CALEDONIA
Offshore Wind Farm

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Volume 7F Intertidal and Combined Assessment Appendices

Appendix 3-1 Climate Change Resilience Assessment

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Volume 7F Appendix 3-1 Climate Change Resilience Assessment

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Acronyms and Abbreviations

CCR	Climate Change Resilience
CEDA	Centre for Environmental Data Analysis
CMIP6	Coupled Model Intercomparison Project Phase 6
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
H&S	Health and Safety
IEMA	Institute of Environmental Management and Assessment
TJB	Transition Joint Bay
IPCC	Intergovernmental Panel on Climate Change
MCCIP	Marine Climate Change Impacts Partnership
NETS	National Electricity Transmission System
O&M	Operations & Maintenance
OnTI	Onshore Transmission Infrastructure
PPE	Personal Protective Equipment
RCP8.5	Representative Concentration Pathway 8.5
SEPA	Scottish Environment Protection Agency
SST	Sea Surface Temperature
UKCP09	United Kingdom Climate Projections 2009
UKCP18	United Kingdom Climate Projections 2018
RLB	Red Line Boundary
WTG	Wind Turbine Generator

1 Introduction

1.1.1.1 This appendix outlines the full methodology and the results of the Climate Change Resilience (CCR) assessment and should be read in conjunction with Volume 6, Chapter 3: Climate Change Resilience. The assessment of CCR is based on the description of the Proposed Development within Volume 1, Chapter 3: Proposed Development Description (Offshore) and, Volume 1, Chapter 4: Proposed Development Description (Onshore) of the Environmental Impact Assessment Report (EIAR). Conclusions of significance are provided within Volume 6, Chapter 3: Climate Change Resilience.

1.1.1.2 The CCR assessment considers the resilience of the Proposed Development to the physical impacts of climate change. The IEMA guidance (IEMA, 2020[1]) defines CCR as the *"ability to respond to changes in climate. If a receptor or project has good climate change resilience, it is able to respond to the changes in climate in a way that ensures it retains much of its original function and form. A receptor or project that has poor climate change resilience will lose much of its original function or form as the climate changes"*.

1.1.1.3 In line with IEMA guidance (IEMA, 2020[1]), the CCR assessment qualitatively assesses the impacts and risks of climate change on the Proposed Development based on professional expertise and judgment. The assessment differs from many other Environmental Impact Assessment (EIA) topics in that it considers how the resilience of a development may be affected by an external factor (i.e., climate change), not how environmental receptors may be affected by a development's impacts. Therefore, the CCR impacts cannot be assigned significance with respect to the severity of impacts in the same way as for the other environmental topics. Instead, a risk-analysis based approach was used.

2 Climate Change Resilience Assessment Methodology

2.1.1 Study Area

2.1.1.1 The Caledonia Offshore Wind Farm (OWF) comprises Caledonia North and Caledonia South Array Areas and Offshore Export Cable Corridor (OECC), collectively referred to as the ('Proposed Development (Offshore)'). The Onshore Transmission Infrastructure (OnTI) comprises the transmission assets required to transfer power from the Proposed Development (Offshore) to the National Electricity Transmission System (NETS) and is referred to as the ('Proposed Development (Onshore)').

2.1.1.2 The study area for the CCR assessment is the area within the boundary for both the Proposed Development (Offshore) and Proposed Development (Onshore) and includes all relevant climate hazards for infrastructure and assets associated with the Proposed Development.

2.1.1.3 This appendix has been separated between the Proposed Development (Offshore) and Proposed Development (Onshore) assessments. The assumptions and limitations of these assessments are divided between construction and operation. This is due to the differing construction and operational requirements for both the Proposed Development (Offshore) and Proposed Development (Onshore) elements of the Proposed Development.

2.1.2 Overview of Methodology

2.1.2.1 The methodology outlined in this section is applicable to both the Proposed Development (Onshore) and Proposed Development (Offshore).

2.1.2.2 The methodology for the CCR risk-based assessment was as follows:

- Step 1: Identify the receptors (e.g., assets and asset groups) included within the Proposed Development that potentially will be at risk from climate change impacts;
- Step 2: Use future climate data to identify relevant climate change hazards (e.g., floods, heatwaves, or droughts) based on the Proposed Development, its location and the changes identified by reviewing climate change projections;
- Step 3: Determine the impact of climate change hazards on the receptors, noting that the assessment was qualitative using professional judgement from climate practitioners, and drawing on technical knowledge of infrastructure design within Caledonia Offshore Wind Farm Limited (the Applicant);

- Step 4: Consider the risk level and initial significance rating of each impact based on the definitions provided within the tables in Sections 2.1.3 Sensitivity and 2.1.5 Magnitude;
- Step 5: Determine the initial significance conclusions based on the matrix in Table 2-7;
- Step 6: Where significant risks were identified, further mitigation within the Proposed Development design was considered and incorporated into the initial assessment; and
- Step 7: Repeat the fourth step for all 'significant' risks, taking into account further mitigation and determine final significance conclusions based on the risk matrix given in Table 2-7.

2.1.2.3 The following climate change hazards have been considered in this CCR risk assessment:

- Increased air temperatures and extreme heat events (Onshore and Offshore);
- Increased frequency of storm events, including extreme winds and lightning (Onshore and Offshore);
- Changes to precipitation and increased flood risk (Onshore);
- Increased risk of drought (Onshore);
- Extreme wave heights (Onshore);
- Increased risk of drought (Onshore);
- Sea level rise and coastal erosion (Onshore); and
- Increased sea temperatures (Offshore).

2.1.2.4 As part of the CCR assessment, the potential sensitivity of the receptors (a combination of value (Table 2-1) and susceptibility (Table 2-2) and magnitude of the impact (a combination of consequence (Table 2-4) and frequency (Table 2-5) of climate change risks during operation of the Proposed Development are scored using a qualitative four-point scale. Definitions for the four components of the scoring (value, susceptibility, consequence, and frequency) are presented below.

2.1.3 Sensitivity

Value

2.1.3.1 The value of each receptor was scored in order to inform the assessment of the overall significance of climate change impacts. The value is qualitatively decided as a function of economic value but also of scale of importance for society, i.e. locally vs nationally important. The specific definitions used in the value scoring are presented in Table 2-1.

Table 2-1: Value definitions

Score	Value definition
High	High importance, e.g., internationally important/beneficial or of high economic value.
Medium	Medium importance, e.g., nationally important/beneficial or of medium economic value.
Low	Low importance, e.g., locally important/beneficial or of low economic value.

Susceptibility

2.1.3.2 The susceptibility of the receptors was considered, as defined in Table 2-2. The susceptibility was assessed when the climate hazard was short term in nature such as a flash flood, or heatwave. Here, consideration was given to how likely the climate hazard was to negatively impact upon the receptor, or the likelihood that a receptor will physically change or lose its function when risks occur, i.e. how resilient is the receptor to the risk or climate hazard.

Table 2-2: Susceptibility definitions for climate change risks

Score	Susceptibility definition
High	Receptor has no ability to withstand projected changes to existing/prevailing climatic hazards. AND/OR Receptor is likely to be substantially altered by the projected changes to existing/prevailing climatic hazards (i.e., to lose much of its original form and function).
Medium	Receptor has some ability to withstand projected changes to existing/prevailing climatic hazards. AND/OR Receptor is likely to be altered to some extent by the projected changes to existing/prevailing climatic hazards (i.e., to retain some elements of its original form and function).
Low	Receptor has the ability to withstand projected changes to existing/prevailing conditions. AND/OR Receptor is likely to only be minimally altered by the projected changes to the existing/prevailing climatic hazards (i.e., retains the majority of elements of its original form).
Negligible	Receptor can withstand projected changes to existing/prevailing climatic hazards. AND/OR Receptor is likely to not be altered by the projected changes to the existing/prevailing climatic hazards (i.e., will retain all of its original function and form).

2.1.4 Sensitivity Scoring

2.1.4.1 Sensitivity was then scored using a combination of using value and susceptibility as outlined in Table 2-3.

Table 2-3: Sensitivity matrix

		Susceptibility			
		High	**Medium**	**Low**	**Negligible**
Value	**High**	High Sensitivity	High Sensitivity	Medium Sensitivity	Low Sensitivity
	Medium	High Sensitivity	Medium Sensitivity	Low Sensitivity	Negligible Sensitivity
	Low	Medium Sensitivity	Low Sensitivity	Low Sensitivity	Negligible Sensitivity

2.1.5 Magnitude

Consequence

2.1.5.1 The consequence of an impact occurring was scored by analysing the possible economic impacts, the associated safety risks, reputational damage that might occur from the risk happening, and possible negative impact on the environment.

2.1.5.2 Table 2-4 presents the specific definitions used to score the consequence. All four aspects of consequence (economic, safety, reputational, and environmental) were considered separately for each risk and the aspect with the highest score was taken for the score of consequence.

Table 2-4: Definitions for consequences of climate change risks

Score	Magnitude definition
High	Very large economic cost or affects assets integral to critically important systems. Very large safety risk or poor performance. Prolonged negative national reporting impacting on reputation. Very large environmental pollution or harm, major breach in compliance and prosecution, adversely affects internationally important species/habitats.
Medium	Large economic cost or affects important asset. Large safety risks or poor performance. Negative regional media or social media. Large environmental pollution or harm, regulatory non-compliance, affects nationally important species/habitats.
Low	Small economic cost or affect to important systems. Presents moderate safety risks or slightly reduces performance.

Score	Magnitude definition
	Negative local media or adverse local stakeholder reaction. Moderate environmental pollution or harm, may cause non-compliance of regional or local policy, affecting locally important species/habitats.
Negligible	Little economic cost or affects individual assets and can be easily repaired/replaced. Very small or no safety risks or reduced performance. Little or no public interest. No statutory control or cause negligible environmental pollution or harm to receptors of little or no importance.

Frequency

2.1.5.3 The frequency of the climate hazard was used to help determine the magnitude of impact if the risk were to occur. The frequency scoring looked both at the number of times a hazard was likely to occur during the lifetime of the Proposed Development and how long the hazard was likely to last. Table 2-5 presents the specific definitions used to score frequency.

Table 2-5: Frequency definitions for climate change risks

Score	Frequency definition
High	Occurs many times during the lifetime of the Proposed Development (e.g., seasonally or lasts many years/ indefinitely).
Medium	Occurs more than once or lasts several months/one year.
Low	Occurs once or lasts several weeks.
Negligible	Unlikely to occurs during the design life or only lasts for a few days.

Magnitude Scoring

2.1.5.4 Magnitude is then scored using a combination of using consequence and frequency as outlined in Table 2-6.

Table 2-6: Magnitude matrix

		Consequence			
		High	**Medium**	**Low**	**Negligible**
Frequency	**High**	High Magnitude	High Magnitude	Medium Magnitude	Low Magnitude
	Medium	High Magnitude	Medium Magnitude	Low Magnitude	Negligible Magnitude
	Low	Medium Magnitude	Low Magnitude	Low Magnitude	Negligible Magnitude
	Negligible	Low Magnitude	Negligible Magnitude	Negligible Magnitude	Negligible Magnitude

2.1.6 Evaluation of Significance

2.1.6.1 The evaluation of significance is a product of the sensitivity and magnitude of each impact (Table 2-7). Final significance conclusions for each impact incorporate confirmed Proposed Development design and mitigation measures.

Table 2-7: Significance matrix

		Sensitivity			
		High	Medium	Low	Negligible
Magnitude	**High**	Major (S)	Major/Moderate (S)	Moderate/Minor (NS)	Minor/Negligible (NS)
	Medium	Major/Moderate (S)	Moderate (NS)	Minor (NS)	Negligible (NS)
	Low	Moderate/Minor (NS)	Minor (NS)	Minor (NS)	Negligible (NS)
	Negligible	Minor/Negligible (NS)	Negligible (NS)	Negligible (NS)	Negligible (NS)
S = Significant | NS = Not Significant					

3 Offshore climate projections summary

3.1 Introduction

3.1.1.1 A review of the literature and data for offshore climate change projections, was used to provide an overview of the future environment for the offshore elements of the Proposed Development (Offshore).

3.1.1.2 The primary data sources used in this assessment, as per IEMA guidance (IEMA, 2020[1]), are listed below:

- The UK Climate Projections (UKCP) 18 accessed via Met Office user interface (United Kingdom Climate Projections 2018 (UKCP18)) (Met Office, 2018)[2];
- UKCP18 additional fact sheet (Met Office, 2018a)[3];
- United Kingdom Climate Projections 2009 (UKCP09) marine data accessed via Centre for Environmental Data Analysis (CEDA) archive projections (CEDA Archive, 2017)[4] ; and
- Marine data from the global model Coupled Model Intercomparison Project (CMIP) (Gutiérrez et al, 2021[5]) was also used to complement the UKCP09 data where variables were not available within UKCP, or where a wider range of dates and climate scenarios were available.

3.1.1.3 This data has been supplemented by several reports prepared and published by the Marine Climate Change Impacts Partnership (MCCIP) (MCCIP, 2022[6]), which provides a comprehensive summary of academic evidence and predictions for changes within the UK marine climate.

3.2 Wind, waves and storms

3.2.1.1 This section summarises the current evidence on how climate change is expected to alter offshore storm events, including high winds and extreme waves. All information on wind, waves and storms has been taken from the MCCIP's summary of the topic (MCCIP, no date)[7] and the related most recent technical paper (Bricheno et al., 2023[8]):

- There is uncertainty regarding future predictions for storms and waves, and it is expected that the frequency and intensity of waves and storms will continue to be influenced by natural variability rather than climate change;
- Future trends are difficult to predict due to a low confidence in attributing historic trends in storms and waves to climate change;
- Ongoing changes in the climate may potentially affect storms with cumulative effects on wind and wave heights;
- In terms of wave height, the mean significant wave height in the north of the UK has reduced over the last 30 years compared with an increase in the south; and

- Data suggests that the trend of an overall reduction in mean significant wave height in the north of the UK will continue through to 2100 but that the height of the most severe waves could increase by the year 2100. These wave height projections are further supported by simulations undertaken for the UKCP18 at Representative Concentration Pathway 8.5 (RCP 8.5) that suggest average wave heights decreasing by 10-20%, with a tendency toward lower wave heights for the 21st Century.

3.3 Sea surface and near bottom temperatures

3.3.1.1 This section summarises the current evidence on how climate change is expected to impact sea surface and near bottom temperatures. All information in this section has been taken from the MCCIP's summary of the topic (MCCIP, no date[9]) and their related most recent technical paper (Cornes et al., 2023[10]):

- Over the past 30 years Sea Surface Temperature (SST) around the UK has generally shown a warming trend of around 0.3°C per decade. This has regional variations and is not consistent across the seas surrounding the UK. In northern region of the North Sea at 0-100m depth, most years since 2000 have been above the 1991-2020 average, while all years prior to 2000 that time were below the average;
- Compared with 1982–1998, the annual number of marine heatwaves has increased around the UK by four events per year on average in the period 2000–2016. However, even larger increases of up to six additional events per year occurred to the north of the British Isles;
- Model simulations indicate a continuing warming trend around the UK, with annual average SST values of 3.11°C (±0.98°C) predicted for the end of the century (2079–2098) under the business-as-usual RCP8.5 scenario; and
- The warming is expected to be greatest across the North Sea in both SST and bottom temperatures, which is a continuation of the spatial pattern of trend observed in recent decades. Specifically for the Northern North Sea an increase of 3.14℃ (±1.02°C) is projected.

3.3.1.2 Climate projection data for both SST and near bottom temperature has been gathered from two sources and summarised for the Proposed Development (Offshore). Table 3-1 and Table 3-2 presents this data and the values reflect the findings of the MCCIP, illustrating a warming trend. The UK specific data was taken from UKCP09 climate projections, whilst now a historical dataset this provides the most appropriate data of this type. In addition, the closest time period to the operation of the Proposed Development (Offshore) available was 2070-2099 and therefore is likely an overestimation of the changes seen within the lifespan of the Proposed Development (Offshore).

Table 3-1: Projected changes to sea surface and near-bottom temperatures for the Proposed Development (Offshore) Array Area. Data is from the UKCP09 dataset.

Temperature variable	1961-1990	2070-2099
Sea surface	℃	℃
Maximum daily mean sea water potential temperature	8.83	11.08
Mean sea water potential temperature	6.65	9.61
Minimum daily mean sea water potential temperature	4.25	6.24
Near - bottom		
Maximum daily mean sea water potential temperature	8.68	10.94
Mean sea water potential temperature	6.65	9.56
Minimum daily mean sea water potential temperature	4.32	6.52

Table 3-2: Projected changes to sea surface temperatures for the Proposed Development (Offshore) Array Area. Data is from the CMIP6 dataset.

Projection Scenario	*Date*	Sea surface temperature (℃)
Baseline	*1995-2014*	10.19
Near term	*2021-2040*	10.46
Medium term	*2041-2060*	10.88
Long term	*2081-2100*	12.25

3.4 Dissolved oxygen

3.4.1.1 This section summarises the current evidence on how climate change is expected to have on dissolved oxygen. All information in this section has been taken from the MCCIP's summary of the topic (MCCIP, no date[11]) and their related most recent technical paper (Mahaffey et al., 2023[12]):

- Dissolved oxygen is vital for all marine life. Oxygen is more soluble in colder water and less soluble in warmer water. Since the 1960s, global oceanic oxygen content has declined by more than 2%;
- Observations in the North Sea show the recent onset of oxygen deficiency in late summer, partly due to ocean warming. The intensity and extent of oxygen deficiency has also increased over time; and

- Future projections suggest that under a high emissions scenario (RCP 8.5), for UK shelf waters, annual mean oxygen concentration will decline most in North Sea regions and the Celtic Sea (with decreases of around 5.6% to 5.9% by 2100).

3.5 Salinity

3.5.1.1 This section summarises the current evidence on how climate change is expected to impact salinity. All information in this section has been taken from the MCCIP's summary of the topic (MCCIP, no date[13]) and their related most recent technical paper (Dye et al.,2020[14]):

- The salinity of UK shelf seas, and the adjacent Atlantic Ocean, has been highly variable on annual and decadal timescales. There are no clear long-term trends;
- Most 21st Century projections suggest that UK shelf seas, and the adjacent Atlantic Ocean, will be less saline than present, driven by ocean-circulation changes in response to climate change; and
- Greater salinity decreases are projected for the North Sea, than the Irish and Celtic Seas.

3.5.1.2 Additionally, projected data for salinity was taken from the UKCP09 Marine projections and is shown in Table 3-3.

Table 3-3: Projected changes to mean salinity, extracted for the Array Area from UKCP09 Marine projections

Mean salinity (*0.001*)	Baseline (1961-1990)	Future (2070 – 2099)
Sea surface	34.95	34.7
Near - bottom	34.96	34.7

3.6 Stratification

3.6.1.1 This section summarises the current evidence on how climate change is expected to impact ocean stratification. All information in this section has been taken from the MCCIP's summary of the topic (MCCIP, no date[15]) and their related most recent technical paper (Sharples et al., 2022[16]):

- Stratification is the process by which less dense water sits above a layer of more dense water. Stratification restricts exchange of water between layers, this limits the exchange of nutrients, phytoplankton, and dissolved gases. Stratification also limits the ventilation of waters beneath the surface mixed layer, with a gradual decrease of oxygen in bottom waters throughout summer months until winter remixing of the entire water column allows replenishment of the oxygen deficit from the atmosphere;

- There is a suggestion of earlier onset of seasonal stratification in UK shelf seas and tentative evidence of long-term trends in the strengthening of stratification. Projections suggest that by 2100, thermal stratification in UK shelf seas will extend in duration by around 2 weeks (with both earlier onset and later breakdown), and increase in strength, due to changes in air temperature; and
- However, UKCP09 data taken from the expected location of the Proposed Development (Offshore) Array Area, suggests that on average the number seasonally stratified days will decrease slightly in the future from 48.1 to 47.1 days.

3.7 Ocean acidification

3.7.1.1 This section summarises the current evidence on how climate change is expected to impact ocean acidification. All information in this section has been taken from the MCCIP's summary of the topic (MCCIP, no date[17]) and their related most recent technical paper (Findlay et al., 2022[18]):

- Ocean acidification is an effect of climate change, whereby the physical and chemical properties of the ocean are altered, with resulting impacts on marine life. Ocean acidification occurs when increases in emitted carbon dioxide (CO_2) are absorbed by the ocean causing a decline in pH. The world's oceans are a major sink for anthropogenic CO_2 emissions, with around a quarter being absorbed by the oceans;
- Ocean acidification is a problem for two reasons, firstly when CO_2 is absorbed by the ocean, hydrogen ions are released (which therefore reduces pH) and are available to bond to carbonate ions, which then reduces the concentration of carbonate ions available for calcifying organisms. Secondly, this process of ocean acidification also reduces the potential for the ocean to absorb and store atmospheric CO_2 in the future;
- The bottom waters around the UK are projected to experience faster rates of reduction in pH. Trends of change in the pH of bottom waters of the greater North Sea are 0.0040/yr under a high emission scenario; and
- Models project that the average continental shelf seawater pH will continue to decline to year 2050 at similar rates to the present day, with rates of reduction then increasing in the second half of the century, depending on the emissions scenario.

3.7.1.2 Additionally, projected data for pH levels were from the Coupled Model Intercomparison Project Phase 6 (CMIP6) Marine projections via the Intergovernmental Panel on Climate Change (IPCC) interactive atlas[19] and this data is shown in Table 3-4.

Table 3-4: Projected pH level at surface level from the CMIP6 climate model.

Projection Scenario	Date	Projected pH level
Baseline	1995-2014	8.125
Near term	2021-2040	8.045
Medium term	2041-2060	7.691
Long term	2081-2100	7.949

3.8 Sea level rise and resultant coastal flooding

3.8.1.1 This section summarises the current evidence on how climate change is expected to have on sea level rise around the UK. All information in this section has been taken from the MCCIP's summary of the topic (MCCIP, no date[20]) and their related most recent technical paper (Horsburgh et al.,2020[21]), as well as the Met Office UKCP18 fact sheet on sea level rise (Met office, 2023[22]):

- Sea level rise and coastal erosion are potential impacts of climate change. Sea level rise is caused by a combination of the continuing decline in sea ice, of land-based ice such as glaciers and ice caps, and the thermal expansion of seawater;
- A long-term increase in the rate of sea level rise in the 20th Century is well-documented and the average rate of global sea level was around 3.2mm per year between 1993 and 2010;
- Projected sea level rise varies across the UK due to local variation in vertical land movement (glacial isostatic adjustment since the last ice age). When accounting for this generally in the UK, less sea level rise is projected in Northern locations. UKCP18 climate projections collated for the project suggest that under the high emissions scenario (RCP8.5), the coastal region within the boundary of the Proposed Development is expected to see a rise in sea level of 0.12m by 2033 (end of the construction latest construction scenario) and 0.29m by 2058 (end of the worst-case operational appraisal period);
- In the UK, there is no observational evidence for long-term trends in either storminess around the UK or resultant storm surges. Storm surge simulations for the 21st Century suggest a best estimate of no significant changes to storm surges; and
- Scottish Environment Protection Agency (SEPA) flood maps show no risk of coastal flooding, current and future, within the boundary of the Proposed Development (Onshore).

4 Climate Change Resilience Assessment Results

4.1 Construction Assessments

4.1.1 Offshore Receptors

4.1.1.1 The assessment includes the main assets that are potentially at risk from projected changes in climate.

4.1.1.2 The receptors (both assets and processes) included within the Proposed Development (Offshore) that would potentially be at risk from climate change impacts are as follows:

- Wind Turbine Generators (WTG) and substructures, both fixed and floating (partially built or complete);
- Vessels;
- Offshore substation platform (partially built or complete);
- Offshore substation platform electrical equipment;
- Harbour/onshore storage facilities (buildings, materials, plant and other equipment);
- Construction staff; and
- Construction materials, plant and equipment (stored offshore).

4.1.2 Offshore Assumptions

4.1.2.1 The following assumptions were made during the scoring process:

- Safety decisions and safety best practice will develop over time to consider any impact of climate change on operations and maintenance (O&M) activities, and asset management;
- Contingency is included in the construction program to consider the possible impacts of adverse weather events on marine activities;
- Seasonal variation in weather and metocean conditions will be considered in the planning of marine activities. Offshore activities will be constrained by the safe working limits of vessels and equipment, for example sensitivity to wind speed or wave height;
- Vessel movements and, O&M activities will be monitored and managed via marine coordination and control procedures. During adverse weather, vessels will remain in or return to port, or relocate to a designated coastal shelter area;
- The safety of project personnel will be prioritised and mobilisation to the offshore site will be subject to the safe working limits of the vessels; and

- Offshore work will be postponed during adverse weather events, where conditions are, or are forecasted to, exceed the safe working limits of vessels or the planned activity.

4.1.3 Proposed Development (Offshore) Results

4.1.3.1 The results from the CCR assessment can be found in Table 4-1.

Table 4-1: Proposed Development (Offshore) Construction CCR Assessment

Receptor	Risk	Embedded Mitigation	Value	Susceptibility	Sensitivity Score	Frequency	Consequence Category	Consequence Narrative	Magnitude Score	Overall Score	Significance Conclusion
Hazard: Increased storms including high wind and lightning strikes											
Offshore physical assets: WTGs - fixed and floating (partially built or complete) OSPs and associated electrical equipment (partially built or complete)	High wind and lightning strikes can cause damage or reduce structural integrity of the offshore assets.	The design and construction of WTGs and OSPs will consider all relevant design codes which include safety factors to account for extreme weather events. Equipment on the OSP would be fully secured in anticipation storms and extreme weather.	**Medium:** WTG/OSP installation and construction integral to the Proposed Development (Offshore). However, this receptor is not considered internationally important during construction.	**Medium:** The assets will be designed to withstand high wind speed. WTGs are susceptible to lightning, but it is likely that only one or a small number of the Array Area would be affected at once, if at all.	Medium	**Low:** Evidence for future storm changes suggests there will not be a large increase to the frequency of storms during the construction period.	Environmental	**Low:** In worst cases small amounts of debris from damaged turbines could be lost in the sea.	Low	Minor	Not significant
							Safety	**Negligible:** Staff safety regulations will ensure staff safety is adequately considered to minimise risk during severe storms.			
							Economic	**Low:** Some economic costs may be associated with damage and associated repair.			
							Reputational	**Negligible:** No reputational damage anticipated.			
Vessels	Possible vessel delays and schedule disruption.	Consideration for such disruptions will be considered within construction programming.	**Low:** Vessel trips for the Proposed Development (Offshore) are of local importance.	**Low:** Vessel trips consider weather, storms may cause delays.	Low	**Low:** Evidence for future storm changes suggests there will not be a large increase to the frequency of storms during the construction period.	Environmental	**Negligible:** No environmental consequences are anticipated.	Low	Minor	Not significant
							Safety	**Negligible:** No safety consequences are anticipated.			
							Economic	**Low:** Some small economic costs may be associated with vessel trip and construction delays.			
							Reputational	**Negligible:** Unless long delays occur, no reputational damage anticipated.			

Receptor	Risk	Embedded Mitigation	Value	Susceptibility	Sensitivity Score	Frequency	Consequence Category	Consequence Narrative	Magnitude Score	Overall Score	Significance Conclusion
Harbour storage facilities (buildings, materials, plant and other equipment)	High wind and lightning strikes can cause damage to or reduce structural integrity of harbour facilities.	Assumed all materials are securely stored and not likely to be blown or damaged by high winds.	**Medium:** Harbour facilities and the materials and equipment stored are integral to the Proposed Development (Offshore).	**Low:** Materials and equipment will be stored securely. Where stored outside, further action will be taken to reduce damage in oncoming storm events.	Low	**Medium:** Evidence for future storm changes suggests there will not be a large increase to the frequency of storms during the construction period.	Environmental	**Negligible:** No environmental consequences anticipated.	Medium	Minor	Not significant
							Safety	**Low:** Unless severe damage occurs, low safety concerns for staff.			
							Economic	**Medium:** Some economic costs may be associated with damage to expensive equipment.			
							Reputational	**Low:** Unless long delays occur, no reputational damage anticipated.			
Staff	Direct physical risks to staff during storms from wind or direct strikes from lightning.	Rigorous health and safety (H&S) protocols will be adhered to and so staff unlikely to continue working during a storm.	**High:** Human life and wellbeing always scored as high.	**Low:** It is assumed that strict health and safety procedures will be adhered to meaning that only in exceptional circumstances would staff be outdoors and exposed during storms.	Medium	**Medium:** Evidence for future storm changes suggests there will not be a large increase to the frequency of storms during the construction period.	Environmental	**Negligible:** No environmental consequences are anticipated.	Medium	Minor	Not significant
							Safety	**Medium:** Major harm to staff may occur from high winds or lightning if exposed. It is unlikely staff will be working during such conditions.			
							Economic	**Negligible:** No economic consequences anticipated.			
							Reputational	**Medium:** Reputational damage possible were serious harm or injury to occur.			
Hazard: Increased extreme / severe wave heights											
Offshore physical assets: WTGs - fixed and floating (partially built or complete)	Potential damage or increased asset degradation and reduced lifespan.	Design standards/ thresholds to account for extreme waves heights.	**Medium:** WTG/OSP installation and construction integral to the Proposed Development (Offshore).	**Low:** Extreme waves heights will be carefully considered in design thresholds.	Low	**Low:** There is uncertainty in how storms and extreme waves will change in the future; wave heights may decrease over time.	Environmental	**Low:** In worst cases small amounts of debris from damaged turbines could be lost in the sea.	Low	Minor	Not significant
							Safety	**Negligible:**			

Receptor	Risk	Embedded Mitigation	Value	Susceptibility	Sensitivity Score	Frequency	Consequence Category	Consequence Narrative	Magnitude Score	Overall Score	Significance Conclusion
OSPs and associated electrical equipment (partially built or complete)			However, receptor is not considered internationally important during construction.					Staff safety regulations ensure staff will not be at sea during severe storms.			
							Economic	**Low:** Some economic costs may be associated with damage and repair.			
							Reputational	**Negligible:** No reputational damage anticipated.			
Vessels	Possible vessel delays and schedule disruption.	Consideration for such disruptions will be considered within construction programming.	**Low:** Vessel trips for the Proposed Development (Offshore) are of local importance.	**Low:** Vessel trips dependent on weather, storms may cause delays.	Low	**Low:** There is uncertainty in how storms and extreme waves will change in the future; wave heights may decrease over time.	Environmental	**Negligible:** No environmental consequences are anticipated.	Low	Minor	Not significant
							Safety	**Negligible:** No safety consequences are anticipated.			
							Economic	**Low:** Some small economic costs may be associated with vessel trip and construction delays.			
							Reputational	**Negligible:** Unless long delays occur, no reputational damage should occur.			
Staff	Direct physical risk to staff during in high waves.	Rigorous health and safety protocols will be adhered to and so staff unlikely to be at sea working during storms or extreme swells.	**High:** Human life and wellbeing always scored as high.	**Low:** It is assumed that strict health and safety procedures will be adhered to meaning that only in exceptional circumstances would staff be outdoors and exposed during storms or extreme swells.	Medium	**Low:** There is uncertainty in how storms and extreme waves will change in the future; wave heights may decrease over time.	Environmental	**Negligible:** No environmental consequences are anticipated.	Medium	Minor	Not significant
							Safety	**Medium:** Major harm to staff may occur from high waves if exposed. It is unlikely staff will be working during such conditions.			
							Economic	**Negligible:** No economic consequences anticipated.			
							Reputational	**Medium:**			

Receptor	Risk	Embedded Mitigation	Value	Susceptibility	Sensitivity Score	Frequency	Consequence Category	Consequence Narrative	Magnitude Score	Overall Score	Significance Conclusion
								Reputational damage possible were serious harm or injury to occur.			
Construction materials, plant and equipment (stored offshore)	Risk of damage or loss from high winds/ storm surge	Assumed equipment stored offshore will be minimal and any that is stored offshore will be stored securely. Work will not be carried out during extreme storms with high waves heights.	**Medium:** Materials and equipment stored are integral to the Proposed Development (Offshore).	**Low:** Materials and equipment will be stored securely. Where stored outside, further action will be taken to reduce damage in oncoming storm events.	Low	**Low:** There is uncertainty in how storms and extreme waves will change in the future; wave heights may decrease over time.	Environmental	**Negligible:** No environmental consequences are anticipated.	Medium	Minor	Not significant
							Safety	**Low:** Unless severe damage occurs, low safety concerns for staff.			
							Economic	**Medium:** Some economic costs may be associated with damage to expensive equipment.			
							Reputational	**Negligible:** Unless long delays occur, no reputational damage anticipated.			
Hazard: Increased air temperature / extreme heat events											
Offshore physical assets: WTGs - fixed and floating (partially built or complete) OSPs and associated electrical equipment (partially built or complete)	Increased temperatures have potential to damage, or reduce structural integrity of the offshore assets. Overheating of electrical equipment causing malfunction	Assumed that design upper temperature thresholds will accommodate future changes to temperature. Electrical equipment will be housed in buildings or protected to reduce the impacts of direct sunlight.	**Medium:** WTG/OSP installation and construction integral to the Proposed Development (Offshore). However, receptor is not considered internationally important during construction.	**Low:** The assets will be designed to withstand future temperature changes seen in the North of Scotland.	Low	**Low:** Heatwaves and extreme heat occur regularly now and will continue to rise in frequency and intensity; North of Scotland is much less intense than other parts of the UK.	Environmental	**Negligible:** No environmental consequences are anticipated.	Low	Minor	Not significant
							Safety	**Low:** Minimal safety consequences are anticipated.			
							Economic	**Medium:** Some small economic costs may be associated with damage and repair.			
							Reputational	**Negligible:** No reputational consequences are anticipated.			
Staff	Heat health risks such as heat stroke, heat	Rigorous health and safety protocols will be adhered to during hot weather.	**High:** Human life and wellbeing always scored as high.	**Low:** Health and safety protocols and standard protective measures	Medium	**Low:** Heatwaves and extreme heat occur regularly now and will	Environmental	**Negligible:** No environmental consequences are anticipated.	Low	Minor	Not significant

Receptor	Risk	Embedded Mitigation	Value	Susceptibility	Sensitivity Score	Frequency	Consequence Category	Consequence Narrative	Magnitude Score	Overall Score	Significance Conclusion
	exhaustion or heat related mortality.			such suncream, summer personal protective equipment (PPE) and hydration breaks will reduce the susceptibility of staff.		continue to rise in frequency and intensity; North of Scotland is much less intense than other parts of the UK.	Safety	**Medium:** Medical treatment may be required if any staff develop heat stroke while working in extreme temperatures.			
							Economic	**Negligible:** No economic costs are anticipated with this risk.			
							Reputational	**Low:** Reputational damage possible were serious harm or injury occur.			

4.1.4 Onshore Receptors

4.1.4.1 The assessment includes the main assets that would potentially be at risk from projected changes in climate.

4.1.4.2 The onshore construction receptors (both assets and processes) included within the Proposed Development (Onshore) that would potentially be at risk from climate change impacts are as follows:

- Car parking and access roads;
- Drainage and associated assets;
- Buildings and structures;
- Electrical equipment;
- Sewerage and septic tank;
- Landscaping;
- Fencing;
- Underground cabling;
- Construction staff;
- Vehicle movements;
- Stored construction materials;
- Construction plant/equipment; and
- Trenching.

4.1.5 Onshore Assumptions

4.1.5.1 The following assumptions were made during the scoring process:

- Extreme heat is unlikely to affect the receptors of construction materials and equipment and movements. Therefore, this was not assessed. Nevertheless, materials and equipment shall be stored in accordance with packaging and handling requirements;
- Extreme heat is unlikely to affect trenching and cabling as this receptor is underground therefore this risk was not assessed;
- The hazards of storms, flooding and drought will not impact on construction staff, as staff will not work in weather deemed unsafe; and
- Temporary drainage will minimise flood risk during the construction phase.

4.1.6 Onshore Results

4.1.6.1 The results from the initial CCR assessment can be found in Table 4-2.

Table 4-2: Proposed Development (Onshore) Construction CCR Assessment

Receptor	Risk	Embedded mitigation	Value	Susceptibility	Sensitivity score	Frequency	Consequence Category	Consequence	Magnitude	Overall score	Significance Conclusion
Extreme heat											
Construction staff	Health and safety risks to staff from heath related illnesses (Heat stroke, heat exhaustion, sunburn).	Staff safety will be addressed through correct H&S procedures relating to working in poor/extreme weather conditions.	**High:** Human life and wellbeing always valued as high.	**Negligible:** Though human health susceptibility is present, comprehensive health and safety procedures and knowledge of heat health risks mean that staff are aware of risks arising from effects of heat on working conditions and effects of long working times in hot weather.	Low	**Medium:** Heatwaves are likely to occur most years during the construction period. However, heatwaves intense enough to cause significant human health risk will represent a portion of such events.	Environmental	**Negligible:** No environmental consequences are anticipated.	Medium	Minor	Not significant
							Safety	**Medium:** Some heat health risks may arise, resulting in illness for staff, though this is likely to be effectively managed.			
							Economic	**Low:** Small loss of productivity and economic costs may arise due to ill health.			
							Reputational	**Medium:** There is potential for Health and Safety incidents to cause reputational risk, at the extreme resulting in possible legal action if severe.			
Other physical assets (Landscaping, fencing, sewerage and septic tanks, car parks and drainage assets) – built and partially built assets.	Risk of material damage e.g. asphalt melting (heat is unlikely to impact other assets directly; additionally, indirect risks such as ground subsidence are discussed under the consideration of risks arising from drought)	Car parks will use asphalt with industry standard temperature thresholds which are unlikely to be surpassed in the North of Scotland during the construction phase.	**Low:** Though access and car parking are important to the construction phase they have has low financial value and does not present critical infrastructure required for project delivery.	**Low:** Due to the embedded mitigation identified it is assumed to have a low susceptibility.	Low	**Low:** Temperatures warm enough to melt asphalt and cause damage are unlikely to occur during the construction phase in the North of Scotland.	Environmental	**Negligible:** No environmental consequences are anticipated.	Low	Minor	Not significant
							Safety	**Negligible:** It is assumed no safety risks arise.			
							Economic	**Low:** Small costs associated with repair/ re-laying asphalt.			
							Reputational	**Negligible:** No reputational damage is anticipated.			
Onshore Substations and electrical equipment: built and partially built assets	Risk of increased extreme thermal expansion of structure; and risk of overheating / malfunctioning of electrical equipment.	Assumed that upper temperature thresholds within design will accommodate future changes to temperature.	**Medium:** Onshore substation will contain electrical equipment which is vital to the successful operation of	**Low:** Embedded mitigation and design thresholds mean that this receptor is not likely to be susceptible to future temperature changes seen in the North of Scotland.	Low	**Low:** Heatwaves and extreme heat occur regularly now and will continue to rise in frequency and intensity although not significantly across the	Environmental	**Negligible:** No environmental consequences are anticipated.	Low	Minor	Not significant
							Safety	**Low:** Unless severe damage occurs, low safety concerns for staff.			
							Economic	**Medium:**			

Receptor	Risk	Embedded mitigation	Value	Susceptibility	Sensitivity score	Frequency	Consequence Category	Consequence	Magnitude	Overall score	Significance Conclusion
		Electrical equipment will be housed in buildings or encased in a protective outer cover reducing the impacts of direct sunlight and internal temperature gains.	the project, although this is unlikely to be present for the full Construction period.			construction phase period.		Damage to the built or partially built structure or electrical equipment during construction would mean moderate economic costs to the project both in repair costs and subsequent construction delays.			
							Reputational	**Negligible:** No reputational damage is anticipated.			
Increased occurrence of storms including high wind events and lightning strikes during storms.											
Other physical assets above ground (Landscaping, fencing, sewerage and septic tanks, car parks and drainage assets) – built and partially built assets.	High wind events and lightning strikes have the potential to cause damage, loss or reduced structural integrity of the above ground assets.	No specific embedded mitigation beyond general design approach.	**Low:** Though access and car parking are important to the construction phase they have has low financial value and does not present critical infrastructure required for project delivery.	**Medium:** Susceptibility is variable for different elements with fencing particularly is susceptible to high winds.	Low	**Medium:** Evidence for future storm changes suggests there will not be a large increase to the frequency of storms during the construction period.	Environmental	**Negligible:** No environmental consequences are anticipated.	Low	Minor	Not significant
							Safety	**Negligible:** No safety consequences are anticipated.			
							Economic	**Negligible:** Primary risk likely to be to fencing and other elements with minimal replacement cost.			
							Reputational	**Negligible:** No reputational damage anticipated.			
Onshore Substations and electrical equipment. - built and partially built assets	High wind events and lightning strikes have the potential to cause damage, loss or reduced structural integrity of the Proposed Development (Onshore) infrastructure / facilities.	It is assumed all structural assets are designed using the return period method to withstand a specific size of extreme event that has a set probability of occurring. It is also assumed that electrical equipment will be shielded from high winds and have in built protection account lightning and resultant electrical surges.	**Medium:** In the construction phase these structures are integral to the Proposed Development (Onshore). However, this receptor would not be considered internationally important during construction.	**Low:** Due to embedded mitigation, it is assumed that the assets will be designed to withstand high windspeed and protected from potential lightning strikes.	Low	**Medium:** Evidence on how storms will change with climate change is unclear. However, the information suggests there will not be a significant change to the frequency of storms during the construction period. Though storms are likely to occur yearly.	Environmental	**Negligible:** No environmental damage anticipated.	Medium	Minor	Not significant
							Safety	**Negligible:** Assumed no safety risk as construction work would pause during inappropriate weather			
							Economic	**High:** Damage to the substation structure would result in large economic costs for the project and subsequent serious delays to construction.			
							Reputational	**Negligible:** No reputational damage anticipated.			

Receptor	Risk	Embedded mitigation	Value	Susceptibility	Sensitivity score	Frequency	Consequence Category	Consequence	Magnitude	Overall score	Significance Conclusion
Flooding											
The construction site and built or partially built assts the following receptors are included: Other physical assets (Landscaping, fencing, sewerage and septic tanks, car parks and drainage assets) – built and partially built assets. Onshore Substations and electrical equipment. - built and partially built assets Construction (construction processes including materials, equipment and movements)	Direct or indirect damage from flooding / water logging of the construction site with potential to impact on all individual assets.	Temporary drainage across construction sites will be designed to effectively drain sites to prevent surface water flooding during the construction phase.	**Medium:** The construction site in its entirety, as well as partially built individual assets, have been assigned a medium value. Value of interim construction site will increase as assets are built out.	**Low:** The assessment of pluvial and fluvial flood risk is set out in Volume 5, Chapter 6: Hydrology and Hydrogeology; it concludes these flood risks to be not significant in EIA terms after appropriate mitigation measures have been implemented. The temporary sites during construction will have appropriately designed temporary drainage to ensure the site does not suffer flooding or excess retention of water.	Low	**Low:** Due to current low flood risk, the risk that a significant flood event will take place within the construction period is considered to be low.	Environmental	**Medium:** Potential for some minor environmental damage to take place should flooding / excess water result in release/discharge of pollutants into existing watercourses.	Low	Minor	Not significant
							Safety	**Negligible:** Assumed no safety risk as construction work would pause during inappropriate weather.			
							Economic	**Low:** Some financial costs associated with site flooding these would vary depending on the extent of flooding and subsequent damage. However, overall are likely to be low in the context of the overall Proposed Development.			
							Reputational	**Negligible:** No reputational damage anticipated.			
Drought											
Drought occurrence causing ground cracking or subsidence effecting receptors such as: Onshore physical assets (Landscaping, fencing, sewerage and septic tanks, car parks and drainage assets) – built and partially built assets. Buried assets (transition joint bay (TJB), export cables and other joint bays) and trenching during construction.	Drought occurrence causing ground cracking or subsidence and subsequent damage to built, or partially built, assets.	Drainage will be adequate to ensure that soils does not get excessively wet (which can contribute to subsidence by causing weaknesses within the ground). Some mitigation of risk will be achieved through drainage strategy (inadequate drainage can lead to increased vulnerability to subsidence etc during periods of low rainfall).	**Medium:** Trenching and cabling is vital to the completion of the Proposed Development (Onshore) during construction.	**Low:** There is no evidence to suggest that the ground within the OnTI Red Line Boundary (RLB) is particularly susceptible to subsidence due to the soils.	Low	**Low:** It is expected that drought sufficiently extreme to cause subsidence is unlikely to occur during the construction period.	Environmental	**Negligible:** No environmental consequences are anticipated.	Low	Minor	Not significant
							Safety	**Negligible:** No safety risks anticipated.			
							Economic	**Medium:** Moderate economic costs associated with repairing the ground/buildings and any associated damage.			
							Reputational	**Negligible:** No reputational damage anticipated.			

4.2 Operational Assessments

4.2.1 Offshore Receptors

4.2.1.1 The assessment includes the main assets that are at risk from projected changes in climate.

4.2.1.2 The receptors included within the Proposed Development (Offshore) that would potentially be at risk from climate change impacts are as follows:

- Vessels;
- Operations and maintenance (O&M) activities;
- WTGs and substructure (fixed and floating);
- Inter-array cables and offshore export cables;
- Offshore Substation Platform structure; and
- Offshore Substation Platform electrical equipment.

4.2.2 Offshore Assumptions

4.2.2.1 The following assumptions were made during the scoring process:

- Offshore O&M activities will take place within the safe working limits of vessels and equipment and not take place under unsuitable weather conditions such as storms of extremely rough seas and severe heatwaves beyond what is considered appropriate at this time. Such events will be assessed by operational health and safety procedures and risk assessment, and it is likely any checks or maintenance will simply be delayed until a suitable a weather window becomes available. Therefore, minimal additional safety risks to staff will results from these weather hazards during operation for offshore and this is not assessed further.
- It is assumed that storm damage would only be to a partial section of the WTG Array Area. The scoring does not consider damage to all, or a significant proportion of the offshore assets being impacted, as this is a much less likely scenario.

4.2.3 Offshore Results

4.2.3.1 The results from the CCR assessment can be found in Table 4-3.

Table 4-3: Proposed Development (Offshore) Operation CCR Assessment

Receptor	Risk	Embedded Mitigation	Value	Susceptibility	Sensitivity Score	Frequency	Consequence Category	Consequence	Magnitude Score	Overall Score	Significance Conclusion
Increased occurrence of storms including high wind and lightning strikes.											
Maintenance (including vessel trips to and from offshore assets)	Delays in maintenance and subsequent degradation of assets	Scheduled maintenance for when storms are less likely, as far as possible. Any unplanned maintenance will take place during suitable safe working weather windows. Some flexibility will be built into maintenance schedules to account for possible delays.	**Low:** Though maintenance is vital to the continued functioning of the Proposed Development (Offshore), if delayed it can be rescheduled, and is unlikely to be delayed for a significant amount of time.	**High:** Trips for offshore O&M activities are highly reliant on the correct weather conditions. Therefore, this receptor is susceptible to storms and storm events including high waves. It is assumed that staff will not work offshore during extreme weather, complying with health and safety standards.	Medium	**High:** Though there is some uncertainty in the projections it is likely that climate change will increase the frequency of storm conditions and high winds which will occur during operation of the Proposed Development (Offshore). Storms strong enough to delay vessel movements are likely to occur most years during operation.	Environmental	**Negligible:** No environmental consequences are anticipated.	Low	Minor	Not significant
							Safety	**Negligible:** No safety consequences are anticipated.			
							Economic	**Negligible:** There may be some impacts to the Proposed Development (Offshore) both directly and indirectly due to delayed maintenance and possible asset degradation due to delayed maintenance (though this is anticipated to be minimal).			
							Reputational	**Negligible:** No reputational consequences are anticipated.			
Offshore physical assets: WTGs - fixed and floating OSPs and associated electrical equipment	Risk of physical damage	WTGs are likely to have lightning and surge protection. As is electrical equipment within the OSP. All physical assets will be designed to be resilient to extreme high winds. These are likely to be thresholds higher than expected during the operational period.	**Medium:** WTGs/OSPs are integral to the operation of the Proposed Development. However, it is highly unlikely that this hazard would impact the full array area collectively at once.	**Low:** Assets will be designed to function within severe storms and be resilient to their impacts.	Low	**High:** Though there is some uncertainty in the projections it is likely that climate change will increase the frequency of storm conditions and high winds which will occur during operation of the Proposed Development (Offshore). Storms strong enough to delay vessel movements are likely to occur most years during operation.	Environmental	**Negligible:** No environmental consequences are anticipated.	Medium	Minor	Not significant
							Safety	**Negligible:** No safety consequences are anticipated.			
							Economic	**Medium:** Damage to a physical asset or multiple would cost the Proposed Development (Offshore) to repair and replace.			
							Reputational	**Negligible:** No reputational consequences are anticipated.			

Receptor	Risk	Embedded Mitigation	Value	Susceptibility	Sensitivity Score	Frequency	Consequence Category	Consequence	Magnitude Score	Overall Score	Significance Conclusion
Increased extreme / severe wave heights.											
Maintenance (including vessel trips to offshore assets)	Delays in maintenance and subsequent degradation of assets.	Scheduled maintenance for when storms are less likely, as far as possible. Any unplanned maintenance will take place during suitable safe working weather windows. Some flexibility will bult into maintenance schedules to account for possible delays.	**Low:** Maintenance is vital to the continued functioning of the Proposed Development (Offshore). If delayed, it can be rescheduled and is unlikely to be delayed for a significant amount of time.	**High:** Vessel movements are highly reliant on the correct weather conditions. Therefore, this receptor is susceptible to storms and storm events including high waves.	Medium	**Medium:** Rough seas and high waves occur yearly. However, with climate change there is some uncertainty into how this will change. The current thinking is that extreme wave height will reduce. Extreme wave height is likely to disturb maintenance vessels many times throughout the operation of the Proposed Development (Offshore).	Environmental	**Negligible:** No environmental consequences are anticipated.	Low	Minor	Not significant
							Safety	**Negligible:** No safety consequences are anticipated.			
							Economic	**Negligible:** There may be some impacts to the Proposed Development (Offshore) both directly and indirectly due to delayed maintenance, and possible asset degradation due to delayed maintenance (though this is anticipated to be minimal).			
							Reputational	**Negligible:** No reputational consequences are anticipated.			
Offshore physical assets: WTGs - fixed and floating OSPs and associated electrical equipment	Risk of physical damage	Offshore assets will be designed considering the effects of extreme wave height.	**Medium:** WTGs/OSPs are integral to the operation of the Proposed Development. However, it is highly unlikely that this hazard would impact the full array area collectively at once.	**Low:** Assets will be designed to function within and be resilient to anticipated wave heights.	Low	**Medium:** Rough seas and high waves occur yearly. However, with climate change there is some uncertainty into how this will change. The current thinking is that extreme wave height will reduce.	Environmental	**Low:** Possible environmental consequences may occur if damage was great enough for parts or pollution to enter the sea.	Medium	Minor	Not significant
							Safety	**Negligible:** No safety consequences are anticipated.			
							Economic	**Medium:** Damage to assets would cost the Proposed Development to repair and replace. However, in within the context of the entire Proposed Development (Offshore) this is will be minimal, assuming storms/high waves are unlikely to damage multiple assets			

Receptor	Risk	Embedded Mitigation	Value	Susceptibility	Sensitivity Score	Frequency	Consequence Category	Consequence	Magnitude Score	Overall Score	Significance Conclusion
								within the Array Area at once.			
							Reputational	**Negligible:** No reputational consequences are anticipated.			
Increased air temperature/ extreme heat events											
Offshore physical assets: WTGs - fixed and floating OSPs and associated electrical equipment	Risk of physical damage	Physical assets and electrical equipment will be designed to be resilient to high temperatures expected in the location. It is assumed that increased temperatures have been included within the design parameters of the electrical equipment. These are likely to be thresholds higher than expected during the operational period.	**Medium:** WTGs/OSPs are integral to the operation of the Proposed Development. However, it is highly unlikely that this hazard would impact the full array area collectively at once.	**Low:** Physical assets will be designed to function within and be resilient to projected extreme air temperatures. Electrical equipment is likely to be housed within a protective casing making it less susceptible to the impacts of extreme temperature and direct sunlight.	Low	**Negligible:** Though there is expected to be an increase in extreme heat and air temperatures generally, it is unlikely to reach temperatures high enough to cause damage to assets during operation of the Proposed Development (Offshore).	Environmental	**Negligible:** No environmental consequences are anticipated.	Negligible	Negligible	Not significant
							Safety	**Negligible:** No safety consequences are anticipated.			
							Economic	**Low:** Damage to assets would cost the Proposed Development to repair and replace. However, in within the context of the entire Proposed Development (Offshore) this is will be minimal, assuming extreme temperatures are unlikely to damage multiple assets within the Array Area at once.			
							Reputational	**Negligible:** No reputational consequences are anticipated.			
Increased sea temperature											
Offshore physical assets: WTGs - fixed and floating, OSPs and associated electrical equipment	Risk of physical damage due to possible increased presence of marine growth. It is unlikely that increased sea temperatures will impact the physical assets in any other ways.	Assets will be designed to accommodate some marine growth. This will be removed on a regular basis, as required.	**Medium:** WTGs/OSPs are integral to the operation of the Proposed Development. However, it is highly unlikely that this hazard would impact the full array area collectively at once.	**Low:** Growth is unlikely to be significant enough to cause damage and the WTGs and OSPs as maintenance activities will likely include regular inspection and cleaning of assets.	Low	**Negligible:** Higher sea temperatures are likely to increase marine growth upon WTGs. However, it is uncertain how much this will increase by. Moreover, due to removal as part of maintenance activities it is	Environmental	**Negligible:** No environmental consequences are anticipated.	Negligible	Negligible	Not significant
							Safety	**Negligible:** No safety consequences are anticipated.			
							Economic	**Low:** Damage to WTGs would cost the Proposed Development money to			

Receptor	Risk	Embedded Mitigation	Value	Susceptibility	Sensitivity Score	Frequency	Consequence Category	Consequence	Magnitude Score	Overall Score	Significance Conclusion
						unlikely that this will be allowed to grow enough to cause damage.		repair and replace. However, within the context of the entire Proposed Development this will be low. It is assumed marine growth would accumulate slowly over time and so no significant damage would occur before this was identified. Additional growth may require additional maintenance. This will be at a cost to the project, however, in the context of the Proposed Development this would be low.			
							Reputational	**Negligible:** No reputational consequences are anticipated.			
Inter-array cables and offshore export cables	Risk of physical damage	Very little of the cable will be exposed to the sea. This will have a protective casing.	**High:** Offshore cables are critical to the functioning of the Proposed Development (Offshore) and is therefore nationally important.	**Low:** The majority of the offshore cables will lie buried within the seabed and so are unlikely to be susceptible to the projected changes in sea temperature.	Medium	**Negligible:** Though there is expected to be an increase sea temperature, this is small compared to design thresholds likely to be used, it is therefore unlikely that the sea reaches temperatures high enough to cause damage to cables during the operation of the Proposed Development. Particularly as the majority of offshore cables will sit on or below the seabed where water temperatures are lowest.	Environmental	**Negligible:** No environmental consequences are anticipated.	Negligible	Negligible	Not significant
							Safety	**Negligible:** No safety consequences are anticipated.			
							Economic	**Medium:** Damage to the offshore cables would have financial implications for the Proposed Development. Costing money to repair and replace. However, in within the context of the entire Proposed Development (Offshore) this is will be low. Further costs might be incurred is damage stopped energy production whilst repairs were made.			
							Reputational	**Negligible:** No reputational consequences are anticipated.			

4.2.4 Onshore Receptors

4.2.4.1 The assessment includes the main assets that are at risk from projected changes in climate.

4.2.4.2 The receptors (both assets and processes) included within the Proposed Development (Onshore) that would potentially be at risk from climate change impacts are as follows:

- Car parking and access roads;
- Drainage and associated assets;
- Buildings and structures;
- Electrical equipment;
- Sewerage and septic tank;
- Landscaping;
- Fencing;
- Underground cabling;
- Perimeter fencing;
- Maintenance; and
- Transition joint bays.

4.2.5 Onshore Assumptions

4.2.5.1 The following assumptions were made during the scoring process:

- It is assumed that extreme heat and storms will only impact above ground assets.
- It is assumed that staff's main roles during the O&M phase can easily be halted or postponed during adverse weather and so climate hazards do not pose risks to staff during operation.

4.2.6 Onshore Results

4.2.6.1 The results from the CCR assessment can be found in Table 4-4.

Table 4-4: Proposed Development (Onshore) Operational CCR Assessment

Receptor	Risk	Embedded mitigation	Value	Susceptibility	Sensitivity	Frequency	Consequence Category	Consequence narrative	Magnitude	Overall score	Significance Conclusion
Extreme heat											
Maintenance staff	Health and safety risks to staff from heath related illnesses (heat stroke, heat exhaustion, sunburn).	Staff will be briefed and follow correct H&S procedures relating to working in poor weather conditions.	**High:** Human life and wellbeing always valued as high.	**Negligible:** Though humans are naturally susceptible to high temperatures, comprehensive H&S procedures and knowledge of heat health risks mean that staff are resilient to the effects of heat.	Low	**Medium:** Climate change will increase the frequency and intensity of extreme heat during the operational period. Heatwaves are likely to occur most years during operation. However, heatwaves intense enough to cause significant human health risk will still occur less frequently.	Environmental	**Negligible:** No environmental consequences are anticipated.	Medium	Minor	Not significant
							Safety	**Medium:** Some heat health risks, resulting in illness for staff, though this is unlikely to be serious.			
							Economic	**Low:** Small loss of productivity and financial due to ill health at work.			
							Reputational	**Medium:** Possible H&S issues have a large reputational risk, possible legal action if severe.			
Non-technical above ground physical assets (Landscaping, fencing, sewerage and septic tanks, car parks and drainage assets)	Risk of asphalt melting *(heat is unlikely to impact other assets directly and indirect risks such as ground subsidence are discussed under drought)*	Car parks expect to use asphalt with industry standard temperature thresholds which are unlikely to be surpassed in the North of Scotland during the construction phase.	**Low:** Car park is both low value to repair and replace.	**Low:** Due to the embedded mitigation identified it is assumed to have a low susceptibility.	Low	**Medium:** Climate change will increase the frequency and intensity of extreme heat during the operational period. However, temperatures warm enough to melt asphalt and cause damage are not likely to occur regularly in the North of Scotland.	Environmental	**Negligible:** No environmental consequences are anticipated.	Low	Minor	Not significant
							Safety	**Negligible:** No safety consequences are anticipated.			
							Economic	**Low:** Small costs associated with repair/ relaying asphalt.			
							Reputational	**Negligible:** No reputational damage is anticipated.			
Onshore Substation and electrical equipment.	Risk of thermal expansion of structure and overheating and malfunction of electrical equipment.	Design upper temperature thresholds will accommodate future changes to temperature. Electrical equipment will be housed in buildings or encased in a protective outer cover reducing the	**Medium:** Onshore Substations will contain some expensive electrical equipment which is vital to the operation of the Proposed Development (Offshore) and Proposed	**Low:** Embedded mitigation and design thresholds mean that this receptor is not likely to be susceptible to future temperature changes seen in	Low	**Low:** Climate change will begin to increase the frequency and intensity of extreme heat during the operational period. However, a heatwave intense enough to cause thermal expansion of structures and or	Environmental	**Negligible:** No environmental consequences are anticipated.	Low	Minor	Not significant
							Safety	**Low:** Minimal safety consequences are anticipated.			
							Economic	**Medium:** Damage to structures or electrical equipment would mean some significant			

Receptor	Risk	Embedded mitigation	Value	Susceptibility	Sensitivity	Frequency	Consequence Category	Consequence narrative	Magnitude	Overall score	Significance Conclusion
		impacts of direct sunlight.	Development (Onshore).	the North of Scotland.		malfunction of electrical components is still not likely to occur regularly in the North of Scotland.		economic costs to the Proposed Development both in terms of fixing the damage and possible operational disruption.			
							Reputational	**Negligible:** No reputational consequences are anticipated.			
Increased occurrence of storms including high wind and lightning strikes											
Other above ground physical assets (Landscaping, fencing, sewerage and septic tanks, car parks and drainage assets)	High wind and lightning strikes can cause damage or reduce structural integrity of the offshore assets.	No specific embedded mitigation.	**Low:** Car parks and fencing are easily replaceable.	**Medium:** Fencing particularly is susceptible to high winds.	Low	**Medium:** Though there is some uncertainty in the projections it is likely that climate change will increase the frequency of storm conditions and high winds which will occur during operation of the Proposed Development (Offshore).	Environmental	**Low:** Minimal environmental damage anticipated, in extreme circumstances breaching of a septic tank could cause local environmental damage.	Low	Minor	Not significant
							Safety	**Negligible:** No safety consequences are anticipated.			
							Economic	**Negligible:** Minimal economic costs anticipated.			
							Reputational	**Negligible:** No reputational damage anticipated			
Technical assets: Onshore Substation and electrical equipment	High wind and lightning strikes can cause damage or reduce structural integrity of the offshore assets. *(not relevant to underground assets such as the TJB)*	It is assumed electrical assets are designed with some in built protection from lightning and subsequent surges. It is also assumed that electrical equipment will be shielded from high winds.	**Medium:** Onshore Substations will contain some expensive electrical equipment which is vital to the operation of the Proposed Development (Onshore)	**Low:** Due to embedded mitigations, it is assumed that the assets will be designed to withstand high windspeed, and protected from potential lightning strikes.	Low	**Medium:** Though there is some uncertainty in the projections it is likely that climate change will increase the frequency of storm conditions and high winds which will occur during operation of the Proposed Development (Offshore).	Environmental	**Negligible:** No environmental damage anticipated.	Medium	Minor	Not significant
							Safety	**Negligible:** No safety consequences are anticipated.			
							Economic	**High:** Damage to the Onshore Substation structure would result in large economic costs for the Proposed Development (Onshore) and subsequent serious delays to construction.			
							Reputational	**Negligible:** No reputational damage anticipated.			

Receptor	Risk	Embedded mitigation	Value	Susceptibility	Sensitivity	Frequency	Consequence Category	Consequence narrative	Magnitude	Overall score	Significance Conclusion
Flooding											
Onshore Substations and electrical equipment	Direct or indirect damage from flooding/ water logging of the assets.	Drainage across the site and cable route will be designed to minimise water held on site preventing surface water flooding.	**Medium:** Substation will contain expensive electrical equipment which is vital for the operation of the Proposed Development (Onshore). Similarly export cables are vital to the transportation of energy.	**Low:** The assessment of pluvial and fluvial flood risk is set out in Volume 5, Chapter 6: Hydrology and Hydrogeology; it concludes these flood risks for the various sections within the OnTI RLB of the Proposed Development (Onshore) to be not significant in EIA terms after appropriate mitigation measures have been implemented.	Low	**Low:** Heavy precipitation events will begin to increase because to climate change during the operational period; due to current low flood risk, it is not anticipated that the Substation site will flood with embedded mitigation.	Environmental	**Medium:** Some damage may result from flooding or water logging. This would be in the form of leachate or waste which might enter the surrounding soil or water courses after flooding subsided.	Low	Minor	Not significant
							Safety	**Negligible:** No safety risks anticipated – assumed that with standard H&S requirements, if any damage were to occur staff would stop work.			
							Economic	**Low:** Possible financial costs associated with site flooding, depending on the extent and subsequent damage.			
							Reputational	**Negligible:** No reputational damage anticipated.			
Sea level rise and coastal flooding											
Buried assets (TJB and near coast export cables)	Damage caused by sea level risk and / or coastal flooding. Only relevant to TJB and near coast section of the export cable due to its coastal location.	It is assumed that projected sea level rise will be considered and integrated into the design.	**Medium:** TJB is vital to the overall functioning of the Proposed Development (Onshore) and Proposed Development (Offshore).	**Low:** Due to assumed embedded mitigation is unlikely that the TJB will be impacted by sea level rise within the operational lifetime of the Proposed Development (Onshore) and the Proposed Development (Offshore).	Low	**Low:** Sea level rise is projected to occur; however, the extent of projected sea level rise is small in this location compared with other areas of the UK and so is unlikely to cause much damage during the operational lifespan.	Environmental	**Medium:** Some environment damage may result from flooding or damage to the TJB. This would be in the form of any pollutants being leaked into the ocean or surrounding soils.	Medium	Minor	Not significant
							Safety	**Negligible:** No safety risks anticipated – assumed that if any danger were to occur staff would stop work.			
							Economic	**High:** The TJB is vital to the transmission of energy and so any damage would cause a pause in production. Moreover, most of the TJB is underground and so repairing is likely to be a high financial cost in the context of the project.			

Receptor	Risk	Embedded mitigation	Value	Susceptibility	Sensitivity	Frequency	Consequence Category	Consequence narrative	Magnitude	Overall score	Significance Conclusion
							Reputational	**Negligible:** No reputational damage anticipated.			
Drought											
Drought occurrence causing ground cracking or subsidence effecting receptors such as: Onshore above ground physical assets (Landscaping, fencing, sewerage and septic tanks, car parks and drainage assets) Buried assets (export cables, TJB and other joint bays)	Drought occurrence causing ground cracking or subsidence	Drainage will be adequate to ensure that soils do not get excessively wet (which can contribute to subsidence by causing weaknesses within the ground). No specific mitigation for dry related cracking or subsidence.	**Medium:** Trenching and cabling is vital to operation of the Proposed Development (Onshore) and Proposed Development (Offshore).	**Low:** There is no evidence to suggest that the ground within OnTI RBL of the Proposed Development is particularly susceptible to subsidence due to the soils.	Low	**Low:** Drought bad enough to cause subsidence are unlikely to occur.	Environmental	**Negligible:** No environmental damage anticipated	Low	Minor	Not significant
							Safety	**Negligible:** No safety risks anticipated			
							Economic	**Low:** Some small economic costs associated with repairing the ground and any associated damage.			
							Reputational	**Negligible:** No reputational damage anticipated			

5 References

[1] Institute of Environmental Management and Assessment (IEMA) (2020) 'Environmental Impact Assessment Guide to: Climate Change Resilience & Adaptation'. Available at: https://www.iema.net/resources/reading-room/2020/06/26/iema-eia-guide-to-climate-change-resilience-and-adaptation-2020 (Accessed 01/10/2024).

[2] Met Office (2018) 'UK Climate Change Projections'. Available at: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index (Accessed 01/10/2024).

[3] Met Office (2018a) 'UKCP18 Factsheet: Sea-level rise and storm surge – supplementary data'. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18_factsheet_sea_level_rise_storm_surge_supp_data_mar23.pdf (Accessed 01/10/2024).

[4] CEDA Archive (2017) 'UKCP09: Marine data for UK waters from past and future multi-level ocean model simulations'. Available at: https://catalogue.ceda.ac.uk/uuid/46f53c4e24f4428cba1c42a608844c82 (Accessed 01/10/2024)

[5] Gutiérrez, et al, (2021) 'Atlas'. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press. In Press. Interactive Atlas available from http://interactive-atlas.ipcc.ch/ (Accessed 01/10/2024).

[6] The Marine Climate Change Impacts Partnership (2022) 'Impacts Hub'. Available at: https://www.mccip.org.uk/all-uk/uk-impacts/hub (Accessed 01/10/2024).

[7] The Marine Climate Change Impacts Partnership (no date) 'Storms and waves'. Available at: https://www.mccip.org.uk/storms-and-waves (Accessed 01/10/2024).

[8] Bricheno, L.M., Amies, J.D., Chowdhury, P., Woolf, D. and Timmermans, B. (2023) 'Climate change impacts on storms and waves relevant to the UK and Ireland'. MCCIP Science Review 2023, 20pp. doi: 10.14465/2023.reu09.str

[9] The Marine Climate Change Impacts Partnership (no date) 'Temperature'. Available at: https://www.mccip.org.uk/temperature (Accessed 01/10/2024).

[10] Cornes, R.C., Tinker, J., Hermanson, L., Oltmanns, M., Hunter, W.R., Lloyd-Hartley, H., Kent, E.C., Rabe, B. and Renshaw, R. (2023) 'Climate change impacts on temperature around the UK and Ireland'. MCCIP Science Review 2023, 18pp.

[11] The Marine Climate Change Impacts Partnership (no date) 'Dissolved Oxygen'. Available at: https://www.mccip.org.uk/oxygen (Accessed 01/10/2024).

[12] Mahaffey, C., Hull, T., Hunter, W., Greenwood, N., Palmer, M., Sharples, J., Wakelin, S. and Williams, C. 'Climate change impacts on dissolved oxygen concentration in marine and coastal waters around the UK and Ireland'. MCCIP Science Review 2023, 31pp.

[13] The Marine Climate Change Impacts Partnership (no date) 'Salinity'. Available at: https://www.mccip.org.uk/salinity (Accessed 01/10/2024).

[14] Dye, S., Berx, B., Opher, J., Tinker, J.P. and Renshaw, R. (2020) 'Climate change and salinity of the coastal and marine environment around the UK'. MCCIP Science Review 2020, 76–102.

[15] The Marine Climate Change Impacts Partnership (no date) 'Stratification'. Available at : https://www.mccip.org.uk/stratification (Accessed 01/10/2024).

[16] Sharples, J., Holt, J., Wakelin, S. and Palmer, M.R. 'Climate change impacts on stratification relevant to the UK and Ireland'. MCCIP Science Review 2022, 11pp. doi: 10.14465/2022.reu04.str

[17] The Marine Climate Change Impacts Partnership (no date) 'Acidification'. Available at: https://www.mccip.org.uk/ocean-acidification (Accessed 01/10/2024).

[18] Findlay, H.S., Artoli, Y., Birchenough, S.N.R., Hartman, S., León, P. and Stiasny, M. 'Climate change impacts on ocean acidification relevant to the UK and Ireland'. MCCIP Science Review 2022, 24pp.

[19] IPCC (no date) 'WGI Interactive Atlas: Regional information (Advanced)'. Available at: https://interactive-atlas.ipcc.ch/regional-information#eyJ0eXBlIjoiQVRMQVMiLCJjb21tb25zIjp7ImxhdCI6MjA5MDUwNiwibG5nIjo1MjY3MTQ2LCJ6b29tIjo3LCJwcm9qIjoiRVBTRzo1NDAzMCIsIm1vZGUiOiJjb21wbGV0ZV9hdGxhcyJ9LCJwcmltYXJ5Ijp7InNjZW5hcmlvIjoicmNwMjYiLCJwZXJpb2QiOiJuZWFyIiwic2Vhc29uIjoieWVhciIsImRhdGFzZXQiOiJFVVItMTEiLCJ2YXJpYWJsZSI6InRhc21heCIsInZhbHVlVHlwZSI6IkFOT01BTFkiLCJoYXRjaGluZyI6IlNJTVBMRSIsInJlZ2lvblNldCI6ImFyNiIsImJhc2VsaW5lIjoiQVI1IiwicmcmlnaW9uc1NlbGVjdGVkIjpbXX0sInBsb3QiOnsiYWN0aXZlVGFiIjoicGx1bWUiLCJtYXNrIjoibm9uZSIsInNjYXR0ZXJ2ZTWFnIjpudWxsLCJzY2F0dGVyWVZhciI6bnVsbCwic2hvd2luZyI6ZmFsc2V9fQ== (Accessed 01/10/2024).

[20] The Marine Climate Change Impacts Partnership (no date) 'Sea level Rise'. Available at: https://www.mccip.org.uk/sea-level-rise (Accessed 01/10/2024).

[21] Findlay, H.S., Artoli, Y., Birchenough, S.N.R., Hartman, S., León, P. and Stiasny, M. Climate change impacts on ocean acidification relevant to the UK and Ireland. MCCIP Science Review 2022, 24pp. Citation: Horsburgh, K., Rennie, A. and Palmer, M. (2020) 'Impacts of climate change on sea-level rise relevant to the coastal and marine environment around the UK'. MCCIP Science Review 2020, 116–13

[22]Met Office (2018) 'UKCP18 Factsheet: Sea-level rise and storm surge - supplementary data'. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18_factsheet_sea_level_rise_storm_surge_supp_data_mar23.pdf (Accessed 01/10/2024).

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