AQUIND Limited

APPENDIX 27.1

Climate Change Resilience

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APPENDIX 27.1 - CLIMATE CHANGE RESILIENCE

1.1 INTRODUCTION

1.1.1.1 This appendix contains the climate vulnerability assessment carried out as part of the PEIR.

1.2 METHODS OF ASSESSMENT

1.2.1.1 This section outlines the approach for assessing the resilience of the Proposed Development to climate change. The methodology consists of four stages and is based on a Climate Risk and Vulnerability Assessment (CRVA) approach, the guidance listed in Chapter 27 Carbon and Climate Change and professional experience of carrying out similar assessments. Initially a vulnerability assessment is undertaken to identify climate variables to which the Proposed Development is vulnerable. A more detailed risk assessment is then undertaken to assess the level of risk associated with hazards caused by the climate variables.

1.2.1.2 The results of Steps 1 and 2 (the vulnerability assessment) are reported in this PEIR and the more detailed risk assessment (Steps 3 and 4) will be reported in the ES.

1.2.1.3 Step 1: Identify receptors - during this stage, relevant receptors which may be affected by climate change are identified. These receptors may comprise both known (i.e. receptors affected by historical flooding gleaned from literature review) and unknown (new) receptors.

1.2.1.4 Step 2: Climate vulnerability assessment - this stage comprises an assessment of the vulnerability of the Proposed Development to change in climate variables. The assessment is qualitative, informed by professional judgement and supporting literature.

1.2.1.5 The vulnerability of a Proposed Development to extreme weather and climate change is a function of:

- The typical sensitivity of the type of the Proposed Development to climate variables; and
- The geographic exposure of the Proposed Development to climate variables.

1.2.1.6 The climate vulnerability assessment is informed by an assessment of sensitivity and exposure. A categorisation is then assigned to each climate variable based on the following scale:

- High: High climate sensitivity/exposure.
- Moderate: Moderate climate sensitivity/exposure.
- Low: No significant climate sensitivity/exposure.

1.2.1.7 The vulnerability of primary receptors climate variables is then determined using the matrix in Table 1 vulnerabilities are taken forward to risk assessment in Step 3.

Table 1 – Vulnerability Rating Matrix

Sensitivity	Exposure		
	Low	Moderate	High
Low	Low vulnerability	Low vulnerability	Low vulnerability
Moderate	Low vulnerability	Medium vulnerability	Medium vulnerability
High	Low vulnerability	Medium vulnerability	High vulnerability

1.2.1.8 Step 3: Risk assessment - firstly, hazards related to Medium and High vulnerabilities are identified. The foundation for this is expert judgment, engagement with the project team and a review of relevant literature. Following identification of hazards, a risk assessment is undertaken. Risk is a product of likelihood and consequence of the hazards occurring. A risk rating for each hazard is assigned by combining likelihood and consequence ratings, as shown in Table 2.

Table 2 – Risk rating matrix

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	Medium	High	Extreme
Moderate	Low	Low	Medium	High	Extreme
Unlikely	Low	Low	Medium	Medium	High
Very unlikely	Low	Low	Low	Medium	Medium

1.2.1.9 Step 4: Mitigation measures - in the final step, mitigation measures for Extreme, High and Medium risks are identified through consultation with the design team and through expert opinion. Designers will be asked to identify what measures they are taking to improve resilience to the identified climate risks. Taking account of these measures, a resilience rating for each hazard is given, based on the following definitions:

- High - a strong degree of climate resilience, remedial action or adaptation may be required but is not a priority.

- Moderate - a moderate degree of climate resilience, remedial action or adaptation is suggested.
- Low – a low level of climate resilience, remedial action or adaptation is required as a priority.

1.2.1.10 Recommendations for supplementary climate change adaptation measures of climate resilience are identified.

1.2.2 SIGNIFICANCE CRITERIA

1.2.2.1 Step 5 - the significance of climate risks and the level of resilience of the Proposed Development to these risks will be defined based on the tables set out above. Table 3 shows how significance will be defined.

Table 3 – Significance Criteria

Risk rating	Resilience rating		
	High	Medium	Low
Extreme	Significant	Significant	Significant
High	Not significant	Significant	Significant
Medium	Not significant	Not significant	Significant
Low	Not significant	Not significant	Not significant

1.2.3 ASSUMPTIONS AND LIMITATIONS

1.2.3.1 This chapter of the PEIR provides preliminary information as it relates to the Proposed Development to date and to data currently available and gathered at this point of the assessment process.

1.2.3.2 The information contained herein is intended to inform consultation responses at this stage. A more detailed assessment of potential significant impacts as a result of the Proposed Development on identified sensitive receptors will be undertaken at subsequent stages to inform the ES.

1.2.3.3 Any gaps in information identified at this PEIR stage will be considered and addressed along with specific mitigation measures as part of the assessments for the production of the ES.

1.2.3.4 The climate resilience assessment has been informed by the latest climate projections for the UK, UKCP09. Updated projections were due to be published in November 2018 but were not available at the time of writing. Subsequent assessments will be informed by the UKCP09 projections.

1.3 RESULTS OF VULNERABILITY ASSESSMENT

1.3.1 STEP 1 – IDENTIFY RECEPTORS

1.3.1.1 As the vulnerability assessment is an assessment of the impacts of climate change on the Proposed Development, the receptor is the Proposed development, as described in Chapter 3 Description of the Proposed Development.

1.3.2 STEP 2 – VULNERABILITY ASSESSMENT

1.3.2.1 The vulnerability of a Proposed Development to extreme weather and climate change is a function of:

- The typical sensitivity of the type of the scheme to climate variables; and
- The geographic exposure of the scheme to climate variables.

Sensitivity

1.3.2.2 Sea - energy sector infrastructure is sensitive to changes in sea level, particularly electrical substations and supporting infrastructure. Section 10 lies within Flood Zone 2/3 and Sections 6, 7, 8 and 9 are within Flood Zone 3 and are therefore at risk of tidal flooding (see Chapter 19 Water Resources and Flood Risk). Sea level rise caused by climate change could increase the risk of tidal flooding over the lifetime of the Proposed Development. Coastal flooding due to sea level rise or storm surge can directly cause damage to energy infrastructure such as cables, cable joints and the transition joint bay as well as potentially reducing earthwork stability and hastening the deterioration of materials. It’s worth noting that flood risk may also depend strongly on the design of the new infrastructure as well as its siting (ASC 2016). Power outages and threats to business continuity are the main risks associated with sea level rise and storm surge.

1.3.2.3 Precipitation - Energy infrastructure is sensitive to high and low rainfall (McColl et al. 2012). Sections 1, 2 and 3 (central/western option) lie in. The Proposed Development within EA Flood Zone 1 and (see Chapter 19 Water Resources and Flood Risk) where there is a risk of fluvial flooding. Fluvial flooding may directly damage energy infrastructure, potentially reducing earthwork stability and hastening the deterioration of materials. Parts of Section 1 and 2 are at risk of pluvial flooding. High ground water levels may also cause pollutants in the soil to be mobilised, potentially affecting building materials.

1.3.2.4 Prolonged periods of low rainfall or drought can also impact built infrastructure. Drying out and cracking of soils and/or the aquifer may affect structural stability and prolonged dry periods can lead to cracking of surfaces and more rapid deterioration of materials. The converter station could be sensitive to the impacts of drought as it is located over an aquifer.

1.3.2.5 Snow and ice can cause damage to above-ground infrastructure, including roofs and damage external plant and equipment.

1.3.2.6 Temperature - energy infrastructure is sensitive to high and low temperatures, primarily through exacerbating existing faults. Higher temperatures over more prolonged periods could lead to overheating of infrastructure or greater demand for cooling. Electronic and ICT equipment and substations are also particularly sensitive to extreme temperatures. Overheating may lead to operational impacts if supporting equipment is damaged or working conditions are unsafe.

1.3.2.7 Higher temperatures could also affect material structure and fabric and may cause the deterioration of certain materials, including buildings. Higher temperatures will also lead to increased temperature of river flows that are used for cooling, thereby reducing efficiency of this process.

1.3.2.8 Wind and storms - high wind speeds and gusts can have impacts on energy infrastructure. It is important to note that whilst the short-term consequences of wind-related disruption are large, repairs may usually be carried out quickly. High winds and storms can affect the stability of above-ground infrastructure and hasten material degradation. High winds can also cause wind-driven rain infiltration into plant, building materials and surfaces which can increase maintenance costs and operational disruption.

1.3.2.9 Lightning strike can cause fire as well as power surges and shock waves which can destabilise energy systems, as well as causing damage to electronic and ICT equipment, including substations.

1.3.2.10 Relative humidity - humidity affects both the performance of energy systems as well as the comfort of personnel. An increase in humidity can increase condensation, mould growth, mildew, staining and the corrosion and decay of metal surfaces, as well as poor performance of insulation.

1.3.2.11 Water quality and soils - water availability can cause a number of impacts to water quality and soils. For example, greater water volumes can increase the mobilisation of pollutants in soils whilst water scarcity can increase the accumulation of chemicals and pollutants which may cause increased salinity and acidification. More acidic soils and/or water will increase the deterioration of building materials.

1.3.2.12 Table 4 shows the sensitivity of the Proposed Development to climate variables, based on the information presented above and professional judgement.

Table 4 – Sensitivity Assessment

Variable		Sensitivity
Sea	Sea level rise	High
	Storm surge and storm tide	High
Precipitation	Change in annual average	Low

	Drought	Moderate
	Extreme precipitation events (flooding)	High
	Snow and ice	Low
Temperature	Change in annual average	Low
	Extreme temperature events	Moderate
	Solar radiation	Low
Wind	Gales and extreme wind events	Moderate
	Storms (inc. lightning, hail)	High
Humidity	Change in annual average	Low
Water quality and soils	Soil moisture	Moderate
	Salinity/pH	Low
	Soil stability	Moderate
	Runoff	Low

Exposure

1.3.2.13 The assessment of exposure is based on current climate and projected climate.

Current climate

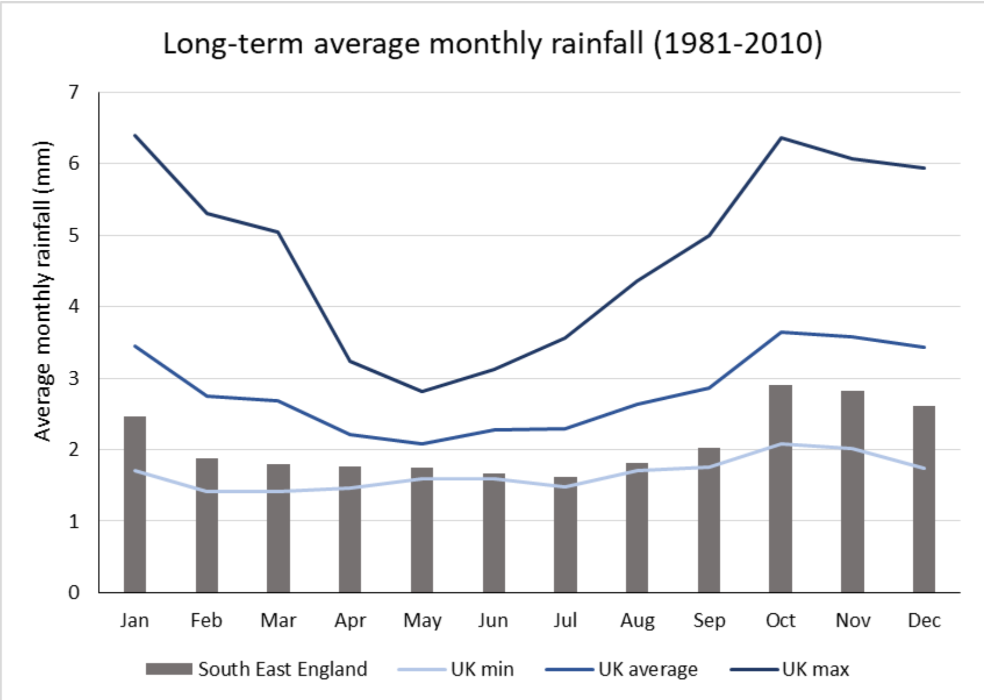
1.3.2.14 The Propsoed Development in the south east of England which has a warm, dry climate, compared to UK average. Information on long term average observed climate variables over the period 1980 – 2010 is presented below. This information is taken from the UKCP09 report, The Climate of the United Kingdom and Observed Trends (Jenkins et al. 2008) and the Met Office regional climate profile for Southern England (Met Office 2017).

Precipitation

1.3.2.15 Rainfall tends to be associated with Atlantic depressions (autumn and winter) or with convection (summer) (Met Office 2017). Figure 1 shows the long-term average monthly rainfall for the South-East Region between 1981 and 2010. It shows that the region is considerably drier than most parts of the UK, with the lowest monthly rainfall in July and the highest in October. Rainfall is generally well-distributed throughout the year but with an autumn/early winter maximum that is more pronounced in counties bordering the English Channel.

1.3.2.16 The occurrence of snow is linked closely with temperature, with falls rarely occurring if the temperature is higher than 4 °C. For snow to lie for any length of time, the temperature normally has to be lower than this. Over most of the area, snowfall is normally confined to the months from November to April. Snow rarely lies outside the period from December to March. The Proposed Development is in the least snow-prone part of the region, with less than 10 days of lying snow per year (Met Office 2017).

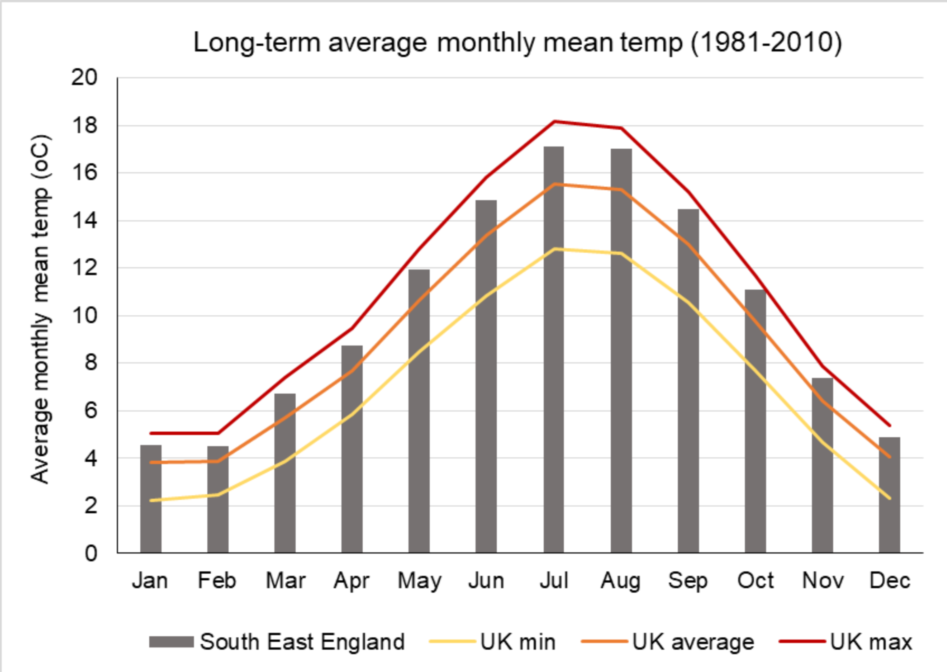
Figure 1 - Long Term Average Mean Monthly Rainfall



Temperature

1.3.2.17 Figure 2 shows the long-term average mean monthly temperature for the south-east region between 1981 and 2010. It shows that the region is warmer than the UK average, with July being the warmest month and February being the coldest month.

Figure 2 - Long Term Average Monthly Mean Temperature (1981-2010)



1.3.2.18 Extreme maximum temperatures can occur in July or August, and are usually associated with heat waves lasting several days. Examples include that of late June/early July 1976, when 35.6 °C was recorded at Southampton on 28 June. Heat waves are usually accompanied by warm nights, and notable examples include minimum temperatures of 23.9 °C at Brighton on 4 August 1990 (setting a UK record) and 23.2 °C at Ventnor, Isle of Wight on 10 August 2003 (Met Office 2017).

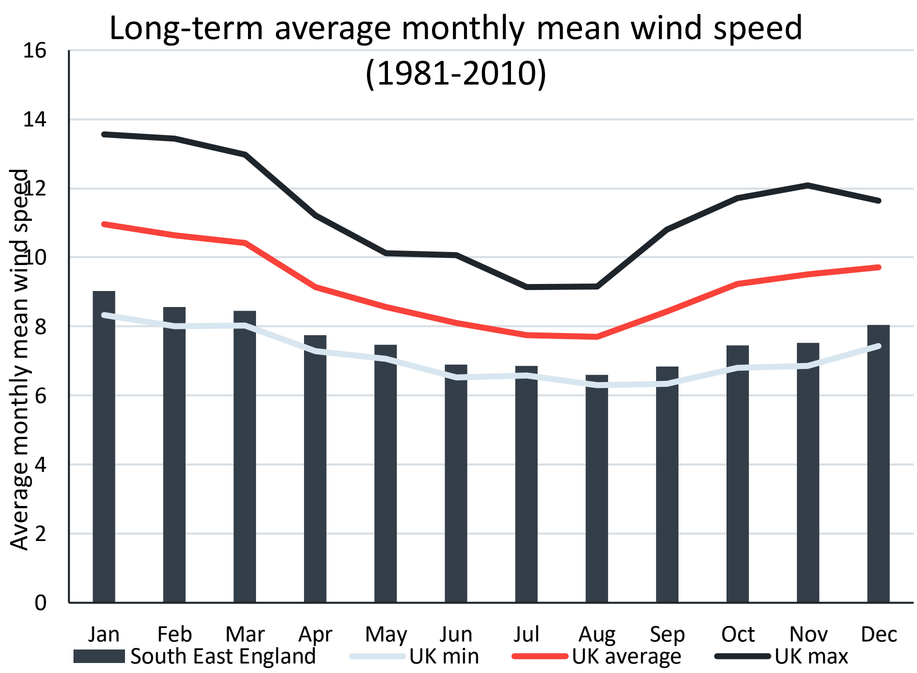
Sunshine

1.3.2.19 The number of hours of bright sunshine is controlled by the length of day and by cloudiness. In general, December is the dullest month and June the sunniest. Southern England includes the sunniest places in mainland UK: on the coast average annual sunshine durations can exceed 1800 hours (Met Office 2017).

Wind

1.3.2.20 Southern England is one of the more sheltered parts of the UK, the windiest areas being in western and northern Britain, closer to the Atlantic. The strongest winds are associated with the passage of deep areas of low pressure close to or across the UK. The frequency and strength of these depressions is greatest in the winter half of the year, especially from December to February, and this is when mean speeds and gusts (short duration peak values) are strongest (Met Office 2017). Figure 3 shows the long-term average monthly mean wind speed in the south-east region between 1981 and 2010.

Figure 3 - Long Term Average Monthly Mean Wind Speed



Sea

1.3.2.21 Sea level change is controlled by two main factors: eustatic (changes related to the expansion and contraction of sea water plus changes in the volume of water stored on land as ice sheets/glaciers) and isostatic (changes related to movement of the land in responses to the effect of glaciers on the Earth's crust). The mean sea level (MSL) trend at Portsmouth between 1900 and 2010 was an increase of 1.21mm/year (+-0.27) (Haigh et al. 2010).

Projected climate

1.3.2.22 Information on projected climate is taken from the UK Climate Projections 2018[1] where available. The UKCP18 are the most up-to-date projections of climate change for the UK, however, at the time of writing this PEIR chapter, only limited information at the administrative region scale was available. This section includes information from UKCP18 where available and is supplemented with information from UKCP09 and peer reviewed literature.

1.3.2.23 UKCP18 includes probabilistic projections of a range of climate variables for different emissions scenarios, Representative Concentration Pathways (RCP)[2] and for a range of timeslices to the end of the 21st Century. In this baseline section, the central estimate (50th percentile) projections for the 2080s high emissions scenario (RCP8.5) are presented.

Precipitation

1.3.2.24 Over land, UKCP18 projects that general trends of climate changes in the 21st century will be similar to the UKCP09 projections, with a move towards warmer, wetter winters and hotter, drier summers. However, natural variations mean that some cold winters, some dry winters, some cool summers and some wet summers will still occur. The projections generally show a pattern of larger increases in winter precipitation over southern and central England and some coastal regions towards the end of the century. Summer rainfall reductions tend to be largest in the south of England.

1.3.2.25 UKCP18 suggests that by the 2080s in the South-East region, mean winter precipitation is expected to increase by up to 30% (50th percentile) under RCP8.5. Figure 4 shows changes in mean winter precipitation for the 2080s under the RCP2.6, RCP4.5, RCP6.0 and RCP8.5.

1.3.2.26 For the summer, by the 2080s in the South-East region, mean summer precipitation is expected to decrease by up 40% (50th percentile) under RCP8.5. Figure 5 shows changes in mean summer precipitation for the 2080s under the RCP2.6, RCP4.5, RCP6.0 and RCP8.5.

[1] Met Office UK Climate Projections. Available at: https://www.metoffice.gov.uk/research/collaboration/ukcp (accessed 16 Jan 2019)

[2] The RCPs provide a range of possible trajectories of how global land use and emissions of GHGs and air pollutants may change through the 21st century. They are named according to their radiative forcing values in the year 2100 (2.6, 4.5, 6.0 and 8.5 Wm-2).

Figure 4 - Changes in mean winter precipitation for the 2080s under the RCP2.6, RCP4.5, RCP6.0 and RCP8.5

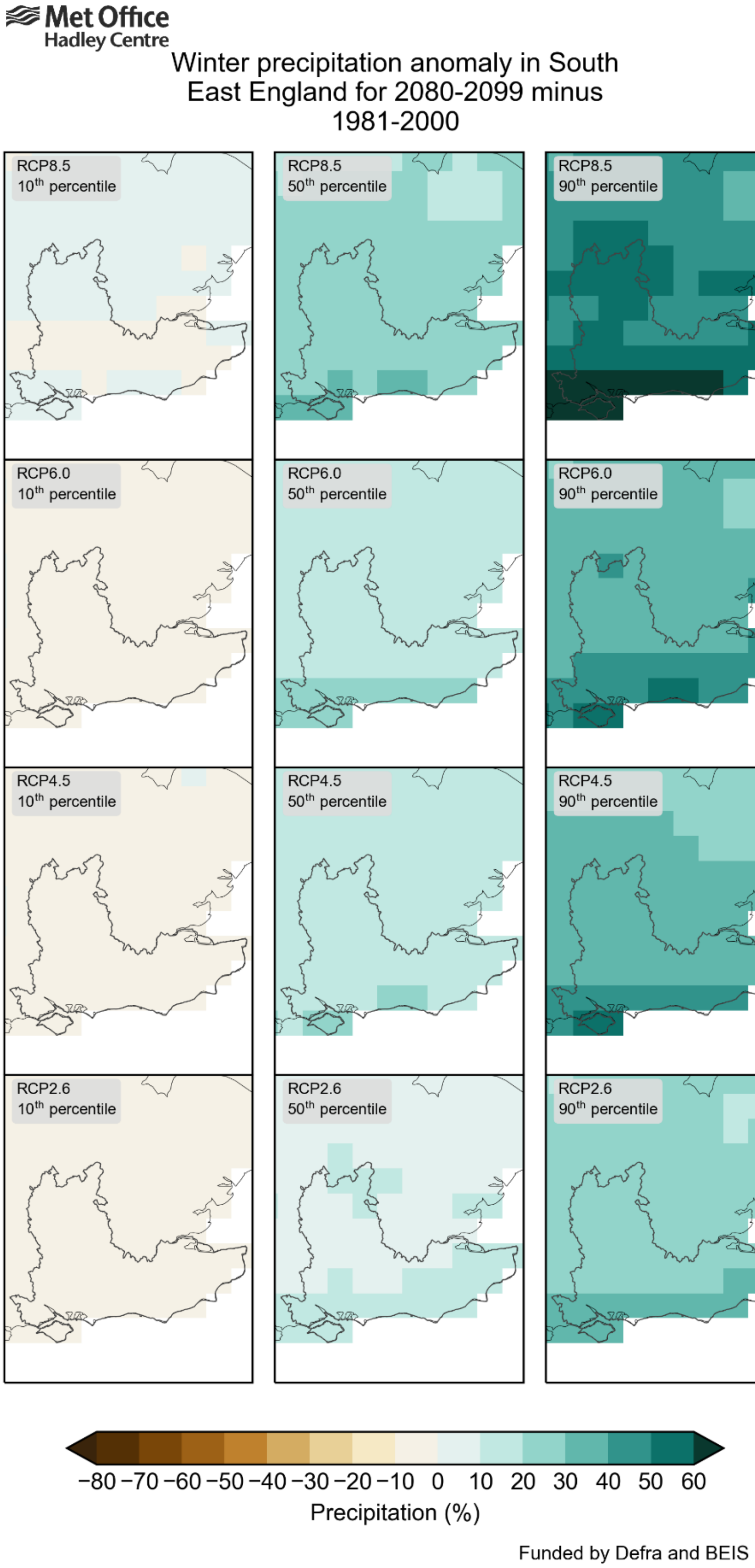
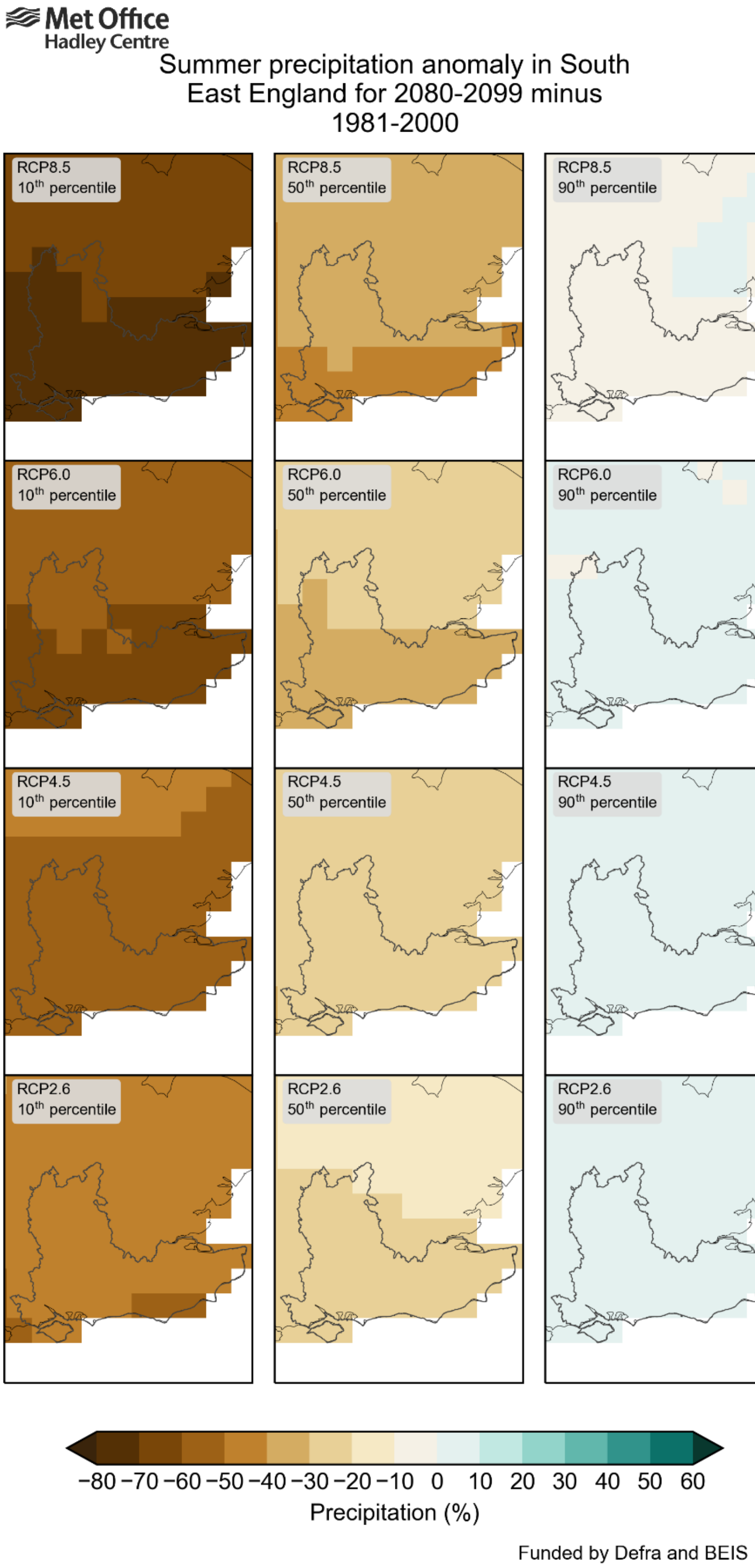


Figure 5 - changes in mean summer precipitation for the 2080s under the RCP2.6, RCP4.5, RCP6.0 and RCP8.5



1.3.2.27 Snowfall is closely linked with temperature, with falls rarely occurring if the temperature is higher than 4°C. For snow to lie for any length of time, the temperature normally must be lower than this. With regards to future changes, rising winter temperatures are likely to reduce the amount of precipitation that falls as snow in winter. UKCP18 does not provide data on snowfall, although UKCP09 projects a reduction of mean snowfall, the number of days when snow falls and heavy snow events by the end of the 21st century. UKCP09 does not provide projections for the nearer-term for snow.

Temperature

1.3.2.28 Climate change is projected to lead to hotter summers and warmer winters. The probabilistic projections show that there is more warming in the summer than in the winter. Additionally, in summer there is a pronounced north-south contrast at the scale of the UK, with greater increases in maximum summer temperatures over the southern UK compared to northern Scotland.

1.3.2.29 UKCP18 suggests that by the 2080s, mean winter temperature in the region is expected to increase by between 2 and 3ºC (50th percentile) under RCP8.5. Figure 7 summarises changes in mean winter temperature for the 2080s under RCP2.6, RCP4.5, RCP6.0 and RCP8.5.

1.3.2.30 For the summer, by the 2080s, mean summer temperature is expected to increase by between 3 and 4ºC (50th percentile) under RCP8.5. Figure 8 summarises changes in mean summer temperature for the 2080s under RCP2.6, RCP4.5, RCP6.0 and RCP8.5.

Figure 7 - changes in mean winter temperature for the 2080s under RCP2.6, RCP4.5, RCP6.0 and RCP8.5

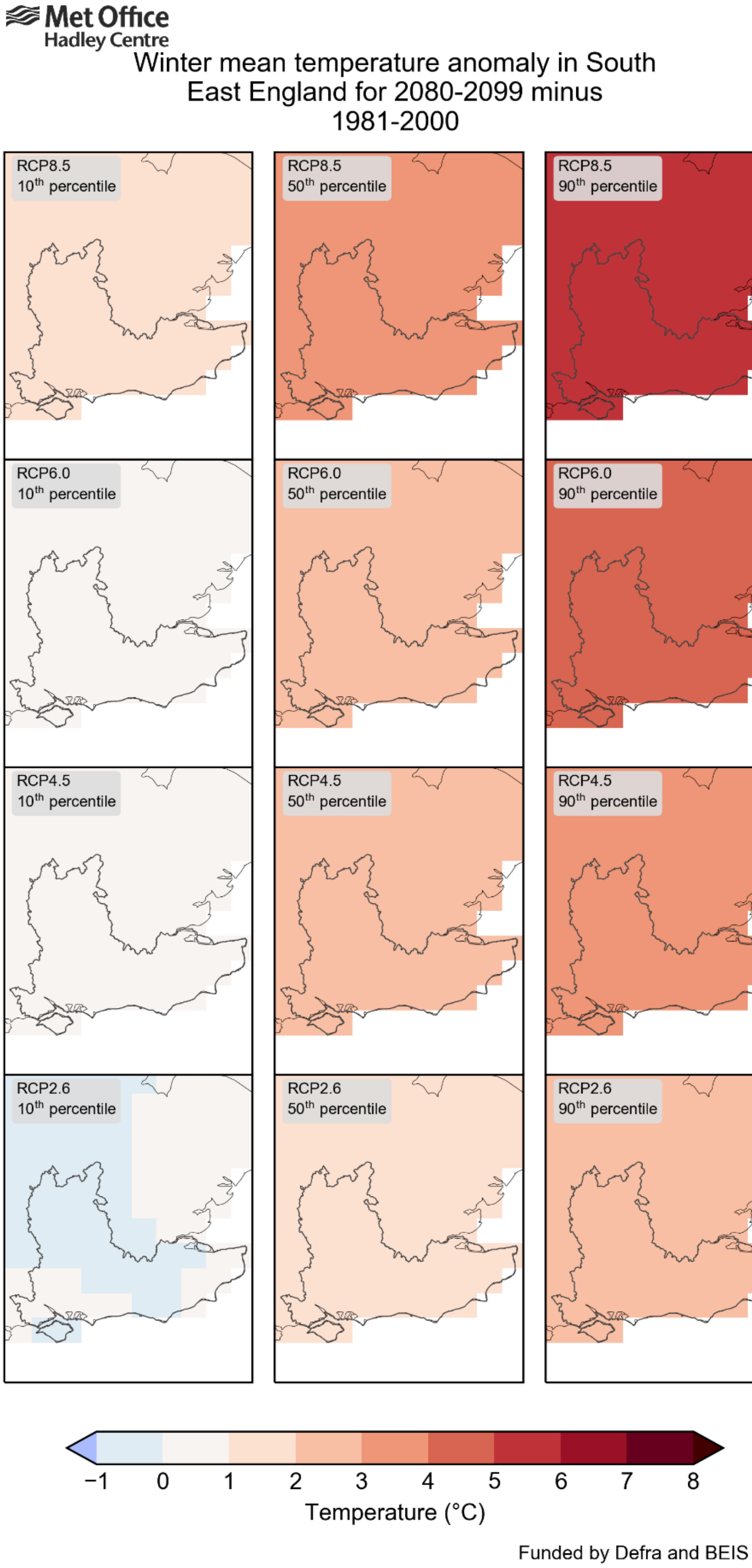
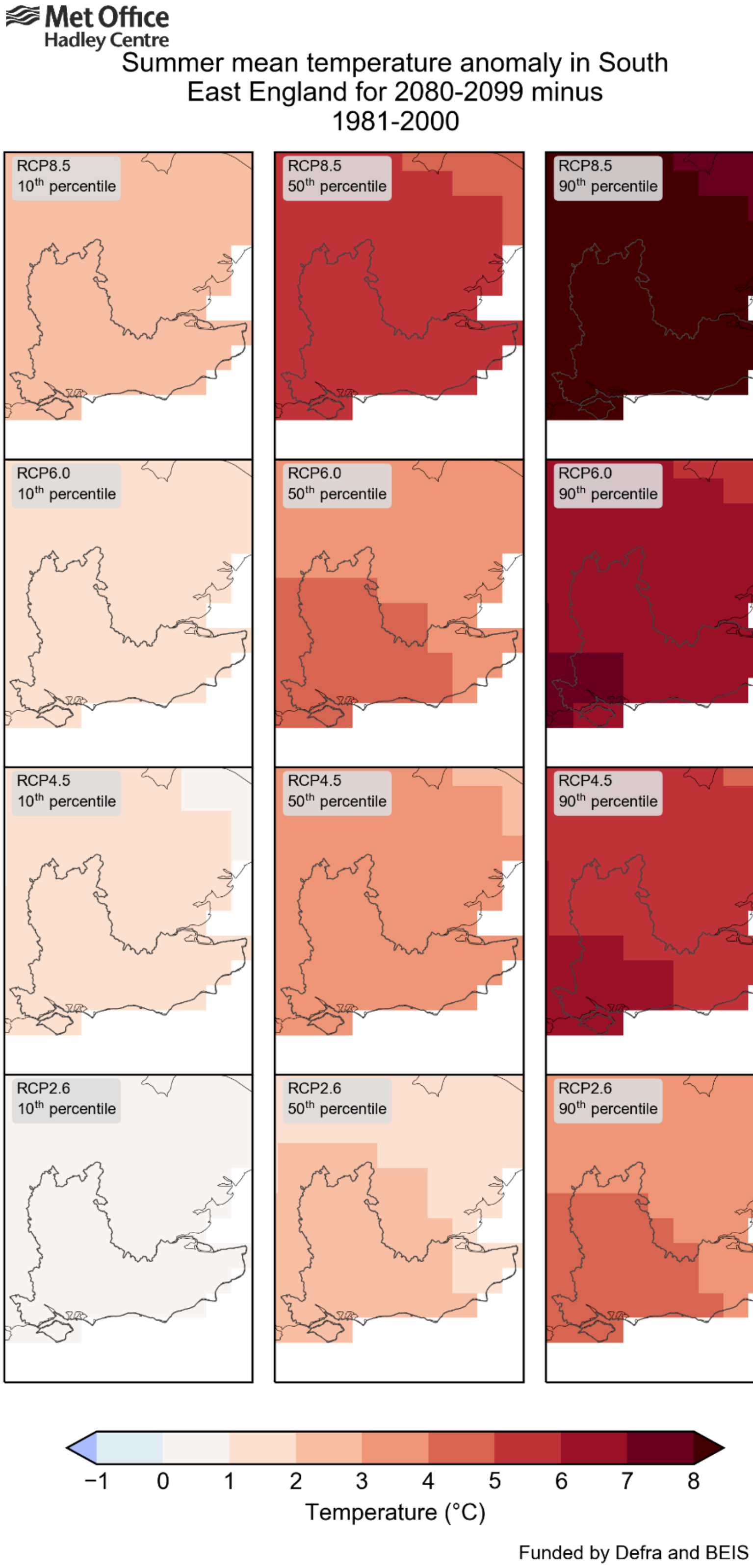


Figure 8 - changes in mean summer temperature for the 2080s under RCP2.6, RCP4.5, RCP6.0 and RCP8.5



1.3.2.31 In addition to changes in seasonal average temperatures, it is likely that there will be more extreme temperature events. By the 2080s, projections for daily maximum summer temperature for the South-East region suggest increases of between 2.0 (RCP 2.6) and 4.0ºC (RCP 8.5), (central estimate). By the 2080s, projections for daily minimum summer temperature suggests an increase of between 1.0 and 2.0ºC, depending on emissions scenario (central estimate).

Wind

1.3.2.32 The UKCP18 projections show an increase in near surface wind speeds over the UK for the second half of the 21st century for the winter season when more significant impacts of wind are experienced. This is accompanied by an increase in frequency of winter storms over the UK.

1.3.2.33 There is large uncertainty in projected changes in circulation over the UK and natural climate variability contributes much of this uncertainty3. It is therefore difficult to represent regional wind extreme winds and gusts within regional climate models4.

Humidity

1.3.2.34 Relative humidity is the most common measure of humidity. It measures how close the air is to being saturated. UKCP18 does not currently provide projections for humidity available. Therefore, UKCP09 will be used for relative humidity future projections.

1.3.2.35 By the 2050s, projections for winter mean relative humidity in the south-east region suggest a decrease of up to 5% under the high emissions scenario (central estimate). By the 2080s, winter mean relative humidity could increase by up to 5% (high emissions scenario, central estimate. The projection for summer mean humidity in the 2050s under the high emissions scenario is a decrease of up to 10% (central estimate). By the 2080s the decrease could be as much as 15% (high emissions scenario, central estimate).

[3] Brown, S., Boorman, P., McDonald, R., and Murphy. J. (2012) Interpretation for use of surface wind speed projections from the 11-member Met Office Regional Climate Model ensemble. Post-launch technical documentation for UKCP09. Met Office Hadley Centre, Exeter, UK.

[4] Brown, S., Boorman, P., Buonomo, E., Burke, E., Caesar, J., Clark, R., McDonald, R. and Perry, M. (2008) A climatology of extremes for the UK: A baseline for UKCP09. Met Office Hadley Centre, Exeter

Sea

1.3.2.36 The UKCP18 projections provide predictions for four cities across the UK of which London is the closest to Portsmouth. Table 5 presents the range of sea level change (m) at London in 2100 relative to 1981-2000 average for a low (RCP2.6), medium (RCP4.5) and high (RCP8.5) emissions scenario[5]. Projected change at the 5th and 95th centile is reported for each RCP.

1.3.2.37 Whilst sea level rise over the coming centuries may affect tidal characteristics substantially (including tidal range), UKCP18 finds that the atmospheric contribution to storm surges is unlikely to change[6].

Table 5 - Range of sea level change (m) at London in 2100 relative to 1981-2000 average for a low (RCP2.6), medium (RCP4.5) and high (RCP8.5) emissions scenario

	RCP2.6		RCP4.5		RCP8.5	
	5th	95th	5th	95th	5th	95th
London	0.29	0.7	0.37	0.83	0.53	1.15

Extreme climate projections

1.3.2.38 A range of 'extreme' climate change scenarios (produced by Wade et al., 2015 have also been reviewed. Wade et al., (2015) considered a range of climate variables including heatwaves, cold snaps, low and high rainfall, droughts, floods and windstorms. The H++ scenarios represent the margins or beyond the 10th to 90th percentile range of the 2080s UKCP09 High emissions scenario as presented in the UKCP09 projections and reported here. These scenarios provide a high-impact, low-likelihood event to compare against more likely outcomes.

[5] UKCP18. UKCP18 factsheet: sea level rise and storm surge. Available at: https://www.metoffice.gov.uk/binaries/content/assets/mohippo/pdf/ukcp18/ukcp18-factsheet-sea-level-rise-and-storm-surge.pdf last accessed 04/02/2019

[6] Ibid

1.3.2.39 The H++ scenarios suggest that average summer maximum temperatures will exceed 30°C across most of the UK, with temperatures of the hottest days are also likely to exceed 40°C[i]. The H++ scenarios for heavy daily and sub-daily rainfall suggest that, for the same period, there is a 60% to 80% increase in rainfall for summer or winter events based on a consideration of new high-resolution modelling and physical processes. This is within the UKCP09 distribution range for the 2080s High emissions "wettest day of the winter" variable but higher than uplifts previously considered for summer.

Exposure assessment

1.3.2.40 Based on the information provided and professional judgement, the exposure of the Proposed Development to climate variables is shown in Table 6.

Table 6 – Exposure assessment

Variable		Exposure
Sea	Sea level rise	High
	Storm surge and storm tide	High
Precipitation	Change in annual average	Moderate
	Drought	Moderate
	Extreme precipitation events (flooding)	High
	Snow and ice	Low
Temperature	Change in annual average	Moderate
	Extreme temperature events	High
	Solar radiation	Moderate
Wind	Gales and extreme wind events	Moderate
	Storms (inc. ligntning, hail)	Moderate
Humidity	Change in annual average	Moderate
Water quality and soils	Soil moisture	Moderate
	Salinity/pH	High
	Soil stability	Moderate
	Runoff	Moderate

Vulnerability assessment

1.3.2.41 The sensitivity and exposure assessments are combined to give an overall assessment of vulnerability of the Proposed Development to climate variables. Table 7 summarises the results of the vulnerability assessment. Climate variables assessed as high or medium vulnerability will be taken forward for more detailed risk assessment during the ES, following the method set out in Steps 3 and 4 in Section 1.3.

Table 7 – Vulnerability assessment

Variable	Type	Sensitivity	Exposure	Vulnerability
Sea	Sea level rise	High	High	High
	Storm surge and storm tide	High	High	High
Precipitation	Change in annual average	Low	Moderate	Low
	Drought	Moderate	Moderate	Medium
	Extreme precipitation events (flooding)	High	High	High
	Snow and ice	Low	Low	Low
Temperature	Change in annual average	Low	Moderate	Low
	Extreme temperature events	Moderate	High	Medium
	Solar radiation	Low	Moderate	Low
Wind	Gales and extreme wind events	Moderate	Moderate	Medium
	Storms (inc. lightning, hail)	High	Moderate	Medium

Humidity	Change in annual average	Low	Moderate	Low
Water quality and soils	Soil moisture	Moderate	Moderate	Medium
	Salinity/pH	Low	High	Low
	Soil stability	Moderate	Moderate	Medium
	Runoff	Low	Moderate	Low

1.4 SUMMARY AND CONCLUSIONS

1.4.1.1 Those climate variables to which the Proposed Development has been identified as having high or medium vulnerability will be taken forward for more detailed risk assessment in the ES. Climate variables which have been assessed as low vulnerability will be scope out of further assessment. As such, the following variable are scoped in:

- Sea level rise;
- Storm surge and storm tide;
- Drought;
- Extreme precipitation events;
- Extreme temperature events;
- Gales and extreme wind;
- Storms (including lighting and hail);
- Soil moisture; and
- Soil stability.