Communities and Local Government

A Cost Benefit Analysis of Options to Reduce the Risk of Fire and Rescue in Areas of New Build Homes

Fire Research Series 1/2010

www.communities.gov.uk
community, opportunity, prosperity

A Cost Benefit Analysis of Options to Reduce the Risk of Fire and Rescue in Areas of New Build Homes

Fire Research Series 1/2010

February 2010
Department for Communities and Local Government

Project Team
Stéphane Gros (former NERA employee), Michael Spackman, Stewart Carter

The findings and recommendations in this report are those of the authors and do not necessarily represent the view of the Department for Communities and Local Government.

Department for Communities and Local Government
Eland House
Bressenden Place
London
SW1E 5DU
Telephone: 0303 444 0000
Website: www.communities.gov.uk

If you require this publication in an alternative format please email alternativeformats@communities.gsi.gov.uk

Communities and Local Government Publications
Tel: 0300 123 1124
Fax: 0300 123 1125
Email: product@communities.gsi.gov.uk
Online via the Communities and Local Government website: www.communities.gov.uk

75% recycled
This is printed on 75% recycled paper

February 2010

Product code: 09 FRDO 6251

ISBN: 978 1 4098 2260 8

Contents

Executive summary

Purpose of this study

The Department for Communities and Local Government (CLG) commissioned NERA Economic Consulting (NERA) to carry out a cost benefit analysis of options for addressing the fire and community safety needs of areas of new build housing, with special reference to the Thames Gateway. Of particular interest is the issue of installing sprinklers in domestic properties, and whether or not the present costs of installing and maintaining sprinkler systems might be justified by the risk reduction that they would provide.

This research does not imply any reconsideration of general Government policy on the installation of sprinklers in domestic properties. It does however provide evidence to help decision making about whether any special characteristics of the Thames Gateway developments might justify serious consideration by the planning authorities of requirements for sprinklers beyond those of current regulations.

The Thames Gateway

The Thames Gateway is a 100,000 hectare region that falls within 18 different Local Authorities in Greater London, south Essex and north Kent.

Between 2007 and 2008, CLG published housing and infrastructure plans for the region, including a target of 160,000 new homes between 2001 and 2016. The housing targets include a range of different housing types, and the plans also include targets for the proportions of new housing that should be in the social housing sector.

The increase in demand for fire and rescue services (FRS) in the Thames Gateway from these developments will depend on a number of factors, including the socioeconomic characteristics of the population and the fire risks associated with the new housing.

Cost benefit modelling approach

NERA was asked by CLG to perform a cost benefit analysis of four options currently being considered to address the fire and community safety needs in areas of new build. One of these is 'do nothing', defined as maintaining the existing FRS provision in the region. This would imply some (modest) increase over time in travel times to emergencies. This option we use as the baseline for assessing the other three options:

- Option I: installation of British Standard sprinklers in all new dwellings, without additional FRS resources;
- Option II: installation of British Standard sprinklers in all new dwellings which are part of the social housing sector, without additional FRS resources; and
- Option III: additional FRS resources in the areas of new dwellings, without sprinklers being installed.

We have developed an original spreadsheet-based model to estimate the benefits and costs over the life cycle of these three Options, relative to the 'do nothing' baseline. We have based many of the relationships, data (such as the response times to FRS incidents) and parameter values on CLG's Fire Service Emergency Cover (FSEC) toolkit and an abridged version (the 'National Model').

To assess the benefits, we look at the impacts of each Option on fatalities, injuries, property loss and CO_2 emissions from dwelling fires, Other Building fires and road traffic collisions. The costs of sprinklers are taken from previous studies and quotes from vendors. We have estimated the cost of providing additional FRS resources from operational cost data for Fire and Rescue Authorities in the UK.

Modelling results and conclusions

We discuss the net social benefits of each policy option relative to the 'do nothing' baseline. We also compare the sprinkler Options I and II with Option III (additional FRS resources). The latter comparison includes as benefits under the sprinkler options the FRS resources saved.

The findings from our modelling are consistent with previous studies in suggesting that the benefits of installing sprinklers in *all new* housing, in terms of reduced fatalities, injuries and property loss, would fall far short of the costs (for example, see sections 5.5 and 7.1). We find some limited and uncertain evidence that installing domestic sprinklers in *new social* housing could lead to similar net social benefits as providing additional FRS resources.

The limited and uncertain evidence for installing domestic sprinklers in new social housing suggests that sprinklers may be cost-effective in some cases. It may therefore be appropriate for providers of new social housing to consider sprinklers on a case-by-case basis.

However, the cost benefit evidence from this study does not support the mandatory installation of sprinklers in all housing or social housing in the Thames Gateway. The benefits from installing sprinklers in social housing would be reduced in particular by the current government planning policy of mixing social and private housing, as the scope for FRS savings would be reduced where both housing types share the same FRS resources.

Beyond the discrete policy options examined in this report, it is of course possible that some combination of fire prevention measures, such as targeting domestic sprinklers in social housing, smoke alarms, education, or other measures at the highest risk areas would provide more net social benefit than any one single measure.

The cost benefit analysis has been carried out from the perspective of society as a whole. To compare the options from other perspectives (e.g. central Government), it is necessary to understand who incurs the costs of the different policy options. For example, the costs of installing (although not necessarily maintaining) sprinklers may be faced partly by housing developers, but extra FRS resource costs may require extra public funds or they may be financed by developers under Section 106 agreements.

Generalisation to other areas of new build

Care is needed in applying the conclusions from this study elsewhere in the UK. We have identified a number of factors that may limit the applicability of the current study's findings outside the study area. For example:

- We found that FRS coverage in the Thames Gateway area currently seems to be relatively good and current FRS resources seem to have relatively low levels of utilisation;
- We assumed that all new housing has smoke alarms fitted, which decreases the net benefit of sprinklers;
- The domestic sprinkler lifecycle costs may depend on the levels of competition between local suppliers, economies of scale and the water supply (e.g. pumps) needs of the area; and
- The requirement for additional FRS resources in areas of new build developments, and therefore the specification of Option III, is largely dependent on local planning needs and what are considered to be 'acceptable' levels of risk.

Despite this, the conclusions from our study appear to hold in the London, Kent and Essex parts of the Thames Gateway, even though each have different socioeconomic, environmental, and housing characteristics.

Chapter 1 Introduction

Communities and Local Government (CLG) commissioned NERA Economic Consulting (NERA) to carry out a cost benefit analysis of options to address the fire and community safety needs of areas of new build housing. The results of this analysis are presented in this report.

1.1 Context

The Government's commitment to build new homes in areas such as the Thames Gateway presents challenges to the fire and rescue service. In the development of new geographically defined communities fire and rescue provision must be considered as part of the planning process.

Building new fire stations may be an obvious response, but there are a number of other protective measures that can contribute to a balanced approach to fire safety.

1.2 Purpose of the Study

The Government does not currently legislate for or regulate the provision of sprinklers in domestic properties (except for high rise flats). Research has demonstrated that, for most property types, the costs of installing and maintaining sprinkler systems are at present generally too high to justify the risk reduction that they would provide. However the Government wishes to revisit the issue for a situation with exceptionally large new housing developments.

This research does not imply any reconsideration of Government policy on the installation of sprinklers in domestic properties. The Government is however concerned with examining whether the unusual circumstance of the Thames Gateway developments might justify serious consideration by the planning communities of requirements for sprinklers beyond those of current regulations.

This study is about the possibilities: providing an evidence base to help decision making about measures to make communities safer.

1.3 Structure of the Report

The rest of this report is structured as follows:

- Chapter 2 provides a detailed account of expected development in the Thames Gateway, along with a discussion of its implication for the Fire and Rescue Services of Essex, Kent and London.
- The methodological framework we have developed to conduct the cost benefit analysis is presented in Chapter 3.
- Our estimating assumptions are set out in Chapter 4, with a particular emphasis on hypotheses related to the cost and the effectiveness of residential sprinkler systems.
- Preliminary cost benefit analysis results can be found in Chapter 5, while Chapter 6 provides the outcomes of a number of sensitivity tests and scenario analyses.
- Chapter 7 concludes with a summary of findings and a brief agenda for future research.

The report also contains the following appendices:

- Appendix A provides a review of the literature contributing to the cost benefit analysis of residential sprinkler systems.
- An overview of the activities undertaken by the Fire and Rescue Services is provided in Appendix B.
- Appendix C provides a list of the major housing developments planned for the Thames Gateway.
- Appendix D provides the names and affiliations of attendees of the workshop we facilitated in July 2008.
- Appendix E provides a list of references and data sources.
- Finally, Appendix F provides the Tables from the report.

Chapter 2 Development in the Thames Gateway and its Implications for the Fire and Rescue Services

2.1 Background to the Thames Gateway

The Thames Gateway is a 40 mile long, 100,000 hectare region that covers parts of Greater London, South Essex and North Kent.

The boundary line for the Thames Gateway region was set by the Department of the Environment, Transport and the Regions (DETR) in its Regional Planning Guidance 9 (RPG9) in 2001, and mainly follows major roads and Ward boundaries. For the purposes of statistical reporting, CLG defined the Thames Gateway in terms of Census and Administrative wards, which fall within 18 different Local Authorities in England.[1] These Local Authorities are listed in Table 2.1.

In 2001 the Thames Gateway region had a population of around 1.45 million (0.5 million in each of London and Kent, and 0.45 million in Essex), and contained around 600,000 households and 613,000 employees.[2]

At the local level, there are nine Local Regeneration Partnership organisations that have been set up to coordinate regeneration projects that cover the Thames Gateway region. These are:

- Basildon Renaissance Partnership;
- Kent Thameside;
- Invest Bexley;
- London Thames Gateway Development Corporation;
- Thurrock Thames Gateway Development Corporation;
- Woolwich Regeneration;
- Swale Forward;
- Medway Renaissance Partnership; and
- Renaissance Southend.

[1] CLG, *The State of the Gateway: a Baseline for Evaluating the Thames Gateway Programme,* November 2006.
[2] CLG, *The State of the Gateway: a Baseline for Evaluating the Thames Gateway Programme,* November 2006.

2.2 Targets for the Thames Gateway Redevelopment

In the Thames Gateway Delivery Plan of November 2007, CLG set out proposals for £9 billion of investment between 2008 and 2011.

The aim of the investment (with some key targets from 2001 to 2016) is to:[3]

- improve the economy (including creating at least 225,000 new jobs);
- increase the number and quality of dwellings (160,000 new homes of all tenures);
- improve local transport (65km of new and upgraded road transport, and 12 new road transport bridges);
- improve education opportunities;
- improve quality of life; and
- develop the Thames Gateway as an eco-region.

2.2.1 Targets for the numbers of new dwellings

The focus for this cost benefit analysis is the numbers and types of new dwellings planned in the Thames Gateway. In its Interim Plan of November 2006, CLG disaggregates by area for its target of 160,000 new homes between 2001 and 2016.[4] Figures for potential new homes, by area in London and by Local Authority in Essex and Kent, are shown in Table 2.2.

Relative to the numbers of households in 2001, these projections represent housing growth of 47.5 per cent in the London Thames Gateway, 17.0 per cent in the Kent Thames Gateway and 16.5 per cent in the Essex Thames Gateway.

2.2.2 Thames Gateway housing types

The Technical Annex to the Interim Plan indicates that the Thames Gateway homes will cover a range of tenures (social, private-rental and owner-occupied), types (flats and houses) and sizes (1-2 bedroom and larger houses for families)[5]. The mix and densities of the housing, however, are subject to local and regional policies, which will be prepared with regard to current housing stock, future housing needs, the economy and the environment.

[3] CLG, *Thames Gateway, The Delivery Plan,* November 2007.
[4] CLG, *Thames Gateway Interim Plan, Development Prospectus*, November 2006.
CLG, *Thames Gateway Interim Plan, Policy Framework*, November 2006.
[5] CLG, *Thames Gateway Interim Plan, Technical Annex to the Policy Framework*, November 2006.

For the mix of housing at the regional level, it is intended that the numbers and types of new Thames Gateway housing will be consistent with Regional Spatial Strategies in London, South East and East of England[6]. Overall the Government has indicated that 35 per cent of new homes in the Thames Gateway should be affordable housing for rent or sale. Affordable housing is made up of 'social rented housing' and 'intermediate housing' – as defined in Box 2.1.

In London, the previous Mayor's London Plan included a target of 50 per cent of new dwellings in London being affordable housing (70 per cent of which should be social housing and 30 per cent intermediate housing)[7]. However, the current London Mayor indicated that these targets are to be scrapped, and instead has set targets for 2008 to 2011 of 50,000 additional affordable homes, including 30,000 additional social rented homes[8].

In the South East region (including the Kent Thames Gateway) there is a target of 25 per cent social rented housing[9]. In the East of England region (including the Essex Thames Gateway), housing number targets indicate that there is a social rented target for new dwellings of just over 25 per cent.[10]

Box 2.1 Social and Affordable Housing Definitions

'Affordable housing includes social rented and intermediate housing, provided to specified eligible households whose needs are not met by the market. Affordable housing should:

- meet the needs of eligible households including availability at a cost low enough for them to afford, determined with regard to local incomes and local house prices; and
- include provisions for:
  - the home to be retained for future eligible households; or if these restrictions are lifted, for any subsidy to be recycled for alternative affordable housing provision.
  - Social rented housing is rented housing owned and managed by local authorities and RSLs, for which guideline target rents are determined through the national rent regime. It may also include rented housing owned or managed by other persons and provided under equivalent rental arrangements to the above, as agreed with the local authority or with the Homes and Communities Agency as a condition of grant.

Intermediate affordable housing is housing at prices and rents above those of social rent but below market price or rents, and which meet the criteria set out above. These can include shared equity *(e.g. HomeBuy)* and other low cost homes for sale, and intermediate rent.'

Source: CLG, Definition of general housing terms, http://www.communities.gov.uk/housing/housingresearch/housingstatistics/definitiongeneral/

[6] CLG, *Thames Gateway Interim Plan, Policy Framework*, November 2006, page 34.
[7] Mayor of London, *The London Plan, Spatial Development Strategy for Greater London*, February 2008, page 76.
[8] Mayor of London, *The London Housing Strategy*, November 2008.
[9] South East England Regional Assembly, *The South East Plan, Section D3: Housing*, March 2006.
[10] East of England Regional Assembly, *East of England Plan, The Revision to the Regional Spatial Strategy for the East of England*, May 2008.

2.3 Development of Projections for CBA Modelling

2.3.1 Housing and population projections

For our CBA modelling, we have based the calculations on snapshots of housing numbers in 2007 (which we take as our base year), 2020 and 2050. This section describes how we have developed these projections, using data and assumptions from a number of sources.

The risk assessment tool used in the CBA is the Fire Service Emergency Cover Toolkit (FSEC), which is provided by CLG to Fire and Rescue Services and is described in Chapter 3 below. FSEC provides housing numbers[11] by 'output area'[12] (which are classified by Ward and Local Authority) for 2001. To estimate housing numbers in 2007, we have used Thames Gateway housing growth outturn estimated by the Valuation Office Agency. The data were provided by CLG and are split by Local Authority. We have applied the relevant Local Authority housing growth rates (from 2001 to 2007) to each of the output areas to estimate housing numbers in 2007.

For the period 2008 to 2020, we have based our housing growth estimates on data provided by Tribal Consulting to CLG on planned major housing developments in the Thames Gateway (e.g. Canning Town, Dartford Town Centre, etc). We provide the full list in Appendix C.[13]

The information from Tribal Consulting includes the number of housing units per development site, the overall timetable for delivery and maps for the location of the sites. Where the development timetables include years before 2007 or after 2020 we have made proportional adjustments to development housing numbers, assuming that additional housing is built at a constant rate over the timetable periods. We have used coordinates provided by Tribal Consulting and information in the Thames Gateway Interim Plan to identify the relevant Wards containing each development. We then split the development housing numbers equally between the output areas in each Ward to estimate the Thames Gateway housing numbers for 2020.

Projections appear to be unavailable for housing numbers in the Thames Gateway much beyond 2020. To generate long-term forecasts, we have assumed that total housing growth in each output area over the half century from 2001 to 2050 are twice the total growth from 2001 to 2020. This reflects our view that annual rates of housing growth after 2020 will be slightly slower than in the period up to 2020 (as housing targets are met and the number of possible development sites diminishes).

[11] And proportions that are social rented housing.
[12] 'Output areas' are small geographic areas defined in FSEC which make up Wards. A typical output area consists of about 300 residents.
[13] Tribal Consulting are advising the CLG Thames Gateway Strategy Group on future public infrastructure needs, in the Thames Gateway.

We have assumed that 50 per cent of new housing in London built from 2001 to 2050 is social housing, and 25 per cent of new housing in Kent and Essex is social housing. These proportions were decided in discussion with Tribal Consulting and CLG and are broadly in line with the regional targets outlined in Section 2.2.2.

The resulting housing number assumptions for 2007, 2020 and 2050 to be used in our CBA model, which are shown in Table 2.3 by Local Authority, are NERA's best estimate of housing growth, based on the latest information available to us. They are not Government estimates and may not reflect the latest Government views on future housing growth in the Thames Gateway.

To estimate population growth, we have applied the housing growth rates for each output area (from 2001 to each of 2007, 2020 and 2050) to the population estimates from FSEC for 2001, assuming that average household sizes remain constant from 2001 to 2050.

To calculate the costs of installing sprinklers, we split dwellings between houses and flats. We use FSEC data on the proportion of dwellings that are purpose-built flats and converted accommodation to estimate the number of flats in each output area. Given a lack of data on the housing type mix of future developments, as a starting point we assume that the mixes of new housing in each output area up to 2020 and 2050 are the same as those of existing housing. We estimate the proportions of dwellings that are houses to be 56 per cent in the London region of the Thames Gateway, 79 per cent in the Essex region and 87 per cent in the Kent region. We revisit these assumptions in the sensitivity analysis.

2.3.2 Other Building projections

FSEC provides, for each output area, the numbers of fourteen types of buildings other than dwellings (hospitals, care homes, hostels, hotels, other sleeping accommodation, further education buildings, public buildings, licensed premises, schools, shops, other premises open to the public, factories, offices, and other workplaces). To construct a realistic picture of fire and rescue service (FRS) demand in the Thames Gateway in the future, we have increased the number of 'Other Buildings' in our CBA model in 2020 and 2050 pro rata to our projected proportional increases in housing, as described below.

- Using FSEC data for 2001, we calculate the number of Other Buildings of each type in each Local Authority per household.
- We calculate the revised numbers of Other Buildings by Local Authority using the 2007, 2020, and 2050 housing number assumptions.
- We first allocate the additional buildings to output areas according to the proportion of households in a Local Authority that are within each output area. We then round down to make sure building numbers in each area are integers.
- We then allocate any remaining buildings to output areas according to the proportion of Other Buildings in a Local Authority that are within each output area, and round down again.

- Finally, we allocate any last remaining buildings to the output areas within each Local Authority that have the most of that building type in the original FSEC data.

We recognise that this is a crude method for estimating the numbers of Other Buildings within each output area in 2007, 2020 and 2050. In particular, a key limitation is that the numbers of Other Buildings are estimated and allocated more on the basis of output area size and density, than on the basis of 'needs'. However, we do not have data specifying how Other Buildings and infrastructure are expected to grow in the Thames Gateway, and so the numbers are best estimates given the information available.

Our estimates for the numbers of Other Buildings in 2001, 2007, 2020 and 2050 are shown in Table 2.4.

2.3.3 Road speed projections

In FSEC and our CBA model, FRS cover for the Thames Gateway is generally determined by vehicle response times to incidents. We have used the FRS vehicle response times from FSEC for each output area as the vehicle response times for 2007, our base year.

Under the 'do nothing' scenario and Options I and II (sprinklers in all new dwellings and new social housing sector dwellings respectively), there are no additional FRS resources. Therefore, we would expect increases in FRS workload in the Thames Gateway in 2020 and 2050 (from increases in dwellings, population, Other Buildings and road traffic) to reduce FRS cover, modelled as vehicle response times.

To estimate changes in response times, we look at vehicle speed projections from the Department for Transport's National Transport Model. Results from the National Transport Model show that vehicle speeds in London are expected to fall by 1 per cent by 2010 (relative to 2003), fall by 7 per cent by 2015, and fall by 15 per cent by 2025.[14] Vehicle speeds in other urban areas, for example, are expected to be the same in 2010 (relative to 2003), fall by 2 per cent by 2015 and fall by 4 per cent by 2025.

Using these vehicle speed assumptions as a starting point, we have assumed that travel times in London increase by 10 per cent by 2020 (relative to 2007) and increase by 30 per cent by 2050. For Kent and Essex, we assume that travel times increase by 5 per cent by 2020 (relative to 2007) and increase by 15 per cent by 2050.

We revisit these assumptions in the sensitivity analysis, and in particular look at the CBA results when vehicle response times fall by more than our base case projections, which may be the case if developments affect road speeds by more in the Thames Gateway than in outside areas.

[14] Department for Transport, *Royal Transport Forecasts 2008, Results from the Department for Transport's National Transport Model*, December 2008.

2.4 Implications for the Fire and Rescue Services

2.4.1 Housing development and demand for FRS

The Thames Gateway is the largest single regeneration initiative in North West Europe and the largest area of brown field land (land previously used for industrial and commercial purposes) in the South of England.[15] Section 2.4 looks at the implications of future developments (domestic, commercial, transport) for fire and rescue service demands and risk management.

The developments will have direct impacts on the level and location of risk, as well as indirect impacts on how this risk is managed (amount and location of resources). However, evidence suggests that there is not a simple linear relationship between the numbers of houses (or population) and the demand for FRS, in particular because fire risks are influenced by a number of other factors, including fire prevention provisions made in housing and the socio-demographic characteristics of the population. According to the Kent FRS:

> *'Unlike many public services, demands on the fire and rescue services are not directly driven by population or housing numbers. While of course there is a general relationship of scale, the key factors are centred around risk levels, against the service's overall capacity and response times or travel distances.'*[16]

Using the FSEC Toolkit (described in more detail in section 3.4), we find that there are 38 fire stations within the Thames Gateway, with 56 front-line appliances (vehicles). There are an additional 27 front-line appliances within a mile of the Thames Gateway.

Looking at current FRS demands, the FRS vehicles in the Thames Gateway appear to have relatively low utilisation. On average, vehicles are in use around 2.5 per cent of the time across six four-hour time bands, although there is some variation in utilisation across time bands.

2.4.2 Factors affecting the levels of risk

There are a number of factors that affect the levels of risk, including:

- demography, including age and household make-up;
- quality and age of the housing stock;
- social deprivation;
- road accident location and rates;
- environmental factors, including flood risks; and
- special risks, such as industrial complexes, heritage buildings, ports and airports.

[15] Kent Fire and Rescue Service, North Kent Development, SMT 22 August 2008.
[16] Kent Fire and Rescue Service, *Ten-Year Trends*, Internal Document.

The Essex FRS County Wide Review (2008) identified a number of risks from changes in demographics including:[17]

- increases in the number of vehicles owned and driven by young persons: increases in road traffic collisions (RTCs);
- increases in the number of immigrants living and working in Essex: difficulties in effectively communicating with the immigrant community; and
- increases in the number of older persons who will be entering the over 80 age group in the next five to ten years: greater number of persons in this higher risk group.

The Integrated Risk Management Planning process (IRMP) Steering Group in Kent, looking at developments for the next five to 15 years, found the following:[18]

> *'It is predicted that rented accommodation will increase from 39 per cent to 46 per cent. In areas of older housing stock, less will be occupied by 'two parent two child' families as elder parenting, increased longevity and higher divorce rates diversify the range of occupancies in dwellings (…) these factors (…) will increase the risk profile of the county (older people, more people, increased renting).'*

Therefore, changes in the levels of risk in the Thames Gateway will be driven by changes in population growth, changes in the population mix or socio-demographics (e.g. average age, household size), changes in housing (e.g. tenure, type of housing, proportions of social housing, age of accommodation), changes in traffic conditions, and infrastructural changes that accompany housing developments. The housing and infrastructure developments may also replace older, high-risk structures with newer, low-risk structures, reducing fire risks.

Overall, the increased risks associated with an increasing and ageing population are likely to be at least partly mitigated by the provision of newer housing, built to better, more modern standards featuring fire and smoke detection (especially that which is 'hard-wired'). In this study we assume that all new homes in the Thames Gateway have smoke alarms fitted (either mains or battery operated), reducing the risk of fire fatalities and property damage by quicker discovery times.

2.4.3 Fire risks and other incidents

FRS activities include emergency response, community safety and fire prevention, road safety and accident prevention, dealing with major emergencies, and other ancillary activities. Appendix B provides a detailed look at recent fire risk and incident data in the UK and the Thames Gateway.

[17] Essex County FRS, 2008 *County Wide Review, Strategic Risk Assessment of the Medium to Longer-Term Fire Service Operating Environment*, 2008, page 33.
[18] IRMP Steering Group, *Development in Kent*, 13 October 2006

In 2007-08, the Kent FRS, for example, attended a total of 21,863 incidents, disaggregated as follows:

- 16,997 fire-related incidents (7,381 actual fires and 9,616 false fire alarms)
- 4,119 'special services' incidents, including:
  - 1,209 road traffic collisions
  - 459 lock in/out
  - 414 lift rescues
  - 247 flooding incidents, and
  - 153 animal rescues or releases.
- 747 other incidents.

In Kent, road traffic collisions (RTCs) account for 64 per cent of FRS incident fatalities, illustrating the importance of traffic collision relative to property fire risks.[19] Housing developments, such as those in the Thames Gateway, will increase road traffic and congestion, in addition to increasing flooding risks, lift rescues, etc.

The important ancillary activities for the FRS include Home Fire Safety Checks (or Visits), where the FRS will visit and undertake fire safety checks in homes and where needed install a free smoke detector. For example, 'Operation Castle' in Kent is a recent initiative that identifies higher risk community areas for concentrating safety checks. The FRS also makes risk-based inspections of commercial buildings.

Incidents and activities that FRSs need to be able to attend that are unrelated to dwelling fires further complicate the relationship between increases in fire risks from additional housing developments and total demands for FRS resources.

2.4.4 Risk management strategies

The FRS Act 2004 made it a legal requirement for Fire and Rescue Services to take actions to *prevent* fires and other emergencies. This is done through 'community safety' activities or services, including home fire safety checks, media campaigns, advice and guidance, lobbying activities, education programmes in schools, events, and demonstrations. This requires associated business planning, analysis, and marketing.

To provide an efficient balance between community safety work and operational response, preventative services are provided in proportion to the nature and potential severity of the risks facing individuals or communities (Kent FRS Community Safety Strategy, 2007 – 2010) and may depend on the levels of fire cover provided by the FRS.

[19] Kent FRS, FSEC and the Risk Maps.

In providing pro-active management of risk, strategies aim to limit additional demand on the FRS by reducing risk at the planning and development stages (e.g. by building in additional safety features), distinct from the provision of additional fire stations and staff.[20]

In addition, risk management is helped by increased collaboration between the different FRSs; for example, the memorandum of understanding between Kent and Essex FRS ('Joint Working with Essex County Fire and Rescue Authority', 20 June 2008).

2.4.5 The options considered in this study

For the purposes of analysis and modelling for this report, the options relating to prevention of fire and responses to fire are assumed to be mutually exclusive. In practice there is likely to be a mix of prevention responses to housing developments. Determining the socially-optimal mix of these and response activities is beyond the scope of this report.

We summarise below some preliminary FRS views offered on the FRS resource and domestic sprinkler options in this study:

- Adding traditional FRS resources would not necessarily save lives in the same way as sprinkler systems. The number of true rescues from dwelling fires is relatively limited and deaths occur prior to FRS arrival in most cases. Additional fire resources may not necessarily reduce the number of fatalities.
- Despite domestic sprinklers, there will remain a need for FRS resources for fires in Other Buildings (for example, many buildings will remain unsprinklered, such as shops), and other rescue operations.
- Some trade-offs will be possible and different types of resources will be needed with sprinklered houses. For example, new stations may be needed but not necessarily with the same, traditional fire equipment. There are possible reductions in fire cover requirements, but cost reductions will be limited if sprinklers are installed in areas with limited fire cover (high minimum attendance times).

We discuss our treatment of the options in more detail in chapter 3, which looks at the methodological framework we use for our CBA model.

[20] Kent FRS, *Note for Roundtable Meeting, Briefing on Section 106*, 2008.

Chapter 3
Methodological Framework

Cost benefit analysis (CBA) is widely used in the appraisal of projects, programmes or policies. It entails the monetary valuation of expected costs and benefits over the life cycle of the project, programme, or policy. These values are discounted over time using a social discount rate.

CBA considers not only financial impacts, but also non-marketed social benefits (such as reductions in the risk of death or injury), and non-marketed costs (such as environmental pollution). In practice there are often also significant impacts that cannot be explicitly valued in monetary terms; these need to be separately identified and considered alongside those impacts that can be valued.

To estimate benefits and costs over the life cycle of the options considered in this study, we have developed a spreadsheet-based simulation model using data, relationships and parameter values from the FSEC toolkit and the 'National Model' (an abridged version of FSEC). Our model is then used to produce value-for-money metrics following general guidelines set forth in the HM Treasury Green Book.

In this section, we present the general framework developed for the study and provide a detailed description of the equations used in the estimation of benefits and costs. The main assumptions we have chosen to populate this model are introduced in Section 4.

3.1 The Baseline and Investment Alternatives

We are considering a total of four options. Of these, we take 'do-nothing' as a 'baseline'. The three other options to be assessed against 'do nothing' are, as specified by CLG:

- Option I: installation of British Standard sprinklers in all new dwellings, without additional FRS resources;
- Option II: installation of British Standard sprinklers in all new dwellings which are part of the social housing sector, without additional FRS resources; and
- Option III: additional FRS resources (such as new fire stations, or additional crew and equipment) in the areas of new dwellings, without sprinklers being installed.

As discussed at the end of Section 2, and in line with the approach advocated by the Fire and Rescue Services Act, Options I and II are designed to reduce – or contain – demand for fire and rescue services by focussing on prevention and early intervention.

Option III represents a more traditional approach in which additional services are supplied, rather than demand for those services being contained. The definition of that option is, in itself, relatively complex. It involves defining an adequate level of (additional) resources and an 'optimal' location for those resources. A poor or sub-optimal definition will alter the costs and benefits of that option.

To define Option III, we have relied on the expertise of the head of FSEC help desk, who is a former FRS officer. We have reviewed the profile and distribution of fire risks across portions of the Thames Gateway, on the basis of FSEC output, and under current housing and population growth projections. We have then identified the areas of increased risks and assessed possible locations for additional resources, iteratively. Details on the resource levels used in the CBA are presented later in the report in Section 4.

In our sensitivity and scenario analysis (Section 6), we have also reviewed the definition of the counterfactual, and assessed how deviations from the 'do nothing' (implicitly 'do absolutely nothing') scenario alter the conclusions of the CBA. In particular, we compare Options I and II with Option III (additional FRS resources) so that benefits from reduced FRS resources under sprinklers are included.

Finally, we have estimated the benefits of all three options *relative* to the baseline scenario, while controlling for potential 'leakage', 'displacement', and 'deadweight' effects. The HM Treasury Book defines these effects as follows:[21]

- 'leakage' effects benefit those outside the spatial area which the 'intervention' is intended to benefit. They would include changes in fire cover in the vicinity of the Thames Gateway;
- 'displacement' effects measure the extent to which the benefits of a project are offset by reductions in welfare elsewhere; and
- 'deadweight' effects refer to outcomes or benefits that would have occurred in the absence of intervention.

In our framework, we have tried to account for all three effects as much as possible through our modelling and use of FSEC.

3.2 The Study Area

The study areas for the CBA model comprise the Thames Gateway, including splits between the London, Essex and Kent areas within the Gateway.

The London part of the Thames Gateway falls within the boundaries of eight Local Authorities; the Essex and Kent parts each fall within the boundaries of five Local Authorities. More information, including the definition of the Thames Gateway area, can be found in Chapter 2 of this report.

[21] HM Treasury Green Book, page 53.

We have built the CBA model to present full CBA results for the London, Essex and Kent Thames Gateway areas separately, as each area has its own FRS, regional policies, housing characteristics, and risk profiles.

While the results are presented for the Thames Gateway area only, the FRS response times from FSEC modelling incorporate fire stations outside of the Thames Gateway boundary. However, no adjustments have been made for utilisation of these stations (or stations within the Thames Gateway) for housing growth outside the Thames Gateway boundary.

3.3 Time Horizon and Social Discount Rate

Following general guidelines set forth in the HM Treasury Green Book, we have retained a time horizon of **50 years** to estimate the costs and benefits under all options, but vary this duration for sensitivity analysis (to 30 and 40 years). We start the 50-year time horizon from the starting date of dwelling sprinklers installation in our CBA model, 2008. We use 2008 as the start year for discounting and sum discounted benefits and costs from 2007 (our base year) to 2057.

To compare costs and benefits over time, we have used a real discount rate of **3.5 per cent** per annum for the first 30 years, and **3.0 per cent** per annum thereafter, as specified in the HM Treasury Green Book.

3.4 Use of the FSEC Toolkit and National Model

3.4.1 General description of FSEC

To estimate the impacts of changes in the balance between FRS resources and demand, we have used the Fire Service Emergency Cover (FSEC) Toolkit, with local incident data for London, Kent and Essex counties at the output area level (about 300 residents per area). We have worked closely with the FSEC helpdesk to adjust and calibrate the toolkit as required by the analysis.

The FSEC toolkit is a GIS-based application made available to each FRS to allow them to: (i) assess their region's risks from fire, special service incidents and major incidents; (ii) plan the resources they need to respond to incidents; and (iii) model the consequences of resource choices on these risks.[22]

[22] The elements made available to each FRS include: WINGS GIS and FSEC software; digital maps; 2001 Census and road data; Valuation Office data to assist with the risk assessment of 'Other Buildings'; and three to five years of incident data by brigade area. Each FRS then has the responsibility of maintaining and updating the data in the model.

Key outputs provided by FSEC include the rate of fire fatalities and the level of property damage (for buildings other than dwellings). To estimate these, FSEC uses national relationships for the impact of brigade response time on the rate of fire and special services fatalities (as a function of the fire casualty rate), and property damage (for non-dwelling fires). These relationships are derived using the FDR1 database.[23] Data on the risks of fire casualty by area and the specified level of resource allocations are used to estimate incident attendance times by area and the subsequent fatality and property damage levels.[24]

FSEC is made up of a number of modules devoted to different FRS risks. These include separate modules for dwellings fires, Other Building fires, special services, and major incidents.

3.4.2 General description of the National Model

The National Model is an abridged version of FSEC (with both GIS and Excel parts). Simplifications include:

- data and outputs for 9,550 Census Wards (instead of output areas);
- response times and partial benefit parameters for only two vehicles (instead of four in FSEC);
- regression formulae used to estimate casualties from dwelling fires, instead of using incident data;
- simplified Road Traffic Collision fatality methodology (using national road and traffic data from the Department for Transport); and
- other special service and major incident risks are not included.

3.4.3 How we have used FSEC and the National Model

To produce a CBA model that is transparent and flexible, and can facilitate sensitivity analysis, most calculations take place in our model. The model draws however on assumptions and outputs from FSEC and the National Model.

[23] This database uses results from forms that investigating officers complete for fire incidents, which includes information on the causes of and damage from the fire.

[24] The FSEC outputs (which can be exported into a *.csv* format for viewing and manipulation using Excel) can be used in a number of different ways. For example, the base case outputs could be compared with other resource allocation scenarios for cost benefit analysis, or to aid FRSs in targeting high risk areas.

In summary, we have used FSEC as follows:

- create an FSEC overlay, grouping the London, Essex and Kent parts of the study area, with local incident data used within each segment;
- establish the baseline (incidents, dwelling numbers, etc.) in the London, Kent and Essex Thames Gateway areas;
- implement assumptions regarding the numbers and locations of new residential and non-residential premises (as described in Section 2);
- adjust assumptions related to the availability and location of FRS resources based on risk and model impacts, in particular under Option III (additional FRS resources);
- estimate response times for each output area;
- use the 'Workload' module to assess the impact of simultaneous call-outs;
- export data, parameters and results for each output area into an Excel format; and
- cross-check CBA model results with FSEC output.

In summary, from the National Model we have:

- identified and adapted its methodologies and relationships to estimate fatality and property loss costs and benefits (using response times from FSEC); and
- identified default parameter values for use in the equations.

In discussion with CLG, we have used updated relationships and parameters from those used in the National Model where updated information have been available.[25]

3.5 Estimation of Averted Damages

This section provides a summary of the methodology used in the CBA model to value the impacts of the three options on dwelling fire fatalities and injuries, Other Building fires and fatalities, and road traffic accidents.

3.5.1 Damage from fire incidents

3.5.1.1 Dwelling fire fatalities and injuries

This section discusses the methodology used in the CBA model to estimate the number of fatalities and injuries resulting from fires in dwellings.

[25] For example, from Greenstreet Berman, *Risk assessment research work in support of the FSEC toolkit and related applications, Task 3 – update of response time loss relationships,* Draft Report for the Department for Communities and Local Government, November 2008.

The initial step is to estimate the number of casualties per year for each housing type.[26] As we want to apply different rate of fire assumptions for each housing type, we use an approach to calculating casualty rates different from that used in the National Model, which does not differentiate between them. In our approach, we use data from FSEC on the rates of casualty and fire for each output area (expressed in terms of one casualty/fire per *x* population) and adjust the rates of fire for each housing type to calculate different rates of casualty.

In particular, *a priori*, dwellings in the social housing sector might be expected to have higher rates of fire than other dwellings, either because of the dwellings themselves or characteristics of the inhabitants. Research from the Office of the Deputy Prime Minister, as well our simple analysis of the correlation between social housing proportions and fire rates from FSEC outputs,[27] suggest that fire rates for social housing are about 50-100 per cent higher than the average fire rate across all housing types. We use 50 per cent as our starting assumption, but we look at the impact of changing this to 100 per cent in our sensitivity analysis.

To make sure that we achieve the same average rates of fire across all housing, we calculate the corresponding decrease in fire rates for non-social sector dwellings using region-wide weights based on the proportions of social-housing in each of London, Essex and Kent. We calculate from these figures that non-social sector dwellings have fire rates that are 30 per cent lower than the average across all housing types in London, and 10 per cent lower in Essex and Kent (reflecting the lower proportions of social-sector dwellings in these two regions).

Table 3.1 shows the fire rates calculated by FSEC (described as 'unadjusted'), with our adjustments by housing type, for each Thames Gateway region. For example, the adjusted rate of fire for social housing in London is 0.0015 fires per year per person, equivalent to one fire per year for every 650 people.

These adjustments by housing type are aggregates across each of the three Thames Gateway regions. We have not further disaggregated the adjustment to smaller areas within each region.

For the base case, we have not adjusted the rates of fire between existing housing (up to 2007) and new housing (from 2007 to 2050). This is because we have not been able to find robust evidence on the relationship between dwelling age and rates of fire.[28] However, as part of the sensitivity analysis, we look at how different trends in fire rates between 2007 and 2050 would affect our CBA results.

[26] 'Casualties' in this report include both fatal and non-fatal casualties. See CLG, *Fire Statistics, United Kingdom*, 2006, for definitions of these terms.

[27] For example, the ODPM found in 2004-05 that the fire prevalence rate in social rented households in England was 2.2 per cent, compared with an overall risk of 1.5 per cent, an increase of about 50 per cent (ODPM, *Fires in the Home: findings from the 2004-05 Survey of English Housing*).

[28] For example, the ODPM found in 2004-05 that the fire prevalence rate in English households has been largely unchanged when comparing 1946 to 1984 and 1985 onwards (ODPM, *Fires in the Home: findings from the 2004-05 Survey of English Housing*).

To estimate the number of dwelling fatalities, we have adapted the approach used in the National Model. In the National Model, response times for fire service vehicles are used to map numbers of casualties to numbers of fatalities. As discussed in section 2.4.2, we assume that all new dwellings have smoke alarms fitted. Based on CLG fire statistics on smoke alarms, we assume that the fatality rates for new housing in the Thames Gateway will therefore be 10 per cent lower. We assume no effect on injuries.[29] Our fatality rate assumptions by response time band are shown in Table 3.2. We revisit these assumptions in the sensitivity analysis.

The fatality rates for when each of the first four fire service vehicles arrive (which depend on their respective response times) are used to calculate a weighted average fatality rate using the partial benefit parameters (which sum to one, and represent the respective impact of each vehicle) in Table 3.3.

The fatality and casualty rates and population numbers are then used to calculate the number of fatalities per year for each output area.

FSEC and the National Model do not calculate injuries from dwelling fires. To estimate the number of injuries we have used published statistics on types of injuries for non-fatal casualties in dwelling fires.[30] We have used the breakdown by nature of injury for 2006 to estimate the number of non-fatal casualties that are serious burn injuries (12 per cent), smoke and fumes injuries (32 per cent), and minor injuries (46 per cent, including precautionary check-ups and physical injuries).

3.5.1.2 Dwelling fire property loss

FSEC and the National Model do not calculate property loss from dwelling fires. Therefore, we have developed an approach using published data.

As with the approach for dwelling fatalities, we start by using the FSEC rates of fire (this time in terms of fires per dwelling per year, rather than per person), and adjust the rates of fire for each housing type. We have applied the same adjustments to fire rates for social housing and non-social housing as those shown in Table 3.1. The resulting rates of fire per dwelling are shown in Table 3.4.

[29] Table 2.6 (CLG, *Fire Statistics, UK,* 2006) shows that the number of fatal casualties per 1,000 fires in 2006 was 63 per cent lower for fires where the alarm was present and operated, as opposed to where the alarm was absent or not raised. Approximately 80 per cent of households in England and Wales own working smoke alarms (Table 2.3), which will be reflected in the National Model fatality rates. Therefore, a 10 per cent reduction in fatality rates for new housing with smoke alarms is a rough estimate of the smoke alarm impact, and assumes that smoke alarms in new housing will not always activate. The rate of non-fatal casualties, on the other hand, was almost unchanged.

[30] The published source, CLG, *Fire Statistics, United Kingdom*, 2006, Tables 8 and 9, provides a breakdown by nature of injury for all fires only. The breakdown for dwelling fires was provided by CLG.

In the National Model the property loss from fires in Other Buildings is calculated using a 'linear' model of fire growth, where fire expands at a constant rate of square metres per minute. Following some critical feedback on adopting this approach for dwellings, we have decided to calculate property loss under two different sets of assumptions: linear fire growth, and time-squared fire growth. We use linear fire growth in the base case, but look at results from time-squared fire growth in the sensitivity analysis.[31]

For both methods, we have started by assuming a period of six minutes between the ignition of the fire and the call to the fire brigade, using the median timings for dwelling fires reported in a paper by Holborn *et al*. (2004).[32] However, as discussed in section 2.4.2, we assume that all new dwellings have smoke alarms fitted, which is likely to result in faster discovery times. Based on CLG fire statistics on smoke alarms, we assume that the mean reporting time for new housing will be five and a half minutes, reducing property loss. We revisit this assumption in the sensitivity analysis.[33]

Having estimated reporting times, we then estimate property loss rates in terms of property damage costs per minute from fire ignition to FRS response. As a starting point, we assume that the property losses per square metre of fire damage in London, Essex and Kent (in 2007 prices) are equal to the average property values per square metre in these counties in 2007, which we take from HBOS.[34] This gives us values for damage per square metre equal to £3,920 for London, £2,389 for Essex and £2,194 for Kent.

To eliminate some of the problems with using property values as proxies for property loss from dwelling fires (e.g. property losses being closely related to the value of contents), we calibrate the calculation using a 2006 report by ODPM on the economic cost of fire, which estimated that the average property damage of a domestic fire (in England and Wales) was £7,300 in 2004.[35] We combine this with an average property value per square metre of £1,780 in England and Wales in 2004 (from HBOS),[36] and an average time from dwelling fire ignition to FRS response of 12 minutes. This response time is based on the median of 11 minutes taken from London FRS data in Holborn *et al*. (2004), which we have increased slightly to account for response times in Essex and Kent. These figures imply an average burn rate of 0.34 square metres per minute.[37]

31 This seems sensible as the linear fire growth parameters are calibrated using published fire statistics, whereas the time-squared fire growth parameters are based on a single journal article.

32 Holborn, P.G., Nolan, P.F. and Golt, J., *An analysis of fire sizes, fire growth rates and times between events using data from fire investigations*, Fire Safety Journal 39, 2004.

33 Table 2.6 (CLG, *Fire Statistics, UK*, 2006), shows that 63 per cent of dwelling fires in 2006 were discovered in less than five minutes where smoke alarms were present and operated. This compares with 52 per cent of fires where smoke alarms were absent or failed. We used geometric means of time bands, the above proportions, and data that approximately 80 per cent of households in England and Wales own working smoke alarms (Table 2.3), to estimate an approximate reporting time of 5.5 minutes for new housing with smoke alarms.

34 HBOS, Economics, *Research Releases*, 12 March 2008.

35 Office of the Deputy Prime Minister, *The Economic Cost of Fire: Estimates for 2004*, April 2006.

36 HBOS, *Historical house price data*, http://www.hbosplc.com/economy/historicaldataspreadsheet.asp

37 [Average property damage per fire (£7,300)/Average price per m^2 (£1,780)]/Average response time (12 mins) = Average burn rate in m^2 per minute (0.34).

The estimated burn rate and property values imply following the average loss rate estimates (in 2007 prices) for linear growth in dwelling fires, in terms of minutes from ignition to FRS response:

- £1,339 per minute for dwellings in London;
- £816 per minute for dwellings in Essex; and
- £750 per minute for dwellings in Kent.

These property loss rates imply a property loss per fire that is greater than the ODPM estimate for 2004 of £7,300 (even after adjusting for price inflation). This seems reasonable as the ODPM estimate accounts for all dwelling fires, not only those requiring FRS responses, and the property values in London, Essex and Kent are above the averages for England and Wales. However, given the uncertainty behind the parameters used in this calculation, we adjust the property loss assumptions in the sensitivity analysis.

For time-squared fire growth, we rely on parameter estimates from a report by Holborn *et al*. (2004) that analyses fire data from London Fire Brigade.[38] The paper estimates that heat release from the fire (Q, in kW) can be represented by the relationship below, where α is the fire growth parameter (kW/s^2) and t is the time after ignition (in seconds).

$$Q = \alpha \cdot t^2$$

From the report, we use the expected value of the parameter α (0.006), and an estimate that 250 kW/m^2 is the approximate heat release per unit area of fire, to calculate a time-squared burn rate of fire of 0.000024m^2 per s^2. Combining this with the property values, we get loss rate estimates (in 2007 prices) for time-squared growth in dwelling fires, in terms of seconds from ignition to FRS response. Comparing these estimates with property loss from linear fire growth, and with average dwelling fire property loss from ODPM, we find that these estimates appear to over-estimate the property loss by a factor of about two. We therefore adjust the property loss downwards by 50 per cent, giving us the following loss rate estimates:

- £0.05 per second squared for dwellings in London;
- £0.03 per second squared for dwellings in Essex; and
- £0.03 per second squared for dwellings in Kent.

The property loss per year under both methods is calculated using the calculated loss rates, number of dwellings, rates of fire, and vehicle response times weighted according to the partial benefit parameters. As advised by CLG, the entire benefit is assigned to the first FRS vehicle.

For both methods in the base case, given the lack of available data, we assume that the property loss rates are constant in real terms over time, and that they do not differ between social housing and non-social housing. We revisit these assumptions as part of the sensitivity analysis.

[38] Holborn, P.G., Nolan, P.F. and Golt, J., *An analysis of fire sizes, fire growth rates and times between events using data from fire investigations,* Fire Safety Journal 39, 2004.

3.5.1.3 Other Building 'individual risk' fire fatalities

The National Model and FSEC use only so-called 'societal risk' (i.e. substantial multiple deaths or rescues) rates of fire for Other Buildings, covering the rate of fire in Other Buildings with five or more deaths or rescues. However, we have used a new approach set out by Greenstreet Berman (2008)[39], which examines 'individual risk' and 'societal risk' fires separately.

For individual risk, we use the formula below to calculate the fatality rate per year per building, where 0.0128 is a constant, 0.003 is the effect of the response time in minutes (t) on the fatality rate, and 1.7 is the average number of fatalities, non-fatal casualties and rescues per fire. In other words, we start with the potential number of lives available to be saved, and net off a number of people saved that is dependent on the response time.

$$\textit{Fatalities per year per building} = [((0.003 * t) + 0.0128) * 1.7] * \textit{Rate of fire}$$

The rates of 'individual risk' fires are shown in Table 3.5, from the Greenstreet Berman report. We have assumed that the fire rates are the same across London, Essex and Kent.

The methodology in the Greenstreet Berman report implies that there are no partial benefits from more than one FRS vehicle. Therefore, for each type of Other Building, the number of fatalities per year is calculated using the above formula for fatalities per building, and multiplying this by the number of buildings in each output area.

We assume that these fire rates do not change between 2007 and 2050.

3.5.1.4 Other Building 'societal risk' fatalities

The National Model calculates the number of 'societal risk' fatalities from fires in Other Buildings. We use a combination of the approaches and parameters set out in Greenstreet Berman (2008) and the National Model to estimate the number of societal fire deaths for each type of Other Building.

Similar to the formula for individual fire fatalities, the fatality rate is calculated using the formula below, where t is the response time in minutes.

$$\textit{Fatalities per fire} = ((0.003 * t) + 0.0128) * \textit{Number of potential fatalities}$$

The number of potential fatalities depends on the assumed occupancy levels of the buildings. For example, there are eight potential fatalities for occupancies of between 20 and 49 people, and 15 potential fatalities for occupancies of between 50 and 99 people. We have been advised by CLG to use the occupancy levels for each building type in Greenstreet Berman (2003).[40]

[39] Greenstreet Berman, *Risk assessment research work in support of the FSEC toolkit and related applications, Task 3 – update of response time loss relationships*, November 2008.

[40] Greenstreet Berman, *Development of the Fire Service Emergency Cover Planning Methodology*, Final Report, November 2003.

In line with the National Model and Greenstreet Berman (2008), we have doubled the fatality rates where building types are assumed to be a single compartment (rather than multiple compartments). We have been advised by CLG to assume the building type is a single compartment where it has also been assumed in Greenstreet Berman (2003).

The fire rates, from Mott MacDonald (2006), are shown in Table 3.5[41]. However, in discussion with CLG, adjustments have been made to the fire rates for shops, factories, offices and other workplaces, according to the proportions of those building types considered in Mott MacDonald (2006) to be at risk from societal fires (e.g. 11 per cent of factories). We have assumed that the fire rates are the same across London, Essex and Kent.

Using the advice from CLG, the partial benefits for Other Building societal fires are shown in Table 3.6.

To estimate the number of 'societal risk' fire fatalities for each building type, the fatalities per fire are first calculated separately using the response times for each of the four FRS vehicles, with a weighted average fatality rate calculated using the partial benefit parameters and the single compartment multiplier (for applicable building types). The fatality rates are then multiplied by the fire rates and the number of Other Buildings to estimate the number of 'societal risk' fire fatalities per year in each output area for each building type.

We assume that these fire rates also do not change between 2007 and 2050.

3.5.1.5 Other Building property loss

The National Model calculates the property loss from fires in Other Buildings. We have used the methodology from the National Model with some updated parameter values from different sources.

In line with the National Model, for each building type the reporting time is calculated by combining the geometric means of ranges of reporting times with parameters in the National Model that show the proportions of fire reporting times that are within each time band. The mean reporting times have been calculated based on the assumption that all building types are occupied, but do not have automatic fire alarms, which is the default assumption in the National Model.

The vehicle arrival times are calculated as the weighted average of the sum of mean reporting times and vehicle response times for each of the four FRS vehicles. The weights used are the partial benefit parameters in Table 3.7, provided by CLG.

The fire rates for each building type are shown in Table 3.5, and are from a document supplied by CLG that contains updated parameters for FSEC.[42]

[41] Mott MacDonald, *FSEC Toolkit, Calculation of Other Building Fire Frequencies,* July 2006.
[42] CLG, *FSEC Software Update 014*, September 2006, provided by CLG.

In line with the National Model, the property loss per building is calculated using the formula below, where the arrival time is the sum of reporting and response times, and the initial loss period is five minutes.

*Property loss per building = [((Arrival time (mins) – Initial loss period (mins)) *Average loss rate(£/min)) + Initial loss (£)] *Rate of fire*

The parameter values used for the average loss rate and initial loss are from Greenstreet Berman (2008), and are in 2007 values. The parameters are shown in Table 3.8, with the same parameters used for buildings in London, Essex and Kent.

The resulting estimates for property loss per building are then multiplied by the number of each type of building in each output area to calculate the property loss for each type of Other Building.

In the base case we assume that the property loss rates stay constant in real terms between 2007 and 2050. However, we revisit this assumption in the sensitivity analysis.

3.5.2 Damage from non-fire incidents

3.5.2.1 Road traffic collisions

The National Model calculates the number of fatalities from road traffic collisions (RTCs), based on FRS response times and published statistics. The National Model methodology is a simplified version of the FSEC methodology, due to lack of data on RTC incidents. We use the same broad approach in our model as the National Model, with some updated parameter values.

In the National Model, CLG calculates the number of potential fatalities from RTCs per kilometre of road length using statistics published by the Department for Transport (DfT). To calculate the fatalities per kilometre, we use arithmetic means from annual data from DfT on road lengths and fatalities (by road type) from 2005 to 2007.[43] The means are calculated for Great Britain as a whole (we use the same results for London, Essex and Kent), for motorways, A roads, B roads and minor roads (results assigned to C and unclassified roads).

The estimates for potential fatalities per kilometre are shown in Table 3.9. We keep these constant from 2007 to 2050.

[43] Department for Transport, *Road Lengths in Great Britain: 2005-2007*, http://www.dft.gov.uk/pgr/statistics/datatablespublications/roadstraffic/roadlengths/. Department for Transport, *Road Casualties Great Britain*, Annual Report (2005, 2006 and 2007).

The potential fatality rates in Table 3.9 are assumed to apply for response times between six and ten minutes. In the National Model additional 'FRS effectiveness multipliers' are applied to the potential fatality rates for response times that are between zero and five minutes, and that are greater than ten minutes. We have updated the multipliers using RTC fatality rates in Greenstreet Berman (2008), which are 0.64 for times between zero and five minutes, and 1.29 for times greater than ten minutes. We use the same multipliers for each road type and region.

The multipliers used to calculate the numbers of RTC fatalities are the weighted average of the multipliers for each FRS vehicle (based on respective response times), weighted by the partial benefit parameters shown in Table 3.10. These were provided by CLG.

The number of fatalities per year for each road type is estimated by multiplying the potential fatalities per kilometre by the weighted average effectiveness multiplier and the number of kilometres of that road type.

In our CBA model, we also estimate the cost of serious injuries from RTCs within the Thames Gateway. However, we have assumed that these costs do not depend on FRS response times, and therefore are not part of the net benefit calculation.

3.5.2.2 Other incidents attended by the FRS

We do not, in our CBA, attempt to value explicitly the costs of other FRS interventions, such as flooding, lift releases, and effecting entry. Instead, we include these incidents through qualitative assessment.

Also, we do not estimate costs of injuries from Other Building fires or RTCs, as we cannot draw on methods used in the National Model or FSEC and we have not found robust methods or parameters to estimate this from reviewing relevant literature. However, the costs of fatalities are much greater than the costs of injuries, and so we would not expect these exclusions to have a significant impact.

We have not included property damage resulting from RTCs, mainly because this is unlikely to have a relationship with FRS response times and so would not be part of the net benefit estimates in our CBA model.

3.6 Estimation of FRS Resource Savings

The four Options, as outlined earlier in the report, have implications for the nature and amount of resources consumed in the delivery of fire and rescue services. Thus, the installation of sprinklers in new dwellings may reduce the need for FRS vehicles, pumps and other fire suppression equipment to keep risks at an acceptable level. We can compare the Options with Option III, rather than 'do nothing' to estimate the impacts of these resource savings.

In the sprinkler options, the amount of water needed to suppress a fire in new dwellings located in the Thames Gateway would most likely be dramatically reduced, and FRS staff time could be put to more productive uses. In addition, any reduction in the FRS workload under sprinklers could reduce travel times given the lower probability of multiple call-outs, so resource savings are possible without changing response times relative to the 'Do Nothing' scenario.

In this study we look at the FRS resource savings in the context of Option III where, instead of fire prevention using sprinklers, FRSs provide additional resources. We can use a comparison of CBA results under Options I and II (with the installation of sprinklers) with results under Option III to estimate the possible impacts of FRS resource savings from installing sprinklers.

However, since our definition of Option III will differ from actual FRS resource additions, and does not include other savings, such as those from using less water or re-organising staff to increase productivity, we are unlikely to have quantified the full resource savings from sprinklers. We therefore revisit this in considering the non-monetised benefits and costs.

3.7 Estimation of Other Impacts

3.7.1 Provision of ancillary services

In addition to FRS interventions, we have assessed the impact of the proposed options on the ability of FRSs to provide ancillary services, such as Home Fire Risk Checks in existing dwellings, educational visits and awareness campaigns.

We have not quantitatively analysed the extent of these services, mainly because it is so difficult to quantify the long term consequences, especially in terms of prevention, potential changes in the provision of Home Fire Risk Checks and other educational services. It would also require data on current and projected staff utilisation, internal task prioritisation, and expected demand growth for ancillary services.

Instead, we conduct a broad qualitative assessment of these effects as non-monetised benefits and costs, focussing on the extent to which these services may or may not be fulfilled (comparing demand with available 'supply'). This makes use of information from FSEC on the current utilisation of FRS resources in the Thames Gateway.

3.7.2 Environmental impacts

We have considered the following environmental impacts:

- changes in the use of fire fighting vehicles and associated air pollution and carbon emissions;[44]
- changes in airborne pollution resulting from fires;
- changes in the amount of pollutants being released into the water course from run-off at incident sites (e.g. spillage of fire fighting foam); and
- CO_2 produced from constructing replacement buildings and recycling damaged materials.

However, having conducted an extensive review of the literature and consulted with subject matter experts (internal and external to NERA), overall we have found only limited evidence on how to quantify most of these impacts.

The main piece of evidence, from Rafal Pisula (2008), allows us to estimate the CO_2 produced from dwellings and Other Building fires.[45] To estimate the CO_2 produced, we use the author's estimates of dwelling contents (in kg of combustible materials) and emissions factors (kg CO_2 per kg material), and use an estimate of average m^2 per dwelling (109m^2, derived from HBOS house price data) to derive an estimate of 0.072 tonnes of CO_2 per m^2 of fire in dwellings. We assume that this is also true for Other Building fires.

The calculation of CO_2 released as a result of fires is simply the product of the tonnes of CO_2 per m^2 and our estimated sizes of fires (in m^2) in each year.

We discuss the other sources of CO_2 and other pollutants as part of the non-monetised benefits and costs.

[44] Emission savings can be estimated using standard emission rates (expressed in tons of pollutants per vehicle kilometre travelled, by vehicle type and average vehicle speed) available from the DfT or other agencies.

[45] Rafal Pisula, *Estimates for the Impact of FRS Activity on Greenhouse Gas Emissions*, January 2008.

3.7.3 Design freedoms

With the installation of sprinklers, there can be benefits from freer, more flexible design of dwellings, and cost savings from reductions in the need to meet certain requirements for access and fire protection, such as fire doors and escape routes.

An initial question therefore is can residential sprinklers be used as an alternative approach to satisfying structural fire requirements in building regulations in the UK? BASA (2006) includes an extensive discussion of design freedoms and trade-offs that can be made if sprinkler systems are installed. The term trade-off is defined as a 'concession that is made in recognition of the benefits that sprinklers provide in relation to life safety.'

With regard to residential premises, BASA (2006) provides an illustration of possible trade-offs that can be made. For example, a secondary escape route from the topmost storey of a four storey town-house is required in the absence of sprinkler systems. The secondary escape route is not required if sprinkler systems are present. See BASA (2006), section 6.3, for a more detailed list of design freedoms that have been allowed as a result of installation of residential sprinklers.

In discussion with the BRE, we were advised that cost reductions in terms of design freedoms from the installation of sprinklers are unlikely to be significant, although there are likely to be some benefits from architectural freedoms, more open space and more pleasing designs.

In contrast, the Scottsdale, Arizona experience found significant benefits and cost savings from installing sprinklers, including increasing housing density, cul-de-sac lengths and fire hydrant spacing. Further details are provided in Box 3.1. Our discussions with people in the sprinkler industry seem to support the view that benefits will be material.

We provide a qualitative assessment of the benefits in terms of design freedoms as non-monetised benefits and costs.

Box 3.1 Design Freedoms in Scottsdale, Arizona

Scottsdale, a fast-growing suburb of Phoenix, Arizona, encompasses 182 square miles and has a population of 175,000. On January 1, 1986, the Scottsdale City Council implemented Ordinance #1709 mandating the use of fire sprinklers in all new single-family residences.

Based on the Scottsdale Fire Department's belief that equipping new homes with fire sprinklers would greatly reduce the severity and duration of fires originating in those homes, the ordinance included the following changes:

- Housing density was allowed to increase by 4 per cent.
- Minimum street widths were reduced to 28 from 32 feet.
- Maximum cul-de-sac lengths were increased from 600 to 2,000 feet.
- Hydrant spacing was increased from 600 feet to 1,200 feet, resulting in immediate savings of $2,000 per hydrant as well as ongoing future maintenance costs.
- Required fire flow demand was reduced by 50 per cent, which resulted in a typical one-step reduction in water main size and allowed for smaller water storage tanks.
- One-hour construction standards were eliminated. Actual live testing indicated that when non-rated materials were used in conjunction with the proactive protection of fast-response sprinklers, the structure had a better chance of being less impacted by the growth and destruction associated with a typical residential fire. 'In real life experience,' a 1997 report on the Scottsdale ordinance notes, 'the theory of one hour compartmentalization is an optimistic assumption that might be effective if people did not move into the structure.'

At the time the ordinance was proposed, the major impact was a projected infrastructure saving of $7.5 million for the water distribution system. In addition, it was anticipated that the sprinkler ordinance would reduce the size or eliminate entirely at least three fire stations, with savings of $6 million in capital costs and $1 million in annual expenses.

Source: Residential Fire Sprinklers: Is Dramatic Growth at Hand? John Koski, August 29, 2000, PM Engineer.

Chapter 4
Cost and Effectiveness Assumptions

In this section, we present the assumptions we have selected for the three key variables in the cost benefit analysis of residential sprinklers: costs, effectiveness and valuation of the benefits. We also present assumptions for the cost and effectiveness of 'traditional' FRS resources (e.g. fire fighting equipment and staff).

4.1 Overview of Data Sources

To develop assumptions for the cost and effectiveness of residential sprinkler systems, we have relied *primarily* on published research, as summarised in reports and other publications from the United Kingdom, New Zealand and the United States. Our review of the literature is provided in Appendix A at the end of this report. Key findings from the literature are summarised below.

Where possible, the cost estimates found in the technical literature have been updated with quotes from vendors of residential sprinkler systems. We have contacted a total of eight vendors and received four independent quotes.

We have also relied on the comments and suggestions received during – and in the immediate aftermath of – our July 2008 workshop, and on other discussions with the Fire and Rescue Services of London, Kent and Essex, the BRE, and representatives of the sprinklers industry.

The final assumptions (i.e., those used in the CBA) were selected by us.

We understand that many of these assumptions are uncertain, and some may be controversial. We address this uncertainty through sensitivity analysis (Section 6), where we allow key variables to deviate from their 'central' base value.

4.2 Sprinklers Cost Estimates

The direct life-cycle costs of residential sprinkler systems include initial installation and water supply costs, and ongoing inspection, maintenance and replacement costs. Indirect costs include property damage associated with false triggering: the likelihood of such event, however, is reported to be low. Residential sprinkler systems are also expected to generate (indirect) cost savings, through design freedoms, i.e. relaxation of building or land use regulations in relation to fire safety.

4.2.1 Overview of evidence reported in the literature

In the technical literature, the direct costs of sprinkler systems are generally categorised as: one-off capital costs and ongoing costs. Capital costs are sometimes further split into installation costs and water supply costs.

Installation costs have two main components: raw materials needed to install the system (sprinkler heads, water pipes, valve set, etc.) and design, planning and labour costs. They vary by dwelling type, dwelling size and region.[46] They are higher for retro-fitting an existing dwelling than for installation during construction of the dwelling.

Water supply costs are the costs of ensuring that the water pressure in the sprinkler system conforms to the relevant standard. This cost depends on, among other things, the characteristics of the local water system, including:

- if the pressure of the local water supply is adequate, the cost of supplying water is limited to the cost of a dedicated pipe that links the water mains to the sprinkler system; and
- in areas of low pressure (e.g. as in and around London), a pump or water tank and pump is generally required.[47]

Ongoing costs include inspection,[48] maintenance and replacement costs. Sprinkler systems generally have a long life-span and evidence suggests that they require limited maintenance overall. Higher maintenance costs are likely if a pump is required.

Some studies (such as EC Harris (2007) – in the context of schools – and BASA (2006)) suggest possible cost savings through the relaxation of building regulations (regulations that relate to fire safety) in the presence of sprinklers. These savings would be reflected in lower construction costs. However, we take the advice of the BRE that cost savings from 'trade-offs' are expected to be limited for domestic premises.[49]

Papers such as Ford (1997) and Wade and Duncan (2000) present cost estimates that are specific to a particular country (United States and New Zealand respectively), and are not directly relevant in the present context. Nonetheless, there are important conclusions to be drawn from these studies. Evidence from Scottsdale, Arizona, for example, suggests that the average cost of fitting residential sprinkler systems fell considerably over time as the market developed.

In all the publications we have reviewed, the direct cost estimates have been obtained from vendors. Estimates obtained specifically for this study are discussed in section 4.2.2.

[46] Installation costs have a large labour component, and labour costs vary considerably across regions.
[47] Our understanding is that the water pressure in the Thames Gateway is low, and water tanks and pumps are likely to be required in some areas.
[48] This typically includes a visual inspection of the system, as well as testing of the flow switch and integrated alarm.
[49] In addition, trade-offs will be associated with changes in risks, which need to be accounted for in estimates of effectiveness.

4.2.2 Estimates received from vendors

We have contacted a total of eight vendors of residential sprinkler systems to obtain quotes for the cost of installing a British Standard sprinkler system in a new build home.[50]

Table 4.1 presents a summary of cost estimates for residential sprinkler systems (excluding pumps and tanks, and VAT) based on the two most detailed quotes we have received. We also provide comments based on the other quotes we have obtained.[51]

Points that emerge from this information include:

- the cost of installation falls for large developments, because of economies of scale in sprinkler installation;
- the cost of installation is also likely to fall over time if there is a large and stable market, because of competition between suppliers and deepening experience;[52]
- there is considerable variation in cost estimates (this may in part reflect different interpretations by vendors of what is a 'typical' property);
- although the two vendors who provided the most detailed estimates gave identical estimates of maintenance costs, one vendor noted that these can in some cases be very large; and
- the estimates provided are generally *higher* (even after adjusting for inflation) than those used in the BRE (2004) report (see Appendix A for details).

Table 4.2 provides a summary of the information we have received on the costs associated with pumps and tanks.

The figures show that the cost of residential sprinkler systems could be significantly higher in areas of low water pressure, where a tank and a pump set might be required. However the sprinklers industry notes that *'an additional cost for the provision of pumping and/or water storage may occur, but this is the exception rather than the rule when two-storey properties are concerned and especially within large well designed new build estates.'*[53]

We address this issue through sensitivity analysis.

[50] We have contacted eight vendors, as well as the FSA/RSA (Fire Sprinklers Association/Residential Sprinklers Association) and BAFSA. We have received quotes from three vendors, plus one cost estimate from the FSA/RSA.

[51] Following BRE (2004), we have distinguished between five different types of properties, and asked vendors to provide cost estimates for a 'typical' property.

[52] Note that these cost savings rely on residential sprinkler installation being a viable market for competition between suppliers over long time periods. A detailed assessment of the likelihood of this is beyond the scope of this report.

[53] Communication with Henry Lloyd, Managing Surveyor, Staysafe UK Ltd/Westminster.

4.2.3 Assumptions selected for the analysis

The assumptions selected as 'preferred' values for the CBA are presented in Table 4.3.

These estimates should be viewed as applying to an 'average' house or flat (average in terms of building size and height) in a typical development, as planned in the Thames Gateway.

We have assumed that:

- the installation of sprinkler systems in new dwellings would occur in the context of relatively large developments, keeping the average fitting costs relatively low; and
- the average cost per flat is lower than the average cost per house.

Given the uncertainty over the water storage and pumping requirements for new build homes in the Thames Gateway (which may depend in part on the proportion of flats and building specifications such as height), we vary the proportions of dwellings that have pumping requirements in the sensitivity analysis, as shown in Table 4.4.

Given the lack of evidence on how much the costs of installing and maintaining sprinklers might fall with increasing scale of application and over time, we revisit our cost estimates in the sensitivity analysis in section 6.

We assume that the sprinkler systems and tank do not require replacement over the 50-year period of the CBA model, but that pump sets require replacement every 20 years.

4.3 Estimates of Sprinkler Effectiveness

To estimate the benefits of the residential sprinklers (Options I and II) relative to the baseline, we have developed a number of assumptions regarding their effectiveness.

4.3.1 Overview of evidence reported in the literature

The effectiveness of residential sprinkler systems is typically taken to refer to the effect of sprinklers on the fatalities, injuries and property damage caused by fires. Thus, the effectiveness of sprinklers is often measured by:

- a percentage reduction in fatalities caused by fires;
- a percentage reduction in injuries caused by fires; and
- a percentage reduction in property damage caused by fires.

These measures are often estimated directly from observed outcomes (i.e. fire statistics). Direct estimates of effectiveness are based on a comparison of the number of fatalities and injuries, and the extent of property damage caused by fires in properties with sprinklers against those without.

In some cases, however, indirect methods are used. Examples of indirect approaches include exploiting the relationship between fire outcomes and another variable, whose value might be affected by sprinklers (e.g. area of fire damage in BRE (2004)), or developing estimates based on controlled experiments, as in Ruegg and Fuller (1984).[54]

Some indicators presented in the literature may be misleading. For instance, the most frequently used indicator of the effect of sprinklers on injuries is the percentage change in the *number* of injuries in premises equipped with sprinklers. This measure, however, does not account for the severity of the injuries.[55]

A second more general problem relates to how sprinkler effectiveness is estimated.

In the studies we have reviewed, a number of estimation issues result in either unreliable estimates of effectiveness, or estimates that cannot be easily compared with each other. These estimation issues include:

- Uptake of residential sprinkler systems in the UK is too limited to provide reliable *direct* estimates of effectiveness. Data availability on the performance of sprinklers in other countries is also limited. The main U.S. fire statistics database,[56] for example, contains 287,000 records (after adjustment) in one family and two family dwellings, but only 619 of these were equipped with sprinklers.
- Standards to which sprinklers are installed differ across countries, making it difficult to draw inferences from studies in other countries.[57]
- The characteristics of dwellings (including building layout, construction material, or fire safety standards) vary across countries – or even regions within countries– with important implications in terms of fire rates, the speed at which fires spread, or even the likelihood of escape in case of emergency.
- Estimates from different studies may not be consistent with each other. For example, some studies measure the effectiveness of sprinklers *plus* smoke alarms relative to the effectiveness of smoke alarms alone; others provide estimates for the joint effectiveness of sprinkler systems and smoke alarms, relative to the situation with neither.
- In some cases, estimates might suffer from a bias: regulations usually require *new* residences to be fitted with sprinkler systems, but outcomes in these residences are often compared with those in older properties that, besides not having sprinklers, tend to have other poorer fire protection characteristics.

[54] Ruegg and Fuller (1984) is not included in our review of the literature. As noted in the FSA report, this study was written at a time when there was very limited experience with the use of sprinkler systems in residential dwellings. Instead, the results from Ruegg and Fuller (1984) are discussed in the review of NIST (2007).

[55] Moreover, in the UK, any individual attended to by emergency service personnel (even for a check-up) is recorded as being injured in official fire statistics; BRE (2004), Section 3, page 5.

[56] NFIRS 5.0.

[57] The UK standard BS 9251:2005 is, however, based on US standard NFPA 13 – D.

4.3.2 Summary of findings reported in the literature

Table 4.5 presents a summary of the results reported in the publications we have reviewed. A detailed description of these studies can be found in Appendix A (Literature Review).

As can be seen in Table 4.5, the different estimates reviewed suggest that, compared to a baseline situation with no sprinklers (with or without smoke alarms), residential sprinkler systems *might*:

- reduce fatalities caused by fires by 70 to 100 per cent;
- reduce injuries caused by fires by 30 to 80 per cent; and
- reduce property damage caused by fires by 40 to 90 per cent.

The only report pertaining to the UK is BRE (2004). As explained in Appendix A, estimates of sprinklers' effectiveness derived in that study were based on an indirect approach consisting of:

- using UK fire statistics to estimate the relationship between the horizontal area of fire damage and the number of casualties caused by a fire; and
- assuming that sprinklers limit this area of fire damage (to $1m^2$).

Using that general approach, the BRE concluded (as shown in Table 4.5) that sprinklers would result in a 70 per cent reduction in the number of fatalities (with a range of ±15 percentage points), a 30 per cent reduction in the number of injuries (also with a range of ±15 percentage points), and a 50 per cent reduction in property damage (still within the same range).[58]

The BRE (2004) also reports a number of summary statistics, based on their own review of the literature. These statistics are presented in Table 4.6, for cases where only smoke alarms are present (first row), cases where only sprinklers are present (second row) and cases where both smoke alarms and sprinklers are installed.

The only other source of information on UK experiences is a case study of the Studley Green social housing development, in Trowbridge, Wiltshire.[59]

The case study (see Box 4.1 below) includes a few statistics on sprinklers installation and maintenance costs. It also confirms that sprinklers can help avoid fatalities and prevent property damage. The sample size, however, is too small to justify use of these figures in this study.

[58] The effect of sprinklers on property damage was estimated using fire statistics from the U.S. See Appendix A for details.
[59] We received information on Studley Green from Julian Parsons, Group Manager Protection, Wiltshire Fire and Rescue Service.

Box 4.1 The Studley Green case study

The Studley Green social housing development consists of 204 properties, ranging from bungalows to one-bedroom flats, to six-bedroom houses. All properties at the site have been equipped with sprinklers since 1999.

The average cost of an installation was approximately £950 (with a total capital investment of £300,000). For an average three-bedroom semi-detached property, total fitting costs might have reached £1,500.

There is an annual inspection and service cost of about £30. According to the housing association in charge of the site, replacement parts have brought the actual annual cost close to £100 (per unit).

Two fires have been successfully controlled by sprinklers since 1999. The local FRS believes that without the sprinklers activation, two lives would have been lost; and the properties would have had to have been completely rebuilt.

Finally, there have been at least two documented issues with the system. The first involving a leaking joint; the second, an occupier trying to water his garden using the sprinkler test valve.

Source: Sprinkler Update, Studley Green, Trowbridge, Wiltshire.

In summary, there is to date very limited evidence on the effectiveness of residential sprinkler systems in the UK, and – as demonstrated in this section – only limited scope for using evidence collected in other countries.

This might change in the near future as sprinkler systems are reportedly being installed in new developments in the UK, as cost-saving planning trade-offs against other factors (such as providing multiple exit routes). In addition, sprinklers have been required for all new flats in buildings higher than 30 metres since April 2007.

The latest available information relates to calendar year 2002. In that year, the FRS attended 22 fires in dwellings equipped with sprinklers. No deaths were reported. In the same period, there were 64,613 fires in dwellings without sprinklers and 443 deaths.[60]

[60] Statistics reported by the Fire Brigade Union, in *Understanding the IRMP Process*, page 21.

4.3.3 Assumptions selected for the analysis

The assumptions selected as 'base case' values for the CBA are presented in Table 4.7.

These estimates would apply in properties where sprinklers and smoke alarms are fitted, relative to a 'baseline' where only smoke alarms are installed. As a reminder, these estimates account for potential malfunctioning of the system (e.g., failure to activate).

As can be seen in Table 4.7:

- we have selected the central values developed by the BRE as our base case estimates;
- we regard these estimates as reasonable given that the overall effectiveness of sprinklers appears to be lower when smoke alarms are already present (as assumed in our study). We have chosen not to consider lower values in our sensitivity analysis; and
- the values we have selected for our 'optimistic' scenario are significantly higher than our base case estimates (and outside the ranges developed by the BRE), but still appear possible given the evidence reported in the literature.

As part of the sensitivity analysis presented in Section 6, we also estimate 'switching values' for all effectiveness variables, i.e. the minimum percentage reduction in fatalities, injuries and property damage that would be required for the sprinklers options to break even (so that total benefits equal total costs).

4.4 Cost and Effectiveness of Traditional FRS Resources

To estimate the costs under Option III (additional FRS resources) relative to the baseline, we have collected and analysed cost data including installation and building costs for FRS buildings, costs of vehicles and equipment, on-going maintenance costs, operating costs, equipment replacement costs and additional staff costs.

As we discuss in section 4.4.2, the additional FRS resources do not include the installation and building costs of additional FRS stations. Therefore, we do not report these data.

4.4.1 Cost estimates for extra appliances and firefighters

We have analysed estimates of annual operating expenses from statistics published by the Chartered Institute of Public Finance and Accounting (CIPFA) for 2006-07. Average expenses across the 1,446 fire stations in England are summarised in Table 4.8.

Average annual operating expenses in Essex, Kent and London are shown in Table 4.9. We note that the weighted averages of annual operating expenses in London, Essex and Kent are higher than the national average, but that this is driven by significantly higher costs in London.

We now discuss how we estimate the costs associated with possible changes in resources using the CIPFA operating cost data.

The types of fire station in FSEC are split into 'whole-time', 'day-crew' and 'retained'. This affects the employment costs.[61] We have been advised by CLG that a second whole-time pump and crew will require approximately 22 additional whole-time firefighters – a crew of four over four shifts during the week, plus an additional six firefighters in case of absence (based on a 'ridership factor' of 1.4). We have assumed a crew of twelve retained firefighters for a pump in a retained station.

Using CIPFA operating cost data we have calculated employment expenses per whole-time firefighter and per retained firefighter separately in London, Essex and Kent. Having cross-checked these with illustrative data from CLG, we assume average whole-time firefighter staff costs of £35,000 in Kent and Essex and £40,000 in London, and retained firefighter staff costs of £10,000 in Essex and Kent (London has no retained fire stations). Multiplying these by the number of crew members we get the following broad estimates:

- Whole-time crew employment cost of **£880,000 per year** in London and **£770,000 per year** in Essex and Kent.
- Retained crew employment cost of **£120,000 per year** in Essex and Kent.

We also use CIPFA operating cost data to calculate the transport related expenses per pump and per operational appliance. Comparing these with estimates from CLG, we have assumed an average cost per pump of **£50,000 per year** in London, Essex and Kent.

To convert all costs and benefits to market prices, we add VAT to the FRS resource costs as well as sprinkler costs.

Under Option III, changes in FRS resources (for example, employing a whole-time crew in place of a retained crew) are modelled using the differences in the annual employment costs above, as well as using the annual appliance cost.

We looked at previous firefighter pay increases published by the Fire Brigades Union.[62] Based on this, in our base case we assume an **annual real increase (above CPI)** in operating costs of **0.5 per cent**.

[61] 'Whole-time' firefighters are those whose sole employment is as a firefighter. 'Retained' firefighters are local fire-fighters who are summoned to incidents but have additional employment outside of fire-fighting. 'Day-crewed' stations are an arrangement where whole-time firefighters work at the station during the day and retained firefighters provide emergency cover at night.

[62] Fire Brigades Union, Workplace, Pay, http://www.fbu.org.uk/workplace/pay/index.php

We have cross-checked these cost estimates with CLG to make sure that they are sensible and reflect the changes in FRS provision carried out in FSEC. However, the differences between estimates derived from CIPFA data and illustrative cost estimates from CLG, the fact that additional costs may be incurred when adding resources (e.g. refurbishment costs, extra operational costs), and the uncertainty in operating cost increases over the period, all suggest a certain amount of uncertainty surrounding these assumptions. Therefore we revisit them in the sensitivity analysis.

4.4.2 Placements of additional FRS resource choices

To define Option III, we need to determine where additional FRS resources would probably be located in the Thames Gateway, given the locations and size of housing developments and the current locations and coverage of FRS resources.

To do this, we worked with the FSEC help desk, which used FSEC to model the predicted dwelling fatality risks in the Thames Gateway under current housing levels and under a scenario using current housing plans. We also looked at the current and planned utilisation of existing FRS resources pre- and post-development.

This work showed that, both pre- and post-development, no areas in the Thames Gateway were expected to have ‘well above average’ fatality risks. In addition, many areas kept the same risk rating in both scenarios, suggesting that ‘average’ and ‘above average’ risks are broadly considered to be acceptable in these areas.

The fatality risk and workload analysis suggested that it is not obvious where any new fire stations would be most required. Instead, as discussed with CLG, we looked at existing stations with high utilisation, or in high risk areas, where the level of crewing could be adjusted.

Based on this work, under Option III we have made three changes to FRS resource levels in the Thames Gateway: two additional whole-time pumps and crew; and one change from a retained crew to a whole-time crew.

Having defined this scenario, CLG staff used FSEC to provide us with new response times with these additional FRS resources. These show reduced response times in the areas around these fire stations.

4.4.3 Estimates of effectiveness

Under Option III, we model the impacts of the additional FRS resources in the areas of new dwellings using FSEC to estimate FRS vehicle response times to incidents.

We use the response times under the additional FRS resources to estimate fatalities, injuries and property loss from dwelling fires, Other Building fires and road traffic collisions in our CBA model (see Chapter 3 for details on the methodology). We provide qualitative assessments of impacts on ancillary FRS services and other incidents.

For example, in one area with a second whole-time pump and crew, the (simple) average response time for the second FRS vehicle fell by almost one minute. In the area with a change from retained to whole-time crewing, average response times for the first FRS vehicle fell by about four minutes.

To retain consistency with the sprinkler assumptions, which have a 50-year time horizon, and for simplicity of modelling, we apply the response times and annual costs with additional resources from our base year of 2007, which are then discounted to calculate present values.

We apply the same road speed projections as under the 'do nothing' option (see section 2.3.3 for details on how these are derived) to increase travel times between 2007 and 2050, although we revisit these assumptions as part of the sensitivity analysis.[63]

4.5 Other Assumptions Used in the Valuation of Benefits

Here, we discuss the assumptions required to express benefits in monetary terms.

4.5.1 Monetary values of prevented casualties

For the value of an avoided fatality, we use an estimate provided by CLG.[64] This is the value used by the Department for Transport (DfT) in the appraisal of road schemes, which is widely used in other government applications.

The social cost of a fatality is estimated at £1.547 million (in 2007 prices), taking account of personal willingness-to-pay to reduce the risk of death, net lost output, and medical and ambulance costs.[65]

Similarly, for the value of injuries, we use the estimates recommended by CLG, as follows, again in 2007 prices:

- cost of non-fatal injury involving burns = £174,354 (based on the DfT estimate for 'serious injuries');
- cost of non-fatal injury involving being overcome by smoke or fumes = £44,019 (based on a weighted average of serious and minor injuries costs); and
- other minor injuries (precautionary check ups, physical injuries) = £574.

[63] A more dynamic method may be to increase the FRS resources (and therefore reduce response times) gradually over time as new dwellings are built. However, this is a substantially more difficult scenario to define and model. We discuss this in our conclusions and as possible further work in this area.

[64] CLG, Fire and Rescue Service partnership working toolkit for Local Area Agreements, February 2008.

[65] The ODPM explained that values of fatalities and injuries used in estimating the economic cost of fire should be based on the DfT estimates but recognises that there may be differences between the age profile of fatalities in road accidents and fires, and that this may affect the average value of life.

The real monetary value of these benefits will increase over time, as real incomes increase. Following the recommendations set forth in the HM Treasury Green Book and by CLG, we adjust the above estimates in line with assumed changes in GDP per head (real increases of 2 per cent per year, throughout the appraisal period).

A problem with costing injuries is that 30 to 40 per cent of fire 'injuries' reported in UK fire statistics are only precautionary hospital referrals.[66] The extent to which fire suppression systems would help prevent 'serious' as opposed to 'slight' injuries is also unclear. We apply the same sprinkler effectiveness rates to all injuries, but we address this problem by adjusting the effectiveness in reducing injuries in the sensitivity analysis.

Finally, it is sometimes held that death – or injury – by fire is particularly 'dreaded' so that estimates of willingness-to-pay to avoid death – or injury – in a road accident may not be applicable to fire risks. However, we have found no evidence to support the idea that people are materially more averse to the risk of death from fire than from road accidents.

4.5.2 Value of averted property damage

We discussed how we calculate property damage from fires in sections 3.5.1.2 and 3.5.1.5 above. Our estimates are based on property values per m^2, calibrated using published data on the economic cost of fire from ODPM, and are already expressed in monetary terms in 2007 prices.

In the base case we assume that property damage is constant in real monetary terms over the study period from 2007 to 2050. However, it seems plausible that average property damage per fire will increase by more than inflation and people become on average more prosperous, so we look at the impacts of real increases in property damage as part of the sensitivity analysis.

4.5.3 Cost of CO_2 emissions

We follow the Department of Energy and Climate Change (DECC) guidance on the cost of carbon, as stated in its July 2009 report, 'Carbon Evaluation in UK Policy Appraisal: A Revised Approach'.

It provides a replacement of the previous approach of shadow prices based on the damage cost, basing estimates now on the abatement costs associated with emissions reduction targets. We have used DECC's central case for non-traded carbon (deflated to 2007 prices using CPI), giving us the following assumptions:

- in 2007: £47.30 per tonne;
- in 2020: £56.80 per tonne; and
- in 2050: £189.20 per tonne.

66 Communication with the BRE.

4.6 Comparisons with BRE (2004)

The Building Research Establishment Report of 2004 on 'Effectiveness of Sprinklers in Residential Properties' is described in Appendix B (as item 6). Section 6 of that Report, drawing heavily in places on data set out and interpreted in Section 3 (the Pilot Study), sets out a cost benefit analysis of sprinklers for seven types of residential premises. This current study differs in that it is applied to a specific context (the Thames Gateway), and it takes account of FRS costs as well as costs to residents and property owners.[67] However the current study shares most of the challenges of interpreting diverse data on sprinkler costs and sprinkler effectiveness to derive values to apply in the UK context.

Here, we compare the BRE methodologies with our own in these areas, considering in turn sprinkler costs, sprinkler effectiveness and general methodology.

4.6.1 Comparison of sprinkler cost estimates

As explained in section 4.2 above, the estimates of sprinkler installation costs (excluding any possible costs for pumps or tanks) obtained from vendors for this current exercise were higher than those obtained by the BRE, but by no more than might reasonably be expected given cost inflation. As also noted in section 4.2, installation of sprinklers in the Thames Gateway would probably be in relatively large developments, which should reduce unit costs. The current study therefore takes 'preferred values' for sprinkler installation costs as a little below the lower end of the nominal ranges in BRE (2004).[68]

The current study also makes a 'preferred assumption' that 33 per cent of houses and flats would be supplied directly from the mains, with no need for pumps or tanks, although sensitivity analysis is tested for this with all dwellings requiring pumps and tanks (at £1,300 per house and £400 per flat), or pumps only. BRE (2004) appears to assume that fifty percent of houses would be fitted with pumps and tanks, at a cost of £930 per house. There is little evidence to go on here. It is possible that, in the Thames Gateway, all house installations would have to be fitted with tanks[69] and pumps because of the relatively low pressure, and sometimes relatively low reliability, of water supplies in London.

Annual maintenance costs were assumed in BRE (2004) to be £50 (in 2002 prices), while in the current study, we assume these to be £75 (in 2007 prices), which, with a discount rate of 3.5 per cent per year over 50 years, is equivalent to an extra capital cost of about £1,800 per dwelling.

Overall the net difference in cost assumptions between the current study and BRE (2004) does not appear to be very substantial.

[67] BRE (2004) noted that 'The reduction in rescues required could result in lower fire brigade cover for an area, maybe fewer pumps sent to each incident or longer call out times. However for the purposes of this cost benefit analysis the benefits will not be quantified. It will be assumed that they are negligible in comparison to the other benefits.'
[68] The BRE assumption for a single house was £1,500 – £1,800 in 2002 prices. The current study assumes £1,500 in 2007 prices.
[69] Which might in fact be the tank for the domestic water supply.

4.6.2 Comparison of sprinkler effectiveness estimates

4.6.2.1 The effect of smoke alarms

BRE (2004) records some international data on the effectiveness of residential sprinklers with and without smoke alarms, which suggests that, as would be expected, the reduction in fatalities achieved by sprinklers with smoke alarms is much less than it is with no smoke alarms.

For this current study, the appropriate baseline is clearly *with* smoke alarms, as most of the properties would be new and would have alarms built in. However the BRE (2004) assessment appears to be based on historical UK fire statistics, for fires in properties of which many may not have had operational smoke alarms.[70] This factor may have greatly increased, in this respect, the estimated effectiveness of sprinklers relative to that of the current study, especially in terms of numbers of prevented fatalities.

4.6.2.2 Prevention of fatalities and non-fatal injuries

As noted in section 4.3 above and explained in Appendix B, BRE (2004) adopted an ingenious approach to measuring effectiveness at reducing fatalities and non-fatal injuries, by assuming that sprinklers would restrict residential fires to a certain maximum size. The BRE Pilot Study (Section 3 of the Report) recorded fairly robust relationships, from UK fire statistics for the seven residential property types, between horizontal fire area, numbers of fires and numbers of deaths and of non-fatal injuries per fire. From this data, figures can be estimated for reductions in deaths and in non-fatal injuries if fire areas are never allowed to grow beyond a specified maximum.

It was then assumed that 'in the absence of better information, it might be estimated that the sprinklers' effectiveness could be represented as restricting the area of fire damage to about $1m^2$.' In fact, the average was taken of the estimates for fire areas restricted to $1m^2$ and to $2m^2$.

One problem with this approach is that a strong judgement has to be made about the effect of sprinklers on fire size, on which there appears to be little or no data for residential properties. Any final estimate also has to incorporate some explicit or implicit judgement about sprinkler reliability, on which the BRE did record some international data.

The current study adopts the more transparent, and in our view analytically more robust, approach of applying judgement directly to the relevance to UK residential properties of the largely international data on sprinkler effectiveness.

However, as explained in section 4.3, we adopt the BRE (2004) *percentage* reductions in fatalities and non-fatal injuries as 'preferred values', albeit applied to smaller, smoke alarmed, baseline casualties. We also regard these percentages as conservatively low estimates. For sensitivity analysis we consider only a set of higher values.

[70] This is one of a number of questions on which the BRE chose not to respond to requests for information about their study.

4.6.2.3 Reduction in property damage

BRE (2004) explains that 'the effectiveness of sprinklers in reducing the average property damage per fire cannot be estimated from the UK statistics. Instead a typical value of 50 per cent shall be used, based on an examination of US statistics. The variability of this value is about ±15% over the different residential building types.'

The current study also takes 50 per cent as a base case value, but with only a higher value for sensitivity analysis. As part of the sensitivity analysis, we look at the impacts on our results of estimating property loss using estimated fire size under sprinklers (with fire damage restricted to $1m^2$ or $2m^2$), similar to the approach used by BRE (2004).

4.6.3 Valuation of deaths and injuries over time

Values of avoided deaths and non-fatal injuries are derived by both BRE (2004) and the current study from the figures estimated by the Department for Transport. However BRE (2004) might be criticised insofar as it assumes no real monetary increase in these values after its base year of 2002.

A more defensible assumption, as applied in the current study, is to assume that the monetary values increase according to real increases in incomes, which we assume to be 2 per cent per year. We then discount the monetary values at the Green Book rate of 3.5 per cent. For a 50 year sprinkler lifetime this increases the present value of such benefits by about 50 per cent.

4.6.4 General assumptions and methodology

4.6.4.1 Choice of numeraire

The Green Book convention is that CBA should be carried out using a numeraire of market prices, largely because willingness to pay valuations of impacts such as prevented fatalities are derived in market prices. BRE (2004) is inconsistent in comparing such willingness to pay valuations of benefits with costs that exclude VAT. The costs should have been increased, as in the current study, by adding VAT (regardless of the fact that VAT is not in fact charged to new housing).

4.6.4.2 Sprinkler installation lifetime and time discount rate

Both BRE (2004) and the current exercise assume a 'preferred' sprinkler installation lifetime of 50 years and apply the Treasury Green Book discount rate of 3.5 per cent in real terms. Under these assumptions, a sum of £100 in the base year is the present value of £4.30 per year, or £10 per year has a present value of £235.

4.6.4.3 Design freedoms

BRE (2004) noted that, 'Trade-offs' have not been investigated in [their] study since it is not possible to quantify the risk level and cost implications of all the possible options.' The BRE also advised us that the benefits of design freedoms are very small. On the other hand, as noted in section 3.7.3, the sprinkler industry places significant weight on design freedoms.

In addition, the study by the quantity surveyors EC Harris for CLG on the costs and benefits of sprinklers in schools estimated that the benefits of design freedoms allowed by sprinklers were in that context substantial; the Scottsdale, Arizona case study also found significant design freedom benefits.

Due to difficulties in quantifying these impacts, the current study follows BRE (2004) in not including any adjustment for design freedoms in the quantified net benefits. However, we do look at these in considering non-monetised net benefits.

4.6.4.4 The handling of uncertainty

BRE (2004) devotes a considerable amount of analysis to the conversion of assumptions about the uncertainty around all of the variables into estimates of the probability that a particular application of sprinklers will have a positive net present value.

There are two fundamental problems with this process. One is that most of the uncertainty estimates are based on little, if any, empirical evidence. The other is that the probability that a present value will be positive is not often of much interest in public policy (whereas for a private enterprise the risk of the financial outturn of a project falling below some critical value may be catastrophic). Of much more interest in most public policy applications is the expected value.[71]

A further problem with the BRE (2004) approach is its lack of transparency. A virtue of sensitivity analysis is that it allows readers to apply their own judgements about the inputs and obtain some idea of how changes from the analyst's main assumptions might affect the outputs.

The current study thus uses the more conventional approach of sensitivity analysis to test the effects of uncertainties in the inputs.

[71] In cases where (in contrast to the case of sprinklers in private premises) there is a constrained input such a public expenditure, the ratio of benefits to that input is also of course of great interest for setting expenditure priorities.

Chapter 5
Cost Benefit Analysis Results

In this Chapter we present summaries of the monetised social costs and benefits – along with non-monetisable impacts – from the perspective of society as a whole. We also consider, in Chapter 7, other perspectives, such as the public sector and the Fire and Rescue Services (FRSs).

As discussed in Chapter 3, we have retained the 'do nothing' as our baseline scenario. The three other Options we have assessed against 'do nothing' are:

- Option I: installation of British Standard sprinklers in all new dwellings, without additional FRS resources;
- Option II: installation of British Standard sprinklers in all new dwellings which are part of the social housing sector, without additional FRS resources; and
- Option III: additional FRS resources (such as new fire stations, or additional crew and equipment) in the areas of new dwellings, without sprinklers being installed.

We present costs and benefits separately for each of the three Fire and Rescue Authorities (FRAs) (London, Essex and Kent), and for the entire Thames Gateway region.

The annual cost and benefit estimates are presented as social net present values. We also present in most cases the ratios of gross present value benefits to present value costs, to illustrate in another way how the costs and benefits compare. However, since we do not consider in this study any major constraints (e.g. those imposed by CLG or FRS budgets) the choice between options is indicated by the maximisation of net social benefits, rather than by ranking in terms of benefit-cost ratios.[72]

We have paid particular attention to the interpretation of the numbers and to their implications for decision-making. In Chapter 7 we comment in more depth on their potential applicability to other geographical areas, and any generic conclusions that can be drawn from them.

[72] This is sometimes referred to in economic literature as the 'fundamental principle' of cost benefit analysis. One problem with using benefit-cost ratios in isolation (for example), is that they are determined by the classification of impacts as either benefits or costs, which may not be clear-cut (net benefits on the other hand are not affected by the classification). For further explanation see, for example, Gramlich, E. M., *A Guide to Benefit-Cost Analysis*, 2nd Edition, 1990.

5.1 Comparative Life Cycle Cost Estimates

The total undiscounted costs of installing the sprinklers (Options I and II) and the costs of additional FRS resources (Option III) are shown in Table 5.1.

The costs are presented as totals over the 50-year time horizon and as a cost per year. They are in real terms, in the money value of 2007 (described as '2007 prices'). Thus the increases in many of the values over time are unrelated to inflation. Total sprinkler costs are highest for the areas with the most growth in housing (e.g. the London area of the Thames Gateway).

The relative total costs of Option I and Option II depend on the assumed proportion of new housing that is social housing. For example, the Essex Thames Gateway sprinkler cost under Option II is 25 per cent of the cost under Option I, equal to its social housing target of 25 per cent.

The additional FRS resources under Option III have been placed in London and Kent only and so the costs (and the benefits) are estimated for the London Thames Gateway and Kent Thames Gateway only.

5.2 Economic, Social and Environmental Impacts

Table 5.2 shows the CBA model outputs for 2007, 2020 and 2050. These include impacts from dwelling fires, Other Building fires and road traffic collisions (RTCs), in terms of numbers of fatalities and injuries, the cost of property loss, and the cost of CO_2 emissions. The relationships used in the model mean that the outputs (e.g. number of fatalities) are not necessarily round numbers.

The numbers of fatalities and injuries and the cost from property loss and CO_2 emissions increase between 2007 and 2050 due to growth in housing and population, as well as real changes in the valuation of impacts and increases in travel times.

As sprinklers are installed in the model after 2007, the model outputs are the same for 2007 under each Option. However, with sprinklers being installed in new housing up to 2020 and 2050 in Options I and II, the dwelling fire fatalities, injuries and property loss in these years are below those in the 'do nothing' baseline. The sprinkler Options do not affect impacts from Other Building fires or RTCs.

Under Option III (additional FRS resources), there are impacts in 2020 and 2050 on all the model outputs, including those impacts of all building fires and of RTCs (relative to the 'do nothing' baseline).

5.3 Present Value of Costs and Benefits

Table 5.3 shows the model outputs in terms of present values (i.e. discounted sums) for 50 years from 2007.

Table 5.3 also shows the differences between present values under each Option and present values in the baseline. Under Option I, for example, the present value of the costs of dwelling fire fatalities in the London area of the Thames Gateway is £51.1 million lower than under 'do nothing', which can be interpreted as a benefit from installing residential sprinklers. Under Option III, this dwelling fire fatalities benefit from additional FRS resources is £0.38 million.

Table 5.4 summarises the present values of costs and benefits under each Option, aggregated over the whole Thames Gateway area. The benefits represent differences in the present values of fire and RTC impacts between the Options and the 'do nothing' baseline. The costs are additional costs, relative to the baseline, from either installing sprinklers in new homes or providing additional FRS resources.

Table 5.4 shows that the estimated benefits from installing sprinklers in all new dwellings, or all new social housing sector dwellings, are lower than the costs of installing the sprinklers (including installation costs, water supply costs, replacement costs and maintenance costs). For Option I and Option II, for the whole Thames Gateway, we estimate the aggregate benefits to be respectively 35 per cent and 55 per cent of the costs.

The higher (less negative) net social benefit and benefit-cost ratio for Option II reflects the assumption that rates of fire are higher in social housing. This increases the number of prevented deaths, injuries and levels of property damage per dwelling when sprinklers are installed, without changing the costs of installation.

Looking at benefit-cost ratios, the CBA results split by area suggest that installing sprinklers in new homes in London is closer to being cost beneficial than in Essex and Kent. This is mainly driven by the following differences:

- The FSEC results, used in our CBA model for 2007, show that rates of fire are higher in London than in Kent and Essex;
- A larger proportion of new housing in London, relative to Essex and Kent, is assumed to be in the social sector, with the social housing sector assumed to have a higher rate of fire; and
- Road speeds are assumed by 2020 and 2050 to decrease by more in London, increasing FRS travel times relative to Essex and Kent.

Other reasons are that the FSEC results show a slightly higher average number of casualties per fire in London than in Essex and Kent, and that the fire rates that matter most are those in local areas with the greatest housing growth. Some simple analysis indicates that housing growth in London, in particular, is concentrated in areas with above-average rates of fire.

For Option III (additional FRS resources), the estimated benefit-cost ratio for the entire Thames Gateway (0.53) is similar to that for Option II (installing sprinklers in social housing only), but the net social benefit is higher for Option III. Table 5.3 shows that *most* of the benefits under Option III are from reduced RTC fatalities, which does not result from Options I and II. Most of the benefits under Options I and II are from reduced dwelling fire fatalities and property damage.

Given the negative net social benefits under each Option, we conclude that none of the Options appear to be cost beneficial when compared with the 'do nothing' baseline. The lower net social benefits for Options I and II than Option III mean that, even with inclusion of the FRS resources saved with Options I and II, the costs of installing domestic sprinklers still exceed the benefits.

Looking separately at the London, Essex and Kent areas of the Thames Gateway, we estimate that in Kent the installation of sprinklers in new social housing (Option II) is preferable to (i.e. has a lower net social cost than) increasing conventional FRS resources (Option III). However, the difference is small, and the benefits under Option II are only 30 per cent of the costs.

To check the robustness of our modelling results, we have carried out a number of 'top-down' cross-checks. For the 'top-down' analysis, we have cross-checked our model results against results from FSEC, the National Model, CLG's *Fire Statistics for the UK* (e.g. using the proportion of the UK population within the Thames Gateway), and the ODPM's *Economic Cost of Fire*. Our results are broadly consistent with the outputs that would be expected from inspection of these sources. In some cases where estimated impacts (e.g. the numbers of fatalities) are slightly lower than we might expect from UK-wide data, this supports our finding from FSEC modelling that FRS coverage in the Thames Gateway is already fairly good.

5.4 Non-Monetised Costs and Benefits

In this section we look at the impacts of domestic sprinklers or additional FRS resources that it has not been practicable to monetise in our cost benefit model. As mentioned in section 3.5.2.2 we focus here on a qualitative assessment of the potential effect of these non-monetised impacts, rather than using a formal scoring mechanism, given the very weak evidence on the likely magnitude of such impacts.

Box 5.1 shows the potential costs and benefits that have not been monetised for Option I (sprinklers in all new housing) and Option II (sprinklers in all new social housing). Box 5.2 shows potential costs and benefits that have not been monetised for Option III (no sprinklers, additional FRS resources).

Box 5.1 Non-Monetised Costs and Benefits from Sprinkler Options I and II

Benefits

- *Reductions in the level of FRS resources* under Options I and II not accounted for under Option III (e.g. fewer FRS staff needed for dwelling fires with sprinkler activation relative to non-sprinklered dwelling fires, and reductions in water used by the FRS to suppress sprinklered fires).
- *Benefits from changes in the mix of existing FRS resources* under Options I and II not accounted for under Option III (e.g. staff time allocated to more productive tasks).
- *Additional benefits from modelled impacts*, including reduced property loss from water damage caused by the FRS.
- *'Leakage' benefits from reductions in the demand for FRS resources* (resource savings and reallocation of existing resources) *outside the Thames Gateway region* given sprinkler installation within the Gateway.
- *Environmental benefits from reductions in pollutants other than CO_2* resulting from fires, including pollutants in water from run-off at FRS incidents and those from the reconstruction of housing.
- *Planning gains from the installation of sprinklers*, including the ability of developers to provide narrower streets, longer dead-end streets, fewer fire hydrants and to reduce the distance between houses.
- *'Leakage' benefits from reductions in costs of installing sprinkler systems in the rest of the UK* due to economies of scale and experience from the roll-out of sprinklers in the Thames Gateway.

Costs

- *Environmental costs from the installation of sprinklers* (e.g. importing of necessary materials, construction of new water infrastructure).
- *Property damage from false sprinkler activations*.

Although the list of non-monetised benefits under Options I and II is longer than the list of costs, most of these benefits are unlikely to have a material impact. We have also shown that environmental costs do not appear to be significant relative to the other costs of fire.

However, some of the non-monetised impacts may be important. In particular, we are likely to have underestimated the benefits from sprinklers in producing FRS resource savings and improving productivity. A large proportion of incidents attended by the FRS are unrelated to fires (20 per cent of incidents in England in 2007-08, as shown in Appendix B.1.3), and the FRS also carries out a large number of other activities, including building risk checks and education. There may be significant benefits from sprinklers from focussing FRS resources on activities other than dwelling fires, which have not been captured in our model. This applies both within and outside the Thames Gateway region. We have not included any impacts on insurance premiums because these cash flows are in effect transfers of wealth. The payments affect the distribution of the burden of fire damage, but not the level of damage.

The other benefits that are likely to be significant are the planning gains from the installation of sprinklers. These are discussed in section 3.7.3 and include cost reductions from design freedoms in new developments and the relaxation of fire safety requirements. The U.S. Scottsdale case study suggests that these benefits in that case were very significant. However such planning freedoms may well reduce the other beneficial impacts of sprinklers, so at least partially offsetting the benefits from cost reductions.

Given that the environmental benefits from reductions in CO_2 caused by fire were only a small part of the benefits under Options I and II, we would not expect the environmental costs from the installation of sprinklers to have a material impact on the conclusions. In addition, as discussed in section 4.2, the probability of false triggering of sprinklers is reported to be low, and so we would not expect this cost to be material.

Box 5.2 Non-Monetised Costs and Benefits from FRS Resource Option III

Benefits

- *Benefits from increases in the supply of FRS resources* (and therefore reductions in response times) *for attending incidents not included in our model*, including lift rescues, major incidents and any additional incidents resulting from major infrastructure schemes in the Thames Gateway.
- *Additional benefits beyond the modelled impacts*, including reductions in injuries from Other Building fires.
- *Benefits from increases in the supply of FRS resources for carrying out ancillary services* such as Home Fire Risk Checks and educational visits.
- *'Leakage' benefits* from increases in the supply of FRS resources *for attending incidents and providing ancillary services outside the Thames Gateway*.
- *'Leakage' benefits from any FRS resource savings outside the Thames Gateway* resulting from extra resources within the Gateway.
- *Environmental benefits from reductions in pollutants other than* CO_2 resulting from fires.
- *'Multiplier' benefits resulting from the increase in employment and therefore income* from additional FRS resources.

Costs

- *Environmental costs resulting from additional FRS resources* (e.g. pollutants from appliances).
- *Costs* from providing FRS resources *not included in the construction and operating costs*, including any costs from land use, disruption during construction, and blight.
- The *opportunity cost* of the public funds spent on additional FRS resources.

Box 5.2 shows that the list of non-monetised benefits under Option III, as with Options I and II, is longer than the list of costs. However, most of the benefits and costs are unlikely to have a material impact on the results or conclusions.

The most important non-monetised impacts are likely to include the non-monetised benefits from increasing FRS resources on the response times to incidents not included in our model and from increasing availability for ancillary services such as Home Fire Risk Checks and educational visits. However, this may be partly offset by some extra costs of such expanded FRS activities.

On balance it seems possible that the net monetised benefits are underestimated under Options I and II in particular, mainly because of planning gains and FRS resource savings not included in our model. Under Option III, it is difficult to predict the net impact of non-monetised benefits (e.g. from focussing FRS resources on incidents and activities not included in our model) and costs (e.g. opportunity cost of public funds).

For Options I and II to be cost-beneficial compared with ‘do nothing’, Table 5.4 shows that any additional present value benefits would need to be approximately £250 million and £70 million for each Option respectively. It seems unlikely that the net non-monetised impacts would fully reduce these shortfalls.

5.5 Assessment of Value for Money

Table 5.5 summarises the monetised costs and benefits for each Option, relative to the ‘do nothing’ baseline and relative to Option III.

As discussed in sections 5.3 and 5.4, the figures suggest that the costs of installing sprinklers in all new housing in the Thames Gateway would greatly exceed the social benefits. This applies whether we take the ‘baseline’ (or ‘benchmark’) as ‘do nothing’, or ‘additional FRS resources’ (Option III).

However, when comparing the net benefits in Table 5.4, we did find some limited evidence that installing domestic sprinklers in new social housing could lead to net social benefits similar to or somewhat greater than those of providing additional FRS resources. Therefore, the installation of sprinklers in new social housing might, from these figures, be justified as an alternative to additional FRS resources, if such resources on the scale specified in Option III were to be proposed.

In this study we have separately examined different policy options. However, it seems likely that some combination of fire prevention measures targeted at the highest risk areas (whether from domestic sprinklers in social housing, smoke alarms, education or other measures) and additional fire cover will be more beneficial than the discrete options considered in this study.

In considering the non-monetised costs and benefits discussed in section 5.4 we conclude that benefits may be somewhat underestimated under Options I and II. The net impact of non-monetised benefits and costs on Option III is less clear. Therefore, inclusion of the non-monetised benefits and costs may change the ranking of the Options in net benefits terms, although it is likely that any sprinkler policy should still focus on the higher risk social housing sector, rather than providing economic justification for installing sprinklers in all new housing.

In Chapter 6 we discuss and present sensitivity and switching value analysis around key modelling parameters and their implications for our conclusions.

In Chapter 7 we bring together the key findings from this report, and look at how our conclusions might be generalised beyond the Thames Gateway.

5.6 Effects on Housing Supply and Demand

In its 2007-08 Fire and Resilience Research Programme, CLG identifies as a strategic priority the delivery of '…a better balance between housing supply and demand, by supporting sustainable growth, reviving markets and tackling abandonment.'[73] CLG has asked NERA to consider, as an addition to the cost benefit analysis of sprinkler options, the effects of a requirement to install sprinklers in all new homes on the supply, demand and affordability of new homes in the Thames Gateway.

Our understanding of the potential effects on housing supply, demand and affordability, is as follows:

- House prices in the Thames Gateway are predominantly determined by general market conditions in and around the Greater London area, where land values are high and development and construction costs have relatively smaller impacts on asking prices.
- In some cases the costs of the sprinkler-based approach may be borne by developers in the form of reduced margins, with little or no impact on affordability and demand; similarly, the cost of the additional FRS resources under Option III could be borne by developers (through the Section 106 agreements).
- HBOS house price data for 2007 showed the standard house price to be around £310,000 in Greater London and about £260,000 in the South East. An installation cost for sprinklers plus pump and tank water supply of £2,800 per house (see section 4.2.3) thus equals about 0.9 per cent of typical house prices in Greater London and about 1.1 per cent in the South East.[74] These small proportions suggest that sprinklers are unlikely to have a material impact on housing supply and affordability.

There is a possibility that buyers will attach value to sprinklers, increasing demand for housing with sprinklers. However, a requirement for sprinkler installation would not in our view have a significant impact on the supply, demand, or affordability of housing within the Thames Gateway.

[73] Communities and Local Government, *Fire and Resilience Research Programme 2007-08*, page 9.

[74] We would expect these percentages to be even smaller as we have not taken into account the cheaper cost of sprinkler installation in flats, the possibility that the water supply costs are not included, and any additional savings in costs from installing sprinklers in large numbers of housing.

Chapter 6
Sensitivity and Scenario Analysis

To assess the level of uncertainty in our CBA outcomes, and evaluate the extent to which these outcomes may vary as a result of changes in estimating assumptions and model parameters, we have:

- identified the most uncertain and 'critical' variables, i.e. the variables whose plausible variations would have the greatest impact on the CBA outcomes;
- estimated 'switching values', i.e. determined the value that variables would have to take to have an Option produce zero or positive net social benefits; and
- conducted a scenario analysis, where all CBA outcomes are estimated under what would be for sprinklers a pessimistic scenario (constructed as a set of assumptions leading – other things being equal – to an increase in costs, or a reduction in benefits), and under a corresponding optimistic scenario.

In addition, we have carried out a *qualitative* risk assessment, with the identification of key risk factors and a discussion of their possible impacts on the relative performance of the options.

6.1 Identification of Critical Variables

In this section we check the impacts on our results, and possible implications for our conclusions of making changes to critical or uncertain base case assumptions.

We present these sensitivity results for the whole Thames Gateway only. Although benefit-cost ratios are not in this case appropriate for prioritising Options, these are in some cases presented in this section to provide helpful background information.

6.1.1 Sprinkler installation costs

We first look at the sensitivity of the cost benefit results under higher and lower installation costs for sprinklers. The assumptions for high and low sprinkler costs are taken from Table 4.3. We retain the assumption that installation costs are constant in real terms over the 50-year horizon.

The cost benefit results under the base case, low installation cost and high installation cost scenarios are shown in Table 6.1. The changes in costs do not have a material impact. In particular, the increase in the net benefits for Option II under low installation costs is much less than sufficient for its net benefits to become less negative than those for Option III, which remain unchanged.

6.1.2 Water supply and replacement costs

In this section we look at the sensitivity to higher and lower water supply and replacement costs. In the base case we assumed that 33 per cent of dwellings with sprinklers did not need a pump or tank, 33 per cent needed a pump and 33 per cent needed both a pump and tank. For the low cost scenario, we take the extreme case where 50 per cent of dwellings do not need pumps or tanks, and 50 per cent need pumps only. For the high cost scenario, we take the other extreme case where 100 per cent of dwellings need pumps and 50 per cent also need tanks.

The results under the base case, low and high cost scenarios are shown in Table 6.2. Under the low cost scenario, the net benefits for both Option I and Option II are still more negative than those of Option III, which remain unchanged. However, the net benefits of Options I and II are significantly less negative under the low cost scenario.

6.1.3 Sprinkler annual inspection and maintenance costs

In this section we look at the sensitivity of the results under higher and lower annual maintenance and inspection costs. In the base case we assumed that the annual costs are £75 on average. For the low and high cost scenarios, we assume annual costs of £50 and £100 respectively.

The cost benefit results under the base case, low and high cost scenarios are shown in Table 6.3. These changes in costs do not have a material impact.

6.1.4 Real changes in sprinkler costs

We have assumed in the base case that sprinkler costs stay constant in real terms over the 50-year time period. We are therefore assuming that any real increases in costs from above-inflation rises in labour and materials costs are offset by real decreases in costs from economies of scale, technological advances and competition between vendors.

It is plausible that costs might fall in real terms. We look at the results with 1 per cent and 2 per cent annual falls in installation costs and water supply and replacement costs. A 2 per cent annual reduction has a moderately significant effect.

6.1.5 Sprinkler effectiveness

This section looks at the sensitivity of the results to higher sprinkler effectiveness parameters. The assumptions for higher effectiveness are from Table 4.3, and show greater effectiveness of domestic sprinklers in reducing fatalities, injuries and property loss from dwelling fires. We also run a high effectiveness scenario where we differentiate between the effect on serious injuries (involving burns) and slight injuries. In this scenario we assume that instead of 60 per cent effectiveness on all injuries, sprinklers reduce serious injuries by 75 per cent but slight injuries by only 45 per cent.

The results under the base case and high sprinkler effectiveness scenarios are shown in Table 6.5. The changes in effectiveness have a relatively large positive impact on the net present values of both Options I and II, particularly in the case where serious injuries are differentiated from slight injuries. Also, in both alternative scenarios, the net present value of Option II is less negative than that of Option III. Sprinkler effectiveness is revisited in the scenario analysis in section 6.2.

6.1.6 FRS resource costs

This section looks at the sensitivity of the cost benefit results to higher and lower FRS resource cost parameters. The high and low cost scenarios show costs that are 25 per cent above and 25 per cent below the base case respectively.

The results under the base case, low and high cost scenarios are shown in Table 6.6. The net benefits for Options I and II are unaffected by these changes. However, even under the assumption of high FRS resource costs, Option III still has a less negative net present value than the other two alternatives.

6.1.7 Real changes in FRS resource costs

This section looks at the sensitivity of the results to changes in the real growth in annual FRS resource costs. In the base case we have assumed real growth of 0.5 per cent per year (under the CPI inflation assumption of 2 per cent per annum), based on Fire Brigade Union data on wage rises for fire fighters (see section 4.4.1). We now look at scenarios where there is no real growth in FRS resource costs and where there is 2 per cent real growth per year (based on historical nominal wage inflation in the UK of 4 per cent).

The results under the base case, low and high cost scenarios are shown in Table 6.7. We reach the same conclusion under the assumptions of both low and high real cost growth as with the base case scenario. When there is no real growth in costs, the net benefit of Option III becomes less negative. When there is real growth of 2 per cent in costs, the net benefit becomes more negative. In this case, however, it reaches a similar level to, but does not become more negative than the net benefit of Option II.

6.1.8 Changes to the proportions of houses and flats

This section looks at the sensitivity of the cost benefit results to a change in the proportions of new dwellings in the Thames Gateway that are flats or houses. As discussed in section 2.3.1, in our modelling we have assumed that the proportions of new flats and houses are equal to the proportions for existing dwellings up to 2007 in each region.

While this seems like a reasonable starting assumption (especially as there do not seem to be targets for proportions of flats, for example, set for the Thames Gateway), it is possible that the proportion of flats will be higher in new housing, either because developers wish to build more housing units per area, or because the proportions are different within the social housing sector, for which there are regional government targets.

We look at a scenario where the ratio of flats to houses is 50:50 in each of the (London, Essex and Kent) areas of the Thames Gateway. This represents an increase from the base case in the proportion of flats in each area. Table 6.8 shows that the effect of this change on the results is very small.

6.1.9 Changes to the rates of fire by housing type

This section looks at sensitivity to changes in the rates of fire by housing type. In the base case we assume that the rates of fire are 50 per cent higher in the social sector than the all dwelling average, and that non-social sector dwellings have rates of fire that are 30 per cent (for London) or 10 per cent (for Essex and Kent) lower than the average for all dwellings.

We assume two alternative scenarios. In one there is no difference in the fire rates, all properties being subject to current average rate. In the other the fire rates are larger for social sector dwellings (100 per cent greater than the average for all dwellings) and rates for other dwellings are well below the average.

Results under the base case and the alternative scenarios are shown in Table 6.9. Removing the difference in fire rates between social and non-social housing, the net present values for Options I and II both become more negative, whilst there is only a negligible change in the net present value for Option III. When the difference in fire rates becomes larger, the net benefits for Options I and II become less negative, with a greater proportionate increase for Option II. This is because sprinklers are concentrated in higher-risk housing, such as social housing. This effect is significant for Option II, and brings its net benefit much closer to the net benefit for Option III.

6.1.10 Changes to road speeds and travel times

This section looks at the sensitivity to different changes in road speeds (and hence travel times) between 2007 and 2050. For sensitivity we consider the possibility that housing and population growth in the Thames Gateway dramatically increases travel times. In particular we assume that travel times are 20 per cent and 60 per cent higher by 2020 and 2050 respectively in London, and 10 per cent and 30 per cent higher in Essex and Kent. This increases the net benefit of sprinklers.

The results under the base case and high travel time changes are shown in Table 6.10. For all three Options, these changes in travel times have very little impact on net present values. For Options I and II in particular, decreases in fatality costs are partially offset by increases in injury costs, reducing any additional benefits from installing sprinklers in new housing.

6.1.11 Changes to property damage cost growth

In the base case we have assumed that property damage costs per fire (for dwellings and Other Buildings) remain constant in real terms over the period. While this seems like a reasonable starting point, it is possible that property damage costs will increase at a rate above general inflation, for example in line with property price rises. Therefore, in this section we look at the sensitivity of the cost benefit results to two scenarios with annual real growth in property damage costs of 2 per cent and 4 per cent respectively.[75]

The effects of these changes are shown in Table 6.11. With annual real growth in property damage costs of 2 per cent, the net benefits of all options become less negative, although only slightly in the case of Option III. With annual real growth of 4 per cent, the effect becomes very substantial, although for all Options the net benefits are still heavily negative. Under this scenario the net benefits of Option II are less negative than those of Option III. This means that Option II, in terms of net present values, is preferred to Option III.

6.1.12 Changes to time horizon

In the base case we have used a time horizon of 50 years to calculate the sum of discounted costs and benefits. For sensitivity analysis, we look at the cost benefit results under 30-year and 40-year time horizons.

Table 6.12 shows the results under the base case, 30-year and 40-year horizons. Under the shorter time horizons, the net present values for all three options are slightly more negative than in the base case. This effect is more pronounced under the 30-year time horizon, although the changes in net present values are still small.

6.1.13 Changes to fire growth calculation

In the base case we have calculated dwelling fire property damage by means of a linear fire growth calculation, calibrated using published data (see section 3.5.1.2). Based on stakeholder advice, we have also built into the CBA model a capability to calculate property damage under time-squared fire growth (see section 3.5.1.2). We look at the sensitivity of the cost benefit results to the choice of method under the case where the time-squared growth is unadjusted, and the case where it is calibrated using published data.

Table 6.13 shows the results under the base case, and under the adjusted (calibrated) and unadjusted time-squared methods. The differences are minimal under the adjusted time-squared method. Using the unadjusted time-squared method, the net present values of Options I and II are significantly less negative, but still more negative than those of Option III, which improves slightly.

[75] It is likely that property damage growth will not be the same between dwellings and Other Building types, and between the London, Essex and Kent regions. However, it seems highly unlikely that average real growth over the Thames Gateway would be more than 4 per cent per annum and so the sensitivities should be considered bounds for the results.

6.1.14 Changes to dwelling fire property loss rates

This section looks at the impacts on the results of higher or lower property loss rates for dwelling fires. For the sensitivities we assume that the average loss rates, in terms of damage costs (in 2007 prices) per minute, are 75 per cent and 125 per cent of the rates assumed in the base case.

The results under the base case and these alternative scenarios are shown in Table 6.14. When average loss rates are lower, the net benefits of all Options become more negative; and conversely when average loss rates are higher. However these effects are not significant.

6.1.15 Changes to calculation of sprinkler impact on property loss

In the base case we have calculated the impact of residential sprinklers on property damage as a percentage reduction in total property damage. We have built an alternative formulation into the model, in which sprinklers restrict the size of the damaged area. We look at the sensitivity of the cost benefit results when the average size of the damaged area is restricted to $1m^2$ and $2m^2$.

Table 6.15 shows the cost benefit results when this alternative methodology is used. Under the assumption that the average size of the damaged area is no more than $1m^2$, the net benefits for Options I and II increase slightly. When the average size is restricted to only $2m^2$, the net benefits for Options I and II both become less negative, but the effect is very small.

6.1.16 Changes to smoke alarm adjustments in new housing

In the base case we have used published data to make adjustments for smoke alarms to dwelling fire fatality rates (per casualty) and average fire reporting times (which determine property damage) in new housing; we have assumed that smoke alarms are fitted in all new housing (see section 2.4.2). In this section we look at the sensitivity of the results when these adjustments for smoke alarms are removed (i.e. there is no difference between new and existing houses), and when these adjustments are larger (i.e. the difference between new and existing houses is larger).

The effects of these changes are shown in Table 6.16. When smoke alarm adjustments are removed, the net benefits for Options I and II are slightly less negative. When adjustments are larger, the net benefits for Options I and II are slightly more negative. However, there is little impact on the net benefits for Option III. But these effects are not significant. (The impact under the 'No Difference' scenario for Option III is small but appears as zero because of rounding.)

6.1.17 Changes to FRS response effectiveness in road traffic collisions

This section looks at the sensitivity of results to changes in the effectiveness of FRS responses to road traffic collisions, as measured by changes in fatality rates under different response times. In the base case we have assumed that the fatality rate falls by 36 per cent when response times fall from 6-10 minutes to 0-5 minutes, and increases by 29 per cent when response times increase from 6-10 minutes to above ten minutes. For sensitivity we look at scenarios where the impact of response times on fatality rates is smaller and where it is larger.

Table 6.17 shows the results under the base case, and these alternative scenarios. As Options I and II do not include impacts on RTCs, the net benefits for these Options are unaffected by these changes. As expected, changes in the effectiveness of FRS responses have a significant effect on the present value of net benefits for Option III. When FRS responses are less effective at reducing fatalities, the net benefits for Option III fall considerably. In this case, it is no longer clear that Option III is better than Option II. Correspondingly, when FRS responses are more effective, the net benefits for Option III increase significantly. The material conclusions in both cases, however, are the same as those under the base case.

6.2 Scenario Analysis

In this section we have constructed scenarios to examine the impacts of changing multiple parameters and assumptions in our CBA model.

The sensitivity analysis highlighted the sprinkler effectiveness and sprinkler cost assumptions as having some of the largest impacts on the cost benefit results. In addition, there seems to be a large degree of uncertainty and variation in estimates of domestic sprinkler costs and sprinkler impacts. Given this, we have run two scenarios that represent consistent overestimation or underestimation of effectiveness and costs relative to the base case. Table 6.18 shows the cost benefit results under the base case, and under these two scenarios.

In the first scenario we apply the high sprinkler effectiveness assumptions (see section 6.1.5), the low cost assumptions for installation costs (see section 6.1.1), annual inspection and maintenance costs (see section 6.1.3) and water supply and replacement costs (see section 6.1.2), and also assume that sprinkler costs (excluding annual costs) fall in real terms by 1 per cent per annum (see section 6.1.4).

Under the first, 'sprinkler-friendly' scenario, as we can see from Table 6.18, the net benefits for both Option I and Option II are less negative than the net benefit for Option III. Indeed the net benefit for Option II becomes positive.

In the second, 'sprinkler-unfriendly' scenario we apply the base case sprinkler effectiveness assumptions, the high cost assumptions for installation costs, annual inspection and maintenance costs and water supply and replacement costs, and also assume that sprinkler costs (excluding annual maintenance costs) rise in real terms by 1 per cent per annum (for example, due to real increases in input costs).

As Table 6.18 shows, and as expected, the higher costs under the second scenario significantly reduce the net present values of Options I and II, but do not affect the net present value of Option III. Therefore, as in the base case, Option III has the highest net benefit of the three Options, but this remains negative.

6.3. Determination of Switching Values

We also calculate switching values for different parameters, for each Option, identifying the sets of parameter values that would move the net benefit of the Option from negative to positive, relative to the ‘do nothing’ Option.

We consider sprinkler effectiveness (Table 6.19), real sprinkler cost growth (Table 6.20), sprinkler installation, inspection and maintenance costs (Table 6.21), and FRS resource costs (Table 6.22). In each case we vary multiple parameters simultaneously. Thus the combinations chosen are samples from indefinite numbers of possibilities, and presented for illustrative purposes. Values used in the base case are also presented for comparison.

Table 6.19 shows the switching value results for sprinkler effectiveness. Under Option I, there are no parameter values such that its net present value is greater than or equal to zero. Under Option II, the rates for fatalities, injuries and property loss must all increase to 90 per cent to raise the net present value of the Option to zero. These are significantly above the values assumed under the base case. Switching values do not exist for Option III as its net present value is unaffected by sprinkler effectiveness.

Table 6.20 shows the switching values for real sprinkler cost growth. Under Option I, installation costs, inspection and maintenance costs, and water supply and replacement costs must all fall in real terms by at least 7 per cent each year in order to generate a positive net present value. For Option II, all costs must fall in real terms by at least 4 per cent each year. Compared to the base case of flat costs, this requires a significant year-on-year fall in costs.

Switching value results for sprinkler installation, inspection and maintenance costs are presented in Table 6.21. For Options I and II, these costs must all fall considerably in order to generate a positive net benefit; we keep the differences in costs between houses and flats similar in all cases. The reductions required for Option II, however, are significantly less than those for Option I.

Finally, switching value results for FRS resource costs are shown in Table 6.22. To make Option III beneficial in net terms, the annual cost for an additional whole-time pump must fall to £500,000 for both London and Kent, and the annual cost for changing from a retained to a whole-time pump must fall to £500,000 in Kent. In each case, this represents an approximate halving of annual costs.

6.4 Identifying Other Key Risks

In addition to the sensitivity results presented in this chapter, there are a number of other risks that might materially affect the CBA results. We identify and discuss below the implications of some of the key risks.

- There is a risk that the **housing, population, Other Building and road speed projections** for the Thames Gateway are significantly incorrect. In particular, a poor outlook for the construction industry currently (including private property development) could mean that housing growth rates are below current targets. As sprinkler costs and benefits in our model are both driven by housing growth, we would not expect these changes to have large impacts on the CBA results for Options I and II. However, it would reduce the net benefits from additional FRS resources under Option III unless the costs of added FRS resources were reduced (which may be difficult if investment is 'lumpy').
- We have assumed no changes in fire rates arising from **changes in population demographics or decay in housing quality over time**. It is possible that an ageing population and decaying housing quality could lead to increases in fire rates over time, which would increase the benefits from installing sprinklers or providing additional FRS resources. However, there is also a risk that new housing will attract a population demographic with lower fire risks, so reducing the benefits of more fire protection.
- We have assumed that the **proportions of new dwellings that are social housing** are based on regional targets. The targets are above the current proportions of social housing and this implies risks that fewer new dwellings than predicted will be social housing. This would reduce the overall risks of dwelling fires, and so reduce the benefits of installing sprinklers in all new housing, or providing additional FRS resources.
- There are risks that **FRS demands do not increase linearly with increases in housing and population, but perhaps increase exponentially instead** (e.g. due to increasing housing density and taller buildings, which make it more difficult to attend incidents and increase response and set-up times). This would mean that our model underestimates the benefits from sprinklers and additional FRS resources.
- There are risks that the **national and international relationships and data** (e.g. from FSEC and the sprinkler effectiveness assumptions from BRE (2004)) used in our CBA model **do not apply to the new developments in the Thames Gateway**. While we have tried to use regional data where possible (e.g. for property values), it is possible that the Thames Gateway region could experience different costs and benefits under Options I, II and III beyond what is captured in our model.
- Finally, there are risks that the **non-monetised costs and benefits are sufficiently significant** for the net monetised benefits to produce misleading results. We have provided only a qualitative assessment of the non-monetised impacts.

These risks reinforce the need for care in interpreting the results, especially where the net benefits are close between Options and where results are generalised outside of the Thames Gateway.

Chapter 7
Summary of Findings and Conclusions

7.1 Summary of Findings

In this study, we have revisited the question of whether the costs of installing and maintaining domestic sprinkler systems justify the reductions in risk that they provide, in the context of large new housing developments in the Thames Gateway region.

Our cost benefit model has separately assessed the following three Options, specified by CLG, for risk reduction relative to a 'do nothing' baseline:

- Option I: installation of British Standard sprinklers in all new dwellings, without additional FRS resources;
- Option II: installation of British Standard sprinklers in all new dwellings which are part of the social housing sector, without additional FRS resources; and
- Option III: additional FRS resources (in this case additional crew and equipment) in the areas of new dwellings, without sprinklers being installed.

Under the base assumptions, we showed in Chapter 5 that there appears to be no good case for requiring installation of sprinklers in all new homes (Option I), whether we compare this option with 'do nothing' or with adding FRS resources under Option III. The estimated net social cost of such a requirement appears to be very high.

The estimated net social cost of Option II (sprinklers in all new social housing) is also high, but less than that of installation in all new houses. There are circumstances in which Option II might offer a lower net social cost than Option III.

As we discuss in section 5.4 there are a number of non-monetised costs and benefits, the importance of which is far from certain, but which may on balance slightly favour the installation of sprinklers. In addition, in section 6.4 we identified other key risks to our results, with reinforce our view that care is needed in interpreting the results.

We carried out extensive sensitivity, scenario and switching values analysis in Chapter 6. Under some of the sets of assumptions Option II provided lower net social costs than Option III. In a scenario with low sprinkler installation and maintenance costs and high sprinkler effectiveness in reducing fatalities, injuries and property damage, Option II produced positive net social benefit.

The findings from our modelling are consistent with previous studies in suggesting that the benefits of installing sprinklers in *all new* housing, in terms of reduced fatalities, injuries and property loss, would fall far short of the costs. We find some limited and uncertain evidence that installing domestic sprinklers in *new social* housing could lead to similar net social benefits as providing additional FRS resources.

The limited and uncertain evidence for installing domestic sprinklers in new social housing suggests that sprinklers may be cost-effective in some cases. It may therefore be appropriate for providers of new social housing to consider sprinklers on a case-by-case basis.

However, the cost benefit evidence from this study does not support the mandatory installation of sprinklers in all housing or social housing in the Thames Gateway. The benefits from installing sprinklers in social housing would be reduced in particular by the current government planning policy of mixing social and private housing, as the scope for FRS savings would be reduced where both housing types share the same FRS resources.

This study has not examined in any depth the distributional impacts of the Options. It is possible that the costs of installing (although not necessarily maintaining) sprinklers would be faced by housing developers, whereas the costs of additional FRS resources may require extra public funds, with a higher opportunity cost. In this case, there may be a stronger argument for domestic sprinkler installation. Alternatively, the extra costs of FRS resources may be faced by developers under Section 106 agreements.

Also, while we have assessed options for fire prevention or FRS cover in this study, we have not assessed combinations of fire prevention and extra FRS resources. Under some sets of modelling assumptions we estimate relatively similar net social benefits between Option II and Option III. Thus the socially optimal strategy might be some combination of extra FRS resources and domestic sprinklers targeted for high risk housing.

7.2 Generalisation to Other Areas of New Build

In this study we have looked at options for reducing fire risk in the specific context of the Thames Gateway. However, the broad conclusions from this work could be relevant for other areas of new build housing. This is supported by the fact that we have studied policy options separately for the very different (e.g. in terms of social housing targets) London, Essex and Kent areas of the Thames Gateway, without significant changes in our conclusions.

However, as part of this study we found that the Thames Gateway seems to have relatively good FRS coverage with some low levels of utilisation. In addition, we assumed that all new housing have smoke alarms fitted, which decrease the additional benefit of sprinklers. Therefore, the case for installing sprinklers is likely to be stronger in high risk areas where FRS coverage is lower, is more utilised (because more FRS resources are freed up by sprinklers), or where smoke alarms are not automatically installed.

We showed that substantially lower sprinkler costs than the base values used could be sufficient to make this the better policy option than adding FRS resources. Therefore, the applicability of this study's conclusions elsewhere will depend on the cost savings in other areas from competition between suppliers and economies of scale.

Also, we have modelled Option III in the very specific Thames Gateway context. The requirement for additional FRS resources in areas of new build developments is largely dependent on local planning needs, and therefore the definition and net social benefits under 'Option III' may be very different in other areas.

Overall, we have shown that care is needed in applying the conclusions from this study elsewhere in the UK.

7.3 Suggestions for Further Study

While we have tried to be comprehensive in considering the benefits and costs of the different policy options, there are a number of areas which may benefit from further study. We have identified a number of ideas throughout the report, including:

- Further examination of the benefits from housing development design freedoms in UK housing if domestic sprinklers are installed;
- Studies on the cost levels and trends over time for domestic sprinklers in developing markets with increasing competition between suppliers, and under different pumping and water storage needs;
- A more in-depth look at who faces the final cost of providing the additional FRS resources and domestic sprinklers, and how that affects the costs and benefits from different viewpoints; and
- An assessment of the costs and benefits of different combinations of extra FRS resource provision and fire prevention measures such as domestic sprinklers.

This list is certainly not comprehensive, but may provide some impression of specific areas of work that can support policymaking on risk reduction in areas of new build homes and beyond.

Appendix A – Literature Review

This Appendix reviews a selection of the literature on residential sprinklers, from the US, New Zealand and the UK. Most of the documentation in this field covers only one or two of the three key variables for the cost benefit analysis of sprinklers, namely effectiveness, costs, and valuation of the benefits. The coverage of each is shown in the list below. Few publications cover valuation of the benefits.

The reports are listed in reverse chronological order. They vary widely in character. Some provide very good and others mediocre technical analysis, while some are mainly descriptive or, in a few cases, polemical.

Report		Coverage		
		effectiveness	costs	valuation
1	Butry, D.T., Brown, M.H. and Fuller, S.K. (2007) *Benefit-Cost Analysis of Residential Fire Sprinkler Systems*, National Institute of Standards and Technology (NIST), for US Department of Homeland Security	✓	✓	✓
2	Hall, J.R. Jr. (2007) *US Experience With Sprinklers and Other Automatic Fire Extinguishing Equipment*, US National Fire Protection Association (NFPA)	✓		
3	EC Harris (2007) *A Cost Analysis of Sprinklers in Schools*, Department for Education and Skills		✓	
4	Arup Fire (2006) *Use and Benefits of Incorporating Sprinklers in Buildings and Structures*, Draft 2 (January), Ove Arup & Partners Ltd for British Automatic Fire Sprinkler Association (superseded 1995 edition)	✓	✓	
5	Brown, H. (2005) *Economic Analysis of Residential Fire Sprinkler Systems*, National Institute of Standards and Technology (NIST), for US Department of Homeland Security		✓	
6	Building Research Establishment (2004) *Effectiveness of Sprinklers in Residential Premises,* Project report 204505, BRE, for Office of the Deputy Prime Minister	✓	✓	✓
7	Fire Sprinkler Association (2004) *An appraisal of the ODPM – BRE Report, Effectiveness of Sprinklers in Residential Premises*, Fire Sprinkler Association	✓	✓	✓
8	Siarnicki, R.J. (2001) *Residential Sprinklers: One community's experience twelve years after mandatory implementation*, US National Fire Academy, Executive Fire Officer Programme	✓	✓	
9	Ford, J. (2001) *A 15 Year Update on the Impact and Effectiveness of the Scottsdale Sprinkler Ordinance*, [Executive Summary only] and Ford, J. (1997) *Saving Lives, Saving Money: Automatic Sprinklers, A ten Year Study*, Scottsdale Rural/Metro Fire Department, Arizona	✓	✓	
10	Wade, C.A. and Duncan, C.R. (2000) *Cost Effective Fire Safety Measures for Residential Buildings in New Zealand*, BRANZ Study Report No. 93	✓	✓	✓

1. NIST (2007) ***Benefit-Cost Analysis of Residential Fire Sprinkler Systems*** by D.T. Butry, M.H. Brown and S.K. Fuller for the US Department of Commerce, National Institute of Standards and Technology

This study documents a cost benefit analysis of installing fire sprinklers in three types of new single-family house in the United States. It updates a widely quoted National Bureau of Standards (NBS) study from more than twenty years earlier,[76] which suggested that residential sprinklers were not cost-effective. It concludes, in contrast, that sprinklers 'are economical'. But this is on the basis of a valuation of prevented fatalities that is several times larger than those used in the UK or many other countries.

The US Fire Administration's National Fire Incident Reporting System (NFIRS) 5.0 database is the primary source of information.[77] However this database only contains data provided by participating fire departments. It is therefore supplemented by a survey by the National Fire Protection Association (NFPA). The NFPA survey reports the numbers of fires in different categories, and is used to scale the NFIRS 5.0 data.[78]

From NFIRS 5.0 data for one and two family dwellings, between 2002 and 2005, the study obtains estimates for the numbers of deaths in properties with sprinklers and smoke alarms, and properties with smoke alarms only. However there are only limited observations of fires where sprinklers are present. Over the period the average number of fires reported per year was 296,500, but of these only 490 were in premises with sprinkler systems.

The study also notes that 'caution should be made before assuming that reductions in the rate of civilian fatalities and injuries, and direct property damage are fully attributed to the presence of a wet-pipe sprinkler system', because dwellings without sprinkler systems may not be comparable to dwellings with sprinkler systems.[79] The study notes that 'such a determination is difficult given the data available, and beyond the scope of the analysis.'

The study, similar to the earlier NBS study, used a willingness to pay approach to derive the value of a statistical life. They used revealed preference figures derived from labour and product market choices between risk and wage or between risk and price. It notes that an international survey[80] had quoted revealed preference values typically ranging from $4 million to $9 million, with a median value of about $7 million (in 2000 dollars). The study uses an inflation adjusted median value of $7.94 million (in 2005 dollars).

[76] Ruegg, R.T., and S.K. Fuller (1984) 'A Benefit-Cost Model of Residential Fire Sprinkler Systems', NBS Technical Note 1203. Gaithersburg, MD: National Bureau of Standards.

[77] NIST (2007) states that 'the data contained within NFIRS 5.0 is quite detailed and provides a rich accounting of fire incidents in the US, including information regarding the ignition and structure ignited, reported casualties and property loss. NFIRS 5.0 data also contain information regarding the presence of smoke alarms and sprinkler systems.'

[78] This procedure of scaling NFIRS 5.0 data is best explained with an example. The NFPA survey estimates that 287,000 fires occurred in one and two family dwellings in 2005, whereas the NFIRS 5.0 reports 66,292 fires. The number of fires occurring in premises with smoke alarms and those with sprinkler systems in one and two family dwellings reported in the NFIRS 5.0 database (36,223 and 143 respectively) is scaled up by the ratio between the number of fires reported in NFIRS 5.0 and the NFPA survey (i.e. 287,000/66,292 = 4.33). This procedure is applied to all the statistics reported in NFIRS 5.0.

[79] For example Table 3.7 of the report records that NFIRS 5.0 data report property damage from fires in properties without sprinklers or smoke alarms about 10 per cent *lower* than for properties with both devices, and about 40 per cent lower than for properties with smoke alarms only.

[80] Viscusi, W.K. and Aldy, J.E. (2003) 'The Value of a Statistical Life: A Critical review of Market Estimates Throughout the World', The Journal of Risk and Uncertainty, 27(1): 5-76.

The study assumes that installing sprinklers in properties which already have smoke alarms results in a 100 per cent reduction in fatalities, and a 57 per cent reduction in injuries.

The NFIRS 5.0 database shows that, in properties with sprinkler systems *and* smoke alarms, property damage is 32 per cent lower than properties with smoke alarms only. The study values insured damage savings in terms of reduced insurance premiums, to which it adds savings in uninsured damage, both direct and indirect.[81] The 32 per cent reduction applies to both.

2. Hall (2007) *US Experience With Sprinklers and Other Automatic Fire Extinguishing Equipment* by J.R. Hall Jr. for the National Fire Protection Association (NFPA)

This study of sprinkler effectiveness is an update of Rohr (2000)[82], which is a widely quoted source. Though the main source of information is the NFIRS 5.0 database, as in reference 1 above, the study also reviews evidence from other sources. It presents effectiveness estimates for a range of residential properties, including apartments, one and two family dwellings and hotels. We focus here on the results reported for apartments and one and two family dwellings.

The study highlights some problems with estimates of fatality risks based on historical data. Two problems highlighted are:

- Sprinklers are often installed in new properties, which may generally be better equipped in any case for preventing deaths. This will tend to lead to overestimation of the benefits of sprinklers.
- Many data sets are based on fires that have been attended to by the fire brigade. These are fires that have not been controlled by sprinklers, and are therefore usually larger fires. These larger fires will be associated with a greater number of fatalities. This will tend to lead to underestimation of the benefits of sprinklers, as the data will not include some of the smaller fires that sprinkler systems will have controlled.

The report also notes a possible problem with statistics on property damage. More affluent houses tend to install fire sprinklers, but they also have more expensive possessions. This will increase the value of property damage in properties with sprinklers and hence tend to underestimate sprinkler effectiveness.

The study concludes that, averaging over all residential buildings, sprinkler systems reduce the number of deaths by 77 per cent.[83] Figures for specific residential categories are 57 per cent for apartments, and 100 per cent for one and two family dwellings and for hotels or motels. The study notes, however, that the sample size of one and two family dwellings with sprinklers is too small for this estimate to be considered reliable.

[81] Indirect property damage refers to secondary costs such as the cost of temporary accommodation, incurred as a result of the fire.
[82] Earlier updates include Rohr (2002), Rohr (2003) and Rohr and Hall (2005).
[83] Statistics for specific residential categories are also provided. Sprinkler systems reduce fatalities in apartments by 57 per cent, and in hotels or motels by 100 per cent.

For residential apartments, the reduction in property loss as a result of sprinkler systems is 40 per cent. The authors do not report the reduction in property damage in one and two family dwellings, as the number of fires reported is too small.

3. E.C. Harris (2007) *A Cost Analysis of Sprinklers in Schools,* for the Department of Education and Skills

This study analyses the costs of installing sprinkler systems in schools, based on inspection of a sample of 26 schools. The focus was mainly on new construction. Some points from the study are also relevant to residential sprinkler systems. It is not stated whether or not the estimates include VAT, although we assume that EC Harris quotes figures exclusive of VAT. [84]

The estimated additional capital costs vary widely, with an average of 2.5 per cent of total construction costs but a range from 1.4 per cent to 4.5 per cent. The corresponding range in costs per square metre was £23/m^2 to £68/m^2, with an average of £40/m^2.

The estimated maintenance costs are shown in Table A.1 below. These costs are much higher than those from any of the other papers reviewed in this study, but allow for a much higher frequency of testing and inspection than would be expected in most residential systems.

Table A.1 EC Harris (2007), Breakdown of Maintenance Costs for a School

Category	*Cost, £ per annum (2007 prices, possibly excluding VAT)*
Monitoring company – 12 months x £15	180
Sub Contractor Inspection, discharge test, pump and valve overhaul – two per year	500
Pump test by Caretaker – 0.5 hours x 12 months x £30	180
Cost of fuel for tests	120
Cost of water for tests	120
Total cost per annum	1,100

Source: EC Harris (2007), page 19.

We understand that the EC Harris estimates of capital costs are considerably higher than those previously provided to the Department by the European Sprinkler Network. However the installation cost figures are consistent with those in reference 4 overleaf, which was commissioned by the fire sprinkler trade association. The EC Harris estimates for maintenance costs are, however, much higher.

[84] New build is VAT zero rated, so that labour costs incur no VAT, but VAT is paid on materials.

4. Arup Fire (2006) *Use and Benefits of Incorporating Sprinklers in Buildings and Structures*[85]

This report is a descriptive rather than analytical document, written from the perspective of the trade association for the fire sprinkler industry who commissioned it. It is nonetheless informative and objective.

It includes a two page descriptive chapter on residential sprinklers. This summarises the results of the pilot study experiments reported on the BRE (2004) report (reference 6 below), which are described as finding 'that for the majority of scenarios experimentally studied the provision of residential sprinklers proved effective in potentially reducing casualties in the room of fire origin and connected spaces'. In a later discussion of 'common misperceptions' it quotes a British Standards Institution risk assessment[86] which estimates the probability of a sprinkler system operating successfully on demand as 90 per cent.

The discussion of residential sprinklers also summarises the measures in Scotland to introduce sprinklers into some residential premises and provides a useful summary of the regulatory trade offs that have been allowed for residential sprinklers.

In a chapter on 'Cost versus Benefit' the report notes that estimating the costs of sprinkler pipe work and heads is relatively straightforward, but that water supply costs depend considerably on mains pressure, building height and hazard classification. It suggests guide prices as 'rough estimates', as shown in Table A.2 below.

Table A.2 Capital Costs of Sprinkler Systems, BASA (2006)

System classification	*£/m² of serviced area, Outer London June 2004 (excluding VAT)*
Light Hazard	23-28
Ordinary Hazard	27-37
Extra-High Hazard	33-39

Source: BASA (2006), page 28.

It also reports that, for school premises, the extra costs of providing sprinklers in new build have been estimated as being between 2 and 3 per cent, excluding 'mark ups by main contractors or project professionals'.

85 These notes are based on Draft 2, published in January 2006, a year after the first draft and including BASA review comments. In March 2006 the final version was published in hard copy by the Stationery Office with the title 'Sprinklers for Safety: Uses and Benefits of Incorporating Sprinklers in Buildings and Structures'. http://www.tsoshop.co.uk/bookstore.asp?Action=Book&ProductID=9780955262807 available also by subscription online from the Construction Information Service: http://www.thenbs.com/PublicationIndex/DocumentSummary.aspx?PubID=969&DocID=284320

86 BSI (2003) 'PD 7974-7:2003: Application of fire safety engineering principles to the design of buildings. Probabilistic risk assessment', BSI.

BASA (2006) provides some guidance figures, noting that 'costs are project specific and subject to change. …The … figures could be used for rough estimates, (but) a detailed estimate should always be made when sprinklers are being considered.' It is not stated whether the estimates refer to new build or retro-fitting. The estimates are presented in the table below.

The report also provides figures as a guide for 'typical maintenance costs' as shown in Table A.3 below.

Table A.3 Typical Maintenance Costs of Sprinkler Systems, BASA (2006)

Protected building	*Typical maintenance cost per annum (excluding VAT)*
Small domestic property	£75
Small school	£250-£350
Large school	£500-£750
Large warehouse or retail premises	£750-£1,500

Source: BASA (2006), page 29.

5. NIST (2005) *Economic Analysis of Residential Fire Sprinkler Systems* by H. Brown for the US Department of Commerce, National Institute of Standards and Technology

This study compares the life cycle cost of different sprinkler systems which comply with the National Fire Protection Association standard 13D. The actual cost estimates are specific to the US, and therefore of limited relevance in a UK context. Nonetheless, the paper presents the most detailed treatment of sprinkler system costs in the papers reviewed.

The cost estimates reported in this study have been obtained from vendors in the United States. The study defines the life cycle cost of a sprinkler system as the sum of: (i) first cost: this includes the purchase cost, design cost, and installation cost; (ii) operation and maintenance costs, including the inspection cost; (iii) repair cost; (iv) the cost of replacing components of the system; and (v) the cost of disposal.

The results from this study are used in the cost benefit conducted in NIST (2007).

6. BRE (2004) *Effectiveness of Sprinklers in Residential Premises*

This report describes a two and a half year study, commissioned by the Office of the Deputy Prime Minister (ODPM) and prompted in part by the publication in 2000 and 2002 of draft British Standards (DD 251 and 252) for sprinkler systems in residential premises. The study covers six tasks, including a Cost Benefit Analysis and a Pilot Study, which includes a useful literature review and also provides many of the CBA inputs. The report is described in this study. In the main text (section 4.6) we comment on the differences between this BRE study and our own CBA.

BRE Estimates of Sprinkler Effectiveness

The Pilot Study notes that a direct method of estimating the effectiveness of sprinklers would involve 'comparing fires in sprinklered buildings with similar fires in unsprinklered buildings' but it rejects this approach because of the quality of the data available in the UK. For example, records for 1996 of fires in properties with sprinklers all come from the same fire brigade.

Instead, the report uses an indirect method for estimating the effectiveness of sprinkler systems, based on two steps:

- using actual data to estimate the relationship between the horizontal area of fire damage and the number of deaths caused by a fire; and
- assuming that sprinklers limit this area of fire damage.

The study collects data on the number of deaths associated with fires of different areas. Sprinklers are assumed to limit the fire size to a maximum area AMAX. Then:

- the number of deaths associated with fires, which would have been of a size larger than AMAX in the absence of sprinklers, is assumed to be equal to the number of deaths associated with fires of size AMAX
- all fires smaller than AMAX are assumed to be unaffected by sprinklers. Thus the number of deaths caused by fires of size less than AMAX is not changed by sprinklers.

The report uses ODPM data, based on FDR1 forms filled out by fire brigades after a fire, to calculate the percentage reduction in deaths for different levels of AMAX.[87] They then assume that sprinklers limit the size of fires to $1m^2$. The authors cite a study by Ramachandran (1993), which had applied this methodology to commercial buildings and had presented evidence for commercial buildings in the U.S., showing that sprinklers 'had little or no influence on fires smaller than $3m^2$'. The BRE argue that 'in domestic and residential buildings, sprinklers would be expected to restrict fires to smaller sizes (than commercial buildings) on average'. They also note that for several reasons, such as the possibility that sprinkler systems may fail to activate, 'the method is not particularly precise.'

For the purpose of the CBA, the report does not distinguish between different types of dwellings, but takes an average of the percentage reduction in deaths across different types of dwellings. The final figure for the percentage reduction in deaths in the presence of sprinklers used by BRE (2004) is 70 per cent.[88] The report compares its estimate for effectiveness with Rohr (2000). The latter estimates that sprinklers result in a 73 per cent reduction in fatalities, and the BRE study notes that its estimates are in 'close agreement'.

[87] The different levels of AMAX reported in BRE (2004) are less than $1m^2$, $2m^2$, $4m^2$ and $9m^2$.

[88] A series of statistical calculations are made involving assumptions about the nature of the probability distributions of different variables (e.g. the number of fires), to derive a range (two standard deviations) for this quantity of ±15 percentage points.

The study uses the same approach to estimate the effect of sprinklers on the risk of injuries. Sprinklers are estimated to result in a 30 per cent reduction in the number of injuries, again with a range of ±15 percentage points.

The study concludes that the effect of sprinklers on property damage cannot be estimated from UK statistics. It therefore uses a value of 50 per cent for the reduction in property damage from sprinklers, again with a range of ±15 percentage points. This value is 'based on an examination of US statistics.'

BRE Estimates of Sprinkler Costs

For the CBA the Pilot Study considers installation costs, water supply costs, and annual inspection costs. Installation costs and water supply costs have been separated 'in an attempt to make a better estimate of the overall cost of providing a system,' because 'variation in water supply costs contributes a large fraction of uncertainty in the total costs of the system.'

Estimates of installation costs are 'based on figures provided by the Fire Sprinkler Association.' These estimates were found to be lower than those reported by members of the project steering committee, but were taken as 'more representative of the two data sets.' Installation costs were also assumed to be 20 per cent higher for retrofitting compared to new-build. The values are as in Table A.4 (in 2002 prices). It is unclear whether the figures include VAT.[89]

These costs are for a one-off installation designed and installed to the draft standard DD 251. The authors note that installation costs vary across regions, owing to variation in labour costs.

Table A.4 BRE (2004) Installation Costs Excluding Water Supply (2002 prices, possibly excl, VAT)

Property type	*Estimate (£)*
House single*	1,500 – 1,800
House, multiple occupancy***	500 – 600
Flat, purpose-built*	900
Flat, converted**	1,100
Care home (old persons, 19 bed)***	4,050 – 4,860
Care home (children, nine bed)***	2,550 – 3,035
Care home (disabled people, eight bed)***	2,400 – 2,880

Source: BRE (2004), Section 6, page 4.

** New Build; ** Retrofit; *** Unknown installation.*

[89] As with other construction cost data VAT is probably excluded. However the BRE were unable to advise us on questions of this kind.

The report notes that water supply costs vary according to the characteristics of the installation (e.g. type of dwelling, pressure of local water supply). Water supply costs can be negligible, or can be as much as £1,500 if a pump and an additional storage tank are required. The estimates are shown in Table A.5.[90]

Table A.5 BRE (2004) Cost of Water Supply (2002 prices, possibly excl., VAT)

Property type	*Estimate (£)*
House, single	0 – 930
House, multiple occupancy	96 – 183
Flat, purpose-built	0 – 155
Flat, converted	68 – 155
Care home (all types)	0 – 1,095

Source: BRE (2004), Section 6, page 5.

The report assumes a value of £50 per annum (2002 prices) for annual maintenance costs, reflecting the cost of one man hour (one man hour maintenance requirement quoted by the FSA).

BRE Valuation of the Benefits of Sprinklers

As noted above, the Pilot Study includes estimated impacts as follows for use in the CBA (to each of which was ascribed a two standard deviation range of 15 percentage points).

Table A.6 BRE (2004) Valuation of the Benefits of Sprinklers

	Percentage reduction	*Basis*
Deaths	70	Calculation based on fire-area, as described above
Injuries	30	
Property damage	50	Examination of US statistics

Source: BRE (2004), Section 6, page 3

The baseline levels of deaths, injuries and property damage are taken from the ODPM publication 'The Economic Costs of Fire: Estimates for 2000'. The monetary valuations are taken from the same source except for adjustment from 2000 to 2002 prices. The RPI is used for property values. The ODPM had used DETR transport values for deaths and injuries and these values were adjusted pro rata to GDP.

[90] The primary source of the water supply costs is a personal communication by I. Whittaker. Further details of the source are not provided.

Costs and benefits are estimated for a range of domestic property types and for residential care homes. For domestic properties, 50 per cent of the benefits were typically attributable to fewer deaths and about 25 per cent each to fewer injuries and to less property damage. For care homes property damage savings were greater.

BRE Conclusions

The study concludes that residential sprinklers are probably cost effective for residential care homes (old persons, children and disabled) and for tall blocks of flats (eleven stories and above) but not cost effective for other dwellings.

It concludes that, for sprinklers to be effective in a broader range of dwellings, installation and maintenance costs must be minimal and/or trade offs may be necessary to provide sufficient savings or extra benefits elsewhere.

7. FSA (2004) *An Appraisal of the ODPM–BRE Report 'Effectiveness of Sprinklers in Residential Premises'*, Fire Sprinkler Association (FSA)

The FSA produced a critique of the BRE (2004) study, commenting extensively on the assumptions made about sprinkler effectiveness. The report notes that 'the data used depends heavily on reports by Rohr (2002) and Ruegg and Fuller (1984)'. The FSA questions the use of these two sources. With regards to Ruegg and Fuller (1984), it states that 'in 1984 there was very little experience with residential sprinkler systems anywhere in the world' and that the 'findings would have been largely based on the use of conventional sprinklers and are therefore not valid in this context' (i.e. in the context of the BRE cost benefit analysis). The Rohr (2002) study is criticised for not making any attempt 'to determine whether properties claimed to have sprinkler systems fitted did in fact have them and/or that they were operational at the time of the fire. As a result the Rohr report inaccurately suggests there are many fatalities in sprinkler protected properties each year.' The study goes on to state that 'reports from Scottsdale and Vancouver are more accurate but were dismissed.'

These criticisms of the BRE (2004) report's reliance on Ruegg and Fuller (1984) and Rohr (2002) appear to be based on a misreading of the BRE report. BRE (2004) only use Rohr (2000)[91] as a reference, and note that their estimate for the effect of sprinkler systems on fatalities is in 'close agreement' with Rohr (2000). Otherwise, the Rohr (2000) estimate is not used in the BRE (2004) report. Similarly, information from Ruegg and Fuller (1984) is not used in the BRE cost benefit analysis.

The FSA critique also states that the linear relationship assumed in BRE (2004) between risk of death and fire size is 'flawed.' This, however, is a misinterpretation of the BRE methodology, which does not assume a linear relationship. Rather the relationship between fire size and death rates is derived from empirical data, and is not perfectly linear.

[91] The BRE report cites evidence from Rohr (2000), and not Rohr (2002). Rohr (2002) is an update of Rohr (2000). Subsequent updates include Rohr (2003), Rohr and Hall (2005), and Hall (2007). Hall (2007) is reviewed as part of this literature survey.

The FSA report also criticises the BRE effectiveness estimates of the reduction in fire size because they are based on data from commercial sprinklers. The FSA notes three problems with this:

- 'residential sprinkler systems work quite differently to commercial system;
- residential fires are quite different to commercial fires, both in the material that burns, and the size and shape of the compartment in which it burns; and
- residential systems are designed to save lives whereas commercial/industrial systems are primarily installed for property protection.'

However this criticism relates to the BRE assumption that sprinkler systems reduces fire size to a maximum of 'about $1m^2$'. As noted when discussing the BRE report above, the BRE base their value on results for commercial properties reported in Ramchandran (1993); but whereas Ramchandran (1993) reports a maximum area of $3m^2$, the BRE assume that sprinklers in domestic dwellings would reduce fire area to a maximum of $1m^2$.[92]

The FSA also questions the BRE assumptions about the number of deaths in the absence of sprinkler systems. The DETR commissioned 1997 ENTEC report is shown to estimate a higher number of fatalities from fire in the UK than the BRE report. Finally, the FSA criticises the BRE report for failing to distinguish between variations in the effectiveness of sprinkler systems between buildings of different heights.

In sum, the FSA report contends that the final estimate of a 70 per cent reduction in fatalities as a result of sprinkler systems used in BRE (2004) is an underestimate of sprinkler effectiveness. It asserts that the BRE methodology does not concur with the 'actual recorded number of deaths in a sprinkler protected building in the UK – namely none'.[93]

8. Siarnicki (2001) *Residential Sprinklers: One Community's Experience Twelve Years After Mandatory Implementation*

Siarnicki is Fire Chief of the Prince George's County Fire/EMS Department. The report provides a general review of the experience of Prince George's County, Maryland following the mandatory requirement of domestic sprinkler systems in 1992.[94] It is in some respects rather polemical, the abstract opening with the assertion that the fire sprinkler is the most significant lifesaving device known to man, and much of the text addresses issues of public administration. However, it contains some industrious and fairly interesting empirical work.

[92] According to data presented in BRE (2004), Section 3, page 12, with a maximum area of $3m^2$ instead of 1, the percentage reductions presented in Table A.6 would change form 70 per cent to 40-50 per cent for deaths; and from 30 per cent to 10 per cent for injuries.
[93] FSA (2004), page 16.
[94] The type of sprinklers used in homes corresponds to the NFPA approved standard 13D.

Data is analysed for fires in properties with sprinklers for the period between January 1992 and December 1999, compiled from reports filed by on-duty inspectors. These reports include an explicit section on the number of lives saved. The figure on the number of lives saved 'was based upon the numbers of people that were in close proximity of the fire's origin or were in the immediate areas of the living unit where the fire occurred.'

Estimates of property damage were also based on the 'damage physically viewed by the fire inspector, immediately following the reported occurrence. (The) damage figure was limited to the fire damage and water damage caused by the sprinkler activation.'

A general search through fire records was conducted to select properties without sprinklers that had similar characteristics to properties with sprinklers. The statistics for the former relate to the period between January 1990 and December 1993. In total, 121 reports of fires in properties with sprinklers and 50 reports of fires in properties without sprinklers were examined.

The study reports a number of results as follows, which are of interest although they do not relate directly to the standard measures of sprinkler effectiveness. Results are tabulated for every fire, each identified as, for example, multi-family, townhouse, condo, motel, hotel, or dormitory, but, presumably because of the small sample sizes, the analysis is confined to aggregates for the whole set of observations. These are as follows:

- no deaths occurred as a result of fires in properties with sprinkler systems; according to the on-duty inspector reports, 154 lives were saved;
- 22 deaths occurred in properties without sprinkler systems;
- the number of *burn injuries* reported in fires at properties with sprinkler systems was seven (out of 121 fires);
- the number of *injuries (including smoke and burn injuries)* reported in fires at properties without sprinkler systems was 22 (out of 50 fires);
- average damage as a result of fires in properties with sprinkler systems was $3,300; and
- average damage as a result of fires in properties without sprinkler systems was $80,000.

Siarnicki (2001) notes that because of differences in the structure of properties with and without sprinklers, the figure for average property damage is misleading. The paper also lists property damage for different types of fires. For property types where statistics are reported, the minimum reduction in property damage is 88 per cent, and the maximum is 98 per cent.

9. Ford (2002) *A 15 Year Update on the Impact and Effectiveness of the Scottsdale Sprinkler Ordinance [Executive Summary] and Ford (1997) Saving Lives, Saving Money: Automatic Sprinklers, A Ten Year Study*

These reports present information on fires that have occurred in Scottsdale, Arizona after the implementation of the Sprinkler Ordinance in 1985, which has attracted considerable national and international interest. From the beginning of 1986, all new single family homes were required to fit sprinkler systems.

The reports are written by the long standing Assistant Chief/Fire Marshall and in the style of political rather than technical papers, vigorously defending and promoting the case for residential sprinklers and recording the history of their introduction in Scottsdale. Thus, while interesting data and case studies are quoted, they are presented to make the argument more than provide clear analysis.

They do not provide estimates of the percentage reduction in fatalities or injuries as a result of sprinklers. They only provide estimates of the absolute number of lives saved and it is not clear how this is measured. Ford (1997) states that at least four lives were saved in single and multi family homes and, in total, eight lives were saved in all buildings, including commercial buildings. The follow-up 2002 study reports that, in total, 13 lives were saved as a result of sprinkler systems.

Ford (2002) reports that the civilian fire fatality rate had over the 15 years fallen by 50 per cent, but this is presumably attributable to many factors. More strikingly, it reports that 'several design and technical improvements have allowed the installation cost to average between \$0.55 and \$0.75 per square foot (\$5.9 and \$8.1/m^2). This is usually less than one per cent of the cost of a new home.'

Ford (1997) reports that over the ten year period, average property damage in properties with sprinkler systems was 87 per cent less than in properties without sprinklers. Ford (2002) reports 90 per cent less damage.

Despite the difficulties in interpreting the data as presented, figures attributed to Ford (1997) appear to be widely quoted. For instance, BRE (2004) (reference 6 above) reports that the use of sprinkler systems and smoke alarms has resulted in a 98.5 per cent reduction in fatalities. And Wade and Duncan (2000) (reference 10 below) infer from Ford (1997) a reduction in fatalities of 80 to 90 per cent and a reduction in property losses of 84 per cent. It is not clear how these numbers have been derived.

10. BRANZ (2000) *Cost Effective Fire Safety Measures for Residential Buildings in New Zealand,* C.A. Wade and C.R. Duncan

This paper reports a CBA of residential sprinkler systems (and of smoke alarms).

It states that 'each variable for the 'cost per life saved' equation is derived from New Zealand Fire Service statistics and commercial costs.' However the death rate used for fires in premises with neither sprinklers nor smoke alarms is based on a variety of US estimates. The authors assume that the number of deaths due to fires in New Zealand is half of that in the US.[95] The injury rate with no sprinklers appears to be based on a literature review. This suggests that at least some assumptions about the reduction in the number of fatalities and injuries are based on other literature.

The report states that 'it was estimated that the presence of a fire sprinkler system would reduce the number of deaths caused by domestic fires by 80%' and 'it was estimated that the presence of a fire sprinkler system would reduce the number of injuries caused by domestic fires by 63%.' The study assumes that sprinkler systems lead to an 84 per cent reduction in property damage (based on Ford (1997)).

It considers two types of sprinkler systems, one that met the New Zealand standards then prevailing, and one that met a then proposed draft revision to the standard that was assumed to be as effective, but much less expensive (with about two thirds of the installation cost and less than half of the annual maintenance costs).

For the more expensive system it derived a cost per life saved (for single new build) of NZ$35 million (roughly £12 million) and for the prospective new sprinkler standard a cost of NZ$18 (roughly £6 million) per life saved. The study does not quote any threshold acceptable value for the cost per life saved, but concludes without discussion that these figures show that these options are 'not cost-effective'. It notes, however, that further cost reductions could be achieved from further refinements in sprinkler design and installation requirements, and that for some scenarios, such as high cost properties and properties with a high probability of fire occurrence, sprinklers become more cost-effective anyway.

The study makes a brief comparison with a contemporary Australian study that found a wider range of costs per life saved.[96] As with the BRANZ study, the costs per life saved for (single new build) compliance with the contemporary Australian standard were very high, at AUD$53 million to $30 million (roughly £20 to £12 million). For an 'alternative sprinkler system from domestic supply' the costs were not much less, but the Australian figures included very high annual maintenance costs. For this same standard but assuming it was maintenance free the costs per life saved fell dramatically to AUD$5 to $3 million (roughly £2 to £1.2 million); and for a 'new medium density housing estate' and a maintenance cost of AUD$100/year (roughly £40) the estimated cost per life saved fell to AUD$2 million (roughly £0.8 million).

[95] The assumption of the death rate in New Zealand being half that of the US is based on limited evidence from a study in New Zealand (Irwin (1997)), which shows considerably lower death rates than the US.

[96] Beever, P. and Britton, M. (1999) 'Research into Cost-Effective Fire Measures for Residential Buildings', Centre for Environmental Safety and Risk Engineering, Victoria University of Technology, Melbourne.

Appendix B
Fire and Rescue Services in England

Central government, through CLG, has ultimate responsibility for the provision of the fire service in England and Wales and is therefore responsible for setting priorities and objectives for the Service (through the *Fire and Rescue National Framework*), but also for putting in place the necessary legislative frameworks.

The demands on the fire service have changed considerably over the last few decades. The role of the Service in responding to terrorist incidents and other threats (e.g. flooding) has grown. In addition, assistance at road traffic accidents has become a significant element of work for the Service; overall more people are rescued by the Service from car accidents than from fires.[97]

Reflecting the changing and developing role for the Service, in 2002 the government published a review of the UK fire service by Professor Sir George Bain. The report was charged with making recommendations over the future organisation and management of the Service. Following Professor Bain's report, in 2004 the government passed the Fire and Rescue Services Act. This Act provided a comprehensive reform of the existing statutory framework which dated back to the 1940s and 1950s.

Under the 2004 Act, responsibility for local fire and rescue services was devolved to Fire and Rescue Authorities (FRAs), of which there are currently 45 in England. The Authorities, which are largely based on County Council areas, are made up of civilians and councillors. The Authorities' responsibilities are split into 'core' functions and 'other' functions. The core functions are:

- fire safety;
- fire-fighting;
- assisting at road traffic accidents; and
- assisting in other emergencies.

The Act therefore gives a statutory role to the FRAs in areas outside of the traditional fire-fighting role. In defining it as a core function, the Act clearly puts fire safety at the heart of FRA responsibility. Reflecting this priority the Fire Public Service Agreement for England, which came into effect in April 2005, required the number of accidental fire-related deaths in the home to fall by 20 per cent by 2010, and the number of deliberate fires to be reduced by 10 per cent.[98]

[97] Office of the Deputy Prime Minister, *The Fire and Rescue National Framework 2006-08*, page 15.
[98] Office of the Deputy Prime Minister, *The Fire and Rescue National Framework 2006-08*, page 77.

Although the FRAs have responsibility for the provision of fire and rescue services in their jurisdiction, the services are provided by individual Fire and Rescue Services (FRSs). The FRSs are also sometimes referred to as the 'fire brigade'. Each FRS is directly funded and governed by the FRA.

In the case of the Thames Gateway, there are three relevant FRAs:

- London Fire and Emergency Planning Authority;
- Essex Fire and Rescue Authority; and
- Kent Fire and Rescue Authority.

The 2007 Comprehensive Spending Review (CSR) included central government funding for the Fire and Rescue Service for the three years from 2008-09 to 2010-11.[99] Most FRA funding is delivered through the Formula Grant, with County FRA funding coming from the overall county allocation. The Formula Grant is a combination of the Revenue Support Grant, redistributed National Non-Domestic Rates (or Business Rates) and the Principle Formula Police Grant. The average increase in funding for single purpose FRAs will be 2.4 per cent in 2008-09, 1.4 per cent in 2009-10 and 1.4 per cent in 2010-11 (with floors for single FRAs of 1 per cent in 2008-09 and 0.5 per cent in 2009-10 and 2010-11). This includes a 1.6 per cent per annum efficiency target.

As an example of the budget required for a county fire service, the Essex County Fire and Rescue Service had an estimated revenue requirement of £67.9 million for 2007-08.[100] Of this, approximately 6 per cent was financed through the Revenue Support Grant, 38 per cent through National Non-Domestic Rates, 56 per cent through council tax, and the remainder from the collection fund surplus.

B.1. Domestic Demands on the UK Fire and Rescue Services

B.1.1. Drivers of demands on FRS in England

Recent CLG statistics for FRSs in England show that fires, false alarms for fires and non-fire incidents all contribute significantly to FRS operations.[101]

Figure B.1 shows how the number of incidents, classified by fire, fire false alarms and non-fire incidents, has changed between 2003-04 and 2006-07 in England. Over the period, the number of fire incidents was decreasing relatively quickly. The number of false alarms was also decreasing, although at a slower rate. The number of non-fire incidents, in contrast, has remained fairly constant.

[99] CLG, *CSR07 Funding for the Fire and Rescue Service*, 7 December 2007.
[100] Essex County Fire and Rescue Service, *Fire Authority Budget 2007-08*, http://www.essex-fire.gov.uk/images/pics/Budget_Book_2007_08_unlinked.pdf
[101] CLG, *Fire and Rescue Service Operational Statistics Bulletin for England: 2005-06*, June 2007.

Figure B.1 Number of Incidents to which FRSs Responded in England, 2003-04 to 2006-07

Source: CLG, Fire and Rescue Service Operational Statistics Bulletin for England: 2006-07, May 2008.

Fire incidents are broadly made up of primary fires, secondary fires and chimney fires. Primary fires are fires in dwellings, occupied buildings, vehicles, outdoor structures, and all fires that involve casualties, rescues, or escapes, or if five or more fire engines are employed. Secondary fires are derelict building, grassland, refuse and derelict vehicle fires.

The false alarms include malicious calls, good intent calls and automatic fire alarms.

Non-fire incidents cover a range of activities, which include road traffic incidents, chemical, biological and radioactive exposures and spills, severe weather conditions, collapsed buildings and rescues of trapped people, including in lifts.

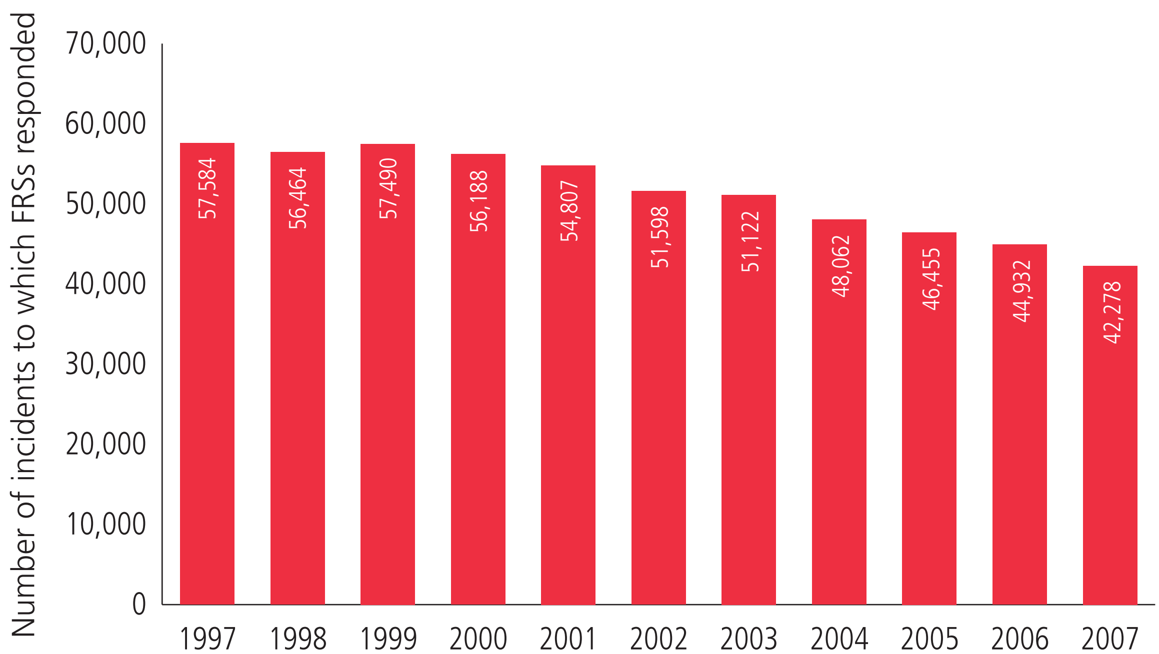
B.1.2. Demands on FRS from domestic fires

In 2007 the Fire and Rescue Service in England attended 630,000 fires or false alarms. This was a 9 per cent reduction on the previous year.[102] In total just under a half of these call outs were actual fires (i.e. there were 296,000 actual fires). Fires in dwellings constituted 42,300 of the total number of fires.

[102] CLG, *Fire Statistics Monitor, Issue No. 04/08, November 2008*, page 2.

Figure B.2 shows the trend in the number of dwelling fires per year in England from 1997 to 2007 attended by the FRS. It shows that since 1999 dwelling fires have fallen year-on-year in England, from a level of 57,490 in 1999 to a provisional level of 42,278 in 2006. This follows the recent fall in all fire incidents in England shown in Figure B.1.

Figure B.2 Number of Dwelling Fires per Year in England (1997 to 2007)



Source: CLG, Fire Statistics Monitor Quarter 4: 1 January 2007 – 31 December 2007, published 21 November 2008. Notes: Dwellings include caravans, houseboats and other non-building structures used as a permanent dwelling; 2002 and 2003 data include estimates for incidents not recorded during periods of industrial action; and 2007 level is provisional.

From the 2004-05 Survey of English Housing (SEH),[103] it was found that 22 per cent of domestic fires in the 12 months were attended by the FRS, which includes 15 per cent of fires inside the house, and 71 per cent of fires outside the house. By cause of fire, the highest proportions of call-outs show the FRS being called to 70 per cent of arson fires, 67 per cent of fires caused by children playing with fire (but not matches or cigarette lighters), and 31 per cent of fires caused by electrical equipment or wiring.

Of the fires to which the FRS were called, they extinguished 55 per cent. This means that of all fires, FRS put out only 12 per cent, compared with 79 per cent, the proportion put out by the respondent or someone else living in the household.

Provisional data for 2007 from the CLG *Fire Statistics Monitor* show that there were 355 fire deaths in England,[104] of which 240 occurred in dwellings.[105] Furthermore, in total there were 10,400 non-fatal casualties, of which 8,500 casualties were from dwelling fires.

[103] Office of the Deputy Prime Minister, *Fires in the Home: findings from the 2004-05 Survey of English Housing*, January 2006.
[104] CLG, Fire Statistics Monitor, Issue No. 04/08, November 2008, page 9.
[105] Down from 398 fire deaths, and 287 deaths in dwelling fires, in 2006 (according to the same source).

From the 2004-05 Survey of English Housing (SEH),[106] it was found that 91 per cent of domestic fires did not result in personal injury. Of the personal injuries, 52 per cent were from smoke inhalation, and 36 per cent from burns and scalds.

In the 2004-05 SEH, 1.5 per cent of English households had experienced domestic fires in the previous 12 months (of which 0.1 per cent had experienced two or more fires). The total incidence rate was 1.6 fires per 100 households. Of the 308,000 households that experienced at least one domestic fire in the previous 12 months, 273,000 had a fire inside the house, and the remaining 35,000 households had fires outside the house.

There are regional differences around the average 1.5 per cent prevalence rate of fires. In the 2004-05 SEH, London has the highest prevalence rate of about 1.9 per cent, and Yorkshire and Humber region the lowest at 1.1 per cent of households.

Using bivariate and multivariate analysis, a number of factors were identified using SEH data, which affect the probability of experiencing a domestic fire. These include the housing type, household structure, deprivation level, economic status, socio-economic group, satisfaction with accommodation and local area, and frequency of candle and room heater use.

According to the 2004-05 SEH accidents while cooking caused 53 per cent of domestic fires in 2004-05, with 60 per cent of domestic fires starting in the kitchen. Other causes include electrical equipment or wiring (which caused 11 per cent), arson (which caused 7 per cent) and candles (which caused 7 per cent).

For households experiencing domestic fires, 43 per cent of fires were discovered between 6pm and midnight, and 36 per cent between midday and 6pm. The highest proportion of fires were discovered because the survey respondent was in the room (30 per cent), while 27 per cent smelled smoke and 21 per cent saw smoke, flames or sparks. Of the households experiencing a fire, 75 per cent owned a smoke alarm, but only 12 per cent of households discovered the fire due to the alarm going off.

Looking at fire prevention, 86 per cent of respondents to the 2004-05 SEH owned a smoke alarm and 20 per cent a fire extinguisher. Less than 1 per cent owns a sprinkler system and 10 per cent of respondents did not own any fire safety measures. Of the 86 per cent which owned a smoke alarm, 80 per cent had at least one working smoke alarm (32 per cent owned one working smoke alarm, 36 per cent owned two working smoke alarms and 12 per cent owned three or more). Of respondents that own smoke alarms 92 per cent of smoke alarms were located in the hall or landing, 44 per cent tested their smoke alarm at least once per month and 56 per cent less often.

Working smoke alarm ownership does vary by region. The average of 80 per cent of respondents in England compares with a high of 84 per cent in the West Midlands to a low of 70 per cent in London. Bivariate and multivariate analysis of the 2004-05 SEH data

[106] Office of the Deputy Prime Minister, *Fires in the Home: findings from the 2004-05 Survey of English Housing*, January 2006.

show that there are a number of factors that influence smoke alarm ownership, including household type and structure, where someone smokes, age of the house, tenure, household composition, satisfaction with accommodation, ethnicity, and socio-economic group.

B.1.3. Other non-fire drivers of demand

In 2007-08 there were 164,688 non-fire incidents in England, which is about 20 per cent of all incidents in England to which fire and rescue services responded.[107] Of this proportion, 6 per cent were road traffic incidents and 14 per cent were incidents unrelated to road traffic.

With its *Fire and Rescue Service Operational Statistics Bulletin*, CLG publishes a more detailed breakdown of the types of non-fire incidents that FRSs responded to in England between 2003-04 and 2007-08. There was little change in the proportions of incidents by type responded to over the period, although assistance to police and ambulance increased slightly over the period. The following is a list of all incidents that made up more than 5 per cent of (non-fire) incidents responded to in 2007-08:

- road incidents of which persons were extricated from vehicles (9,350 incidents);
- road incidents of which services only rendered (23,943);
- water – removal/provision (14,334);
- effecting entry (13,857);
- lift releases (22,955);
- other rescue/release of people (8,854); and
- service not required, good intent (12,778).

Other incidents responded to by the FRS include: spills and leaks, animal rescues, removal of objects from people, first aid, making safe, assistance to the Police and Ambulance services, and suicides or attempted suicides.

B.2. Fire and Rescue in the Thames Gateway

The CLG Fire Statistics Monitor and the Survey of English Households (SEH) on domestic fires, which we have summarised above in section B.1.2, give recent data on the frequency of fire and characteristics in England and across the nine Government Office Regions.

The Thames Gateway housing developments are taking place in the London, South East and East of England regions.

[107] CLG, *Fire and Rescue Service Operational Statistics Bulletin for England: 2007-08, Appendices*.

As shown in the 2004-05 SEH, the prevalence rates of domestic fires in the previous 12 months varied by region. The highest prevalence, and therefore risk, of fire was in London (1.9 per cent of households), with lower prevalence in the South East (1.4 per cent) and the East (1.3 per cent). The average prevalence rate in England was 1.5 per cent.[108]

In addition, working smoke alarm ownership varies by region. In London, 69.7 per cent of households have at least one working smoke alarm. In the South East, 83.0 per cent own a working smoke alarm, slightly above the 82.6 per cent of households in the East. The average for England is 80.0 per cent of households. *Therefore, statistics clearly show London has a relatively higher risk of fire and a lower incidence of smoke alarms relative to the rest of England, including the South East and East of England*.

Using multivariate logistic regression modelling of the 2004-05 SEH data, odds ratios have been derived for a number of variables, which show that a number of factors influence the risk of domestic fire.[109] The most important factors are listed below:

- frequency of using candles – compared with never using candles, households that use them frequently increase their risk by 2.5 times;
- deprivation – households in deprived areas have 1.9 times more risk than households in non-deprived areas;
- satisfaction with accommodation – households that are dissatisfied are 1.8 times more at risk than those at least fairly satisfied;
- frequency of using room heaters – households that use room heaters rarely or frequently are 1.6 times more at risk than households that never use room heaters;
- economic status of household reference person (HRP) – compared with a retired HRP, where the HRP is in full-time employment or economically inactive (other than retired), the risk is 1.5 and 2.6 times respectively;
- socio-economic group – relative to the HRP being in a lower supervisory and technical occupation, a managerial and professional HRP has 2.0 times the risk for example; and
- satisfaction with area – a household that is dissatisfied has 1.6 times the risk compared with a household at least fairly satisfied with the area.

In addition to the results from the multivariate analysis, bivariate analysis showed that living in a social rented property, being dissatisfied with the accommodation, or having a household composition of a lone parent with dependent children each lead to higher risk of domestic fire.

[108] Office of the Deputy Prime Minister, *Fires in the Home: findings from the 2004/05 Survey of English Housing*, January 2006.
[109] Office of the Deputy Prime Minister, *Fires in the Home: findings from the 2004/05 Survey of English Housing*, January 2006, Chapter 4 and Annex B.

The bivariate and multivariate analysis of the 2004-05 SEH indicate that the relative risk of domestic fires in the new Thames Gateway development will depend on the types of accommodation, as well as characteristics of the tenants. For example, the results show that social rented homes (which are likely to be a large proportion of the Thames Gateway) have a higher relative risk of domestic fire, and satisfaction with the area and accommodation are important to reducing fire risk.

Figure B.3 shows the split of incidents by type that the FRS responded to in 2006-07 for each Thames Gateway region (London, Essex and Kent). Relative to London, the proportions of fire incidents are relatively higher in Essex and Kent, and the proportions of other incidents unrelated to road traffic are relatively lower.

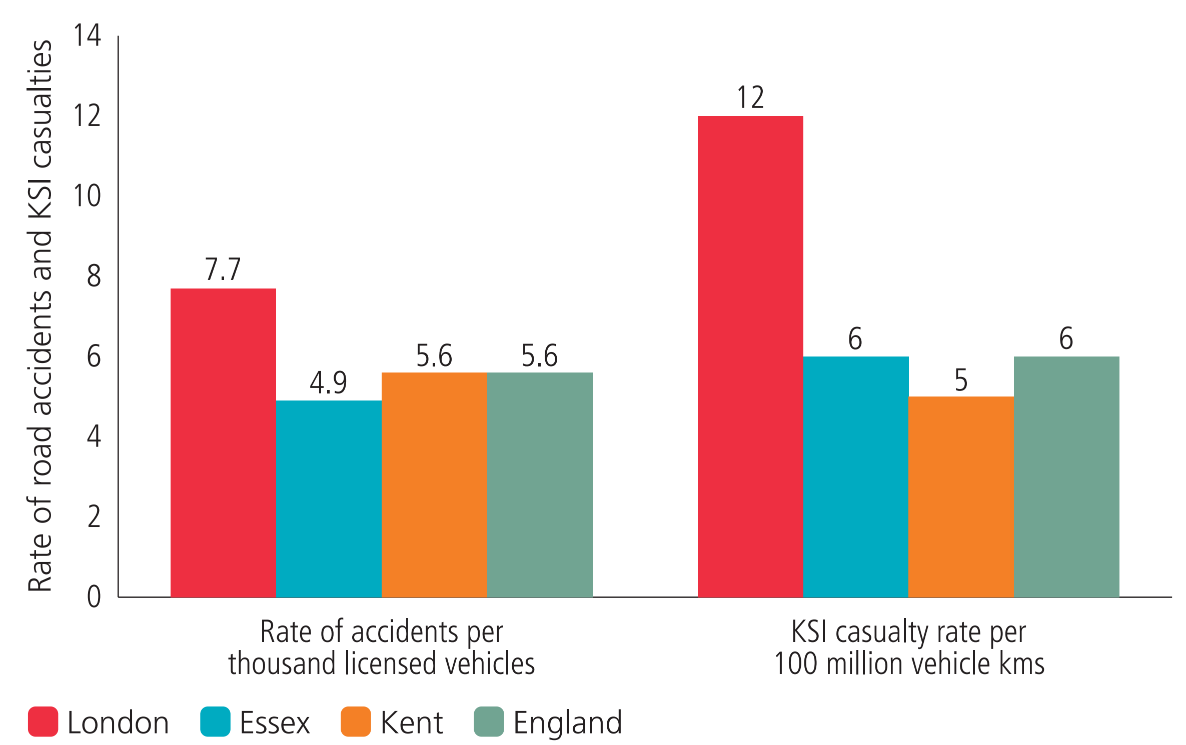
Figure B.3 Proportion of Incidents Responded to by Type and Region, 2006-07

Source: Communities and Local Government, Fire and Rescue Service Operational Statistics Bulletin for England: 2006-07, May 2008, Appendices.

As seen in Figure B.3, a large proportion of FRS activities in the Thames Gateway development area are likely to be non-fire activities, especially in London. As discussed in section B.1.3, these will include road traffic accidents, which we discuss further, and non-road traffic incidents.

Using Department for Transport data on road traffic accidents and casualty rates by region in England in 2007,[110] Figure B.4 shows how the rate of road accidents and casualties varies between London, Kent, Essex and the average for England. The rate of road accidents is measured per thousand licensed vehicles, and the rate of killed or seriously injured (KSI) casualties per 100 million vehicle kilometres.

Figure B.4 Rate of Road Accidents and KSI Casualties by Region, 2007



Source: Department for Transport, Road Casualties English Local Authority Tables: 2006, September 2007.

Figure B.4 shows that both Essex and Kent have similar road accident and casualty rates to the average for England. In contrast, London has higher rates, which means that the development of new homes and roads in the Thames Gateway region may lead to relatively higher demand for FRS services for road traffic incidents in London for each extra car-owner.

[110] Department for Transport, *Road Casualties English Local Authority Tables: 2007*, November 2008.

B.3. The Use of Domestic Sprinkler Systems

In the 2004-05 Survey of English Housing (SEH), households were asked which fire safety measures they had in their homes. *Less than 1 per cent responded that they had a sprinkler system*.[111]

Instead, the most common fire safety measures in homes in England are:

- smoke alarms (owned by 86 per cent of households);
- fire escape/wide opening windows (owned by 28 per cent of households);
- fire extinguishers (owned by 20 per cent of households);
- fire blankets (owned by 9 per cent of households);
- fire doors (owned by 7 per cent of households); and
- practice fire drill/planned escape route (7 per cent of households).

Sprinklers are not mandatory and are largely unused in residential properties in the UK. They are much more common in business properties.

[111] Office of the Deputy Prime Minister, *Fires in the Home: findings from the 2004-05 Survey of English Housing*, January 2006, page 20.

Appendix C
Major Thames Gateway Housing Developments

Local Authority	Housing Development	Number of New Homes
Barking & Dagenham	Barking Riverside & Town Centre	10,491
	South Dagenham	2,900
Bexley	Belvedere	250
	Erith	806
Lewisham	Deptford & New Cross	2,981
Greenwich	East Greenwich & Peninsula	13,172
	Woolwich Town Centre	6,068
Newham	Northern Royals	2,000
	Southern Royals	7,000
	Canning Town	9,920
	Olympic Arc	5,483
Tower Hamlets	Lower Lea Valley & Connections	8,957
	Bromley by Bow & Three Mills	4,871
Basildon	Basildon Town Centres	4,550
	Basildon Business Economy	540
	Basildon Housing	1,600
Castle Point	Castle Point Employment & Town Centres	1,000
Thurrock	East Thurrock	423
	Grays	2,647
	Purfleet	3,438
	West Thurrock Lakeside	3,400
Southend-on-Sea	Central Southend	1,935

Local Authority	Housing Development	Number of New Homes
Dartford	Dartford Town Centre	1,524
	Ebbsfleet Valley	3,694
	Kent Thameside Waterfront Development	5,695
Gravesham	Ebbsfleet Valley	3,694
	Gravesend Town Centre	1,100
	Kent Thameside Waterfront Development	5,695
Swale	Queenborough & Rushenden	1,000
	Sittingbourne	4,734
Medway	Chatham Maritime	2,082
	Chatham Centre & Waterfront	3,000
	Medway Community Enterprise Hubs & Innovation Centre	30
	Rochester	1,475
	Strood	1,530

Source: Tribal Consulting

Appendix D.
Summer 2008 Workshop Attendees

Table D.1 List of Workshop Attendees

Name	Organisation
Bowers, Paul	Essex County Fire & Rescue Service
Brinson, Alan	European Fire Sprinkler Network
Chissell, Nicola	Communities & Local Government
Eady, Paul	London Fire and Planning Authority
Feeley, Bill	Kent Fire & Rescue Service
Gough, Ian	British Automatic Fire Sprinkler Association
Griffiths, Steve	Kent Fire & Rescue Service
Higgins, Judith	Kent Fire & Rescue Service
Hood, Max	London Fire and Planning Authority
King, Ronnie	National Fire Sprinkler Network
Larking, Mike	Communities & Local Government
Parsons, Julian	Wilts Fire & Rescue Service
Pisula, Rafal	Communities & Local Government
Reynolds, Catherine	Communities & Local Government
Young, Ian	Kent Fire & Rescue Service
Carter, Stewart	NERA Economic Consulting
Gros, Stéphane	NERA Economic Consulting
Spackman, Michael	NERA Economic Consulting

Appendix E
References and Data Sources

Arup Fire – British Automatic Sprinkler Association (2006) 'Use and Benefits of Incorporating Sprinklers in Buildings and Structures', Draft 2, January 2006.

Beever, P. and Britton, M. (1999) 'Research into Cost-Effective Fire Measures for Residential Buildings', Centre for Environmental Safety and Risk Engineering, Victoria University of Technology, Melbourne.

BRANZ (2000) 'Cost Effective Fire Safety Measures for Residential Buildings in New Zealand', C.A. Wade and C.R. Duncan.

BRE (2004) 'Effectiveness of Sprinklers in Residential Premises', by the Building Research Establishment Ltd Project report number 204505 for the Office of the Deputy Prime Minister.

Chartered Institute of Public Finance and Accountancy (2007) 'Fire and Rescue Service Statistics'.

Communities and Local Government, 'Definition of general housing terms', http://www.communities.gov.uk/housing/housingresearch/housingstatistics/definitiongeneral

Communities and Local Government, 'Fire Statistics, United Kingdom, 2006'.

Communities and Local Government 'FSEC Software Update 014, September 2006', provided by CLG.

Communities and Local Government (2006a) 'The State of the Gateway: a Baseline for Evaluating the Thames Gateway Programme', November 2006.

Communities and Local Government (2006b) 'Thames Gateway Interim Plan, Development Prospectus', November 2006.

Communities and Local Government (2006c) 'Thames Gateway Interim Plan, Policy Framework', November 2006.

Communities and Local Government (2006d) 'Thames Gateway Interim Plan, Technical Annex to the Policy Framework', November 2006.

Communities and Local Government (2007) 'Thames Gateway, The Delivery Plan', November 2007.

Department for Environment, Food and Rural Affairs (2007) 'The Social Cost of Carbon and the Shadow Price of Carbon: What they are, and how to use them in Economic Appraisal in the UK'.

Department for Transport 'Road Casualties Great Britain, Annual Report', 2005, 2006 and 2007.

Department for Transport 'Road Lengths in Great Britain: 2005-2007'.

Department for Transport (2008) 'Road Transport Forecasts 2008, Results from the Department for Transport's National Transport Model', December 2008.

East of England Regional Assembly (2008) 'East of England Plan, The Revision to the Regional Spatial Strategy for the East of England', May 2008.

EC Harris (2007) 'A Cost Analysis of Sprinklers in Schools', for the Department of Education and Skills.

ENTEC (1997) 'Fire Risks in Houses in Multiple Occupation' by Wright, M., DETR Housing Research Report.

Essex County Fire & Rescue Service (2008) '2008 County Wide Review, Strategic Risk Assessment of the Medium to Longer-Term Fire Service Operating Environment'.

Ford (1997) and Ford (2002) 'Saving Lives, Saving Money: Automatic Sprinklers, A 10 Year Study by J. Ford, 1997' and 'A 15 Year Update on the Impact and Effectiveness of the Scottsdale Sprinkler Ordinance by J. Ford' for the Home Fire Sprinkler Coalition.

FSA (2004) 'An Appraisal of the ODPM –BRE Report 'Effectiveness of sprinklers in residential premises'', Fire Sprinkler Association (FSA).

Greenstreet Berman (2008), 'Risk assessment research work in support of the FSEC toolkit and related applications, Task 3 – update of response time loss relationships', Draft Report, November 2008.

Hall (2007) 'US Experience With Sprinklers and Other Automatic Fire Extinguishing Equipment', National Fire Protection Association (NFPA).

HBOS 'Historical house price data',
http://www.hbosplc.com/economy/historicaldataspreadsheet.asp

HBOS (2008), 'Economics, Research Releases', 12 March 2008.

HM Treasury, 'The Green Book, Appraisal and Evaluation in Central Government'.

Holborn, P.G., Nolan, P.F. and Golt, J. (2004) 'An analysis of fire sizes, fire growth rates and times between events using data from fire investigations', Fire Safety Journal 39.

IRMP Steering Group (2006) 'Development in Kent', 13 October 2006.

Kent FRS (2008) 'Note for roundtable meeting, Briefing on Section 106'.

Koski, J. (2000) 'Residential Fire Sprinklers: Is Dramatic Growth at Hand?', August 29, 2000, PM Engineer.

Mayor of London (2008) 'The London Housing Strategy', November 2008.

Mayor of London (2008) 'The London Plan, Spatial Development Strategy for Greater London', February 2008.

Mott MacDonald (2006) 'FSEC Toolkit, Calculation of Other Building Fire Frequencies', July 2006.

NIST (2005) 'Economic Analysis of Residential Fire Sprinkler Systems' by H. Brown for the US Department of Commerce, National Institute of Standards.

NIST (2007) 'Benefit-Cost Analysis of Residential Fire Sprinkler Systems' by D.T. Butry, M.H. Brown and S.K. Fuller for the US Department of Commerce, National Institute of Standards.

Office of the Deputy Prime Minister (2004) 'The Economic Costs of Fire: Estimates for 2000'.

Office of the Deputy Prime Minister (2006a) 'The Economic Costs of Fire: Estimates for 2004'.

Office of the Deputy Prime Minister (2006b) 'Fires in the Home: findings from the 2004-05 Survey of English Housing'.

Pisula, R. (2008) 'Estimates for the Impact of FRS Activity on Greenhouse Gas Emissions', January 2008.

Ramchandran, G. (1993) 'Early Detection of Fire and Life Risk', Fire Engineers Journal, pp. 33-37, December 1993.

Rohr, K. (2000) 'US Experience with Sprinklers', National Fire Protection Association, January 2000.

Rohr, K. (2001) 'US Experience with Sprinklers', National Fire Protection Association, September 2001.

Rohr, K. (2003) 'US Experience with Sprinklers', National Fire Protection Association, January November 2003.

Rohr and Hall (2005) 'US Experience with Sprinklers and Other Fire Extinguishing Equipment', August 2005.

Ruegg, R.T., and S.K. Fuller (1984) 'A Benefit-Cost Model of Residential Fire Sprinkler Systems', NBS Technical Note 1203, Gaithersburg, MD: National Bureau of Standards.

Siarnicki (2001) 'Residential Sprinklers: One community's experience twelve years after mandatory implementation' by R.J. Siarnicki (Fire Chief, Prince George's Country Fire/EMS Department) for the National Fire Academy.

South East England Regional Assembly (2006) 'The South East Plan, Section D3: Housing', March 2006.

Viscusi, W.K. and Aldy, J.E. (2003) 'The Value of a Statistical Life: A Critical review of Market Estimates Throughout the World', The Journal of Risk and Uncertainty, 27(1): 5-76

Appendix F
Tables

List of Tables

Table 2.1 Local Authorities in the Thames Gateway

London Thames Gateway	*Kent Thames Gateway*	*Essex Thames Gateway*
Barking & Dagenham	Dartford	Basildon
Bexley	Gravesham	Castle Point
Greenwich	Medway	Rochford
Hackney	Swale	Southend
Havering	Tonbridge & Malling	Thurrock
Lewisham		
Newham		
Tower Hamlets		

Source: CLG.

Table 2.2 Potential New Homes in the Thames Gateway

Area	*Potential Homes, 2001 to 2016*
London Thames Gateway	
Isle of Dogs	13,000
Deptford and Lewisham	9,950
Greenwich Peninsula	7,200
Stratford and Olympic Park	9,200
Lower Lea	16,700
Royal Docks	15,900
Barking Town Centre	5,900
London Riverside	10,000
Woolwich, Thamesmead, Belvedere and Erith	11,200
Other Developments	950
North Kent Thames Gateway	
Dartford	9,990
Gravesham	5,824
Medway	11,672
Swale	6,462
South Essex Thames Gateway	
Basildon	7,850
Castle Point	2,750
Rochford	3,100
Southend	4,375
Thurrock	13,500
London Thames Gateway Total	**100,000**
North Kent Thames Gateway Total	**33,948**
South Essex Thames Gateway Total	**31,575**
Thames Gateway Total	**165,523**

Source: CLG, Thames Gateway Interim Plan, Development Prospectus, November 2006.

Table 2.3 Thames Gateway Housing Projections

		2001	*2007*		*2020*		*2050*	
Region	*Local Authority*	*Number of housing units*	*Number of housing units*	*Change from 2001, %*	*Number of housing units*	*Change from 2001, %*	*Number of housing units*	*Change from 2001, %*
London Thames Gateway	Barking and Dagenham	7,776	8,189	*5.3*	15,238	*96.0*	22,699	*191.9*
	Bexley	56,966	58,097	*2.0*	58,755	*3.1*	60,544	*6.3*
	Greenwich	57,083	64,186	*12.4*	72,902	*27.7*	88,721	*55.4*
	Hackney	4,841	4,841	*0.0*	4,841	*0.0*	4,841	*0.0*
	Havering	10,332	10,562	*2.2*	10,562	*2.2*	10,792	*4.5*
	Lewisham	30,153	33,508	*11.1*	36,092	*19.7*	42,030	*39.4*
	Newham	28,458	31,959	*12.3*	59,671	*109.7*	90,884	*219.4*
	Tower Hamlets	20,630	28,107	*36.2*	30,299	*46.9*	39,968	*93.7*
	Total	**216,239**	**239,449**	***10.7***	**288,359**	***33.4***	**360,480**	***66.7***
Kent Thames Gateway	Dartford	25,815	28,111	*8.9*	30,811	*19.4*	35,807	*38.7*
	Gravesham	34,274	36,227	*5.7*	38,337	*11.9*	42,399	*23.7*
	Medway	100,718	104,592	*3.8*	108,111	*7.3*	115,503	*14.7*
	Swale	40,192	43,549	*8.4*	47,070	*17.1*	53,949	*34.2*
	Tonbridge & Malling	1,615	1,615	*0.0*	1,615	*0.0*	1,615	*0.0*
	Total	**202,614**	**214,094**	***5.7***	**225,944**	***11.5***	**249,274**	***23.0***
Essex Thames Gateway	Basildon	41,739	42,559	*2.0*	47,825	*14.6*	53,911	*29.2*
	Castle Point	35,799	36,704	*2.5*	37,704	*5.3*	39,609	*10.6*
	Rochford	2,997	3,302	*10.2*	3,302	*10.2*	3,607	*20.4*
	Southend	70,287	72,087	*2.6*	73,019	*3.9*	75,750	*7.8*
	Thurrock	49,542	53,502	*8.0*	61,574	*24.3*	73,606	*48.6*
	Total	**200,364**	**208,154**	***3.9***	**223,424**	***11.5***	**246,484**	***23.0***

Source: NERA estimates.

Table 2.4 Thames Gateway Other Buildings Projections

		2001	*2007*		*2020*		*2050*	
Region	*Local Authority*	*Number of other buildings*	*Number of other buildings*	*Change from 2001, %*	*Number of other buildings*	*Change from 2001, %*	*Number of other buildings*	*Change from 2001, %*
London Thames Gateway	Barking and Dagenham	712	746	*4.8*	1,387	*94.8*	2,070	*190.7*
	Bexley	2,584	2,629	*1.7*	2,661	*3.0*	2,742	*6.1*
	Greenwich	3,286	3,686	*12.2*	4,188	*27.4*	5,101	*55.2*
	Hackney	308	308	*0.0*	308	*0.0*	308	*0.0*
	Havering	614	626	*2.0*	626	*2.0*	638	*3.9*
	Lewisham	2,491	2,762	*10.9*	2,974	*19.4*	3,465	*39.1*
	Newham	3,188	3,574	*12.1*	6,678	*109.5*	10,175	*219.2*
	Tower Hamlets	2,463	3,350	*36.0*	3,610	*46.6*	4,763	*93.4*
	Total	**15,646**	**17,681**	***13.0***	**22,432**	***43.4***	**29,262**	***87.0***
Kent Thames Gateway	Dartford	1,726	1,870	*8.3*	2,050	*18.8*	2,385	*38.2*
	Gravesham	2,437	2,570	*5.5*	2,718	*11.5*	3,008	*23.4*
	Medway	6,228	6,460	*3.7*	6,677	*7.2*	7,132	*14.5*
	Swale	2,658	2,873	*8.1*	3,105	*16.8*	3,560	*33.9*
	Tonbridge & Malling	38	38	*0.0*	38	*0.0*	38	*0.0*
	Total	**13,087**	**13,811**	***5.5***	**14,588**	***11.5***	**16,123**	***23.2***
Essex Thames Gateway	Basildon	2,302	2,343	*1.8*	2,629	*14.2*	2,965	*28.8*
	Castle Point	1,771	1,810	*2.2*	1,860	*5.0*	1,954	*10.3*
	Rochford	358	391	*9.2*	391	*9.2*	426	*19.0*
	Southend	5,097	5,222	*2.5*	5,289	*3.8*	5,486	*7.6*
	Thurrock	2,821	3,039	*7.7*	3,502	*24.1*	4,186	*48.4*
	Total	**12,349**	**12,805**	***3.7***	**13,671**	***10.7***	**15,017**	***21.6***

Source: NERA estimates.

Table 3.1 Rates of Fire per Person, by Housing Type

Weighted average rates of fire by Thames Gateway region		*Social Housing (Unadjusted)*	*Social Housing (Adjusted)*	*All Other Dwellings (Unadjusted)*	*All Other Dwellings (Adjusted)*
London	Rate of fire (# fires/year/person)	0.0010	–	0.0010	–
	per centage change in rate of fire	–	+50%	–	–30%
	Rate of fire (# fires/year/person)	–	0.0015	–	0.0007
	Rate of fire (one fire/year/# people)	975	650	975	1,393
Essex	Rate of fire (# fires/year/person)	0.0007	–	0.0007	–
	per centage change in rate of fire	–	+50%	–	–10%
	Rate of fire (# fires/year/person)	–	0.0010	–	0.0006
	Rate of fire (one fire/year/# people)	1,474	983	1,474	1,638
Kent	Rate of fire (# fires/year/person)	0.0006	–	0.0006	–
	per centage change in rate of fire	–	+50%	–	–10%
	Rate of fire (# fires/year/person)	–	0.0009	–	0.0006
	Rate of fire (one fire/year/# people)	1,580	1,053	1,580	1,756

Sources: FSEC, NERA analysis

Table 3.2 Fatality Rates per Dwelling Fire Casualty

Vehicle response time (in minutes)	*Fatality rate per casualty (CLG National Model)*	*Fatality rate per casualty (NERA, existing dwellings)*	*Fatality rate per casualty (NERA, new dwellings)*
t<=5	0.02037	0.02037	0.01833
5<t<=10	0.02596	0.02596	0.02336
10<t<=15	0.04227	0.04227	0.03804
15<t<=20	0.04787	0.04787	0.04308
t>20	0.08725	0.08725	0.07853

Source: Table 1, Update14.doc, in correspondence with CLG, NERA analysis.

Table 3.3 Partial Benefits for Dwelling Fire Fatalities

	Partial Benefit Parameters
Partial Benefit 1 (Vehicle 1)	0.72
Partial Benefit 2 (Vehicle 2)	0.25
Partial Benefit 3 (Vehicle 3)	0.015
Partial Benefit 4 (Vehicle 4)	0.015

Source: Correspondence with CLG.

Table 3.4 Rates of Fire per Dwelling, by Housing Type

Weighted average rates of fire by Thames Gateway region		*Social Housing (Unadjusted)*	*Social Housing (Adjusted)*	*All Other Dwellings (Unadjusted)*	*All Other Dwellings (Adjusted)*
London	Rate of fire (# fires/year/dwelling)	0.0024	–	0.0024	–
	per centage change in rate of fire	–	+50%	–	–30%
	Rate of fire (# fires/year/dwelling)	–	0.0036	–	0.0017
	Rate of fire (one fire/year/# dwellings)	422	282	422	603
Essex	Rate of fire (# fires/year/dwelling)	0.0016	–	0.0016	–
	per centage change in rate of fire	–	+50%	–	–10%
	Rate of fire (# fires/year/dwelling)	–	0.0023	–	0.0014
	Rate of fire (one fire/year/# dwellings)	640	427	640	712
Kent	Rate of fire (# fires/year/dwelling)	0.0015	–	0.0015	–
	per centage change in rate of fire	–	+50%	–	–10%
	Rate of fire (# fires/year/dwelling)	–	0.0023	–	0.0014
	Rate of fire (one fire/year/# dwellings)	654	436	654	727

Sources: FSEC, NERA analysis

Table 3.5 Rates of Fire per Building for Other Buildings

Building Type	*'Individual Risk' Fire Rate*	*'Societal Risk' Fire Rate*	*Property Risk Fire Rate*
Hospital	0.03843	0.000588	1.000
Care home	0.00321	0.000128	0.050
Hostel	0.00036	0.000167	0.175
Hotel	0.00263	0.000077	0.050
Other sleeping accommodation	0.00809	0.000034	0.075
Further education	0.00159	0.000022	0.125
Public building	0.00004	0.000022	0.075
Licensed premises	0.00134	0.000021	0.025
School	0.00074	0.000022	0.050
Shop	0.00017	0.00000625	0.005
Other premises open to the public	0.00044	0.000022	0.015
Factory	0.00039	0.0000009	0.015
Office	0.00005	0.00000138	0.005
Other workplace	0.00017	0.000002	0.005

Sources: Greenstreet Berman, November 2008; Mott MacDonald, July 2006; Update14.doc, in correspondence with CLG; and NERA estimates, in discussion with CLG.
Notes: Fire rates are expressed in fires per building per year.

Table 3.6 Partial Benefits for Other Building Societal Fire Fatalities

	Partial Benefit Parameters
Partial Benefit 1 (Vehicle 1)	0.375
Partial Benefit 2 (Vehicle 2)	0.375
Partial Benefit 3 (Vehicle 3)	0.2
Partial Benefit 4 (Vehicle 4)	0.05

Source: In discussion with CLG.

Table 3.7 Partial Benefits for Other Building Property loss

	Partial Benefit Parameters
Partial Benefit 1 (Vehicle 1)	0.83
Partial Benefit 2 (Vehicle 2)	0.10
Partial Benefit 3 (Vehicle 3)	0.04
Partial Benefit 4 (Vehicle 4)	0.03

Source: CLG.

Table 3.8 Property Loss Parameters for Other Buildings

Building Type	*Average Loss Rate (£ per minute)*	*Initial loss incurred within first five minutes (£)*
Hospital	4,211	61,982
Care home	2,539	88,542
Hostel	3,351	41,984
Hotel	2,490	45,087
Other sleeping accommodation	2,490	45,087
Further education	2,318	43,655
Public building	2,506	44,975
Licensed premises	1,897	47,818
School	1,830	63,904
Shop	1,156	49,864
Other premises open to the public	4,090	31,617
Factory	1,997	130,752
Office	2,284	68,245
Other workplace	591	47,448

Source: Greenstreet Berman, November 2008.

Table 3.9 Potential Fatalities Per Kilometre

	Number of Potential RTC Fatalities per Year per Kilometre		
Road Type	**London**	**Essex**	**Kent**
Motorway	0.054	0.054	0.054
A road	0.037	0.037	0.037
B road	0.014	0.014	0.014
C road	0.002	0.002	0.002
Unclassified	0.002	0.002	0.002

Source: DfT, Road length in Great Britain; DfT, Road Casualties Great Britain; and NERA estimates.

Table 3.10 Partial Benefits for RTC Fatalities

	Partial Benefit Parameters
Partial Benefit 1 (Vehicle 1)	0.4
Partial Benefit 2 (Vehicle 2)	0.4
Partial Benefit 3 (Vehicle 3)	0.1
Partial Benefit 4 (Vehicle 4)	0.1

Source: CLG.

Table 4.1 Capital and Maintenance Cost Estimates for Residential Sprinkler Systems (2008 prices, excluding VAT)

Type of property	*Estimate (£)*	*Comments*
House of single occupancy	1,750 – 2,800	Costs are reported to be between 18 and 31 per cent lower for large developments. Costs could be as low as £1,200 for a semi-detached house (at the lower end of the market) *within a large estate*.
House in multiple occupancy	3,500 – 4,000	It is unclear how many units these estimates refer to, but the quotes suggest these costs are for two occupancies.
Flats	900 – 1,200	One estimate suggests that costs may be significantly lower in large developments. For ten to 50 flats, costs were reported to be £750 per unit, and for more than 50 flats, costs were £625 per unit.
Care home for children (9 beds)	6,000 – 8,000	
Care home for elderly (19 beds)	12,000 – 20,000	
Annual maintenance costs	50 – 100	One vendor noted that these can vary between £50 and £850, depending on how complex the system is.

Source: Data collected from sprinkler system vendors (2008).

Table 4.2 Cost Estimates for Pumps and Tanks for Residential Sprinkler Systems (2008 prices, excluding VAT)

Pump capacity	*Estimate (£)*	*Comments*
Domestic operation (single occupancy residence)	1,200 – 1,350	In one case, separate estimates for a tank (£700) and pump set (£650) were provided.
Residential operation (multiple occupancy residence)*	6,000 – 7,500	In one case, separate estimates for a tank (£6,000) and pump set (£1,500) were provided.

Source: Data collected from sprinkler system vendors (2008).

* *Including apartments, houses of multiple occupancy, residential homes and nursing homes.*

Table 4.3 Cost Estimates Selected for Analysis (2007 prices, excluding VAT)

Cost category		*Base case estimate (average cost in £)*	*Values for sensitivity analysis (£)* low	*Values for sensitivity analysis (£)* high
Installation:	House	**1,500**	1,200	2,200
	Flat	**750**	600	900
Water supply (pump only):	House	**700**	700	700
	Flat	**200**	200	200
Water supply (pump and tank):	House	**1,300**	1,300	1,300
	Flat	**400**	400	400
Annual inspection and maintenance:	House – with pump	**75**	50	100
	Flat – with pump	**75**	50	100
Replacement:	House:			
	Valves, heads, pipes, …	**0**	0	0
	Pump set	**700 (20 years)**	700 (20)	700 (20)
	Tank	**0**	0	0
	Flat:			
	Valves, heads, pipes, …	**0**	0	0
	Pump set	**200 (20 years)**	200 (20)	200 (20)
	Tank	**0**	0	0

Source: NERA, based on quotes from vendors (2008).

Table 4.4 Water Supply Requirements Selected for Analysis

Water supply category		*Base case estimate (proportion of new housing, %)*	*Values for sensitivity analysis (%)*	
			low	*high*
Water supply (no pump or tank):	House (% of total)	33	50	0
	Flat (% of total)	33	50	0
Water supply (pump only):	House (% of total)	33	50	50
	Flat (% of total)	33	50	50
Water supply (pump and tank):	House (% of total)	33	0	50
	Flat (% of total)	33	0	50

Source: NERA.

Table 4.5 Effectiveness of Residential Sprinklers, Summary of Literature Findings (Relative to 'No Sprinklers')

Study	*Country*	*Fatalities (% reduction)*	*Injuries (% reduction)*	*Property damage (% reduction)*	*Comments*
Butry et al., NIST (2007)	United States	100	57	32	For sprinkler systems and smoke alarms, relative to properties with smoke alarms only.
Hall (2007)	United States	77	46	42	For all residential categories, with limited sample size. Injuries and property damage figures from Ruegg and Fuller (1984).
BRE (2004)	United Kingdom	70	30	50	Based on an indirect approach. Property damage based on US statistics.
Siarnicki (2001)	United States	100	87	88 – 98	Limited sample size.
Wade and Duncan, BRANZ (2000)	New Zealand	80	63	84	Property damage based on Ruegg and Fuller (1984). Unclear whether figures are based on literature review or are direct estimates.
Ford (1997)	United States	80 – 98.5	n/a	84	Range of reduction in fatalities reported in BRE (2004) and Wade and Duncan (2000). Injuries not reported.

Table 4.6 Effectiveness of Residential Smoke Alarms and Sprinklers, Summary of Findings Prepared by the BRE

	Fatalities (% reduction)	*Injuries (% reduction)*	*Property damage (% reduction)*
Smoke alarms only	53	70	–
Sprinklers only	70 – 80	45 – 65	40 – 50 or 85
Sprinklers plus smoke alarms only	83	45 – 85	Presumably the same as per sprinklers only

Source: BRE (2004), Section 3, page 25.

Table 4.7 Estimates of Sprinklers' Effectiveness Selected for Analysis

Measure of effectiveness	*Base case estimate (%)*	*Values for sensitivity analysis (%)*	
		Low	*High*
Percentage reduction in the number of fatalities	70	70	90
Percentage reduction in the number of injuries	30	30	60
Percentage reduction in the size of the area damaged by fire	50	50	80

Source: NERA.

Table 4.8 Average Annual Operating Expenses (England)

	£ per fire station	*£ per whole time FTE fire fighter*	*£ per FTE fire fighter*	*£ per 1,000 population*
Employment expenditure	1,248,400	59,200	42,200	35,800
Transport	66,100	3,100	2,200	1,900
Supplies and services	93,500	4,400	3,200	2,700
Third party services	6,100	300	200	200
Support services	36,800	1,700	1,200	1,100
Income	–66,000	–3,100	–2,200	–1,900
Other expenses	5,400	300	200	200
Total annual expenses	**1,390,300**	**65,900**	**47,000**	**40,000**

Source: CIPFA, 2006-07.
Notes: Some costs not included ('premise related costs' and 'capital charges'); estimates based on England population of 50,395,700; averages over all 1,446 stations; average station has 30 FTE fire fighters (whole time and retained).

Table 4.9 Average Annual Operating Expenses (Essex, Kent and London)

	£ per fire station	*£ per whole time FTE fire fighter*	*£ per FTE fire fighter*	*£ per 1,000 population*
Essex	1,219,100	64,400	48,300	38,000
Kent	990,800	70,700	39,600	40,000
London	3,543,500	67,300	67,300	52,500
Weighted average	**2,309,900**	**67,400**	**59,400**	**48,400**

Source: CIPFA, 2006-07.

Table 5.1 Life Cycle Cost Estimates – All Thames Gateway

2007 Prices, including VAT	*Do Nothing*		*Sprinklers, no additional FRS resources*		*Sprinklers in social housing sector only, no additional FRS resources*		*Additional FRS resources, no sprinklers*	
	Total Cost, £m, (2008-2057)	*Cost/ year, £m*	*Total Cost, £m, (2008-2057)*	*Cost/ year, £m*	*Total Cost, £m, (2008-2057)*	*Cost/ year, £m*	*Total Cost, £m, (2007-2057)*	*Cost/ year, £m*
London TG								
Cost of Sprinklers	£0	£0	£228.9	£4.6	£114.4	£2.3	£0	£0
Cost of FRS Resources	£0	£0	£0	£0	£0	£0	£29.6	£0.6
Essex TG								
Cost of Sprinklers	£0	£0	£80.6	£1.6	£20.2	£0.4	£0	£0
Cost of FRS Resources	£0	£0	£0	£0	£0	£0	£0	£0
Kent TG								
Cost of Sprinklers	£0	£0	£72.8	£1.5	£18.2	£0.4	£0	£0
Cost of FRS Resources	£0	£0	£0	£0	£0	£0	£53.5	£1.0

Source: NERA estimates.

Table 5.2 Economic, Social and Environmental Outputs (Physical Units) – All Thames Gateway

2007 Prices, including VAT		*Do Nothing*			*Sprinklers, no additional FRS resources*			*Sprinklers in social housing sector only, no additional FRS resources*			*Additional FRS resources, no sprinklers*		
		Scenario Outputs			*Scenario Outputs*			*Scenario Outputs*			*Scenario Outputs*		
		2007	***2020***	***2050***	***2007***	***2020***	***2050***	***2007***	***2020***	***2050***	***2007***	***2020***	***2050***
London TG													
Dwelling Fires	# fatalities	3.83	4.77	6.29	3.83	4.14	4.67	3.83	4.34	5.17	3.82	4.77	6.28
	# burn injuries	21.47	27.17	35.48	21.47	25.46	31.27	21.47	26.00	32.56	21.47	27.17	35.48
	# smoke injuries	58.26	73.72	96.27	58.26	69.08	84.85	58.26	70.56	88.33	58.26	73.72	96.27
	# minor injuries	83.71	105.92	138.32	83.71	99.25	121.92	83.71	101.38	126.92	83.71	105.93	138.32
	Property loss (£'000)	7,498	9,604	13,099	7,498	8,673	10,664	7,498	8,969	11,413	7,498	9,604	13,099
	CO_2 emissions (*t* CO_2)	137.79	176.51	240.72	137.79	153.86	179.83	137.79	161.07	198.55	137.79	176.51	240.72
Other Building Fires	# fatalities	0.25	0.33	0.45	0.25	0.33	0.45	0.25	0.33	0.45	0.25	0.33	0.45
	Property loss (£'000)	19,841	25,162	33,022	19,841	25,162	33,022	19,841	25,162	33,022	19,831	25,151	33,008
	CO_2 emissions (*t* CO_2)	1,006.58	1,296.36	1,707.75	1,006.58	1,296.36	1,707.75	1,006.58	1,296.36	1,707.75	1,006.16	1,295.90	1,707.18
RTCs	# fatalities	9.44	9.69	10.42	9.44	9.69	10.42	9.44	9.69	10.42	9.29	9.55	10.28
	# serious injuries	116.24	116.24	116.24	116.24	116.24	116.24	116.24	116.24	116.24	116.24	116.24	116.24
Essex TG													
Dwelling Fires	# fatalities	2.03	2.21	2.55	2.03	2.11	2.27	2.03	2.18	2.44	2.03	2.21	2.55
	# burn injuries	10.23	11.05	12.28	10.23	10.80	11.66	10.23	10.96	12.05	10.23	11.05	12.28
	# smoke injuries	27.75	29.98	33.33	27.75	29.31	31.65	27.75	29.74	32.69	27.75	29.98	33.33
	# minor injuries	39.88	43.07	47.89	39.88	42.11	45.47	39.88	42.74	46.97	39.88	43.07	47.89
	Property loss (£'000)	3,029	3,329	3,845	3,029	3,213	3,538	3,029	3,287	3,728	3,029	3,329	3,845
	CO_2 emissions (*t* CO_2)	91.36	100.39	115.96	91.36	95.36	102.40	91.36	98.59	110.79	91.36	100.39	115.96
Other Building Fires	# fatalities	0.27	0.29	0.33	0.27	0.29	0.33	0.27	0.29	0.33	0.27	0.29	0.33
	Property loss (£'000)	15,207	16,252	17,927	15,207	16,252	17,927	15,207	16,252	17,927	15,207	16,252	17,927
	CO_2 emissions (*t* CO_2)	742.44	798.47	885.99	742.44	798.47	885.99	742.44	798.47	885.99	742.44	798.47	885.99
RTCs	# fatalities	13.04	13.22	13.82	13.04	13.22	13.82	13.04	13.22	13.82	13.04	13.22	13.82
	# serious injuries	133.96	133.96	133.96	133.96	133.96	133.96	133.96	133.96	133.96	133.96	133.96	133.96

Source: NERA estimates.

Table 5.2 Economic, Social and Environmental Outputs (Physical Units) – All Thames Gateway (continued)

2007 Prices, including VAT		*Do Nothing*			*Sprinklers, no additional FRS resources*			*Sprinklers in social housing sector only, no additional FRS resources*			*Additional FRS resources, no sprinklers*		
		Scenario Outputs			*Scenario Outputs*			*Scenario Outputs*			*Scenario Outputs*		
		2007	*2020*	*2050*	*2007*	*2020*	*2050*	*2007*	*2020*	*2050*	*2007*	*2020*	*2050*
Kent TG													
Dwelling Fires	# fatalities	2.18	2.35	2.73	2.18	2.27	2.46	2.18	2.32	2.62	2.15	2.31	2.67
	# burn injuries	10.45	11.09	12.37	10.45	10.89	11.79	10.45	11.02	12.14	10.45	11.09	12.38
	# smoke injuries	28.34	30.09	33.56	28.34	29.56	31.98	28.34	29.90	32.93	28.35	30.10	33.58
	# minor injuries	40.72	43.23	48.22	40.72	42.47	45.95	40.72	42.97	47.31	40.73	43.25	48.24
	Property loss (£'000)	2,906	3,146	3,652	2,906	3,060	3,381	2,906	3,116	3,545	2,873	3,106	3,597
	CO_2 emissions ($t\ CO_2$)	95.42	103.32	119.92	95.42	99.23	106.76	95.42	101.86	114.74	94.36	101.98	118.11
Other Building Fires	# fatalities	0.46	0.50	0.58	0.46	0.50	0.58	0.46	0.50	0.58	0.45	0.49	0.57
	Property loss (£'000)	20,070	21,305	23,809	20,070	21,305	23,809	20,070	21,305	23,809	20,008	21,237	23,728
	CO_2 emissions ($t\ CO_2$)	891.18	946.44	1,057.54	891.18	946.44	1,057.54	891.18	946.44	1,057.54	888.39	943.35	1,053.81
RTCs	# fatalities	18.95	19.56	20.21	18.95	19.56	20.21	18.95	19.56	20.21	18.45	19.02	19.68
	# serious injuries	170.35	170.35	170.35	170.35	170.35	170.35	170.35	170.35	170.35	170.35	170.35	170.35

Source: NERA estimates.

Table 5.3 Economic, Social and Environmental Outputs (£) – All Thames Gateway

2007 Prices, including VAT		*Do Nothing*	*Sprinklers, no additional FRS resources*		*Sprinklers in social housing sector only, no additional FRS resources*		*Additional FRS resources, no sprinklers*	
		Scenario PV	*Scenario PV*	*Difference from Do Nothing*	*Scenario PV*	*Difference from Do Nothing*	*Scenario PV*	*Difference from Do Nothing*
		PV, £m	*PV, £m*	*PV, £m*	*PV, £m*	*PV, £m*	*PV, £m*	*PV, £m*
London TG								
Dwelling Fires	Fatalities	295.1	244.1	–51.09	259.8	–35.30	294.8	–0.38
	Burn injuries	188.2	173.0	–15.16	177.7	–10.47	188.2	0.01
	Smoke injuries	128.9	118.5	–10.39	121.7	–7.18	128.9	0.00
	Minor injuries	2.4	2.2	–0.19	2.3	–0.13	2.4	0.00
	Property loss	248.3	220.7	–27.66	229.3	–19.04	248.3	0.00
	CO_2 emissions	0.4	0.3	–0.08	0.4	–0.05	0.4	0.00
Other Building Fires	Fatalities	20.6	20.6	0.00	20.6	0.00	20.6	–0.05
	Property loss	642.9	642.9	0.00	642.9	0.00	642.6	–0.29
	CO_2 emissions	3.0	3.0	0.00	3.0	0.00	3.0	0.00
RTCs	Fatalities	564.7	564.7	0.00	564.7	0.00	556.6	–8.11
	Serious injuries	745.5	745.5	0.00	745.5	0.00	745.5	0.00
Essex TG								
Dwelling Fires	Fatalities	131.4	122.6	–8.81	128.2	–3.27	131.4	0.00
	Burn injuries	73.0	70.7	–2.22	72.1	–0.82	73.0	0.00
	Smoke injuries	50.0	48.5	–1.52	49.4	–0.56	50.0	0.00
	Minor injuries	0.9	0.9	–0.03	0.9	–0.01	0.9	0.00
	Property loss	83.9	80.5	–3.47	82.6	–1.29	83.9	0.00
	CO_2 emissions	0.2	0.2	–0.02	0.2	–0.01	0.2	0.00
Other Building Fires	Fatalities	17.1	17.1	0.00	17.1	0.00	17.1	0.00
	Property loss	406.4	406.4	0.00	406.4	0.00	406.4	0.00
	CO_2 emissions	1.7	1.7	0.00	1.7	0.00	1.7	0.00
RTCs	Fatalities	763.4	763.4	0.00	763.4	0.00	763.4	0.00
	Serious injuries	859.1	859.1	0.00	859.1	0.00	859.1	0.00

Source: NERA estimates. Note: Due to rounding, non-zero values may be shown as zero.

Table 5.3 Economic, Social and Environmental Outputs (£) – All Thames Gateway (continued)

2007 Prices, including VAT		*Do Nothing*	*Sprinklers, no additional FRS resources*		*Sprinklers in social housing sector only, no additional FRS resources*		*Additional FRS resources, no sprinklers*	
		Scenario PV	*Scenario PV*	*Difference from Do Nothing*	*Scenario PV*	*Difference from Do Nothing*	*Scenario PV*	*Difference from Do Nothing*
		PV, £m	*PV, £m*	*PV, £m*	*PV, £m*	*PV, £m*	*PV, £m*	*PV, £m*
Kent TG								
Dwelling Fires	Fatalities	140.3	132.3	–7.94	137.2	–3.06	137.8	–2.44
	Burn injuries	73.5	71.6	–1.98	72.8	–0.76	73.6	0.03
	Smoke injuries	50.4	49.0	–1.36	49.8	–0.52	50.4	0.02
	Minor injuries	0.9	0.9	–0.03	0.9	–0.01	0.9	0.00
	Property loss	79.7	76.8	–2.87	78.6	–1.09	78.6	–1.05
	CO_2 emissions	0.2	0.2	–0.02	0.2	–0.01	0.2	0.00
Other Building Fires	Fatalities	29.6	29.6	0.00	29.6	0.00	29.1	–0.49
	Property loss	535.8	535.8	0.00	535.8	0.00	534.0	–1.73
	CO_2 emissions	2.0	2.0	0.00	2.0	0.00	2.0	–0.01
RTCs	Fatalities	1,120.8	1,120.8	0.00	1,120.8	0.00	1,090.9	–29.92
	Serious injuries	1,092.6	1,092.6	0.00	1,092.6	0.00	1,092.6	0.00

Source: NERA estimates. Note: Due to rounding, non-zero values may be shown as zero.

Table 5.4 Present Value of Costs and Benefits – All Thames Gateway

Scenario Summary, PV, £m	*Economic and Social Benefits*	*Environmental Benefits*	*Sprinklers Cost*	*FRS Resource Cost*	*Net Benefits*	*Benefit/ Cost Ratio*
Option I: Sprinklers in all new housing, no additional FRS resources						
London TG	104.5	0.08	–228.9	0.0	–124.3	0.46
Essex TG	16.0	0.02	–80.6	0.0	–64.6	0.20
Kent TG	14.2	0.02	–72.8	0.0	–58.6	0.19
Thames Gateway Total	**134.7**	**0.11**	**–382.3**	**0.0**	**–247.5**	**0.35**
Option II: Sprinklers in social housing sector only, no additional FRS resources						
London TG	72.1	0.05	–114.4	0.0	–42.3	0.63
Essex TG	6.0	0.01	–20.2	0.0	–14.2	0.30
Kent TG	5.4	0.01	–18.2	0.0	–12.8	0.30
Thames Gateway Total	**83.5**	**0.07**	**–152.8**	**0.0**	**–69.2**	**0.55**
Option III: Additional FRS resources, no sprinklers						
London TG	8.8	0.00	0.0	–29.6	–20.8	0.30
Essex TG	0.0	0.00	0.0	0.0	0.0	–
Kent TG	35.6	0.01	0.0	–53.5	–17.9	0.67
Thames Gateway Total	**44.4**	**0.01**	**0.0**	**–83.1**	**–38.7**	**0.53**

Source: NERA estimates. Present values are shown relative to the baseline.

Table 5.5 Summary Table – All Thames Gateway

	Sprinklers in all new housing, no additional FRS resources	*Sprinklers in social housing only, no additional FRS resources*	*Additional FRS resources, no sprinklers*
Relative to 'Do Nothing'			
Total monetised costs (PV, £m)	382.3	152.8	83.1
Total monetised benefits (PV, £m)	134.8	83.6	44.4
Net monetised benefits (PV, £m)	–247.5	–69.2	–38.7
Relative to Option III (additional FRS resources)			
Total monetised costs (PV, £m)	382.3	152.8	–
Total monetised benefits (PV, £m)	173.5	122.3	–
Net monetised benefits (PV, £m)	–208.8	–30.5	–

Source: NERA estimates.

Table 6.1 Sprinkler Installation Cost Sensitivity Results

Variables	*Units*	*Base Case*	*Low Cost*	*High Cost*
Sprinklers installation costs	**£ (2007, exc. VAT)**			
House		1,500	1,200	2,200
Flat		750	600	900
Net Benefits (PV)	**£m**			
Option I: Sprinklers in all housing		–247.5	–214.4	–315.7
Option II: Sprinklers in social housing		–69.2	–56.1	–95.8
Option III: Additional FRS resources		–38.7	–38.7	–38.7
Benefit/Cost Ratio	**PVB/PVC**			
Option I: Sprinklers in all housing		0.35	0.39	0.30
Option II: Sprinklers in social housing		0.55	0.60	0.47
Option III: Additional FRS resources		0.53	0.53	0.53

Source: NERA analysis

Table 6.2 Water Supply and Replacement Cost Sensitivity Results

Variables	*Units*	*Base Case*	*Low Cost*	*High Cost*
Sprinklers water supply and replacement costs	%			
% dwellings with no pump or tank		33%	50%	0%
% dwellings with pump only		33%	50%	50%
% dwellings with pump and tank		33%	0%	50%
Net Benefits (PV)	£m			
Option I: Sprinklers in all housing		−247.5	−177.9	−356.0
Option II: Sprinklers in social housing		−69.2	−41.4	−112.7
Option III: Additional FRS resources		−38.7	−38.7	−38.7
Benefit/Cost Ratio	PVB/PVC			
Option I: Sprinklers in all housing		0.35	0.43	0.27
Option II: Sprinklers in social housing		0.55	0.67	0.43
Option III: Additional FRS resources		0.53	0.53	0.53

Source: NERA analysis.

Table 6.3 Sprinkler Pump Inspection and Maintenance Cost Sensitivity Results

Variables	*Units*	*Base Case*	*Low Cost*	*High Cost*
Sprinkler pump annual inspection and maintenance costs	**£ (2007, exc. VAT)**			
House		75	50	100
Flat		75	50	100
Net Benefits (PV)	**£m**			
Option I: Sprinklers in all housing		–247.5	–206.1	–289.0
Option II: Sprinklers in social housing		–69.2	–52.3	–86.1
Option III: Additional FRS resources		–38.7	–38.7	–38.7
Benefit/Cost Ratio	**PVB/PVC**			
Option I: Sprinklers in all housing		0.35	0.40	0.32
Option II: Sprinklers in social housing		0.55	0.62	0.49
Option III: Additional FRS resources		0.53	0.53	0.53

Source: NERA analysis.

Table 6.4 Real Changes in Sprinkler Costs Sensitivity Results

Variables	*Units*	*Base Case*	*1% p.a. Reduction*	*2% p.a. Reduction*
Annual real changes in sprinklers costs	% p.a.			
Installation costs		0%	-1%	-2%
Water supply and replacement costs		0%	-1%	-2%
Net Benefits (PV)	£m			
Option I: Sprinklers in all housing		–247.5	–205.7	–173.6
Option II: Sprinklers in social housing		–69.2	–52.8	–40.1
Option III: Additional FRS resources		–38.7	–38.7	–38.7
Benefit/Cost Ratio	PVB/PVC			
Option I: Sprinklers in all housing		0.35	0.40	0.44
Option II: Sprinklers in social housing		0.55	0.61	0.68
Option III: Additional FRS resources		0.53	0.53	0.53

Source: NERA analysis.

Table 6.5 Sprinkler Effectiveness Sensitivity Results

Variables	*Units*	*Base Case*	*High Effectiveness*	*Different Injury Reductions*
Sprinklers effectiveness	% reduction			
Reduction in fatalities		70	90	90
Reduction in serious injuries		30	60	75
Reduction in slight injuries		30	60	45
Reduction in property loss		50	80	80
Net Benefits (PV)	£m			
Option I: Sprinklers in all housing		–247.5	–174.9	–158.7
Option II: Sprinklers in social housing		–69.2	–24.0	–13.9
Option III: Additional FRS resources		–38.7	–38.7	–38.7
Benefit/Cost Ratio	PVB/PVC			
Option I: Sprinklers in all housing		0.35	0.54	0.59
Option II: Sprinklers in social housing		0.55	0.84	0.91
Option III: Additional FRS resources		0.53	0.53	0.53

Source: NERA analysis.

Table 6.6 FRS Resource Cost Sensitivity Results

Variables	*Units*	*Base Case*	*Low Cost*	*High Cost*
Additional whole-time pump	**£ per year**			
London		1,092,750	819,500	1,366,000
Essex		–	–	–
Kent		963,500	722,500	1,204,500
Retained to whole-time pump	**£ per year**			
London		–	–	–
Essex		–	–	–
Kent		1,010,500	758,000	1,263,000
Net Benefits (PV)	**£m**			
Option I: Sprinklers in all housing		–247.5	–247.5	–247.5
Option II: Sprinklers in social housing		–69.2	–69.2	–69.2
Option III: Additional FRS resources		–38.7	–17.9	–59.5
Benefit/Cost Ratio	**PVB/PVC**			
Option I: Sprinklers in all housing		0.35	0.35	0.35
Option II: Sprinklers in social housing		0.55	0.55	0.55
Option III: Additional FRS resources		0.53	0.71	0.43

Source: NERA analysis.

Table 6.7 Real Growth in FRS Resource Cost Sensitivity Results

Variables	*Units*	*Base Case*	*No Real Growth*	*Higher Real Growth*
Annual Real Changes in Resource Costs	% p.a.			
All costs		0.5%	0%	2%
Net Benefits (PV)	£m			
Option I: Sprinklers in all housing		–247.5	–247.5	–247.5
Option II: Sprinklers in social housing		–69.2	–69.2	–69.2
Option III: Additional FRS resources		–38.7	–31.3	–68.4
Benefit/Cost Ratio	PVB/PVC			
Option I: Sprinklers in all housing		0.35	0.35	0.35
Option II: Sprinklers in social housing		0.55	0.55	0.55
Option III: Additional FRS resources		0.53	0.59	0.39

Source: NERA analysis.

Table 6.8 Changes to the Proportions of Housing Types Sensitivity Results

Variables	*Units*	*Base Case*	*Equal Split*
London Thames Gateway	%		
% of new dwellings that are houses		56%	50%
% of new dwellings that are flats		44%	50%
Essex Thames Gateway	%		
% of new dwellings that are houses		79%	50%
% of new dwellings that are flats		21%	50%
Kent Thames Gateway	%		
% of new dwellings that are houses		87%	50%
% of new dwellings that are flats		13%	50%
Net Benefits (PV)	£m		
Option I: Sprinklers in all housing		–247.5	–218.0
Option II: Sprinklers in social housing		–69.2	–60.1
Option III: Additional FRS resources		–38.7	–38.7
Benefit/Cost Ratio	PVB/PVC		
Option I: Sprinklers in all housing		0.35	0.38
Option II: Sprinklers in social housing		0.55	0.58
Option III: Additional FRS resources		0.53	0.53

Source: NERA analysis.

Table 6.9 Rate of Fire by Housing Sensitivity Results

Variables	*Units*	*Base Case*	*No Difference*	*Larger Difference*
Change in rate of fire for London	**% change from all dwelling average**			
Social sector dwellings		50%	0%	100%
All other dwellings		–30%	0%	–60%
Change in rate of fire for Essex and Kent				
Social sector dwellings		50%	0%	100%
All other dwellings		–10%	0%	–20%
Net Benefits (PV)	**£m**			
Option I: Sprinklers in all housing		–247.5	–259.4	–235.6
Option II: Sprinklers in social housing		–69.2	–97.1	–41.4
Option III: Additional FRS resources		–38.7	–38.9	–38.5
Benefit/Cost Ratio	**PVB/PVC**			
Option I: Sprinklers in all housing		0.35	0.32	0.38
Option II: Sprinklers in social housing		0.55	0.36	0.73
Option III: Additional FRS resources		0.53	0.53	0.54

Source: NERA analysis.

Table 6.10 Travel Time Changes Sensitivity Results

Variables	*Units*	*Base Case*	*Higher Change*
Change in London travel times	%		
2007-2020		10%	20%
2007-2050		30%	60%
Change in Essex and Kent travel times	%		
2007-2020		5%	10%
2007-2050		15%	30%
Net Benefits (PV)	£m		
Option I: Sprinklers in all housing		–247.5	–242.4
Option II: Sprinklers in social housing		–69.2	–66.0
Option III: Additional FRS resources		–38.7	–37.4
Benefit/Cost Ratio	PVB/PVC		
Option I: Sprinklers in all housing		0.35	0.37
Option II: Sprinklers in social housing		0.55	0.57
Option III: Additional FRS resources		0.53	0.55

Source: NERA analysis.

Table 6.11 Property Damage Growth Sensitivity Results

Variables	*Units*	*Base Case*	*Real growth, 2% p.a.*	*Real growth, 4% p.a.*
Real annual changes in property values	% p.a.			
Residential property		0%	2%	4%
Non-residential property		0%	2%	4%
Net Benefits (PV)	£m			
Option I: Sprinklers in all housing		–247.5	–220.7	–167.2
Option II: Sprinklers in social housing		–69.2	–52.3	–18.4
Option III: Additional FRS resources		–38.7	–37.0	–33.9
Benefit/Cost Ratio	PVB/PVC			
Option I: Sprinklers in all housing		0.35	0.42	0.56
Option II: Sprinklers in social housing		0.55	0.66	0.88
Option III: Additional FRS resources		0.53	0.55	0.59

Source: NERA analysis.

Table 6.12 Time Horizon Sensitivity Results

Variables	Units	*Base Case*	*30-Year Horizon*	*40-Year Horizon*
Changes to CBA time horizon	**Years**			
Time horizon for costs and benefits		50	30	40
Net Benefits (PV)	**£m**			
Option I: Sprinklers in all housing		–247.5	–203.5	–229.4
Option II: Sprinklers in social housing		–69.2	–67.3	–70.1
Option III: Additional FRS resources		–38.7	–33.0	–36.7
Benefit/Cost Ratio	**PVB/PVC**			
Option I: Sprinklers in all housing		0.35	0.24	0.30
Option II: Sprinklers in social housing		0.55	0.38	0.47
Option III: Additional FRS resources		0.53	0.48	0.51

Source: NERA analysis.

Table 6.13 Fire Growth Calculation Sensitivity Results

Variables	*Units*	*Base Case*	*Adjusted Time-Sq.*	*Unadjusted Time-Sq.*
Changes to fire growth calculation				
Linear fire growth		✓		
Time-squared fire growth (adjusted)			✓	
Time-squared fire growth (unadjusted)				✓
Net Benefits (PV)	£m			
Option I: Sprinklers in all housing		–247.5	–240.8	–200.0
Option II: Sprinklers in social housing		–69.2	–65.4	–40.1
Option III: Additional FRS resources		–38.7	–36.9	–34.1
Benefit/Cost Ratio	PVB/PVC			
Option I: Sprinklers in all housing		0.35	0.37	0.48
Option II: Sprinklers in social housing		0.55	0.57	0.74
Option III: Additional FRS resources		0.53	0.56	0.59

Source: NERA analysis.

Table 6.14 Changes to Dwelling Property Loss Rate Sensitivity Results

Variables	*Units*	*Base Case*	*75% Base Case*	*125% Base Case*
Average loss rate from dwelling fire	£/min			
London Thames Gateway		1,339	1,005	1,674
Essex Thames Gateway		816	612	1,020
Kent Thames Gateway		750	562	937
Net Benefits (PV)	£m			
Option I: Sprinklers in all housing		−247.5	−256.1	−239.0
Option II: Sprinklers in social housing		−69.2	−74.6	−63.8
Option III: Additional FRS resources		−38.7	−39.0	−38.4
Benefit/Cost Ratio	PVB/PVC			
Option I: Sprinklers in all housing		0.35	0.33	0.37
Option II: Sprinklers in social housing		0.55	0.51	0.58
Option III: Additional FRS resources		0.53	0.53	0.54

Source: NERA analysis.

Table 6.15 Property Loss Calculation Sensitivity Results

Variables	*Units*	*Base Case*	*Impact on Area Damaged, 1m²*	*Impact on Area Damaged, 2m²*
Changes to calculation of sprinkler impact on property loss				
% reduction in property loss		✓	–	–
Impact on area damaged		–	✓	✓
Average area burned per sprinkler fire (m^2)		–	$1m^2$	$2m^2$
Net Benefits (PV)	£m			
Option I: Sprinklers in all housing		–247.5	–235.0	–256.6
Option II: Sprinklers in social housing		–69.2	–61.5	–75.3
Option III: Additional FRS resources		–38.7	–38.7	–38.7
Benefit/Cost Ratio	PVB/PVC			
Option I: Sprinklers in all housing		0.35	0.39	0.33
Option II: Sprinklers in social housing		0.55	0.60	0.51
Option III: Additional FRS resources		0.53	0.53	0.53

Source: NERA analysis.

Table 6.16 Smoke Alarm Adjustment Sensitivity Results

Variables	*Units*	*Base Case*	*No Difference*	*Larger Difference*
Smoke alarm adjustments in new housing	%			
Fatalities per casualty in new housing as % of fatalities per casualty in existing housing		90%	100%	75%
Smoke alarm adjustments in new housing	Mins			
Mean fire reporting time in existing housing		6	6	6
Mean fire reporting time in new housing		5.5	6	4
Net Benefits (PV)	£m			
Option I: Sprinklers in all housing		–247.5	–238.2	–264.3
Option II: Sprinklers in social housing		–69.2	–63.5	–79.6
Option III: Additional FRS resources		–38.7	–38.7	–38.8
Benefit/Cost Ratio	PVB/PVC			
Option I: Sprinklers in all housing		0.35	0.38	0.31
Option II: Sprinklers in social housing		0.55	0.58	0.48
Option III: Additional FRS resources		0.53	0.53	0.53

Source: NERA analysis.

Table 6.17 FRS Effectiveness for RTCs Sensitivity Results

Variables	*Units*	*Base Case*	*Smaller Difference*	*Larger Difference*
Effectiveness of FRS response (fatality rate change)	%			
0-5 mins response		–36%	–10%	–50%
6-10 mins response		0%	0%	0%
>10 mins response		29%	10%	50%
Net Benefits (PV)	£m			
Option I: Sprinklers in all housing		–247.5	–247.5	–247.5
Option II: Sprinklers in social housing		–69.2	–69.2	–69.2
Option III: Additional FRS resources		–38.7	–65.0	–18.2
Benefit/Cost Ratio	PVB/PVC			
Option I: Sprinklers in all housing		0.35	0.35	0.35
Option II: Sprinklers in social housing		0.55	0.55	0.55
Option III: Additional FRS resources		0.53	0.22	0.78

Source: NERA analysis.

Table 6.18 Scenario Results

Variables	*Units*	*Base Case*	*High Effectiveness, Low Cost*	*Base Effectiveness, High Cost*
Sprinklers effectiveness	% reduction			
Reduction in fatalities		70	90	70
Reduction in serious injuries		30	60	30
Reduction in slight injuries		30	60	30
Reduction in property loss		50	80	50
Sprinklers installation costs	£ (2007, exc. VAT)			
House		1,500	1,200	2,200
Flat		750	600	900
Sprinklers annual inspection and maintenance costs	£ (2007, exc. VAT)			
House		75	50	100
Flat		75	50	100
Annual real changes in sprinklers costs	% p.a.			
Installation costs		0%	–1%	1%
Water supply and replacement costs		0%	–1%	1%
Sprinklers water supply and replacement costs	%			
% dwellings with no pump or tank		33%	50%	0%
% dwellings with pump only		33%	50%	50%
% dwellings with pump and tank		33%	0%	50%
Net Benefits (PV)	£m			
Option I: Sprinklers in all housing		–247.5	–10.7	–556.7
Option II: Sprinklers in social housing		–69.2	41.6	–196.2
Option III: Additional FRS resources		–38.7	–38.7	–38.7
Benefit/Cost Ratio	PVB/PVC			
Option I: Sprinklers in all housing		0.35	0.95	0.19
Option II: Sprinklers in social housing		0.55	1.48	0.30
Option III: Additional FRS resources		0.53	0.53	0.53

Source: NERA analysis.

Table 6.19 Sprinkler Effectiveness Switching Values

		Base Case (% reduction)			*Switching Values (% reduction)*		
	Switching Values?	*Fatalities*	*Injuries*	*Property Loss*	*Fatalities*	*Injuries*	*Property Loss*
Thames Gateway							
Option I	✗	70%	30%	50%	–	–	–
Option II	✓	70%	30%	50%	90%	90%	90%
Option III	–	70%	30%	50%	–	–	–

Source: NERA analysis.

Table 6.20 Real Sprinkler Cost Growth Switching Values

		Base Case (real % change in costs p.a.)			*Switching Values (real % change in costs p.a.)*		
	Switching Values?	*Installation costs*	*Inspection & Maintenance costs*	*Water supply & replacement costs*	*Installation costs*	*Inspection & Maintenance costs*	*Water supply & replacement costs*
Thames Gateway							
Option I	✓	0%	0%	0%	–7%	–7%	–7%
Option II	✓	0%	0%	0%	–4%	–4%	–4%
Option III	–	0%	0%	0%	–	–	–

Source: NERA analysis.

Table 6.21 Sprinkler Installation, Inspection and Maintenance Cost Switching Values

		Base Case (£ per dwelling, exc. VAT)				*Switching Values, (£ per dwelling, exc. VAT)*			
		Installation Costs		*Annual Inspection & Maintenance Costs*		*Installation Costs*		*Annual Inspection & Maintenance Costs*	
	Switching Values?	*House*	*Flat*	*House*	*Flat*	*House*	*Flat*	*House*	*Flat*
Thames Gateway									
Option I	✓	1,500	700	75	75	200	100	10	10
Option II	✓	1,500	700	75	75	600	300	30	30
Option III	–	1,500	700	75	75	–	–	–	–

Source: NERA analysis.

Table 6.22 FRS Resource Cost Switching Values

		Base Case (£, annual cost per resource change)				*Switching Values (£, annual cost per resource change)*			
		Additional whole-time pump		*Retained to whole-time pump*		*Additional whole-time pump*		*Retained to whole-time pump*	
	Switching Values?	*London*	*Kent*	*London*	*Kent*	*London*	*Kent*	*London*	*Kent*
Thames Gateway									
Option I	–	1,092,750	963,500	–	1,010,500	–	–	–	–
Option II	–	1,092,750	963,500	–	1,010,500	–	–	–	–
Option III	✓	1,092,750	963,500	–	1,010,500	500,000	500,000	–	500,000

Source: NERA analysis.

Cover Price £25

ISBN: 978 1 4098 2260 8

ISBN 978-1 4098 2260-8