VikingCCS

Viking CCS Pipeline

Environmental Statement Volume II - Chapter 19: Major Accidents and Disasters

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19 Major Accidents and Disasters

19.1 Introduction

19.1.1 This chapter of the Environmental Statement (ES) presents an assessment of the Major Accidents and Disasters that have the potential to arise during the construction, operation and decommissioning of the Viking CCS Pipeline (hereafter referred to as 'the Proposed Development').

19.1.2 This includes an assessment of the reasonably foreseeable worst-case environmental consequences, the measures envisaged to prevent or mitigate the significant adverse effects of such events on the environment, and details of the preparedness for and proposed response to the hazards and threats relevant to the construction, operation and decommissioning of the Proposed Development.

19.1.3 In the context of Environmental Impact Assessment (EIA) for major accidents and disasters, the following definitions have been applied (Ref 19-17):

- A **major accident** is an event (for instance, a major road traffic accident) that threatens immediate or delayed serious effects to human health, welfare and/or the environment and may require the use of resources beyond those of the Applicant or its appointed representatives (i.e., contractors) to manage; and
- A **disaster** is an external hazard that can be man-made (such as an act of terrorism) or natural (such as an earthquake) with the potential to cause an event or situation that meets the definition of a major accident.

19.1.4 In summary, this chapter seeks to:

- Identify the major accidents and disasters topics and events considered in the environmental assessment;
- Define the approach and methodology for identifying potential major accidents and disaster events and their assessment, in the context of the Proposed Development;
- Assess the reasonably foreseeable worst-case environmental consequences;
- Outline the precautionary measures envisaged to prevent or mitigate such events on the environment; and
- Detail the preparedness for and proposed response to major accidents and disasters relevant to the Proposed Development.

19.1.5 This Chapter is accompanied by the following documents located within *ES Volume IV: (Application Document 6.4)*:

- Appendix 19.1: Major Accidents and Disasters Long List;
- Appendix 19.2: UXO Desk Based Assessment; and
- Appendix 19.3: Draft Emergency Response Principles.

19.2 Legislation, Policy and Guidance

19.2.1 Schedule 4 paragraph 8, of The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (Ref 19-1) requires an ES to provide: "*A description of the expected significant adverse effects of the development on the environment deriving from the vulnerability of the development to risks of major accidents and/or disasters which are*

relevant to the project concerned… Where appropriate, this description should include measures envisaged to prevent or mitigate the significant adverse effects of such events on the environment and details of the preparedness for and proposed response to such emergencies".

19.2.2 A list of additional national legislation, policy and guidance relevant to the major accidents and disasters assessment is provided below. It should be noted that there are no specific requirements within the extant or draft National Policy Statements, National Planning Policy Framework (NPPF) or Planning Performance Guidance (PPG) relating specifically to major accidents or disasters.

Legislation

- Health and Safety at Work etc. Act 1974 (Ref 19-2);
- Construction (Design and Management) Regulations 2015 (CDM) (Ref 19-3);
- Control of Major Accident Hazards Regulations 2015 (COMAH) (Ref 19-4);
- The Planning (Hazardous Substances) Regulations 2015 (Ref 19-5);
- The Supply of Machinery (Safety) Regulations 2008 (Ref 19-6);
- The Dangerous Substances and Explosive Atmospheres Regulations 2002 (Ref 19-7);
- The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016 (Ref 19-8);
- The Pipelines Safety Regulations 1996 (Ref 19-9); and
- The Control of Substances Hazardous to Health Regulations 2002 (Ref 19-10).

Policy

- Overarching National Policy Statement for Energy (EN-1) (Ref 19-11);
- Revised (Draft) National Policy Statement for Energy (EN-1) (Ref 19-12);
- National Policy Statement for Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4) (Ref 19-13);
- Revised (Draft) National Policy Statement for Gas Supply Infrastructure and Gas and Oil Pipelines (EN-4) (Ref 19-14);
- National Planning Policy Framework (Ref 19-15); and
- Associated Planning Practice Guidance (Ref 19-16).

Guidance

19.2.3 There is no published guidance for the application of the legal requirements to assess major accidents and disasters, but there are published guideline documents relating to major accidents and disasters and risk assessments which have been considered in this chapter. In 2020, the Institute of Environmental Management and Assessment (IEMA) released guidance document '*Major Accidents and Disasters in EIA: A Primer*' (Ref 19-17) to increase awareness of major accidents and disasters in EIA and its application, outlining a methodology and key terminology. There is also other relevant guidance and information available on the identification and control of major hazards including:

- Guidelines for Environmental Risk Assessment and Management (Ref 19-18);
- Guideline – Environmental Risk Tolerability for COMAH Establishments (Ref 19-19);
- ISO 31000: 2018 Risk Management – Guidelines (Ref 19-20);

- A guide to the Control of Major Accident Hazards Regulations (COMAH) (Ref 19-21); and
- Further Guidance on Emergency Plans for Major Accident Hazard Pipelines (Ref 19-22); and
- A Guide to the Pipelines Safety Regulations 1996 (HSE) (Ref 19-23).

19.2.4 The following data sources have also been reviewed to identify potential major accidents and disasters:

- Guideline – Environmental Risk Tolerability for COMAH Establishments (Ref 19-19);
- The National Cabinet Office's Emergency Preparedness guidance on part 1 of the Civil Contingencies Act 2004 (hereafter referred to as the 'CCA risk assessment framework') (Ref 19-24);
- The International Federation of Red Cross & Red Crescent Societies Early Warning, Early Action (Ref 19-25);
- The International Disaster Database (Ref 19-26); and
- Reducing Risks, Protecting People: HSE's decision making process, (HSE, 1999) (Ref 19-27).

19.2.5 Guidance and best practice information for carbon capture technology and transport via pipeline is available from the Health and Safety Executive (HSE), which has published a number of documents, which are available on a dedicated page available on its website. The guidance includes the following:

- Guidance on conveying carbon dioxide in pipelines in connection with carbon capture and storage projects (Ref 19-28); and
- CO_2 Pipelines Good Practice Guidelines – Technical Report (Ref 19-29).

19.2.6 Carbon Dioxide (CO_2) is not defined as a dangerous fluid under Pipeline Safety Regulations and, as such, CO_2 pipelines are not classified as Major Accident Hazard Pipelines (MAHPs). Consequently, developments around CO_2 pipelines are not currently subject to formal consultation from the HSE nor subject to the HSE's Land Use Planning (LUP) advice.

19.2.7 However, the Applicant has followed the principle of the Regulations to ensure that safety is of paramount importance and that risks are identified and mitigated during the design and pre-construction stages. This is a key preventative measure which serves to help minimise the risk of a major accident (and subsequent related adverse environmental effects) occurring during the construction, operation, and decommissioning phases of the Proposed Development.

19.2.8 As outlined in *ES Volume II Chapter 3: Description of the Proposed Development (Application Document 6.2.3)*, to ensure a robust assessment, pipeline routing has been determined in accordance with PD 8010 Part 1. Further information is included in Section 19.6. It is recognised that the HSE's LUP methodology only applies to future planning applications once the pipeline has been constructed and notified to the HSE (as one containing dangerous fluids under PSR). However, the LUP methodology for developing risk zones has been taken into consideration during the pipeline routeing development. The Applicant has consulted with HSE through the design process and will continue to consult with HSE throughout the planning process, even where there is no formal requirement to do so.

19.3 Scoping Opinion, Consultation and Feedback on PEIR

Response to Scoping

19.3.1 A scoping exercise was undertaken in early 2022 to establish the content of the major accidents and disasters assessment and the approach and methods to be followed.

19.3.2 The Scoping Report recorded the findings of the scoping exercise and detailed the technical guidance, standards, best practice and criteria to be applied in the assessment to identify and evaluate the risk of major accidents and disasters.

19.3.3 Following receipt of the Scoping Opinion, a copy of which is included within *ES Volume IV: Appendix 5.2 (Application Document 6.4.5.2),* the following items were confirmed by the Planning Inspectorate to be scoped out of the major accidents and disasters assessment:

- Earthquakes, volcanic activity; tsunamis; pluvial flooding; groundwater flooding; avalanches; cyclones/ hurricanes/ typhoons/ storms/ gales; thunderstorms; extreme temperatures; droughts; severe space weather; fog; wildfires; poor air quality; public demonstrations; widespread damage to societies and economies; and the need for largescale humanitarian assistance.

19.3.4 Decommissioning of the Proposed Development is not specifically included as the hazards are anticipated to be encompassed by those assessed for the construction and operation phase, and no additional decommissioning hazards have been identified.

19.3.5 In addition to the items that were originally scoped into the assessment within the Scoping Report, Avian flu was requested by the Environment Agency to be added for further assessment. A summary of the elements scoped in and out is presented in **Table 19-4**, with the full Long List of all topics originally considered presented in *ES Volume IV: Appendix 19.1 (Application Document 6.4.19.1)*.

19.3.6 Following receipt of the Scoping Opinion (*ES Volume IV: Appendix 5.2 (Application Document 6.4.5.2)*), the following requirements shown in **Table 19-1** have been identified by the Planning Inspectorate.

Table 19-1: Major Accidents and Disasters Scoping Opinion

Section Reference to Scoping Opinion	Applicant's proposed matter	Planning Inspectorate / Prescribed Consultee comments	Response
Planning Inspectorate 3.15.1 Table 20-3	Landslides	The Inspectorate notes that Table 20-3 has the options for 'scoped in' and 'scoped out' both ticked. Referring to Appendix H, it is assumed for the purposes of this Opinion that landslides are to be scoped in.	This is noted. Landslides has been scoped in to the major accidents and disasters assessment, refer to Table 19-4 and *ES Volume IV: Appendix 19.1 (Application Document 6.4.19.1).*
Planning Inspectorate 3.15.2 Table 20-3	Other matters proposed to be scoped out: Earthquakes, volcanic activity;	Given the information provided the Inspectorate is in agreement that these matters can be scoped out	Comments noted. No response required.

Section Reference to Scoping Opinion	Applicant's proposed matter	Planning Inspectorate / Prescribed Consultee comments	Response
	tsunamis; pluvial flooding; groundwater flooding; avalanches; cyclones/ hurricanes/ typhoons/ storms/ gales; thunderstorms; extreme temperatures; droughts; severe space weather; fog; wildfires; poor air quality; public demonstrations; widespread damage to societies and economies; the need for largescale humanitarian assistance.	of the ES as significant effects are unlikely.	
Planning Inspectorate 3.15.3 Paragraph 20.2.22	Survey Data	The Scoping Report indicates that the baseline will be established utilising existing datasets from other aspect chapters, rather than specific surveys, however Chapter 2 Section 2.14.1 refers to a fracture assessment, integrity assessment, and CO_2 corrosion assessment.	These assessments were undertaken to determine the suitability of the existing LOGGS pipeline for continued use as part of the Proposed Development and wider Viking CCS Project.
		The Inspectorate considers that all available baseline data including surveys (where relevant to the Proposed Development) should be used to inform the assessment of major accidents and disasters.	All relevant baseline data has been used to inform the assessment of major accidents and disasters.

Section Reference to Scoping Opinion	Applicant's proposed matter	Planning Inspectorate / Prescribed Consultee comments	Response
Environment Agency	Major Accidents and Disasters	We note the various elements and events that Table 20.3. scopes in or out. We note that animal diseases are currently scoped out, but we would mention that there are a large number of poultry houses along the pipeline route and further consideration should be given as to whether or not Avian Flu is an issue that should be scoped in?	Based on recent events, animal diseases have been scoped in (see Table 19-4) and Avian Flu has been assessed, refer to *ES Volume IV: Appendix 19.1 (Application Document 6.4.19.1).*
Lincolnshire County Council	Section 20 -Major accidents and disasters	Methodology proposed is sound as are those events to be scoped in or out. However, Table 20.3 shows landslides to be scoped in and out so clarification on this point is required.	This is noted. Landslides has been scoped in to the major accidents and disasters assessment, refer to Table 19-4 and *ES Volume IV: Appendix 19.1 (Application Document 6.4.19.1).*

Feedback on the Preliminary Environmental Information Report

19.3.7 A summary of the feedback received on the Preliminary Environmental Information Report (PEIR) specific to the major accidents and disasters assessment has been provided in **Table 19-2**.

Table 19-2: Feedback on the PEIR

Stakeholder	Stakeholder comment	Response
North Lincolnshire Council	Having considered Chapter 20 of the PEIR, NLC do not have any objections to the approach set out in the PEIR at this stage.	Noted.
Environment Agency	It is considered that the mitigation proposed to protect groundwater from major accidents and disasters is appropriate.	Noted.

Additional Consultation

19.3.8 No further consultation has been undertaken to inform the assessment of the vulnerability of the Proposed Development to the risk of major accidents and disasters.

19.3.9 Safety was raised by a number of interested parties during the Statutory Consultation which was held between November 2022 and January 2023. Specific responses to the issues

raised is provided in the Consultation Report (*Application Document 5.1*) which has been submitted in support of this DCO.

19.3.10 Safety is the key priority for the Proposed Development throughout the construction, operation, maintenance and decommissioning of the pipeline. The Applicant operates responsibly, securely and in accordance with applicable regulation across all their activities and the pipeline will meet (and in some cases exceed) all current UK safety and operational regulations. The Applicant always works to reduce risks and protect their staff, contractors and the communities within which their activities have the potential to cause impact through the rigorous application of safe operating practices.

19.3.11 The Applicant will ensure that the pipeline is designed, constructed and operated in accordance with the Pipeline Safety Regulations 1996 and best design practice standards. Further information on safety is also included within Section 3.5 of *ES Volume II Chapter 3: Description of the Proposed Development (Application Document 6.2.3)*.

19.4 Assessment Method

General Approach

19.4.1 The major accidents and disasters assessment method differs from that described in *ES Volume II Chapter 5: EIA Methodology (Application Document 6.2.5)* as it identifies the reasonably foreseeable, worst-case consequence of a hazard on human health and the environment and bases it on the potential severity of harm and duration. By definition, all major accidents and disasters could result in some form of damage, the assessment therefore considers the likelihood, or risk, of the event occurring and a key focus is on the prevention of any incidents happening in the first place.

19.4.2 This assessment of major accidents and disasters has been conducted using a staged approach as outlined here:

- Initial identification of a long list of potential elements and events which may give rise to major accidents or disasters;
- Identifying potential risk events (including source / pathways and receptors) related to each event type allowing them to be either scoped into the assessment or scoped out;
- Defining the reasonable worst-case consequence if the event did occur;
- Identifying any possible prevention, minimisation and / or mitigation measures;
- Assessing the likelihood; and then
- Determining whether the risk has been mitigated to ‘as low as reasonably practicable’ (ALARP) and identification of any residual risks and their significance.

19.4.3 Likelihood is qualitatively defined in **Table 19-3**.

Table 19-3: Likelihood Definitions

Probability	Very Low	Low	Medium	High	Very high
Qualitative definition	Should virtually never occur but is theoretically possible	Very unlikely to occur	Unlikely to occur during the total operational life of the system, or the construction period	May occur once during total operational life of the system, or the construction period	May occur several times during operational life, or the construction period

19.4.5 This assessment of major accidents and disasters also considers the vulnerability of the Proposed Development to natural disasters using the findings of the climate change chapter *(ES Volume II Chapter 15: Climate Change (Application Document 6.2.15))* and the *Flood Risk Assessment (ES Volume IV: Appendix 11.5 (Application Document 6.4.11.5))*.

19.4.6 As is stated in HSE Guidance on Conveying Carbon Dioxide in Pipelines (Ref 19-28) in connection with carbon capture and storage projects, *"operators of CO_2 pipelines can demonstrate compliance with Pipeline safety regulations by making sure that the risks from their pipelines are reduced as low as is reasonably practicable (ALARP). In particular, the application of good practice at the design stage is an essential part of this demonstration. However, to support their ALARP justifications, and until detailed standards become available, operators of CO_2 pipelines should use sound engineering and empirical evidence to support un-validated or partially validated probabilistic modelling".*

19.4.7 The incidents considered in the assessment are rare events. All low consequence events, whatever their likelihood, do not meet the definition of a major accident or disaster, as defined in IEMA's Major Accidents in EIA: A Primer (Ref 19-17). For example, minor spills which may occur during construction, but will be limited in area and volume, and temporary in nature, do not meet the definition of a major accident. Such minor events will be assessed within the technical assessments (where applicable) included in chapters 6 to 19 of this ES.

19.4.8 The consequence of a hazard or threat is determined on the basis of a reasonably foreseeable worst-case environmental effect of the event in the absence of mitigation. However, the probability and magnitude of the hazard or threat occurring is also determined whilst considering the proposed mitigation and whether the proposed embedded mitigation measures need augmenting further. This is because mitigation would reduce the likelihood of the maximum severity of harm, duration, consequence, and the frequency of a hazard or threat occurring.

19.4.9 The tolerability of the residual risk is determined by combining the reasonably foreseeable worst-case consequence and probability categories (with engineering design solutions sought to reduce risks and probabilities). All residual risks are categorised as 'tolerable', 'tolerable if ALARP' (as low as reasonably practicable) or 'intolerable'. As a general rule, 'tolerable' and 'tolerable if ALARP' risks are considered as 'not significant' and intolerable risks are considered as 'significant'.

19.4.10 A risk would be determined as 'tolerable' if it had been reduced to an acceptable level, whether this be pre or post mitigation. Similarly, a risk would be determined as 'tolerable if ALARP' if the mitigation measure identified for any particular impact ensured that the risk was lowered to as low as reasonably practicable, in line with industry guidance and guidelines. Any impacts determined to be 'intolerable' would be considered significant and additional measures would need to be considered.

19.4.11 The concept of "*reasonably practicable*" lies at the heart of the British health and safety system. It is a key part of the general duties of the Health and Safety at Work etc. Act 1974 and many sets of health and safety regulations that we and Local Authorities enforce. In most situations, deciding whether the risks are ALARP involves a comparison between the control measures a duty-holder has in place or is proposing and the measures we would normally expect to see in such circumstances i.e., relevant good practice. "Good practice" is defined in the general ALARP guidance as "*those standards for controlling risk that HSE has judged and recognised as satisfying the law, when applied to a particular relevant case, in an appropriate manner*" (Ref 19-42).

Scope of Assessment

19.4.12 This assessment covers the construction phase, including ground enabling work and the operational phase of the Proposed Development. A summary of the elements scoped in and out is presented in **Table 19-4**, with the full Long List of all topics originally considered presented in *ES Volume IV: Appendix 19.1 (Application Document 6.4.19.1)*.

Table 19-4: Summary of Elements Scoped In and Out of Major Accidents and Disasters Assessment

Element and Event	Scoped In	Scoped Out
Natural Hazards - Geophysical		
Earthquakes		✓
Volcanic Activity		✓
Landslides	✓	
Sinkholes	✓	
Tsunamis		✓
Natural Hazards - Hydrology		
Tidal Flooding	✓	
Fluvial Flooding	✓	
Pluvial Flooding		✓
Groundwater Flooding		✓
Avalanches		✓
Natural Hazards - Climatological and Meteorological		
Cyclones, hurricanes, typhoons, storms and gales		✓
Thunderstorms		✓
Wave surges	✓	
Extreme temperatures: Heatwaves Low (sub-zero) temperatures and heavy snow		✓
Droughts		✓
Severe Space Weather: Solar Flares		✓
Severe Space Weather: Solar Energetic Particles		✓

Element and Event	Scoped In	Scoped Out
Severe Space Weather: Coronal Mass Ejections (CMEs)		✓
Fog		✓
Wildfires: Forest fire, Bush/brush, pasture		✓
Poor Air Quality		✓
Natural Hazards - Biological		
Disease epidemics		✓
Animal diseases	✓	
Plants		✓
Technological or Manmade Hazards – Societal		
Extensive public demonstrations		✓
Widespread damage to societies and economies		✓
The need for largescale multi-faceted humanitarian assistance		✓
The hindrance or prevention of humanitarian assistance by political and military constraints		✓
Significant security risks for humanitarian relief workers in some areas		✓
Famine		✓
Displaced population		✓
Technological or Manmade Hazards - Industrial and Urban Accidents		
Major Accident Hazard Chemical sites	✓	
Major Accident Hazard Pipelines	✓	
Nuclear		✓
Fuel storage		✓
Dam breaches		✓
Mines and storage caverns		✓
Fires	✓	
Technological or Manmade Hazards - Transport accidents		
Road		✓
Rail		✓
Waterways		✓
Aviation		✓
Technological or Manmade Hazards – Pollution accidents		

Element and Event	Scoped In	Scoped Out
Air	✓	
Land		✓
Water		✓
Technological or Manmade Hazards - Utilities failures		
Electricity		✓
Gas		✓
Water Supply		✓
Sewage system		✓
Technological or Manmade Hazards - Malicious Attacks		
Unexploded Ordnance	✓	
Chemical / Biological /Radiological / Nuclear		✓
Transport systems		✓
Crowded places		✓
Technological or Manmade Hazards - Engineering accidents and failures		
Cyber	✓	
Infrastructure		✓
Bridge failure		✓
Flood defence failure	✓	
Mast and tower collapse		✓
Property or bridge demolition accidents		✓
Tunnel failure/fire		✓

19.4.13 Decommissioning of the Proposed Development is not specifically included as the hazards are anticipated to be encompassed by those assessed for the construction and operation phase, and no additional decommissioning hazards have been identified. The current Decommissioning Strategy *(ES Volume IV: Appendix 3.5 (Application Document 6.4.3.5)* states that when the CO_2 pipeline reaches the end of its useful life it will be decommissioned and then left in situ, in accordance with best industrial practice. The associated above ground infrastructure (AGI) is anticipated to be dismantled.

19.4.14 Decommissioning will be in accordance with the Environmental Protection Act 1990 (Ref 19-30), Construction Design and Management Regulations 2015 (Ref 19-3), the Health and Safety at Work etc. Act 1974 (Ref 19-2) and the Management of Health and Safety at Work Regulations 1999 (Ref 19-31) (or subsequent replacement legislation). Details of the decommissioning will be included in the management plans which will be required under the aforementioned legislation to make the risk of a major accident and disaster event as low as reasonably practicable (ALARP).

19.4.15 The Short List of potential major accident and disaster events is detailed in **Table 19-4**. The Long List is provided in *ES Volume IV: Appendix 19.1 (Application Document 6.4.19.1)*.

Assumptions and Limitations

19.4.16 A list of the key assumptions and limitations of this assessment include:

- The assessment is based on information which is publicly available at the time of writing, and on the current design of the Proposed Development, as presented in *ES Volume II Chapter 3: Description of the Proposed Development (Application Document 6.2.3).* If deemed necessary, this will be further refined and re-appraised during the detailed engineering and design phase;
- The design of the Proposed Development is guided by numerous industry standards and codes, many of which are mandatory (as listed in Section 19.2);
- Environmental effects associated with small scale unplanned events that do not meet the definition of a major accident and/or disaster e.g., minor leaks and spills that may be contained within the construction sites are addressed in other relevant ES Chapters;
- In accordance with good safety management measures, it is assumed that all potential risks which have the potential to lead to major accidents and/or disasters and which could impact any environmental or social receptors, will be managed using the ALARP principle; and
- The Construction Stage(s) of the Proposed Development will be managed through the implementation of the Construction Stage Plan (required under the CDM Regulations 2015 (Ref 19-3) and a detailed CEMP will be developed by the construction contractor in line with the Draft Construction Environmental Management Plan that is included within *ES Volume IV: Appendix 3.1 (Application Document 6.4.3.1)*.

19.5 Baseline Environment and Study Area

Establishing the Baseline

19.5.1 The baseline relevant to major accidents and disasters primarily comprises:

- Features external to the Proposed Development that contribute a potential source of hazard to the Proposed Development itself;
- Sensitive environmental receptors at risk of a significant effect; and
- Identified major accident and disaster risks which currently exist within the local area.

19.5.2 The baseline conditions described for major accidents and disaster events are derived from the following desk study sources:

- Technical chapters of this *ES Volume II Chapters 6 to 18 (Application Document 6.2);*
- National Risk Register 2020 (Ref 19-32);
- British Geological Survey ‘Onshore GeoIndex’ (Ref 19-33);
- The Coal Authority Interactive Map (Ref 19-34);
- Health and Safety Executive’s Planning Advice Web App (Ref 19-35);
- COMAH 2015 Public Information Search (Ref 19-36);
- Aerial photography; and
- Google street view maps covering the DCO Site Boundary.

The Study Area

19.5.3 The Study Area for major accidents and disasters has been developed based on professional judgement as there is no regulatory guidance or standardised methodology.

The distances identified for the different features outlined below were identified based on a combination of a review of the Study Areas boundaries set within each of the individual technical chapters of this ES, along with an appraisal of the types of features considered within this major accidents and disasters assessment.

19.5.4 The following factors and associated distances were taken into consideration for setting the Study Area, in order to capture the adverse consequences caused by other events, on the Proposed Development and relate to distances from the DCO Site Boundary within which the pipeline route will be located:

- *Manmade features*:
    - Airports and airfields within 10 kilometres (km), including Humberside Airport and Strubby Airfield;
    - Petrol stations within 1 km, of which there are eight;
    - Rail infrastructure within 1 km including railway lines between Ulceby and Immingham; Grimsby and Habrough; and the Lincolnshire Wolds Railway;
    - Utilities and pipelines (gas, electrical, water, telecommunication, oil/fuels) crossing the DCO Site Boundary, which include 71 different utility and pipeline crossings; and
    - Onsite unexploded ordnance (UXO) as identified within the initial desk based risk assessment (see *ES Volume IV: Appendix 19.2 (Application Document 6.4.19.2)*).
- *Natural features* with the potential to create risks include:
    - Hydrological and geological features such as dam failure and seismic activity within 5 km and hydrological and geological feature such as flood risk and unstable ground conditions within 1 km. Information provided in *ES Volume II Chapter 9: Geology and Hydrogeology (Application Document 6.2.9)* identifies that the geology underlying the Study Area is of no risk or very low risk of seismic hazards. There are also low risks associated with ground stability, such as landslides, ground collapse, ground compression, sinkholes, running sand and shrinking or swelling of clay; and
    - Information provided in *ES Volume II Chapter 11: Water Environment (Application Document 6.2.11)* identifies that whilst the majority of the DCO Site Boundary lies outside of a flood risk zone, a portion within the north, and a larger section within the south do lie within Flood Zones 2 and/or 3 as well as a few other isolated areas in the immediate vicinity of watercourses.
- *Existing Major Accident Hazards* – including COMAH sites within 5km, and major accident hazard pipelines within 1km (including gas and condensate pipelines). As detailed on the HSE COMAH Public Information (Ref 19-37), there are a minimum of 13 such developments, which include:
    - Humber LPG Terminal (Phillips 66 Limited);
    - Humber Refinery (Phillips 66 Limited);
    - Lindsey Oil Refinery (Prax Lindsey Oil Refinery Limited);
    - Immingham Dock, Alexandra Road North (Associated British Ports);
    - Immingham Dock (Origin UK Operation Limited);
    - Immingham Docks (Associated British Ports);
    - Immingham East Terminal (Exolum Immingham Limited);

- Immingham Pipeline Centre (Phillips 66 Limited);
- Immingham Propylene Storage (Phillips 66 Limited);
- Immingham West Terminal (Exolum Immingham Limited);
- Killingholme PSD (Exolum Immingham Limited);
- VPI Immingham Rosper Road (VPI Immingham LLP); and
- Shed 2/3 Immingham Dock (Associated British Ports).

Sensitive Receptors

19.5.5 Receptors are features of the environment that may be affected and thus are subject to assessment under Section 5(2) of the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (Ref 19-1), namely biodiversity, land, soil, water, air and climate, material assets, cultural heritage and landscape. Key receptors also include human populations.

19.5.6 These have been identified through a review of base mapping and aerial photography as well as consultation with the other EIA topics (as presented in *ES Volume II: Chapters 6-18*). **Table 19-5** identifies the key major event receptors within the Study Area.

Table 19-5: Identified Key Receptors for Major Events

Major Event Receptor	Type	Description
Local Residents and General Public; Local Businesses	Human health; Property and Land.	The DCO Site Boundary passes by a number of villages and communities, including South Killingholme, Immingham, Stallingborough, Keelby, Healing, Aylesby, Laceby, Irby upon Humber, Barnoldby le Beck, Brigsley, Ashby cum Fenby, Grainsby, North Thoresby, Ludborough, Covenham St Bartholomew, Covenham St Mary, Utterby, Yarburgh, Fotherby, Little Grimsby, Alvingham, South Cockerington, North Cockerington; Grimoldby, Theddlethorpe All Saints, Theddlethorpe St Helen and Mablethorpe, as well as a number of individual/isolated residential properties.
Construction Workers; Operational Workers	Human Health	Construction workers on site during the construction phase of the Proposed Development. Operational Workers during the operational phase of the Proposed Development.
Railways	Land	Two cross the DCO Site Boundary
Main rivers, ordinary watercourses, canals	Water Environment	A number cross the DCO Site Boundary. In total, there are 142 water crossings.
Lincolnshire Wolds Area of Outstanding Natural Beauty (AONB)	Landscape	An area of outstanding natural beauty (AONB) is land protected by the Countryside and Rights of Way Act 2000 (CROW Act).

Major Event Receptor	Type	Description
Emissions to Atmosphere	Local Air Quality	Emissions to atmosphere as a result of an event
Designated Sites	Ecology and Biodiversity	There are five European designated sites within 10 km of the DCO Site Boundary, and 14 nationally designated sites within 10 km of the DCO Site Boundary.
Protected Species	Ecology and Biodiversity	Ecological surveys undertaken show there are protected species within the DCO Site Boundary.
Heritage assets and archaeology	Cultural Heritage	There are designated and non-designated heritage assets within the DCO Site Boundary and the 1 km Study Area for this topic.

19.5.7 In addition to external receptors that could be affected by the Proposed Development, the Proposed Development itself is a potential receptor, in that it could be impacted by major accidents or disasters.

Future Baseline

19.5.8 A key source of future CO_2 into the Proposed Development, is anticipated to come from the potential carbon capture facilities which make up Humber Zero at VPI Immingham site and P66 site. Consequently, due to the location of these facilities near the Immingham Facility, they have been considered, where appropriate in the assessment. The general industrial nature of Immingham and South Killingholme is expected to continue to be the situation into the future. Elsewhere along the route of the pipeline the general agriculture nature of the environmental is expected to be maintained into the future. At Theddlethorpe, although the former TGT has been demolished, there remains a possibility that other industrial type project will be constructed. The potential for cumulative impacts to occur as a result of other schemes which may occur in the future has been addressed within *ES Volume II Chapter 20: Cumulative Effects Assessment (Application Documents 6.4.20).*

19.6 Development Design and Impact Avoidance

CO_2 Pipelines

19.6.1 CO_2 is not flammable and will not support combustion. Consequently, compared with many other materials conveyed via major pipelines in the UK, such as natural gas and ethylene, the risks to human health and the environment from events such as explosion are relatively low. However, as the concentration of CO_2 in ambient air or water rises, the hazardous effects on people and the environment increase. The key risks to people relate to its potential to act as a toxic material by inhalation at concentrations in excess of 5%v/v and as an asphyxiant at concentrations in excess of 50%v/v where it displaces oxygen in air to dangerously low levels. High levels of dissolved CO_2 in water can also result in impacts from acidification and subsequent effects on shell-forming species.

Design

19.6.2 As stated in section 19.4.5, HSE guidance on Conveying Carbon Dioxide in Pipelines (Ref 19-28) in connection with carbon capture and storage projects, the application of good practice at the design stage is an essential part of any ALARP demonstration. The Proposed Development will be designed, constructed, operated and maintained in line with the

Pipeline Safety Regulations (1996) (Ref 19-9), PD8010 Code of Practice for pipelines – part 1 steel pipelines on land (Ref 19-38) and with current best practise standards.

19.6.3 PD8010 is published by the British Standards Institute, which is the recognised UK National standards body. PD8010 provides recommendations for the design, selection, specification and use of materials, routeing, construction, installation, testing, operation, maintenance and abandonment of land pipeline systems constructed from steel, including carbon dioxide pipelines.

19.6.4 *ES Volume II: Chapter 2 Design Evolution and Alternatives* outlines some of the key design decisions that were made as the Proposed Development evolved, many which were focussed on impact avoidance measures. Particular examples included the drive to avoid more densely populated areas as well as routeing to avoid sensitive ecological and statutory designated sites.

19.6.5 Safety has been key to the design of the Proposed Development. The engineering team has undertaken a number of initial technical studies which have helped to influence the pipeline routeing and the location of key Above Ground Installations including the block valves (which act as emergency shutdown valves). Additionally, detailed engineering work will also be undertaken relating to process safety and safeguarding, isolation, venting, emergency shutdown and if required, depressurisation as part of the Front-End Engineering Design. The engineers will also review the layout of the current plans and give due consideration both to the on-site location of facilities as well as the off-site receptors. Further information on the importance of safety considerations which formed the key design parameters is provided in Section 3.5 of *ES Volume II Chapter 3: Description of the Proposed Development (Application Document 6.2.3).*

19.6.6 As part of the ongoing design of the Proposed Development, the Applicant has taken the decision to construct the entire pipeline using thick wall pipe. In line with PD8010 the design and routeing of the pipeline has taken into consideration the substance to be transported, building proximity and population density to derive a specification for pipeline wall thickness. Standard wall pipe is traditionally used through low population density areas and farmland (class 1 areas). Thick wall pipe is used in areas of higher population (class 2 areas), with due consideration of closeness to occupied buildings and for major road, rail and river crossings.

19.6.7 The initial pipeline design calculations established circa 60% would need to be constructed in thick wall pipe, to achieve a viable and constructable route, whilst meeting the safety requirements of the design code criteria as specified in PD 8010.

19.6.8 In opting to specify thick wall pipe for the entire route, a significant benefit will be through the increased robustness of the pipeline in remote locations, where potential causes of failure could be instigated by accidental damage by agricultural or third-party works. Additionally, the consistent selection of thick wall pipe will eliminate the transition sections between standard and heavy wall pipe, and thus facilitate a more efficient welding process with the associated improvement in weld quality, reliability and ultimately safety due to reduced risk of weld defects.

19.6.9 Further information is included within *ES Volume II Chapter 3: Description of the Proposed Development (Application Document 6.2.3).*

Construction

19.6.10 During the construction phase of the Proposed Development, risks will be mitigated through the use of appropriately trained and qualified contractors selected following a thorough tender process. Work will be controlled with risk assessments, work method statements and operating procedures in order to reduce the likelihood of incident.

19.6.11 A Construction Environmental Management Plan (CEMP) will be prepared to set out how construction activities will be managed and controlled in compliance with the Harbour Energy health and safety and environmental management systems (including ISO 14001), relevant legislation and environmental permits, consents and licences. A Draft CEMP is included in *ES Volume IV: Appendix 3.1 (Application Document 6.4.3.1).* The draft DCO includes a requirement that the CEMP must be submitted to and approved by the planning authority prior to commencement of development.

Operation

19.6.12 Once operational, appropriate control and monitoring procedures, management systems and control measures will be in place to minimise the risk of incidents occurring and to minimise the effects of any such incidents on off-site receptors as well as the operational workforce.

19.7 Assessment of Potential Effects

General overview

19.7.1 Based on the information presented within *ES Volume II Chapter 3 Description of the Proposed Development*, an assessment of the major event types was completed and is presented in **Table 19-6** below. This assessment has also considered comments received during Statutory Consultation as appropriate, including those linked to safety.

19.7.2 In line with the assessment methodology outlined in Section 19.3 above, for each identified event which has been shortlisted in **Table 19-6** as it has the potential to give rise to a major accident or natural disaster, the following parameters and assessment has been provided including:

- Identification of the potential risk events (including source / pathways and receptors) related to each event type;
- defining the reasonable worst-case consequence if the event did occur;
- Identifying any possible prevention, minimisation and / or mitigation measures;
- Assessing the likelihood; and
- Determining whether the risk has been mitigated to ‘as low as reasonably practicable’ (ALARP) and identification of any residual risks and their significance.

19.7.3 The assessment identifies potential risks and whether these are able to be managed to be ALARP or whether further mitigation would be required. HSE guidance (Expert Guidance on Risk Management (Ref 19-42) considers what is meant by the term ‘reasonably practicable’, noting the definition set out in the Court of Appeal (in its judgment in Edwards v. National Coal Board, [1949] 1 All ER 743):

> *"'Reasonably practicable' is a narrower term than 'physically possible' … a computation must be made by the owner in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) is placed in the other, and that, if it be shown that there is a gross disproportion between them – the risk being insignificant in relation to the sacrifice – the defendants discharge the onus on them."*

The HSE guidance goes on to state:

> *“In essence, making sure a risk has been reduced ALARP is about weighing the risk against the sacrifice needed to further reduce it. The decision is weighted in favour of health and safety because the presumption is that the duty-holder should implement the risk reduction measure. To avoid having to make this sacrifice, the duty-holder must be*

able to show that it would be grossly disproportionate to the benefits of risk reduction that would be achieved. Thus, the process is not one of balancing the costs and benefits of measures but, rather, of adopting measures except where they are ruled out because they involve grossly disproportionate sacrifices. Extreme examples might be:

To spend £1m to prevent five staff suffering bruised knees is obviously grossly disproportionate; but

To spend £1m to prevent a major explosion capable of killing 150 people is obviously proportionate."

19.7.4 As outlined in the section on "scope of assessment", the assessment includes an overview of events that may happen during both construction and operational phases of the Proposed Development. This chapter has used the potential short listed major accidents and disasters agreed during the scoping process as a guide to structure the assessment.

Potential Impacts of Major Accidents Associated with Carbon Dioxide Releases

19.7.5 CO_2 is not flammable and will not support combustion. The principal human health risk from CO_2 is the potential for it to act as an asphyxiant due to it being denser than air. High levels of CO_2 in water can result in acidification and cause subsequent effects on shell-forming species.

19.7.6 The HSE has undertaken a Dangerous Toxic Load assessment for CO_2 which concludes a significant danger to humans through loss of consciousness if they inhale CO_2 at concentrations above around 7% in air (i.e. > 70,000 parts per million (ppm)) (Ref 19-43). The HSE has derived and published Specified Level of Toxicity (SLOT) and Significant Likelihood of Death (SLOD) Levels for hazardous substances and concluded that CO_2 data indicates it does not meet the criteria for classification as a dangerous substance (Ref 19-43).

19.7.7 The HSE publication on the major hazards associated with CO_2 (Ref 19-39) states that this gas is an asphyxiant which displaces oxygen in air at a concentration of 50% volume per volume (v/v). However, even at lower concentrations, CO_2 creates an immediate threat to life at a concentration of only 15% in air due to the toxicological impact it has on the body when inhaled at this concentration (Ref 19-30).

19.7.8 Dense phase CO_2 transport enables a more efficient transport of mass of CO_2 per pipeline size. The Viking CCS pipeline has been sized to materially decarbonise the Humber and Lincolnshire area. The maximum capacity of the pipeline when operating at the maximum allowable operating pressure is 17mtpa. The development of the CO_2 capture industry in the Humber and Lincolnshire region is foreseen to increase over the decade from 2027 to the late 2030s as UK-based industries seek to decarbonise. The base case for the Viking CCS pipeline is to reach 10-to-11mtpa flow rate by 2030 and then gradually increase in flow rate through the 2030s.

19.7.9 Gas phase CO_2 transport limits the mass of CO_2 that can be transported for a similar pipeline size. Analysis of the Viking CCS pipeline indicates that for the same 24" diameter pipeline (610mm) which could transport 17mtpa in the dense phase, would be limited to less than 4mtpa in the gas phase. Transport in the gas phase only would therefore potentially require multiple gas phase pipelines to reach the same target flowrate, needed for the decarbonisation of the Humber region, compared to a single dense phase pipeline for an equivalent capacity.

19.7.10 There are specific hazards associated with handling CO_2 in dense phase (this is when large quantities of CO_2 are conveyed at high pressures). These can arise if a release occurs, resulting in a sudden pressure falls or complete loss of inventory. Cryogenic burns and

embrittlement of metallic structures can occur should there be a release of CO_2 that results in a sudden reduction of pressure.

19.7.11 The project team has reviewed historical incidents involving CO_2 transportation in order to understand the mechanisms that led to a failure. The project team then evaluated the Viking CCS pipeline design against these failure modes to ensure the risks of a similar incident are mitigated.

19.7.12 Incidents relating to pipelines in the UK are rare, and with reference to previous examples of incidents, the most likely cause is due to an external event (e.g. a landslide) rather than an operational issue. A wide range of factors have been taken into account in determining the preferred pipeline route, with safety being the key consideration. The Viking CCS pipeline will be constructed so it does not cross any areas that would have a significant landslide potential, as identified from the British Geological Survey and the preferred route ensures that all current developments and known planned developments comply with the Health and Safety Executive's guidelines. There will be 24-hour monitoring of the Viking CCS pipeline operations and facilities will be provided to enable routine internal inspection of the pipeline.

19.7.13 Research has been undertaken to refine and validate the software used for modelling dense phase CO_2 releases to further understand the potential hazards of a major release. The Applicant (Harbour Energy) commissioned their own technical assessment using industry standard tools to model CO_2 releases. The outcomes of the modelling were reviewed by the team and have been used to help further refine the preferred pipeline corridor.

19.8 Mitigation Measures and Emergency Response

Mitigation Measures

19.8.1 As outlined in the Development Design section above, the Applicant intends to construct, manage and operate the Proposed Development in accordance with all applicable legislation and design codes in order to ensure the likelihood of any major hazard or accident is reduced to ALARP. These principals are embedded into the design of the Proposed Development.

19.8.2 In addition, project specific operating documentation in line with the Harbour Energy HSES management systems, will be developed to help reduce risks and ensure adequate planning and preparation is in place in the event of a major incident occurring. Key documents/systems of note include:

- Risk management system and adherence to all applicable HSE guidelines;
- Adherence to the CEMP;
- Undertaking additional studies, where required, to produce an inherently safer design and to ensure residual risks are managed to be ALARP;
- Preparation of bespoke incident response plans to ensure reasonably foreseeable incidents can be managed appropriately; and
- Developing detailed emergency plans for dealing with potential major incidents.

19.8.3 The Draft Construction Environmental Management Plan (CEMP) (ES Volume IV, Appendix 3.1 (Application Document 6.4.3.1)) sets out additional mitigation measures identified in this assessment of likely significant effects within the Mitigation Register. Section N of the Mitigation Register sets out the following additional mitigation measures in respect of major accident and disasters:

- **N1**: The safety lifecycle requirements demanded by industry best practices such as IEC 61508/61511 standards (implemented in the UK as BS EN 61508/61511) will be followed;
- **N2**: Adhere to applicable legislation (such as The Avian Influenza (H5N1 in Wild Birds) (England) Order 2006, amended in 2021));
- **N3**: Follow the current guidelines in place with regards to notification of finding dead birds, including notifying DEFRA (via their helpline 03459335577);
- **N4**: Refer to the additional information provided within the "Stop the Spread" webinars, located at: https://www.gov.uk/government/publications/avian-influenza-bird-flu-stop-the-spread-webinars/stop-the-spread-webinars;
- **N5**: Compliance with the Pressure Equipment (Safety) Regulations 2016 and the Pipelines Safety Regulations (PSR) (HSE, 1996);
- **N6**: Pipeline safety systems and leak detection system to be installed along with operational controls and monitoring;
- **N7**: Detailed emergency plans will be produced for the installation in accordance with all applicable Regulations. Construction methods would include risk assessments;
- **N8**: Implementation of a permit to work system;
- **N9**: Close coordination and communication between other nearby operators would be undertaken to ensure all relevant emergency procedures are made available to the Proposed Development;
- **N10**: Close coordination and communication between other pipeline operators to ensure the Proposed Development can be constructed safely;
- **N11**: Fire detection and fire protection systems will be installed at other developments, and at the Proposed Development;
- **N12**: Implement measures to minimise storage volumes of high hazard materials; and
- **N13**: Compliance with Pipeline Safety Regulations (HSE,1996) and additional specific safety measures for CO_2 pipelines will apply.

19.8.4 The Operational Phase Mitigation (ES Volume IV, Appendix 3.6 (Application Document 6.4.3.6)) sets out mitigation measures identified in this assessment of likely significant effects during operation. The following additional mitigation measure is included in respect of major accident and disasters during the operation of the Proposed Development:

- **Op12:** During operation, the design of the Proposed Development will allow for it to be safely shutdown in an emergency situation.

Emergency Response to Major Accidents

Overview

19.8.5 The Applicant's (Harbour Energy) Emergency Response and Crisis Management Standard will be the over-arching document upon which bespoke response plans for the Proposed Development will be developed. The standard follows a three-level response structure where each level will have a specific focus, establishing a hierarchy of response that is structured to provide successive tiers of incident support depending upon the nature and scale of the incident.

19.8.6 The typical structure for responding to an emergency situation is illustrated below in **Figure 19-1**. 'This will be developed further with appropriate adaptation where necessary for CO_2 transport and storage.

Emergency Response Plan Potential Contents

19.8.7 The bespoke Viking CCS response plan may include information on the following areas.

- Details of the emergency response organisation;
- Emergency roles and responsibilities;
- Emergency equipment;
- Identified major accidents, including those to the environment and specific responses to each;
- Identified off-site emergencies (i.e. pipelines);
- Other non-major accident emergencies and security threats;
- Muster and evacuation plans for site personnel;
- Medical response plans;
- Arrangements for communication and co-ordination of emergency response;
- Details of any site alarms and public alert systems; and
- Actions by external emergency response organisation.

Coordination with External Agencies

19.8.8 Coordination with external emergency response agencies will be key to the response to an emergency event. The external emergency response organisation will typically comprise:

- The local emergency services (Fire and Rescue Service, Ambulance Service and Police); and
- Local authorities.

19.8.9 These may be supplemented by others such as:

- The Environment Agency;
- Coastguard;
- Health Protection Agency; and
- Health and Safety Executive.

19.8.10 In order to ensure any required response is efficient and effective, the Applicant is committed to:

- Liaise with the emergency services during the preparation of emergency response plans;
- Ensure ongoing familiarisation visits are held with the emergency response crews; and
- Ensure suitable plans, maps and information are supplied to the emergency response organisations and that any such plans are kept up to date.

Figure 19-1: Emergency Response Planning

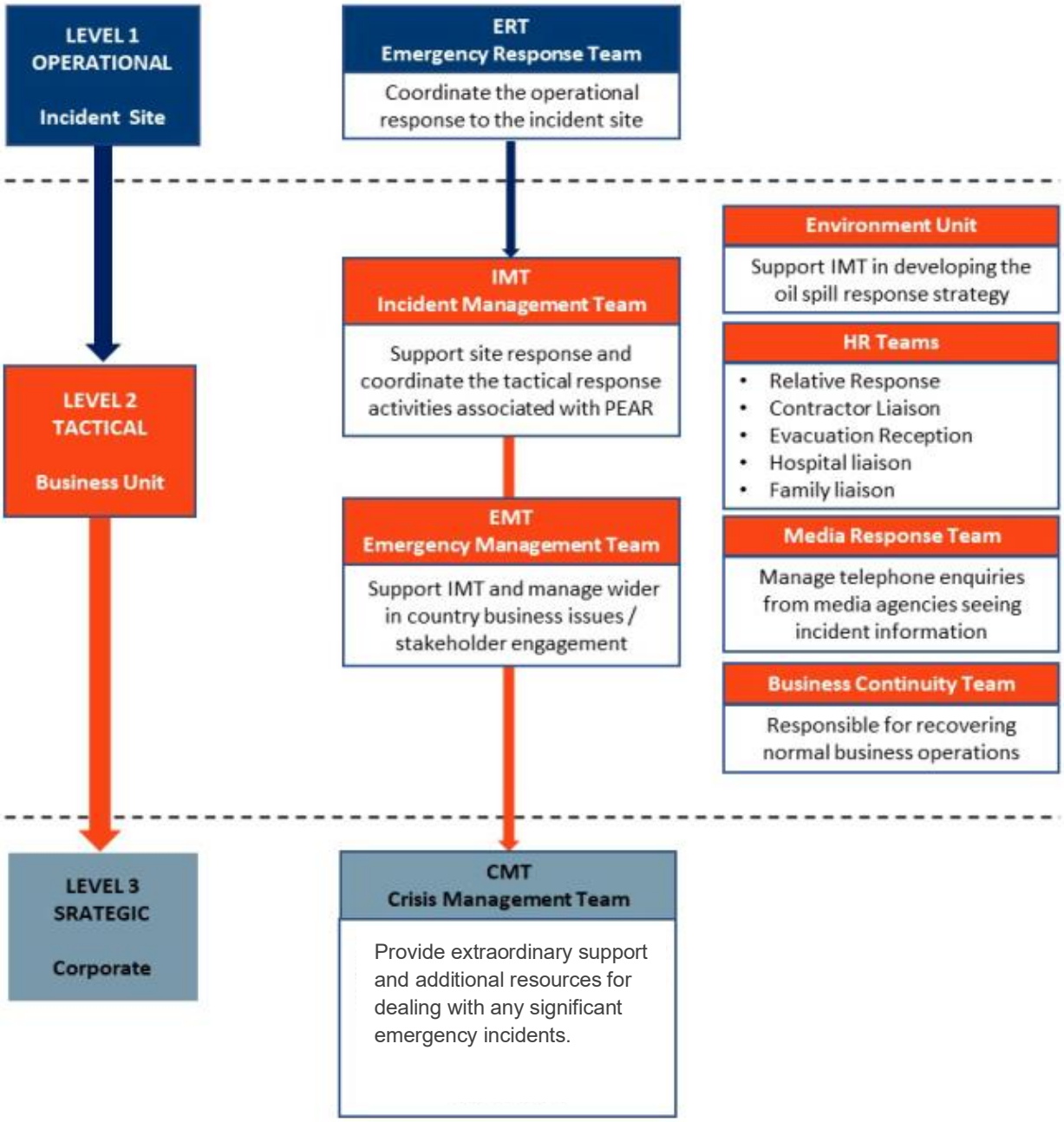

Table 19-6: Assessment of Short-Listed Major Accident and Disasters

Major Event Group	Major Event Category	Major Event Type	Proposed Development Phase	Risk Description	Receptors	Hazard sources and pathways	Reasonable worst consequence if event did occur	Mitigation	Likelihood	Is this ALARP ? Y/N	Tolerability
Natural Hazards	**Geophysical**	**Landslides and Sinkholes**	*Construction and Operation*	The risk of a natural landslide event occurring or sinkhole opening up along the pipeline route, causing damage to the Viking CCS Pipeline, during either construction or operation. Damage to the pipeline caused by a landslide or sink hole has the potential to lead to a significant release of CO_2. Any event during construction could impact upon construction workers.	• Construction and operational workers; • Construction plant and materials; • Local residents; • Property and land; • General Public; • Water Environment; • Ecology and Biodiversity.	The superficial geology underlying the Proposed Development include the following: Glacial Till, Tidal Flat Deposits, Glaciofluvial Deposits, Alluvium, Lacustrine Deposits. The bedrock geology that underlies the Proposed Development includes various chalk formations. Construction and development modifying surface drainage or altering the loads imposed on the ground without adequate support can cause sinkholes to develop. No historic landslides have been identified within the DCO Site Boundary from a review of the BGS National Landslide Database Index. However, one incident has been located within 50 m of the DCO Site Boundary at West Laceby (Landslide ID 14387).	Mass CO_2 release leading to a toxicity and fogging hazard affecting those people in the immediate area, as described in paragraphs 19.7.6 to 19.7.10. Potential death and/ or injury to construction workers or members of the public. Loss of construction materials and plant / built infrastructure. Delays to the Proposed Development programme if occurs during construction phase. Total shutdown of Proposed Development if occurs during operation.	Compliance with all applicable legislation and design codes including the Pressure Equipment (Safety) Regulations 2016 and PD8010 as well the relevant aspects of part 3 of the Pipelines Safety Regulations (PSR) (HSE, 1996), despite it not being required for a CO_2 pipeline. Appropriate selection of pipeline routes, using geological and geophysical data to ensure ground conditions are suitable for pipeline installation, with additional localised ground investigations undertaken if deemed necessary. Use of thick wall pipe across entire length of the pipeline route. Construction of safety systems to prevent pipeline damage, such as the installation of concrete barriers in certain crossing locations. Pipeline safety systems and leak detection system to be installed along with operational controls and monitoring. Detailed emergency plans will be produced for the installation in accordance with all applicable Regulations.	Very Low	Y	Tolerable (**not significant)**

Major Event Group	Major Event Category	Major Event Type	Proposed Development Phase	Risk Description	Receptors	Hazard sources and pathways	Reasonable worst consequence if event did occur	Mitigation	Likelihood	Is this ALARP ? Y/N	Tolerability
								Construction methods would include risk assessments to reduce the probability of any incidents occurring.			
Natural Hazards	**Hydrology**	**Tidal Flooding**	*Construction and Operation*	Risk of tidal flooding in Sections 1 and 5 of the Proposed Development.	• Construction and operational workers; • Construction plant and materials; • Local residents; • Property and land; and • General Public; • Water Environment.	A review of the Environment Agency Flood Map for Planning (Rivers and Sea) (Environment Agency, 2020) indicates that some parts of Sections 1 and 5 of the DCO Site Boundary are at risk of tidal flooding. Tidal flooding has the potential to impact upon construction activities, in those areas which are outlined above. Tidal flooding has limited potential to impact the Proposed Development once operational, as it will be possible to be shutdown in case of any incidents of tidal flooding.	Flooding of sections of the pipeline route during construction. Potential harm to construction workers. Flooding during operation leading to potential damage to infrastructure. A flood risk assessment is contained in *ES Volume IV: Appendix 11.5 (Application Document 6.4.11.5),* which provides more details on the effect which flooding may have on the Proposed Development.	Embedded mitigation built in the design to help minimise impacts of flooding such as appropriately designed pre- and post construction drainage. Additional mitigation measures are set out in the Flood Risk Assessment (*ES Volume IV: Appendix 11.5 (Application Document 6.4.11.5*). A commitment in the Draft CEMP includes the production of an Emergency Flood Plan. During operation, the design of the Proposed Development will allow for it to be safely shutdown in an emergency situation.	Low	Y	Tolerable (**not significant**)
Natural Hazards	**Hydrology**	**Fluvial Flooding**	*Construction and Operation*	Risk of fluvial flooding in Sections 1 and 5 of the Viking CCS Pipeline.	• Construction and operational workers; • Construction plant and materials;	A review of the Environment Agency Flood Map for Planning (Rivers and Sea) (Environment Agency, 2020) indicates that there are numerous locations associated with main rivers or water	Flooding of sections of the pipeline route during construction.	Suitable mitigation measures are set out in the Flood Risk Assessment *(ES Volume IV: Appendix 11.5 (Application Document 6.4.11.5)).* A commitment in the Draft CEMP includes the	Low	Y	Tolerable (**not significant**)

Major Event Group	Major Event Category	Major Event Type	Proposed Development Phase	Risk Description	Receptors	Hazard sources and pathways	Reasonable worst consequence if event did occur	Mitigation	Likelihood	Is this ALARP ? Y/N	Tolerability
					• Local residents; • Property and land; • General Public; • Water Environment.	courses along the pipeline route which are located in flood zone 2 or 3. Fluvial flooding has the potential to impact upon construction activities, in those areas which are outlined above. Fluvial flooding has limited potential to impact the Viking CCS Pipeline once operational.	Potential harm to construction workers. Potential damage to infrastructure. Impacts on property and people if the Proposed Development exacerbated flood risk. A flood risk assessment is contained in *ES Volume IV: Appendix 11.5 (Application Document 6.4.11.5)* which provides more details.	production of an Emergency Flood Plan. During operation, the design of the Proposed Development will allow for it to be safely shutdown in an emergency situation.			
Natural Hazards	**Climatological and Meteorological**	**Wave surges**	Construction and Operation	Risk of tidal wave surges affecting the Proposed Development at Immingham and Theddlethorpe	• Construction and operational workers; • Construction plant and materials; • Local residents; • Property and land; • General Public; • Water Environment.	The Proposed Development is located in an area at risk of tidal flooding. The floodplains of the Humber Estuary and North Sea are at risk of tidal flooding. The pipeline is below ground and therefore would not be subject to the direct hydraulic forces of a wave surge. The Immingham and Theddlethorpe Facilities are sited far enough inland so as not to be subject to wave surges, but further consideration has been given to this	Potential damage to infrastructure. Potential Flooding at the Immingham Facility. Potential Flooding at the Theddlethorpe Facility. Potential Flooding of the Dune Isolation Valve on the existing LOGGS pipeline.	Existing Flood defences in Immingham and Theddlethorpe mean that there is no significant risk to the site from wave surges. During operation, the design of the Proposed Development will allow for it to be safely shutdown in an emergency situation. Additional information and mitigation measures are set out in the Flood Risk Assessment *(ES Volume IV: Appendix 11.5 (Application Document 6.4.11.5)).*	Very Low	Y	Tolerable (**not significant**)

Major Event Group	Major Event Category	Major Event Type	Proposed Development Phase	Risk Description	Receptors	Hazard sources and pathways	Reasonable worst consequence if event did occur	Mitigation	Likelihood	Is this ALARP ? Y/N	Tolerability
						and is included in the tidal flooding section above. The Dune Isolation Valve on the existing LOGGS Pipeline will be within a located within a sealed environment and thus would not be vulnerable to wave surges.					
Technolog-ical or Manmade Hazards	**Industrial and Urban Accidents**	**Major Accident Hazard Chemical sites**	*Construction and Operation*	Risk of an incident at the Proposed Development (e.g. fire/explosion) affecting COMAH sites during either construction or operation	• Construction and Operational workers; • Construction plant and materials; • Local residents; • Property and land; • General Public; • Ecology and Biodiversity; • Atmosphere; • Water Environment.	There are at least 13 establishments within the Immingham Docks/VPI Immingham/P66 site locations, within proximity of Section 1 of the DCO Site Boundary, which are covered by the Control of Major Accident Hazard (COMAH) Regulations 2015. The Immingham Facility covers only a small area of land (just over 1 hectare) and is located remotely from the main operational areas of neighbouring facilities at VPI and P66. However, it is acknowledged that there is an active planning application in place to build a large carbon capture storage facility on land adjacent to the Immingham Facility. An incident at the Immingham Facility part of the Proposed Development would have the potential to impact the carbon capture facility, if built.	Death and/ or injury to workers or members of the public. Loss of construction materials and plant. Delays to the Proposed Development programme and congestion in surrounding area. Knock-on impact to other industrial sites and their operations. Firewater run-off reaching areas of unmade ground could contain contaminants which would be potentially harmful to groundwater.	Compliance with all applicable legislation and design codes including the Pressure Equipment (Safety) Regulations 2016 and PD8010 as well the relevant aspects of part 3 of the Pipelines Safety Regulations (PSR) (HSE, 1996), despite it not being required for a CO_2 pipeline. Appropriate selection of pipeline routes, using geological and geophysical data to ensure ground conditions are suitable for pipeline installation, with additional localised ground investigations undertaken if deemed necessary. Use of thick wall pipe across entire length of the pipeline route. Construction of safety systems to prevent pipeline damage, such as the installation of concrete barriers in certain crossing locations.	Very Low	Y	Tolerable (**not significant**)

Major Event Group	Major Event Category	Major Event Type	Proposed Development Phase	Risk Description	Receptors	Hazard sources and pathways	Reasonable worst consequence if event did occur	Mitigation	Likelihood	Is this ALARP ? Y/N	Tolerability
						During construction there is no realistic potential for an incident to occur which could affect other sites within the Immingham area. During operation, a pipeline full bore breach could result in significant harm to people on Site, if they were present at the time. There is extremely limited potential for harm to people and businesses off-site, such as radiant heat burns and impact injuries from explosions associated with the Proposed Development.		Instrumented protection systems provided to mitigate pressure and temperature excursions outside design limits. Leak detection systems and pressure monitoring. Isolation valves in the pipeline system to minimise inventory release to the atmosphere. Proposed Development will follow the safety lifecycle requirements demanded by industry best practices such as IEC 61508/61511 standards (implemented in the UK as BS EN 61508/61511). Detailed emergency plans will be produced for the installation in accordance with all applicable Regulations. Construction methods would include risk assessments to help minimise the probability of any incidents occurring. Implementation of a permit to work system.			
Technolog-ical or Manmade Hazards	**Industrial and Urban Accidents**	**Major Accident Hazard Chemical sites**	*Construction and Operation*	Risk of an incident (e.g. fire /explosion) at other sites affecting the Proposed Development	• Construction and Operational workers; • Construction plant and materials; • Local residents;	The Immingham Facility would have the potential to be affected by incidents occurring at other sites. There are a minimum of 13 establishments within the Immingham Docks/VPI Immingham/P66 site	Death and/ or injury to workers or members of the public. Loss of construction materials and plant.	All other projects will be designed and operated in line with applicable regulations (e.g. COMAH). Consequently, all will have specific plans and procedures in place to avoid and/or minimise the potential for and impacts of unplanned events.	Very Low	Y	Tolerable (**not significant**)

Major Event Group	Major Event Category	Major Event Type	Proposed Development Phase	Risk Description	Receptors	Hazard sources and pathways	Reasonable worst consequence if event did occur	Mitigation	Likelihood	Is this ALARP ? Y/N	Tolerability
					• Property, businesses and land; • General Public; • Ecology and Biodiversity; • Atmosphere; • Water Environment.	locations, within proximity of Section 1 of the DCO Site Boundary, which are covered by the Control of Major Accident Hazard (COMAH) Regulations 2015. These include the sites located at P66 and VPI, which are located in relatively close proximity to the Immingham Facility and are of a much more significant scale as to the components of the Proposed Development. In addition, it is acknowledged that there is an active planning application in place to build a large carbon capture storage facility on land adjacent to the Immingham Facility. An incident at the carbon capture plant (if built), would have the potential to impact on the Immingham Facility of the Proposed Development. Fire and/or explosion at other sites could, result in significant harm to people on the Proposed Development Site (if present), with the potential for fatal injuries. There is also the potential for an offsite explosion to damage the Immingham Facilities or buried pipeline (though this is less likely),	Delays to the Proposed Development programme and congestion in surrounding area.	The Proposed Development has been designed and located with due consideration of other facilities. This includes the appropriate selection of pipeline routes, depth of cover in areas of higher risk, the agreement to use heavy wall pipe for the entire pipeline route and the construction of safety systems to prevent pipeline damage, such as the installation of barriers. Close coordination and communication between other nearby operators would be undertaken to ensure all relevant emergency procedures are made available to the Proposed Development. An Environmental Emergency Response Plan will be produced by the Contractor (as outlined in the Draft CEMP included in Appendix 3.1 *ES Volume IV (Application Document 6.4.3.1*). The high concentration of industrial facilities in the local area also provides a wealth of experience in the planning and preparation work for the management of major accidents.			

Major Event Group	Major Event Category	Major Event Type	Proposed Development Phase	Risk Description	Receptors	Hazard sources and pathways	Reasonable worst consequence if event did occur	Mitigation	Likelihood	Is this ALARP ? Y/N	Tolerability
						leading to harm to people and businesses off-site.					
Technolog-ical or Manmade Hazards	**Industrial and Urban Accidents**	**Major Accident Hazard Pipelines**	*Construction*	Damage to a major accident hazard pipeline causing loss of containment	• Construction workers; • Construction plant and materials; • Local residents; • Property, businesses and land; • General Public; • Ecology and Biodiversity; • Atmosphere; • Water Environment.	There are Major Accident Hazard (MAH) pipelines within or close to the DCO Site Boundary. There is therefore the potential for damage to occur during construction activities. The extent of the release of contaminant would depend upon how severe the incident was and what the contents of the pipeline affected were, but could obviously lead to pollution incidents to the local surface and groundwater and /or releases to the atmosphere.	Contamination of ground and/or water supply. Potential dispersion to air.	The preferred pipeline route has been designed to avoid other buried infrastructure where reasonably possible. Detailed design engineering will seek precise details on presence and location of other potential pipelines including protective provisions and appropriate design measures. Site surveys and scans along with localised trial trenching. Close coordination and communication between other pipeline operators to ensure the Proposed Development can be constructed safely. Construction methods would include risk assessments and would be in compliance with the CEMP, including protective provisions and appropriate design measures. An Environmental Emergency Response Plan will be produced by the Contractor (as outlined in the Draft CEMP included in Appendix 3.1 *ES Volume IV (Application Document 6.4.3.1*).	Very Low	Y	Tolerable (**not significant**)

Major Event Group	Major Event Category	Major Event Type	Proposed Development Phase	Risk Description	Receptors	Hazard sources and pathways	Reasonable worst consequence if event did occur	Mitigation	Likelihood	Is this ALARP ? Y/N	Tolerability
Technolog-ical or Manmade Hazards	**Industrial and Urban Accidents**	**Fire**	*Operation*	Risk of Fire at either an offsite location or at the Proposed Development	• Operational workers; • Local residents; • Property, businesses and land; • General Public; • Ecology and Biodiversity; • Atmosphere; • Water Environment.	A fire at either the Proposed Development, or on a nearby industrial facility could impact operations. The location of the fire and the severity of it would determine the extent to which impacts would occur. For example, if it was a localised fire which was contained at the source then this would only affect the site it occurred. But if the fire was out of control, it would lead to a risk of nearby properties and areas, and may even lead to the risk of explosions. There is therefore the potential for damage to occur during operational activities.	Fire and/or explosion could result in significant harm to people on Site, with the potential for fatal injuries and damage to industrial property. There is also the potential for harm to people and businesses off-site, such as radiant heat burns and impact injuries from explosions. The environmental impact of a major fire could affect the air, water environment and local ecological receptors.	Other developments will be designed and operated in line with applicable regulations (e.g. COMAH) and environmental permits. Consequently, all will have specific plans and procedures in place to avoid and/or minimise the potential for and impacts of unplanned events. Fire detection and fire protection systems will be installed at other developments, and at the Proposed Development. Pipeline safety systems and gas/liquid pressure regulation to be installed along with operational controls and monitoring. Measures will be put in place to minimise storage volumes of high hazard materials. Compliance with the Pressure Equipment (Safety) Regulations 2016 and the Pipelines Safety Regulations (PSR) (HSE, 1996). An Environmental Emergency Response Plan will be produced by the Contractor (as outlined in the Draft CEMP included in appendix 3.1 *ES Volume IV (Application Document 6.4.3.1*).	Low	Y	Tolerable (**not significant**)

Major Event Group	Major Event Category	Major Event Type	Proposed Development Phase	Risk Description	Receptors	Hazard sources and pathways	Reasonable worst consequence if event did occur	Mitigation	Likelihood	Is this ALARP ? Y/N	Tolerability
Technolog-ical or Manmade Hazards	**Pollution accidents**	**Release to Air**	*Operation*	An accident or natural hazard could lead to an incident by which part of the Proposed Development's CO_2 inventory is released to the air	• Operational workers • Local residents; • Local property, businesses and land; • General public; • Atmosphere; • Ecology and Biodiversity.	A significant loss of containment event involving the pipeline would result in a large-scale release of CO_2 to the environment. CO_2 is an odourless and transparent gas which can, in certain circumstances be toxic and act as an asphyxiant, depending on the concentration in air. It is also heavier than air. A leak or rupture of a system containing high pressure (dense phase) CO_2 will likely be noisy and will be observed with the naked eye due to the condensation of water vapour in the atmosphere. There will be an associated large reduction in temperature from a high pressure release. A release of CO_2 could be caused by mechanical failure or impact damage resulting in a loss of containment.	CO_2 toxicity, asphyxiation and fogging hazard affecting those people in the immediate area. The impact of the release on people and the environment depends on the pressure, temperature and mass of material that is lost, however there is the potential for a major accident resulting in significant harm and potential fatalities, both on-site and off-site.	The Proposed Development will use heavy wall pipe for the entire pipeline route. Multiple safety systems will be inbuilt into the Proposed Development to prevent pipeline damage. The pipeline route has been deliberately sited away from more densely populated areas and will be buried to minimise risk of 3rd party damage. Detailed standards and codes of practice written specifically for the design and operation of dense phase or supercritical CO_2 plant and pipelines are still being developed, therefore industry codes and standards for gas and chemical pipelines will be applied where appropriate. According to the HSE, *"ongoing work suggests that the hazards involved with the bulk transport of CO_2 are similar to the hazards transporting natural gas".* Compliance with all applicable legislation and design codes including the Pressure Equipment (Safety) Regulations 2016 and PD8010 as well the relevant aspects of part 3 of the Pipelines Safety Regulations (PSR) (HSE, 1996), despite it not being required for a CO_2 pipeline.	Very Low	Y	Tolerable (**not significant**)

Major Event Group	Major Event Category	Major Event Type	Proposed Development Phase	Risk Description	Receptors	Hazard sources and pathways	Reasonable worst consequence if event did occur	Mitigation	Likelihood	Is this ALARP ? Y/N	Tolerability
								Instrumented protection systems provided to mitigate pressure and temperature excursions outside design limits. Leak detection systems and pressure monitoring. Isolation valves in the pipeline system to minimise inventory release to the atmosphere. Vent stacks at both Immingham and Theddlethorpe will be designed to be able to safely release inventory direct to atmosphere if required during an emergency situation. The Proposed Development will follow the safety lifecycle requirements demanded by industry best practices such as BS ISO 31000 – Risk Management Guidelines. *(ES Volume IV: Appendix 3.1 (Application Document 6.4.3.1)).*			
Technolog-ical or Manmade Hazards	**Malicious Attacks**	**Unexplod-ed Ordnance (UXO)**	*Construction*	Risk of encountering UXO during ground investigation or construction activities	• Construction workers; • Construction plant and materials; • Local residents; • Property, businesses and land; and • General Public.	The DCO Site Boundary contain a UXO moderate to high risk area. Impacts would only occur should any UXO were disturbed during any construction activities. Measures would be undertaken during the construction phase to raise awareness of this issue to construction site staff and operatives, and to define the appropriate	Death and/ or injury to construction workers or members of the public. Fire/explosion affecting the construction works and neighbouring property.	An initial desk based UXO assessment has been commissioned for the Proposed Development. This has identified any significant sources of UXO hazard and has been used as part of the design process. A copy of this report is included in *ES Volume IV: Appendix 19.2 (Application Document 6.4.19.2).* Additional work relating to UXO will be commissioned	Low	Y	Tolerable (**not significant**)

Major Event Group	Major Event Category	Major Event Type	Proposed Development Phase	Risk Description	Receptors	Hazard sources and pathways	Reasonable worst consequence if event did occur	Mitigation	Likelihood	Is this ALARP ? Y/N	Tolerability
						response strategies should any be discovered during the works (as discussed in the mitigation section).		as part of the FEED to confirm the exact UXO hazard level within the refined pipeline alignment. If required, any additional UXO risk mitigation measures recommended will be included in the CEMP. A series of procedures, protocols and training required for all construction workers during the construction phase are initially outlined in the Draft CEMP (*ES Volume IV: Appendix 3.1 (Application Document 6.4.3.1*)) Further details will be detailed within the Final CEMP, prepared by the chosen contractor.			
Technolog-ical or Manmade Hazards	**Engineering accidents and failures**	**Cyber**	*Operation*	Potential for cyber interference of sabotage of the Proposed Development once operational	• Operational workers; • Maintenance operators; • Local residents; • Property, businesses and land; and • General Public.	The Block Valve Stations, Immingham Facility and Theddlethorpe Facility would be remotely monitored rendering the Proposed Development vulnerable to a cyber-attack.	A cyber attack could hinder the standard operating procedures or lead to a temporary shut down of all activities.	The Applicant is accountable to the Secretary of State (SoS) for Department for Energy Security and Net Zero (DESNZ) for ensuring resilience of their operations, including from terrorism, cyber-attack, natural hazards and other risks. The Proposed Development will be designed using the latest technology and controls which will be specifically designed to manage vulnerability to cyber-attack.	Very Low	Y	Tolerable (**not significant**)
Technologi cal or Manmade Hazards	**Engineering accidents and failures**	**Flood defence failure**	*Construction and Operation*	Potential for flood defences to fail (e.g. due to extreme weather events)	• Construction workers; • Operational Workers;	There are locations within the DCO Site Boundary that benefit from flood defences (e.g. at the Theddlethorpe and Immingham Facilities). If a failure	Loss of construction materials and plant.	The design of the Proposed Development will include allowances for future climate change predicted effects on flooding. The potential risk of breech events has been	Very Low	Y	Tolerable (**not significant**)

Major Event Group	Major Event Category	Major Event Type	Proposed Development Phase	Risk Description	Receptors	Hazard sources and pathways	Reasonable worst consequence if event did occur	Mitigation	Likelihood	Is this ALARP ? Y/N	Tolerability
					• Construction plant and materials; • Property, businesses and land; • Water Environment	was to occur, flooding could lead to problems predominantly during construction, but also during operation	Delays to the Proposed Development programme and congestion in surrounding area. Temporary shutdown of operations	considered in the EIA, specifically in the Flood Risk Assessment *(ES Volume IV: Appendix 11.4 (Application Document 6.4.11.4). An assessment in relation to climate change is provided in ES Volume II: Chapter 15 Climate Change (Application Document 6.2.15).*			
Natural Hazards	**Biological**	**Avian Influenza**	*Construction*	Potential for construction activities to cause the spread avian influenza	• Birds.	According to DEFRA, the risk of incursion of highly pathogenic (HPAI) avian influenza H5 in wild birds in Great Britain remains at *High* (that is, event occurs very often). The risk to poultry with stringent biosecurity is maintained at *Low* (event is rare, but does occur). However, the risk to poultry exposure to HPAI H5 in Great Britain with suboptimal biosecurity has been increased to *Medium* (event occurs regularly) in light of the increased number of infected premises. As of the latest available data (June 2023), in Great Britain there have been 186 confirmed cases of avian influenza since 1st October 2022, and 288 cases overall since the outbreak started in October 2021 (Ref 19-40). Following the number of detections of avian influenza in poultry and wild and captive birds,	Avian Influenza would become more widespread amongst the wild bird population, causing more fatalities. Avian Influenza would also become more widespread amongst poultry farms, especially those with suboptimal biosecurity, leading to issues related to food availability.	The Proposed Development will adhere to good construction practices and measures as set out in the Draft CEMP (*ES Volume IV: Appendix 3.1 (Application Document 6.4.3.1)*). which will help reduce the risk of spreading infection. This includes: • N2: Adhere to applicable legislation (such as The Avian Influenza (H5N1 in wild Birds (England 2006 and amended in 2021); • N3: Follow the current guidelines in place with regards to notification of finding dead birds, including notifying DEFRA (via their helpline 03459335577). • N4: Refer to the additional information provided within the "*Stop the Spread*" webinars, located at: https://www.gov.uk/government/publications/avian-influenza-bird-flu-stop-the-spread-webinars/stop-the-	Low	Y	Tolerable (**not significant**)

Major Event Group	Major Event Category	Major Event Type	Proposed Development Phase	Risk Description	Receptors	Hazard sources and pathways	Reasonable worst consequence if event did occur	Mitigation	Likelihood	Is this ALARP ? Y/N	Tolerability
						the whole of Great Britain is now in an Avian Influenza Prevention Zone (AIPZ). There is now a legal requirement for all bird keepers to implement enhanced biosecurity measures to help protect their flocks and stop the disease spreading.		spread-webinars (Ref 19-41).			

19.9 Assessment of Residual Effects

19.9.1 The assessment has concluded that the identified risk is tolerable and the design and additional mitigation measures ensure that the level of risk remains as ALARP.

19.9.2 Based on the embedded design measures and additional mitigation outlined above and in the supporting technical chapters of this ES, It is therefore considered that the impact of identified potential major accident and disaster events identified during the construction and operation of the Proposed Development will all be managed to be ALARP and will be classed as being not significant. Key to this is the vast array of preventative measure which are built into the design of the Proposed Development's to help try and prevent any incidents occurring in the first place. Additional emergency response planning has also been identified which is of direct relevance to the Proposed Development. Consequently, **no significant residual effects** have been identified.

19.10 Summary

19.10.1 This assessment has identified the potential major accidents and disasters that could be applicable to the Proposed Development. Principally, these have included natural hazards related to geophysical (i.e. landslides and sinkholes); hydrology (tidal and fluvial flooding); climatology and meteorology (wave surges); biological (animal diseases); as well as technological or manmade hazards such as Industrial and urban accidents (COMAH sites and major accident hazard pipelines); pollution accident (release to air); malicious attacks (unexploded ordnance); engineering accidents or failures (cyber and flood defence).

19.10.2 The consequences of these events happening could include fires, explosions, physical damage and the release of CO_2 gas. These incidents have an extremely low probability of occurrence but could have significant impacts on people and the environment without mitigation.

19.10.3 The engineering design of the Proposed Development will incorporate appropriate standards, proven design methods and control measures necessary to reduce the risks of such accidents to an acceptable level, i.e., ALARP, which is the standard expected by the Regulatory Authorities (HSE and Environment Agency). This includes using heavy wall pipe for the entire length of the pipeline route. Reducing the probability of an incident occurring has been a key focus for the engineering design of the Proposed Development. Additionally, a set of emergency plans and procedures will be developed and implemented should any incident occur, further controlling and mitigating the impact.

19.10.4 With the implementation of these measures, risks are considered to have been mitigated to a 'tolerable' level and therefore the effects are considered as '**Not Significant**' for both construction and operation.

19.11 References

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