in such a way to ensure the infrastructure remains secure should flooding occur;
- electrical supply entering the Proposed VPI Development from height and down to required connections;
- use of flood barriers on access points;
- protecting wiring for operational control of the Proposed VPI Development, telephone, internet and other services by suitable insulation in the distribution ducts to prevent damage;
- materials with low permeability up to 0.3 m and accept water passage through building at higher water depths;
- flood proofing including the use of flood resistant building materials, use of water resistant coatings, use of galvanised and stainless steel fixings and raising electrical sockets and switches;
- utilising floor materials that are able to withstand exposure to floodwater without significant deterioration and that can be easily cleaned, e.g. concrete-based or stone;
- incorporating water resistant services within the buildings, i.e. avoid services using ferrous materials;
- design development to drain water away after flooding;
- provide access to all spaces to permit drying and cleaning;
- carefully considering the usage and layout of ground floor areas to minimise the potential impact on business operations following a flood; and
- any below ground infrastructure must be designed to withstand hydrostatic pressures and built with flood resilient materials.

7.3 Flood Warnings and Alerts

The Environment Agency operates a Flood Warning Service[27] for many areas at risk of fluvial and tidal flooding. The service currently consists of three stages:

- Flood Alert – flooding is possible and that you need to be prepared;
- Flood Warning – flooding is expected and that you should take immediate action. Action should be taken when a flood warning is issued and not wait for a severe flood warning; and
- Severe Flood Warning – there is severe flooding and danger to life. These are issued when flooding is posing significant risk to life or disruption to communities.

Each code gives an indication of the expected level of danger. Although some members of the public find Flood Alerts useful, they are predominantly targeted towards professional partners, alerting them to expected flooding of low-lying land and roads.

All stages of warning are disseminated via the ‘Flood Warning Service’ which is a free service that provides warnings to registered customers by telephone, mobile, email, SMS text message and fax. Local radio, TV, loudhailers, sirens and Floodline are also used to deliver flood warning messages.

[27] Environment Agency Flood Warning Service. Available at: https://www.gov.uk/sign-up-for-flood-warnings. Retrieved: 09/02/2023

The Floodline number is 0345 988 1188, and it is always kept up to date with the Environment Agency's latest flooding information. More detailed information on the likely extent and time scale of these warnings can be obtained by request from the Environment Agency, by their 'Quickdial' recoded information service, or via their website.

The Environment Agency aim to issue fluvial Flood Warnings at least 2 hours prior to the onset of flooding mainly based upon actual river level rise. Tidal flood warnings are issued based on forecast information, and therefore the lead time provided is longer. The Environment Agency aim to issue Flood Warnings a minimum of 6 hours in advance by depending on confidence in the forecast they could be issued 24 or even 36 hours in advance.

7.3.1 Proposed Phillips 66 Development

Phillips 66 are already subscribed to the Environment Agency Flood Risk Warning Service (Humber Resilience Forum alert process) and it is assumed that the Proposed Phillips 66 Development will continue to receive warnings and alerts as part of this ongoing service.

7.3.2 Proposed VPI Development

VPI Immingham are already subscribed to the Environment Agency Flood Risk Warning Service (Humber Resilience Forum alert process) and it is assumed that the Proposed VPI Development will continue to receive warnings and alerts as part of this ongoing service.

7.4 Emergency Evacuation and Planning

Developments in flood risk areas must provide safe, dry access and egress to enable evacuation of people, routes for emergency services and flood defence authorities to carry-out the necessary duties during a flood event.

7.4.1 Proposed Phillips 66 Development

As the main PCC development area within the Phillips 66 Site is located in Flood Zone 1 and is not located within the 2115 flood hazard breach extent a place of safe refuge will not be required. The 2115 breach hazard mapping (**Plate 5.3**) clearly shows that access and egress to the Phillips 66 Site, along Eastfield Road, remains clear of flood water during the 2115 breach flood event allowing full evacuation of the Site.

Flood emergency procedures for the Phillips 66 Site will be included within the existing Phillips 66 Emergency Response Plan.

7.4.2 Proposed VPI Development

The Northern Area Tidal Breach Mapping Study outputs provided by the Environment Agency (Annex A to this FRA), suggest that the Site is at risk of being flooded to significant depths (>1.6 m) in the event of a breach in the defences coinciding with the 0.5% AEP climate change flood event. Although the impact to the VPI Site in the event of a breach is high, the probability of a breach occurring is considered to be low.

If a flood event was to occur with sufficient warning, i.e. via the Environment Agency Flood Warning Service, it is possible for a full evacuation of the VPI Site to take place in line with a Flood Response Plan that will be provided for the VPI Site (likely to be via an amendment to the existing Emergency Plan for the wider CHP Plant which encompasses flood events).

Any 'no notice' flooding events (events not notified by the Environment Agency Flood Warning service) following breaches in defences or surface water flooding will require a safe refuge above 6.3 m AOD such that all site users can take immediate action to keep themselves safe without relying on intervention from outside.

7.5 Surface Water Management

7.5.1 Proposed Phillips 66 Development

A new, separate foul and surface water drainage system will be constructed for the Phillips 66 Site. Further details on the design of the drainage system, including attenuation, discharge to South Killingholme Drain and accounting for climate change is provided in Appendix 9C (ES Volume II).

7.5.2 Proposed VPI Development

A new, separate foul and surface water drainage system will be constructed for the VPI Site. Further details on the design of the drainage system, including attenuation, restricted discharge to South Killingholme Drain and accounting for climate change is provided in the VPI Drainage Strategy presented in Appendix 9C (ES Volume II).

7.6 Watercourse Diversion (Proposed VPI Development)

South Killingholme Drain passes across the VPI Site. The Drain is to be diverted to the south of the proposed VPI PCC plant. The diversion construction will follow best practice guidance, including:

- excavation of the diversion channel in a dry, isolated working environment, retaining 'plugs' at the upstream and downstream end until it is completed;
- removal the downstream plug first and then the upstream plug to prevent flow 'washing' through the new channel;
- maintaining the existing channel through diversion construction, to prevent temporary changes to flood risk;
- only allowing water to flow through the channel once all material/equipment has been removed, and the diversion channel has been created and permanently stabilised through vegetation or other sediment stabilisation methods, to prevent mobilisation of silt and sediment;
- stockpiling of material excavated during formation of the diversion channel away from the channel edges (minimum 20 m) or protect stockpiles, to prevent sediment run-off during rainfall or high flows; and
- maintaining existing channel capacity through the diversion channel to prevent increased flood risk upstream or downstream.

8. Conclusions

AECOM has prepared this FRA on behalf of Phillips 66 and VPI Immingham in accordance with the NPPF and associated PPG, to support a planning application for the Proposed Developments.

8.1 Proposed Phillips 66 Development

The conclusions regarding flood risk to and from the Proposed Phillips 66 Development are summarised below.

- The Proposed Phillips 66 Development comprises a PCC plant and associated facilities for the FCC at the Humber Refinery.
- The main Phillips 66 PCC plant and majority of the CO_2 pipeline are located in Flood Zone 1. The CO_2 pipeline to the north-east of the Network Rail railway line is located in Flood Zone 3 and infringes upon Flood Zone 2.
- A review of the NPPF and local planning policies suggests that the Proposed Phillips 66 Development is considered as 'Essential Infrastructure'. In accordance with Table 3 of the PPG 'Essential Infrastructure' is permitted in Flood Zones 1, 2 and 3, however the exception test is required. The Proposed Phillips 66 Development will contribute towards the Local Plan aim to reduce North Lincolnshire's carbon footprint and the UK target to reduce carbon emissions by 100% by 2050. As such the development satisfies the requirements of the Exception Test.
- Flood risk to the Proposed Phillips 66 Development from tidal sources and Ordinary watercourses is low and considered to be a residual risk. As such, mitigation measures are recommended including flood resilience and resistance measures and an Emergency Response Plan.
- The Proposed Phillips 66 Development is not considered to be at risk of flooding from main rivers, canals or reservoirs.
- The flood risk to the Proposed Phillips 66 Development from surface water is considered to be low.
- The flood risk to the Proposed Phillips 66 Development from groundwater is considered to be medium given the bedrock and aquifers beneath the Phillips 66 Site that indicated high permeability. Any below ground infrastructure must be designed to withstand hydrostatic pressures and built with flood resilient materials.
- The impact of the Proposed Phillips 66 Development on flood risk from all sources of flooding i.e. from Main Rivers, Ordinary Watercourses, surface water, groundwater, canals, reservoirs, sewer and water supply infrastructure are considered to be low over the lifetime of the Proposed Phillips 66 Development.
- The Proposed Phillips 66 Development will slightly increase the area of impermeable surfaces at the Phillips 66 Site. As such, the Proposed Phillips 66 Development will include a new separate foul and surface surface water drainage system which will tie into the existing treatment systems on the Humber Refinery site.. Attenuation storage will be provided within the new pipelines and the existing No.1 and No.2 Holding Ponds with exceedance flows stored onsite to the southeast of the wider Phillips 66 Site, as the current scenario Surface water will be discharged to the South Killingholme Drain at the current permitted discharge rate.

The FRA has demonstrated that it will be possible to manage flood risks to and from the Proposed Phillips 66 Development in compliance with the NPPF and accompanying Planning Practice Guidance.

8.2 Proposed VPI Development

The conclusions regarding flood risk to and from the Proposed VPI Development are summarised below.

- The Proposed VPI Development comprises a PCC plant and associated facilities for the VPI Immingham CHP Plant.
- The entire VPI Site is located in Flood Zone 3.
- A review of the NPPF and local planning policies suggests that the Proposed VPI Development is considered as 'Essential Infrastructure'. In accordance with Table 3 of the PPG 'Essential Infrastructure' is permitted in Flood Zone 3, however the exception test is required. The Proposed VPI Development will contribute towards the Local Plan aim to reduce North Lincolnshire's carbon footprint and the UK target to reduce carbon emissions by at least 100% by 2050. As such the Proposed VPI Development satisfies the requirements of the Exception Test.

- Flood risk to the Proposed VPI Development from tidal sources and Ordinary watercourses is low and considered to be a residual risk. As such, mitigation measures are recommended including flood resilience and resistance measures, an Emergency Response Plan and provision of safe refuge above 6.3 m AOD.
- The South Killingholme Drain will be diverted from its current location across the VPI Site to the southern site boundary. The diversion channel design provides a slight increase in both the length and capacity of the watercourse above the existing scenario.
- The Proposed VPI Development is not considered to be at risk of flooding from main rivers, canals or reservoirs.
- The flood risk to the Proposed VPI Development from surface water is considered to be low.
- The flood risk to the Proposed VPI Development from groundwater is considered to be medium given the bedrock and aquifers beneath the VPI Site that indicated high permeability. Any below ground infrastructure must be designed to withstand hydrostatic pressures and built with flood resilient materials.
- The impact of the Proposed VPI Development on flood risk from all sources of flooding i.e. from Main Rivers, Ordinary watercourses, surface water, groundwater, canals, reservoirs, sewer and water supply infrastructure are considered to be low over the lifetime of the Proposed VPI Development.
- The Proposed VPI Development will increase the area of impermeable surfaces at the VPI Site. As such, the Proposed VPI Development will include a surface water drainage system which will be capable of attenuating all runoff from the Proposed VPI Development up to and including the 1% AEP plus 25% climate change event. In addition, surface water will be discharged to South Killingholme Drain at a restricted greenfield rate.

The FRA has demonstrated that it will be possible to manage flood risks to and from the Proposed VPI Development in compliance with the NPPF and accompanying Planning Practice Guidance.