THE LONDON TUNNELS
WST 05 – ADAPTION TO CLIMATE CHANGE REPORT

BREEAM Non-Domestic Refurbishment and Fit-Out 2014

INTRODUCTION

The purpose of this report is to present the required information to comply with the BREEAM Wst05 - Adaptation to Climate Change credit. The aim of this credit is to recognise and encourage measures taken to mitigate the impact of extreme weather conditions arising from Climate Change over the lifespan of the development.

BREEAM Wst05 awards one point to projects that consider climate change adaptation as part of the design process. In order to comply with BREEAM the team should conduct a climate change adaptation strategy appraisal for structural and fabric resilience by the end of Concept Design (RIBA Stage 2 or equivalent).

This report focuses on the impact of the extreme weather to the structures, fabric and building services of The London Tunnels project. Systematic risk assessment focusing on structures and fabric has been conducted to identify and evaluate the expected extreme weather condition arising from Climate Change and their impact to the development's systems.

PROJECT SUMMARY

The Proposed Development comprises the "Change of use of existing deep level Tunnels (Sui Generis) to visitor and cultural attraction, including bar (F1); demolition and reconstruction of existing building at 38-39 Furnival Street; redevelopment of 40-41 Furnival Street, for the principle visitor attraction pedestrian entrance at ground floor, with retail at first and second floor levels and ancillary offices at third and fourth levels and excavation of additional basement levels; creation of new, pedestrian entrance at 31-33 High Holborn, to provide secondary visitor attraction entrance (including principle bar entrance) with retail at ground floor level; provision of ancillary cycle parking, substation, servicing and plant, and other associated works."

The project is to be formally registered with BRE Global Ltd. It is the client aspiration that this project achieves a rating of BREEAM 'Very Good'.

HAZARD IDENTIFICATION

Causes of increased pressures / hazards to the development's structure and fabric include:

- Flooding
- Storms (including high winds)
- Heat waves (including temperature increases)
- Drought (including reduced summer rainfall)
- Wetter winters leading to greater winter rainfall
- Temperature variation

- Precipitation e.g. rain and snow

When carrying out the assessment the tables on the "Construction", "Comfort" and "Water" tabs were used, which have been reproduced from "Design for future climate" by the Technology Strategy Board (Appendix B). The full publication can also be consulted for further information.

HAZARD ASSESSMENT

A brief description of the likely impacts and potential effects of the identified hazards is presented in the risk assessment matrix in Appendix A. The hazards consider the following aspects as a minimum:

- Structural stability and robustness,
- Weather proofing and detailing,
- Material durability,
- Health and safety of building occupants and others,
- Impacts on building contents and business continuity.

RISK ESTIMATION

Risk and impacts have been identified in terms of severity and likelihood from hazards to the development.

Each risk has taken into account the aspects as described in the 'hazard assessment' section. The following Risk Assessment Matrix as shown here has been used for the assessment.

Risk Assessment Matrix

		S - Severity				
		0 - Insignificant	1 - Low	2 - Medium	3 - High	4 - Extreme
P - Probability	0 - Negligible	L	L	L	L	M
	1 - Unlikely	L	L	L	M	M
	2 - Possible	L	L	M	M	H
	3 - Probable	L	M	M	H	H

	Probability	Description
0 - Negligible	1 in 20,000	Can be discounted based upon current climate change science
1 - Unlikely	1 in 200	Current climate change science is inconclusive and historic data shows no trends
2 - Possible	1 in 20	Climate change science is inconclusive but historic data shows clear trends
3 - Probable	1 in 2	Current climate change science shows trends and relationships

Appendix A provides an overview of the key climate change risks that have been considered, as well as a matrix to assess probability (P), severity (S) and overall risk rating (R) prior to, and following the implementation of mitigation measures where applicable.

RISK EVALUATION AND MANAGEMENT

The potential impacts of Climate Change on the development have been evaluated to determine the tolerable risk threshold based on the risk matrix score using a simple traffic light system.

IMPLEMENTING ROBUST SOLUTIONS

Based on the risk evaluation, robust design solutions are proposed where necessary in the risk assessment. It is expected the opportunities to mitigate against climate impacts outlined in this report are reviewed in the next design stage. This review process should be used to update measures (where required) and embed them into design and specifications.

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Appendix A

Hazard Assessment

Asset Category	Hazard Identification	Risk	Hazard Assessment			Risk Evaluation		Risk Management / Mitigation	Residual Risk		
			P	S	R	Tolerable Risk Threshold	Unacceptable Risk?		P	S	R
Structural Stability and Robustness	Flooding	Increased risk of water damage to building and tunnel.	1	2	L	L	No	The site is shown to be in Flood Zone 1 and therefore is considered to be at very low flood risk.	1	1	L
	Storms (including high winds)	High winds and storm events.	2	3	M	M	No	Whilst the frequency of storms bringing wind, rain and flooding are likely to change, there are no indications yet that the current peak wind velocities allowed for in current building standards will need to be increased. It is important to note that should a change in building design standards be required in the future, clear guidance will be given on the impact on any existing buildings. Therefore, in accordance with the LETI guidance to reduce embodied carbon in buildings now, the current design standards will continue to be adhered to in regard to wind loading.	1	2	L
	Cold events	Additional Snow Loads	2	2	M	M	No	Snowfall is expected to decrease over the coming years. No adverse effects upon the building are expected.	1	1	L
Weather proofing and detailing	Storms (including high winds)	Water infiltration	2	1	L	L	No	The building will be water-tight and waterproof membrane will be installed.	1	1	L
	Wetter winters leading to greater winter rainfall	Mold and damping	3	1	M	M	No	Select materials that are easily cleanable.	1	2	L
Material Durability	Flooding	Increased risk of water damage to building and tunnel.	1	2	L	L	No	The site is shown to be in Flood Zone 1 and therefore is considered to be at very low flood risk.	1	2	L
	Storms (including high winds)	Increased degradation of building finishes	2	2	M	M	No	Detail design of robust facade system to provide sufficient allowance for potential future increase in wind loading.	1	1	L
	Cold events	Risk of cracking and leakages	2	2	M	M	No	Detail design to provide sufficient allowance in design for potential future cold events.	1	1	L
	Heat waves (including temperature increases)	Risk of cracking and leakages	3	2	M	M	No	Detail design to provide sufficient allowance in design for potential future increase in temperature variation.	1	1	L
	Warmer summers and increased solar radiation	Increased degradation of building finishes and paintwork	3	1	M	M	No	Selected the materials with high robustness.	1	1	L
	Temperature variation	Increased degradation of building finishes	3	2	M	M	No	Selected the materials with high robustness.	1	1	L
	Precipitation	Mold and damping	3	1	M	M	No	Select materials that are easily cleanable.	1	1	L
Health and Safety of building occupants and others	External overheating	Hotter, drier summers	3	1	M	M	No	Increasing the quantity of green infrastructure on the Furnival terrace will help to reduce the impact of urban heat island, as plants will mitigate heat build-up of heat.	1	1	L

Asset Category	Hazard Identification	Risk	Hazard Assessment			Risk Evaluation		Risk Management / Mitigation	Residual Risk		
			P	S	R	Tolerable Risk Threshold	Unacceptable Risk?		P	S	R
Weather proofing and detailing	Flooding	Water damage to systems	1	2	L	L	No	The site is shown to be in Flood Zone 1 and therefore is considered to be at very low flood risk.	1	1	L
	Storms (including high winds)	Water ingress into plantrooms	2	3	M	M	No	Ground levels should fall away from building entrances / thresholds in order to mitigate against surface water runoff entering the ground floor during extreme storm events.	1	2	L
	Cold events	Frost damage.	2	1	L	L	No	High performance pipework insulation will be proposed.	1	1	L
	Wetter winters leading to greater winter rainfall	Flooding and water ingress into outdoor plants	2	3	M	M	No	Design rain water and drainage for extreme events. Specify equipment to withstand water damage.	2	1	L
	Precipitation e.g rain and snow	Flooding and water ingress into plantrooms. Snow loadings on roof.	2	3	M	M	No	Design rain water and drainage for extreme events. Specify equipment to withstand water damage.	2	1	L
Material Durability	Flooding	Water damage to systems	1	2	L	L	No	The site is shown to be in Flood Zone 1 and therefore is considered to be at very low flood risk.	1	1	L
	Cold events	Frost damage.	2	1	L	L	No	High performance pipework insulation.	1	1	L
	Wetter winters leading to greater winter rainfall	Flooding and water ingress into outdoor plants.	2	3	M	M	No	Design rain water and drainage for extreme events. Specify enclosure to withstand water damage.	2	1	L
	Precipitation e.g rain and snow	Flooding and water ingress into outdoor plants.	2	3	M	M	No	Design rain water and drainage for extreme events. Specify enclosure to withstand water damage.	2	1	L
Health and Safety of building occupants and others	Flooding	Flooding and water ingress into building	2	3	M	M	No	Ground levels should fall away from building entrances / thresholds in order to mitigate against water runoff entering the ground floor during extreme storm events.	2	1	L
	Cold events	Under heating.	2	1	L	L	No	Design to suitable heating design criteria. Emphasis on building fabric performance including thermal performance and air tightness.	1	1	L
	Heat waves (including temperature increases)	Buildings become too hot to occupy	2	2	M	M	No	An efficient water-cooled system allows mitigation of overheating spaces.	1	1	L
	Drought (including reduced summer rainfall)	Water supply restrictions	2	3	M	M	No	The Development will employ design measures regarding water conservation and will have reduced mains water demand over typical performance.	2	1	L
	Wetter winters leading to greater winter rainfall	Flooding and water ingress into building	2	3	M	M	No	Design rain water and drainage for extreme events.	2	1	L
	Warmer summers and increased solar radiation	Buildings become too hot to occupy	2	2	M	M	No	An efficient water-cooled system allows mitigation of overheating spaces.	1	1	L

Asset Category	Hazard Identification	Risk	Hazard Assessment			Risk Evaluation		Risk Management / Mitigation	Residual Risk		
			P	S	R	Tolerable Risk Threshold	Unacceptable Risk?		P	S	R
Impacts on building contents and business continuity	Flooding	Flooding and water ingress into building	2	3	M	M	No	Ground levels should fall away from building entrances / thresholds in order to mitigate against water runoff entering the ground floor during extreme storm events.	2	1	L
	Storms (including high winds)	Damage to external lighting.	2	3	M	M	No	Use of robust fixings.	1	1	L
	Cold events	Under heating.	2	1	L	L	No	Design to suitable heating design criteria. Emphasis on building fabric performance including thermal performance and air tightness.	1	1	L
	Heat waves (including temperature increases)	Buildings become too hot to occupy	2	2	M	M	No	Design in natural ventilation measures. Solar control glazing. Shading. Include thermal weight to construction fabrics. Undertake a thermal comfort analysis using future weather file.	1	1	L
	Drought (including reduced summer rainfall)	Water supply restrictions	2	2	M	M	No	The Development will employ design measures regarding water conservation and will have reduced mains water demand over typical performance.	2	1	L
	Wetter winters leading to greater winter rainfall	Flooding and water ingress into building	2	3	M	M	No	Design rain water and drainage for extreme events.	2	1	L
	Warmer summers and increased solar radiation	Buildings become too hot to occupy	2	2	M	M	No	An efficient water-cooled system allows mitigation of overheating spaces.	1	1	L
Building for and design	Hotter, drier summers	Increased degradation of glass technologies from increased heat and UV	2	1	L	L	Yes, there is an operational impact if glazing does not perform to intended requirement.	Include in building specification glass panels and elements with extra UV protection and elements that avoid degradation. Contact glass manufacturer/supplier during stage 4.	1	1	L
	Hotter, drier summers	Increased conflict between maximising daylight and overheating	1	1	L	L	Yes: Impacts on potential use of the space.	Carry out an overheating and daylight analysis at RIBA stage 3 and 4 for design consideration.	1	1	L
	Solar radiation	Increased reliance of thermal mass in significantly warmer climate.	2	1	L	L	Yes - influences the room finished	Select fabric with good thermal mass.	2	1	L
	Colder, wetter winters	Improved building fabric insulation standards required to cope with colder days.	2	2	M	M	Yes - impacts on room design conditions	Good fabric insulation proposed.	2	2	M
Systems and controls	Warm, wetter winters	Consider controls strategy for adjusting if winters are getting warmer.	1	1	L	L	Yes - energy cost savings if the heating requirement during the winter months can be reduced	The heating controls to consider allowance for future heating requirement changes.	1	1	L

Appendix B

Interrelationships between anticipated changes in climate and opportunities for design

(Reference: "Design for future climate" by the Technology Strategy Board)

Designing for construction

This table summarises some interrelationships between anticipated changes in climate and opportunities for design, and indicates the timescales to consider when developing design strategies.†

Key

Climate trend	
☀	Hotter, drier summers
☀ ☁	Warmer, wetter winters
⚠	More extreme events

Climate information	
P	Primary issue
S	Secondary issue

Time˙	
◔	Short – 10 years
◑	Medium – 25 years
◕	Long – 50 years

Climate	Structural stability – below ground	Temp – summer mean*	Temp – summer mean max*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean min (night)*	Temp – warmest night of the season*	Temp – winter mean*	Temp – winter extremes, min and max*	Wind – summer mean**	Wind – summer still periods**	Wind – direction**	Wind – summer extremes**	Wind – winter average**	Wind – winter extremes**	Sunshine – average (Weather Generator)**	Rainfall – summer average*	Rainfall – summer droughts (Weather Generator)**	Rainfall – summer extremes*	Rainfall – winter average*	Rainfall – winter wet periods (Weather Generator)**	Rainfall – winter extremes*	Time
☀ ☁ ⚠	Foundation design – subsidence / heave / soils / regions											S		P	P	S	S	S	S		◕
☀ ☁ ⚠	Underpinning											S		P	P	S	S	S	S		◕
☀ ☁ ⚠	Retaining wall and slope stability													P	P	S	P	P	P		◕

Climate	Structural stability – above ground																					Time
⚠	Lateral stability – wind loading standards											P										◕
☁ ⚠	Loading from ponding											S					S	P	P			◕

Climate	Fixings and weatherproofing																					Time
⚠	Fixing standards – walls, roofs											P							P			◑ ◕
⚠	Detail design for extremes – wind – 3-step approach											P							P			◑ ◕
⚠	Lightning strikes (storm intensity)										P	P				P			P			◑ ◕
⚠	Tanking / underground tanks in relation to water table – contamination, buoyancy, pressure																P	P	P			◑ ◕
⚠	Detail design for extremes – rain – thresholds / joints											P						S	P			◑ ◕

Climate	Materials behaviour																					Time
☁ ⚠	Effect of extended wetting – permeability, rotting, weight												S				P	P	P			◔ ◑
☀	Effect of extended heat / UV – drying out, shrinkage, expansion, de-lamination, softening, reflection, admittance, colour fastness	S	P	P	S								P									◔ ◑
⚠	Performance in extremes – wind – air tightness, strength, suction / pressure															S	S	S	P			◔ ◑
☁ ⚠	Performance in extremes – rain																S	P	P			◔ ◑

Climate	Work on site																					Time
☀	Temperature limitations for building processes		P	P	S	S								P								◔
☀ ☁ ⚠	Stability during construction											P							S			◔
☀ ☁ ⚠	Inclement winter weather – rain (reduced freezing?)																P	P	P			◔
☀	Working conditions – site accommodation	S	P	P	S	S			S			S	P						S			◔
☀	Working conditions – internal conditions in incomplete / unserviced buildings (overlap with robustness in use)	S	P	P	S	S			S				P									◔

†Designers should also consider the following issues: low carbon, low energy world; behaviours will adapt to the climate; existing stock; design for robustness, maintenance and reparability; regulation vs competitive advantage; delight; regional variation. ˙10 years until replacement or upgrade *Full probabilistic information is available from UKCPO9 **Information is not available or only by using the UKCPO9 Weather Generator (see appendix 1).

Designing for comfort

This table summarises some interrelationships between anticipated changes in climate and opportunities for design, and indicates the timescales to consider when developing design strategies.[†]

Key

Climate trend	
☀	Hotter, drier summers
☀	Warmer, wetter winters
⚠	More extreme events

Climate information	
P	Primary issue
S	Secondary issue

Time[˙]	
◔	Short – 10 years
◑	Medium – 25 years
◕	Long – 50 years

Climate	Design opportunities: Keeping cool – building design	Temp – summer mean*	Temp – summer mean max*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean min (night)*	Temp – warmest night of the season*	Temp – winter mean*	Temp – winter extremes min and max*	Wind – summer mean**	Wind – summer still periods**	Wind – direction**	Wind – summer extremes**	Wind – winter average**	Wind – winter extremes**	Sunshine – average (Weather Generator)**	Rainfall – summer average*	Rainfall – summer droughts (Weather Generator)**	Rainfall – summer extremes*	Rainfall – winter average*	Rainfall – winter wet periods (Weather Generator)**	Rainfall – winter extremes*	Time
☀	Shading – manufactured	P	P	S	S	S				P	S	S		S	P		S					◔ ◑
☀	Shading – building form	P	P	S	S	S				P	S	S		S	P		S					◕
☀	Glass technologies	P	P	S	S	S				P	S	S			P		S					◑
☀	Film technologies	P	P	S	S	S				P	S	S			P		S					◔
☀	Green roofs / transpiration cooling	P	P	S	S	S				P	S	S			P		S					◑ ◕
☀	Shading – planting	P	P	S	S	S				P	S	S			P		S					◔ ◑ ◕
☀	Reflective materials	P	P	S	S	S				P	S	S			P		S					◔ ◑
☀	Conflict between maximising daylight and overheating (mitigation vs adaptation)	P	P	S	S	S				P	S	S			P		S					◔ ◑ ◕
☀	Secure and bug-free night ventilation	P	P	P	P	P				P	S	S			P		S					◔ ◑
☀	Interrelationship with noise and air pollution	P	P	P	P	P				P	S	S			P		S					◑ ◕
☀	Interrelationship with ceiling height	P	P	P	P	P				P	S	S			P		S					◑ ◕
☀	Role of thermal mass in significantly warmer climate	P	P	P	P	P				P	S	S			P		S					◕
☀	Enhancing thermal mass in lightweight construction	P	P	P	P	P				P	S	S			P		S					◑ ◕
☀	Energy efficient / renewable powered cooling systems	P	P	P	P	P				P	S	S			P		S					◑
☀	Groundwater cooling	P	P	S	S	S				P	S	S			P	S	S		P			◑
☀	Enhanced control systems – peak lopping	P	P	S	S	S				P	S	S			P		S					◔ ◑
☀	Maximum temperature legislation	P	P	P	P	P				P	S	S			P		S					◑ ◕

Climate	Design opportunities: Keeping cool – external spaces	Temp – summer mean*	Temp – summer mean max*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean min (night)*	Temp – warmest night of the season*	Temp – winter mean*	Temp – winter extremes min and max*	Wind – summer mean**	Wind – summer still periods**	Wind – direction**	Wind – summer extremes**	Wind – winter average**	Wind – winter extremes**	Sunshine – average (Weather Generator)**	Rainfall – summer average*	Rainfall – summer droughts (Weather Generator)**	Rainfall – summer extremes*	Rainfall – winter average*	Rainfall – winter wet periods (Weather Generator)**	Rainfall – winter extremes*	Time
☀	Built form – building to building shading	P	P	S	S	S				P	S	S			P		P					◕
☀	Access to external space – overheating relief	P	P	S	S	S				P	S	S			P		P					◕
☀	Shade from planting	P	P	S	S	S				P	S	S			P		P					◔ ◑ ◕
☀	Manufactured shading	P	P	S	S	S				P	S	S		S	P		P					◔ ◑
☀	Interrelationship with renewables	P	P	S	S	S				P	S	S			P		P					◑
☀	Shading parking / transport infrastructure	P	P	S	S	S				P	S	S			P		P					◔ ◑
☀	Role of water – landscape / swimming pools	P	P	S	S	S				P	S	S			P		P				S	◑ ◕

Climate	Design issue and opportunities: Keeping warm	Temp – summer mean*	Temp – summer mean max*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean min (night)*	Temp – warmest night of the season*	Temp – winter mean*	Temp – winter extremes min and max*	Wind – summer mean**	Wind – summer still periods**	Wind – direction**	Wind – summer extremes**	Wind – winter average**	Wind – winter extremes**	Sunshine – average (Weather Generator)**	Rainfall – summer average*	Rainfall – summer droughts (Weather Generator)**	Rainfall – summer extremes*	Rainfall – winter average*	Rainfall – winter wet periods (Weather Generator)**	Rainfall – winter extremes*	Time
⚠	Building fabric insulation standards						P	P				S	S	P								◑ ◕
⚠	Relevance of heat reclaim systems						P	P				S	S	P								◑
⚠	Heating appliance design for minimal heating – hot water load as design driver						P	P				S	S	P								◔ ◑

[†]Designers should also consider the following issues: low carbon, low energy world; behaviours will adapt to the climate; existing stock; design for robustness, maintenance and reparability; regulation vs competitive advantage; delight; regional variation. ˙10 years until replacement or upgrade *Full probabilistic information is available from UKCPO9 **Information is not available or only by using the UKCPO9 Weather Generator (see appendix 1).

Designing to manage water

This table summarises some interrelationships between anticipated changes in climate and opportunities for design, and indicates the timescales to consider when developing design strategies.†

Key

Climate trend	
☀	Hotter, drier summers
☀ 🌧	Warmer, wetter winters
⚠	More extreme events

Climate information	
P	Primary issue
S	Secondary issue

Time˙	
◔	Short – 10 years
◑	Medium – 25 years
◕	Long – 50 years

Climate	Water conservation	Temp – summer mean*	Temp – summer mean max*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean min (night)*	Temp – warmest night of the season*	Temp – winter mean*	Temp – winter extremes, min and max*	Wind – summer mean**	Wind – summer still periods**	Wind – direction**	Wind – summer extremes**	Wind – winter average**	Wind – winter extremes**	Sunshine – average (Weather Generator)**	Rainfall – summer average*	Rainfall – summer droughts (Weather Generator)**	Rainfall – summer extremes*	Rainfall – winter average*	Rainfall – winter wet periods (Weather Generator)**	Rainfall – winter extremes*	Time
☀	Low water use fittings														P	P		S				◔ ◑ ◕
☀	Grey water storage														S	S		S				◔ ◑
☀	Rain water storage														P	P		S				◔ ◑ ◕
☀	Alternatives to water-based drainage														P	P		S				◕
☀	Pools as irrigation water storage	S	S	S										S	P	P						◑ ◕
☀	Limits to development														P	P		S				◕
☀ 🌧	Water-intensive construction processes														P	P						◔

Climate	Drainage – external / building related	Temp – summer mean*	Temp – summer mean max*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean min (night)*	Temp – warmest night of the season*	Temp – winter mean*	Temp – winter extremes, min and max*	Wind – summer mean**	Wind – summer still periods**	Wind – direction**	Wind – summer extremes**	Wind – winter average**	Wind – winter extremes**	Sunshine – average (Weather Generator)**	Rainfall – summer average*	Rainfall – summer droughts (Weather Generator)**	Rainfall – summer extremes*	Rainfall – winter average*	Rainfall – winter wet periods (Weather Generator)**	Rainfall – winter extremes*	Time
🌧 ⚠	Drain design															S	S	P	P			◕
🌧 ⚠	SUDS and soakaway design															S	S	P	P			◑ ◕
⚠	Gutter / roof / upstand design																		P			◑ ◕

Climate	Flooding – avoidance / resistance / resilience	Temp – summer mean*	Temp – summer mean max*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean min (night)*	Temp – warmest night of the season*	Temp – winter mean*	Temp – winter extremes, min and max*	Wind – summer mean**	Wind – summer still periods**	Wind – direction**	Wind – summer extremes**	Wind – winter average**	Wind – winter extremes**	Sunshine – average (Weather Generator)**	Rainfall – summer average*	Rainfall – summer droughts (Weather Generator)**	Rainfall – summer extremes*	Rainfall – winter average*	Rainfall – winter wet periods (Weather Generator)**	Rainfall – winter extremes*	Time
⚠	Environment Agency guidance – location, infrastructure															P	S	P	P			◕
⚠	Combination effects – wind + rain + sea level rise										P		P			P	S	P	P			◕
⚠	Flood defence – permanent														S	S	S	P	P			◕
⚠	Flood defence – temporary – products etc															S	S	P	P			◔ ◑
⚠	Evacuation / self sufficiency															S		P	P			◕
⚠	Flood tolerant construction															S	S	P	P			◕
⚠	Flood tolerant products and materials															S	S	P	P			◑ ◕
⚠	Post-flood recovery measures															S		P	P			◕

Climate	Landscape	Temp – summer mean*	Temp – summer mean max*	Temp – duration of hot periods (Weather Generator)**	Temp – summer mean min (night)*	Temp – warmest night of the season*	Temp – winter mean*	Temp – winter extremes, min and max*	Wind – summer mean**	Wind – summer still periods**	Wind – direction**	Wind – summer extremes**	Wind – winter average**	Wind – winter extremes**	Sunshine – average (Weather Generator)**	Rainfall – summer average*	Rainfall – summer droughts (Weather Generator)**	Rainfall – summer extremes*	Rainfall – winter average*	Rainfall – winter wet periods (Weather Generator)**	Rainfall – winter extremes*	Time
☀ 🌧	Plant selection – drought resistance vs cooling effect of transpiration	P	P	P								S	P	P	P	S		P	S			◑ ◕
☀ 🌧	Materials behaviour in high temperatures	S	P	S																		◑ ◕
☀ 🌧	Changes to ecology	P	P	P								S	P	P	P	S		P	S			◑ ◕
☀	Irrigation techniques	P	P	P								S	P	P	P	S		P	S			◔
☀	Limitations on use of water features – mosquitoes etc	P	P	P								S	P	P	P	S		P	S			◑ ◕
☀	Role of planting and paving in modifying micro climate and heat island effect	P	P	P								S	P	P	P	S		P	S			◑ ◕
	Failsafe design for extremes – water																		P			◕
☀	Firebreaks	P		P				S	S	S	S			P	P	P		S				◕

†Designers should also consider the following issues: low carbon, low energy world; behaviours will adapt to the climate; existing stock; design for robustness, maintenance and reparability; regulation vs competitive advantage; delight; regional variation. ˙10 years until replacement or upgrade *Full probabilistic information is available from UKCPO9 **Information is not available or only by using the UKCPO9 Weather Generator (see appendix 1).