CLIMATE CHANGE RISK ASSESSMENT
FOR STONEHENGE AND AVEBURY
WORLD HERITAGE SITE

United Nations
Educational, Scientific and
Cultural Organization

Stonehenge, Avebury and Associated Sites inscribed on the World Heritage List in 1986

CLIMATE CHANGE RISK ASSESSMENT
FOR STONEHENGE AND AVEBURY WORLD HERITAGE SITE

United Nations
Educational, Scientific and
Cultural Organization

Stonehenge, Avebury and Associated Sites inscribed on the World Heritage List in 1986

Avebury

Stonehenge

CONTENTS

Back to Contents Page

EXECUTIVE SUMMARY

This study has identified a range of 22 possible impacts to the World Heritage Site (WHS) which could occur as a result of climate change, notably in terms of precipitation and temperature changes. Some are localised and specific to the monuments themselves, whereas others are more global impacts which could affect the historic environment as a whole. These projected impacts have been ranked subjectively according to their potential likelihood and severity at the Stonehenge and Avebury WHS, with an estimate of the time-scale over which they may operate. Some, such as damage to grassland and soils resulting in localised erosion, and flooding at Avebury, are already happening. These 22 impacts have been developed into a risk assessment for the WHS considering the impacts, management response and any strategic adaptation measures necessary to manage their impact onto the monuments and setting of the WHS.

Climate change impacts are best perceived as a risk multiplier, so that problems which are already apparent will increase or accelerate. Eventually, new problems will arise. Actions for the future will, therefore, partly comprise 'business as usual' – for example effective management of visitor and animal movement to minimise erosion – but also monitoring trends. Many of the projected problems outlined in the Tables below will probably prove to be insignificant. Others may demand attention and management.

What actions are required now? First, there is no need to panic. Changes will occur, but these monuments have undergone significant climate change in the past and have proved to be resilient. The risk assessment below at Table 1 plainly indicates issues that require immediate attention (those at the top of the Table). In fact many of these issues are already being addressed as part of regular management. The implications of flooding at Avebury are being actively considered and urgent attention is required to increasing the resilience of archives. Other issues require, fundamentally, a defined programme of monitoring, which should assess risk, report at regular intervals and highlight new problems that need attention. These needs should be incorporated into the updated version of WHS Management Plan for Stonehenge and Avebury with relevant actions clearly indicated and responsibility for their delivery agreed. This risk assessment should be monitored regularly and reviewed every 5 years in order to reflect changes as they occur.

Back to Contents Page

SUMMARY OF RISKS TO STONEHENGE AND AVEBURY WORLD HERITAGE SITE	
1.0	Erosion by movement of people both on foot and in vehicles causing damage to monuments and buried archaeology.
2.0	Peak visitor numbers and increased access at key observances e.g. Winter & Summer Solstices causing damage to archaeology, visitor infrastructure and natural environment.
3.0	Extreme weather events such as storms and gales causing damage to archaeological deposits and the cultural material and biological remains contained with them.
4.0	Freeze/thaw causing damage to monuments.
5.0	Erosion by livestock causing damage to monuments and buried archaeology.
6.0	Flooding (at Avebury) causing damage to buried archaeology and artefacts.
7.0	Change to vegetation cover causing damage to monuments and buried archaeology and their setting.
8.0	Increases in domestic and overseas visitors as tourist areas popular now (Spain, Italy etc) become too hot.
9.0	Conditions may become too uncomfortable for visitors and livestock.
10.0	Changes in burrowing animal population.
11.0	Changes in pathogens, invasive species and pests.
12.0	Effect on tree species.
13.0	Longer growth season.
14.0	Less vigorous grassland.
15.0	Threat to lichens on megaliths.
16.0	Changes in farming practice as a result of climate change. Response to local climatic conditions or national/global economic incentives.
17.0	Change to water table.
18.0	Changes in water abstraction may affect habitats and landscape and the setting of monuments
19.0	Water shortages may impact on visitor experience.
20.0	Increase in wildfires/accidental fires.
21.0	Stability of megaliths affected by drier soils.
22.0.	Pressure of development and land-use change.

Back to Contents Page

INTRODUCTION

1. During the development of the Stonehenge World Heritage Site (WHS) Management Plan 2009 the issue of climate change and its potential impact on the WHS was raised. Issue 19[i] noted that UNESCO published a strategy in 2007 (Climate Change and World Heritage, World Heritage Occasional Paper 22, Paris 2007) and requested that all WHS integrate climate change issues into revised Management Plans. In paragraph 8.7.5 the Stonehenge Management Plan notes:

2. At first sight the likely impact of climate change on the attributes of Outstanding Universal Value (OUV) does not appear dramatic, but there could be significant changes to the character of the landscape. It will be necessary therefore over the next Plan period to analyse the risks to the Stonehenge WHS of climate change and to develop appropriate adaptation strategies to minimise its effects."

3. This is summarised in Policy 3k – **A study of the possible impacts of climate change should be carried out and appropriate adaptation strategies identified**[ii].

4. The Avebury World Heritage Site Management Plan was published in 2005 prior to the UNESCO Climate and World Heritage Paper and therefore there is no explicit objective or action related to climate change. However an assessment of potential climate change impacts on conservation and appropriate adaptation strategies are clearly equally relevant to both halves of the World Heritage Site. The Climate Change Risk Assessment will inform the joint Stonehenge and Avebury WHS Management Plan currently under preparation.

[i] Stonehenge WHS Management Plan 2009 p70
[ii] Stonehenge WHS Management Plan 2009 p102

Back to Contents Page

Group visits Stonehenge March 2013 © P Murphy English Heritage

Differential grass trampling at Stonehenge March 2013 © P Murphy English Heritage

Back to Contents Page

METHODOLOGY

5. As a first step in developing this Climate Change Risk Assessment, English Heritage invited a variety of local and national colleagues from a range of organisations to a workshop in March 2013 to discuss the issues and put together a draft framework to develop a risk assessment for both halves of the Stonehenge & Avebury WHS. This was preceded by a site visit to Stonehenge to look at the impacts of climate change on the ground.

6. This Workshop involved presentations on a number of topics including an overview of climate change from pre-history to the present day as shown in the archaeological evidence. This demonstrated that the WHS has already seen significant changes in climate since the end of the last Ice Age. More recently there has been a steady increase in temperature since the mid-nineteenth century which has noticeably accelerated in the latter part of the 20th century.

7. Following the presentations, two smaller groups led by the Stonehenge and Avebury WHS Co-ordinators discussed the conservation objectives for the WHS and the main impacts, both direct and indirect, that could reasonably be expected based on the ***UK Climate Projections 2009*** (UKCP09: summarised in Jenkins et al. 2009)) South West England and the County of Wiltshire. The names of the participants are shown at Appendix A

8. This risk assessment methodology has been adapted from that of the Royal Society for the Protection of Birds (RSPB) and we thank Olly Watts, Senior Climate Change Policy Officer of the RSPB for providing us with this toolkit which is available from the RSPB on request.

Traditional grass management using sheep © P Murphy English Heritage

Back to Contents Page

Visitor erosion at gate March 2013 © P Murphy English Heritage

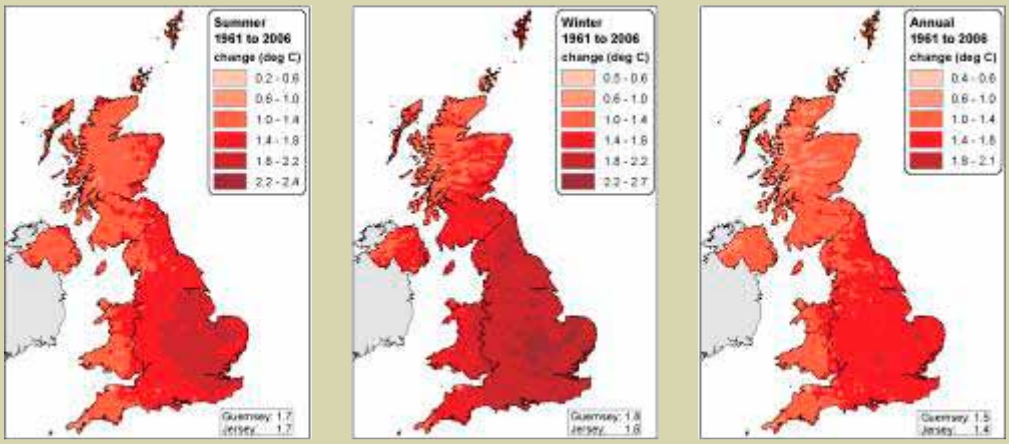
Visitor erosion Cursus barrow group March 2013 © P Murphy English Heritage

Back to Contents Page

CLIMATE CHANGE AND THE STONEHENGE & AVEBURY WORLD HERITAGE SITE

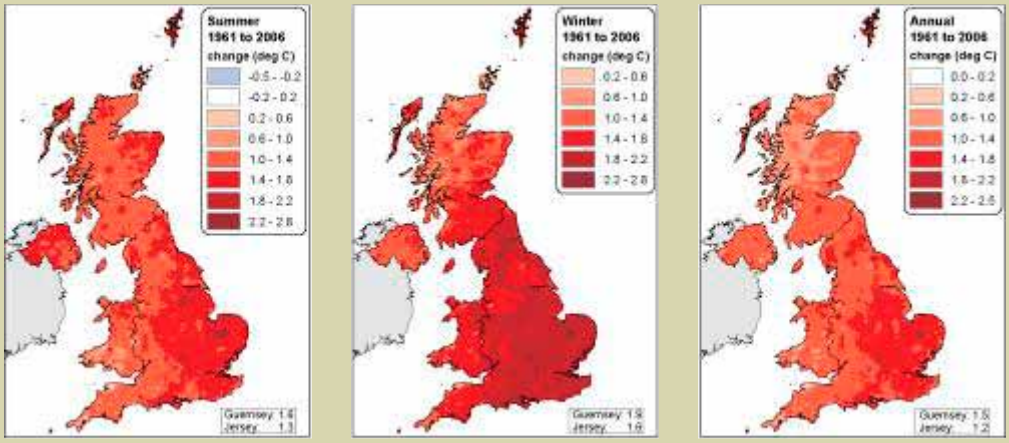
9. The report ***Adapting to Climate Change: UK Climate Projections 2009*** (UKCP09: summarised in Jenkins et al. 2009) demonstrates how both mean temperatures and

Winter *Annual*



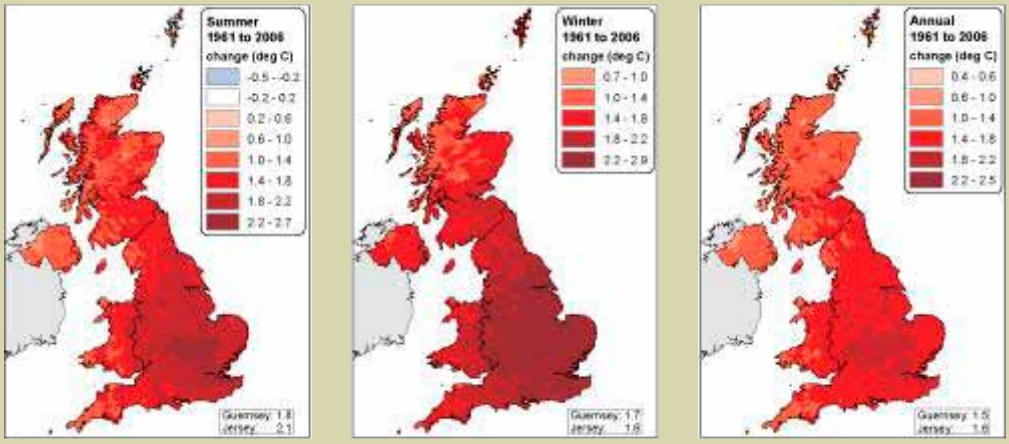
Change in average daily mean temperature (°C) from 1961 to 2006.

Summer *Winter* *Annual*



Change in average daily minimum temperature (°C) from 1961 to 2006.

Summer *Winter* *Annual*



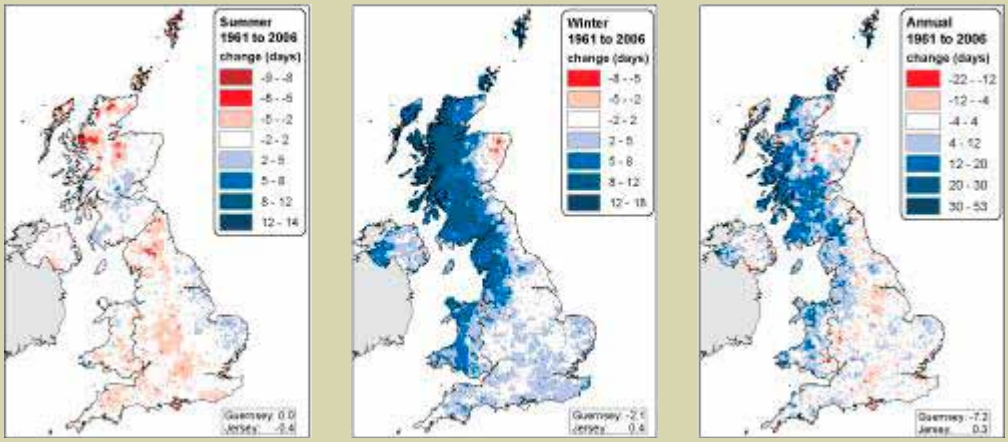
Change in average daily maximum temperature (°C) from 1961 to 2006.

Back to Contents Page

total precipitation and days of rainfall have already increased over the past 45 years resulting in hotter, drier summers and warmer, wetter winters. Climate predictions vary depending on assumptions but the consensus for the UK is that we can expect more extreme weather events, increased seasonal precipitation and hotter, drier summers. The charts below from the UKCP09 show the changes in daily temperature and precipitation from 1961 – 2006. "By the 2080s, the UKCP09 projections for different parts of the UK suggest an increase in average summer temperatures of between about 1°C and 8°C; an increase in average winter rainfall volumes of between around 3% and 70%; a projected change in average summer rainfall volumes ranging from a decrease of about 60% to an increase of about 10%; and by 2095 a projected rise in sea levels around London, for instance, of between about 20 cm and 70 cm."[iii]

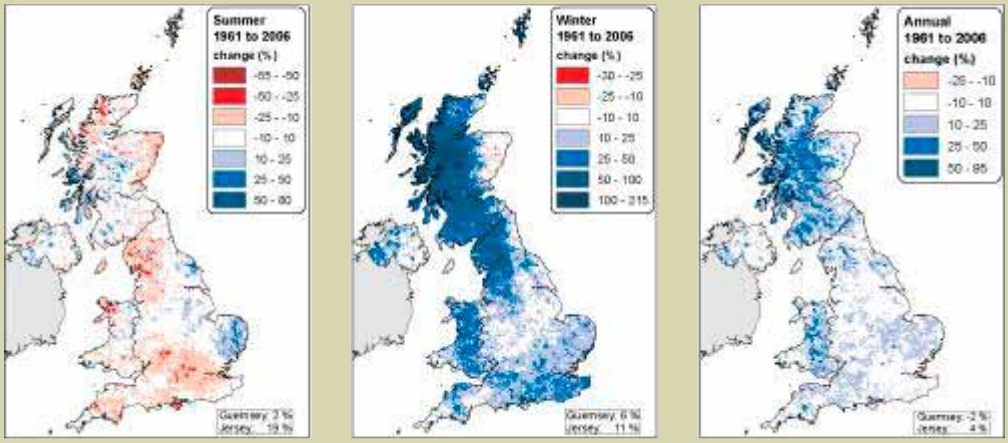
10. There is still a great deal of uncertainty about the exact nature of climate change and the effect it will have on our landscape and economy. Already in the past 3 years we have had both drought and records for precipitation as well as record high temperatures in 2013. Changes in the climate appear to be already underway and it is clear that developing a better understanding of their impacts on the Stonehenge & Avebury WHS is required. These will require review and monitoring on a regular basis as part of an ongoing management process.

Summer *Winter* *Annual*



Change in average number of days of rain @ 1mm (days) from 1961 to 2006.

Summer *Winter* *Annual*



Change in average precipitation (mm) from 1961 to 2006.

[iii] Stonehenge WHS Management Plan 2009 p70
[iv, v] © UK Climate Projections 2009

Back to Contents Page

CONSERVATION OBJECTIVES FOR THE STONEHENGE & AVEBURY WORLD HERITAGE SITE

11.

i. Protect the WHS in order to sustain its Outstanding Universal Value (OUV) both now and in the future. This not only includes protecting the physical fabric of monuments and buried archaeology but also the setting of the monuments, including their relationship to the topography of the area and water courses and their relationship to one another. In addition it should enhance the ability to appreciate the astronomical alignment in the design of certain monuments.

ii. Allow visitors to explore, enjoy and understand the WHS and its OUV through sustainable tourism.

iii. Enable residents to adapt to climate change without damaging the WHS and its OUV.

iv. Ensure the design, scale and location of any proposed renewable energy schemes do not damage the WHS and its OUV.

v. Work in partnership to protect other designated assets in the WHS such as Sites of Special Scientific Interest (SSSI), National Nature Reserves (NNR), the North Wessex Downs Area of Outstanding Natural Beauty (AONB), Special Protection Areas (SPA) and Special Areas of Conservation (SAC).

Party inspects fencing and recovery March 2013 © P Murphy English Heritage

Back to Contents Page

POTENTIAL IMPACTS OF CLIMATE CHANGE ON THE STONEHENGE & AVEBURY WHS

12. A number of generic climate change issues with potential impacts on the WHS were identified during the workshop and have been considered as part of the risk assessment below. Further work may be required over the life of the next WHS Management Plan on the more detailed and specific climate change related questions raised. Examples of these include whether or not standing water around Silbury Hill following periods of prolonged precipitation could be a threat to buried archaeology, the stability of megaliths in drier soils and the effects of changes in water table levels on the preservation of burials and the vegetation of chalk downland. The paragraphs below summarise further potential impacts beyond the scope of this document.

13. The historic and natural environments are closely interrelated in the landscape of the Stonehenge & Avebury WHS. It is human interaction with the natural environment over time that has led to the historic landscape features for which the WHS is listed. The exact impact of climate change on the natural environment is still unclear but there may be increased stress on the existing ecosystems due to changes in temperature. Changes in the ecology of the chalk grassland may affect the setting and conservation of NNR, SSSI & SAC.

Cattle damage on the Cursus March 2013 © P Murphy English Heritage

Back to Contents Page

Erosion Control Cursus Barrows October 2012 © B Thomas English Heritage

Example of gullying © John Boardman

Back to Contents Page

14. Growing concerns over the negative impacts of climate change have created greater impetus for its mitigation. Pressure to increase the number and scale of alternative energy sources such as wind turbines and solar arrays may result in increased political and local pressure to install these technologies. Stonehenge & Avebury WHS partners needs to agree an approach to this demand which could affect the setting of the WHS and its attributes of OUV both within and outside the site and cause below ground disturbance to buried archaeology within the WHS.

15. In addition to the WHS there are a number of statutory protections (SAM, SSSI, AONB, and Listed Buildings) that may be at risk due to global pressures outside the our direct influence. These global pressures may affect both setting and physical survival of the attributes of OUV.

16. Increases in temperature or rainfall, or extreme weather events could place pressure upon agricultural land in both the UK and overseas and therefore lead to the need for more intensive production. Recognition of the need to cope with such issues could lead to their prioritisation under agri-envrionment schemes and a resultant reduction of resources for managing rural heritage. In a worst case scenario migration into the area of populations displaced from areas adversely affected by climate change could lead to increased pressure for development. Although very unlikely, this could also have an adverse impact upon heritage, either physically or upon its setting.

17. Given that we are still uncertain about the effects of climate change on the landscape it is essential that regular monitoring is carried out both by individual WHS partners and across the WHS as a whole. Further research on the impact of climate change on chalk grassland is necessary in order to better anticipate any future changes and potential adaptation measures that could protect the Stonehenge & Avebury WHS and its Outstanding Universal Value in the short, medium and long term.

18. The potential impacts listed below are a summary that will inform the production of the joint Stonehenge & Avebury WHS Management Plan and related action plan for the relevant WHS partners. Table 1 reflects the two most likely change scenarios: A – Wetter Conditions and B - Hotter Conditions. Under each, the possible impacts on the WHS are noted with explanations and examples listed beneath. These impacts have been risk assessed based on their likelihood and severity which are indicated on a scale of 1 to 3 with 1 being the most likely and the most severe. A severity score of 1 would indicate a widespread impact across the WHS or very severe impact on key attributes. A score of 2 would indicate some limited impact on the WHS or moderate impact on key attributes. A score of 3 would indicate that it would have little impact across the WHS or low impact on key attributes within the WHS. The probable imminence or timescale is indicated as short, medium or long range. The definition of these timescales is "short" i.e. impacts are already apparent, "medium" i.e. 10 – 20 years and "long" i.e. end of the 21st century.

Back to Contents Page

19. Table 2 details indicators, management responses and strategic adaptation measures to address the risks identified in Table 1. They are presented in order of their likelihood and severity and are colour-coded from red to yellow. A short, medium or long timescale is set out for management and adaptation. Many of the responses proposed reflect management best practice already in place. The additional risks related to climate change will in many cases simply mean stepping up existing management regimes and increasing the sensitivity and regularity of monitoring. There may be some risks which cannot be effectively managed or have positive impact on the WHS such as changes in biodiversity which would benefit the WHS.

LIKELIHOOD	SEVERITY	TIMESCALE
1 = Very likely/definitely 2 = Likely 3 = Not very likely	1 = wide impact/very severe impact 2 = limited impact/moderate impact 3 = very limited impact/low impact	S - short range (already apparent) M - medium range (10-20 years) L - long range (by the end of the 21stC)

"Drapes" placed on henge bank at Avebury to prevent visitor erosion © B Thomas English Heritage

Flooding at Swallowhead Spring, River Kennet, Avebury, © B Thomas, English Heritage

Back to Contents Page

Table 1 RISK ASSESSMENT

A: WETTER CONDITIONS (INCREASED PRECIPITATION AND HEAVIER, MORE INTENSE RAINFALL)

		Likelihood	Severity	Timescale
1.0	Erosion by movement of people both on foot and in vehicles causing damage to monuments and buried archaeology.	1	1	S
1.1	Wetter conditions lead to increased "rutting" by vehicles and churning up of the ground by visitors' feet potentially exposing buried archaeology to direct damage as protecting topsoil cover is reduced. This would also result in damage to upstanding archaeological earthwork features composed of chalk rubble.			
1.2	Damage to buried drains which can lead to increased water-logging and flooding.			
1.3	Erosion more likely at pinch points such as gates and information points and on desire lines.			
2.0	Peak visitor numbers and increased access at key observances e.g. Winter & Summer Solstices potentially causing damage to archaeology, visitor infrastructure and natural environment.	1	2	S
2.1	Numbers at both the Summer & Winter Solstices have been increasing. If ground conditions are not favourable there is potential for damage to the paths, entrance gates and areas immediately around the key monuments as well as abrasion damage to lichens growing on standing stones, especially at Stonehenge.			
3.0	Extreme weather events such as storms and gales causing damage to archaeological deposits and the cultural material and biological remains contained with them.	2	1	S
3.1	Gales and storms High winds could lead to trees being blown over/uprooted leading to exposure of archaeological deposits or damage to buildings.			
3.2	Floods and flash floods Intense precipitation could lead to run off and loss of archaeological deposits through for example localised "gullying".			
4.0	Freeze/thaw causing damage to monuments	2	2	M
4.1	Freeze/thaw action can result in damage to upstanding archaeological features and damage to stonework.			
5.0	Erosion by livestock causing damage to monuments and buried archaeology	1	2	S
5.1	As with visitor footfall, wetter ground conditions lead to more ground disturbance by cattle and sheep particularly at watering points/livestock feeders and gates.			
5.2	Prolonged wet conditions could alter viability of sheep grazing leading to increased incentive to cultivate and consequent possible damage to monuments.			
6.0	Flooding (at Avebury) causing damage to buried archaeology and artefacts.	1	2	S
6.1	The River Kennet above the Swallowhead Spring is currently a winter bourne (it only flows for part of the year, primarily over the winter months). Recent heavy and prolonged precipitation has led to flooding in Avebury village and around Silbury Hill. This could potentially threaten the current museum store at Avebury and possibly damage archaeological deposits within the area surrounding Silbury Hill.			
7.0	Change to vegetation cover causing damage to monuments and buried archaeology and their setting.	2	2	M
7.1	Wetter conditions may result in change to predominant species or loss of species of the grassland communities.			
7.2	Hyper-abundant species or weedy species may grow to the detriment of less well-adapted species and become highly invasive. This would lead to a lack of bio-diversity and affect the setting of the monuments and the landscape within which they sit.			

Back to Contents Page

B: HOTTER CONDITIONS (DRIER SUMMERS, MILDER WINTERS)

		Likelihood	Severity	Timescale
8.0	Increases in domestic and overseas visitors as tourist areas popular now (Spain, Italy etc) become too hot.	3	2	L
8.1	Areas traditionally visited for holidays such as Spain, South of France, Greece and Italy may later this century become intolerable in the summer months. This may result in more domestic tourists who will no longer need to travel to find the sun. In addition there may be an increase in visitors from southern Europe because the climate will be more tolerable in the UK.			
8.2	Sun-seekers will no longer need to travel abroad and may choose to stay in the UK. This could result in pressure on water supplies, roads and parking. It could also result in increased erosion and deterioration of the visitor experience.			
9.0	Conditions may become too uncomfortable for visitors and livestock.	3	3	L
9.1	As temperatures increase in the summer months, it may become necessary to consider more "Mediterranean" opening hours, with a break over lunch and opening earlier and closing later in the day to accommodate visitors.			
9.2	Shade may be required which could impact on the setting of monuments.			
9.3	Reduce ability to explore the wider landscape.			
10.0	Changes in burrowing animal population.	1	1	S
10.1	Milder winters may result in a population rise of badgers and other burrowing animals due to increased availability of food and survival of young. The increase in damage to monuments was noted in the Condition Survey 2010. The burrowing activity leads to loss of fabric and the damage of archaeological remains buried in banks and barrows and other areas of the WHS.			
10.2	Hotter/drier summers may lead to a reduction in food source for badgers and other burrowing animals and therefore a reduction in numbers and damage.			
11.0	Changes in pathogens, invasive species and pests.	1	2	M
11.1	Increased mean temperatures combined with human activity such as the movement of timber and nursing stock have already resulted in the migration of alien species into southern England e.g. Water Fern, Ash Die Back, Oak Processionary Moth, Horse Chestnut Leaf Miner, Citrus Longhorn Beetle, Asian Longhorn Beetle, Japanese Knotweed, Himalayan Balsam.			
11.2	New pathogens and pests moving into certain areas as a result of increased mean temperatures may influence the survival of individual plant species. In the longer term this may negatively affect the character of the landscape, setting and physical survival of monuments.			
12.0	Effect on tree species.	2	2	M
12.1	Hotter, drier summers may mean that some species are no longer able to thrive. For example it is known that beech trees which play a prominent role in the landscape of the WHS are intolerant of drought. This may result in careful consideration of choice of species, origin and provenance if planting any new trees or thinning existing ones. In addition, the possible future damage to the monuments of the WHS needs to be considered should the current beech trees begin to die off and become susceptible to falling or being blown. The resulting tree throw could be extremely damaging particularly where they are for example positioned on Bronze Age barrows.			
13.0	Longer growth season.	2	2	M
13.1	Warmer winters may result in stronger growth of scrub and increased growth rates which can be damaging to archaeology.			
13.2	Some herbaceous species may dominate vegetation to the detriment of less well-adapted species and lead to reduced biodiversity.			
14.0	Less vigorous grassland.	2	3	M

Back to Contents Page

		Likelihood	Severity	Timescale
14.1	Changes in sward may lead to increased damage from visitors at certain times of the year. The existing predominantly grass ground cover is more wear-tolerant. Climate change is likely to lead to an increase in broadleaved species which offer less protection for soil.			
14.2	Colonisation of current sward by different species which may have longer, more damaging root systems.			
15.0	Threat to lichens on megaliths.	3	3	L
15.1	The lichens on the megaliths at Stonehenge and on Fyfield Down NNR at Avebury are rare and protected as Sites of Special Scientific Interest (SSSI). Drier weather may mean that the environment required for these to thrive is no longer possible or that there are changes to the types of lichen.			
16.0	Changes in farming practice as a result of climate change. Response to local climatic conditions or national/global economic incentives.	2	1	M
16.1	Changes in farming practice may lead to planning pressure. Changes in crop or other agricultural practices may result in pressure to provide more industrial scale barns and facilities which could impact on the OUV of the site.			
16.2	Changes to livestock farming or type of livestock may have similar development pressure to provide necessary infrastructure or shelter.			
16.3	Climate change may mean that some cultivated species are no longer viable in the landscape of the WHS and other crops/livestock have to be considered by farmers.			
16.4	Global markets affect price of crops. An increase in price of grain means farmers more likely to use land for arable production rather than pasture.			
16.5	Subsidies for bio-fuel or other types of crops may encourage cultivation which could damage buried archaeology.			
16.6	Certain crop types have more invasive root systems or require more invasive cultivation techniques that might be damaging to buried archaeology.			
17.0	Change to water table.	2	2	M
17.1	Fluctuating groundwater conditions - water logging followed by drying out - could lead to increased fragility of materials such as ceramics as physical stresses cause the material to fragment. Where buried archaeological deposits and artefacts are being protected in moist soils and the underlying deposits are permanently waterlogged then drying out or repeated dry/wet conditions are likely to lead to biodegradation and oxidation.			
17.2	Perched water tables can result in damaged drains remaining dry as water is unable to reach them. It is important to map and understand where drains are and to maintain them so that they are able to cope with peak water levels at times of heavy precipitation.			
17.3	Changes to the water table may lead to loss of surface expression of springs and water courses which could make it harder to perceive the relationship of monuments to the topography; a key attribute of OUV.			
18.0	Changes in water abstraction may affect habitats and landscape and the setting of monuments.	1	2	S
18.1	The River Avon SSSI and the River Kennet are already considered by some to be over abstracted. A reduction in abstraction may result in vegetation change with implications for the setting of monuments.			
19.0	Water shortages may impact on visitor experience.	3	2	L
19.1	If water becomes scarcer, particularly in the summer months this may mean water restrictions are imposed. This will have an impact on both tourist attractions and the infrastructure to support them such as B&B, guest houses, hotels and restaurants.			
20.0	Increase in wildfires/accidental fires.	3	3	L
20.1	Hotter drier weather over prolonged periods could result in a higher risk of wild fires/accidental fires. These would damage landscape, both visible and buried archaeology and pose a risk to the safety of visitors.			

Back to Contents Page

		Likelihood	Severity	Timescale
20.2	Grasslands for hay crops are particularly at risk of this.			
21.0	Stability of megaliths affected by drier soils.	3	3	L
21.1	Some have hypothesised that drier soils may affect the stability of the megaliths. More consideration/research needs to be done on this issue to understand whether this is a credible threat in these particular soils.			
22.0	Pressure of development and land-use change.	1	2	S/M
22.1	Impacts on the WHS from renewable energy projects, risks from fracking, and bio-fuels (including more tree planting).			

Localised flooding after prolonged rainfall prevents access across R Kennet to West Kennet Long Barrow, © B Thomas, English Heritage

Erosion control Henge Bank Avebury © B Thomas, English Heritage

Back to Contents Page

STONEHENGE & AVEBURY WHS – CLIMATE CHANGE RISK ASSESSMENT

CONSERVATION OBJECTIVES FOR THE STONEHENGE & AVEBURY WORLD HERITAGE SITE

i. Protect the WHS in order to sustain its Outstanding Universal Value (OUV) both now and in the future. This not only includes protecting the physical fabric of monuments and buried archaeology but also the setting of the monuments, including their relationship to the topography of the area and water courses and their relationship to one another. In addition it should enhance the ability to appreciate the astronomical alignment in the design of certain monuments.

ii. Allow visitors to explore, enjoy and understand the WHS and its OUV through sustainable tourism.

iii. Enable residents to adapt to climate change without damaging the WHS and its OUV.

iv. Ensure the design, scale and location of any proposed renewable energy schemes do not damage the WHS and its OUV.

v. Work in partnership to protect other designated assets in the WHS such as Sites of Special Scientific Interest (SSSI), National Nature Reserves (NNR), the North Wessex Downs Area of Outstanding Natural Beauty (AONB), Special Protection Areas (SPA) and Special Areas of Conservation (SAC).

Wood chips used to prevent spread of mud at gate Avebury Henge © B Thomas, English Heritage

Back to Contents Page

Table 2 RISK ASSESSMENT: MANAGEMENT RESPONSE

	Impact, threat or opportunity	Likelihood	Severity	Event trigger/ indicator	Management response	Strategic adaptation measure	Timescale to achieve adaptation
1.0	Erosion caused by human activity (pedestrians & vehicles)	I	I	Loss of vegetation	Restrict visitor/vehicle access or divert traffic Re-seeding/ turfing	Communication strategy with visitors which might include messages to discourage visits to key locations at certain times of the year, via digital media and potentially through the visitor centre.	S
				Localised erosion Spread of mud onto otherwise healthy grass.	Changing "desire lines" regularly with mowing. Consider hardening surfaces at information points or relocating them. Harden surfaces at pedestrian and agricultural gates	Cross organisational communication. Consider setting "limits of acceptable change" for key areas of the WHS. Review traffic regulation order on by-ways.	S
					Look at placing of fences & gates	Develop alternate visitor routes using resting paths etc	S
					Increased monitoring	Landscape scale strategies	S
2.0	Affect of burrowing animals	I	I	Evidence of increase in number of setts (badgers) warrens (rabbits) and mole hills	Monitoring Assess source and carry out pest control as appropriate and legal Apply for licences as appropriate for any badger works	Periodic survey of monuments	S

Back to Contents Page

	Impact, threat or opportunity	Likelihood	Severity	Event trigger/ indicator	Management response	Strategic adaptation measure	Timescale to achieve adaptation
				Increase in damage to monuments	Monitoring Assess, source and carry out pest control as appropriate and legal Apply for licences as appropriate for any badger works Protection of monuments where possible with wire meshing, exclusion etc. Harrowing mole hills as appropriate and hand raking	Consider permissible methods to control or exclude population. Develop a landscape scale burrowing animal strategy to establish a holistic approach	S
3.0	Changes in farming practices	I	I	Return of land to cultivation/ introduction of new crops e.g. Short Rotation Coppice		Review of agri-environment schemes & tenancy agreements where relevant Advocate for greater incentives for grassland restoration/ retention Maintain and build on relationships with landowners/ farmers Explore less harmful diversification	S
				Increase in planning applications for barns/ stores, micro-generation energy plants etc		Additional supplementary planning guidance for the WHS Produce WHS Setting Study	S

Back to Contents Page

	Impact, threat or opportunity	Likelihood	Severity	Event trigger/ indicator	Management response	Strategic adaptation measure	Timescale to achieve adaptation
4.0	Damage to areas of site at peak times	1	2	Damage to ground surfaces on footways and gates		Continue to work with event organisers and groups to develop awareness of potential damage and the responsibility of individuals Review attendance at events/ observances Use highways as routes where possible	S
5.0	Erosion by livestock	1	2	Damage at gates & watering points Poaching Scrapes Damage to banks and other upstanding monuments	See 1.0 above. Move watering points from sensitive areas Ensure water points don't overflow Hard standing at some watering points/ livestock feeders may be appropriate Review fencing for livestock management	Use smaller breeds/ reduce stocking levels	S
6.0	Flooding at Avebury	1	2	Flooding at Avebury	Review current arrangements for storage of archive materials & museum collections Training on disaster planning & management Sign up to Environment Agency flood warning system if appropriate.	Look at alternate location for archive/store	S/M

Back to Contents Page

	Impact, threat or opportunity	Likelihood	Severity	Event trigger/ indicator	Management response	Strategic adaptation measure	Timescale to achieve adaptation
7.0	Increase in pathogens & pests	1	2	Incidence of pathogen or pest infestation	Monitor Observation Report notifiable pests to DEFRA/ Forestry Commission. Consider choice of plant species before introducing into the WHS.	Periodic Species survey	S
8.0	Water Abstraction	1	2	Disappearance or reduction in established water courses/ springs	Work with the Environment Agency to establish current levels, plans for changes and assess risk to attributes of OUV. Work with local action groups to monitor the situation.	Periodic survey of water courses/spring	S
9.0	Extreme Weather Events	2	1	Waterlogged ground	Monitor flooded areas Maintain existing drains to ensure effectiveness Consider additional drainage where appropriate Review fencing to manage livestock	Put research programme in place to identify monuments most at risk and suitable mitigation measures	S

Back to Contents Page

	Impact, threat or opportunity	Likelihood	Severity	Event trigger/ indicator	Management response	Strategic adaptation measure	Timescale to achieve adaptation
				Localised gullying	Monitor gully patterns In filling where appropriate	Investigate water flow patterns and drainage	S
				Tree throws	Archaeological inspection Remove fallen tree Potentially replace root ball	Regular tree inspections to anticipate any potential risk due to storm damage or end of life of tree Silvi-cultural methods to reduce risk of wind-throw such as timely thinning and tree crown management Agree and implement policy regarding future management of hedgehog barrows. planted with beech clumps at Avebury	S
10.0	Potential pressure of development	2	2	Planning Applications for new development of wind-farms, fracking etc. Changes in government policy	Collaboration with planning authorities and participation in Enquiries.	Development Control through planning system. Lobbying for changes in planning system. Advocacy. Education.	S/M
11.0	Change to vegetation cover	2	2	Loss of cover Change in predominant species	Monitor Observation Joint study with Natural England to look at change in species composition in terms of biodiversity and setting – see also 15.0.	Periodic species survey	M

Back to Contents Page

	Impact, threat or opportunity	Likelihood	Severity	Event trigger/ indicator	Management response	Strategic adaptation measure	Timescale to achieve adaptation
12.0	Effect on tree species	2	2	Observation Results of species survey	Monitor changes to individual species Observation Assess the likely changes from a) climate conditions b) pests and pathogens	Periodic species survey Discuss adaptations with Forestry Commission. Review and update WHS Woodland Strategy	M
13.0	Longer growth season	2	2	Spread of scrub Over abundant vegetation.	Monitor changes to both botanical and entomological species.	Adapt grazing/ cutting regimes accordingly Scrub clearance	M
14.0		2	2	Change in surface water levels and spring activity	Assess scale of predicted change to groundwater and assess risks	Maintain drainage systems to ensure free flow.	M
15.0	Increase in visitor numbers	2	2	Overcrowding and complaints by visitors and residents. Queues, lack of parking. Increased erosion levels at gates, congestion on roads etc	Monitor visitor numbers at paid attractions Monitor movement across the landscape using pedestrian counters. Change opening hours. Review capacity at key points of WHS Review marketing messages and information	Communication strategy to be developed in order to manage visitor numbers at times when the WHS is under stress due to climate change and severe weather events etc. Establish Limits of Acceptable Change	M

Back to Contents Page

	Impact, threat or opportunity	Likelihood	Severity	Event trigger/ indicator	Management response	Strategic adaptation measure	Timescale to achieve adaptation
16.0	Less vigorous herbaceous grassland	2	3	Observation	Monitor changes to individual species Joint study with Natural England to look at change in species composition in terms of biodiversity and setting Establish alternate "resting paths" for visitors Using "soft" landscape techniques like mown paths to vary visitor movement Consider reinforcing the grass surface at key points where appropriate.	Periodic species survey Adapt management regime to minimise detriment to unimproved grasslands	M
17.0		3	2	Water shortages Hose pipe bans	Install water recycling and storage facilities at sites Study of supply and demand levels with modelling of potential changes; assess pipe-end solutions for improving water efficiency	Review current facilities and look at adaptation	L
18.0		3	3	Observed damaged following period of freeze thaw	Study of stone and buried deposits susceptible to spalling or damage		M

Back to Contents Page

	Impact, threat or opportunity	Likelihood	Severity	Event trigger/ indicator	Management response	Strategic adaptation measure	Timescale to achieve adaptation
19.0	Conditions become too un-comfortable for visitors & livestock	3	3	Observation Results of visitor surveys	Look at shelter/shade for visitors and livestock which does not compromise physical monuments or setting Change in opening hours (earlier and later) to avoid heat of the day		L
20.0	Threat to lichens on monuments	3	3	Loss or damage to lichens	Further study of lichens and programme of monitoring set up		M
21.0	Increase in wildfires/ accidental fires	3	3	Numbers of reported or observed fires Areas of fire damage	Discourage smoking in the WHS and strict litter control Manage grazing regime appropriately to reduce risk Monitor recovery of burnt areas. Re-seeding may be required	Management of sward height Consider fire rides if vegetation cannot be kept low over large areas	L
22.0	Stability of megaliths affected by drier soils	3	3	Movement of megaliths	Monitor	Study of soil stability and vulnerability of megalith	L

Back to Contents Page

ACKNOWLEDGMENT

We should like to acknowledge the assistance given freely by a great number of colleagues, and in particular those who are listed at Appendix A, who not only attended the Workshop in March 2013 but also kindly commented on the developing risk assessment. We are indebted for their generosity in sharing their expert knowledge and ideas.

Peter Murphy, Sarah Simmonds, Beth Thomas
November 2013

Example of erosion at pinch point, Avebury
© B Thomas, English Heritage

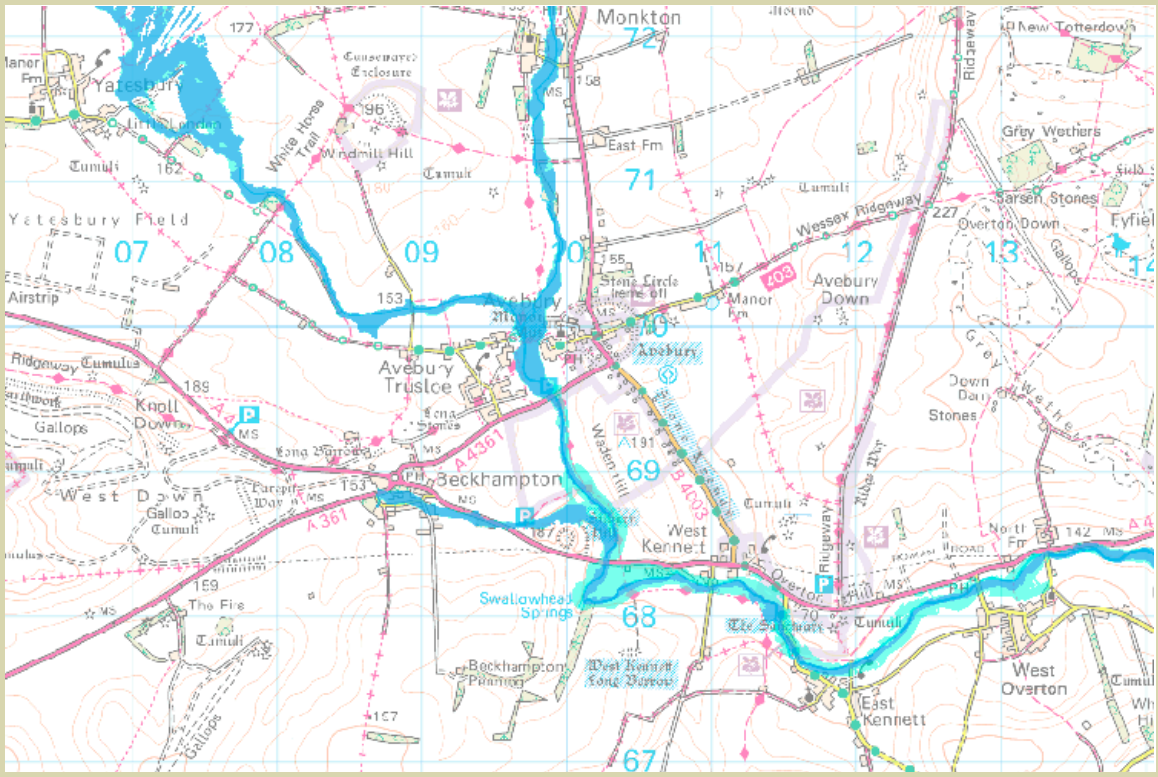
Back to Contents Page

APPENDIX A

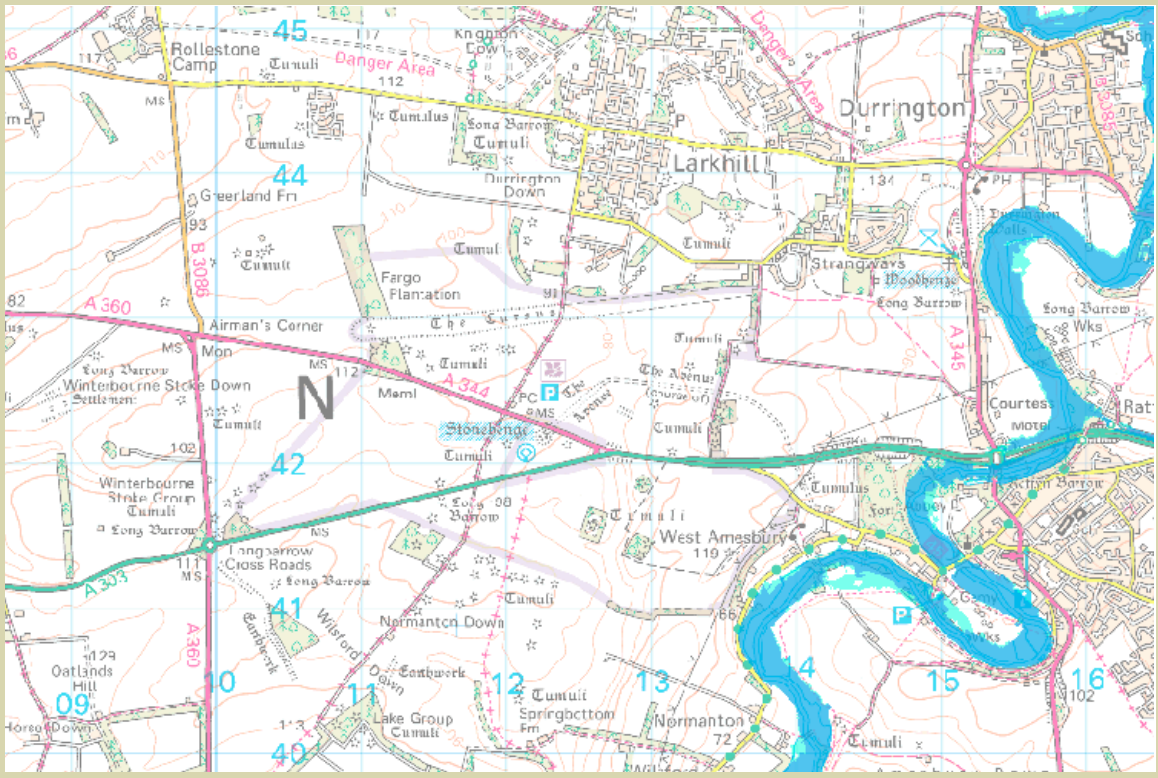
Vincent Albano	Green Economy Manager	Wiltshire Council
Chris Bally	Landscape Manager	English Heritage
Ian Barnes	Head of Archaeology	National Trust
Gill Campbell	Head of Environmental Studies	English Heritage
Alan Cathersides	Senior Landscape Manager	English Heritage
Mike Dando	Head Ranger, Wiltshire Countryside & Stonehenge Landscape	National Trust
CatherineDixon	Environmental Manager	Wiltshire Council
Rachel Foster	Assistant County Archaeologist	Wiltshire Council
Jen Heathcote	Historic Environment Intelligence Analyst (Environment)	English Heritage
Vince Holyoak	Head of National Rural & Environmental Advice	English Heritage
Andrew Lord	Planning Advisor	NWD AONB
Mike Morecroft	Head of Profession – Climate Change	Natural England
Peter Murphy	Historic Environment Intelligence Officer (Climate Change)	English Heritage
Andy Neale	Senior Specialist - Climate Change Adaptation	Natural England
Stephanie Payne	Land Management and Conservation Lead Adviser	Natural England
Heather Sebire	Property Curator	English Heritage
Sarah Simmonds	Avebury WHS Officer	Wiltshire Council
Vanessa Straker	Science Adviser, South West	English Heritage
Beth Thomas	Stonehenge WHS Coordinator	English Heritage
Olly Watts	Senior Climate Change Policy Officer	RSPB
Jenifer White	Senior Landscape Advisor	English Heritage
Julian Wright	Senior Advisor for Climate Change	Environment Agency
Christopher Young	Head of International Advice	English Heritage

Back to Contents Page

APPENDIX B



Flood Risk Map 2013, Avebury © Environment Agency



Flood Risk Map, Stonehenge 2013 © Environment Agency

Back to Contents Page

BIBLIOGRAPHY

Adaptation Assessment: A framework for embedding climate change implications in the RSPB's work
O. Watt, RSPB, 2012

Avebury World Heritage Site Management Plan
M. Pomeroy Kellinger 2005

Burrowing Animal Survey
D. Trump, Natural England, 2012

Climate Change and the historic Environment
M. Cassar UCL 2005

Climate Change and World Heritage, World Heritage Occasional Paper 22,
UNESCO Paris 2007

Case Studies on Climate Change and World Heritage
UNESCO 2007

Operational Guidelines
UNESCO 2012

Policy Document on the Impacts of Climate Change on World Heritage Properties
UNESCO 2008

Stonehenge World Heritage Site Management Plan
C. Young, A. Chadburn, I. Bedu, English Heritage, 2009

UK Climate Projections: Briefing report.
Met Office Hadley Centre, Exeter, UK
G. J Jenkins, J. M., Murphy, D. M. H., Sexton, J. A., Lowe, P. Jones, and C. G. Kilsby, (2009).

Intergovernmental Panel on Climate Change (2012) ***Managing the Risks of Extreme Weather Events and Disasters to Advance Climate Change Adaptation.*** Special Report of the IPCC (eds Field, C.B, Barros, V., Stocker, T.F., Dahe, Q. and others). Cambridge University Press: Cambridge.

United Nations
Educational, Scientific and
Cultural Organization

Stonehenge, Avebury and Associated Sites
inscribed on the World Heritage List in 1986