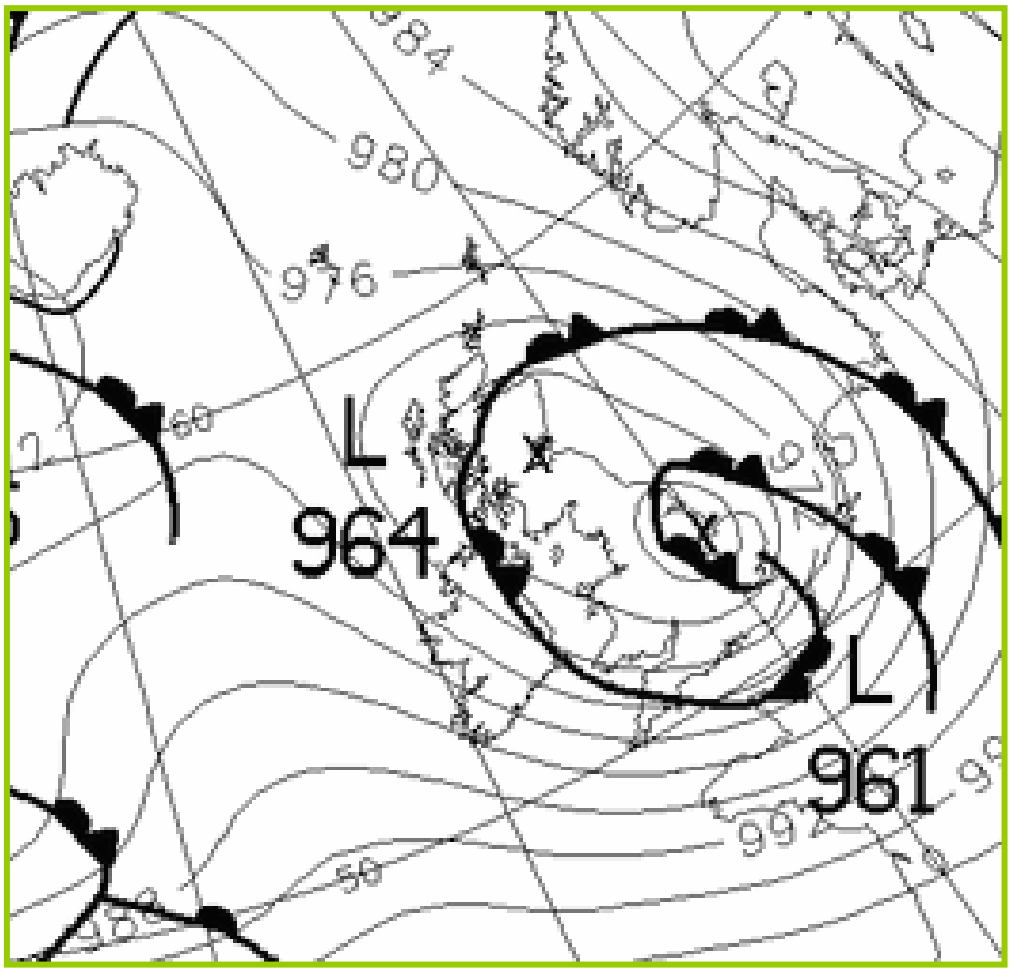
Plymouth's Vulnerability To Climate Change

Initial Scoping Study



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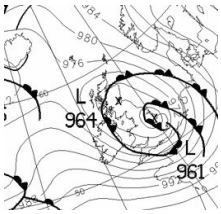

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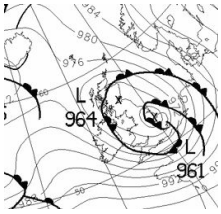


1.0 Executive Summary

1.1 There is now little doubt that climate change will become a key driver of change within our local communities – very few activities will escape and, in the worst case scenario, there is already evidence that some of the identified threats could result in the loss of life and irrevocable damage to property and profits.

1.2 Although some might argue that the climate change debate is emotionally charged, we can no longer take the risk that it won't happen. We need to look to the future and 'future-proof' the city.

1.3 Adapting to the changing conditions means making the most of the opportunities on offer and, more importantly, preparing for the threats the changes will deliver. We also need to be able to tackle – or mitigate – those impacts; reducing the likelihood of physical or financial damage before it is experienced. To make a judgement on this we need to consider the evidence available and to assess what the impact of climate change might mean for Plymouth – how vulnerable are we ?

1.4 Adapting the city of Plymouth to the impact of climate change is a responsibility that will gain increasing significance in the next few decades. Our future quality of life and our prosperity may depend upon it. Being prepared is the best approach to take in the circumstances.

1.5 This report sets out much of the detail available under a series of related chapter headings and looks ahead to the 2020's, the 2050s and the 2080s wherever possible. It looks more closely at the evidence available for Plymouth; taking in to account the city's noted microclimate and location and considering aspects of business continuity and risk assessment that will assist in addressing the impacts.

1.6 However, to start the process of thinking ahead, the 'headline' changes are set out here.; with evidence drawn from the UKCOP09 predictions for Plymouth and the regional predictions collated by Climate South West.

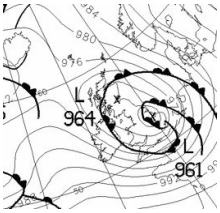
1.7 They can be summed up as warmer, wetter winters, hotter drier summers, an increase in extreme weather with storm events, heatwaves and cold weather becoming more defined and occurring more frequently, increased heavy rainfall leading to a greater likelihood of flooding from run off and the potential for coastal flooding from a small rise in sea levels and the likely increase in tidal surges.

Table 1.0 Summary of Likely Impacts

Likely Impact	Predicted Change	2020s	2050s	2080s
Temperatures – predictions available for Spring, Summer, Autumn and Winter	Gradually warming with periods of extreme heat and cold. An annual warming of between 1.0 and 2.5 deg C. Years as warm as 1999 (+1.2 deg C) become more common. Extremes pose greater risk to vulnerable members of society and place greater pressure on public services (including health).			
Spring	Greater warming in Summer and Autumn than in Winter and Spring.		Warmer by 1 to 2 deg C	Warmer by 1.5 to 3.5 deg C
Summer	Greater day time than night time warming		Warmer	Warmer

	in Summer.		by 1.5 to 3.5 deg C	by 2.0 to 5.5 deg C
Autumn			Warmer by 1.5 to 3.0 deg C	Warmer by 2.0 to 5.0 deg C
Winter	Greater night time than day time warming in Winter.		Milder by 1.0 to 2.0 deg C	Milder by 1.5 to 3.5 deg C
Precipitation – also available for the four seasons	Greater contrasts between summer (drier) and winter (wetter) seasons.			
Spring	Winter and Spring precipitation becomes more variable.	Similar to now	Similar to now	Similar to now
Summer	Summers as dry as 1995 (37% drier than average) or as wet as June 2012 (wettest since 1766) become more common.		Drier by 15 to 30%	Drier by 25 to 55%
Autumn			Drier by 0 to 10%	Drier by 5 to 15%
Winter	Heavy rainfall in Winter becomes more common.		Wetter by 5 to 15%	Wetter by 10 to 30%
Snowfall	Will decrease significantly.			Decrease by 70 to 90%
Cloud Cover	Reduction in summer and autumn cloud. Increase in radiation. With greater risk of exposure to the sun/health implications. Small increase in winter cloud cover.			
Humidity	Specific humidity increases throughout the year. Relative humidity decreases in the summer. Greater pressure on those vulnerable to respiratory ailments.			
Storm Events (Extreme weather)	Winter depressions become more frequent (including the deepest ones). Storm events will become more extreme and will be experienced more frequently. Greater pressure on insurance premiums which will rise to reflect the changes.			
Sea Level Rise	Sea levels are expected to rise in response to global climate change. Increased pressure on flood defences and planning for coastal management.			Increase by up to 1 m by the 2080s. (EA)
Tidal surges/wave heights	Potential increase in the number and frequency of tidal or coastal surges. Wave heights expected to increase putting pressure on coastal properties and habitats.			20% increase in wave heights expected by the 2080's

Flooding	Heavier rainfall could lead to greater risk of flooding from run off. Increased pressure on need for proactive flood risk assessment and planning implications. Increased pressure on business continuity planning.
Drought	The increased risk of summer heatwaves could result in pressures on water supplies. Increased pressure on health services and those caring for vulnerable populations.
Biodiversity	Increase in invasive species with potential for new pests and diseases and possible loss of native species.



Possible Solutions

Key Impacts to consider……

- ✓ Changes in temperature
- ✓ Changes in rainfall and humidity.
- ✓ Changes in cloud cover and exposure to UV radiation.
- ✓ Extreme weather events
- ✓ The impact on health
- ✓ The impact on wealth
- ✓ The impact on quality of life
- ✓ The impact on infrastructure

Table 2.0 : Possible solutions and recommended actions

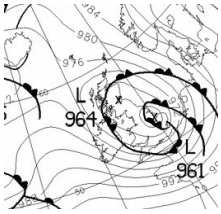
Likely Impacts	Possible Actions	2020s	2050s	2080s
1.0 : Maintenance and management of buildings and infrastructure :				
1.1 : Temperature increases affect thermal comfort.	1.1a : Retrofit or upgrade energy efficient heating, ventilation and/or cooling systems. 1.1b : Invest in shading.			
1.2 : Wetter winters causing damp, condensation and mould problems.	1.2a : Upgrade weather proofing systems. 1.2b : manage internal environments to maintain acceptable conditions.			
1.3 : Higher risk to buildings and contents currently located in flood plains, areas vulnerable to surface water run off or coastal areas.	1.3a : Consider flood proofing measures or potential for relocation. 1.3b : Move vulnerable equipment (servers etc) to the first or second floors. 1.3c : Consider landscaping to draw waters away from buildings. 1.3d : Invest in sustainable urban drainage systems. 1.3e : Introduce flood warning systems and awareness campaigns, 1.3f : Ensure maintenance of sewer			

	system allows for the venting of gas build up created by possible seawater intrusion.			
1.4 : Risk of damage by high winds and storm events.	1.4a : Include risk assessment for storm damage for all key buildings.			
1.5 : Higher insurance premiums likely due to threat of increased damage from extreme weather events and/or flooding.	1.5a : Ensure financial planning takes account of increased premiums.			
1.6 : Drier summers increase risk of foundation subsidence.	1.6a : Consider changes to procedures and inspections to ensure that all foundations are resilient to changes in temperature.			
1.7 : Contribution of corporate emissions to climate change.	1.7a : Introduce and maintain a carbon management plan seeking a year on year reduction in emissions through resource management. 1.7b : Design for sustainability; introducing means of maximum energy efficiency in both new builds and refurbishments. 1.7c : Introduce regular energy and water audits to identify gaps in use and potential to make financial savings. 1.7d : Invest in energy efficient equipment, double glazing and renewable technologies to provide solutions to energy and resource security issues. 1.7e : Maintain a careful review of energy procurement options and investigate the potential for options that enable investment in offsetting services.			
Homes and householders				
1.8 : Changes in temperature and extreme weather events may have a negative impact on household in fuel poverty and those with vulnerabilities.	1.8a : Maintain a close review of the numbers of households in fuel poverty and ensure that everything possible is done to limit the impact of extremes of heat and cold. 1.8b : Maintain a dynamic affordable warmth programme based on effective communication and local engagement. 1.8c : Promote funding and upgrade opportunities that encourage energy efficiency. 1.8d : The inclusion of this evidence in a comprehensive strategy for housing provision; with suitable targets for reducing fuel poverty and improving the quality of the residential infrastructure past, present and future.			
1.9 : Buildings maintenance issues to include :	1.9a : Plan for preventative action and remedial maintenance for			

Increased risk of subsidence as soils shrink in hotter weather. Higher risk to homes on recognised flood plains or in coastal areas.	existing stock. 1.9b : Ensure structural surveys take climate change in to account. 1.9c : Restrict development in flood plains or in areas at risk. Design flood proofing measures and sustainable flood defence measures for both existing buildings (retrofitted) or for any new builds.			
Temperature change may influence comfort of living conditions Greater reliance on air conditioning.	1.9d : Use the thermal properties of materials to improve cooling, install insulation, shading and energy efficient systems. 1.9e : Design for solar gain, energy efficiency, shading and the impact of climate change in new developments (allowing for this in local policies).			
Warmer conditions may encourage greater potential for outdoor living.	1.9f : Ensure design allows for shading and increased tree cover. 1.9g : Ensure awareness campaigns focus on the risks of exposure to the sun.			
Flood Planning, Sea Level Rise and Tidal Surges				
1.10 : (i) Higher risk of flooding and threat of erosion to susceptible developments in flood plains, coastal margins and areas prone to surface water run off. (ii) Increased risk of flooding resulting from extreme weather or increased precipitation beyond the city boundaries. (iii) Sea level rise may limit access to the South West by rail.	1.10a : Ensure planning policies take account of future trends in flooding and erosion. 1.10b : Conder the application of appropriate and sustainable defences. 1.10c : Locate new development away from the areas of highest risk ensuring that drainage systems do not add unnecessary pressure to the natural drainage of the area. 1.10d : Ensure emergency plans, procedures and equipment are updated to meet increased risk. 1.10e : Ensure travel continuity requirements are considered in terms of the impact of climate change. 1.10e : Ensure that the obligations of the Flood and Water Management Act 2010 are met in liaison with local communities and the business sector. Actions to include improved communication and knowledge transfer where necessary.			
Water Resources and Supplies				
1.11 : Climate change may limit the supply of water in periods of dropught or when linked to population growth and higher demand from business and	1.11a : Consider potential supply and demand implications when siting new developments and planning for growth.			

industry.	1.11b : Incorporate landscape features to absorb water within developments. 1.11c : Enable the use of grey water by installing collection tanks and reuse systems as part of both new build and refurbishments. 1.11d : Support campaigns to raise awareness of water as a finite resource.			
Transport, Access and Highways				
1.12 : (i) Increased opportunities for sustainable transport options. (ii) Increased risk of disruption due to flooding, wetter winters, cold snaps and severe weather. (iii) Changes to travel densities as wet weather encourages more school runs. (iv) Service disruption and heat stress caused by consistently higher temperatures. (v) Increased costs in the provision of grit and additional safety measures during cold spells and repairs to road surfaces during hot spells. (vi) Increased rainfall intensity affecting embankments and bridge piers; washing more debris in to gullies and drainage channels and leading to more intense cleaning and associated costs. (vii) Drier summers increase the risk of subsidence and surface damage. (viii) Higher risk to roads located in flood plains, coastal areas and low lying areas. (ix) Climate change may impact on growth patterns of roadside verges and other managed areas resulting in changes to management plans and planting schedules.	1.12a : Ensure that the options for reducing energy use and emissions through the use of public transport are clearly set out in the LTP3 and Plymouth Plan. 1.12b : Plan to flood-proof or resite key infrastructure and plan new routes to minimise disruption. 1.12c : Avoid exposed waiting areas; providing cool, shaded options. 1.12d : Plan for the speed of impact and the response required to tackle extreme weather events; ensuring adequate supplies of grit and/or salt especially for emergency routes. 1.12e : Increase frequency of structural monitoring and drainage maintenance. 1.12f : Examine road structure design and ensure it complements the impacts of climate change. Implement remedial works for existing roads. 1.12g : Aim to flood proof or re-route strategically important roads. 1.12h : Revise planting, mowing and weed control schemes to take account of growth created by changes in conditions.			
Biodiversity, Habitats and Greenspace				
1.13 : (i) Increased rates of growth leading to all year round maintenance requirements. (ii) Increased watering of sports and leisure venues. (iii) Loss of trees and shrubs due to	1.13a : Adapt maintenance schedules and resources to meet new demands. 1.13b : Introduction of water saving management. Introduction of hose pipe and watering bans if necessary. 1.13c : Awareness of the			

drier summers and wetter winters.	temperature limits of planting schemes and introduction of adaptive options.			
(iv) Loss of native species, increase in invasive species and introduction of new, condition tolerant pests and diseases.	1.13d : Plan for wildlife corridors and enhanced habitat management.			
(v) Fire risks to habitats due to drier summers.	1.13e : Ensure risk assessments consider the impact of wild fires (nb to include insurance costs)			
(vi) Drought threats to existing greenspace and habitats.	1.13f : Plan for availability of water resources.			
(vii) Wetter winters and increased surface water run off threaten soil erosion, siltation and changes in soil condition.	1.13g : Increase ditch clearance and gulley emptying activities to limit blockages Ensure pollution from road runoff does not increase by installing grease traps.			
(viii) Loss of coastal habitats due to sea level rise and threat from tidal surges.	1.13h : Ensure management plans take account of the threat from sea level rise and take action to protect habitats if possible.			
(x) Opportunities to benefit from introduction of new species such as energy crops.	1.13i : Plan for the introduction of new crops but acknowledge the impact they may have on the traditional countryside, landscapes and existing species.			



2.0 Introduction

2.1 Acting Locally, Thinking Globally

2.1.1 There is now little doubt that climate change will become a key driver of change within our local communities – very few activities will escape and, in the worst case scenario, there is already evidence that some of the identified threats could result in loss of life and irrevocable damage to property and profits.

2.1.2 Although some might argue that the climate change debate is emotionally charged, we can no longer take the risk that it won't happen. We need to look to the future and 'future proof' the city.

2.1.3 We will need to adapt to the conditions climate change creates – making the most of new opportunities and preparing for the threats the change will deliver. We also need to be able to tackle – or mitigate – those impacts; reducing the likelihood of physical or financial damage before it is experienced. To make a judgement on this we need to consider the evidence available and to assess what the impact of climate change might mean for Plymouth.

2.1.4 Hotter, drier summers, warmer and wetter winters, higher relative sea levels and more intense, and more frequent storm events, will all have widespread implications for the communities of the city and the services provided by the City Council and other service providers.

2.1.5 Adapting the city of Plymouth to the impact of climate change is a responsibility that will gain increasing significance in the next few decades. Our future quality of life and our prosperity may depend upon it. Being prepared is the best approach to take in the circumstances.

2.2 Local Implications ?

2.2.1 Plymouth has already gained a reputation for innovative and creative thinking on this subject and a consistent commitment to act has been in place since 2004 when the Local Strategic Partnership endorsed 'Has it Sunk In Yet' : a report that considered the potential impact of climate change on the city. Formal frameworks, strategic commitments and effective partnerships followed as did access to the evidence needed to support projections for the future. This report builds on this evidence by suggesting what could be the next – and by far the most active – step to future-proof the city.

2.3 The Argument For Action :

2.3.1 By 2011the World's scientists had reached a consensus of agreement – that climate change is happening, it will have a potentially disastrous impact on our quality of life and, although there are some natural processes we cannot ignore, climate change has been hugely influenced by mankind's use of carbon based 'fossil fuels' – the 'anthropogenic impacts'. In almost every case it is now possible to find supporting, baseline evidence to support arguments in favour of taking positive action to limit what might happen next.

2.3.2 However, whilst the media are often quick to pick up on the bad news stories, climate change has also brought about valuable opportunities. Perhaps the most significant of these is the development of the low carbon economy and its impact on jobs, skills, technologies, alternative ways of using resources, scientific research and development and both innovation and creativity. As the link between costs and the availability of resources is recognised there is no doubt that business and industry will need to adapt to this

new 'sector'…if only to maintain business continuity, increase resilience to change and keep the lights on. But there is more to it than developments in renewable energy.

2.3.3 Globally, nationally and locally there is the potential to introduce new ways of tackling both the impacts and the potential of climate change – or 'climate wealth' as it has been renamed by global entrepreneurs such as Sir Richard Branson. This opportunity has already introduced new ways of thinking and planning for our future and the development of the low carbon and environmental sector is particularly relevant to Plymouth.

2.3.4 Through the development and application of plans and policies, climate change presents us with a political challenge – what to do to limit, or stop, the impacts of climate change. It encourages us to think about our responsibilities and the actions we could, or should, take to preserve life, to protect property and to limit the damage that could be caused to our quality of life. This alone has significant implications for local authorities.

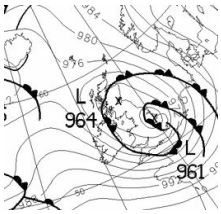
2.3.5 There will always be an element of uncertainty just as there will always be those who will argue that the evidence is flawed or the impacts are insignificant. But we now have enough evidence to be able to predict what the impact of climate change could mean for those of us living and working in Plymouth and, unlike the weather (which is what is happening outside your door on any given day) we can start to look ahead for the next thirty or fifty years and the time scales suggested by the globally recognised Intergovernmental Panel on Climate Change and take heed of the provisions of the UK Climate Change Act 2008 – the very first piece of international legislation to tackle this broad and complex subject.

Supporting Evidence :

- UN Intergovernmental Panel on Climate Change (IPCC) : http://www.ipcc.ch/
- The Climate Change Act 2008 : http://www.decc.gov.uk/en/content/cms/legislation/cc_act_08/cc_act_08.aspx

- National Climate Change Risk Assessment 2012 : http://www.defra.gov.uk/environment/climate/government/risk-assessment/

- Has it Sunk In Yet ? – LSP's 2004 Report : http://www.plymouth.gov.uk/climatechangeplymouth.pdf
- Plymouth's Climate Change Framework 2008 to 2020 : http://www.plymouth.gov.uk/climate_change_strategy.pdf
- Plymouth's Climate Change Action Plan 2009 to 2012 : http://www.plymouth.gov.uk/acting_on_climate_change.pdf



3.0 Understanding the Issue

3.1 Climate change can be a very complex issue with huge levels of variability and uncertainty. It is therefore essential to be clear about the terms being used and their context. The most obvious confusion arises from the difference between 'weather' and 'climate' which are distinctly separate but closely linked.

3.2 'Weather' or 'climate' – the 30 year rule ?

3.2.1 ***Weather*** is a description of the environmental conditions that occur at a particular moment in time or what you see when you glance through the window. Categorised in to a range of conditions, the weather can be described in many ways including sunshine, rainfall, snow, fog, cloud, the cold and warmth (temperature). Closely linked to the topography of the area, weather patterns often follow a noticeable pattern depending on the location's proximity to the sea or high ground or its location on the planet. Globally applicable weather systems, such as the powerful 'jet stream' can also have a significant impact on winds and storm events. Our location in the South West is also particularly susceptible to the interaction between atmospheric systems and the oceans where systems such as the Gulf Stream and North Atlantic Oscillation are applicable to the conditions we see on a daily basis.

3.2.2 ***Climate*** is a representation of these weather patterns over much longer periods of time. The timescale used by the United Nations Intergovernmental panel on Climate Change (IPCC) to describe a region's climate is 30 years. In Plymouth we are therefore considering weather patterns from the early 1980s.

3.3 Climate Change

3.3.1 ***Climate change*** is a global phenomenon brought about by interruptions to these weather patterns. The impact of these changes can be tracked on a global basis or at a local level. We know that the Earth's climate is not static and that some climate change occurs naturally. There may have been significant changes in the distant past in response to a variety of causes but 'climate change' (often called 'global warming') can also be attributed to the impact of human activity and, in particular, the burning of fossil fuels since the Industrial Revolution.

3.4 Global Warming

3.4.1 The main driver for the Earth's climate is the energy received from the Sun (solar radiation) which is partly reflected back in to space and partly absorbed. This absorbed energy warms up the Earth and is gradually given up again as infrared radiation. A balance of the energy entering and leaving the atmosphere is created which is being affected by the increased concentration of greenhouse gases; so called because they act like the glass of a greenhouse and keep the heat in.

3.4.2 Natural changes occur as a result of interactions between the oceans, the land and the atmosphere, changes in the Earth's orbit, fluctuations in the energy emitted by the sun and even the ash clouds created by volcanic eruptions. The Earth's atmosphere is also made up of a range of gases and these keep the surface of the Earth warmer than it would be if they were not present. Conditions would be very uncomfortable without the atmospheric gases. Plymouth's average temperature, for example, would be below freezing all year round if these 'greenhouse gases' weren't there.

3.4.3 However, as the increased concentration of greenhouse gases is trapping more of the radiated energy, the Earth is now getting warmer – hence the term '***global warming'***.

3.5 Our Contribution – Global to Local

3.5.1 The main human influence on the Earth's climate is likely to be the increasing emissions of 'greenhouse gases' such as carbon dioxide (CO2) and methane (CH4). These changes are further complicated by increased emissions of other pollutants such as sulphur dioxide (SO2) which, once they are in the atmosphere, transform in to small particles.

3.5.2 The amount of CO2, for example, has increased by about 30% in the last 200 years and, unless remedial action is taken, is expected to have double by 2050. This has a knock on impact on global conditions. Greenhouse gas emissions, for example, are now 'on track' to warm the world by at least 3°C on average by 2100. (GEO-5, UNEP, 06.06.12[1]).

3.5.3 It is estimated that, by 2009, the activities of households in Plymouth contributed 5.0 tonnes of carbon dioxide per person – or approximately 1,300,000 tonnes – per year. As it takes over one hundred years for natural processes to remove this extra carbon dioxide, we may find that by the time these emissions are reduced, the effects they cause have become impossible to alleviate. We will need to adapt to the impact they have and, to do that, it helps to be able to calculate the amount of emissions being created – our '***carbon footprint***'.

3.6 How much impact do we have as a city ?

3.6.1 It is increasingly becoming possible to calculate our carbon footprint. Nationally available data (produced since 2005) uses our use of energy to calculate the emissions we create. These figures suggest that, in 2005, Plymouth's carbon footprint was 1,473,670 tonnes of CO2 (tCO2). By 2009 this had been reduced to 1,281,180 tCO2 and, following a very cold winter, the figures for 2010 highlighted a slight rise in the citywide carbon footprint to 1,315,200 tCO2.

3.6.2 Although the impact of extreme weather will continue to have an effect on the amounts of energy we use to heat homes and businesses, it is therefore essential that Plymouth continues to mitigate the negative effects of carbon emissions by proactively reducing emissions of greenhouse gases from our everyday activities – an activity governed by clearly identified targets in the city's Climate Change Framework (see : http://www.plymouth.gov.uk/climate_change_strategy.pdf)

3.6.3 Globally it is now agreed that human (or anthropogenic) activity is contributing to climate change on an unprecedented scale. Any plans to reduce identified impacts therefore require a flexible approach that considers :

- ✓ The mitigating actions that can be taken to prevent further change and to reduce the emissions that contribute to climate change.
- ✓ The adaptive actions that are needed to prepare for the predicted conditions over time.
- ✓ The planning and management processes required for corporate and collective action.
- ✓ The responsibilities and accountabilities we share with the communities of Plymouth, the UK and the world.
- ✓ The positive benefits climate change could present – ensuring we invest where possible.

3.6.4 All five aspects must be considered if the proposed recommendations are to deliver economically and environmentally sustainable options.

[1] See : http://www.unep.org/geo/geo5.asp#

3.7 Adaptation

3.7.1 Adapting to climate change is not always a precise science. Although carbon footprints can be relatively accurate, it is almost impossible to provide predictions that are 100% accurate over time. However, the ability to assess future changes is gaining credibility and it is now possible to consider what those changes could mean for Plymouth.

3.7.2 Separating out the impact of weather events from the longer term impacts of climate change is the first challenge. Three terms are commonly used to describe what these impacts might be :

- ✓ **(i) Adaptive capacity** – the ability of a system to adjust to extremes of weather and a changing climate, to minimise potential damages, to take advantage of any opportunities or to cope with the consequences.

- ✓ **(ii) Climate sensitivity** is the degree to which a system would be affected, either adversely or beneficially, by the weather and climate related stimuli.

- ✓ **(iii) Climate vulnerability** defines the extent to which a system is susceptible to, or unable to cope with, the adverse effects of weather and climate change. It depends not only on the systems sensitivity but also on its capacity to adapt and change.

3.8 Weather Forecasting – 'red sky at night' ?

3.8.1 Potentially one of the oldest topics of discussion in the World, the ability to predict weather patterns has been nurtured for centuries and is the basis for some on the UK's most popular folklore. Forecasting, however, can trace its roots to very practical applications and, many of these, travel, growing seasons, safety and shelter, still rely on the forecasts provided by the Met Office and communicated regularly by the media.

3.8.2 Although the subject of much debate, the evidence available for forecasting has improved significantly over the last fifty years and predictions for both the short and long term can now be used to highlight the action that should be taken. Increasingly we have been able to highlight the potential impact of events as simple as a summer shower or a major hurricane.

3.8.3 Historic records of the weather also support these predictions by providing baseline evidence against which change can be monitored. This is particularly significant in terms of predicting the impact of climate change. The UK Climate Projections initiative, for example, uses the records kept between 1961 and 2006 and, by working with the Met Office, the City Council has access to Plymouth's weather records for 1961 to 1990 and 1971 to 2000 based on the figures recorded for the city's weather station at Mountbatten.

3.9 Additional Data

3.9.1 Additional evidence is also being made available. Sea level rise, for example, has been monitored at Newlyn in Cornwall since 1916 and related data is available for Devonport for 1962 to 2004.

3.9.2 Sea temperature data is available from 1957 to 1993.

3.9.3 Tidal surges are also recorded by the National Oceanography Centre who also assist in monitoring (See : http://www.pol.ac.uk/ntslf/model.html)

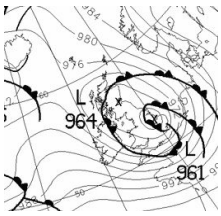
3.9.4 Much of the available data has been complied in to a profile for Devon and/or Plymouth. These profiles can be found at :

Devon : http://www.swenvo.org.uk/themes/atmosphere/climate-change/
Plymouth : http://www.swenvo.org.uk/themes/atmosphere/climate-change/ukcp09/

3.9.5 Although the Met Office provides technical details of the UK's past weather events (1990 to 2012) at http://www.metoffice.gov.uk/climate/uk/interesting/ the events themselves, including flooding incidents, heatwaves and cold snaps, can be a little more difficult to research as the local evidence is often anecdotal and limited to media reporting. However, even this gives an indication of the disruption caused and its impact on the local community. Here media archives are used to assess the impact, frequency and local reactions.

3.10 An Evidence Base

3.10.1 An extensive archive of the evidence reviewed to inform this report is set out at the end of this report and clearly shows the extent of data available to the city.



4.0 Assets At Risk

Key Impacts/Local Implications

- ✓ Costs
- ✓ Quality of life
- ✓ Health and safety
- ✓ Business continuity
- ✓ Sustainability
- ✓ Growth
- ✓ Resilience to change
- ✓ Energy and water security

4.1 "A Dynamic and Vibrant Waterfront City".....But For How Long ?

4.1.1 Plymouth enjoys a wealth of local assets but what could be at risk from future climate change ?

(i) People .....including

- The quality of life of 256,400 residents (July 2012 based on 2011 census data) and 109,300 households.
- The quality of life of the 14,000 households at risk from fuel poverty.
- One of the lowest eco footprints in the South West at 4.38 gha per person.
- Plymouth's overall and per capita carbon footprints.
- Access to 41,133,300 litres of water a day and 3762 kwhs of electricity per person per year.
- The health, safety and wellbeing of those more vulnerable to the slightest change.
- The threat of flooding in low lying areas.
- Insurance premiums and energy costs.
- Future food supplies.
- Tackling new health threats – the cold, the heat and new diseases and the costs of health provision.
- Jobs, employment and household budgets.

(ii) The Economy ....including

- Europe's largest military port.
- A nuclear base.
- The proposed site of the Waste to Energy plant.
- A marine sector providing 12% of all employment in the area.
- Three commercial harbours.
- Five international marinas.
- Twenty six boat yards.
- The value of the visitor economy and new opportunities to increase footfall throughout the city.
- A strategic transport hub where rail and road access could be under threat (Marsh Mills)
- A low carbon economy that meets growth aspirations.
- Insurance premiums, cost effectiveness, productivity and business continuity.
- The safety and well being of Plymouth's businesses (resilience to change)
- A growing reputation for 'green' thinking, research, education and development.

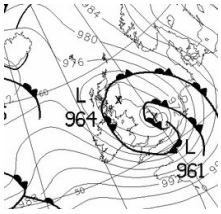
(iii) The Environment .....including

- Existing and planned infrastructure including the drainage and sewer systems.
- The historic environment and housing assets with noted barriers to retrofitting and insulation.
- Two areas of notable risk from flooding – Devonport and Plympton
- The quality and resources offered by five rivers and the Sound itself.

- A European Marine Site and recognised Special Areas of Conservation and Special Protected Areas.
- 35,000 m2 of green space at 391 sites and covering 42% of the city.
- Nine sites of special scientific interest (SSSIs)
- Seven Local Nature Reserves (LNRs)
- Twenty four County Wildlife Sites
- Six historic parks and gardens
- A location in an Area of Outstanding Natural Beauty.
- Acknowledged areas of heritage value – including South Yard at Devonport and military buildings.
- Ten miles of the South West Coastal Path (Jennicliff to the Cremyll Ferry at Stonehouse).
- Over 50kms of waterfront.

Supporting Evidence :

- SW State of the Environment report 2010 : http://www.swenvo.org.uk/state-of-the-environment-2010/
- SW SoE2010 Environment Section : http://www.swo.org.uk/sotsw2010/environment/
- SWENVO's 2011 Plymouth profile : http://www.swo.org.uk/EasysiteWeb/getresource.axd?AssetID=50048&type=full&servicetype=Inline
- Tamar Estuaries Management Plan to 2012 :
- http://www.plymouth.gov.uk/homepage/environmentandplanning/natureconservation/natureprojects/tecf/tecfabout/tecfmanagementplan.htm



5.0 Weather

5.1 Starting with the South West

What's already changed regionally ?

- ✓ Between 1961 and 2006 the average daily temperature increased by 1.37 deg C.
- ✓ The number of days of air frost decreased by 20.9 days.
- ✓ 10th August 2003 saw the hottest ever max temperature in the UK (38 deg C)
- ✓ Annual rainfall also increased between 1961 and 2006.
- ✓ The largest increase (28.6%) being experienced in the autumn.
- ✓ A small decrease in the total summer rainfall has also been recorded (8.8%)
- ✓ Heavy winter rain (a seasonal variation) has increased by 5.5%.
- ✓ Absolute sea level around the South West has risen by approx 1 mm per year over the 20th Century.
- ✓ However, this rise appears to be at a faster rate in the 1990s and 2000s.

What can we expect ?

- Warmer and wetter Springs
- Warmer and drier Summers.
- Warmer and wetter Autumns.
- Warmer and wetter Winters
- A significant decrease in snowfall
- More extreme weather events – including heatwaves, cold snaps and storms.
- Sea levels to rise by 18 to 20cm by the 2040s and by 37 to 40 cm by the 2080s.

5.1.1 It has long been acknowledged that Plymouth's location and topography have created a micro-climate for the city.

5.1.2 With much of the city built in a natural bowl, conditions in the City Centre can often be very different to those on the edge of Dartmoor and the rest of the South West region.

5.1.3 It is important to acknowledge that many of the weather patterns, and climate impacts, we experience in Plymouth are influenced by the rest of the South West and our location in the UK.

5.1.4 The city's weather is frequently the topic of local conversation but, jokes aside, patterns can be identified and the often subtle differences between the city and the wider South West are becoming much easier to identify.

5.1.5 A detailed assessment of the region's climate can be found on the Met Office website at :

(i) South West England Climate Data : http://www.metoffice.gov.uk/climate/uk/sw/print.html

5.1.6 A further useful source, Devon County Council's Weather Impacts Assessment, provides excellent background information for the South West and pointers to the framework of action that will be required for Plymouth. However, it should be made clear that DCC have yet to assess the impact of climate change. See :

http://www.devon.gov.uk/weatherimpactsassessmentondevoncountycouncilservices.pdf

5.1.7 Other sources of information are listed in the Supporting Evidence box that follows :

Supporting Evidence :

- Average weather data for Devon 1971 to 2000 (Met Office)
  http://www.metoffice.gov.uk/climate/uk/averages/19712000/index.html

- Weather profiles for Plymouth 1961 to 1990 and 1971 to 2000 (The Met Office at www.metoffice.com)

Weather information sites :

- Plymouth weather : http://plymouthweather.co.uk/raindetail.html
- Plymouth's climate : http://www.climatetemp.info/united-kingdom/plymouth.html
- Weather stats for Plymouth (Holiday weather .com) : http://www.holiday-weather.com/plymouth/averages/

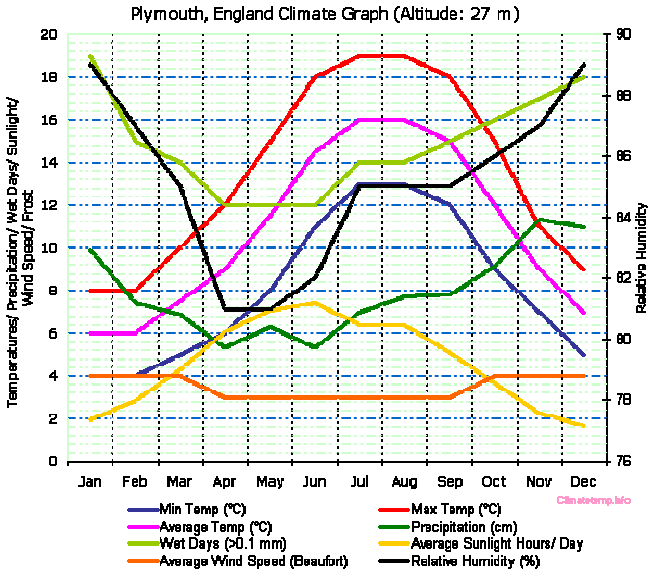
Devon's Weather Impacts Assessment 2010 :
http://www.devon.gov.uk/weatherimpactsassessmentondevoncountycouncilservices.pdf

5.2 Thinking Locally

5.2.1 Starting with the Basic Statistics for temperature (rainfall stats are included in the Section on Water).

Location	Plymouth, England, Latitude and longitude 50°21' N, 4°7'W.
Altitude	27 m (89 ft)
Average temperature	10.8 deg C (51 deg F)
Range of average monthly temperature	10 deg C
Warmest average max/high temperature	19 deg C (July and August)
Coolest average min/low temperature	4 deg C (January and February)
Average hours of sunshine per day	From 1.7 hours in December to 7.4 hours in June.
Annual hours of sunshine	1677 hours
Daily sunshine average	4.6 hours.

Where are we now ?



5.2.2 Plymouth's climate is typical of that of the South West with the main influences being our proximity to the sea and the topography of the surrounding countryside and moors.

5.2.3 Dominated by westerly air streams that draw in maritime air masses from the Atlantic Ocean, we are warmed by the Gulf Stream. It is this position that also means we are vulnerable to south westerly gales.

5.2.4 The overall pattern is one of mild winters, moderately warm summers and relatively high rainfall. However the amounts of rainfall (precipitation) in any particular year may vary considerably from the average figures.

5.2.5 Seasonality is another feature of Plymouth's weather, with most of the rain falling in the Autumn and Winter (November being the wettest) and with April and June emerging as the driest months. Snow

usually falls on the Moors above the city but seldom settles in the city centre. Coastal fogs are common with 'blankets' of mist, created by a process called 'thermal climatic inversion' commonly cloaking the many inlets of the surrounding rivers and the estuary of the River Tamar at a low level.

5.3 The Evidence

5.3.1 Plymouth's weather patterns are supported by good sources of statistical evidence which now include climate estimates for 1961 to 1990 and 1971 to 2000 from the Met Office.

5.3.2 In addition to a number of websites dedicated to weather data and weather forecasting (including the BBC and Met office), live weather data and a meteorological data archive (from September 1996) can be found on the University's website at http://www.plymouth.ac.uk/metnet (although it should be noted that access to particular data toolkits is needed to access the information).

5.3.3 Climate Temp Info gives a summary of average conditions in an easily readable format (see http://www.climatetemp.info/united-kingdom/plymouth.html) and detailed historical weather data (1973 to 2012) can be found at http://www.tutiempo.net/en/Climate/Plymouth/38270.htm

- Plymouth's weather is highly influenced by its location with its proximity to the coast, the influence of the Tamar Valley and the high ground of Dartmoor and its topography (lying within a 'bowl' in the landscape) creating conditions that are commonly referred to as Plymouth's micro climate.
- This means that conditions in Plymouth can vary substantially from those in the surrounding region.
- Plymouth shares an average mean temperature of between 11°C and 12°C with the rest of Cornwall – a figure which is reflected in the annual mean sea temperature (the highest in relation to the UK).
- Temperatures range by about 9°C between the warmest and hottest months.
- February is commonly the coldest month – but very low temperatures have also been recorded by comparison. 13th January 1987 is thought to have been the coldest day of the 20th Century in the South west with temperatures as low as -9°C at St Mawgan.
- Frosty weather with clear, calm nights have also produced record low figures (24 January 1958 -15°C in Exeter).
- July and August are the warmest months with temperatures that match those for the rest of the South West (between 19°C and 21°C). This is considered to be slightly lower than the London area where the impact of an 'urban heat island' could be recorded.
- Instances of extremely high temperatures are rare but can be experienced when strong sunshine is supported by winds drawn from mainland Europe.
- Frost patterns vary with the possibility of 35 to 60 days per year – both air frost and ground frost can be experienced as late as April or May when the conditions are right.
- Average annual sunshine hours total 1600 hrs+ with June being the sunniest month.
- Rainfall is closely linked with humidity with higher levels on the higher ground.
- Altitude has an impact on rainfall – a comparison of the records for Plymouth and Princetown (23 km apart in distance but 403 metres in height) shows that rainfall in Princetown is roughly twice that of Plymouth.
- Monthly rainfall is variable – Rainfall of over 100mm has been recorded for every month in Plymouth but totals in excess have only been recorded between December and February. Rainfall patterns are likely to be significantly affected by climate change in the years to the 2080s.
- Plymouth can usually expect between 15 or 16 'wet days' in the winter, with 9 or 10 in the late spring and summer..
- Snowfall in the city is rare and has seldom been recorded beyond the period between December to March.
- Despite being the mildest region of the UK, the South West has experienced some of the most severe blizzards to affect the country.
- The city has recorded high wind speeds but there are variations between the monthly mean wind speed and the highest gusts. The highest winds occur between November and March (with gusts as high as 80+ knots in December and January) and the lightest between June and August.
- Gale force winds have also been recorded (34 + knots). The average for the South West is 24 days per year but Plymouth registers approximately 16 days per year.

- Places sheltered by hills and valleys, wooded areas and urban areas generally have lower wind speeds and fewer days of gales.

5.4 Reporting Change

5.4.1 We are all familiar with the headlines used to report the impact of weather and these, in turn, often provide some idea of the type of impacts experienced and the financial costs incurred. Recommended as an effective way of assessing local impacts, this evidence commonly forms the basis of the Local Climate Impact Profile or LCIIP that formerly supported the reporting process for national indicator 188 (planning to adapt to climate change).

5.4.2 For example the high winds and heavy rainfall of the unseasonal storm in June 2012 created the following local stories as well as national coverage of the impacts :

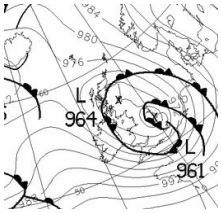
- Emergency crews called to release the occupants of a car crushed by a fallen tree.
- Trees brought down around Plymouth and the surrounding area.
- Cars damaged by a fallen tree in Ernesettle.
- Hyde Park Road half blocked by a fallen tree.
- Lipson Terrace completely blocked and a tree falls down on Royal Parade narrowly missing passers by.
- Blunts lane closed for an hour because of concerns for a large fir tree.
- Dustbins knocked over in Derriford, litter blown on to the street in Manadon and garden waste littered the streets in Peverell.
- One lane of the Tamar Bridge closed overnight because of high winds
- Plymouth Breakwater shut during the night.
- Homes in Plymstock left without power when a power line was brought down by a tree.
- The Environment Agency issued flood warnings for the south west area.
- Five fishermen towed to safety Plymouth Sound after being stranded in stormy waters.
- Plymouth lifeboat sent to the assistance of a yacht 20 miles off Fowey.
- Several small boats sink in Hooe lake.
- Outdoor marquee on North Hill was completely blown down.
- The south west receives between 15mm and 25mm of rain and winds of up to 65 mph

5.4.3 Although some of the reported incidents verge on the insignificant, the report also highlights the impact of the extreme weather on citywide services. The key driver here is the preservation of life (rescues and safety), followed by the protection of property but, it is also clear that, following the storm, action will be needed to restore power lines, ensure that properties are undamaged and that access is restored to main roads and services. The scale of direct and indirect costs that need to be accounted for is also apparent.

5.4.4 With more extreme weather incidents predicted for the next few decades we can expect to see a greater interest in reporting as these incidents impact on the social and economic quality of life within the City. Whilst many of the reported impacts may be negative, it is also likely that such impacts will create positive interest. The potential of the climate of the South West to mirror the conditions of the present day Mediterranean may, for example, feature in the marketing of tourism on a local, national and international basis.

5.4.5 Whether householders are 'popping to the shops' in the middle of an annoying downpour, planning a family day out, trying to keep warm (or cool) or enjoying locally produced fruit and veg, changes to Plymouth's weather patterns will have an impact on every resident and we should be aware of our vulnerability to the slightest impact. Whether supported by increasingly accurate data and predictions or responding to anecdotal evidence, the weather will continue to be a feature of Plymouth's character and is something we cannot ignore.

(Seen on a T Shirt promoting local holidays)
"Postponed due to Climate Change : 'Plymouth's Rain Festival
1st January to 31st December"



6.0 Extremes

Key Impacts/Local implications

- ✓ Severe gales
- ✓ Heavy rain
- ✓ Heavy snow and ice
- ✓ Thunderstorms and lightning.
- ✓ Heat and sun
- ✓ Dense fog
- ✓ High winds

6.1 Local Events

"We are already vulnerable to extreme weather. Climate change will make this worse. We need to plan for both current and future vulnerability." (Climate South West, 2010).

6.1.1 Although the UK is not particularly noted for extreme weather events the location of the South West peninsula makes it particularly vulnerable to localised incidents. There is evidence that, due to climate change, these incidents will become more frequent and more severe in nature.

6.1.2 In future the South West can expect more frequent weather extremes such as heavy rainfall and heatwaves. Droughts such as that experienced in 1976 (that led to the use of standpipes and cost agriculture up to £500 million in failed crops) will also be more frequent.

6.1.3 Small increases in storm surges will also be experienced putting low lying areas and coastal zones at risk but the largest increases are predicted to take place along the Bristol Channel and Severn Estuary.

6.1.4 Changes in extreme conditions will have the greatest impact on infrastructure; with potential damage to properties and utilities including those providing power and water. The threat to the built environment is significant. 70% of the buildings that will be here in the 2050s have already been built; making it essential to retrofit existing buildings as well as to integrate protective measures in new builds. This precautionary approach is particular applicable to buildings of recognised heritage value.

6.1.5 Housing will be increasingly at risk from flooding and storm events. In the Gloucestershire floods 6000 properties were flooded, 10,000 people were trapped on the M5 and on the railways, 42,000 were without power for 42 hours and 350,000 were without water for up to 17 days.

6.1.6 Rail travel is considered to be particularly susceptible with periodic flooding causing major disruption. The coastal routes are likely to be vulnerable to sea level rise, tidal surges and cliff instability and tunnels are liable to flooding. In high temperatures rail tracks tend to buckle, road surfaces melt and public transport can become uncomfortably hot.

6.2 The Evidence

- Winter 1982 – temperatures lower than those in Central Europe and Moscow recorded.
- Summer 1975 and 1976 – temperatures as high as 35°C recorded with drought and water shortages.
- The UK is commonly affected by anti-cyclones which can last for days or weeks.
- The winter of 2010/11 brought long periods of cold, dry weather.
- Lynmouth 1952 – flash floods caused by intense rainfall resulted in 34 deaths and the complete loss of 38 properties.
- Boscastle 2004 – flash floods exacerbated by poor land management caused damage to the village and harbour.

- Great Storm 1987 – strong winds associated with low pressure systems caused 23 fatalities.
- The UK actually suffers from approximately 33 tornadoes a year.
- Highest rainfall on one day was recorded at Martinstown in Dorset (279mm) on 18th July 1955.
- Heavy rain recorded on the 20th and 25th June 2007 created a months rainfall in one day, caused four deaths (in the flooding that followed) and caused over £1.5 billion of damage to businesses and properties.
- Thunderstorms are more common in southern England and are often followed by hailstorms.
- Hail stones caused drifts of 1.8 metres in Ottery St Mary in October 2008.
- The South West frequently experiences poor weather associated with Hurricanes.
- Hurricanes Floyd and Lili of 1996 and Gordon of 2006 both crossed the UK causing transport closures, power cuts and flooding in the South West.
- Unexpected storm activity in 2012 contributed to one of the wettest Summers on record.

6.3 The Losses

- Lives – four deaths were directly attributed to the Gloucestershire flooding.
- Based on climate related damages in the US in 2010/11 (tornadoes, hurricanes, flooding and wild fires),
- Reuters estimated that the value of insurance losses was between $18 billion and $37 billion and that
- insurance rates would double.
- The Association of British Insurers (2009) suggested that property insurance premiums in the UK would increase by up to 50% as global temperatures rise. A 4°C rise would result in a 27% rise, with a 2°C rise – considered likely by 2040 and inevitable by 2090 – would result in a 16% rise.
- River flooding and flash flooding are likely to be the main causes for claims with a rise of up to 14% to £633 million based on a 4°C temperature rise.
- Wales and the South West were identified as the regions that would be worst affected. In the South West insured losses for the average annual flood and wind damage could rise by 29% and 24% respectively.

6.4 Recommended Actions

6.4.1 The Met Office website has detailed advice of what to expect and what to do in the case of severe or hazardous weather with the potential to cause danger to life and/or damage to properties and widespread disruption. Weather forecasts carry information of predictions for up to five days in advance and, for all extreme weather, a series of red, amber and green 'warnings' are issued.

6.4.2 The most serious of these (red) is supported by the following advice :

(i) All Severe Weather :

- Take precautionary action, remain vigilant and follow any orders or advice given by the authorities.
- Expect significant disruption to normal daily routines.
- Avoid all non essential journeys.
- Carry emergency food, clothing and blankets.

(ii) Rain :

- Widespread flooding of properties.
- Sever disruption to travel.
- Loss of gas, electricity and water supplies.
- Significant disruption to communities with possible evacuation.
- Significant risk to life.

(iii) High Winds :

- Widespread structural damage – roofs, mobile homes and equipment, power lines and trees.
- Risk to personal safety from flying debris.
- Widespread and prolonged interruptions to power.
- Disruption to travel plans, blocked roads and danger to high sided vehicles and motorcyclists.

(iv) Storms (including lightning)

- Lightning always seeks a conductor on the ground so care should be taken to unplug electrical equipment and to avoid using communications equipment.
- Sporting equipment can also act as a conductor (e.g. gold clubs or fishing rods).
- Downed power lines or broken cables can pose a risk of electrocution.
- Reconnection times can vary; with an associated impact on productivity and supply lines.

(v) Heatwaves :

- Whilst hotter, drier summers may encourage visitors to the city, care also needs to be taken to avoid over exposure.
- Certain groups of people are more vulnerable than others to the effects of heat and ultraviolet radiation – this may increase as cloud cover decreases.
- It should be noted that it doesn't have to be hot for the UV index to be high.
- Awareness campaigns promoting the use of sun barriers and avoiding the hottest part of the day should be supported.
- Internal conditions may become uncomfortable requiring assisted ventilation, shading or air conditioning.
- The care of animals should also be noted; ensuring they are not left in hot conditions or locked in cars.

(vi) Dense Fog

- Fog can drift rapidly and is often patchy.
- Warnings are issued when visibility is expected to drop below 200m.
- Poor visibility – severe disruption can occur when visibility drops to below 50m.
- Slippery roads – freezing fog occurs when water droplets freeze on contact with road surfaces.

(vii) Snowfall and Icy Conditions

- Health implications - When temperatures fall to sub-zero, the number of deaths from heart attacks peaks three days later, from strokes five days later and from respiratory infections ten days later.
- Many roads closed or impassable.
- Stranding of drivers.
- Disruption to road, rail and air transport.
- Risk to personal safety.
- Significant disruption to normal daily life – transport, school closures.
- Widespread black ice
- Danger of falls, trips and slips and collisions.

Supporting Evidence :

More specific information on the risks associated with extreme weather conditions can be found on the Met Office website at : http://www.metoffice.gov.uk/guide/weather/severe-weather-advice

National extremes : http://www.metoffice.gov.uk/climate/uk/extremes/
National past weather events : http://www.metoffice.gov.uk/climate/uk/interesting/
Regional climate data (Met office) : http://www.metoffice.gov.uk/climate/uk/regional/
South West England Climate Data : http://www.metoffice.gov.uk/climate/uk/sw/print.html

National Risk Assessment : http://www.defra.gov.uk/environment/climate/government/risk-assessment/
Evidence report : http://randd.defra.gov.uk/Document.aspx?Document=TheUKCCRA2012EvidenceReport.pdf
Lloyds Insurance 360 Risk Project : http://www.lloyds.com/~/media/3be75eab0df24a5184d0814c32161c2d.ashx
F&C (Reo Research) Report : The Insurance Industry's Response to Climate Change : http://www.fundnets.net/fn_filelibrary/file/co_gsi_Climate_Change_Insurance_Report.pdf
Association of British Insurers findings (including predictions for the South West : http://www.nce.co.uk/climate-change-to-trigger-50-rise-in-insurance-costs/5211022.article

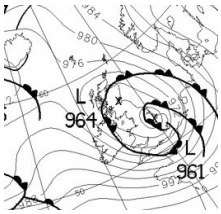
6.5 Addressing the Impacts

6.5.1 Extreme weather and climate change impacts should be integrated in to planning, policy and decision making at all levels.

- Transport and utility companies need to introduce risk assessments that identify vulnerable locations and the likely consequences of climate change and increased extreme weather and should look to develop appropriate adaptation responses such as the creation of alternative routes.
- Those responsible for developing and managing housing stock need to consider the impacts of extreme weather and climate and to act to ensure that housing remains fit for purpose and comfortable for future residents.
- Companies are encouraged to consider the needs of their supply networks – especially if these are located in other parts of the UK or Europe. For example, research indicates that many advanced manufacturing companies consider the risks from extreme weather from an operations point of view but few translate this in to future proofing or planning.
- Companies and service industries need to consider :
    - The impact on travel as the speed and reliability of product procurement and delivery could be disrupted.
    - The damage to infrastructure and consequent costs – particularly to communications and overhead cables for power supplies and sewers and drains for water and waste management.
    - The increased downtime from loss of energy supplies and communications.
    - The capacity of IT networks to cope with the additional loads created during periods of extreme weather as more people are likely to work from home.

- Insurance companies are highly vulnerable to financial losses created by claims for damages. Companies and service industries need to be aware that insurance premiums could rise as a result of climate change and budget accordingly.
- Properties in high risk areas will lose value and become uninsurable or unsaleable resulting in losses for lending institutions and debt pressures.
- Financial planning should take account of potential losses and impacts.

- Increased storminess will have an impact on coastal shipping and fisheries.
- The affects of sea level rise and tidal surges need to be assessed against the introduction of new protective technologies and coastal defence needs. The impact on coastal based facilities, supply lines and customers will be acute as incidents of extreme weather increase.
- The impact of extreme weather should be considered across all key priority sectors including tourism and leisure where 56% of businesses have been affected in the past.
- Local authorities and public health services need to adapt their business continuity plans to allow for increases in extreme weather incidents; integrating solutions in to operating practices and adopting actions that will counteract the negative consequences for their local areas.



7.0 Water

Key Impacts

- ✓ Wetter winters & drier summers
- ✓ Incidents of heavy rainfall
- ✓ Changes in humidity
- ✓ Extreme weather events
- ✓ Increased runoff and flood events
- ✓ Supplies and quality

7.1 Why Water ?

7.1.1 As a city by the sea, and a city surrounded by rivers, water makes a fundamental contribution to Plymouth's quality of life. Here, as in every other location, both water supply and water quality are intrinsically linked with the local environment, with weather patterns, resource management, climate change, population growth (demand), changes in land use and recreational use all creating limits for its use.

7.1.2 Water is also responsible for one of the major climate change impacts – flooding. Whilst increased rainfall might guarantee our ability to provide for adequate supplies of drinking water, the run-off created by heavy rainfall on the moorland above Plymouth can also be responsible for flooding incidents and the associated pollution, siltation or soil erosion it causes.

7.1.3 Key considerations :

- Basic details
- Adapting to climate change – where are we now ?
- Water supplies – including predicted capacity
- Water management - Planning for future demand.
- Rainfall – including the threat of flooding
- Water quality and climate change – including Sea Temperatures, Bathing water quality and managing coastal, estuarine and river habitats – see Habitats
- Sea level rise and tidal surges.

7.2 Basic Details for Plymouth, England, Latitude and longitude 50°21' N, 4°7'W.

Altitude	27 m (89 ft)
Average annual rainfall	950 mm (37.4 in)
Average monthly rainfall	79 mm (3.1 in)
Days on which more than 0.1 mm of precipitation	178 annually or 15 days in an average month.
Driest months	April and June (53 mm rainfall)
Wettest month	November (113mm precipitation over 17 days)
Average mean relative humidity per year	85.2%
Mean relative humidity ranges per month	From 81% in April/May to 89% Dec/Jan

7.3 Where are we now ?

7.3.1 Getting Wetter

- Monthly rainfall is highly variable between years.
- Totals below 20mm have been recorded in coastal districts for most months of the year but, by way of example, more than 100mm a month has fallen in Plymouth at some point in time reflecting its location and the impact of its unique micro-climate.

- Plymouth's rainfall records are also available and show an increased trend since the drought of 1975/76, although there were also periods of increasing rainfall at the start of the 1900s and in the 1920s.
- In the South West annual precipitation also increased between 1961 and 2006 with the biggest increase (28.6%) taking place each autumn.
- Over the same time period there was an 8.8% decrease in summer precipitation – exacerbating the potential for drought.
- The contribution of heavy rainfall increased by 5% - creating significant increases in the potential for flooding.
- Many of the changes predicted to date appear to be relatively benign as far as Plymouth is concerned but even the slightest changes could result in significant pressures on both services and infrastructure.
- Flooding has already been identified as a key risk. In Plymouth increased levels of surface water runoff will require management and may be exacerbated by heavy rainfall on the high ground beyond the city.
- The predicted increase in storm events, their relative severity, and the impact of hotter summers and more extreme cold weather are predicted to be the next most significant impact of climate change.
- Extreme weather, which includes heatwaves, cold weather, heavy winds, heavy rain fall and storm events, will have impacts on financial planning and business continuity as well as the physical environment. Plans will need to be adapted accordingly. See : Extremes.

7.4 Water Supplies

- South West Water remains the key supplier of water to the majority of homes and businesses in the City of Plymouth.
- The legal responsibility for the quality and protection of those supplies and the use of water as a resource lies with the Environment Agency.
- Plymouth's supplies are managed under the Tamar Catchment Abstraction Management Strategy (Environment Agency) which considers supply and demand management to 2014.
- This, in turn, is supported by the South West River Basin Management Plan that considers the threats to localised supply and the mitigating actions that might be taken.
- Burrator Reservoir remains the key source of water for the city but other supplies are drawn from abstraction points along the surrounding rivers.
- Allowing for an estimated population of about 260,000 residents, the city would require 34,840,000 litres of treated water per day to maintain current water use.
- The usage rates in 1999/200 of 146.5 litres per person per day had risen to 159 litres per person per day by 2007.
- Consumption rose to just under 160 litres per person per day in 2004/05 (SWW)
- Consumption has dropped significantly to 134 litres per person per day in 2011/12 mainly due to an increased uptake in water metering technology. (SWW)
- Evidence of stresses on supplies, particularly in response to recent drier winters, has already become the cause for concern.
- Flooding incidents are commonly associated with excess surface water run off that overwhelms the city's drainage system. Heavy rainfall on the high ground above the city could, in future, increase this risk.

7.5 Predicted Capacity

7.5.1 In 2005 the Environment Agency predicted that demand for water would grow by 5% over the next twenty years (to 2025) based on the consumption of 1,293,000 litres of drinking water per day in the South West, where personal consumption is also rising. Details of the availability of water resources and the likelihood of drought conditions are available on the Environment Agency's website.

7.6 Water Management – Planning for Future Demand

7.6.1 As the key suppliers, South West Water is responsible for planning ahead to ensure that water supplies for the South West will be adaptable enough to deal with the impact of climate change. Key planning documents include :

- The SWW Water Resources Plan 2010 to 2035
- The (draft) Drought Plan 2011

7.6.2 Both provide a strategic approach to planning water resources for the future and assessments of the impact climate change may have on supplies. In addition the specific impacts of climate change have been addressed in a specific report to Government dated January 2011 (SWW Climate Change Adaptation Report).

7.6.3 SWW have confirmed that flooding is identified as one of the biggest risks of climate change and have begun an extensive programme to ensure that water treatment facilities are protected from threats. Actions taken to date include sealing doors against flooding and raising electrical equipment in pumping and treatment facilities.

7.7 Recommended Action(s)

- Regular reviews of the impact of longer droughts on water demand is recommended (for example, a 4% rise in household water demand by 2021)
- Raise awareness of the increasing pressure on water supplies and encourage increased water efficiency in businesses and households.
- Support the introduction of water meters to reduced demand and save money.
- Introduce sustainable urban drainage and other flood risk management measures in construction policies and practice to mitigate the risk of flooding in urban areas.
- Ensure that at risk households are aware of the risk to insurance premiums and the potential for increased costs.
- Maintain awareness of the impact of soil erosion and run-off as a result of heavy rainfall and manage water courses accordingly.
- Ensure drainage systems are not put under pressure by heavy rainfall by reappraising design standards.
- For recommendations on coastal flooding see Habitats.

Supporting Evidence :

SWW Water Resources Plan 2010 to 2035 : http://www.southwestwater.co.uk/index.cfm?articleid=1556

SWW Drought Plan 2011 : http://www.southwestwater.co.uk/index.cfm?articleid=9183

SWW Climate Change Adaptation report – available from South West Water. See http://www.southwestwater.co.uk/index.cfm?articleid=8341&searchkey=Climate%20change%20impacts

Tamar Catchment Abstraction Management Strategy 2007 (Environment Agency) : http://publications.environment-agency.gov.uk/PDF/GESW0307BMCH-E-E.pdf

River basin management : http://www.environment-agency.gov.uk/research/planning/125027.aspx

Environment Agency water status details : http://www.environment-agency.gov.uk/homeandleisure/drought/31749.aspx

7.8 Rainfall

7.8.1 Although drier, hotter summers and warmer but wetter winters are predicted, it is very likely that :

- Incidents of heavy or intense rainfall will increase between now and 2050.
- Short periods of intense rainfall can cause flash flooding.
- Longer periods of widespread heavy rain can cause rivers to over flow.
- Between the 2020s and 2080s annual precipitation is expected to decrease by 0 to 15%.
- Winter precipitation is expected to increase by 0 to 15%.
- Summer precipitation is expected to decrease gradually by 0 to 15% by the 2020s, by 15 to 30% by the 2050s and possible by as much as 60% by the 2080s if a high emissions scenario prevails.

7.8.2 See also the Section on Weather.

7.9 Flooding

7.9.1 Flooding is generally predicted to be the key threat to the South West. Additional information can be found in the Section entitled Extremes.

Supporting Evidence : Flooding

Flood and Water Management Act 2010 : http://www.legislation.gov.uk/ukpga/2010/29/contents

Planning Policy Statement 25 : Development and Flood Risk :
http://www.communities.gov.uk/archived/publications/planningandbuilding/pps25floodrisk

Environment Agency Flood Maps : http://www.environment-agency.gov.uk/homeandleisure/floods/31650.aspx
DEFRA / LGA Flooding Portal for advice on flooding, how to plan for it and the funding pots available.
http://www.local.gov.uk/floodportal;jsessionid=F59B24800A8DCFCAF867EE05035B9ED3

City of Plymouth Flood Mapping : http://maps.environment-agency.gov.uk/wiyby/wiybyController?x=247500.0&y=56500.0&topic=floodmap&ep=map&scale=9&location=Plymouth,%20City%20of%20Plymouth&lang=_e&layerGroups=default&distance=&textonly=off#x=247135&y=56623&lg=1,&scale=8

PCC Advice on flooding : http://www.plymouth.gov.uk/flooding
PCC Emergency plans :

Planning applications objected to on flood grounds by the Environment Agency 2007/2008 :
http://www.environment-agency.gov.uk/research/planning/33704.aspx
Flood Risk Assessments : Plymouth
http://www.plymouth.gov.uk/sfra_section_one.pdf
http://www.plymouth.gov.uk/sfra_section_two.pdf
http://www.plymouth.gov.uk/sfra_section_two.pdf
Flood Risk Assessments : Plympton.
http://www.plymouth.gov.uk/plympton_sfra.pdf

- New legislation has been introduced under the Flood and Water Management Act 2010.
- Guidance on the preparation required for flooding can be found in the nationally applicable Planning Policy Guidance Statement 25 (since replaced by the National Planning Policy Framework).
- This, in turn, informs the detailed Flood Risk Assessments undertaken for Plymouth and Plympton.

- The locations at risk of flooding from a variety of sources in Plymouth can be viewed on the Environment Agency's flood map which reveals the city's vulnerability to the rivers that surround it and the streams and watercourses that run through it.
- Evidence shows that surface water run off (often from high ground above the city) is a key threat.
- Flood assessments therefore take account of changes in rainfall patterns and the incidence of heavy rainfall.
- Many of the city's watercourses have been developed over time; changing the nature of the land use and the extent of any risk. Here plans for sustainable urban drainage are applied.
- Flooding at key sites, including the Embankment through Laira, would threaten a strategic access and transportation route.
- Others, such as Sutton Harbour and the Barbican, would threaten homes and business properties.
- Others, such as the infilled creeks in Stonehouse, would threaten the public open space of Victoria Park.
- Although there are few areas with higher concentrations of properties at risk, two areas, Devonport and Plympton, are notable for the heightened risk.
- Objections to development on the grounds of flood risk are increasing but, to 2008, no major or minor developments were approved contrary to advice in Plymouth.
- Reactions to flood incidents are clearly set out in the city's Emergency Plans.
- Evidence suggests that, in the South West, a 2°C rise could increase annual insured flood losses by 19% - leading to a potential price increase to premiums of up to 16%. (ABI 2009)

7.9.2 Information and guidance, including details of flood alerts, can be found on the Met Office website where information on heavy rain can also be found.

7.9.3 Recommended Actions

- The obligations of the Flood and Water Management Act 2010 are met.
- Adaptation actions should be integrated in to development policy and planning at every level. Ignoring climate change is not a viable option as the inaction will be far more costly that adaptation.
- Climate change impacts should be taken in to account in project management and delivery practice – ensuring the use of sustainable urban drainage, managed water courses and flood defence schemes.

7.10 Water Quality and Climate Change

7.10.1 The 'definition' of Plymouth's water quality extends much further than drinking water and the quality and capacity for future supplies. Fisheries, the condition of the Sound and its almost unique habitats and the value of recreational use to local tourism and the economy also need to be considered in terms of predicted climate change.

7.11 Pollutants

- With wetter winters, watercourses and ground water will be increasingly subjected to an increased risk of pollution from nitrates and harmful organisms such as cryptosporidium. This, in turn will have an impact on the risk to human health.
- Prolonged dry periods (warmer summers) will also increase this risk due to the organisms being flushed in to watercourses when the first rainstorms arrive.
- Lower river flows in the summer will also result in reduced water quality caused by the poorer dilution of pollutants.

7.12 Sea Temperatures

7.12.1 Understanding and forecasting current and future consequences of coastal warming require a fine-scale assessment of the near-shore temperature changes.

7.12.2 Despite the fact that 71% of the world's coastlines are significantly warming, rates of change have been highly heterogeneous both spatially and seasonally.

7.12.3 It can be demonstrated that 46% of the coastlines have experienced a significant decrease in the frequency of extremely cold events, while extremely hot days are becoming more common in 38% of the area. The onset of warm seasons is significantly advancing earlier in the year in 36% of the temperate coastal regions. (MCCIP)

7.12.4 More importantly, it is now possible to analyse local patterns within the global context, which is useful for a broad array of scientific fields, policy makers and general public.

- Records of sea temperatures are available for Plymouth from 1957 to 1993 and reveal clear seasonal variation.
- Overall the mean sea temperatures have remained relatively consistent and do not appear to have reflected an increasing trend – although the figures for 1993 to 2012 should be compared to confirm this.
- Changes in sea temperatures are likely to have a significant impact on the biodiversity and productivity of the Sound.
- This, in turn, may impact on fisheries and the Sound's unique marine environment, fauna and flora.

7.13 Bathing Water Quality

- Bathing Water profiles for Plymouth Hoe East and Plymouth Hoe West are available on the Environment Agency's website.

Supporting Evidence : Bathing Water Quality

http://www.environment-agency.gov.uk/static/documents/bwprofiles/BW_26400_Plymouth_Hoe_East.pdf
http://www.environment-agency.gov.uk/static/documents/bwprofiles/BW_26500_Plymouth_Hoe_West.pdf

- Records dating back to 1988 (available on the Environment Agency website) show consistent improvement in the quality of the designated bathing waters at both locations.
- The impact of South West Water's Clean Sweep programme has clearly been recognised but the Profiles both note that the bathing water quality at both locations is subject to changes in the quality of the River's Tamar and Plym and that these, in turn, could respond to variations in weather and climate change conditions.
- Concern has recently been expressed at the impact of climate change on the incidence of algal blooms in the Sound and their impact on bathing water quality and recreational use.

7.14 Sea Level Rise

- Predictions currently suggest that sea levels will rise by 18 to 20 cm by the 2040s and by 37 to 40 cm by the 2080s with associated impacts for low lying areas, properties and coastal defences.
- Rising sea levels, unpredictable coastal dynamics and possible increased wave heights will increase coastal erosion and damage coastal amenities.
- Absolute sea level (corrected for land movement) has risen by approx 1mm per year over the 20th Century with evidence that this rate has increased during the 1990s and 2000s.
- Natural land movement in the South West (getting lower over time) is likely to enhance the effect of rising sea levels leading to a greater potential for coastal flooding and erosion.

7.15 Tidal Surges

- Tidal surges (often referred to as mini tsunamis) are rare but not unheard of in the South West.
- The Bristol Channel Floods of 30 January 1607 resulted in 3000 deaths and damage to 200 square miles of farmland on both sides of the Channel. The damage on the Welsh coast was reported as far as 23 km inland.
- The Lisbon earthquake of 1755 also created a minim tsunami that impacted on a number of coastal villages in South Cornwall and was recorded in Devonport.
- Tidal surges are often thought to be created by underwater mudslides (which do not register as seismic activity). Probable incidents from activity beneath the Western Approaches have been reported, with the most recent being reported in August 2008 and on the 29 June 2011 when a 'wave' of up to 0.3m was seen in local estuaries.
- Evidence for the highest and lowest tidal surges between 1987 and 2007 show that the surges have reached as much as 0.94 m (16 Oct 1987) and dropped as low as 0.59m (30 January 2003).
- For the South West as a whole, small increases in storm surges are predicted everywhere with the largest increases expected in the Bristol Channel and Severn Estuary.
- Storm surges, often associated with storm events, can be the cause of coastal flooding. Tidal surges linked to these events are increasingly causing concern and are now monitored by the Met Office with frequent reports to the Environment Agency.
- The Storm Tide Forecasting Service Operational Report (1st June 2007 to 31st March 2008) for example, records the storm surge of the 10th March 2008 – the largest during this period of reporting and the result of a storm that influenced the whole of the South West region.
- Businesses located in coastal locations are increasingly taking action to assess the vulnerability of their operations to both flooding and tidal surges.
- Two notable local examples are Devonport Dockyard and the MVV Waste to Energy Plant planned for Devonport. Both have considered resilience to flooding in relation to specific circumstances.
- The report for Devonport (see : http://www.babcock.co.uk/media/334194/babcock_report_final_.pdf) clearly highlights the vulnerability of the nuclear dockyard and its associated risks and draws on the experience of the nuclear power plant at Fukishima in Japan following the 2011 earthquake.
- The report for MVV is a standard Flood Risk Assessment. See MVV Flood Risk Assessment : http://www.mvvenvironment.co.uk/environment/web/media/downloads/environment_1/plymouth/planningapplication/4_environmental_statement/volume_03_appendices/111_Flood_Risk_Assessment.pdf

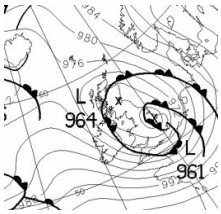
7.16 Responding to the potential of increased tidal activity.

7.16.1 Although relatively rare, care will be needed in future to link the potential for tidal surges with the prediction of extreme weather events and the management of responses to issues such as coastal defence, flooding and, in particular, nuclear safety.

7.16.2 Predictive data is available for tidal monitoring over 28 day periods.

7.16.3 Data packages for longer term modelling are also available from the National Oceanography Centre (see : http://www.pol.ac.uk/).

See SWENVO Climate profiles for Devon : http://www.swenvo.org.uk/themes/atmosphere/climate-change/



8.0 Health

Key Impacts

- ✓ Changes in temperature
- ✓ Changes in cloud cover and exposure to UV radiation.
- ✓ Extreme weather
- ✓ Impacts on air quality

8.1 Local Implications

8.1.1 Improving resilience, the ability to react to incidents, improved communication, public awareness and working partnership are all identified as key drivers of the health sectors response to climate change impacts.

8.1.2 As a city, Plymouth is well rehearsed in reacting to 'emergencies' and, as such, services and personnel can be easily deployed to provide the care and support required. Proactively Plymouth is supported by a strong Local Resilience Forum and has developed its own versions of the national Cold Weather and Heatwave Plans.

8.1.3 As vulnerable communities, such as the elderly, the very young and those with existing medical conditions are all at risk from extremes of cold, heat, humidity and damp and changes in air quality, the potential impacts of climate change have already been taken in to account. The challenge, as health services are in transition, will be to embed this awareness and to continue to ensure that levels of communication and shared resources are maintained. In addition to the general risks, two specific issues were highlighted :

8.1.4 Exposure to UV radiation : Plymouth already has the 3rd highest incidence of skin cancer in the UK. As summers become increasingly hotter and cloud cover is reduced the risk of melanomas will increase.

8.1.5 Poor quality housing : Plymouth has a high level of privately rented housing with category one hazards; risks that have an increasing impact on the more vulnerable householders renting the properties. Here the climate change impacts include damp, which can encourage moulds and associated respiratory conditions, poor housing standards, including low levels of insulation, and fuel poverty.

8.1.6 Air Quality :

- Plymouth already benefits from extensive and legally binding requirements for air quality monitoring although no specific reports have been created linking the impacts of climate change to air quality.
- Air quality monitoring in Plymouth includes levels of sulphur dioxide, carbon monoxide, nitrogen dioxide, benzene and ozone. Of these, ozone can, on occasions, occur in naturally high levels.
- Ozone is the third most significant greenhouse gas.
- When inhaled it can cause serious damage to respiratory systems with an estimated 21,400 premature deaths caused annually in the EU.
- More commonly associated with the Montreal Protocol, CFC pollutants and the ozone hole over the Antarctic, it is estimated that by 2050 the global efforts to cut related pollution will have been negated by climate change.

8.2 Vulnerability

8.2.1 Identified Health Risks include :

- ✓ Greater risks of communicable disease through water, contact and food borne routes.
- ✓ Higher risk of accidental death – drowning and/or electrocutions associated with flooding incidents.

- ✓ Higher risks of skin cancer and sun burn due to hotter, drier summers and more outdoor recreation.
- ✓ Heat stress leading to dehydration.
- ✓ Increased incidences of food poisoning, infectious disease and infections related to contaminated water (flooding)
- ✓ Increased evidence of organisms such as *Cryptosporidia, Giardia* and other bacteria..
- ✓ Higher levels of dust, pollens and irritants in the air leading to respiratory discomfort.
- ✓ Impacts on respiratory function caused by changes in air quality.
- ✓ Higher levels of damp and mould in accommodation.
- ✓ Increased use of air conditioning and poor maintenance that could contribute to the spread of Legionnaires Disease.
- ✓ Increased likelihood of insect infestations and/or disease carried by biting insects (malaria).
- ✓ Increased algal blooms and their health implications limiting the use of seaside facilities.
- ✓ Pressures on water companies and the Environment Agency to prevent cross contamination from storm water and sewage outfalls that impact on beaches and waterfront areas.
- ✓ Increased pressure on accident and emergency services during extreme weather as falls and breaks are recorded.
- ✓ Greater risk of fire and burns due to drier conditions.
- ✓ Increased pressure to address Category One hazards in private accommodation.
- ✓ Additional displacement of hospital patients during extreme weather events.
- ✓ Service continuity disrupted as staff are unable to reach patients or resources.
- ✓ Pressures to maintain comfortable living conditions in private homes and in care facilities.
- ✓ Higher costs of care and health insurance.
- ✓ Broader impacts on health and wellbeing as both environments and economies change.

8.2.2 Additional impacts include :

- ✓ Concern for the health and welfare of pets and livestock in extreme conditions.
- ✓ The increased use of pesticides and other toxic substances designed to counteract infestations.

Supporting Evidence :

National Cold Weather Plan :
http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_130564

National Heatwave Plan : http://www.dh.gov.uk/health/2012/05/heatwave-plan/

Plymouth's Cold Weather Plan : *Details to follow*
Plymouth's Heatwave Plan :
http://www.plymouthpct.nhs.uk/CorporateInformation/boardpapers/Documents/Board%20Papers%20-%202010/Board%20Papers%20-%20June%202010/Item%205%205%20Heat%20Wave%20Plan.pdf

Emergency Plans : *Access to be agreed*
Trend data and local statistics : e.g. Excess Winter Mortality Figures, no of category one hazards in housing, risk factors for vulnerable communities

National Air Quality and climate change report 2011
http://www.defra.gov.uk/publications/files/pb13378-air-pollution.pdf
Air quality reporting and policies : NB No reports linking air quality and climate change impacts have been prepared for Plymouth.
http://www.plymouth.gov.uk/homepage/environmentandplanning/pollution/airquality.htm
Air Quality Assessment for Plymouth 2004
http://www.plymouth.gov.uk/detailed_assessment_of_air_quality_in_plymouth_2004.pdf

'*Climate Change and Communicable Disease – what are the risks*' ? Nichols, Richardson and Maynard, University of Plymouth Faculty of Health, Sept 2010 (Journal of Infection Prevention) : Website details requested.

8.3 Addressing the Impacts

8.3.1 Many of the mitigating actions required to address the impact of climate change on health relate to communication, awareness, partnership working and resource management rather than direct interactions with the city's infrastructure. One of the key actions will be the introduction of greater levels of public awareness without increasing levels of fear or stress.

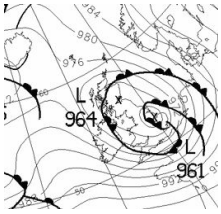
8.3.2 Adaptive strategies are recommended that do not increase the identified risks or introduce new hazards and that can be applied at individual, community and population wide levels. (Lindley et al, 2006 in *Adaptation Strategies for Climate Change in the Urban Environment)*.

8.3.3 "It is imperative that those tasked with preventing and controlling communicable disease in the UK should take an interest in climate change and implement policies and action plans accordingly." (Nicols, Richardson & Maynard, 2010).

8.3.4 The suggested actions include :

- ✓ Ensuring that resilience to the impact of climate change is retained as a concern as the health services is transformed.
- ✓ Maintain the strong partnership of the Local Resilience Forum.
- ✓ Ensuring that the impacts of climate change are embedded in business continuity, resource management and emergency plans.
- ✓ Ensuring a strong, well informed and informative partnership between health providers that benefits those most at risk.
- ✓ The need for multi agency action to limit the risks.
- ✓ Building our understanding of the impacts of climate change on health and responding appropriately.
- ✓ Maintaining levels of air quality monitoring and taking action to advise vulnerable households of any significant impacts arising.
- ✓ Establishing the means to address Category One hazards and improving housing conditions.
- ✓ Addressing fuel poverty – energy advice and insulation schemes.
- ✓ Strengthening Plymouth's message on health awareness and, particularly, the dangers of over exposure to the sun.
- ✓ Applying sustainable design (in new builds and in refurbishments) that allow for greater levels of shading and improved means of cooling or heating.
- ✓ Strengthening public awareness of the risks of food poisoning and improving public hygiene standards.
- ✓ Considering the need to hose down urban streets if necessary (and subject to water resource availability).
- ✓ Ensure infestations and the introduction of new species can be addressed without the added pressures of additional pollutants.
- ✓ Ensuring that animal welfare plans are adapted to address the changing conditions.

8.3.5 When considered as a theme in its own right, it is clear that the relationship between health care, costs and the potential impact of climate change is significant in terms of the vulnerability of Plymouth to change and the provision of deliverable solutions.



9.0 Wealth

Key Impacts

- ✓ Extreme weather events
- ✓ Risk of flooding
- ✓ Employee comfort
- ✓ Supply networks
- ✓ Financial and legal limitations
- ✓ Business continuity
- ✓ Reduced carbon footprints

9.1 Local Implications

9.1.1 Climate change has the potential to create conditions that could seriously damage Plymouth's economy if action is not taken to identify, and plan for, their implications.

- The risks highlighted by the current evidence suggest that local businesses should be able to invest in actions that will limit the impact of physical damage (from flooding or extreme weather events) and that this, in turn, will limit the financial losses arising from repairs, lost productivity and rising insurance premiums.
- The inclusion of climate change considerations in business continuity planning is increasingly being recommended as a means of building resilient to change and future-proofing the viability of businesses of every size.
- Increases in the costs of insurance premiums are considered to be closely related to temperature rise and the associated impacts of flooding and storm events (high winds).

9.1.2 In addition to adapting to climate change and limiting increases in insurance costs, businesses also have a great deal to gain from limiting the impact of climate change by reducing their emissions. In doing so they have the potential to manage resources more effectively, to save money on supplies of energy, and to contribute to reducing the city's overall carbon footprint.

9.1.3 As the evidence suggests that the impact of historic climate change could take up to 50 years to address, the future resilience of the city is of considerable concern but there is also evidence that tackling climate change through the development of a low carbon economy could also bring benefits to the city in terms of new investment, new jobs and an extended profile for related research and development.

9.2 The Good News : Mitigating Against Change – reducing the city's carbon footprint.

9.2.1 The extent to which we can adapt to climate change is commonly measured against predictions that take high, medium and low emission scenarios in to account. These, in effect, give us the best and worst case scenarios against which to plan for the future and are, in turn, based on the carbon footprint of the city and the collective efforts recorded to reduce this over time.

9.3 The Basics :

i.	Plymouth's baseline footprint	1,473,670 tCO2 in 2005 (DECC 2012)
ii.	Value at 2012 CRC prices of £12/tCO2	£17,684,040
iii.	Plymouth's per capita footprint	5.9 tpc (tonnes per capita) in 2005
iv.	Plymouth's reduction targets	20% by 2013, 35% by 2020, 60% by 2035 and 80% by 2050
v.	Reported reduction to date	192,490 tCO2 by 2009 (-13.07% to 1,281,180) and 0.9 tpc by 2009 (15.26% to 5 tpc).

9.4 The Value :

- £100 million invested in the marine sector alone over the last seven years.
- 880 new jobs predicted in the low carbon and environmental sector by 2020
- Employed 3200 FTE employees in 2008 – 2.9% of the FTE workforce.
- Valued at £192 million in gross value added in 2008.
- GVA per FTE was £60,300 – 60% higher than the city's average.
- 45% of the sector was in manufacturing – 15% higher than the national average.
- Employment in the sector grew between 2007 and 2009 and is expected to expand further.
- By 2020 the sector will be valued at a further £127 million in GVA.
- The CRC (green tax) is estimated to impact on approx 47 local companies including the City Council.
- Mandatory carbon accounting introduced for the top 100 LSE registered companies with a review in 2016 expected to extend the requirement to smaller companies.

Supporting Evidence :

Plymouth's Local Carbon Framework 2012 to 2050 : http://www.plymouth.gov.uk/lcfprospectus.pdf
National emissions estimates (published annually by DECC) :
http://www.decc.gov.uk/assets/decc/11/stats/climate-change/2751-local-and-regional-co2-emissions-estimates.xls
Plymouth's Low Carbon Economy (Regional Economic Development Group 2010) :
http://www.plymouth.gov.uk/uoplowcarboneconomyfullreport.pdf
Analysis of carbon reduction policies for Plymouth (University of Exeter, 2010) :
http://www.plymouth.gov.uk/uoecarbonscenariosreport.pdf
Climate South West's Profile reports :
Building Resilience to Extreme Weather and Climate Change in the South West :
http://climatesouthwest.org/warming-to-the-idea

UKCIP/DEFRA : Climate Change – Assessing the Impacts and Identifying the Responses (the first 3 years of the UK Programme : http://www.ukcip.org.uk/wordpress/wp-content/PDFs/3year_summary.pdf

The potential impact on tourism : http://www.geog.ox.ac.uk/news/events/ccamts/appendix13.pdf

National case study – tourism in the South West : Cost a South West (South West Tourism, the Environment Agency and Climate South West) :
http://ukclimateprojections.defra.gov.uk/media.jsp?mediaid=88427&filetype=pdf

9.5 Addressing the Impacts

9.5.1 After flooding (See : Water), the impact of extreme weather is considered to be the most significant climate change impact in relation to business continuity and the provision of local services. These impacts are considered in more detail in the next Section : Extremes.

a. Business Continuity Planning

Businesses, particularly those considered to be at risk from flooding or other identified climate change impacts, are encouraged to address their business continuity plans and to embed actions that would limit the impact of climate change on their operation and productivity.

These actions could be very simple – such as ensuring that power disruptions do not interrupt communication – or they could be more comprehensive and take in to account the broader impacts on staff, customers and suppliers.

A working example is provided by a real-time experience set out below :

" Thank you for your patience and support in helping us to identify the ICT issues caused by yesterday's power disruption. We have been monitoring systems from 7.00 this morning but have been unable to recreate the same conditions that occurred yesterday. We have again forced a disruption to the power in the datacentre to try and replicate the issue but, as designed, everything has stayed working. We will continue to review logs with our supplier. The good news is we are confident that the ICT infrastructure is stable, we can survive power disruptions and that yesterday's event is unlikely to reoccur. We have learnt much from this event across the organisation which will help us improve business continuity arrangements going forward."

Planning for resilience to change is likely to become a priority for management as the threat of climate change becomes more obvious to local companies. Being prepared for the potential impact is also likely to feature significantly in management plans and in insurance cover; with knock on impacts on the costs of premiums, training and clean up costs.

b. Risk Assessments

In addition to health and safety, risk assessments are increasingly considering the impact of climate change and its potential to damage financial security.

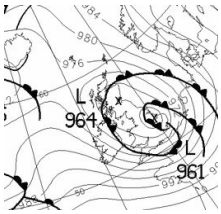
Businesses are recommended to take these in to account in their Risk Logs and to ensure that staff are both aware of the potential and able to tackle incidents safely and effectively.

c. Financial Assessments

In addition to the potential savings created by effective carbon and environmental resource management, businesses are encouraged to carefully assess the potential financial impact of incidents related to extreme weather or climate change and to embed contingency plans in to their planning process.

d. Legal Implications

In addition to the legal implications of registration for carbon accounting (CRC/Climate Change Levy or the EU ETS), businesses are encouraged to ensure that they are fully and appropriately insured against loss and damage and the risk assessments suggested above are kept up to date.



10.0 Habitats

Key Impacts

- ✓ Changes in temperature
- ✓ Flooding, sea level rise and surges.
- ✓ New species

10.1 Local Implications

10.1.1 Evidence

10.1.2 In addition to the scoping study undertaken by Climate South West (see Building Resilience to Extreme Weather and Climate Change in the South West : http://climatesouthwest.org/warming-to-the-idea) which placed a strong emphasis on 'our natural environment', there appears to be a significant amount of background evidence for the impact of climate change on local habitats, biodiversity and management plans.

10.1.3 Although not all of the reports identified consider climate change as a specific theme, many of them do take in to account the changes over time that will inevitably influence management strategies. A selection of the reports are listed in the Supporting Evidence box below but three key 'management plans' provide the background for the local action that could be taken :

- The Plymouth Green Space Strategy
- The Tamar Estuaries Management Plan 2006 to 2012
- The Dartmoor Management Plan 2007 to 2012.

Supporting Evidence :

England Biodiversity Strategy : Towards Adaptation to Climate Change : http://nora.nerc.ac.uk/915/1/Mitchelletalebs-climate-change.pdf
Dartmoor Management Plan 2007 to 2012 : http://www.dartmoor-npa.gov.uk/lookingafter/pl-dnpmgmtplan
Charter for the Countryside and Seas Around Plymouth : http://www.plymouth.gov.uk/a_charter_for_the_countryside___seas_around_plymouth-2.pdf

⇨ Plymouth Sound and Estuaries Coastal Planning Study : http://www.plymouth.gov.uk/homepage/environmentandplanning/planning/planningpolicy/ldf/ldfbackgroundreports/brplymouthsoundcoastalplanning.htm

⇨ Tamar Estuaries Management Plan to 2012 : http://www.plymouth.gov.uk/homepage/environmentandplanning/natureconservation/natureprojects/tecf/tecfabout/tecfmanagementplan.htm
Tamar Estuaries Management Plan to 2013 to 2018 (consultation): http://plymouth.limehouse.co.uk/portal/planning/tecf/tecf?pointId=2151910#document-2151910

⇨ Plymouth's Green Space Strategy : http://www.plymouth.gov.uk/green_space_strategy_2008_2023.pdf

⇨ Sites protected for nature conservation : http://www.plymouth.gov.uk/sitesprotectedfornatureconservation.pdf

⇨ Basking shark sightings : http://www.swenvo.org.uk/themes/atmosphere/climate-change/

⇨ Bracken, ticks and heather indicators of climate change, Bodmin, Dartmoor and Exmoor: http://www.swenvo.org.uk/themes/atmosphere/climate-change/

10.1.4 Existing assessments of the threat of climate change to the South West place a great deal of emphasis on the value of the region's coastline, beaches, moors and countryside to both local residents (5 million in the South West) and visitors (21 million p.a.). This is reflected in the statutory protection afforded to the landscapes and habitats surrounding, and within, Plymouth.

10.2 Addressing the Impacts

- Habitats are particularly susceptible to soil erosion and flooding. Areas at risk should be identified and protected with long term management schemes that enhance infiltration and prevent soil erosion and run off. This, in turn, helps to reduce the impact of surface water flooding as well as sequestering carbon, enhancing biodiversity and protecting our archaeological history.
- Awareness should be raised with developers seeking to build on flood plains. Householders already in residence should be supported in attempts to implement flood resistance and resilience measures.
- Greater protection should be sought for noted habitats and species. Referred to as Strategic Nature Areas, these habitats are the most likely places for species resilience.
- Areas of green space should be encouraged – especially within urban areas – to assist with mitigating rising temperatures and the provision of shade.
- Levels of vulnerability should be informed by local consultation and action.
- Changes in rivers, seas, estuaries and coastal environments should be consistently managed to highlight the potential threats to habitats and biodiversity.
- As species distribution may occur in response to climate change, consideration should be given to flexible designations and joint management responsibilities.

10.3 Woodlands

10.3.1 Climate change will affect the health of trees; resulting in different management requirements. From extreme weather events to increased temperatures, soil erosion and drought these impacts may become particularly significant to Plymouth's urban and street trees and to the wooded areas of the city's steeper valleys.

10.3.2 Both trees and woodlands are important as they help to reduce the impacts of climate change; acting as absorbers of carbon dioxide through photosynthesis. They also offer shade, provide stability, alleviate the potential for flooding and provide essential wildlife habitats.

- The location of trees and woodlands needs careful consideration as they can be affected by soil moisture deficits in summer and stress in times of drought. This, in turn, has an impact on their health and productivity if used for timber supplies.
- Changes in pests and diseases will also be notable. Trees will exhibit greater susceptibility to fungal diseases (such as Phytophthora ramorum) and species such as the green spruce aphid.
- Areas of Plymouth will benefit from floodplain forestry where short rotation coppicing can be used.
- Some species may benefit from higher carbon dioxide concentrations with increased growth rates, productivity and growing seasons.

10.4 Fisheries

10.4.1 Plymouth's role in the fishing industry is already challenged but sea fisheries remain an important part of the city's economy.

10.4.2 Ecologically, the coastal waters off Plymouth mark a boundary between warm southern and cooler northern seas; making them perfect for a broad range of species. There is, however, evidence that species distribution patterns are changing and that stocks of warm water fish are growing.

10.4.3 Further details are available from the Marine Climate Change Impacts Partnership (see http://www.mccip.org.uk/).

- Overall ocean productivity is likely to be reduced affecting species across the entire marine food chain.
- Ocean acidification, caused by higher levels of carbon dioxide, are threatening marine ecosystems and the ability of some species to create shells. Acidity has already increased by 30% over the last 200 years (MCCIP 2010).
- Plymouth Marine Laboratory is considered as a leading centre for research in the fields of ocean acidification and marine climate change. The Sir Alistair Hardy Foundation for Ocean Science, also based in Plymouth, has the responsibility for a plankton survey that has been undertaken for 80 years; contributing substantially to our understanding of oceanic climate change.
- Fish are particularly sensitive to small changes in temperature. Predicted changes in the temperatures around Plymouth may have a knock on impact on the fishing industry and the contribution it makes to the local economy.
- Choice may also change. Cod populations have been shown to fall as the seas warm up.

10.5 Coastal Environments

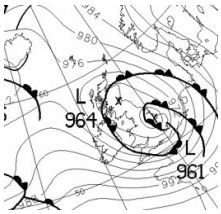
- Plymouth enjoys over 19km of waterfront environments.
- Rising sea levels, unpredictable coastal dynamics and possible increased wave heights will impact on coastal erosion and amenities.
- Beaches, wetlands, mudflats, salt marshes and dunes could be lost with associated impacts on their fauna and flora.
- Protecting or managing some coastal areas may be too expensive so, in some cases, managed retreat may be required.
- In Plymouth key transport links could be at risk.

10.6 Rivers

- Plymouth's location benefits from five key rivers, the Tamar Estuary and the Sound.
- Climate change impacts further upstream could result in changes to flow rates.
- This, in turn, could impact on water supplies (from abstraction points) and the river's habitats and wildlife.
- Regionally concerns over algal blooms and fish deaths have been voiced in relation to increasing temperatures.

10.7 Biodiversity

- Climate change will encourage the relocation of some species.
- Evidence shows that some species have moved up to 60km north and an average of 25km 'up hill'.
- Gains in the South West include little egrets, greater horseshoe bats and red eyed damsel flies.
- The South West stands to lose golden plovers, ring ouzels and greater mouse-eared bats.
- Habitats such as the Plym Estuary (mudflats at low tide) and Crabtree could be at risk from changes in sea level.
- Changes in life cycles could also be experienced as the seasons adjust to climate change. This in turn could impact on food chains and life expectancies.
- There will be an increase in pests and diseases, with some new introductions threatening both habitats and human health. Increases in mosquitoes have already been noted in areas of Cornwall (Hayle).



11.0 Homes

Key Impacts

- ✓ Energy security & fuel poverty
- ✓ Alternative solutions
- ✓ Rising costs
- ✓ Changing temperatures
- ✓ Flooding and extreme weather
- ✓ Sustainable design

11.1 Local Implications

11.1.1 Plymouth's homes and the future quality of life for the city's householders will inevitably be affected by climate change but these impacts will be felt in different ways. The extent to which we can mitigate these impacts will depend on the type and extent of the impact in question – some will be direct. Other impacts may be indirect and an outcome of changes at a national or, even, international level.

11.1.2 Direct impacts might include :

- Flooding
- Damage from extreme weather.
- The socio-economic and health impacts of fuel poverty.

11.1.3 Indirect impacts could be considered as :

- Energy security and rising costs.
- Sustainable design and building regulations –the coding for energy efficient homes.

11.1.4 For Consideration :

- Plymouth's population in mid 2010 was 258,700.
- The city has approximately 93,000 households.
- In 2009 there were 114,900 domestic electricity meter points in Plymouth; 5% of the regional total of 2.4 million.
- Average electricity consumption per consumer is 3762 kwhs per year.
- The average energy consumption of a nuclear family is 5480 kwh per year.
- Based on these figures, Plymouth's household carbon footprint could be as much as 277,866 tCO2 p.a.
- 14,000 households in Plymouth are considered to be fuel poor (at Jan 2013)
- The City Council aims to build approximately 30,000 new homes.
- 80% of these will be on brownfield sites and 12,250 will be built by 2016.
- The number of households is predicted to rise by 23.6% between 2008 and 2033 – accounting for 26,000 additional households.
- The potential to install certain types of renewable resources (biomass/wind) will be limited due to Plymouth's urban nature.
- Biomass options are gaining strength in the city with at least two proposals currently in development.
- Wind power is limited due to lower urban wind speeds, planning constraints in residential areas and some military objections, communication and flight path issues.
- Micro renewables are more likely to be employed subject to on site renewable policy compliance but larger installations may be required to fulfil low or zero carbon development needs.
- Plymouth's waste to energy plant will provide a significant option for low carbon energy.
- Options are being developed for anaerobic digestion and the processing of food waste.

11.2 Flooding (See : Water).

11.2.1 Areas at risk from flooding, commonly from excess surface water run off after heavy rain, are identified on the Environment Agency's flood maps and are also taken in to account in the Flood Risk Assessments undertaken for the City as part of the Local Development Framework. As periods of heavier rainfall are predicted as an outcome of climate change, the enhanced risk will need to be taken in to account in future planning proposals together with the threat of sea level rise for low lying sites, tidal surges and additional ground water ingress.

11.2.2 Although certain areas of Plymouth, notably Plympton and Devonport, are highlighted as being more vulnerable to flooding, evidence shows that the Environment Agency has had no reason to object to planning applications on the grounds of flood risk in recent years. Nevertheless key installations, including the dockyards and the proposed waste to energy plant at Camels Head, clearly take the risk of flooding and tidal surges in to account and focused studies and/or Flood Risk Assessments are available to view.

11.3 Extreme Weather (See : Extremes)

11.3.1 The predicted increase in the number and severity of storms and high winds should also be considered in relation to homes and properties. Although severe damage is rare, preventative action is recommended to limit the damage and disruption that could be caused.

11.3.2 Actions required :

- Considerations for future developments will need to take account of the guidance issued in Planning Policy Guidance Note 25 as amended by the National Planning Policy Framework 2012 to ensure that proposed development is not at risk from flooding.
- Householders and businesses should take preventative measures to limit the potential of damage from flooding and extreme weather events.
- Householders and businesses should be encouraged to review their insurance provision and needs as increases in the cost of insurances premiums are predicted in response to the threat of climate change.
- Risk assessments are recommended to ensure electrical and IT equipment is not at risk as a result of its location in the basements of buildings. Relocation to upper floors should be recommended if the flood risk is considered to be too high.
- Those properties at risk should be aware of the Emergency Plans applicable to their location and in the event of an incident, should respond to the instructions of the emergency services.
- The local authority and other citywide services should be prepared to respond to the ongoing needs of householders and their families in the event of an incident as relocation may be required until their homes are fit for habitation.
- Businesses should plan for an incident response in their Business Continuity Plans and allow for the costs of clean ups, lost productivity and interruptions to supply chains.

11.4 Social Considerations

11.4.1 Fuel Poverty

11.4.2 Although possibly not a direct outcome of our vulnerability to climate change, those in fuel poverty or those vulnerable to health implications will be at risk from extremes of weather and, particularly, those associated with cold weather.

Supporting Evidence :

Plymouth's Flood Risk map (Environment Agency) :
http://maps.environment-agency.gov.uk/wiyby/wiybyController?x=247500.0&y=56500.0&topic=floodmap&ep=map&scale=8&location=Plymouth,%20City%20of%20Plymouth&lang=_e&layerGroups=default&distance=&textonly=off#x=247500&y=55442&lg=1,&scale=9

Plymouth's Flood Risk Assessment(s) :
http://www.plymouth.gov.uk/sfra_section_one.pdf
http://www.plymouth.gov.uk/sfra_section_two.pdf
http://www.plymouth.gov.uk/sfra_section_two.pdf

Flood Risk Assessments : Plympton.
http://www.plymouth.gov.uk/plympton_sfra.pdf

Planning policy Statement 25 : Development and Flood Risk
http://www.communities.gov.uk/archived/publications/planningandbuilding/pps25floodrisk

11.4.3 Actions required

- The inclusion of targets to reduce fuel poverty and improve the quality of residential infrastructure in a strategic approach to housing provision in Plymouth.
- Continued efforts to lift householders out of fuel poverty and to encourage engagement in energy related promotions including local campaigns and energy mutuals.
- Continued efforts to retrofit vulnerable properties using appropriate energy efficiency technologies.
- Continued encouragement for the installation and use of renewable energy resources and for microfitting wherever possible.
- The inclusion of the predicted threats of climate change in developing policies and partnerships for citywide health, growth and development.
- Continued review of the health implications associated with the impacts of climate change and their use in informing updates of both the Cold Weather and Heatwave Plans.

11.5 Energy Security

11.5.1 Again, energy security could be considered as a distant impact of climate change. However, there are two strategic considerations that could be of relevance to the city's future.

a. Peak Oil[2] and Energy Supplies.

In terms of global resources there is general consensus that conventional oil production reached its peak between 2004 and 2008 and that supplies are now available only as a result of economic, market and policy driven forces. Although new technologies are being applied (for example 'fracking' – or shale gas exploitation), energy supplies will increasingly be dependent on resources such as coal or gas (also fossil fuels) or on nuclear power. Both are associated with impacts on

[2] The point at which no more oil can be extracted and the production of fuels such as petrol and diesel enter terminal decline.

climate change – the former for their impact on greenhouse gas emissions and the latter for its long term impact on the environment.

Although new locations for exploration are being opened up in response to the melting of the Earth's ice caps (a further impact of climate change), the World's towns and cities will need to consider how 'Peak Oil' might impact on their productivity and quality of life and, wherever possible, apply alternative technologies to meet demand. The installation of renewable energy sources therefore have a direct impact on limiting the impact of climate change.

As a city, Plymouth is already taking account of its potential for the use of renewable energy but, at present, it is still reliant on standard supplies – for example, the gas fired power station at Langage and the nuclear power station at Hinkley in Somerset.

Suggested Solutions

Unless forced by necessity, it is unlikely (at this point) that Plymouth will ever completely adjust to energy services provided exclusively from renewable resources. Although possible, self sufficiency in energy is unlikely and this, in turn, limits the city's options for carbon neutrality.

However, there are increasing opportunities for the installation of renewable technologies and, subject to local limitations, these should be encouraged wherever possible.

b. Energy Mutuals and Localised Schemes.

A sustainable approach to energy security relies as much on energy management as it does on energy provision. Such an approach will become increasingly important as energy prices rise in response to demand and, possibly, potential limitations on supply.

Again Plymouth has already taken steps to review the city's response to energy provision; with studies considering the impact and potential of :

- Energy Services Companies (ESCos)
- An Energy Co-operative and Solar Club.
- Combined Heat and Power (CHP)
- District heating
- Renewable resources – retrofitting
- Community schemes for insulation and retrofitting.

In addition, provision will need to be linked to schemes that manage both supply and demand; with options for different payments schemes offering choice for Plymouth's residents. Options here include existing and potential projects associated with :

- Community enterprise schemes for renewables
- Energy mutuals and/or co-operatives.
- The application of Government incentives such as the Feed in Tariff (FiTs) and the Renewable Heat Incentive.
- Options for Green Deal (including the economy benefits of green skills).

Suggested Solutions

Although a considerable amount of work has already supported the development of some of the options, the full impact of Peak Oil on Plymouth has never been fully considered. If a study of this

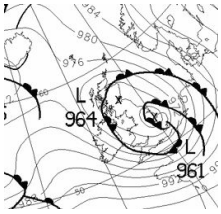
nature were to be undertaken (given Bristol's Peak Oil Study[3] as an example) it would inform the future development of both future 'energy mutual' projects and ongoing community enterprise initiatives related to citywide renewable energy and green skills.

11.6 Sustainable Design, Low Carbon Buildings and Energy Efficient Homes

11.6.1 Both existing and new homes and properties will increasingly need to take the impact of climate change in to account. In addition to the threats of flooding and extreme weather conditions (which might affect the location, siting and outlook of designs), properties will increasingly need to incorporate measures to reduce glare, provide shade and cooling, air conditioning or energy efficient heating. The requirements for IT provision (server rooms) and other production technologies will also need to be taken in to account.

11.6.2 The Energy Saving Trust's codes (see http://www.energysavingtrust.org.uk/Professional-resources/Housing-professionals/New-housing/The-Code-for-Sustainable-Homes) for low and/or zero carbon homes have been taken in to account in the support provided by Core Strategy 20 of Plymouth's Local Development Framework which sets out the policy conditions for the provision of new housing.

[3] See https://docs.google.com/file/d/0B_uigthaDDMhMjZmNWQzYjMtYTMyMi00MWIyLWIzNmItMGNkZDkyYWUyZDU5/edit?hl=en_GB&pli=1



12.0 Evidence

12.1 Assets at Risk

- National data online at the Office of National Statistics : http://www.ons.gov.uk/ons/index.html
- SW State of the Environment report 2010 : http://www.swenvo.org.uk/state-of-the-environment-2010/
- SW SoE2010 Environment Section : http://www.swo.org.uk/sotsw2010/environment/
- SWENVO's 2011 Plymouth profile : http://www.swo.org.uk/EasysiteWeb/getresource.axd?AssetID=50048&type=full&servicetype=Inline
- Local Development Framework : Full List of Background evidence and supporting documents : http://www.plymouth.gov.uk/homepage/environmentandplanning/planning/planningpolicy/ldf/ldfbackgroundreports.htm

12.2 Weather

- Average weather data for Devon 1971 to 2000 (Met Office)
- http://www.metoffice.gov.uk/climate/uk/averages/19712000/index.html
- Max and min temp, air frost, rainfall and sunshine records available.
- http://www.swenvo.org.uk/themes/atmosphere/climate-change/
- Plymouth weather : http://plymouthweather.co.uk/raindetail.html
- Plymouth's climate : http://www.climatetemp.info/united-kingdom/plymouth.html

- Weather stats for Plymouth (Holiday weather .com) : http://www.holiday-weather.com/plymouth/averages/

- Devon County Council Weather Impact Assessment 2010 : http://www.devon.gov.uk/weatherimpactsassessmentondevoncountycouncilservices.pdf

12.3 What to Expect

- UN Intergovernmental Panel on Climate Change (IPCC) : http://www.ipcc.ch/
- The Climate Change Act 2008 : http://www.decc.gov.uk/en/content/cms/legislation/cc_act_08/cc_act_08.aspx
- Department of Energy & Climate Change home page : http://www.decc.gov.uk/
-
- National Climate Change Risk Assessment 2012 : http://www.defra.gov.uk/environment/climate/government/risk-assessment/

- National Risk Assessment : http://www.defra.gov.uk/environment/climate/government/risk-assessment/
- Evidence report : http://randd.defra.gov.uk/Document.aspx?Document=TheUKCCRA2012EvidenceReport.pdf

UK Climate Impact Projections 09 :

- UKClimate Projections 09 (UKCP09) : http://www.ukcip.org.uk/ukcp09/
- (See also http://ukclimateprojections.defra.gov.uk/)
- UK Emissions Estimates :
- http://www.decc.gov.uk/assets/decc/11/stats/climate-change/2751-local-and-regional-co2emissions-estimates.xls

- UKCP09/DEFRA : Climate Change – Assessing the Impacts and Identifyinf Responses (The first 3 years of the UKCP09 programme : http://www.ukcip.org.uk/wordpress/wp-content/PDFs/3year_summary.pdf

- For Plymouth : http://www.swenvo.org.uk/themes/atmosphere/climate-change/ukcp09/
- SWENVO Climate profiles for Devon : http://www.swenvo.org.uk/themes/atmosphere/climate-change/

- SWENVO Climate profiles for Plymouth – UKCP09 scenarios : http://www.swenvo.org.uk/themes/atmosphere/climate-change/ukcp09/

Climate South West's Profile reports :

- Warming to the Idea 2003 Scoping Study : http://climatesouthwest.org/warming-to-the-idea
- Building Resilience to Extreme Weather and Climate Change in the South West : http://climatesouthwest.org/warming-to-the-idea

- South West Planners Toolkit of Climate Change (REGEN SW) : http://www.regensw.co.uk/climate-change-pps
- National reporting Power : http://www.defra.gov.uk/publications/files/pb13740gov-summary-adapt-reports.pdf

Local Action

- Has it Sunk In Yet ? – LSP's 2004 Report : http://www.plymouth.gov.uk/climatechangeplymouth.pdf
- Plymouth's Climate Change Framework : http://www.plymouth.gov.uk/climate_change_strategy.pdf
- Plymouth's Climate Change Action Plan (to 2012) : http://www.plymouth.gov.uk/acting_on_climate_change.pdf
- Plymouth's Local Carbon Framework (2012 to 2020) : http://www.plymouth.gov.uk/lcfprospectus.pdf
- Scenario Report : http://www.plymouth.gov.uk/uoecarbonscenariosreport.pdf

12.4 Extremes

- Met office advice on extreme weather : http://www.metoffice.gov.uk/guide/weather/severe-weather-advice
- National extremes : http://www.metoffice.gov.uk/climate/uk/extremes/
- National past weather events : http://www.metoffice.gov.uk/climate/uk/interesting/
- Regional climate data (Met office) : http://www.metoffice.gov.uk/climate/uk/regional/
- South West England Climate Data : http://www.metoffice.gov.uk/climate/uk/sw/print.html
- Lloyds Insurance 360 Risk Project : http://www.lloyds.com/~/media/3be75eab0df24a5184d0814c32161c2d.ashx
- F&C (Reo Research) Report : The Insurance Industry's Response to Climate Change : http://www.fundnets.net/fn_filelibrary/file/co_gsi_Climate_Change_Insurance_Report.pdf
- Association of British Insurers case study : http://www.nce.co.uk/climate-change-to-trigger-50-rise-in-insurance-costs/5211022.article

12.5 Water

Flooding, sea level rise, tidal surges and Flood Risk Management :

- Flood and Water Management Act 2010 : http://www.legislation.gov.uk/ukpga/2010/29/contents

- National Assessment of Flood Risk : http://publications.environment-agency.gov.uk/PDF/GEHO0609BQDS-E-_E.pdf
- Planning policy Statement 25 : Development and Flood Risk
- http://www.communities.gov.uk/archived/publications/planningandbuilding/pps25floodrisk
- Env Agency flood map for Plymouth :
- http://maps.environment-agency.gov.uk/wiyby/wiybyController?x=247500.0&y=56500.0&topic=floodmap&ep=map&scale=8&location=Plymouth,%20City%20of%20Plymouth&lang=_e&layerGroups=default&distance=&textonly=off#x=247500&y=55442&lg=1,&scale=9
- DEFRA / LGA Flooding Portal for advice on flooding, how to plan for it and the funding pots available. http://www.local.gov.uk/floodportal;jsessionid=F59B24800A8DCFCAF867EE05035B9ED3
- Planning applications objected to on flood grounds by the Environment Agency 2007/2008. http://www.environment-agency.gov.uk/research/planning/33704.aspx
- Flood Risk Assessments : Plymouth
  http://www.plymouth.gov.uk/sfra_section_one.pdf
  http://www.plymouth.gov.uk/sfra_section_two.pdf
  http://www.plymouth.gov.uk/sfra_section_two.pdf
- Flood Risk Assessments : Plympton.
  http://www.plymouth.gov.uk/plympton_sfra.pdf
- River basin management :
  http://www.environment-agency.gov.uk/research/planning/125027.aspx

- MVV Flood Risk Assessment : http://www.mvv-environment.co.uk/environment/web/media/downloads/environment_1/plymouth/planningapplication/4_environmental_statement/volume_03_appendices/111_Flood_Risk_Assessment.pdf
- University of Plymouth Study (Devonport) : http://meetingorganizer.copernicus.org/EGU2011/EGU2011-4561.pdf

- Sea level rise at Newlyn : http://www.swenvo.org.uk/themes/atmosphere/climate-change/
- Sea level rise (Devonport) : http://www.pol.ac.uk/psmsl/pubi/rlr.annual.data/170157.rlrdata
- Devonport (highest and lowest tidal surges) : http://www.pol.ac.uk/ntslf/surgehilo.php?port=devonport
- Storm surges and tidal monitoring : http://www.pol.ac.uk/ntslf/model.html
- Coastal erosion : http://www.environment-agency.gov.uk/news/139061.aspx
- Monthly Mean Sea Temperature for Plymouth at 50 deg 22 N, 4 deg 10 W
- http://www.cefas.co.uk/data/sea-temperature-and-salinity-trends/presentation-of-results/station-25-plymouth.aspx

- Resilience planning for Devonport (After Fukishima) :
- http://www.babcock.co.uk/media/334194/babcock_report_final_.pdf

Water Resources :

- SWW Draft Drought Plan 2011 : http://www.southwestwater.co.uk/media/pdf/6/8/South_West_Water_Draft_Drought_Plan_October_2011.pdf
- SWW Water Resources Plan : http://www.southwestwater.co.uk/media/pdf/g/a/WRP_Final.pdf with additional details (including tables, appendices and environmental impact assessments) at http://www.southwestwater.co.uk/index.cfm?articleid=1556
- SWW Ready for Climate Change – a report to Government : Info can be found at
- http://www.southwestwater.co.uk/index.cfm?articleid=8341&searchkey=Climate%20change%20impacts
- Water Abstraction – Getting the Balance Right – The Tamar Catchment Abstraction Management Strategy : Environment Agency 2007 : http://publications.environment-agency.gov.uk/PDF/GESW0307BMCH-E-E.pdf

12.6 Health

- National Air Quality and climate change report 2011 : http://www.defra.gov.uk/publications/files/pb13378-air-pollution.pdf

- Air quality reporting and policies : NB No reports linking air quality and climate change impacts have been prepared
- for Plymouth. : http://www.plymouth.gov.uk/homepage/environmentandplanning/pollution/airquality.htm

- Air Quality Assessment for Plymouth 2004: http://www.plymouth.gov.uk/detailed_assessment_of_air_quality_in_plymouth_2004.pdf

- 2011 Air Quality Monitoring Progress report : http://www.plymouth.gov.uk/laqm_plym_2010_progress_report.pdf

Heatwaves

- National Heatwave Plan 2012 : http://www.dh.gov.uk/health/2012/05/heatwave-plan/
- Plymouth's Heatwave Plan :

- http://www.plymouthpct.nhs.uk/CorporateInformation/boardpapers/Documents/Board%20Papers%20-%202010/Board%20Papers%20-%20June%202010/Item%205%205%20Heat%20Wave%20Plan.pdf

Cold Weather

- National Cold Weather Plan :
- http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_130564
- Climate Change and Communicable Disease – what are the risks ? Nichols, Richardson and Maynard, University of Plymouth Faculty of Health, Sept 2010 (Journal of Infection Prevention) : Website details requested.

12.7 Wealth

- UK Carbon Plan : http://www.decc.gov.uk/assets/decc/What%20we%20do/A%20low%20carbon%20UK/1358-the-carbon-plan.pdf
- Plymouth's Low Carbon Economy (for LCF) : http://www.plymouth.gov.uk/uoplowcarboneconomyfullreport.pdf
- National case study – tourism in the South West : Cost a South West (South West Tourism, the Environment Agency and Climate South West) : http://ukclimateprojections.defra.gov.uk/media.jsp?mediaid=88427&filetype=pdf
- The Economic Contribution of the Renewable Energy and Energy Efficiency Sectors in the South West of England – An Update : http://regensw.s3.amazonaws.com/1274870876_286.pdf

12.8 Habitats

- Shoreline Management Plan : http://www.sdadcag.org/docs/html/frameset.htm
- Plymouth Sound and Estuaries Coastal Planning Study http://www.plymouth.gov.uk/homepage/environmentandplanning/planning/planningpolicy/ldf/ldfbackgroundreports/brp
- lymouthsoundcoastalplanning.htm
- Tamar Estuaries Management Plan to 2012 :
- http://www.plymouth.gov.uk/homepage/environmentandplanning/natureconservation/natureprojects/tecf/tecfabout/tecfmanagementplan.htm
- Tamar Estuaries Management Plan to 2013 to 2018 (consultation):
- http://plymouth.limehouse.co.uk/portal/planning/tecf/tecf?pointId=2151910#document-2151910
- Port of Plymouth Evidence Base Study : http://www.plymouth.gov.uk/homepage/environmentandplanning/planning/planningpolicy/ldf/ldfbackgroundreports/por
- ofplymouthstudy.htm
- SEA/Sustainability Appraisal for Sutton Harbour Area Action Plan : http://www.plymouth.gov.uk/homepage/environmentandplanning/planning/planningpolicy/ldf/ldfbackgroundreports/evi
- encebasesutonseasa.htm
- Charter for the Countryside and Seas Around Plymouth :
- http://www.plymouth.gov.uk/a_charter_for_the_countryside___seas_around_plymouth-2.pdf
- Tamar Estuary Management Plan 2006 to 2012 : http://www.plymouth.gov.uk/tamar_estuaries_management_plan_2006_to_2012.pdf
- Dartmoor Management Plan 2007 to 2012 : http://www.dartmoor-npa.gov.uk/lookingafter/pl-dnpmgmtplan
- England Biodiversity Strategy : Towards Adaptation to Climate Change : http://nora.nerc.ac.uk/915/1/Mitchelletalebs-climate-change.pdf
- Plymouth's Green Space Strategy : http://www.plymouth.gov.uk/green_space_strategy_2008_2023.pdf
- Sites protected for nature conservation : http://www.plymouth.gov.uk/sitesprotectedfornatureconservation.pdf
- Basking shark sightings : http://www.swenvo.org.uk/themes/atmosphere/climate-change/
- Bracken, ticks and heather indicators of climate change, Bodmin, Dartmoor and Exmoor :
- http://www.swenvo.org.uk/themes/atmosphere/climate-change/
- Marine Climate Change Impacts Partnership : http://www.mccip.org.uk/

12.9 Homes

Design

National Planning Policy Framework 2012 :
http://www.communities.gov.uk/planningandbuilding/planningsystem/planningpolicy/planningpolicyframework/

Building a Greener Future : Towards Zero Carbon Development (DCLG) March 2007 : http://www.communities.gov.uk/documents/planningandbuilding/pdf/153125.pdf

Design Code Guidance : http://www.plymouth.gov.uk/design_codes.pdf
Feasibility Studies for an Energy Services Company in Plymouth : Two reports at : http://www.plymouth.gov.uk/homepage/environmentandplanning/planning/planningpolicy/ldf/ldfbackgroundreports/feasibilitystudyforesco.htm
Climate Change & Infrastructure (national guidance) : http://www.defra.gov.uk/publications/files/climate-resilient-infrastructure-full.pdf

EU Env Agency – Urban Adaptation to Climate Change.
https://connect.innovateuk.org/web/sustainabilityktn/articles/-/blogs/report-warns-of-need-for-urgent-action-on-urban-climate-adaptation;jsessionid=9688983E31B77AFC592564D870F66A4F.MekushUdbew4

Towards Zero Carbon Development Guidance
http://www.communities.gov.uk/archived/publications/planningandbuilding/buildinggreener
Sustainable Design Strategies :
http://www.plymouth.gov.uk/homepage/environmentandplanning/planning/planningpolicy/ldf/spds/ldfdesignstrategies.htm

Code for Sustainable Homes (EST) : http://www.energysavingtrust.org.uk/Professional-resources/Housing-professionals/New-housing/The-Code-for-Sustainable-Homes

Energy Use, resources, security, renewables and fuel poverty :

- UK Energy Use Trends (DUKES) : http://www.decc.gov.uk/en/content/cms/statistics/publications/dukes/dukes.aspx

- Fuel poverty indicator : http://www.fuelpovertyindicator.co.uk/
- Renewables Viability Study 2007 :
- http://www.plymouth.gov.uk/070416,_plymouth_renewables_study_-_final_version_march_2007-2.pdf
- Updated Addendum for the City of Plymouth District Energy Study :
- http://www.plymouth.gov.uk/addendum_plymouth_district_energy_excluding_devonport__22_05_12.pdf

- Bristol's Peak Oil Study : https://docs.google.com/file/d/0B_uigthaDDMhMjZmNWQzYjMtYTMyMi00MWIyLWIzNmItMGNkZDkyYWUyZDU5/edit?hl=en_GB&pli=1
- Guidance for onsite renewables policy (CS20) : http://www.plymouth.gov.uk/guidance_cs20_policy.pdf
- Plymouth City Centre and Derriford Sustainable Energy Study 2009 : http://www.plymouth.gov.uk/plymouth_city_derriford_sustainable_energy_study.pdf

- Energy Services Company
- http://www.plymouth.gov.uk/homepage/environmentandplanning/planning/planningpolicy/ldf/ldfbackgroundreports/feasibilitystudyforesco.htm
- On site Renewables
- http://www.plymouth.gov.uk/homepage/environmentandplanning/planning/planningpolicy/ldf/ldfbackgroundreports/guidanceforonsiterenewables.htm
- Derriford Sustainable Energy Study
- http://www.plymouth.gov.uk/plymouth_city_derriford_sustainable_energy_study.pdf
- Renewable Energy Study
- http://www.plymouth.gov.uk/homepage/environmentandplanning/planning/planningpolicy/ldf/ldfbackgroundreports/renewableenergystudy.htm
- South West electricity consumption
- http://www.berr.gov.uk/energy/statistics/regional/regional-local-electricity/page36213.html
- South West gas consumption
- http://www.berr.gov.uk/energy/statistics/regional/regional-local-gas/page36200.html
- South West installed renewable energy capacity April 2007.
- http://www.surveys.energysw.com/PDF/RSW%20Annual%20Projects%20Survey2.pdf
- (Plymouth had (no date given for reference) 8 projects creating 7.6 MW)
- Devon installed renewable energy capacity. (2007) : http://www.surveys.energysw.com/PDF/Devon.pdf
- Devon Renewable Heat Capacity 2007 (REGEN SW)
- http://www.surveys.energysw.com/PDF/RSW%20Annual%20Projects%20Survey2.pdf

- (Plymouth = 4 installations in 2007 creating 0.34 MW)

12.10 Transport

- Strategic Public Transport Network :
- http://www.plymouth.gov.uk/homepage/environmentandplanning/planning/planningpolicy/ldf/ldfbackgroundreports/brpublictransportnetwork.htm

- Local Transport Plan 2012 to 2026
- http://www.plymouth.gov.uk/homepage/transportandroads/policyandplanning/ltp/ltp2011-2026.htm

- The case for better rail services (included due to pressures from sea level rise and storms at Dawlish)
- http://www.plymouth.gov.uk/homepage/transportandroads/policyandplanning/betterrailservices.htm

- City Centre Transport Strategy :
  http://www.plymouth.gov.uk/homepage/environmentandplanning/planning/planningpolicy/ldf/ldfbackgroundreports/citycentretransportstrategy.htm