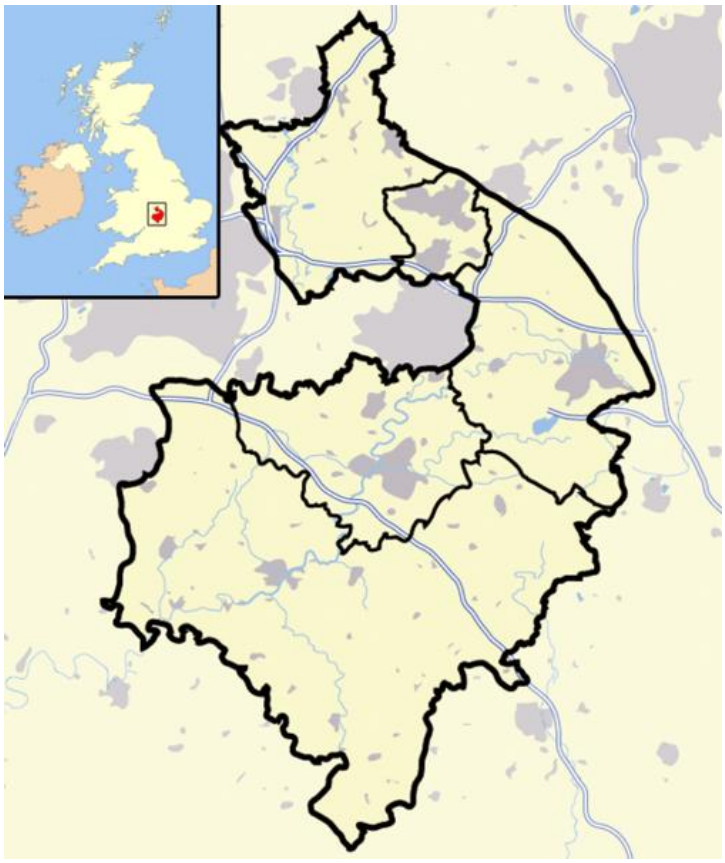
The Effects of Climate Change



on

Warwickshire Fire and Rescue Service

ABSTRACT

This report investigates possible climate change scenarios, and the challenges for Warwickshire Fire and Rescue Service (WFRS) that would be associated with them.

The effects of increasing temperatures, woodland fires, flooding, drought and storms on Fire and Rescue Services are discussed, the risks are analysed, and possibilities for actions that could reduce these risks for WFRS are suggested.

The UK climate has changed, with central England temperature rising by almost 1°C over the last century. The decade of the 1990s was the warmest in central England since records began in the 1660s. Winters across the UK have been getting wetter, and average sea level is rising by about 1 millimetre per year. All of the evidence indicates that these trends will continue. The UK climate will become warmer, with more frequent hot and probably drier summers, and milder wetter winters.

Climate change scenarios published by the Department of Environment, Food and Rural Affairs (Defra) in 2002 showed that annual temperatures across the UK may rise by between 2 and 3.5°C by the end of the century. Climate change will bring more frequent, hot, dry summers, warmer wetter winters and an increased frequency of extreme weather events, such as heavy downpours and flooding, summer droughts, and coastal flooding.

These scenarios demonstrate that climate change will lead to an increase in the frequency of hot summers and therefore to an increase in the number and severity of grassland and woodland fires, requiring significant extra effort from WFRS. These summers are also predicted to be very dry, which may lead to water shortages. Water shortages during the summer will impact on WFRS in both training and fire fighting.

It is also shown that increased winter rainfall and higher sea levels will lead to an increase in the frequency of flooding events during winter. Whilst measures are being taken to address this problem with improved flood defences, new pumping equipment and innovative appliance design, issues such as training, access to water rescue craft and associated equipment, and helicopter support may need to be reviewed with this in mind.

This report concludes that although the potential exists for climate change to be a serious problem in the long term, the effects are dependent on future climate change mitigation and an awareness of possible impacts would be beneficial during planning.

EXECUTIVE SUMMARY

This report investigates the potential effects of climate change on Fire and Rescue Services, in particularly Warwickshire Fire and Rescue Service (WFRS). The conclusions of this report will form the 'Prioritised Risk-based assessment' submission from WFRS for NI 188 – Planning to Adapt to Climate Change (Appendix A).

Climate has changed over the last century and is likely to continue to change throughout the 21st century, affecting all aspects of the UK's environment, society, and economy. In 1997, the Government set up the UK Climate Impacts Programme (UKCIP) to encourage other organisations to look at how vulnerable they are to climate change so that they can prepare for its impacts. UKCIP has produced a wide range of research, guidance and tools for different sectors. In 2002, UKCIP in conjunction with The Hadley Centre and The Tyndall Centre, produced a report detailing future climate scenarios based on the regional climate modelling of the UK.

This report examines past events, and considers implications to Fire and Rescue Services. The likelihood of such an event happening in the future is then determined using the
climate change scenarios. This combination of an effect and a probability provides a good basis on which to base assessments of potential future effects of climate change.

The report considers the impacts of primary and secondary fires, flooding, drought and storms. Climate scenarios show that climate change will lead to an increase in the frequency of hot summers and therefore to an increase in the number and severity of grassland and woodland fires, requiring significant extra effort from WFRS. These summers are also predicted to be very dry, which may lead to water shortages. Water shortages during summer are likely to impact on WFRS in both training and fire fighting.

It is also shown that increased winter rainfall and higher sea levels will lead to an increase in the frequency of flooding events during winter. Whilst measures are being taken to address this problem with improved flood defences, new pumping equipment and innovative appliance design, issues such as training, access to water rescue craft and associated equipment, and helicopter support may need to be reviewed with this in mind. These events may also create a requirement for increasingly short notice access to urban search and rescue equipment and heavy duty pumps. It is unlikely that Warwickshire will suffer flooding as a result of tidal surges or increased sea levels, however, there will be an impact to the region if masses of the population from the eastern coastline are evacuated from the risk areas and rescue teams from all over the United Kingdom are required to assist.

The conclusion of this report is that although serious incidents are predicted to become more frequent in the future, the immediate short term risk is low. Research has shown that the UK's climate has changed over the last century; however the level of future changes in the UK climate is still largely dependent on actions to reduce levels of greenhouse gas emissions. It is important to remember that these predictions contain an element of uncertainty, and are related to the likelihood of specific events occurring. Although the magnitude of climate change on the UK is uncertain, the UKCIP02report states clearly that some climate change is inevitable. The historical choices made by society may have already set elements of climate change in motion. By continuing to reduce emissions, and by implementing new technologies, it may be possible to slow the rate of change, but it is not considered possible to prevent it altogether.

Fire and Rescue Services are dynamic and flexible, and are able to change and adapt to suit the emergencies for which they are needed. Whilst there is currently not enough specific information available to ensure that, if any significant decisions were made based on climate change information, they would be the correct ones, it is recommended that the monitoring of climate change research should be continued, and links should be developed with climate change research organisations. This would ensure that Fire and Rescue Services would be kept apprised of current climate change scenarios and ideas, and that decisions that are being made could be made with an awareness of potential climate change impacts.

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CHAPTER 1
Introduction

In the UK, one of the largest climate change research initiatives is the UK Climate Impacts Programme (UKCIP). The UKCIP website says:
"The UK Climate Impacts Programme (UKCIP) helps organisations assess how they might be affected by climate change, so they can prepare for its impact."

The work of UKCIP is published in the form of a set of scenarios for UK Climate Change. These scenarios take evidence of climate change from the UK historical record, and then use computer models to estimate the effects of climate change in the UK, for a variety of emissions profiles.

Because UKCIP02 uses models to generate scenarios of future climate, its results are affected by past, present and future greenhouse gas emissions. In order for the predictions to take account of society's future choices, UKCIP02 generates scenarios from Intergovernmental Panel on Climate Change (IPCC) models for four different emissions scenarios.
The four scenarios are:
- Low Emissions
- Medium-Low Emissions
- Medium-High Emissions
- High Emissions

UKCIP02 discusses the uncertainty in the UK climate change scenarios, saying:
"Each climate change scenario is based on a different emissions scenario published by the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios. Following the recommendations of the IPCC, we make no attempt to assign probabilities to any one of the four climate change scenarios."

This report uses the UKCIP02 scenarios as a baseline for its climate change predictions, and will mainly refer to the Low Emissions and the High Emissions scenarios. This will enable us to make reasonable estimates for the range of probable changes, and will ensure that the forecast effects will be within these boundaries.

Qualitatively, the expected effects of climate change in the UK as predicted by UKCIP02, can be given as follows:
- UK climate will become warmer
- High summer temperatures will become more frequent and very cold winters will become increasingly rare
- Winters will become wetter, and summers may become drier everywhere
- Heavy winter precipitation will become more frequent
- Relative sea levels will continue to rise around most of the UK's shoreline
- Extreme sea levels will be experienced more frequently

In order to explore the effects of climate change on WFRS, the method that will be used is first to identify an event that has already occurred, and then examine what effect this had on Fire and Rescue Services in the UK.

If we can identify the effects of this event on Fire and Rescue Services, and the probability of this event occurring within Warwickshire, then we are on the way to determining what action should be taken to prepare for the future. This method is limited, in that it can only deal with anomalous events that have already occurred and been monitored at least once, but it does give realistic indications of the potential impact of an event. It provides definite evidence to back up these predictions, and is highly communicable.

One such anomalous event that is well documented is the hot summer and unusually warm year of 1995.

In 1997, a report prepared at the request of the Department of the Environment entitled:
"Economic Impacts of the Hot Summer and Unusually Warm Year of 1995") was published.

The intention of this report was that organisations could use its observations to predict and begin to prepare for the effects of future changes in climate using the procedure described above. The report begins by giving information on why 1995 was a special year.

"The summer of 1995 was embedded in a period of generally high temperatures, the mean Central England Temperature (CET) from November 1994 to October 1995 was the highest since records began in 1659, and was 1.6°C warmer than the 1961-1990 baseline. During the last week of June 1995, and through July and August, the CET anomaly was +3°C, exceeding the previous record of +2.5°C set in 1983.

Although mean rainfall over the period of November 1994 to October 1995 was near normal, this hides a remarkable seasonal contrast, with a very wet winter, a dry spring and a very dry summer. Total England and Wales rainfall for July and August was the driest on record, with only 47mm falling, compared to a 1961-1990 baseline average of 139mm."

The UKCIP02 models forecast that by 2020, for the Medium-High Emissions scenario, each year will have a 1% chance of having a summer equivalent to that of 1995. By 2050 the chance will be 20%, and by 2080, the chance of a summer equivalent to 1995 will be 63%.

For the High Emissions scenario, by the 2080s, it is anticipated that about one summer in three will be both hotter and drier than the summer of 1995, and nearly all summers will be hotter. Roughly one summer in ten will have less than 25 percent of present day rainfall.

Even in the Low Emissions scenario, by 2080 the models suggest that approximately two summers in three will be as hot as, or hotter than the summer of 1995. This means that rather than the 1995 event being an anomaly, unprecedented in over 300 years of temperature measurements, it is expected to become a regular occurrence.

If it is known how probable a summer similar to that of 1995 is to occur, we can look at the extra demands that that summer placed on Fire and Rescue Services. This will help to predict the effects of this element of climate change upon WFRS.

CHAPTER 2
Primary and Secondary Fires

The Department of the Environment report details the effects that the hot summer of 1995 had on various areas of everyday life, including a chapter that deals with the effects of 1995 upon Fire and Rescue Services in the UK.

One of the findings of the report is that there is a clear and demonstrable link between hot dry summers and the number of fires.

The report uses the standard procedure of subdividing fires into primary fires, and secondary fires.

Primary fires are described as fires which involve any of the following:
- Casualties
- Rescues
- Escapes
- Utilisation of five or more appliances at a secondary fire
- Buildings including mobile homes fit for occupation (i.e. not wholly derelict), and those under construction

Any fire in the following locations is also considered a primary fire:
- Caravans, trailers etc.
- Vehicles and other methods of transport (not derelict unless associated with business e.g. scrap metal)
- Outdoor storage, plant and machinery
- Agricultural and forestry premises and property
- Other outdoor structures including postboxes, tunnels, bridges etc

Secondary fires are fires that fall into one of the following six categories:
- Single derelict buildings
- Outdoor fire such as grassland
- Intentional straw/stubble burning
- Outdoor structure

- Refuse, refuse container
- Derelict vehicle

From this list, it can be seen that secondary fires are exactly those that we would expect to be affected by a hot dry summer: they include grass and heathland fires, and straw or stubble burning.

This relationship can be investigated by analysing the numbers of primary and secondary fires with the climate variables for that year. Analysis was carried out by the authors of the Department of the Environment report, who analysed the data for secondary fires between 1984 and 1995, and found that there was a clear upward trend with time. They fitted the data with a linear trendline, and the years containing the hot summers of 1989, 1990 and 1995 were clearly present as large positive anomalies.

The numbers of "additional" secondary fires in the anomalous years were:
- 28,804 in 1989
- 37,459 in 1990
- 88,636 in 1995

These large numbers of extra fires clearly lead to more work for the Fire and Rescue Services, and this can be shown by a few sample figures for call outs.

At the height of the summer of 1995, the number of call-outs to Warwickshire Fire and Rescue Service increased from an average of 50-75 per day to 400 per day, whilst West Midlands Fire Service recorded their busiest day ever on 18 August 1995, with almost 2,000 calls mainly to grass fires.

The Department of the Environment report then goes on to analyse further the link between summer climate and anomalies in the number of fires.

The analysts investigated the impacts of:
- The mean summer (June, July and August) Central England Temperature for the current and previous year
- The mean high summer (July and August) Central England Temperature for each year
- The total summer (June, July and August) England and Wales rainfall in each year
- The total high summer (July and August) England and Wales rainfall in each year

The authors used these results to state that:
"For a 1°C increase in summer temperatures, the Central England Temperature regression equations indicate an increase in the number of outdoor fires of between 24,000 and 40,000 per year for England and Wales and, for a 2°C increase, between 47,000 and 79,000.

When these results are expressed as percentages, the rise in the number of secondary outdoor fires due to a 1°C summer temperature increase would be between 17-28% whilst a 2°C temperature change would lead to a 34-56% increase. Although these figures may appear unrealistically large, it should be noted that the increase in secondary fires in 1995 (+3.5°C), relative to the 1994 figure was 54% (+113,611 fires)."

The climate change scenarios used in UKCIP02 indicate that by 2080, average summer temperatures will have increased by between 1°C and 5°C.

Temperature increases of this size suggest a large increase in the number of secondary fires. The period 2021 to 2050 is forecast to witness a significant increase in the number of hot summers. This will bring a consequent increase in the number of secondary fires, and beyond this, there will also be a measurable increase in average summer temperatures even during non-anomalous summers, resulting in a general increase in the average number of secondary fires.

If the average number of secondary fires increases then this has the potential to create serious implications for the Fire and Rescue Services.

Fire statistics data is collected by Communities and Local Government is published quarterly and yearly as the Fire Statistics Monitor. Of the 378,100 secondary fires reported in 1995, there were 267 grassland fires that merited completion of a Primary Fire Damage Report (FDR1) Form. This means that they were upgraded from secondary to primary fire status, and indicates that either property or life was at risk, or that more than 4 appliances were used at the incident.

Between 1994 and 2001 (not including 1995), there were approximately 70 serious grassland fires a year. In 1995 there were 267. This is almost a fourfold increase.

Analysis of incident data from 684 primary grassland fires between 1994 and 2001 can be used to give an indication of the size of these fires, and the resources needed to deal with them. It is important to be aware that this sample consists of the largest and most resource intensive grassland fires, and that almost all secondary fire will be much smaller than these.

50% of the primary grassland fires were dealt with using 1 or 2 appliances and in 50% of incidents, the appliances were back on station within 2 hours of receiving the call. The most resource intensive 25% of primary grassland fires took 5 hours or more to deal with, and involved 7 or more appliances.

Using the historic increase in the numbers of serious grassland fires, and the estimates of the resources required for grassland fires, it can be estimated that another hot year like 1995 could see 200 additional primary grassland fires, with

100 of those lasting longer than 2 hours, and requiring more than 2 appliances, and 50 of them involving 7 or more appliances, and lasting over 5 hours.

Whilst an increase in the number of secondary fires will not create an increase in the number of fire fatalities or casualties, as secondary fires are those which do not involve fatalities casualties or rescues, they are still required to be attended by the Fire and Rescue Services. The extra workload of attending potentially up to 50% more incidents will stretch the resources of the Fire and Rescue Services. Fire crews will be tired from attending more incidents, sickness and injury levels may rise due to fatigue, and equipment will be under more strain due to increased usage.

This increase in workload will have the largest impact on rural Fire and Rescue Services such as WFRS. A higher fraction of the workload of rural Fire and Rescue Services are secondary fires, and therefore they will see the largest proportional increase in incidents. Rural Fire and Rescue Services rely heavily on firefighters working on the retained duty system. Unlike firefighters working on the wholetime duty system, firefighters working on the retained duty system are paid for every call out that they attend. More call outs will mean that Fire and Rescue Services will require more work from their firefighters. This will have budget implications, and may create difficulty with employers who release their staff to carry out firefighting duties. If firefighters working the retained duty system are required to work more hours, as opposed to using larger numbers of staff doing fewer hours, then this may affect the goodwill of employers to release their staff, as well as the number of people who are willing to perform the role, and this may cause problems with staff recruitment and retention.

Whilst the scenarios indicate that climate change will increase the number of secondary fires in the UK, numbers will still be well below those experienced in hotter parts of the world that exhibit a particular vulnerability to wildland fires such as Australia and California.

In Australia, very large wildland fires are a serious problem. These fires are far more severe than would ever be encountered in the UK, and the widespread construction of wildland interface communities (communities where properties are located very close to sites vulnerable to wildfire) is not something which has occurred in the UK. Due to the volume and potential scale of wildland fires in Australia, fire prevention and protection measures for this type of incident are widely used.

Australian building regulations for wildland-interface communities are very stringent, and require that the type of vegetation surrounding the property (including the use of hazard separation zones, where vegetation is removed or replaced with low hazard varieties around a property), firefighting access to the property, and a supply of water suitable for firefighting are planned during the construction of the property.

Over a 20 year average in Victoria, Australia, the Department of Sustainability and Environment) found that three quarters of Australian wildfires are started by human influences. This means that fire prevention has a vital role to play in the reduction of wildland fire. The Victoria Department of Sustainability and Environment say on their website that:

"Effective fire prevention minimises wildfire damage to life, property, public land assets and values, and minimises suppression costs".

Information on fire prevention measures carried out in Victoria is given on the Department of Sustainability and Environment website, and measures include:
• *Community fire education to maintain public awareness of the wildfire threat, promotes the importance of self-protection, and encourages the responsible use of fire by the community*
• *Investigation into past fires so that patterns can be identified, and education and enforcement programs can be specifically targeted to address the major fire causes*
• *A strategy of fire restrictions and bans, where the use of fire and activities that may cause wildfires are restricted or prohibited during periods where weather and fuel conditions suggest the greatest risk of wildland fires starting.*

Fire prevention programmes of this type could be implemented in the UK to slow the increase in the number of grassland fires that is expected as the effects of climate change become more pronounced. These programs would reduce the number of fires that start, and would therefore help to mitigate the expected increase in workload for the crews.

Whilst in Australia wildland fires endanger both lives and property, in the UK grassland fires are rarely a threat to either. The main effects are environmental damage and the involvement of firefighting resources that could be required elsewhere. In the UK, rural fire prevention work is the responsibility of the landowner, and guidance is issued by Defra and the Forestry Commission.

Within WFRS there is strong evidence of successes through partnership working in a range of preventative interventions such as the initiatives of Warwickshire Car Clear and the work of the Arson Task Force. Further provision of small fires units may also prevent those small grassland/woodland fires becoming out of control.

Climate change suggests that grassland fires will become a larger problem. This may mean that it would be beneficial to conduct a specifically targeted fire safety campaign. If this campaign was to be implemented, it would be important that the low fatality and casualty rates of grassland fires were considered, and that resources were not diverted from home fire safety campaigns which are effective in reducing injuries and deaths from fire.

In addition to warmer summer temperatures affecting the number of incidents, there may be an effect on the difficulty and duration of the call outs. Attending

a rural fire incident such as a grassland or a heath fire, is a physically demanding job, and the tasks involved will be even more difficult if they are required to be carried out during hot weather. This could have implications for the number of firefighters required to safely extinguish a fire and for the techniques and equipment that are used. A physically demanding task such as using beaters to extinguish a rural fire would be much more strenuous if it was being performed in high temperatures, especially if the firefighter was also wearing full Personal Protective Equipment (PPE). In this situation, the working duration of the firefighters would be reduced, and therefore more personnel would be required to deal with the incident, and improved facilities would be required to allow fatigued firefighters to recuperate.

There is the potential to minimise this effect by the use of specialist equipment. Lightweight and more effective equipment would reduce the workload placed on the firefighter, and newer types of PPE could help to maintain a lower core body temperature and allow a longer working duration, whilst still providing adequate levels of protection. WFRS have already provided firefighters with 'wildland tunics' for use when working away from structural fires in order to assist in the reduction of their core temperature.

CHAPTER 3
Woodland Fires

Woodland fires are not usually thought of as a major problem in the UK. We do not have large expanses of forestry, and generally forestry areas do not border straight onto residential areas as they do in other countries, such as in the USA and Australia, where the threat from woodland fire is much greater.

Although the current threat in the UK from woodland fire is not large, it would be unwise to discount it altogether. With the effects of climate change including hotter, drier summers, it is definitely important to investigate the possibility that woodland fires could grow to become a significant problem.

The Department of the Environment report, "Economic Impacts of the Hot Summer and Unusually Warm Year of 1995" states:
"The average annual area of state forest lost due to fire between 1975 and 1995 was 583 ha while the total forest estate is 2 million ha. However a prediction of the Climate Change Impacts Review Group (CCIRG) report (1996) is that forest areas subject to increased drought will also experience increased fire hazard. Hence, woodland fire occurrence in 1995, and the association between fire and drought over the last 20 years, was thought to be an area worthy of investigation."

The Department of the Environment report also makes the following points:
"There have only been four years when the area burned due to fire has exceeded one thousand hectares – 1976, 1980, 1984, and 1994. Although the

years 1976 and 1984 were both drought years (Marsh and Turton, 1996), the years 1980 and 1994 were not."

"In their analysis of fire occurrence in Galicia (northern Spain), Garcia-Diez et al. (1994)) comment that from a physical point of view, weather is not so much the cause of fires; rather it has a catalytic effect."

"In the UK, fires are usually started by neighbours (farmers burning straw or rough grazing), the general public (careless or malicious) and vehicles and machinery (tractors, locomotives etc.) exhausts (Aldhous and Scott, 1993)."

"According to Cannell et al. (1989), if the climate in southern Britain becomes more like that in mid or southern France, we might expect to see a high frequency of forest fires, as already occurs in France and Spain at present, and as occurred in Britain in the dry summers of 1975 and 1976. However the data shows poor correlation between temperature, and the number of forest fires."

"Although the number of woodland fires was higher in 1995 (888 individual fires), the area burned was also larger than in most years since 1984, although less than half the area lost in 1994, and less than a quarter of that lost in 1984."
"The Forestry Commission's Fire Code sets out a basis for the valuation of the area lost due to fire, which in 1995 added up to £350,000. There are however several reasons given as to why this figure is an underestimate of the total cost of woodland fire in 1995.

• First, it does not take account of the cost of putting out fires or of preventing fires from spreading
• Second, it is only a measure of the value of area lost on land owned by the Forestry Commission. No data is available for area lost on woodland under private ownership
• Third, the estimate is performed using the expected market value of mature trees.

This is a poor indicator of their true economic value, since no account is taken of factors such as recreational benefits or carbon storage value"

In March 2000, the Home Office commissioned a report on a risk rating system for vegetation, large heathland and woodland fires. This report takes into account additional costs of woodland, such as the costs of establishment, and environmental benefits. It values coniferous woods at £3,000 per hectare, and broad-leaved woods at £5,000 per hectare.

Using the above figures places the overall value of woodland lost in 1995 at approximately £2,000,000. This figure is markedly higher than the Forestry Commission value of £350,000, and appears to be a more reasonable indication

of the financial losses that could be expected if the UK was subjected to another hot summer similar to that of 1995.

The exact number of woodland fires in the UK is a difficult figure to predict. Generally, in the UK, temperatures are not extreme enough for woodlands to spontaneously ignite. Instead, UK woodland fires are almost always started by human influences.

UKCIP02 forecasts more warm dry summers. More frequent warm dry summers will cause more people to venture outside, and because there are more people outside, it is more likely that a fire will be started.

If a fire is started during dry weather, it has a higher probability of becoming severe. Adry woodland provides a large supply of dead, dry wood and leaf litter on the woodland floor. This litter is the perfect fuel for the propagation of a woodland fire, and such a ready supply of fuel will allow a fire to spread very quickly.

Despite the fact that climate change data analysis gives an increase in the problem, without more data, we cannot accurately estimate the size of this increase.

As a qualitative statement, we can say that climate change will lead to an increase in woodland fires. However, due to the current relatively small-scale problem of woodland fires, it is very unlikely that this increase will have a major impact on the workload of WFRS.

Although the increase in the workload of WFRS will not be large, there are still steps that can be taken to reduce the number and severity of woodland fires. Forestry planning includes the use of roads and other features as fire-breaks to limit the spread of woodland fires, the relative speeds with which trees burn are known, and this information is used when planning planting layouts.

If Fire and Rescue Services have large amounts of forestry land within their area, it would be advisable for the service to develop a plan for a woodland fire. In particular, pre-planning the provision of adequate water supplies to deal with the incident would alert the service to any potential water supply problems, and allow them to be planned for before the incident occurs. Where these plans already exist there may be a need to re-visit them to ensure that the information they contain remains current.

CHAPTER 4
Floods

In the scenarios used by UKCIP02[2], winter precipitation increases. The scenarios show increases in winter precipitation by the 2080s from 5% for the Low Emissions scenario, to over 30% for the High Emissions scenario.

These changes will not be equally distributed over the UK, but will be largest in the East and South of the country.

In the High Emissions scenario, the South East of the country can expect its rainiest day in two years to be over twenty percent wetter than a similarly frequent day in the present day.

The impacts of substantial increases in precipitation are wide-ranging, especially if it does not fall evenly, but instead falls very heavily in short periods. Such a period of heavy rain occurred in January 2005, and led to widespread flooding across the north of the country; further widespread flooding also affected many parts of the country in 2007 including Yorkshire, Humberside, Nottinghamshire, Gloucestershire, Shropshire, Staffordshire, Worcestershire, and Warwickshire.

The city of Carlisle was particularly affected in 2005 when the River Eden and its two tributaries were unable to contain the resulting floodwater. Fire Prevention & Fire Engineers Journal reported that heavy rain fell for 36 hours which flooded nearly 2,000 properties in the city affecting some 6,000 people.

Such situations can put strain on fire and emergency operations with incidents including house to house searches and evacuation of people from flooded homes. Conditions were made even more difficult in Carlisle when the police and fire stations were flooded and power supplies were cut off. A quote given in the Fire magazine in February 2005[1] gives a good example of the type of pressure that heavy precipitation can place onto the Fire and Rescue Services.

"From January 7 to 9, Cumbria Fire and Rescue Service dealt with around 800

incidents in the severely affected area around Carlisle. Fire Control staff dealt with 11,000 calls and 48 of the 50 front line appliances were deployed in the biggest emergency the county has seen in decades."

The Fire and Rescue Services Act 2004) says that the Secretary of State may by order confer on a Fire and Rescue Authority functions relating to emergencies, other than fires and road traffic accidents. During times of flooding, the responsibilities of a Fire and Rescue Service would be similar to those given by the Flood Defence Emergency Response Project Report 1999:

The Fire and Rescue Service role in a major flooding event is as follows:
• The saving of life and rescuing trapped persons from fire, wreckage or debris
• The containment and extinguishing of fires and undertaking protective measures to prevent them
• To prevent, contain and make safe spillage or release of chemicals, radioactive materials or other hazardous substances
• To assist the Ambulance Service with casualty handling
• To assist the Police with recovery of bodies
• The provision of monitoring procedures in respect of health and safety of those persons operating within an established inner cordon
• Carrying out essential damage control operations, such as pumping out flood water and salvage works – WFRS levy a charge on occupiers for such operations with the view that the insurance companies will eventually pay, however, this can be waivered in some circumstances
• To assist other relevant agencies, particularly the Local Authority, to minimise the effects of major flooding on the community

This allows us to split the role of the Fire and Rescue Services during flooding into three main areas:
• The first and most important area is emergency response and rescue. This is responding to 999 calls that come in, and will be primarily in the early stages of the flooding. During the period of rising floodwaters, Fire and Rescue Services are responsible for rescuing people and animals that have become stranded. This is a task that requires specialist equipment, and Fire and Rescue Services in vulnerable areas often have access to inflatable boats and walkways, rope rescue teams, mobile lighting and pumps, emergency vehicles and radio communications to help them
• The second area is damage mitigation. This involves assisting the Local Authorities with minimising the effects of flooding. This may include work such as emergency pumping, building flood defences from sandbags, shoring up dangerous structures, and providing vital supplies to the victims of the flood
• The third area of responsibility occurs when the floodwaters are subsiding, and involves making flooded areas safe before residents are permitted to return to them. This work includes pumping floodwater out of homes and buildings, shoring up structures that have been rendered unsafe, isolating and making safe risks from chemicals and electricity supplies, and assisting the Police and Ambulance Services.

In order to perform all three of these roles effectively, specialist equipment and training is required. If flooding becomes more frequent, Fire and Rescue Services may have to consider adapting their capabilities to allow for a greater flood rescue response capability.

Changes required may include:
• Appliances designed with greater ground clearance and higher mounted air intakes to allow them to better negotiate floodwaters
• Additional equipment for rescue from structural collapses following flooding (i.e. shoring up equipment)
• Changes to training with, or additional equipment (eg more boats/dinghies, dry suits etc) for conducting operations to rescue people from water including improved relationships with organisations such as the Royal Air Force to provide a helicopter rescue capability

• Greater awareness for firefighters of the health implications of working with polluted water
• The availability of additional pumping capability to defensively pump water away from key areas, and to remove remaining water once floodwaters begin to subside
• Greater call centre capacity. During periods of flooding, Fire and Rescue Services receive a huge volume of calls, many more than they would usually have to handle. Whilst this may be reduced by the Environment Agency's "Floodline" service, Fire and Rescue Services can still expect to receive a high volume of calls at short notice. WFRS have an arrangement with neighbouring Fire and Rescue Services that in times of high call volume, quieter Fire and Rescue Services will assist the busier Fire and Rescue Services with their call handling.

As part of the New Dimensions work, additional resources have been procured to assist Fire and Rescue Services in dealing with flooding incidents. One of the resources that has been purchased is a fleet of 50 high volume pumps. These pumps have approximately four times the pumping capability of a single fire appliance (8,000 litres per minute, against 2,250 litres per minute), and include 3km of 150mm hose which can be laid straight from the pump transport unit.

The pumps are distributed throughout the UK on a risk assessed basis, and will be available to provide a two-hour response to natural flooding risks. WFRS have possession of one of these units. They will provide a significant additional pumping capability to Fire and Rescue Services for both defensive pumping and water removal operations. 10 high volume pumping units were deployed to Carlisle during the floods of January 2005 and were critical to a quick recovery and, crucially, providing the restoration of electrical power to the north of the county, as well as the City of Carlisle.

The Fire Prevention & Fire Engineers Journal) describes the role that the high volume pumping equipment played in the incident by saying:

"In the Carlisle area, 1,934 properties were directly flooded. In some areas the flooding reached seven feet in depth and took four days to subside. Responders worked to pump away the flood water and to clear the roads; the high-volume pumping equipment provided under the New Dimension programme gave significant boost to responders' existing capabilities."

Somerset Fire and Rescue Service describe their use of high volume pumps at Glastonbury festival on their website:

"The addition of high volume pumps also aided flood recovery at the Glastonbury festival 2005 where over 300 tents were washed away in severe flooding when a month's rain fell in a few hours. The high volume pumping unit was effective and was reported to have transferred 3 million litres of water from the site"

Unless preventative steps are taken, it is safe to assume that increased winter precipitation will lead to flood events becoming both more frequent and more severe. In a project directed by the UK's Chief Scientific Adviser as part of the DTI's Foresight programme, it was estimated that the number of people at a high risk of flooding could rise from 1.5 million to between 2.3 and 3.5 million by the 2080s.

This may mean that Fire and Rescue Services will be required to utilise specialist resources more frequently. In addition to the costs of this response and specialist flood equipment, it is also important to note that the clean-up response to flooding (such as pumping water out) is a lengthy process, and can often require attendance from Fire and Rescue Services for over 24 hours at a time. Whilst Fire and Rescue Services are under no legislatory obligation to remove floodwater, a refusal to do so would definitely result in negative publicity, and would be best avoided. Unless properly managed, this work will have an effect on the availability of resources to deal with other incidents that may occur, and could lead to increased damage or even loss of life at other incidents whilst resources are committed to the aftermath of the flood. Negotiations are currently in progress for Environment Agency staff to operate the pumps after 36 to 48 hours of attendance by the Fire and Rescue Services. This will limit the utilisation of Fire and Rescue Services resources in the cleanup operation and will increase the effectiveness of the Fire and Rescue Services in responding to other incidents.

Although it is reasonable to assume that increasing winter precipitation will make flooding more severe, this may not be the case. As flooding risks become greater, it is likely that spending on flood management solutions will be increased to allow improved flood defences to be constructed, and new water management plans to be devised in order to change or reduce the risks.

It would be very useful for representatives of the WFRS to be involved in any discussions concerning flood management and defences that are to be developed within Warwickshire. This would allow concerns to be taken on board

at the design stage, and would also assist in creating a greater sense of openness and communication during emergency planning.

The Civil Contingencies Act 2004) states that category 1 responders (a group which includes the Fire and Rescue Service) should assess the risk of an emergency occurring, and also maintain plans for the purpose of ensuring that if an emergency occurs or is likely to occur the body is able to perform its functions so far as necessary for the purpose of reducing, controlling or mitigating its effects. Wide ranging contacts and an attitude of partnership working developed within this planning environment, and as part of planning and practice exercises, could prove to be beneficial in an emergency situation.

CHAPTER 5
Drought

For the Low Emissions scenario used in UKCIP02, by 2080, summer rainfall will decrease by 20%, and for the High Emissions scenario, decreases of up to 50% in the summer rainfall are expected.

The effect of climate change on water supplies in the UK is a complicated and long term issue, and because of the lengthy construction and planning timescales involved in upgrading the water supply infrastructure, UK water companies are taking the problem of water shortage caused by climate change very seriously. UK Water Industry Research Ltd.) was set up by the UK water industry in 1993, and its aim is to:

"*provide a framework for the procurement of a common research programme for UK water operators on 'one voice' issues*"

One of the topic areas for the UK Water Industry Research programme is climate change, and work is underway to estimate the impact on water supply that climate change will have and to develop measures that could be taken to minimise these impacts. New construction work is being planned to mitigate some of the effects, and work to investigate the implications of using alternative water resources is underway.

As water is such a vital resource for Fire and Rescue Services, any problems with supply will have serious implications. Whilst it is hard to quantify them, it is still possible to suggest potential areas of concern.

DO John Cox, writing for Fire Prevention & Fire Engineers Journalsays:
"Water shortages would affect brigades' training and demonstrative capabilities. When there are limits on the water available for basic human needs such as drinking and bathing, it will not present a good public image to have the brigade seen as "wasting" thousands of litres of water on training which may be perceived as non-essential."

A drought will put pressure on Fire and Rescue Services to use less "drinking quality" water during incidents. It is possible that during times of water shortage, the water companies will reduce the pressure in their mains supplies to minimise leakage, and may even stop supplying water to some areas altogether.

Problems with mains supplies, avoiding drinking water and a reduction in the number of easily accessible water sources may force firefighters to fight fires using water from alternative sources such as ponds and rivers.

Determining alternative water sources with which to fight a fire will slow down intervention, and any increase in time between the Fire and Rescue Services' arrival and the time when firefighting operations begin will lead to increased life risk and property damage. There may also be ecological consequences if too much water is extracted from a watercourse.

These concerns may mean that Fire and Rescue Services in the UK will have to relay water across longer distances for firefighting, increasing the resource requirement at incidents.

This might include additional hose lengths or increased use of water tankers. The high volume pumps that are available to Fire and Rescue Services will prove a useful asset for performing water relay operations. They have a pumping capacity of 8,000 litres per minute, and are supplied with 3 km of 150mm hose which they can lay automatically. When water needs to be relayed a large distance then this piece of equipment will prove invaluable. However, it is important to note that when the lengths of hose are deployed, vehicular access over the hose will become impossible thus disrupting the local road network and affecting the local community.

If there is a drought, then there will be less water available, this will mean that Fire and Rescue Services will have to try to use water even more efficiently. This may require changes in training, tactics, procedures, and equipment.

These changes will involve using limited available water in the most effective possible way, and being able to make better use of a variety of water supplies.

Examples of changes that may become necessary are:
• increased use of foam concentrate and wetting agents to make less water go further. However this could lead to incidents becoming increasingly complicated as efforts to ensure contaminants are kept out of streams and rivers will be required more frequently
• fire appliances with larger water carrying capacities
• purchase or make arrangements for loan of specialised water moving equipment such as water tankers or additional high volume pumping units
• more efficient techniques / equipment for water application to fires

• new techniques and equipment to allow long distance water relays to be carried out
• new techniques or equipment to allow water from smaller / shallower natural water sources to be used – watercourses are expected to be smaller in times of drought.

CHAPTER 6
Windspeed and Storms

Windspeed fluctuates greatly throughout the day and observed relationships show that the maximum hourly average windspeed is approximately 30% higher than the daily average, and the maximum gust is typically about twice the daily average.

The UKCIP02 patterns for windspeed are that by 2080, winter windspeed will increase by between 2% and 6%, and summer windspeed will decrease by between 2% and 10% depending on which emissions scenario is considered.

This means that the daily average windspeed that could be expected in Southeast England on a winter day every 20 years (this is known as the 20 year event velocity), increases by between 2% and 6% (depending on the emissions scenario) relative to the current 20 year event velocity.

UKCIP state in their report that climate change models remain rather poor at simulating small-scale and high intensity wind speeds, and that relatively low confidence should be attached to these results.

The last major storm in recent history is the great storm of 1987. Whilst it was described by many as a hurricane, this is incorrect, and it was in fact an exceptional storm. The storm of 1987 can be described as a once in two hundred year storm, meaning that we would expect a storm of this ferocity to occur not more than once every two hundred years.

Inland, gusts of wind exceeded 80 knots, and the destruction caused was immense.
"The storm felled nearly 15 million trees, and whole woodlands were decimated. Buildings suffered severe damage and ships were driven onto the shore. 16 people died as a direct result of the storm damage."

Historic information on the role of Fire and Rescue Services during a severe storm is difficult to find, but it can be assumed that the primary role of Fire and Rescue Services during a storm will be rescuing people. The Fire and Rescue Services will rescue people trapped by fallen trees, collapsed buildings and involved in road traffic accidents. These tasks will be hampered by the actions of the storm, and will be made more difficult by torrential rain and high winds. The weather will also place the firefighters at greater risk, as they will be required to face the dangers of the storm to assist people in trouble.

Once rescue operations have been completed, the Fire and Rescue Service role will involve making the area safe, and assisting with as swift a return to normality as is possible.

Performing rescue and salvage operations during and in the aftermath of a storm is a hazardous procedure. Risks such as falling trees and building collapse will still be present during rescue operations, and specialist training and planning may be needed to assess these risks, and determine appropriate procedures to operate safely.

Many Fire and Rescue Services have begun to train their personnel in Urban Search and Rescue (USAR) and units are available to WFRS from neighbouring Authorities. The skills and techniques that are learnt during this training will be very useful when rescuing people from collapsed structures, and also in making the structures safe both during and after a storm.

In addition to training, specialist equipment can be required for this work. One of the most useful tools for removing fallen trees is a chainsaw, and if storms become significantly more frequent then it may be necessary to either supply chainsaws to all front line appliances as is currently done in some Fire and Rescue Services in the UK, or make provision for the assistance of skilled contractors. A supply of this equipment will allow firefighters to clear roads and debris quicker, and assist with a return to normality. The equipment is however highly specialized, and will require additional and continuous training and maintenance for it to be safely put to best use.

It is also important to remember that storms and in particular fallen trees will block roads, and will increase response times to incidents. Alternative route plans may need to be in place for key journeys so that Fire and Rescue Services can still provide the fastest response to an incident in difficult conditions.

CHAPTER 7
Conclusions

The UK climate has changed over the last century and is likely to continue to change throughout the 21st century, affecting all aspects of the UK's environment, society, and economy.

The UK Climate Impacts Programme (UKCIP) helps organisations assess how they might be affected by climate change, so they can prepare for its impacts.

Scenarios of Climate Change on the UK present four possible future climates spanning different levels of emissions of greenhouse gases, and are used to predict the likely impacts in the coming decades. It is important to remember that these scenarios contain an element of uncertainty, and are related to the likelihood of specific events occurring. The timeframe for reaching these thresholds depends on actions to reduce emissions.

Climate scenarios demonstrate that climate change will lead to an increase in the frequency of hot summers and therefore to an increase in the number and severity of grassland and woodland fires, requiring significant extra effort from Fire and Rescue Services.

These summers are also predicted to be very dry, which may lead to water shortages. Water shortages will impact on both fire fighting operations and training.

These scenarios also show that increased winter rainfall and higher sea levels will lead to an increase in flooding events. Whilst measures are being taken to address this problem with improved flood defences, new pumping equipment and innovative appliance design, issues such as training, access to water rescue craft and equipment, and helicopter support may need to be reviewed with this in mind. These events may also create a requirement for short notice access to urban search and rescue equipment.

Fire and Rescue Services are dynamic and flexible organisations, which are able to change and adapt to suit the emergencies for which they are needed. Whilst it is recommended that research into climate change should continue to be monitored, there is sufficient uncertainty to be unsure that any major decisions made would be correct.

Climate change is unlikely to provide new challenges for Fire and Rescue Services, instead, those challenges that are already faced will potentially become more severe, and also more frequent.

For Fire and Rescue Services in the UK there is potential for increased workloads all year round. Warmer and wetter winters will lead to increased incidences of flooding, and storms, and hotter drier summers will lead to increased numbers of secondary fires, increased ferocity of woodland fires as well as possible droughts and water supply problems.

This report recommends that WFRS begin to plan for climate change, and to have an awareness of climate change when decisions are being made. The current uncertainties surrounding climate change will make it difficult to base decisions entirely upon climate change issues, but when a decision is required to be made, consideration of the effects of climate change could provide benefits to well prepared Fire and Rescue Services.

The continued monitoring of research that is produced on climate change, and the creation of links with those who conduct it would be a prudent strategy. This would ensure that as new information becomes available, WFRS will be aware of it, and will be able to either produce or adapt existing plans to minimise the effect, and will be ready to ask informed questions, and act upon the answers that are received.

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Appendix 1

The Impact of Climate Change on Warwickshire Fire and Rescue Service

RISK:	IMPACTS		RISK SCORE	ADAPTATION POSSIBILITIES
	THREATS	OPPORTUNITIES		
Incidents: Primary and Secondary Fires.	Climate scenarios demonstrate that climate change will lead to an increase in the frequency of hot summers and therefore to an increase in the number and severity of grassland and woodland fires, requiring significant extra effort from Fire and Rescue Services.	Opportunity to build upon the existing prevention work	12	WFRS Improvement Plan – steps 1, 2, 3, 4, 5 and 8 (Appendix 3)
Woodland Fires	Increased tourism will lead to more people accessing grassland/woodland areas leading to an increase in secondary fires.	More people around to spot fires before they become out of control.	12	WFRS Improvement Plan - steps 1, 2, 4, 5 and 8 (Appendix 3) Fire Prevention programme
Road Traffic Collisions (RTC)	Increased number of RTCs due to the increase in tourism.	Increased number of vehicles will reduce the average speed and possible lessen the seriousness of the incident	12	WFRS Improvement Plan – steps 1, 2, 5 and 7 (Appendix 3)
Flooding	Increase in rainfall, especially when it falls very heavily.	Multi-Agency working	16	WFRS Improvement Plan – steps 1,2, 5 and 6 (Appendix 3); HVP provision Partnership working with Environment Agency and Planning Authorities.

Droughts	Reduction in the levels of water available for firefighting and training.	Development of water network	12	The United Kingdom Water Industry Research Project (UKWIR) HVP for water relay
Windspeed and Storms	Damage caused by wind and storms likely to increase	Multi-Agency working	12	WFRS Improvement Plan – steps 1, 2, and 5 (Appendix 3); Specialist Urban Search and Rescue teams – West Midlands/ Hereford & Worcester
Increased leisure use of waterways	Increased number of people requiring rescue	Increased revenue to the local community	8	WFRS Improvement Plan – steps 1,2,5 and 6 (Appendix 3)
Subsidence	Due to reduction in water land may begin to subside causing structural collapse	Multi-Agency working	8	Specialist Urban Search and Rescue teams – West Midlands/ Hereford & Worcester
Built Infrastructure: Heat Stress - incidents	Personnel exposed to higher temperatures. Dehydration and sunstroke of personnel.	Improved monitoring of personnel	9	Continued Incident management, provision of refreshments and appropriate PPE
Heat Stress - offices	Personnel unable to continue working due to working environment becoming unbearable	To introduce new ways of working	9	Strategic Asset Management Planning

Appendix 2

Risk Evaluation and Scoring - Threats

PROBABILITY (Over next 30 years)	Almost certain 0-1 year	5	5	10	15	20	25
	Likely 1-5 years	4	4	8	12	16	20
	Moderate 5-10 years	3	3	6	9	12	15
	Unlikely 10-20 years	2	2	4	6	8	10
	Rare 20-30 years	1	1	2	3	4	5
			1 Insignificant	2 Minor	3 Moderate	4 Significant	5 Major

Key	Immediate Threat	High	Tolerable	Low
	Consider immediate risk action review regularly and report upwards to senior management	Consider risk action and review regularly	Consider risk action and review periodically	No action required. Review annually to ensure risk level does not change.

Appendix 3

Warwickshire Fire and Rescue Service – Improvement Plan

Step 1 - Resources

We need to introduce a fifth watch crewing system by centralisation of training and sickness cover to enable flexible crewing to match the demands on the Service. This will be in addition to the existing four watch model and will include a change to the day crewed system to match the peaks in calls / service demand, so that the Fire and Rescue Service is there when the public need us.
A change in duty systems by changing start and finish times as well as shift length may improve our efficiency and availability. Empowering managers to manage against performance outcomes rather than rigidly prescribing hour by hour activity will allow innovation and creativity in meeting targets.

Step 1a

Following a review of current stations, their turnout areas and calls they attend, a 12 station response model is proposed, linked to a flexible system of duty. This will release resources to be reinvested into the fifth watch system, provide changes to the day crewed system and allow for the establishment of small fires / Community Fire Safety unit(s) as well as ensuring better operational cover overall. The new crewing system will require 243 full time equivalent (wholetime/day crewed) and 74 fte retained firefighters.
This model includes the upgrade of Alcester Fire Station to Wholetime / Retained and has the potential to provide the money to make the other improvements that we need.
Response options need not be maintained at all stations, but initiatives such as the Young Firefighters, Community Advocates (Volunteers) and other community activity would be enhanced at stations to improve access to other services for residents and contribute to wider community outcomes. This will improve operational availability overall and generate additional efficiencies, opportunities and benefits, through the potential transfer of the use of some of our assets to the locality.

Benefits - Improved availability, highly trained and better equipped personnel, improved capacity for community safety activity, mixed crewing, additional resilience, Small Fires Units, and Road Traffic Collisions Units

Step 2 – False Alarm Calls

On average 30% of calls are false alarms. We can release significant capacity by aggressively reducing attendance at the number of automatic false alarm calls.

This project will draw on best practice examples/approaches implemented by other UK Fire and Rescue Services, e.g. Oxfordshire.

Benefits

- Releases firefighters for training, exercises and Community Fire Safety activity
- Increase firefighter and public safety by reducing the number of blue light condition responses
- Improve the impact on the environment (unnecessary journeys)
- Provides resources for Small Fires Units

Step 3 – Smoke Detector Ownership

There is now emerging clear evidence of the relationship between Home Fire Safety Checks (HFSC), smoke detector ownership and significant reduction in fire deaths and injuries. Half of the people who die in fires in the home are dead before we receive the call.

We want to significantly increase the number of HFSCs through the use of both operational firefighters and external agencies (3rd sector) to ensure that all sectors of our most at risk communities are targeted.

Benefits

- Reduces risk of accidental fires in the home for our communities
- Reduces serious injuries and death from fires in the home
- Reduces environmental impact from fewer fires in the home.

Step 4 – Hot Fire Training

We need to double the Hot Fires and Incident Command System training on an annual basis for all operational staff. A new contract was awarded to the Fire Service College in July 2009 to fulfil this priority in the current year.

Benefits

Increases the safety of our firefighters.

Step 5 – Sickness Management

Significant capacity can be released by reducing the number of times that staff are absent, we want to reduce sickness absence and improve health and fitness.

Consistent management of sickness absence management by all managers will increase the availability of staff, will improve the safety of our firefighters and the protection of our communities

Benefits

- Increases the safety of our firefighters
- Guarantees the availability of resources
- Ensures the safety of our communities
- Improves value for money

Step 6 – Flood Response

We need to buy a second boat unit and locate it in the south of Warwickshire to enhance the response to flooding events. This boat will be crewed on a recall to duty basis.

Included in the enhanced flood response is an upgrade to the water response equipment on all front line fire engines, and the training to go with it.

Benefits

- Increases the safety of our firefighters
- Ensures the safety of our communities
- Increases and enhances our response to all water based rescue incidents

Step 7 – Road Traffic Collision Unit

Deploy Road Traffic Collision unit instead of major fire engines to busy roads and motorways linked to the risk profile (Gaydon, Henley). This project will be dependent upon the establishment of a fifth watch system.

Benefits

- Increases the safety of our firefighters
- Ensures the safety of our communities
- Increase and enhances our response to Road Traffic Collisions

Step 8 – Small Fires Unit

Small fires comprise a relatively high percentage of all incidents at predictable times of the day. We will deploy Small Fires units / Targeted Response Vehicles in response to small fires and anti-social behaviour linked to the risk profile.

This project will be dependent upon the establishment of a fifth watch system.

Benefits

- Increases the safety of our firefighters
- Ensures the safety of our communities
- Provide a response option which is scalable to the size of the incident
- Reduces the environmental impact from small fires.