Fire Research Report

Code of Practice for Fire fighting Water Supplies: An Indicative Cost Benefit Analysis

NZIER

November 2004

The NZFS Code of Practice for Fire Fighting Water Supplies was reviewed against other countries legislative regimes and initiatives, to see how it compared to international best practice.

A small survey of residential developers was conducted to assess the level of industry awareness of the code of practice and what they thought of it.

A cost benefit analysis was conducted against a number of scenarios where the code of practice could be implemented.

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Final report

Code of Practice for Fire Fighting Water Supplies

An indicative cost benefit analysis

Report to New Zealand Fire Service

November 2004

Preface

NZIER is a specialist consulting firm that uses applied economic research and analysis to provide a wide range of strategic advice to clients in the public and private sectors, throughout New Zealand and Australia, and further afield.

NZIER is also known for its long-established *Quarterly Survey of Business Opinion* and *Quarterly Predictions*.

Authorship

This report has been prepared at NZIER by Ian Duncan and John Ballingall. The assistance of Sarah Spring is gratefully acknowledged.

We would also like to thank members of the New Zealand Fire Service, staff of local authorities, property developers, and staff of the Insurance Council, all of whom helped us with technical expertise and by sharing their practical experience with us.

8 Halswell St, Thorndon
P O Box 3479, Wellington
Tel: +64 4 472 1880
Fax: +64 4 472 1211

Level 1, 77 Parnell Road
Parnell, Auckland
Tel: +64 9 309 0140
Fax: +64 9 309 0144

econ@nzier.org.nz
www.nzier.org.nz

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Executive Summary

Background to research

There were over 6,000 residential fires in New Zealand in 2002/03, according to the NZFS 2002/03 Annual Report. These fires resulted in 27 fatalities and many more serious injuries, and accounted for thousands of hours of NZFS time. One of the NZFS goals to achieve by 2006 is to reduce residential structure fire fatalities to 10 or less. A key component of the NZFS strategy to attain this goal is the installation of sprinkler systems in homes.

The release, in August 2003, of the new Code of Practice (COP) for Fire fighting Water Supplies (SNZ PAS 4509:2003) is likely to contribute towards this goal. The new COP replaced the 1992 Code of Practice, updating and enhancing it in several significant ways. The new COP contains provisions for new housing developments to have less need for reticulated water supply and pressure, if they install sprinklers in all dwellings in the development.

Research approach

To date, there has been no economic analysis of the new COP. This research uses economic techniques to consider the provisions and possible impacts of the COP. The key components of the research are:

1. A review of legislative and other initiatives in other countries regarding residential sprinklers. This has identified how other countries have legislated to reduce the consequences of residential fires, and provides some guidance as to how the NZFS COP compares to international best practices.

2. A small survey of residential developers to determine the level of industry awareness of the COP, and their reactions to it. The survey was aimed at ascertaining why many developers are currently not installing sprinklers in new residential projects, and determining what incentives are required for them to change their approach to this aspect of fire safety.

3. Cost benefit analyses of a number of scenarios where the COP could be implemented..

Conclusions

The conclusions from our research are as follows:

- To date, there is very little practical experience of how the COP does or would work. In 2004, the public education process was still at an early

stage, and for actual examples to be observed required cooperation/coordination between TLAs, developers, insurers, and the NZFS, and strong enough incentives for uptake to occur.

- Initial discussions with TLAs indicate that it will take some time for the new COP to gain traction because, for example, their processes and those of the developers they deal with are currently founded in the previous COP.
- The general level of awareness of the new code from those developers who we contacted was low, ranging from totally unaware of it to only vaguely aware.
- Some of those contacted were of the view that there were too many rules and other guidelines and that the compliance cost in general was getting too high. None were against the idea of sprinklers, but they were more accustomed to their use in apartment or commercial buildings than in free standing dwellings.
- It appears then, that to date the uptake of the new COP has been very low, due to a lack of awareness amongst TLAs and developers and to some confusion from TLAs regarding the precise role of the COP and its relation to other regulations.
- In addition, the COP appears to deliver installation cost savings for developers only in certain developments. Our small survey of developers indicates that for greenfield developments, installation costs could actually be higher under the COP than under old guidelines.
- However, developers indicated that installation cost savings of around $1,333 per dwelling for in-fill housing developments may be achievable under the new COP.
- An indicative cost benefit analysis suggests that if the take-up rate of the COP amongst developers was to increase from 2% of new in-fill houses in 2005 to 20% in 2030, the net present value of benefits arising from the COP's provisions would be around $15 million. This benefit is comprised of reduced property losses due to a larger proportion of the new housing stock being sprinklered, lower installation costs for developers and fewer deaths from house fires. The benefits to developers via lower installation costs account for 87% of the total benefits over this period.
- Unfortunately, a lack of data means that there is some uncertainty about the specification of the cost benefit model. A sensitivity analysis around this central scenario – conducted by varying the key parameters in the cost benefit analysis framework – indicates that the net present value of benefits could vary between $12 million and $41 million, depending on the initial and eventual take up rates, the proportion of new dwellings that are in-fill housing and the proportion of new homes that are sprinklered.
- Of the various stakeholders that may be affected by the introduction of the COP, under the framework used here, it is the developers who seem

likely to experience the most benefits from adopting its provisions. The owners and occupiers of new housing also benefit to a lesser degree.

- It is more difficult to assess the impact of the COP on local authorities, insurers, the BIA and the NZFS. This is simply because we have little evidence on which to make any judgements at this stage of the COP's development.
- Our research into regulatory practice in other countries led us to the view that it is very hard to make comparisons across countries in their approaches to fire-fighting water supplies.
- This is partly because there are wide variations within and between these countries in progress towards, or regulations for, residential fire-sprinklers and fire-fighting in general. The factors shaping these regulations tend to be quite localised.
- Therefore the emphasis given to water supply e.g. as a factor in sprinkler uptake or incentives for uptake thus differs widely, as do regulatory structures and standards for water supplies in general.
- So in some respects, the New Zealand approach (i.e. in adopting a quite specific code for fire-fighting water supplies) contrasts with most of the approaches we saw in the international literature.
- But, as indicated above, how much difference the new COP makes to water supply practices here, and fire safety, will depends mainly on the trend in awareness of the new code, and its subsequent effects on practices amongst TLAs and housing developers.

Recommendations

1. That the NZFS makes TLAs – and in particular those in which new housing developments are growing rapidly – more aware of the provisions of the COP and how the COP interacts with existing guidelines and regulations (the Building Act, District Plans, etc). The benefits to the TLAs from promoting the COP need to be more clearly understood.

2. That the NZFS releases some simple explanations of the benefits of the COP's provisions aimed at educating developers. A brochure (updated at regular intervals) containing answers to 'frequently asked questions' about the COP may be one method of doing this, in addition to information on the NZFS website.

3. That the NZFS interacts with key players in the housing market (i.e. TLAs and developers) to lift awareness of the COP. If the COP is seen to be being used by major residential development firms, then smaller firms are more likely to follow suit.

4. That the indicative cost benefit framework is re-visited when greater amounts of hard data are available and when the parameters can be determined with greater accuracy and confidence.

5. It may make sense to aim for a region by region analysis, rather than a national one. This is because subdivision patterns, prospective new dwelling construction, and planning and consent practices vary widely between TLAs and regions. All these factors have an important bearing on estimated net benefits from the COP.

6. Systems for collecting relevant data should be considered. In particular our research suggested that the configuration of development (i.e. in-fill versus greenfields) may be an important influence on the size of the cost reductions offered by the new COP. But it is very hard to get meaningful data on recent trends let alone forward information in this regard.

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1. Introduction

In August 2003, the New Zealand Fire Service (NZFS) released a new Code of Practice (COP) for Fire fighting Water Supplies.[1] This replaced the 1992 Code of Practice, updating and enhancing it in several significant ways.

This COP contains provisions for new housing developments to have less need for reticulated water supply and pressure, if they install sprinklers in all dwellings in the development. The code of practice has the status of a guideline, but could be incorporated into relevant bylaws under section 146 (b) of the Local Government Act 2002 or district plans prepared under the Resource Management Act 1991.

The research documented in this report:

- Examines other countries' approaches to fire fighting water supplies and sprinklers in order to determine whether New Zealand is following international best practice or whether the new COP is quite different to regulations overseas.
- Identifies the costs and benefits of the adoption of the COP, using inputs from a small survey of developers. The distribution of the costs and benefits is also discussed.

2. Background

2.1 Residential fires

There were over 6,000 residential fires in 2002/03, according to the NZFS 2002/03 Annual Report. These fires resulted in 27 fatalities and many more serious injuries, and accounted for thousands of hours of NZFS time.

One of the NZFS goals to achieve by 2006 is to reduce residential structure fire fatalities to 10 or less. A key component of the NZFS strategy to attain this goal is the installation of sprinkler systems in homes. As noted by BRANZ (2000), "the success of sprinklers in commercial applications for both life safety and property protection has indicated that domestic sprinklers may be an option for increasing protection from fire in the home".[2] Experience in overseas jurisdictions where residential fire sprinklers have been mandated confirms this view.

[1] SNZ PAS 4509:2003

[2] BRANZ (2000) 'Cost Effective Domestic Fire Sprinkler Systems.' Prepared for the New Zealand Fire Service Commission. August.

2.2 Role of sprinkler systems

Research by Rahmanian (1995) suggests that 'installing domestic sprinkler systems in 10% of existing dwellings each year, in addition to all new dwellings, could save about 550 lives and $1.8 billion worth of property damage over a 30-year period.' [3]

So why haven't developers of residential properties been inclined to install sprinkler systems? First, there is no compulsion for them to do so under existing legislation. Second, sprinkler installation has probably not ranked high in the list of features sought by people purchasing dwellings in New Zealand. (Perceptions of cost, and potential water damage, have been negative influences.) Third, and partly related to the second, at least until recently private returns from such an investment were unlikely to compensate developers for the cost of installing sprinkler systems.

One way to increase the appeal to house purchasers of domestic fire sprinkler systems, and the incentives for developers to install them, is to reduce their costs. These include not just the installation costs of sprinklers in individual dwellings, but also the cost of the water infrastructure in the development as a whole. The latter depends on a range of factors specific to each locality but in the main incorporates:

- The length of the piping network;
- The average bore of the pipes;
- The number of hydrants; and
- Water pressure required.

Design requirements, as codified by Standards New Zealand, were the major barrier to cost reductions of sprinklers for residential purposes. But under a new code (NZS4517:2002) the cost of sprinkler installation has fallen dramatically. Depending on the number of areas covered by sprinklers, and other features, an indicative installation cost is now about $1,500[4] per dwelling, compared with over $6,000[5] under the previous standard.

Under the new standard, plumbing for residential sprinklers can be integrated with the rest of the cold water system, precluding the need for separate systems, valve sets etc. This has simplified both new installation and retrofitting. Under the previous code, costs were high because of requirements from local authorities and building regulators for such features

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3 Rahmanian F (1995) 'An analysis of domestic fire sprinkler systems for use in New Zealand.' Fire Engineering Research Report 95/5, University of Canterbury, Christchurch, New Zealand.

4 April 2004 phone interview with BRANZ

5 BRANZ (August 2000, p.21) – applies to installation in new dwelling to requirements of NZS 4515:1995

as backflow prevention, as well as factors such as the absence of a competitive market for residential sprinkler installation; and insufficient volumes to bring down costs.

2.3 Sprinkler systems and water supply

Through the new code on fire fighting water supplies, the NZFS has contributed to attempts to reduce the cost to residential developers of sprinkler installation.

The aim is to provide techniques to define an adequate fire fighting water supply that may vary according to circumstances. 'This code of practice is for the use of territorial authorities, water supply authorities, and the Fire Service, to establish the quantity of water required for fire fighting purposes in relation to the fire hazard in premises located in urban Fire Districts. It can also be used by developers and property owners to assess the adequacy of the fire fighting water supply to new or existing premises' (SNZ PAS 4509, p. 11).

The underlying philosophy is to encourage flexibility and innovative solutions across all parties concerned with residential development and the role of water in fire safety.[6]

If all residential developers adopted the provisions of the COP, the number of fatalities and amount of property damage caused by residential fires could be greatly reduced. However, the NZFS is unable to make this COP compulsory for new residential projects, as it cannot override the legislative requirements for such developments under the Building Act or District Plans.

2.4 The new code

Salient aspects of the new Code, for the purpose of this analysis are as follows.

"This code of practice sets out the National Commander's considered opinion on what constitutes an adequate supply of water for fire fighting in *urban Fire Districts*. This includes areas covered by any agreements under section 38 or 39 of the Fire Service Act 1975. Compliance with this code of practice does not guarantee that in each and every case the Fire Service can control or extinguish a fire with the water supply available.

[6] This appears to reflect the broader trend in regulations to performance-based rather than prescriptive approaches, for example, as in the newly revised standards (NZS 4404:2003) for land development and subdivision engineering. Refer Standards New Zealand website - www.standards.co.nz

This code of practice provides techniques to define an adequate *fire fighting water supply* that may vary according to circumstances. It relates to the Fire Service requirements only; territorial authorities and building owners may choose to exceed the provisions. It is written in a way that will encourage flexibility and provide different options for developers and territorial authorities.

It is intended that the code of practice will form the basis of a partnership between the New Zealand Fire Service, territorial authorities and developers such that it may be used as a basis for territorial authority conditions of supply or be called up, for example, by territorial authorities in rules regulating subdivisions within the district plan.

This code of practice may not provide specifications for the water supply required for the effective operation of *fire protection systems* that may be installed in buildings or properties. As the requirements for *fire protection systems* may vary, dependent upon design parameters, the practical water requirement must be considered in addition to *fire fighting water supplies*."

The legal context and application of the Code of Practice are summarised in Appendix C.

2.5 Research approach

To date, there has been no economic analysis related to the COP. The research documented in this report addresses the following economic issues:

- The relative costs and benefits to developers, local authorities, the NZFS and the community, of the Code.
- Under which circumstances the net economic benefits of the Code would be maximised.

The key components of the research are:

4. A review of legislative and other initiatives in other countries regarding residential sprinklers. This has identified how other countries have legislated to reduce the consequences of residential fires, and provides some guidance as to how the NZFS COP compares to international best practices.

5. A small survey of residential developers to determine the level of industry awareness of the COP, and their reactions to it. The survey was aimed at ascertaining why many developers are currently not installing sprinklers in new residential projects, and determining what incentives are required for them to change their approach to this aspect of fire safety.

6. Cost benefit analyses of a number of scenarios where the COP could be implemented.

3. Fire sprinklers – overseas approaches

With a few notable exceptions, many jurisdictions broadly comparable to New Zealand seem to be in the early stages of regulation for and adoption of residential sprinklers. In the US, examples of legislative support for residential sprinklers commenced in the 1970s, although even there adoption of such legislation is still limited to a minority of states and municipalities.

Following is a brief review of research and other publications referring to legislation for residential fire sprinklers in the US, Canada, UK and Australia and to the associated research and policy positions regarding fire fighting water supplies.

3.1 United States

3.1.1 Background

In June 2003, the National Fire Sprinkler Association published a report 'Residential Fire Sprinklers…A Step-by- Step Approach for Communities.' In addition to practical implementation advice it also provides some of the broader research-based information on experience with such sprinklers in the US, including a brief history as follows.

In 1973 a sub-committee of the National Fire Protection Association (NFPA) was formed to prepare a standard for the installation of sprinklers systems in dwellings. Such a standard, utilising commercial sprinklers with reduced water supply, was adopted and published in 1975 as NFPA 13D – Standard for the Installation of Sprinkler Systems in One- and Two- Family Dwellings and Mobile Homes.

In 1976 the US Fire Administration (USFA) began to fund research programs focusing on the residential fire problem in general, and residential fire sprinkler protection in particular, in the hope of optimising fire sprinkler devices for residential dwelling use with the dual goals of improved performance and low cost. As a result of multiple research studies and full-scale fire tests, NFPA was rewritten and published in 1980, incorporating the residential test results and requiring, for the first time, the use of fast response residential sprinklers.

Subsequent editions of NFPA 13D in 1984, 1989, 1991, 1994, 1996, 1999 and 2002 have resulted in changes to the rules relating to design and installation of these dwelling systems while maintaining the same basic purpose: *To prevent flashover in the room of fire origin, when sprinklered, and to improve the chances for occupants to escape or be evacuated.*

Despite the relatively long-established fire sprinkler standards, and local initiatives including mandated installation or residential automatic fire sprinkler systems, only around 3% of all US homes had fire sprinklers installed in 2001. However, in some individual communities, the penetration rate is much higher. For example, in Scottsdale, Arizona, which passed the nation's most comprehensive sprinkler ordinance in 1985, a total of about 55% of homes had sprinkler protection in mid-2004.[7]

Over the 20 years to 1995, the number of residential sprinkler models listed at Underwriters' Laboratories grew to from zero to 288.[8]

3.1.2 Residential sprinklers and property loss

A National Fire Sprinkler Association (NFSA) report in 2000 'The case for residential sprinklers'[9] from the US Fire Administration reported (page 2) that the evidence is dramatic. Cobb County, Georgia and Napa, California reported minimal or incidental damage for all of their sprinkler activations, against potential losses extending into the millions, especially for Cobb's multi-family units. Nationally, average property loss in homes with sprinklers is 38% lower than homes without sprinklers, according to a NFPA survey of home fires reported to fire departments from 1983 - 1992.

In July of 1985, when Scottsdale passed Ordinance #1709, there were still numerous questions related to the effectiveness and wisdom of using built-in protection to replace some of the traditional resources commonly used by the fire service. Since then installation costs have been reduced dramatically, from $1.14 sq. ft to $0.59 sq. ft in 1997.[10]

For the city of Scottsdale, in 1995/96, the average fire loss per sprinklered incident was only $1,945, compared to a non-sprinklered loss of $17,067. Automatic protection had a direct role in saving eight lives. One or two heads controlled or extinguished the fire 92% of the time, with the majority of the exceptions a result of flammable liquid incidents. Estimated water flows were substantially reduced for this community. The potential structural fire loss has been dramatically reduced for sprinklered incidents. When the city finally reaches its full growth potential, it is estimated that it will be a community with over 300,000 residents and more than 65% of the

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7 James A Milke (2004, p.7), and (www.nfsa.org/info/the case.html)

8 NFSA (2003, p14)

9 www.nfsa.org/info/the case.html

10 NFSA (2003, p.10)

residential homes and 85% of commercial property protected with automatic sprinkler systems.[11]

3.1.3 Installation costs[12]

Historically, the first and largest issue associated with the requirement for residential sprinkler systems is cost.

The installation costs of residential sprinklers in Scottsdale have been closely monitored since the ordinance went into effect. The City has experienced a consistent reduction in the installation price of residential systems.

The primary reasons behind this trend are: this is a mandatory requirement for the community; established standards are identified for all builders; increased competition for the available business; better availability of quality materials; and an increase in the efficiency of those installing the systems, resulting in better and quicker installations.

It must be recognized that Scottsdale's location in the Southwest has a positive impact on the associated costs due to the climate and dramatic growth associated with the area. Additionally, these same advantages might not apply to all areas of the country. However, what is important is the ability of the industry to become more innovative, productive and cost effective when market conditions allow open competition for the installation of these required systems.

3.1.4 Water supply issues

The Fire Marshalls Association of Minnesota (FMAM, 1997, p.3) noted that ‘At the present time, most municipalities require that the sprinkler connection to the municipal water supply must occur after the water meter.’ This creates a few problems:

1. Most existing standard or typical residential water meters are not designed or intended to handle the types of flows which are seen for sprinkler systems,

2. The pressure loss through standard 5/8 or ¾ inch water meters can be exorbitant. It is not unusual to have 15-25 PSI of friction loss through a standard-sized meter. The friction loss can be substantially reduced by going to a larger size meter but that can affect the cost of installation and the minimum monthly water fee (some municipalities charge a fee based on the size of the meter),

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[11] City of Scottsdale Study (1997)

[12] City of Scottsdale Study (1997).

3. The State Plumbing Code discourages connections prior to the water meter by requiring that a licensed plumber only install this portion of the water supply.

The suggested remedy was to amend the state statute and State Plumbing Code to allow sprinkler contractors to connect ahead of the water meter in an effort to reduce friction loss, especially in existing residences that may have older, marginal water supplies.

'The case for residential sprinklers' (2000, p.5) noted that there were a number of water, and water-related issues connected to sprinklers that need further resolution. One issue related to backflow prevention. Backflow prevention devices, which isolate the water used for sprinkler systems from that used for domestic purpose, are required in many jurisdictions. Various types of devices are available to perform this backflow function; however, in some communities the standards may be more stringent than needed to guarantee drinking water purity. This can adversely affect consumers by pushing up the cost of sprinkler system installation.

Additionally, water authorities in a number of communities around the country had adopted policies of charging fees to homeowners for the initial connection of the sprinkler system to the water supply (connection fee), and for maintaining the availability of water, should it be needed (standby charge).

The amount of the fees varies widely, and in some cases clearly constitutes a pronounced financial disincentive to sprinklers.[13]

Sprinkler proponents believe that these fees, especially the standby fees, are questionable policy. There is no charge to homeowners who have not protected their property with sprinklers for the far greater amount of water that is needed to suppress a fire once it occurs. They are working with national water supply organizations to develop a more rational approach.

The Scottsdale study also examined the issue of water usage during a fire incident. The first 38 sprinklered fire incidents, a combination of fires in commercial, multi-family and single family units, were investigated. Based on the incident timelines, the water flow times for the sprinkler systems were determined and the total water flow was calculated.

The average amount of water used per fire was 357 gallons. Assuming that manual suppression could be accomplished in the same amount of time as the sprinkler flow time, the average amount of water used per fire incident by the fire department would amount to more than 4,800 gallons.

[13] '1993 Fire sprinkler ordinance survey.' Fire Sprinkler Advisory Board of Southern California.

In 1996, a review of the 109 fires that had occurred in sprinklered buildings in Scottsdale included 44 residential fires. In more than 90% of the incidents, the fire was controlled with 1 or 2 sprinklers activated. The average amount of water flowed by the sprinklers was 299 gallons per fire vs. an estimated manual suppression usage of approximately 6,000 gallons per fire. Most importantly, the study indicates that at a minimum 8 lives were saved in these fires by the residential sprinkler systems. [14]

The City of Dallas, Texas, adopted a building code that requires all new buildings or those undergoing major renovation, having an area greater than 7,500 sq ft (697 m^2), to have automatic sprinklers. At the same time, this building code encourages the installation of sprinkler systems by allowing design options that may allow different levels of "passive" fire protection features in exchange for "active" automatic sprinkler alternatives.

The report concludes with the comment that 'while there is growing recognition of the enhanced ability of fast-response sprinklers to protect life and property from fires, it is estimated that less than 3% of the one and two family homes in the United States have them installed.

In 2003 a Bill was introduced in the US House of Representatives to amend the Internal Revenue Code of 1986 to classify automatic fire sprinkler systems as 5-year property for purposes of depreciation. The Act would be known as the Fire Sprinkler Incentive Act 2003.

3.1.5 Insurance issues[15]

There continues to be a tremendous difference in insurance industry recognition of sprinkler system effectiveness between commercial and residential applications. In 1991, the City of Scottsdale, Reliable Sprinkler Corporation and Rural/Metro Fire Department conducted a pilot program to retrofit a small, downtown strip shopping center with an automatic sprinkler system. This retail center was block construction with a flat composition roof and covered 7,790 square feet. According to the Insurance Services Organization (ISO) standards, the complex and individual occupancies experienced a reduction in the insurance costs of approximately 75% as a result of the installation of a sprinkler system.

Recognition for the effectiveness of residential sprinklers by the insurance industry has been slower to materialize and several issues still remain that are related to residential protection. The losses associated with residential

[14] 'Review of Residential Sprinkler Systems: Research and standards' Daniel Madrzykowski, Building and Fire Research Laboratory, National Institute of Standards and Technology and Russell P. Fleming, National Fire Sprinkler Association. Revised December 2002.

[15] City of Scottsdale (1997, pp20, 21)

properties indicate this issue continues to be a major area of concern for the United States.

The NFPA reported that in 1994 nearly 74% of all structure fires occurred in residential properties, 57% of the total structure loss for the year occurred in residential properties (estimated $3.615 billion dollar loss in single family structures), and 80% of fire fatalities occurred in residential buildings (66% of total fire fatalities occurred in single family structures).

A review of the policies associated with several major insurance carriers across the country identified a wide variance in the policies of the industry. Local agents and underwriters still need additional training related to the benefits of residential sprinkler protection and industry policy. Depending on the design of the system and the areas to be protected, the discounts can range from 5% to 45%.

The higher discounts are available only when sprinkler protection is combined with features like smoke detection, monitoring of the systems, installation of fire extinguishers, and deadbolt locks. Surveys of the local insurance industry indicate the majority of insurance carriers will offer some type of discount, with the average being approximately 10% for approved residential sprinkler system protection.

3.2 Canada

Predictably, the research base on residential fire sprinklers for Canada is much more sparse than in the US. As in the US, though, official support for residential fire sprinklers seems to vary widely across jurisdictions i.e. at the provincial/state level and across municipalities.

Although there seems to have been growing support for mandating sprinklers in the National Building Code, the economic case coming out of research is mixed. The main point here is that, in the residential housing stock, fire sprinklers will in the main be fitted to the new building stock which is generally designed to much more fire resistant than the average residential building stock. So in that context, the relative gain in fire safety is limited.

In 1996, the Canadian Mortgage and Housing Corporation (CMHC) published a report on the cost-effectiveness of automatic fire sprinklers in new low-rise and high-rise apartment buildings. The approach to this analysis was structured around the Building Code Assessment Framework (BCAF) which contains a complete financial model for life cycle costs and an acceptable/unacceptable risk and willingness to pay graph which helps compare changes in mortality with incremental life costs.

The base line value of willingness to pay per life saved was taken as $24,000, as applied in a US study on sprinklers. Mandatory sprinklers for the exemplar buildings in the analysis were found to impose a cost of $159,000 to $606,000 per year-of life-saved in low-rise buildings and $252,000 to $1,212,000 per year-of-life saved in high-rise buildings. According to the report, the figures suggest that the cost per-year-of-life saved for sprinklers in low-rise and high-rise apartment buildings is beyond what society appears willing to pay for safety features. One reason is that the risk of death by fire in recently-built apartment buildings is relatively low. With relatively low deaths as a base, the reduction in fatalities and property damage made possible by sprinklers are not great enough to offset the incremental costs for construction and maintenance.

Another CMHC commissioned study, published in 1999, examined the costs and benefits to municipalities of mandatory residential fire sprinklers. The study notes the expanding support in both Canada and the US for the use of sprinklers in buildings, and that a few Canadian municipalities had introduced bylaws requiring sprinklers in new residential buildings.

For example, in April 1990 the City of Vancouver passed by-law requiring all new residential construction in the city, including single-family homes, to be built with fire sprinklers installed.[16]

A case study approach was employed to analyse the costs and benefits of mandatory residential fire sprinklers using six municipalities as case study sites. The 'base case' was established by collection of data (fire department policies and practices, population and growth projections, and capital and operating cost projections) from each site.

The 'sprinklered scenario' was developed to assess the costs and benefits that would accrue to the various parties (municipality, developer, builder and homeowner) due to the introduction of mandatory residential sprinklers. The cost benefit analysis compared the base case costs with the sprinklered scenario costs and benefits and estimates the net present value of these costs and benefits over a 30 year period.

It was assumed that the existing building stock, which consists of sprinklered and unsprinklered buildings, would remain essentially unchanged. Mandatory retrofit of the existing building stock with automatic sprinkler systems was not considered as part of the study, except for the aboriginal reserve case.

Factors considered and relevant to the results include:

- The opportunities for greenfield residential development, and the pattern for growth relative to the areas currently served by the fire department;

[16] Refer Holdgate, 2001.

- Fire department response times across areas served;
- Land development and sprinkler installation costs.

A November 2003 paper by the Chairman of the Canadian Commission on Building and Fire Codes noted: "'…with respect to the debate on requiring sprinklers in new houses, research on the issues found that wired-in smoke alarms actually have a negative cost – the benefits in terms of lives saved far outweigh the costs of installations of the detectors. Wired-in smoke alarms are mandatory in new houses in Canada, sprinklers are not".

3.3 United Kingdom

The May 2002 edition of the British Automatic Sprinkler Association (BASA) publication 'Information File' featured sprinklers in dwellings. It noted that the (then) latest version of the Approved Document B, in support of Building Regulations, incorporated clear recognition of the value of sprinklers in enhancing levels of safety for occupants as well as in preventing the spread of fire.

On its website (www.firesprinklers.org.uk) the Residential Sprinkler Association notes that (as at September 2004) there was no national legislation requiring the use of fire sprinklers for life safety in residential properties in the UK. (It notes however, that London and Manchester have local by-laws requiring sprinklers in certain high-rise buildings and single storey retail premises over 2,000 sq m. have to be sprinkler protected.

In May, 2004, the Fire Sprinkler Association (FSA) in conjunction with the British Automatic Sprinkler Association (BASA) and Water/UK published *Guidelines for the Supply of Water to Fire Sprinkler Systems*. In the introduction these Guidelines note:

"…fire safety requirements made under the Building Regulations in England, Wales and Northern Ireland and the Building Standards in Scotland relating to fire safety measures to be incorporated into the design and construction of buildings may have been relaxed in favour of the fitting of an automatic fire sprinkler system. A failure of such a system at a critical time could also seriously endanger life and property… Because of the importance of automatic fire sprinkler systems as an efficient means of detecting and controlling or extinguishing fires before they become a significant threat to life, property and the environment, coupled with economic use of water, it is important that all the parties concerned co-ordinate their efforts in dealing with water supply issues, both for maintaining the effectiveness of existing systems and for ensuring that new systems are installed and maintained correctly".

In November 2003, the Fire Sprinklers in Residential Premises (Scotland) Bill was introduced into the Scottish Parliament.

At that time, the law relating to fire safety in homes stemmed from the Building (Scotland) Act. The regulations provided for the standards that all new buildings, and converted or altered buildings, had to meet. The regulations specified standards for structural fire protection, means of escape from fire and facilities for fighting fire. There was no requirement in legislation for the mandatory installation of fire sprinkler systems in residential premises.

The supporting document comments on water supply implications. A report by the British Standards Advisory Fire Sub-committee states that "pressures provided in the water mains generally exceed 1.5 bar and pose no particular problems for the effective operation of a system".

Consultation on regulations in support of the requirement 2.15 (Automatic life safety fire suppression systems, cited the results of a study by the Building Research Establishment (BRE) 'The effectiveness of sprinklers in residential premises', completed in February 2004.

The main findings of this study as set out in the Executive Summary included the following:

> *For the majority of scenarios experimentally studied, the addition of residential sprinkler protection proved effective in potentially reducing casualties in the room of fire origin and connected spaces*
>
> *Sprinkler protection was not found to be a complete panacea, slow growing and shielded fires can be a problem*
>
> *Smoke alarms, fitted in the room of fire origin, responded typically in half the time required by sprinklers and well before the conditions had become life threatening*
>
> *Closing the door to the room of fire origin, was found to be effective in keeping tenable conditions in connecting spaces*
>
> *Residential sprinklers are probably cost-effective for residential care homes (old persons, children's and disabled persons care homes)*
>
> *Residential sprinklers are probably cost effective for tall blocks of flats (eleven storeys and above)*
>
> *Residential sprinklers are not cost-effective for other dwellings*
>
> *In order for sprinklers to become cost-effective, high risk buildings may be targeted, and justified on a case-by-case basis using the cost-benefit approach developed in this project*

In order to be cost effective in a broader range of dwellings, installation and maintenance costs must be minimal, and/or trade-offs may be provided to reduce costs by indirect means.

In general, the cost benefit conclusions from other countries' experiences were the same as this project, i.e. that sprinklers were not cost-effective, unless systems were low-cost or trade-offs could reduce costs.

3.4 Australia

The Australian Fire Authorities Council (AFAC) (established in 1993) has had as one of its strategies promotion of the installation of detection and alarms systems and automatic sprinkler systems that will reduce the potential for loss of life and property especially in the home.

The first Water Reticulation Code was published in 1999 by the Water Services Association of Australia (WSAA), the national body for the water supply industry[17]. This code introduced a number of concepts perceived to have a long term impact on the availability of water for fire fighting activities and raised a number of issues including the need for a dedicated fire water code similar to New Zealand's.

A 2nd edition was published as the Water Supply Code in 2002.

There is no Code for supply of water for fire fighting. In Australia requirements for supply of water for fire fighting vary from jurisdiction to jurisdiction. Most jurisdictions have no requirement to supply water for fire fighting from the reticulation system, although the water agencies install hydrants on their systems so that water is available for fire fighting. However, there is no guarantee on flow rates, static and/or dynamic pressure or reliability/continuity of supply. [18]

In 2003, the Australian Water Association made a submission to the Commonwealth Government's Inquiry into Sustainable Cities 2025. This submission noted (p.7) that "fire fighting provisions place a major constraint on the extent to which current service models for water can be modified. The substantial minimum size of the smallest distribution mains, at 100mm diameter, is a function of minimum fire-fighting standards, not domestic water delivery. In fact, the first water mains to towns were initiated to aid fire fighting, not to service household needs. There is a need to seriously consider how else water could be provided for attacking fires e.g. by sprinklers as used in commercial building, or by stored recycled water or rainwater in neighbourhood reservoirs accessible to fire fighters. Until

[17] Version 2.3 of this Code was published in April 2004.

[18] Email from Water Services Association of Australia, September 2004.

agreement is reached with fire standards regulators, there can be no change in the current water network models".

In its draft report on Reform of Building Regulation (August, 2004) the Productivity Commission cited (p.130) comments from the Fire Protection Association of Australia. These warned of the impacts of any changes in regulations to conserve water (under the sustainability agenda), because fire protection systems in buildings require high pressures to meet the performance requirements for fire fighting. The FPAA added:

"Any decrease in towns' waters supply pressure at the meter or in the network will impact on installed and proposed (fire protection) systems. Systems are designed to achieve a minimum pressure at the hydraulically disadvantaged point, based on a minimum acceptable source of supply and agreed pressure. Effective and reliable system operation cannot be assured if pressures are reduced beyond these design limits. Any change in regulation to conserve water must carefully consider the ability to supply water to existing engineered installations and quantify the impact on new build and maintenance routines. (sub.19, p.12)".

4. New Zealand experience

4.1 Overview

As at mid-2004, there was very little practical experience of how the COP does or would work. The whole public education process was still at an early stage, and for actual examples to be observed required cooperation/coordination between TLAs, developers, insurers, and the NZFS, and strong enough incentives for uptake to occur.

Initial discussions with TLAs indicate that it will take some time for the new COP to gain traction because, for example, their processes and those of the developers they deal with are currently founded in the previous COP and it will take time at both conceptual and practical levels for uptake to gather momentum.

In the larger TLAs, for example, District Plans include a variety of requirements from the old code. And several different departments in a TLA can be involved in consent process for new developments, so considerable training and information dissemination can be involved in adopting new regulations.

Part of this 'inertia' reflects different incentives at work for the various parties involved. Most major TLAs are yet to adopt the new COP, in some cases because they might not be satisfied (from an engineering perspective) with all aspect of the new COP. But more generally, they have to be convinced of the advantages to them of the new approach.

TLAs may argue, that there is a conflict (for them at least) between the Building Act/District Plan and the new COP. Under the Building Act, they can't make people use sprinklers in dwellings, so fire hydrants are required at specified proximity to the buildings in question. In Auckland, for example, new development (either single dwellings or multiple dwellings) are on previously 'locked-in' land, well away from the previous street frontage. So water supplies have to be taken up long access routes.

Potentially, the new COP offers 'significant' savings for developers if they can adopt the low water pressure/plus sprinklers solution. But they cannot respond to this private incentive, if it conflicts with TLA practice.

In the case of sub-divisions, one of the practical issues revolves around the development process and the number of parties involved. In some cases, the party that purchases and subdivides the bare land also builds all the dwellings.

But in other cases, the land developer may on-sell to one or a number of builders. The significance of this is that there can be 'a disconnect' between the cost saving incentives offered by the COP at the subdivision (and provision of services) stage, and the parties who construct and sell the dwellings affected by the COP.

4.2 Residential developers

In the first half of 2004 we conducted phone interviews with a selection of land developers/builders (operating in Auckland, Hamilton, and Wellington) to explore for example:

- Their familiarity with the new COP.
- Any experience in working with the COP.
- Understanding how they would normally make decisions (re water supply, sprinklers) and how the new COP affects that process.
- Their interactions with TLAs, building professionals, and insurers.

This was a small sample, and the approach was informal, so the results cannot be presented as representative. A summary of responses was:

- The general level of awareness of the new code was low, ranging from totally unaware of it to only vaguely aware.
- We made contact with only one developer who had come close to using the new code and installing sprinklers but a problem in communications with the responsible TLA resulted in incorrect connections being used, and by the time the error was realised, it was too late to retrofit all the dwellings.

- At the time of writing this report, it was too early to draw any meaningful conclusions about decision-making processes re the water supply and sprinklers and the impacts on this of the new code.
- Some of those contacted were of the view that there were too many rules and other guidelines and that the compliance cost in general was getting too high. None were against the idea of sprinklers, but they were more accustomed to their use in apartment or commercial buildings than in free standing dwellings.
- One developer suggested that because modern houses are often built with concrete floors and fire retardant insulation, they may have generally lower fire risks than older dwellings. This was one of the issues raised in Canadian research. (Refer section 3.2). The effect is to reduce the apparent benefit of sprinklers in new houses because of their lower inherent risk than in older dwellings.

5. Cost-benefit analysis

5.1 Introduction

One way for the NZFS to promote the provisions of the COP is to highlight to the key stakeholders the potential benefits (net of costs) of adopting the COP. The aim of this section is to conduct an assessment of the net benefits associated with residential developers adopting the COP.

The new code is intended to provide an incentive (through cost saving) to developers to install sprinklers in new homes. This should then be reflected in the uptake of sprinklers and consequent fire safety benefits over and above those that would be realised with the previous code.

It is important to understand that this cost benefit analysis (CBA) can only be indicative at this stage. This is because of a number of uncertainties surrounding fire sprinklers in general and the COP for fire fighting water supplies. These uncertainties include:

- The likely uptake rate for residential sprinklers (with or without the new code).
- The cost savings that will accrue to developers from adopting the COP (i.e. in terms of lower costs of providing reticulated water).
- The adoption rate of the new code in District Plans and consequent effects on application to new developments around the country.
- The proportion of new dwellings to which the COP will apply/be relevant.

It is possible to deal with some of the uncertainties mentioned above by conducting sensitivity analyses on the key parameters in the model, thereby presenting a range of possible results between an upper and lower bound.

The model can also be updated in the future when more up to date data is available, for example once the COP has been in place for five years.

Thus the CBA provides NZFS and the other relevant stakeholders with an initial guide to the potential magnitude of the net benefits of the adoption of the COP.

5.2 Methodology: overview

The new Code of Practice is a guide rather than being a ‘regulation’ in the sense of being mandatory. But for the purposes of this analysis we can treat it as a quasi-regulation in the sense of its potential to encourage and achieve socially efficient behaviour with respect to fire safety.

Fire safety regulation is intended to help manage risks in a socially efficient way, that is, on balance over time the benefits of regulation (in terms of risk mitigation and cost reduction) outweigh the costs imposed by regulation (for example, in terms of more complex and costly design and construction processes.)

Here we are using the term economic cost in the 'welfare sense' that would be used in CBA. CBA is concerned with the welfare of society as a whole; the net sum of the economic benefits and costs borne by all those affected by measures to reduce the risk of fires. CBA recognises that there may be costs (in terms of opportunities foregone) which do not figure in financial flows.

In brief, CBA of a regulatory intervention involves:

1. Identifying the relevant stakeholder groups affected.
2. Establishing a realistic base case for comparison purposes.
3. Identifying the effects of the intervention and classifying them as either costs or benefits over an appropriate period.
4. Quantifying these effects and estimating their timing.
5. Monetising them and discounting them to put all costs and benefits on to a like-with-like basis.

In this context, **costs** of the intervention are expenditures that would not be incurred in the absence of the new Code. **Benefits** are costs avoided i.e. both in terms of water infrastructure and fire damage or injury that would occur in the absence of the Code.

5.3 Key parameters

To recap, the code is less prescriptive than before – it takes into account different levels of risk and allows for infrastructure specifications and thus costs to reflect those different levels of risk.

Summary of Table 2 from Fire Fighting Water Supplies Code of Practice SNZ PAS 4509:2003
(for single family dwellings and similar within urban Fire Districts)

Case	Description	Approved sprinkler system	Water supply classification	Domestic supply method	Sprinkler supply method (1)	Fire fighting water supply method (2)	Required flow from hydrants	Required storage for fire fighting (3)(4)
1	Non-reticulated area with no approved sprinkler system	No	W3	Tank	-	Tank	-	45 m^3
2	Reticulated area with hydrants but no approved sprinkler system	No	W3	Mains	-	Hydrant	12.5 l/s within 135 m + additional 12.5 l/s within 270 m	-
3	Non-reticulated area with approved sprinkler system	Yes	W1	Tank	Tank	Tank	-	11 m^3
4	Reticulated area with approved sprinkler system and hydrants	Yes	W1	Mains	Mains	Hydrant	12.5 l/s within a distance given by the NZFS (5)	-
5	Reticulated area with approved sprinkler system but insufficient mains flow for firefighting	Yes	W1	Mains	Mains	Tank	-	11 m^3
6	Reticulated area with approved sprinkler system but insufficient mains flow for domestic supply and firefighting	Yes	W1	Mains or tank	Mains	Tank	-	11 m^3

NOTE –

(1) Where a reticulated water supply is unavailable, or insufficient for fire fighting, tank supply is the preferred alternative. However fire fighting water may be supplied from any year-round source as contained in Appendix B5 of SNZ PAS 4509:2003

(2) Storage for fire fighting water supply should not be used for any other purpose

(3) Where storage for fire fighting water is required, hard standing must be provided for fire appliances as detailed in Appendix B of SNZ PAS 4509:2003

(4) Water supply for a sprinkler system should be based on the hydraulically calculated flow rate and duration specified in the appropriate standard and is additional to the requirements for fire fighting water supply contained in the table. Indicative design flows are contained in Table A1 SNZ PAS 4509:2003

(5) Where an approved sprinkler system is provided, fire hydrant spacing may be increased by agreement with the Chief Fire Officer of the Fire District

All single family homes with a sprinkler system installed to an approved Standard have a water supply classification of W1. This is regardless of the floor area of the home. This then enables a development to occur with smaller pipes from the public main, than would apply with the previous Code, and possibly more widely spaced fire hydrants.

Because the incentive effect of the new code is situation specific (i.e. according to the type of development) we have used various parameters to indicate the range of economic effects of the new Code, i.e. additional to those of residential fire sprinklers under the existing code.

Relevant costs include the initial capital costs (e.g. trenches, pipes, and hydrants, for example) and ongoing inspection and maintenance costs.

5.3.1 Cost effects of the new code

Table 1 below indicates the decision framework facing developers in a couple of examples, with the primary choice between:

- Smaller pipes, fewer hydrants, with approved fire sprinklers in all dwellings in the development.
- Larger pipes, more hydrants, no sprinklers.

We have assumed, based on our discussions with developers, that their main concern will be with the savings (or additional costs) on a per dwelling basis.

Table 1: Fire fighting water supplies

Indicative capital costs ($)

Small in-fill development (e.g. 3 dwellings)	New Code	Old Code	New minus old
Pipe in from public main and hydrant(s) within specified distance of new dwellings	$2,000 to $3,000	$10-$12,000	-$8,500
Sprinklers @$1,500 per dwelling	$4,500		$4,500
Cost saving per dwelling			$1,333
Greenfield development (e.g. 10 dwellings)	New Code	Old Code	New minus old
Pipe in from public main and hydrant (s) within specified distance of new dwellings (s)	$3,000-$4,000	$5,000-$6,000	-$2,000
Sprinklers @$1,500 per dwelling	$15,000		-$15,000
Cost saving per dwelling			($1,300)

Note: For simplicity, we have ignored ongoing maintenance costs.

Source: NZIER

In relative terms the potential saving to developers in applying the new Code seem likely to be greatest in the case of in-fill developments in which a few new dwellings are being constructed at the rear of existing dwellings – and at the end of a right-of-way. The saving in the case of a greenfield development with 10 or more dwellings seems likely to be much smaller. Or, in certain cases, the new Code plus fire sprinklers option may increase average costs-per dwelling.

Further refinements are possible, for example incorporating some of the data include in BRANZ (2000, p21) such as:

- Annual maintenance and survey costs for sprinklers
- Water connection fees.

However, at this stage we have not attempted to model these costs.

5.3.2 Fire risk

Various data is has been published on the difference between fire risk with approved sprinklers installed and fire risk without sprinklers. These provide us with a basis for the fire risk assumptions used in our cost benefit analysis.

The primary source we use here is BRANZ (2000, pp22 & 23) which assumed:

1. A fire incident rate per year per household of 0.004 was used based on NZFS data for 1993-1997.

2. The value for property losses per household was determined to be $17,200 with no sprinkler system or alarm present and $3,000 with a sprinkler system.

3. The number of deaths per 1000 house fires in the absence of any fire protection system was estimated to be 6 The presence of a sprinkler system was taken to reduce this death rate to 1.2 deaths per 1000 house fires.

4. The expected number of injuries per 1000 house fires in the absence of any fire protection system was estimated to be 40. The installation of a domestic sprinkler system is assumed to reduce the number of injuries to 15 per 1000 fires.

Clearly these can be only be guidelines – in particular the historical risk factors are derived in relation to the housing stock as a whole, whereas most of our analysis applies to new homes which, regardless of the use of sprinklers, may have fire risk profiles quite different to those of the housing stock as a whole.

5.4 Indicative cost benefit analysis

5.4.1 Caveats

As the fire-fighting water COP is a new piece of documentation, there is considerable uncertainty regarding its current and future impact. As outlined earlier, our discussions with NZFS personnel, developers and TLAs suggest that, to date, the provisions of the COP are not widely known and have not been taken advantage of. This may well change in the future. However, until we can see greater evidence of actual 'take-up rates' of the COP, our CBA is necessarily indicative only. We have only considered the impact of the

COP of new homes – we do not consider the impacts of retro-fitting sprinklers to the existing housing stock.

A further complication is that many of the parameters in the CBA are subject to uncertainty.

As a consequence, we would recommend that our CBA model's results be used with caution. However, we believe that the development of such a model will allow the NZFS to have at its disposal a tool that can be updated or modified as new data comes to hand.

5.4.2 Costs

As this COP is not mandatory (i.e. it cannot override the legislative requirements for new housing developments under the Building Act or District Plans), developers will not deviate from their current construction practices if the installation costs to them are higher under the provisions of the COP than they were initially.

From our discussions with developers, this appears to be the case for greenfields developments, where under the COP it would cost developers more to install fire-fighting water supplies than under the status quo.

Therefore it seems unlikely that there will be any additional costs arising from the use of the COP – developers will simply choose *not* to operate under the COP if they feel that their installation costs would be higher. Therefore our CBA focuses primarily on the benefits that could accrue to developers and society as whole from wider use of the COP.

5.4.3 Benefits

There are three main sources of benefits that might be present under the COP if it incentivises developers to install more sprinklers in new houses than would occur in the absence of the COP:

1. Reduced installation costs.
2. Reduced property losses from fires.
3. Fewer deaths.

Reduced installation costs

We assume that the COP will only be used for in-fill housing developments. It is unclear what proportion of new houses is built on greenfields sites as opposed to being in-fill developments. A figure of 50% is used in our central scenario, although this is varied in the sensitivity analysis.

By multiplying our annual forecasts of the number of new dwellings by this proportion, we obtained the potential number of houses that might be built under the COP. However, we know from our discussions with developers and local authorities that not many developments are actually being constructed under the provisions of the COP. We thus need to assume a take-up rate. Given the present relative lack of awareness of the COP's provisions, this rate will be low, at least initially. As an indicative figure, we assume that 5% of new in-fill development houses built in 2005 will use the new COP. This proportion is assumed to rise gradually to 20% by 2030. These take up rates are varied in the model in the sensitivity analysis.

We now have the number of new houses to be built, out to 2030, under the COP's provisions. The cost saving to developers, per dwelling, of the new COP is estimated to be $1333 (see Table 1). We can therefore estimate the annual reduction in developers' installation costs out to 2030.

Property losses

The second component of the benefits in our model are the annual falls in the value of property losses arising from a greater number of new homes being sprinklered under the new COP. As discussed above, the average value of property losses from residential fires is $17,200 for unsprinklered homes and $3000 for sprinklered homes.

The value of property losses in new houses in any year is therefore:

Property losses = Number of new homes suffering a fire * [(% of homes sprinklered * $3000) + (% of homes unsprinklered * $17,200)]

We then need to estimate the number of new homes experiencing a fire each year. As mentioned above, BRANZ estimate that the probability of any one home in the housing stock experiencing a fire is 0.004. As the fire risk to the housing stock as a whole is likely to be higher than that for new homes that are constructed with newer materials and methods, we adjust this probability downwards to 0.003. By multiplying this probability by the number of new dwellings to be built from our forecasts, we can estimate the number of new homes having a fire each year.

We assume that the introduction of the COP will increase the proportion of new homes that are sprinklered. We assume that in the absence of the COP, the proportion of new homes being sprinklered is 20%. With the introduction of the COP, we assume this increases to 30%.

Using the formula above and varying the coefficients for the % of homes sprinklered (and thus the % unsprinklered) with and without the COP, we can then work out the difference in property losses that is associated with higher use of sprinklers. This difference is the benefits resulting from the introduction of the COP.

Value of lives saved

We also consider the value of lives saved by additional sprinkler use. As noted above in section 5.3.2, for every 1000 fires in unsprinklered homes, 6 deaths are expected. Given the Ministry of Transport's estimate for the statistical value of life of $2.55 million, we can estimate the costs in terms of deaths from fires each year in unsprinklered homes. A similar exercise can be carried out for the number of sprinklered homes, in which the death rate is far lower at 1.2 deaths per 1000 fires. By increasing the proportion of new houses that are sprinklered after the introduction of the COP (i.e. 20% before its introduction to 30% after its introduction), there will be a drop in the number (and hence statistical value) of deaths from house fires.

The sum of these three benefits over the 2002-2030 timeframe is then converted into a net present value (NPV) figure using a discount rate of 7%.

5.4.4 Results – central scenario

To recap, our central scenario considers a situation in which:

- 40% of new houses are built as in-fill housing.
- 20% of new homes are sprinklered in the absence of the COP.
- 30% of new homes are sprinklered after the introduction of the COP.
- The probability of a new home having a fire is 0.3%.
- The take-up rate for the COP in 2005 is 2% of all new in-fill developments, rising to 20% by 2030.

Our indicative CBA framework suggests that, given these parameters, the NPV of the benefits from 2005-2030 will be in the order of $15 million. The vast majority (87%) of these benefits stem from reduced installation costs for developers. Lower property losses account for around 7% of the benefits, with the saving in the costs of deaths from fires accounting for the remaining 6%.

5.4.5 Results – sensitivity analysis

As there is considerable uncertainty over some of the parameters in this analysis, we also performed a sensitivity analysis around the central scenario by varying some of the key parameters in the model[19]:

- The proportion of new houses that are built as in-fill housing (30% and 50%).
- The take-up rate for the COP in 2005 of all new in-fill developments (5% and 10%)

[19] Note that we also varied the proportion of new houses that might be sprinklered under the COP, but the results were relatively insensitive to this parameter.

- The take-up rate for the COP in 2030 (30% and 40%)

The results from 28 sensitivity analysis scenarios can be seen in Appendix D. They show that the NPV of the net benefits from a wider adoption of the COP range between $12 million and $41 million. The latter figure considers a scenario where 50% of new homes are in-fill developments and the take-up rate of the COP rises from 10% in 2005 to 40% by 2030.

5.4.6 Discussion of results

Our model indicates that a wider adoption of the COP would result in benefits to home owners, developers and to society as a whole. Whilst the benefits are perhaps not as sizeable as might have been initially expected, it should be recognised that – depending on the initial and eventual take-up rates – the annual cost savings are larger as the time period lengthens. That is, as more developers and TLAs become aware of the benefits that can be achieved from adopting the provisions of the COP and the take-up rate lifts, the value of the benefits increase. However, the further into the future are the benefits, the more heavily discounted they are.

Of the various stakeholders that may be affected by the introduction of the COP, under the framework used here, it is the developers who seem likely to experience the most benefits from adopting its provisions. The owners and occupiers of new housing also benefit to a lesser degree. It is more difficult to assess the impact of the COP on local authorities, insurers, the BIA, etc. This is simply because we have little evidence on which to make any judgements at this stage of the COP's development.

Quantifying the potential benefits to the NZFS of the introduction of the COP is also very difficult at this stage. If the COP makes it easier for sprinklers to be placed in new developments, then this aligns well with NZFS objectives on this matter. If the number of serious fires in new homes decreases, as per our model's framework, then the resource cost to NZFS in terms of time spent attending serious fires will decrease. This decrease in resource costs will be non-trivial, but as a proportion of NZFS's overall costs, is likely to be very small. However, given the uncertainties around the model's parameters, placing a monetary value on this resource savings is very problematic.

It has to be recognised that our framework does not consider the cost of fires in the existing housing stock, as the COP focuses on new dwellings. There are an estimated 1.5 million dwellings in the New Zealand housing stock. This compares to around 30,000 new dwellings built in the year to March 2004. As such the proportion of the housing stock to which the COP applies is small. It is perhaps, therefore, not surprising that the benefits are relatively modest at this stage.

6. Conclusions

Our research suggests a number of conclusions:

- To date, there is very little practical experience of how the COP does or would work. In 2004, the public education process was still at an early stage, and for actual examples to be observed required cooperation/coordination between TLAs, developers, insurers, and the NZFS, and strong enough incentives for uptake to occur.
- Initial discussions with TLAs indicate that it will take some time for the new COP to gain traction because, for example, their processes and those of the developers they deal with are currently founded in the previous COP.
- The general level of awareness of the new code from those developers who we contacted was low, ranging from totally unaware of it to only vaguely aware.
- Some of those contacted were of the view that there were too many rules and other guidelines and that the compliance cost in general was getting too high. None were against the idea of sprinklers, but they were more accustomed to their use in apartment or commercial buildings than in free standing dwellings.
- It appears then, that to date the uptake of the new COP has been very low, due to a lack of awareness amongst TLAs and developers and to some confusion from TLAs regarding the precise role of the COP and its relation to other regulations.
- In addition, the COP appears to deliver installation cost savings for developers only in certain developments. Our small survey of developers indicates that for greenfield developments, installation costs could actually be higher under the COP than under old guidelines.
- However, developers indicated that installation cost savings of around $1,333 per dwelling for in-fill housing developments may be achievable under the new COP.
- An indicative cost benefit analysis suggests that if the take-up rate of the COP amongst developers was to increase from 2% of new in-fill houses in 2005 to 20% in 2030, the net present value of benefits arising from the COP's provisions would be around $15 million. This benefit is comprised of reduced property losses due to a larger proportion of the new housing stock being sprinklered, lower installation costs for developers and fewer deaths from house fires. The benefits to developers via lower installation costs account for 87% of the total benefits over this period.
- Unfortunately, a lack of data means that there is some uncertainty about the specification of the cost benefit model. A sensitivity analysis around this central scenario – conducted by varying the key parameters in the cost benefit analysis framework – indicates that the net present value of

benefits could vary between $12 million and $41 million, depending on the initial and eventual take up rates, the proportion of new dwellings that are in-fill housing and the proportion of new homes that are sprinklered.

- Of the various stakeholders that may be affected by the introduction of the COP, under the framework used here, it is the developers who seem likely to experience the most benefits from adopting its provisions. The owners and occupiers of new housing also benefit to a lesser degree.
- It is more difficult to assess the impact of the COP on local authorities, insurers, the BIA and the NZFS. This is simply because we have little evidence on which to make any judgements at this stage of the COP's development.
- Our research into regulatory practice in other countries led us to the view that it is very hard to make comparisons across countries in their approaches to fire-fighting water supplies.
- This is partly because there are wide variations within and between these countries in progress towards, or regulations for, residential fire-sprinklers and fire-fighting in general. The factors shaping these regulations tend to be quite localised.
- Therefore the emphasis given to water supply e.g. as a factor in sprinkler uptake or incentives for uptake thus differs widely, as do regulatory structures and standards for water supplies in general.
- So in some respects, the New Zealand approach i.e. in adopting a quite specific code for fire-fighting water supplies contrasts with most of the approaches we saw in the international literature.
- But, as indicated above, how much difference the new COP makes to water supply practices here, and fire safety, will depends mainly on the trend in awareness of the new code, and its subsequent effects on practices amongst TLAs and housing developers.

7. Recommendations

Our research indicates that that while there are undoubtedly benefits to be gained from the introduction of the COP, and from it being more widely adopted than at present, these benefits will be limited until the COP is more widely understood by the key stakeholders which it could affect. Our recommendations for the NZFS are therefore:

7. That the NZFS makes TLAs – and in particular those in which new housing developments are growing rapidly – more aware of the provisions of the COP and how the COP interacts with existing guidelines and regulations (the Building Act, District Plans, etc). The benefits to the TLAs from promoting the COP need to be more clearly understood.

8. That the NZFS releases some simple explanations of the benefits of the COP's provisions aimed at educating developers. A brochure (updated at regular intervals) containing answers to 'frequently asked questions' about the COP may be one method of doing this, in adddition to information on the NZFS website.

9. That the NZFS interacts with key players in the housing market (i.e. TLAs and developers) to lift awareness of the COP. If the COP is seen to be being used by major residential development firms, then smaller firms are more likely to follow suit.

10. That the indicative cost benefit framework is re-visited when greater amounts of hard data are available and when the parameters can be determined with greater accuracy and confidence.

11. It may make sense to aim for a region by region analysis, rather than a national one. This is because subdivision patterns, prospective new dwelling construction, and planning and consent practices vary widely between TLAs and regions. All these factors have an important bearing on estimated net benefits from the COP.

12. Systems for collecting relevant data should be considered. In particular our research suggested that the configuration of development (i.e. in-fill versus greenfields) may be an important influence on the size of the cost reductions offered by the new COP. But it is very hard to get meaningful data on recent trends let alone forward information in this regard.

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Appendix B: Dwellings forecasts

B.1 Introduction

We have prepared forecasts/projections for March years to 2030 of the number of new dwellings to be constructed. This Appendix outlines our forecasting/projection process.

B.2 Methodology

NZIER currently produces forecasts of the number of consents for new dwellings for a five year period in its *Quarterly Predictions* publication. We have used these for internal consistency between 2005 and 2009, but have assumed that a certain proportion will not be actualised.[20]

Further out, it is difficult to forecast with any degree of accuracy. Rather than use cyclical factors such as interest rates, income, employment, house prices, etc as drivers for our projections, we have instead created a set of demographics-based projections.

As New Zealand's population increases, so too will the demand for new dwellings. We use population projections from Statistics New Zealand to 2030, assuming medium fertility, medium mortality and annual net migration inflows of 5,000. Under these projections, New Zealand's population reaches around 4.7 million by 2030.

The demand for dwellings is also affected by changes in lifestyle/tastes. The number of people per dwelling (PPD) has trended downward constantly since the 1960s. PPD in 1961 was 3.6, which has now lowered to 2.6 in 2002. This is primarily due to more people owning more than one dwelling (holiday homes, etc), and from an ageing population that results in a larger proportion of the population (the elderly) living alone or without family. The shift towards inner city apartment dwelling has also resulted in less people living in each dwelling. We needed to take account of this in our projections.

On a linear trend, PPD would lower to 1.9 by 2028. Leaving it constant at 2.6 was another option. We decided to use an average of the linear trend and holding it constant

[20] That is, the number of consents overstates the amount of new building that will occur, as some consents are not converted into physical buildings. Since 1984, additions to the housing stock have (on average) been lower than the number of consents issued in any year. This reflects both unbuilt consents and the fact that every year some existing houses are scrapped. The average difference between changes to the housing stock and consents issued since 1984 is 0.1% of the housing stock. We assume half of this is due to unbuilt consents, and half is due to scrappage of existing houses.

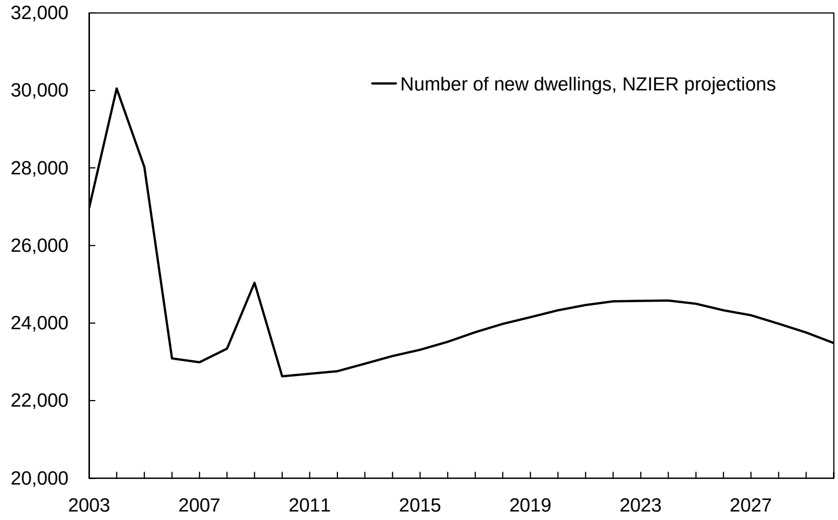
So we have now identified three broad reasons that lead to the construction of new dwellings:

- As the population increases, new dwellings are required.
- As the existing population continue to display preferences for having a lower level of PPD, new dwellings are demanded.
- Old houses become scrapped.

By projecting each of these separately, we came up with a projection for the number of new dwellings demanded to 2030. These projections show demand easing from current levels (around 31,000 in 2005), as population growth is unusually high presently. Over the 2007-2020 period, the number of new dwellings demanded increases gradually, as decreases in PPD more than offset slowing population growth. At the end of the forecast period, population growth slows to just 0.4%. This leads to a slowing in demand for new dwellings to around 23,500 by 2030.

Figure 1 Number of new dwellings

March years



Source: NZIER

Appendix C: City of Scottsdale water ordinance

Following passages have been extracted verbatim from city of Scottsdale (1997, pp15-17).

‘As a result of the staff research and valuable input from the development community, several "design freedoms" were identified. These changes were items which could be inserted into the ordinance, and would help reduce the impact of mandatory sprinkler protection.

In development services, a density increase of 4% for single family communities was initiated. A reduction in residential street width from 32 feet to 28 feet was approved. Cul-de-sac lengths were increased from 600 feet to 2,000 feet. For commercial development, the 360 degree access requirement for fire apparatus was eliminated for fully sprinklered structures. In the building code, the requirement for one hour construction was eliminated for single and multi-family dwellings.

The standards for rated doors separating single family homes from garages was also eliminated. The most substantial impact was in the water resources department. Fire hydrant spacing was increased from 330 feet to 700 feet for sprinklered commercial and multi-family developments and from 600 feet to 1200 feet in fully sprinklered single family home developments. The required fire flow demand for structures was reduced by 50%, and resulted in a typical one step reduction in water main size. These changes also resulted in the ability to provide smaller water storage tanks.

An additional feature included with the water resource issue, was the ability to use reclaimed or "grey water" to provide supplies for the fire protection systems in commercial structures where community potable water systems were inadequate. The Uniform Fire Code had to be amended to require sprinkler protection in all occupancies and revisions were made to the fire flow demands that are located in the appendix.

A closer evaluation related to the impact of the allowable design freedoms has also been completed.

Several comments and concerns were registered by members of the fire protection community relating to the increase of hydrant spacings now 700 feet for commercial and 1200 feet for residential. Concern was expressed that the ability of suppression forces to conduct fire combat operations would be negatively impacted by the changes.

First, it must be remembered the focus for the community fire protection was being changed from traditional or reactive activities, to built-in protection and that these spacings apply only to fully sprinklered residential developments and commercial structures. Actual practical drills indicated, that even with the most dramatic spacing (1200 feet for residential) the longest hose lay would be only 600 feet. When this distance was combined with the large diameter hose which is carried on all apparatus and used for supplying engine companies, the impact was minimal as it related to the time needed for performing the supply line operation and the ability to receive adequate water. The reduction in hydrants also had a positive economic affect in two other areas. An evaluation of the fire hydrant distribution plans indicated a reduction by approximately 1/3 in the total number of hydrants required. This resulted in a savings of $2,000 per hydrant and has contributed to reducing the future, ongoing maintenance costs which the city is required to provide.

The justification for narrower streets and longer cul-de-sacs was related to the risk and possibility of multiple alarm fires occurring in sprinklered structures. It was determined, with the vast majority of fires starting in the protected living areas of a residence (67.5% per NFPA statistics) that the required sprinkler protection would result in smaller, lower impact fire incidents.

The development community is also actively pursuing various methods to develop in the upper desert and foothills regions of the city with minimal impact to the environment. The longer narrower street design resulted in actual dollar savings to the project. This also gave the development community another tool to accomplish their reduced environmental impact goals, without having any measurable or negative impact on fire suppression forces.

A practical evaluation of the one hour construction and compartmentalization building requirements for residential structures was also completed. Several evaluations of one hour construction, indicate this laboratory rating is obtained under optimum testing conditions and often does not translate to actual material or construction practices and real time fire conditions. In real life experience, the theory of one hour compartmentalization is an optimistic assumption that might be effective if people did not move into the structure. Post fire investigations and reports regularly reveal, the required one hour construction components had easily been voided and provided questionable protection. It was recognized that each structure will still receive a measure of compartmentalization with the use of 1/2 inch non-rated gypsum materials.

Actual live testing indicated, when non-rated materials were combined with the proactive protection of working fast response sprinklers, the structure has a better chance of being less impacted by the growth and destruction associated with typical structure fire events.

During the three years it took to identify and develop these economic guidelines, several new projects in the City of Scottsdale were allowed to use the "design freedom" concept to establish and complete their projects. They were the Harbor Point apartment complex, Paseo del Norte nursing facility, and the Boulders residential resort. These test projects identified, that the concept of fully sprinklered facilities could be more cost effective and allowed the fire department more latitude to establish acceptable protective guidelines for projects that presented difficult design challenges.

When the ordinance was ready to be presented to the city council, the primary focus and impact identified not only the life saving factors, but, the economic benefits that could be expected for the approximately 100 square miles of the city still essentially undeveloped.

Estimates for the infrastructure costs were based on the current city master plan and showed that substantial savings were possible. The major impact was projected at $7.5 million in infrastructure savings for the water distribution system.

Additionally, it was anticipated that the sprinkler ordinance would result in the reduction in size or elimination of at least three fire stations at a savings of $6 million in initial capital costs and annual savings of over $1 million. The final determination identified that the cost of requiring this type of comprehensive fire protection was minimal compared to the life safety, emergency resource management, and property conservation results that would be achieved.’

Appendix D: NZ code of practice 2003

D.1 Legal context

"This code of practice is published under section 30(3) of the Fire Service Act 1975. The code of practice is intended to assist the National Commander of the New Zealand Fire Service to carry out the duties specified in section 30(2) of the Act. This code of practice has the status of a guideline but could be incorporated into relevant bylaws under section 146(b) of the Local Government Act 2002 or district plans prepared under the Resource Management Act 1991. It may also be referenced in New Zealand Standards and other Standards. In doing so, the body incorporating the code must make a clear distinction between the obligation on the territorial authority to supply the water and the requirements (if any) placed on third parties to enable the territorial authority to meet that obligation.

Section 92(2) of the Fire Service Act 1975 enables regulations to be made specifying requirements for fire hydrants. However, the National Commander considers that including guidelines on these requirements in this code of practice will be a more cost effective method for achieving appropriate standards through voluntary compliance. Regulations will only be resorted to if the guidelines in this code prove to be ineffective in achieving compliance."

D.2 Application

"This code of practice is for the use of territorial authorities, water supply authorities and the Fire Service to establish the quantity of water required for fire fighting purposes in relation to the fire hazard in premises located in *urban Fire Districts*. It can also be used by developers and property owners to assess the adequacy of the *fire fighting water supply* to new or existing premises.

The code of practice is based on an assessment of the water supplies needed to fight a fire and to limit fire spread. The *fire fighting water supplies* required to address the *fire hazard* may be established by use of simplified tables (see 4.2), or by calculation (see 4.3).

For any premises, this code of practice establishes the minimum *fire fighting water supply* that is required for the *fire hazard*. To comply with this code of practice it must be shown that this minimum supply is designed to be available at all times. If it is not, then either the supply must be increased or the *fire hazard* in the premises must be reduced.

This code of practice provides for minimum flows for fire fighting water supplies. It does not take account of the requirements of other users. If there are other users in the vicinity of the premises, then to comply with this code, it must be shown that all reasonable and appropriate steps have been taken to ensure that their expected usage has been taken into consideration in applying this code.

Although this code of practice has been developed for *urban Fire Districts*, the provision may also be relevant in other areas as a guideline for what is an appropriate water supply for structural fire fighting.

Fire Service personnel giving advice on *fire fighting water supplies* must do so in accordance with the provisions of this code of practice.

For planning purposes, the territorial authority may choose to provide a *fire fighting water supply* in accordance with a water supply classification selected from table 1. Any deficiencies identified for particular premises would have to be remedied by increasing the *fire fighting water supply* or reducing the fire hazard in order to meet the requirements of this code.

Under Regulation 19(5) of the Fire Safety and Evacuation of Buildings Regulations 1992, territorial authorities are required to provide the Fire Service with information on changes of use of a building. This information will allow the Fire Service to reassess the relevant *fire hazard* and to determine the adequacy of the *fire fighting water suppl*y."

Appendix E Sensitivity analysis results

Summary of CBA sensitivity analysis results

Varying in-fill %, initial and final take up rates, and COP sprinkler %

Proportion of new houses that are in-fill	30%	30%	30%	30%	30%	30%	30%	30%
Proportion of new homes sprinklered (BAU)	20%	20%	20%	20%	20%	20%	20%	20%
Proportion of new homes sprinklered (COP)	30%	40%	30%	30%	30%	30%	30%	30%
Probability of home experiencing a fire in a year	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0%
Take-up rates of new COP 2005	2%	2%	5%	10%	2%	2%	5%	10%
Take-up rates of new COP 2030	20%	20%	20%	20%	30%	40%	40%	40%
NPV of benefits	**$11,716,102**	**$13,960,709**	**$13,909,659**	**$17,565,587**	**$15,720,664**	**$19,725,225**	**$21,918,782**	**$25,574,711**

	Central scenario							
Proportion of new houses that are in-fill	40%	40%	40%	40%	40%	40%	40%	40%
Proportion of new homes sprinklered (BAU)	20%	20%	20%	20%	20%	20%	20%	20%
Proportion of new homes sprinklered (COP)	30%	40%	30%	30%	30%	30%	30%	30%
Probability of home experiencing a fire in a year	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%
Take-up rates of new COP 2005	2%	2%	5%	10%	2%	2%	5%	10%
Take-up rates of new COP 2030	20%	20%	20%	20%	30%	40%	40%	40%
NPV of benefits	**$ 14,873,267**	**$17,117,874**	**$17,798,010**	**$22,672,581**	**$20,212,682**	**$25,552,098**	**$28,476,841**	**$33,351,412**

Proportion of new houses that are in-fill	50%	50%	50%	50%	50%	50%	50%	50%
Proportion of new homes sprinklered (BAU)	20%	20%	20%	20%	20%	20%	20%	20%
Proportion of new homes sprinklered (COP)	30%	40%	30%	30%	30%	30%	30%	30%
Probability of home experiencing a fire in a year	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%	0.30%
Take-up rates of new COP 2005	2%	2%	5%	10%	2%	2%	5%	10%
Take-up rates of new COP 2030	20%	20%	20%	20%	30%	40%	40%	40%
NPV of benefits	**$ 18,030,432**	**$20,275,039**	**$21,686,360**	**$27,779,574**	**$24,704,701**	**$31,378,971**	**$35,034,899**	**$41,128,113**