Fire Research Report

THE ECONOMIC COSTS OF FIRE IN NON-RESIDENTIAL BUILDINGS

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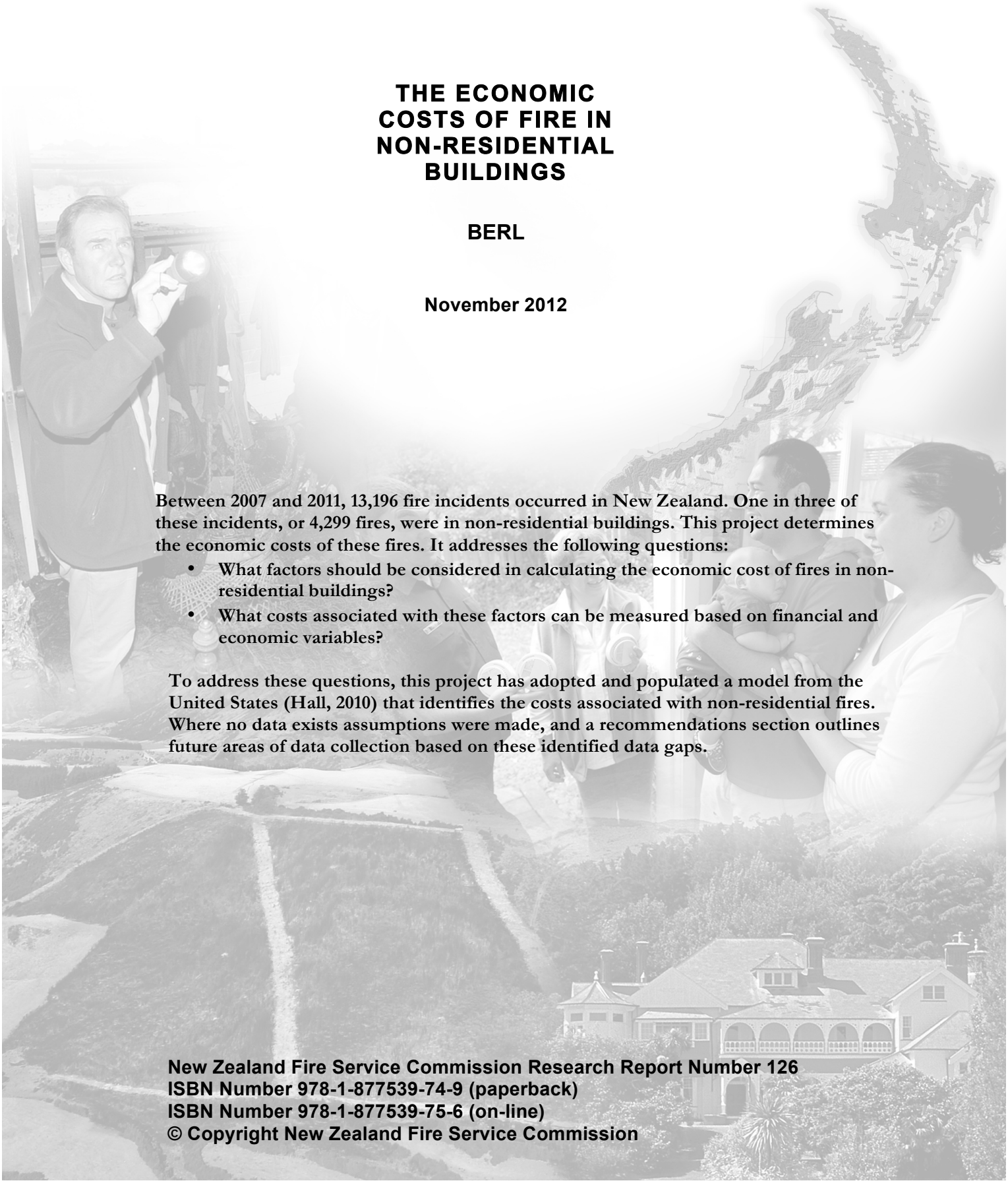

Between 2007 and 2011, 13,196 fire incidents occurred in New Zealand. One in three of these incidents, or 4,299 fires, were in non-residential buildings. This project determines the economic costs of these fires. It addresses the following questions:

- What factors should be considered in calculating the economic cost of fires in non-residential buildings?
- What costs associated with these factors can be measured based on financial and economic variables?

To address these questions, this project has adopted and populated a model from the United States (Hall, 2010) that identifies the costs associated with non-residential fires. Where no data exists assumptions were made, and a recommendations section outlines future areas of data collection based on these identified data gaps.

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THE ECONOMIC COSTS OF FIRE IN NON-RESIDENTIAL BUILDINGS

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The Economic Costs of Fire in Non-Residential Buildings

Tables

1 Summary

The economic cost of fires in non-residential buildings was $656.3 million in 2011. This is less than 0.5 percent of New Zealand's Gross Domestic Product. Overall, 86 percent of this cost is not associated with the direct losses caused by the fire.

Table 1.1 Economic cost of non-residential fires, 2011

Cost components	2011 ($millions)
Fire protection systems	$273.0
Fire Service levy	$151.7
Net fire insurance	$124.0
Fire damage	$93.2
Human factors	$14.4
Total economic cost	**$656.3**

Source: BERL, NZFS, ICNZ, PWC, BECA

The largest economic cost is the installation of fire protection systems in buildings. In 2011, this was 42 percent of the total economic cost of non-residential fires. While termed a cost, the installation of fire protection systems could also be considered a benefit, as it potentially limits the cost of any future fire incidents that may occur in this building.

The second largest cost component also relates to fire protection systems, the Fire Service Levy at $151.7 million, or 23 percent of the total cost. Here, the Fire Service levy on commercial material damage insurance and other business insurance was estimated and used as a proxy for the cost of responding to fires in non-residential buildings.

Net fire insurance is the total cost of insurance premiums paid for commercial material insurance. This covers fire damage to non-residential buildings and their contents, minus the value of fire-based insurance claims. In 2011 this was $124 million, or 19 percent of the total cost of non-residential fires.

Fire damage in non-residential buildings, was estimated at $93.2 million, or 14 percent of the total cost of fires. This includes the estimated cost of replacing and repairing buildings damaged by fire, and the loss of building contents. It also includes estimates of damage from unreported fires, and indirect damage caused by fires in non-residential buildings.

Human factors include the loss of life and injury as a result of fire, and the cost of volunteer firefighters' time. This was estimated at $14.4 million, or two percent of the total cost.

2 Introduction

Between 2007 and 2011, 13,196 fire incidents occurred in New Zealand. One in three of these incidents, or 4,299 fires, were in non-residential buildings. This project determines the economic costs of these fires. It addresses the following questions:

- What factors should be considered in calculating the economic cost of fires in non-residential buildings?
- What costs associated with these factors can be measured based on financial and economic variables?

To address these questions, this project has adopted and populated a model from the United States (Hall, 2010) that identifies the costs associated with non-residential fires. Where no data exists assumptions were made, and a recommendations section outlines future areas of data collection based on these identified data gaps.

Excluded from the scope of this project are the economic costs associated with residential fires, and fires that occur outside of buildings such as forest, scrub, and vehicle fires. Also outside of the project scope is the inclusion and measurement of intangible costs, which are often unable to be quantified using financial and economic variables. Intangible costs may include factors such as fire damage to heritage buildings or the loss of recreational areas.

This report is divided into three sections, excluding the executive summary and technical appendices. Section 3 discusses BERL's literature review on international models and tools used to determine the economic costs of fires, and current research gaps in determining the cost of fire.

Section 4 provides a detailed breakdown of the cost components that make-up the total economic cost of fires in New Zealand non-residential buildings. This section describes each component and the data or assumptions used. The economic costs are calculated for a five year period, 2007 to 2011.

Section 5 analyses fires in non-residential buildings in New Zealand for the five year period examined. Data from the New Zealand Fire Service FIRS database is used to examine trends in the number, location and size of reported non-residential fires.

3 International estimates of the cost of fire

To date, the economic cost of fire in non-residential buildings in New Zealand has not been determined. Studies completed by BRANZ have discussed the cost of fire damage from the point of view of changing building materials and design, and the cost of repairing fire-damaged residential buildings. In addition, NZIER and Corydon Consultants Ltd have analysed the economic costs of fires in schools from a social well-being point of view.

This section of our report discusses research completed internationally on the economic cost of fire. It describes the cost components identified and used in these studies, and some of the assumptions or proxies used.

3.1 International research on the cost of fire

Research projects completed in Australia, Canada, the United Kingdom, the United States, and parts of the European Union have estimated the economic cost of fire at between 0.9 and 2.0 percent of their Gross Domestic Product.

However, these studies may be underestimates as some components are hard to put values on, and the data may not be readily available (Ashe et al, 2009). Despite this, as more evidence and data becomes available, these studies have been revised and updated, and the associated assumptions tested.

In addition, there is currently no internationally agreed methodology on how to calculate the cost of fire. This means the cost categories included in these calculations vary between countries, and comparisons between countries on the estimated costs of fire cannot be made, and are therefore not included in our study.

3.2 International cost estimates

In Canada, the total cost of fire was estimated at $11 billion in 1991. The cost of fire protection in structures, vehicles and equipment, at $5.6 billion, was the largest cost component. The cost of the fire service was noticeably smaller at $2.2 billion, and the cost of the direct losses caused by fire was smaller again at $1.7 billion (NRCC, 1995).

This research was originally undertaken to raise awareness about the cost of fire, to stimulate prevention and mitigation efforts, and to provide some rationale for resource allocation (NRCC, 1995). Completed in 1995, this is the earliest research on the cost of fire we have located. Unfortunately we have been unable to find an updated version of this research.

In England and Wales, the total cost of fire was estimated at £8.3 billion in 2008. This is one percent higher than an estimate in 2006 of £8.2 billion (DCLG, 2011). This cost includes commercial fire damage of £865 million. In addition, business interruption following fires result in insurance claims of around £200 million per year (ABI, 2009).

In Australia the total cost of fire was estimated at $8.5 billion in 2009. This study found that, overall, 93 percent of the total cost of fires is not associated with the direct losses caused by the fire (Ashe et al, 2009). The largest cost component was costs in anticipation, which was 55 percent of the $8.5 billion. This is the cost of having a fire service ready and able to attend fires. The cost of response to fire was 30 percent of the total cost, while the cost of the consequences of fire was 15 percent (Ashe et al, 2009).

In the United States the total cost of fire was estimated at $347 billion or approximately 2.5 percent of GDP in 2007 (Hall, 2010). This figure includes the losses caused by fire and money spent on fire prevention, protection and mitigation.

These costs include property damage ($18.6 billion), insurance coverage ($17.2 billion), the cost of the career firefighters ($36.8 billion), fire protection costs within buildings ($61.5 billion), other economic costs ($42.3 billion), the monetary value of donated time from volunteer firefighters ($128 billion), and the estimated monetary equivalent of deaths and injuries due to fire ($42.4 billion).

Research completed by the Office of the Deputy Prime Minister in the United Kingdom argues that the economic costs of fire, and subsequent losses to the community and the economy, are significantly less than the sum of the losses to individual businesses (ODPM, 2006). This is because lost output in one company may result in a gain in orders or output in another, so the overall impact on the economy may not be as large as initially thought (ODPM, 2006).

3.3 Economic cost components

International research has grouped the economic cost of fire in one of two ways. The first method groups costs into cost in anticipation of fire, cost in response to fire, and cost as a consequence of fire. The second method groups costs into pre-suppression, suppression of fire, and after fire costs.

In the United Kingdom and Australia the total cost of fire is broken down into three categories: costs in anticipation, costs as a consequence, and costs in response (Ashe et al, 2009; DLCG, 2011).

Across each of the cost categories, some cost data is available while others are estimated or inferred. For example, property losses and lost output are estimated costs as a consequence of fire, while the costs to the community as a consequence of fire, and heritage and cultural costs are inferred (DLCG, 2011).

Costs in anticipation are predominantly protection and prevention measures to prevent or mitigate the damage caused by fire. These can include active and passive fire protection in buildings such as sprinklers and fire walls. They also include the resources and capital costs involved in training and fire safety, and the administration costs involved in insurance.

Costs as a consequence are costs incurred as a result of fire, and can be borne by individuals, businesses or the community. Costs included here are the cost of property damage and total cost of lost business, the cost of fatalities and injuries, and the cost to the justice system in terms of the Police and victims.

Costs in response are the costs associated with extinguishing and clearing up after the fire, and these costs are borne predominantly by the community. They include capital costs in responding to fire-related incidents, and the resource costs of the fire and rescue service responding to fire-related incidents.

In the Australian study, eight components were considered under the cost in anticipation category, nine components in the cost as a consequence category, and four in the cost in response category. Each of these components are similar to those in the UK study, with the exception being that costs as a consequence in Australia includes environmental losses, and heritage and cultural costs.

In the United States the total cost of fire is defined as the losses that "fire causes, directly and indirectly, and the cost of provisions to prevent or mitigate the losses caused by fire" (Hall, 2010). Cost calculations include core total costs, costs that are estimated through one-off special studies, and the donated time of volunteer firefighters.[1]

Core total costs include actual transaction costs where money changes hands that can be calculated annually. These costs include direct and indirect property damage in fire, government expenditure on fire protection, the portion of new construction expenditure that relates to fire protection, and the net insurance premiums for fire hazards divided by the estimated fire losses covered by that insurance (Hall, 2010).

[1] Hall calculates the economic value of the donated time of the volunteer fire-fighters separately, as he argues it is volunteer time rather than operating in a market.

In an earlier version of this model, Hall estimates the indirect losses caused by fire. This model calculates the indirect loss as a multiple of the direct loss, where the magnitude of the multiple varies depending on the type of property affected (Hall, 2005). This model does not take into account the redistribution of activity between businesses as a result of fire.

3.4 Challenges and assumptions

There are three key challenges in assessing the economic costs of fire; not all cost components are easily estimated, there is not a standard methodology for measuring these costs, and the model that generates these cost estimates relies on robust data.

The first step in determining the economic cost of fire is to identify what impacts of fire should be included in the total costs, and what is the most appropriate method of measuring these impacts (ODPM, 2006). Once identified, not all cost components can be directly measured or easily estimated, and an order of magnitude is often difficult to determine. This means evidence-based assumptions need to be made and proxies used.[2]

In Australia, Ashe et al found it difficult to obtain information on business losses due to fire. Due to this lack of information, this study adopted estimates from the United Kingdom of £40 million, which they translated to approximately AUD$30 million (Ashe et al, 2009). Another area that is largely unknown in terms of cost is the annual heritage and cultural costs due to fire. Again, an estimate was used in the Ashe study, this time an annual figure of AUD$20 million (Ashe et al, 2009).

There is not a standard methodology for measuring the economic costs of fire. This makes it difficult to make comparisons across studies, and ensure our study is following best international practise. Despite this, Ashe et al (2009) have drawn some comparisons across the cost categories.

- This study argued that costs in anticipation are between 48 and 55 percent of the total cost of fire in Australia, Canada, the United Kingdom, the United States, and Denmark.
- Australia and the United States have a similar approach to allocating resources to the three cost categories. For example, greater resources were put into costs in anticipation than costs as a consequence of fire.

[2] See for example, the assumptions made in ODPM. (2006). The Economic Cost of Fire: Estimates for 2004. ODPM Publications: West Yorkshire.

Finally, the model that generates these cost estimates relies on robust data therefore estimates of the economic costs of fire should be used with caution. The quality of the estimates produced relies on the completeness and validity of the various data sources used. When data is available it can be added, and every effort is made to make the model representative, but it is essentially a model or mechanism for generating estimates (DLCG, 2011).

This section has detailed the research completed internationally on the economic cost of fire. In the next section of our report we provide a detailed breakdown of the cost components we have used to determine the total economic cost of fires in non-residential buildings in New Zealand. These cost components are based on a model devised by John Hall in the United States, and the costs are calculated for a five year period, 2007 to 2011.

4 Economic cost of fires in non-residential buildings

Our research considers the economic costs of non-residential fires. These costs are resources that could be allocated to other areas of the economy. Therefore, any decreases in the economic costs of non-residential fires are beneficial.

This section of our report provides a detailed breakdown of the cost components that make-up the total economic cost of fires in non-residential buildings. It describes each component and the data or assumptions used. The economic costs are calculated for a five year period, 2007 to 2011.

4.1 Why estimate the economic cost of fire?

The impact of fire can be measured in various ways. For example, the average rate of fires, fire fatalities, structural fires and fire injuries per 100,000 population has fallen in recent years in New Zealand. Some of these improvements may be the direct result of NZFS action such as advertising and awareness campaigns and better readiness and response to fires, while others may be due to external factors such as changing demographics and improvements in building materials.

Internationally, the number of fire incidents is declining at a time when the total cost of fire is rising (NRCC, 1995; ABI, 2009). In the United Kingdom, targets are in place to reduce the number of fires, arson attacks, and deaths from fires. The Association of British Insurers argues that targets also need to be put in place to decrease the economic costs of fire, which have been rising (ABI, 2009).

The Association argues there are a variety of reasons why the cost of fire is increasing, including open plan buildings allowing fires to spread more easily, and buildings or commercial developments in remote locations where fires may start without people noticing (ABI, 2009). In the United Kingdom, the most common causes of fires in workplaces are faulty appliances, faulty leads, equipment misuse, appliance misuse, and electrical accidents (ABI, 2009).

This project has not examined if the cost of non-residential fire has risen in New Zealand nor has it examined the causes of non-residential fire. Instead, this project is a benchmark from which assumptions can be tested, and additional data and further research can refine the cost components and their associated values.

4.2 What is the economic cost of fire in New Zealand?

The total economic cost of fires in non-residential buildings was an estimated $656.3 million in 2011. This estimation is based on a definition used in research completed in the United States. It defines the total cost of fire as the losses that fire causes, directly and indirectly, and the cost of provisions to prevent or mitigate the losses caused by fire (Hall, 2010).

Table 4.1 Summary of the cost components of fires in New Zealand, 2007–2011[3]

Cost components	2007 ($millions)	2008 ($millions)	2009 ($millions)	2010 ($millions)	2011 ($millions)
Fire protection systems	$315.2	$338.9	$339.5	$283.0	$273.0
Fire Service levy	$128.6	$137.7	$149.4	$141.8	$151.7
Net fire insurance	$67.1	$46.6	$124.6	$73.0	$124.0
Fire damage	$127.3	$159.0	$75.0	$139.0	$93.2
Reported fire damage	*$90.8*	*$116.7*	*$54.5*	*$104.4*	*$70.4*
Unreported fire damage	*$12.3*	*$15.9*	*$7.4*	*$14.2*	*$9.6*
Indirect fire damage	*$24.2*	*$26.5*	*$13.1*	*$20.4*	*$13.3*
Human factors	$19.4	$17.4	$14.8	$15.3	$14.4
Monetary cost of Human losses	*$7.4*	*$5.4*	*$2.8*	*$3.3*	*$2.4*
Donated time of volunteer firefighters	*$12.0*	*$12.0*	*$12.0*	*$12.0*	*$12.0*
Total economic cost	**$657.5**	**$699.7**	**$703.3**	**$652.2**	**$656.3**

Source: BERL, NZFS, ICNZ, PWC, BECA

Between 2007 and 2011, the economic cost of fire in New Zealand has varied. This variation is due to the number of new buildings being constructed, which impacts on the cost of fire protection systems, and the amount of levy collected on all contracts of fire insurance. These are the two largest cost components in regards to the economic cost of fires.

4.3 Fire protection systems in non-residential buildings

This cost component is the annual cost of building and installing fire protection systems in non-residential buildings. It is the largest cost component in our model that determines the economic cost of fires in non-residential buildings.

[3] This table does not include data from July to December 2009 and from August to December 2011 due to industrial action by career firefighters.

- Fire protection systems include fire separations between properties, external surface finish requirements, internal compartment requirements, escape route requirements, fire safety precautions such as smoke alarms or sprinklers, and structural fire protection requirements.

Over the last five years the costs of fire protection systems in non-residential buildings have varied between $273 and $338 million.

Table 4.2 Cost of fire protection systems, non-residential buildings, 2007–2011

	2007 ($millions)	2008 ($millions)	2009 ($millions)	2010 ($millions)	2011 ($millions)
Fire protection systems	$315.2	$338.9	$339.5	$283.0	$273.0

Source: BERL, BECA

Fire protection systems can be viewed as an insurance measure, as they limit the amount of building damage in the case of fire, and assist the building owner in paying lower business insurance premiums.

4.3.1 Measurement points

The cost of fire protection systems in non-residential buildings can be measured at the point of construction, when they are an identifiable proportion of the building cost, or as part of the rental value of a building.[4]

International research favours the first approach, and Table 4.3 shows estimates of fire protection systems as a percentage of total construction costs across four research projects.

Table 4.3 Fire protection systems, percentage of construction costs

%	US	US	Canada	UK	ranges
Residential	2.5	2.5	4.9	0 - 2.5	0 - 5
Industrial	9.0	12.0	6.0	5.0	5 - 12
Commercial	9.0	12.0	6.0	5.0	5 - 12
Institutional	4.0	4.5	4.5	5.0	4 - 5
Other	3.0	3.0	3.0	5.0	3 - 5
report source:	*WPI*	*Meade*	*TriData*	*Weiner*	

Source: BERL

[4] Roy D. (1997). The Cost of Fires: A Review of the Information Available. London: Home Office.

Overall, fire protection systems can be between three and 12 percent of the total cost of constructing a non-residential building. The range in costs reflects cross-country differences, such as building regulations and construction materials, as well as variations in the estimation procedure used.

4.3.2 Cost component calculation

In 2005 BERL commissioned Beca to determine the cost of fire protection measures in a range of buildings in New Zealand.[5] Their advice was to use the measure of average fire proportions. Fire proportions were calculated for three categories of non-residential buildings, industrial (10-14 percent), commercial (4-5 percent), and other (6-7 percent).

Taking a weighted average of fire proportions across the three categories of non-residential buildings indicates that 7.5 percent of the total cost of constructing a non-residential building is spent on fire protection systems.

As a formula this component is calculated as:

Cost of fire protection systems =

[7.5% x (value of non-residential construction excluding communications, power, and rail)]

4.4 The Fire Service levy

The Fire Service levy is used to measure the fixed cost of the NZFS providing a 'standing force' of firefighters and equipment. The levy rate is reviewed annually by the Minister of Internal Affairs. It is currently calculated at 7.6 cents per $100 insured. This cost is the second largest cost component in our model that determines the economic cost of fires in non-residential buildings.

- Section 48 of the Fire Service Act 1975 requires insurance companies, insurance brokers, parties that self insure, parties that insure property located in New Zealand and offshore, and certain others to collect a levy on all contracts of fire insurance, and to remit this to the NZFS Commission.

[5] Beca. (2005). The Cost of Managing the Risk of Fire in New Zealand: A Review of Fire Safety in Typical Buildings and Associated Costs. Beca: Wellington.

Table 4.4 Fire Service levy, 2007–2011[6]

	2007 ($millions)	2008 ($millions)	2009 ($millions)	2010 ($millions)	2011 ($millions)
Fire service levy	$128.6	$137.7	$149.4	$141.8	$151.7

Source: BERL, NZFS

Over the last five years the income provided from the levy on insurance premiums for commercial material damage insurance has risen from $129 million in 2007, to $152 million in 2011.

4.4.1 Measurement points

The NZFS needs to operate within the budget determined by levy collections. This operation includes meeting the National Commander's public performance goals and responding to incidents in a way that reflects community expectations of the NZFS.

4.4.2 Cost component calculation

The Fire Service levy is divided into seven categories, commercial/material damage cover; residential building; residential contents; private motor vehicles (under 3.5 tonne); commercial motor vehicles (over 3.5 tonne); marine cargo; and other business.

The Fire Service levy on commercial material damage insurance, and other business insurance was used as a proxy for the cost of the NZFS attending fires in non-residential buildings. Data on the Fire Service levy was supplied by the NZFS.

4.5 The net cost of fire insurance

This cost component is the net cost of non-residential building owners and occupants insuring themselves against fire damage.

- The cost is calculated as the total amount of premiums paid to insurance companies for fire protection insurance, minus the total amount of claims paid out by insurance companies for fire-related damage.

Table 4.5 Net cost of fire insurance, 2007–2011

	2007 ($millions)	2008 ($millions)	2009 ($millions)	2010 ($millions)	2011 ($millions)
Net fire insurance	$67.1	$46.6	$124.6	$73.0	$124.0

Source: BERL, ICNZ

[6] This data includes commercial/material damage cover and other businesses categories of the Fire Service levy as provided by the NZFS.

Net fire insurance costs have varied but been positive over the last five years. This indicates claims for fire damage to non-residential buildings is less than the insurance premiums paid.

4.5.1 Measurement points

Our economic cost model is based on a model developed in the United States by John Hall (Hall, 2010). Hall's model used five cost components to calculate the total cost of fire in residential and non-residential buildings. These costs include the cost of building damage caused by fire, the cost of fire departments, the net amount paid to insurance companies for fire insurance (premiums minus claims), the cost of fire protection systems in buildings; and the human costs of fire such as lives lost, injuries suffered, and time donated by firefighters.

According to the US model, net fire insurance is estimated using fire insurance premiums; twenty-one percent of commercial and farm-owner multi-peril premiums; the total estimate of direct property damage in fires reported to the fire departments, excluding vehicle and outdoor properties, and fifty percent of the estimated indirect losses caused by fire.

4.5.2 Cost component calculation

In 2002, BERL undertook an economic assessment of industrial fires for the NZFS. As part of this research, BERL surveyed insurance companies, asking them to provide data on the value of all industrial fire insurance claims in the year 2000.

The total value of the surveyed claims was $22 million. However, industry sources indicated this figure represents only 50 percent of the total insurance market (BERL, 2002). Therefore the survey data can be scaled up by a factor of two, which implies a total market value of approximately $44 million for the year 2000.

Data published by the Insurance Council of New Zealand indicated that the value of all business claims was $108 million in 2000. These claims include those incurred for fire, flood, theft, white-collar crime, etc. It can therefore be deduced that fire-related claims represent forty percent of all business insurance claims.

We do not have detailed information on fire insurance premiums and claims, and without this information we had to use a proxy. The proxy measure we used is an estimate of the total cost of direct damage to buildings, and fifty percent of the indirect losses associated with fire damage.

This proxy measure was used, because if all the damage caused by fires in non-residential buildings was insured, then the cost of the direct and indirect damage would be the same as the total claims submitted to insurance companies.

To calculate the net fire insurance costs, gross premiums paid to all insurers for commercial material damage insurance was sourced from the Insurance Council of New Zealand.

Applying our formula, we subtracted from the gross premiums paid our estimate of the total cost of direct damage to buildings, and a proportion of the indirect losses associated with the fire damage. These two measures of the value of fire damage were used as a proxy for the value of claims from insured commercial properties.

As a formula this component is calculated as:

Cost of net fire insurance =

[40%[7] x (homeowner, commercial, and farm owner multi-peril premiums)]

[Estimate of direct property damage in fires reported to NZFS, excluding vehicle and outdoor properties]

[50% x (estimate of indirect loss)]

4.6 The economic cost of fire damage

This cost component is the cost associated with fire damage, and any changes that can be quantified before and after the fire that may be temporary or permanent. These costs include damage caused by water, smoke and other fire products, the loss of building contents and stock, and business interruption.

- If a non-residential building houses a business or group of businesses, then short or long-term changes in business activity as a result of fire can reduce production and income.
- These costs can be identified and measured through economic output and employment, and information such as insurance claims can be used to assess major elements of this change.

[7] In the US model this input is 21 percent. We used 40 percent, which is based on previous research BERL completed for the NZFS in 2002.

Table 4.6 Economic cost of fire damage, 2007–2011

	2007 ($millions)	2008 ($millions)	2009 ($millions)	2010 ($millions)	2011 ($millions)
Economic cost	$127.3	$159.0	$75.0	$139.0	$93.2
Reported fire damage	$90.8	$116.7	$54.5	$104.4	$70.4
Unreported fire damage	$12.3	$15.9	$7.4	$14.2	$9.6
Indirect fire damage	$24.2	$26.5	$13.1	$20.4	$13.3

Source: BERL, NZFS

The economic cost of fire damage varies each year as fire is a highly unexpected event. Over the last five years, the economic cost has varied from $75 to $159 million. In 2011, fires in non-residential buildings cost $93 million in damages. This cost includes $70 million in reported direct fire damage, $10 million in unreported fire damage, and $13 million in indirect losses from fire damage.

4.6.1 Measurement points

BERL identified three economic costs associated with fire damage:

- Estimated direct damage from reported fires using information from the NZFS database and Rawlinson's Construction Handbook 2011.
- Estimated direct damage from unreported fires. This is estimated at 13.6 percent of the direct damage in reported fires, as per Hall's US model.
- Estimated indirect damage using information on the total cost of fire by building category. These categories include manufacturing and industrial use, public assembly, educational, store, office, storage or special structure, and structures excluding storage or special structures.

The three items enumerated above all came from BERL's estimate of the value of fire damage and the NZFS database. In the absence of data on the direct damage of unreported fires and the indirect damage of fires, BERL adapted proportions used in Hall's US model.

4.6.2 Cost component calculation

As a formula, the three components are calculated as:

Direct damage in reported fires =

[Rawlinson's square meter cost of building + NZFS calculations on fire size]

Direct damage in unreported fires =

[13.6% x (direct damage in reported fires)]

Indirect damage in fires =

[65% x (direct damage in reported fires in manufacturing or industrial buildings)]

+ [25% x (direct damage in reported fires in public assembly, educational, institutional, store, or office buildings)]

+ [10% x (direct damage in reported fires in storage, or special structures)]

+ [4 x 2% x (direct damage in reported fires in non-residential buildings excluding storage and special buildings)]

4.7 Human factors

This cost component includes the cost of death and injury due to fire in non-residential buildings, and the cost of the time that volunteer firefighters donate to attend fire incidents.

4.7.1 Loss of life and injury

The monetary cost of human life can be estimated using the Value of a Statistical Life (VoSL). Research completed by BERL for the NZFS in 2007 estimated a fire-based VoSL calculated at two-thirds of the road-based VoSL produced by NZTA (NZTA, 2009).

In 2009, the NZTA road-based VoSL was estimated at $3.5 million, which means we can estimate the fire-based VoSL at $2.3 million. NZTA also estimated the cost of injury was seven percent of the VoSL.

Table 4.7 Cost of loss of life and injury, 2007–2011

	2007 ($millions)	2008 ($millions)	2009 ($millions)	2010 ($millions)	2011 ($millions)
Loss of life and injury	$7.4	$5.4	$2.8	$3.3	$2.4

Source: BERL

Over the last five years, the costs associated with the loss of a life have declined with a decrease in the number of deaths. The number of injuries due to non-residential fire has been variable.

As a formula, this component is calculated as:

Cost of human loss =

[BERL VoSL x number of deaths] + [7.0% x BERL VoSL x number of injuries].

As NZTA updates their road-based VoSL each year, we can use this as an estimate for our fire-based VoSL, and apply the above formula to calculate the cost of deaths and injuries caused by non-residential fires.

4.7.2 Cost of donated time by volunteer firefighters

NZFS staff can be broken down into career firefighters, volunteer firefighters, communication centre staff, and management and support staff. There are approximately 1,700 career firefighters and 7,000 urban volunteer firefighter positions in New Zealand. These firefighters work at fire stations within fire districts. New Zealand currently has 346 urban fire districts, 440 fire stations and approximately 960 fire appliances.

Hall's model estimated the cost of the donated time of volunteer firefighters at 87 percent of the cost of career firefighters. Here, we have used research that estimated the cost of employing volunteer firefighters and paying them a wage (PricewaterhouseCoopers, 2009). This research estimated an annual cost of $12 million.

Table 4.8 Cost of volunteer firefighters donated time, 2007–2011

	2007 ($millions)	2008 ($millions)	2009 ($millions)	2010 ($millions)	2011 ($millions)
Donated Time of volunteer firefighters	$12.0	$12.0	$12.0	$12.0	$12.0

Source: PWC

4.8 Data challenges and limitations

A number of data challenges and limitations were encountered in this research project:

- Data was not provided due to the commercially sensitivity nature of the material
- Data was not readily available and required a significant amount of time to generate
- Data was at an aggregate level
- Some cost components were not measured.

Data on insurance claims was not provided due to the commercially sensitive nature of the material. Insurance companies that were approached as part of this research were not able to provide detailed information on insurance premiums or claims, except for what was included in their annual reports.

- To fill this data gap, BERL used total gross premiums that are reported annually by the Insurance Council of New Zealand. For claims information, BERL used the direct damage caused by fire as a proxy for insurance claims.

The NZFS database provides estimates on the size and value of an area damaged by flame or smoke. It does not provide estimates on building replacement costs.

- To fill this gap, BERL used the Rawlinson's Construction Handbook 2011 and associated database.

Intangibles costs have not been included, but it is acknowledged that these types of fires will cause costs outside of the factors included and measured here.

An analysis of the number, type and damage caused by non-residential structural fires is set out in the next section of this report.

5 Fires in non-residential buildings

This section of our report discusses the number and type of fires in non-residential buildings in New Zealand between 2007 and 2011. It also discusses the smoke and flame damage caused by fire, and the value of this damage. It is this damage that causes the most cost variation in our model. The data presented in this section of our report is from the NZFS FIRS database.

5.1 A snapshot of fires in non-residential buildings

- A total of 4,299 fire incidents were recorded between 2007 and 2011.
- The highest number of incidents during this period occurred in shops, restaurants and taverns, with 707 fires or 16.4 percent of the total. A quarter of these fire incidents occurred in Auckland.
- Farm buildings had the second highest number of incidents with 665 fires or 16 percent; followed by fires in miscellaneous buildings, 618 or 14 percent; fires in factories and industrial buildings, 453 or 11 percent; fires in education buildings, 427 or 10 percent; and fires in social, cultural, or religious buildings, 409 or 10 percent.
- 30 percent of fires in non-residential buildings were confined to part of a room or the area the fire originated in.
- The highest average cost of damage per fire incident was in storage buildings, with $242,213 worth of damage. This was followed by damage in farm buildings of $114,999, damage in factories and industrial buildings of $111,486; and damage in social, cultural, and religious buildings of $109,647.

5.2 Fire incidents by general property use

The NZFS uses 47 General Property Use (GPU) categories to classify fires in non-residential buildings. BERL reclassified these GPUs into the Statistics New Zealand classifications of non-residential buildings/structures. This decreased the number of identified buildings from 47 to 11. We then ranked these properties based on the number of fire incidents.[8]

[8] Refer to the Appendix for the list of NZFS general property uses and the SNZ list of non-residential buildings.

Table 5.1 Fire incidents, SNZ classifications, 2007-2011

Non-residential building classification	2007	2008	2009	2010	2011	Total
Education buildings	114	81	83	96	53	427
Factories and industrial buildings	119	116	68	86	64	453
Farm buildings	132	127	121	147	138	665
Hospitals, nursing homes	41	34	18	35	18	146
Hostels, boarding houses	33	27	15	35	15	125
Hotels & other short-term accommodation	30	32	16	27	23	128
Miscellaneous buildings	134	146	98	148	92	618
Offices, administration buildings	79	85	67	75	64	370
Shops, restaurants and taverns	165	177	125	129	111	707
Social, cultural, religious buildings	109	102	60	80	58	409
Storage buildings	61	78	34	44	34	251
Total	1,017	1,005	705	902	670	4,299

Source: BERL, Statistics New Zealand

5.3 NZFS exposure categories

Exposure numbers are used by the NZFS to indicate whether a fire has spread from another fire or if it is the primary origin of the fire.[9]

Table 5.2 Fire incidents by exposure number, SNZ classifications, 2007-2011

Non-residential building classification	Exposure Number					Total
	0	1	2	3	4	
Education buildings	404	21	2	0	0	427
Factories and industrial buildings	432	19	2	0	0	453
Farm buildings	615	46	3	1	0	665
Hospitals, nursing homes	139	6	1	0	0	146
Hostels, boarding houses	120	5	0	0	0	125
Hotels & other short-term accommodation	124	4	0	0	0	128
Miscellaneous buildings	585	29	3	1	0	618
Offices, administration buildings	352	17	0	1	0	370
Shops, restaurants and taverns	683	19	3	1	1	707
Social, cultural, religious buildings	390	19	0	0	0	409
Storage buildings	221	22	7	1	0	251
Total	4,065	207	21	5	1	4,299

Source: BERL, Statistics New Zealand

In terms of affected areas, other than the primary area of origin (e.g. exposure number 1), farm buildings have the most number of fire incidents, followed by miscellaneous buildings and social, cultural, and religious buildings.

In the case of 95 percent of fires, only the building or structure where the fire originated is affected. This means only five percent of all fire incidents originate in another building.

[9] A 0 exposure number means the building is the primary origin of the fire and in most cases there is only one building involved. Where the exposure number is 1 or higher, this building was affected by a fire external to the building. The external fire may have been in another building, or from a vehicle or vegetation fire adjacent to the building.

5.4 Flame damage categories

In the NZFS database eight categories of flame damage are identified. These include confined to cell of origin, confined to floor of origin, confined to object of origin; confined to part of a room or area of origin; confined to room of origin; confined to structure of origin; extended beyond structure of origin; and those not classified elsewhere.

Table 5.3 illustrates that 30 percent of fire incidents are confined to part of the room or area that the fire originated in.

Table 5.3 Fire incidents by flame damage, SNZ classification, 2007–2011

Non-residential building classification	Flame damage									Total
	No damage of this type	Confined to object of origin	Confined to part of room or area of origin	Confined to room of origin	Confined to fire cell of origin	Confined to floor of origin	Confined to structure of origin	Extended beyond structure of origin	Not Recorded	
Education buildings	7	95	176	25	13	10	85	15	1	427
Factories and industrial buildings	8	125	150	30	17	12	84	26	1	453
Farm buildings	4	71	106	43	10	16	336	79	0	665
Hospitals, nursing homes	8	45	56	16	4	7	7	3	0	146
Hostels, boarding houses	3	26	44	23	5	5	17	2	0	125
Hotels & other short-term accommodation	5	33	58	8	3	3	13	5	0	128
Miscellaneous buildings	7	187	161	40	15	18	159	31	0	618
Offices, administration buildings	13	97	111	29	18	18	74	10	0	370
Shops, restaurants and taverns	24	206	255	50	23	13	115	20	1	707
Social, cultural, religious buildings	7	114	126	20	9	15	103	15	0	409
Storage buildings	4	48	49	22	12	8	87	21	0	251
Total	90	1,047	1,292	306	129	125	1,080	227	3	4,299

Source: BERL, Statistics New Zealand

Given that 16 percent of fires in non-residential buildings occurred in shops, restaurants and taverns over the last five years, it is unsurprising that these buildings also suffered the most flame damage.

5.5 Total fire damage

Table 5.4 shows the total cost of damage to non-residential buildings between 2007 and 2011. This amount varies, and was highest in 2008 at $116.7 million, and lowest in 2009 at $54.4 million worth of damage. However, low values in 2009 and 2011 could be due to industrial action during these years, which resulted in missing data.

Table 5.4 Total cost of damage ($m), SNZ classifications, 2007 - 2011

Non-residential building classification	2007	2008	2009	2010	2011	Total
Education buildings	5.3	7.7	8.1	9.3	3.3	33.7
Factories and industrial buildings	16.1	16.4	3.7	11.0	3.2	50.5
Farm buildings	12.6	9.7	10.1	22.0	22.1	76.5
Hospitals, nursing homes	3.7	3.5	0.3	1.7	0.5	9.8
Hostels, boarding houses	0.9	1.6	1.1	1.9	2.3	7.9
Hotels & other short-term accommodation	2.2	1.9	1.6	4.2	1.1	10.9
Miscellaneous buildings	6.8	8.9	5.9	22.9	8.6	53.0
Offices, administration buildings	3.8	6.3	6.5	6.7	12.8	36.2
Shops, restaurants and taverns	15.1	13.6	9.9	4.6	9.5	52.7
Social, cultural, religious buildings	10.6	11.0	5.6	14.3	3.3	44.8
Storage buildings	13.7	35.9	1.7	5.8	3.7	60.8
Total	90.8	116.7	54.5	104.4	70.4	436.8

Source: BERL, Statistics New Zealand

Although shops, restaurants and taverns had the highest number of fire incidents (Table 5.1), this building category only ranked fourth in terms of the highest cost of damage over the last five years, with $52.7 million.

Between 2007 and 2011, the cost of damage to farm buildings was the highest, at $76.5 million. This was followed by the cost of damage to storage buildings at $60.8 million, and damage to miscellaneous buildings at $53 million

Storage buildings had the highest average cost per fire incident, at $242,213. This was followed by farm buildings with $114,999; factories and industrial buildings with $111,486; and social, cultural, and religious buildings with $109,647.

Table 5.5 Average cost of damage per fire incident, SNZ classifications, 2007-2011

Non-residential building classification	2007	2008	2009	2010	2011	Average
Education buildings	46,357	95,145	97,309	97,297	62,211	78,936.3
Factories and industrial buildings	135,700	141,718	54,654	128,119	49,699	111,485.7
Farm buildings	95,452	76,364	83,354	149,625	160,112	114,998.5
Hospitals, nursing homes	90,732	103,577	15,429	49,105	29,028	66,853.0
Hostels, boarding houses	28,322	60,022	75,404	53,402	154,559	62,989.8
Hotels & other short-term accommodation	72,158	59,632	102,685	154,718	45,719	85,506.3
Miscellaneous buildings	50,570	61,180	59,874	154,777	93,069	85,834.4
Offices, administration buildings	47,944	74,629	96,829	89,548	200,513	97,750.1
Shops, restaurants and taverns	91,374	77,068	79,074	35,423	85,682	74,514.9
Social, cultural, religious buildings	97,450	108,160	94,084	178,347	56,528	109,647.3
Storage buildings	224,243	459,622	49,565	132,615	110,168	242,212.6

Source: BERL, Statistics New Zealand

Overall, this analysis provided us with a better understanding of non-residential fires, and helped us to identify appropriate cost components for our economic model.

The next section of our report discusses our recommendations for further research, particularly our overarching recommendation that this project be seen as the first step in a benchmarking exercise.

6 Recommendations for further research

Our research has found that the economic cost of fires in non-residential buildings in 2011 was $656.3 million. The largest cost component in this calculation, at $273 million, was fire protection systems in buildings; however, fire damage is the cost component with the largest amount of variability annually.

Our overarching recommendation is that as more evidence and data becomes available, the cost components considered in this research are revised and updated, and the associated assumptions tested. We would recommend that this project be seen as the first step in a benchmarking exercise.

6.1 Further areas of research

A number of potential areas of further research were identified. These are listed in no particular order:

- The cost of business interruption due to fire
- An extension of the costs in anticipation component to include fire safety work
- An estimation of the economic costs of fire at a regional or fire district level
- The economic costs of fire in heritage and culture buildings

6.1.1 Business interruption costs

Further research could be completed on business interruption costs. This cost component may be an underestimation, as the impact on a business may be larger than that indicated through insurance claims. This new research could draw on findings from projects that are currently underway on earthquake-prone buildings and building strengthening.

Earthquake research considers the impact of building strengthening from the point of view of business interruption costs and lost productivity. It does this by considering building type, building use, and the number of people per floor in each building in a central business district area.

It considers how long after an earthquake of a certain magnitude does it take for people to return to work due to damage or destruction of the building they work in. These workings focus on lost productivity and business interruption costs as part of determining the total cost of strengthening earthquake-prone buildings.

6.1.2 Costs in anticipation could include fire safety

In the United Kingdom, fire safety is included as a cost component in estimations on the total cost of fire.

- In the cost category of costs in anticipation, fire safety activity is measured by data on fire inspections undertaken by the Fire and Rescue Service. This data is further disaggregated into domestic, commercial and private sector buildings.

- The work of the Fire and Rescue Service in promoting fire safety in the community is also measured through publicity events and marketing activities (ODPM, 2006).

This activity has not been measured in our current research project, but we would recommend that in future studies these costs be considered. This data may be available from the NZFS database; alternatively it may be a new measure/variable that the NZFS may wish to consider measuring/collecting.

6.1.3 Regional cost estimates

Again, drawing on examples from the United Kingdom, regional cost estimates are provided by splitting the costs categories of costs in anticipation, consequence and response across the various fire districts (DLCG, 2011). This estimate is used instead of gathering data at a local level.

In New Zealand, the NZFS could consider the economic cost of non-residential fires at a regional or fire district level. This may assist with the resource allocation of the NZFS, and encourage some building owners to further invest in fire protection systems if they are isolated.

6.1.4 The economic costs of fires in heritage and cultural buildings

There is a noticeable data gap in regards to the costs associated with fires in heritage and cultural buildings. We would recommend that a research project is completed on this subject.

Again, this new research could draw on projects currently being completed by the Ministry of Culture and Heritage, and the New Zealand Historic Places Trust in the wake of the Christchurch earthquakes. The NZFS could work with the Ministry and the New Zealand Historic Places Trust to establish suitable measures for these costs. Here, the NZFS could draw on earlier research on marae and fire protection.

In addition, the NZFS could work with Museums Aotearoa and their members at a community level, and with the Ministry of Culture and Heritage at an advocacy or policy level, to raise awareness about the economic costs of fire in these types of buildings, and the benefits of fire protection systems.

6.1.5 Buildings as a sense of place

In this research we have considered non-residential structures as essentially commercial buildings where work takes place. However, non-residential buildings are also places of worship and the sites of community well-being. Buildings can characterise a city, and this is often reinforced through images of a town or city as characterised by the built landscape.

Recent events in Christchurch have highlighted how buildings can be deeply associated with a 'sense of place' and community. What happens when these buildings are destroyed? What happens when the built landscape changes? People are able to find temporary buildings to continue with their work, but what about their sense of community? It is difficult to quantify the connection between buildings and a sense of community, but it is a worthwhile consideration from the point of view of the benefits of fire prevention and protection.

Again, drawing on examples from Christchurch may provide some interesting case studies and parameters from which the wider costs and benefits associated with fire protection and non-residential buildings can be considered in the future.

7 Appendix A: NZFS Database

The aspects of the NZFS database used in this project include:

- Location in terms of current Territorial Local Authority (TLA), Suburb
- Exposure number[10]
- Incident type
- General property use
- Specific property use
- Flame damage
- Area flame damage (in square meters)
- Area smoke damage (in square meters)
- Estimated cost of damage ($)
- Number of injuries
- Number of fatalities.

The database provided data from 2007 through to 2012. For the purposes of this study, BERL considered the data until 2011. Data is missing from July to December 2009, and from August 2011 to March 2012, due to industrial action.

[10] The exposure number indicates whether this fire spread from another fire. Most incidents have an exposure number of 0 which means they are the primary fire and in most cases there was only one building involved. Where the exposure number is 1 or higher then it means this building was affected by a fire external to the building. The external fire may have been in another building, or from a vehicle or vegetation fire adjacent to the building.

8 Appendix B: Building classifications

Table 8.1 NZFS General Property Use Classifications

	General Property Use (NZFS classification)
1	Airport
2	Boarding house, Half-way house, Dormitory
3	Church, Cemetery, Religious use
4	Commercial - not classified above
5	Commercial forestry
6	Communications, Research - not classifi
7	Community hall
8	Conservation, Recreation park, Reserve
9	Construction, Renovation - not classifi
10	Construction, Renovation, Demolition si
11	Doctors/Dentists emergency clinic, Medi
12	Educational, Health, Institutional - not classified above
13	Farming, Horticulture, Agricultural use
14	Hospital, Hospice, Rest home, Rehabilitation
15	Hotel, Motel, Lodge, Timeshare
16	Industrial, Manufacturing
17	Laboratory, Research use
18	Library, Museum, Art gallery, Court etc
19	Lifestyle block
20	Marae, Maori Culture use
21	Mine, Quarry, Oil well
22	Not Recorded
23	Office, Bank, Embassy, Fire/Ambulance/Police station
24	Open land
25	Passenger terminal
26	Power station
27	Prison, Correctional institution
28	Public Toilet
29	Railway property
30	Recreational use, Theatre, Indoor sport
31	Recreational, Assembly - not classified
32	Restaurant, Pub, Tavern
33	Road, Street, Motorway
34	Rubbish tip, Transfer station, Hazardou
35	Rural - not classified above
36	School: Pre-school through to Secondary
37	Service/Repair use, Dry cleaner, Laundr
38	Shop, Shopping mall, Supermarket, Servi
39	Sports club, Health club
40	Sportsfield, Stadium
41	Storage, Warehousing
42	Stormwater, Harbour, Lake, River, Beach
43	Studio: Radio, TV
44	Telephone exchange, Communications use,
45	Unable to classify
46	University, Polytech, Teachers college,
47	Vacant building, Section

Table 8.2 Statistics New Zealand classification of non-residential buildings

	General Property Use (SNZ classification)	NZFS GPU
1	Education buildings	36, 46
2	Factories and industrial buildings	16
3	Farm buildings	5, 13, 19
4	Hospitals, nursing homes	11, 14
5	Hostels, boarding houses	2
6	Hotels & other short-term accommodation	15
7	Miscellaneous buildings	1, 4, 9, 10, 12, 17, 21, 24 - 29, 33 - 35, 42, 44, 47
8	Offices, administration buildings	6, 23, 37, 43, 44
9	Shops, restaurants and taverns	32, 38
10	Social, cultural, religious buildings	7, 8, 18, 20, 30, 31, 39, 40
11	Storage buildings	41

9 Appendix C: Building valuation method

The NZFS FIRS database provides an estimate of flame damage to residential and non-residential buildings. However, this research project needed to take this information a step further and determine the replacement value of the damage – flame and smoke - to different categories of non-residential buildings.

To do this, BERL examined the method developed by BRANZ (2009) for valuing the damage caused by fires in residential buildings. We also reconsidered the methodology we developed for the NZFS in 2002 to estimate the value of fire damage to industrial buildings (BERL, 2002). In conclusion, we decided to reuse the BERL 2002 methodology, of calculating a value for a non-residential building, as our measure of building value.

From here we constructed an estimate of the replacement value of the building damaged by combining the construction costs of a new building of a similar type to the one damaged, with the size of the building affected by the fire from the NZFS database.

- The Rawlinsons New Zealand Construction Handbook 2011 database is typically used in feasibility studies or property valuations.
- In this project this database is used to estimate the dollar value of buildings damaged by fire and can be thought of as reflecting the replacement cost of the damaged parts of the non-residential structures.
- The Rawlinsons data provides an estimate of the average per metre construction cost of a range of commercial buildings. These costs are the average cost of building the structure excluding land, chattels, and equipment costs.
- The Rawlinsons New Zealand Construction Handbook was used to estimate the per metre construction costs for each of the 47 buildings types used in this project if these buildings were to be rebuilt. These building types were provided by the NZFS in their FIRS database.

We used the following formula to estimate the replacement value of the damage to the non-residential building caused by a fire:

BERL estimate of building replacement value =

> *(square meter cost of construction by building type X the number of square meters damaged by flame for each building from the NZFS database)*
>
> *+ (square meter cost of construction by building type X the number of square meters damaged by only smoke for each building from the NZFS database X 10 percent)*[11]

For example, a 1,000 square meter secondary school building had a small fire that caused, two square meters of flame damage, and five additional square meters of smoke damage to the building.

> *Secondary school building = $2,025 per square meter*

So we get the following formula:

> *(2,025 x 2) + (2,025 x 5 x 0 .1) = $5,062.5*

This shows the cost of replacing the damaged section of the building would be around $5,062.

[11] Smoke damage to a non-residential building is estimated at 10 percent of value of flame damage to a non-residential building.

10 Appendix D: References

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