F I N A L R E P O R T

SURREY FIRE SERVICE
HIGH-RISE FIRE SERVICE STUDY
CITY OF SURREY, BRITISH COLUMBIA

PRESENTED BY:

MANITOU INCORPORATED

DECEMBER 2008

FINAL REPORT

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CITY OF SURREY, BRITISH COLUMBIA

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BACKGROUND

The City of Surrey had an estimated population of 452,396 in 2007, with its population expected to increase to over 566,000 by 2016. This growth in population is attributable to a number of factors – Surrey's large inventory of vacant or agricultural land available for development; its proximity to Vancouver, a highly desirable urban place and the most temperate major urban area in Canada; and the ease of commuting along the recently-completed Skytrain, which serves Surrey's Centre.

Surrey plans to achieve this growth in large measure through infill development and increased density in areas of existing infrastructure. As a consequence of this strategy, Surrey expects to see a major increase in the number of high-rise buildings in the City. High-rise buildings are those greater than 75 feet – usually corresponding to more than 7 storeys. A small number of existing high-rise buildings is expected to be supplanted by a comparable number of new, taller high-rises.

Like most fire services with a small number of high-rise buildings, Surrey has developed procedures and dealt with them as a small part of its overall portfolio of risk to be managed. Existing programs, such as the Pre-incident Planning Program (PIP), are exemplary. Surrey has good basic information on these buildings available to responders, and this doubtless has contributed to their readiness to handle a potential high-rise fire.

However, with the increasing number of high-rise buildings, these structures will be a greater part of the Surrey Fire Service operating environment. Taller, newer buildings have more complicated protection systems and this require greater awareness on behalf of the fire service.

The Surrey Fire Service contracted Manitou, Inc. beginning in May 2008 to assist in positioning it to deal it this emerging issue. This process consisted of three phases – a review of incident information in Surrey; a qualitative review of attitudes and perceptions of firefighters of the high-rise fire problem in Surrey; an identification of "gaps" between current practice and recognized and potential challenges; and recommendations to position Surrey to excel in meeting these challenges. Surrey's desire was to adopt a "best practices" stance, rather than merely achieving compliance with industry norms.

Manitou, Inc., a research and analysis consulting firm specializing in fire and homeland security issues, was selected for this assignment for several reasons. First, Manitou uses a novel, data-driven approach to measuring fire risk, and second, Manitou's principal on this project has considerable experience in the study of high-rise fire incidents stretching back into the mid-1980s. Finally, Manitou uses a "systems approach" to addressing problems. In the case of high-rise fires, this approach includes fire suppression, fire and buildings codes and enforcement, and public education/human factors.

Manitou is delivering this report as the culmination of the project, and it includes an itemized list of recommendations that will form the basis for development of an implementation plan to be carried forward by the Surrey Fire Service.

INTRODUCTION: THE HIGH-RISE PROBLEM

High-rise buildings are challenging and complex environments for fire services. From their inception, they posed difficult challenges – time and effort required to ascend to the fire, coordination of occupants on multiple floors, and reliance on building standpipe systems for firefighting. The earlier generation of high-rises used very conservative structural design and had an inherent degree of compartmentation consisting of masonry walls separating offices or tenants.

Newer high-rises utilizing lightweight construction techniques, and glass curtain walls, and incorporating modern innovations such as central air conditioning and the fuel load from electronic and communications equipment, significantly altered fire performance of these structures.

The review was generally confined to North America, although there is a considerable fire record in high-rise buildings around the world. This is by no means intended to be an inclusive or systematic review, but is intended to demonstrate some of the challenges facing fire services in these structures. The vast majority of fires in high-rise buildings escape major media attention, and incidents causing one to two deaths or injuries are not uncommon, and more often than not do not gather national media attention.

High-rise fires are unique in that they challenge many aspects of a fire service's preparation and capability simultaneously. As such, they are notorious for revealing weaknesses and areas for improvement. By studying major incidents, we see the potential that these fires can have on buildings, occupants, and fire services, even in cases where the fire is confined to part of a floor. The reader is referred to the bibliography for a more thorough history of high-rise fires and their challenges.

Selected High-Rise Incidents

<u>First Interstate Bank Building (1988)</u>

The First Interstate Bank building fire occurred in Los Angeles in 1988. The fire started after hours on the 12th floor of the 62-storey building. Fire spread throughout the 12th floor, and spread upward through a combination of autoexposure and penetration of gaps between the floor and curtain wall system. Ultimately, the fire spread up to the 16th floor. After delays of over 14 minutes, a series of activated fire alarm on the 12th floor and other floors were investigated by a maintenance employee. On arrival on the 12th floor, fire conditions prevented his escape. Although he called for help on a radio, other staff were unable to assist him because he had the elevator on “independent service.” He was the only fatality.

The fire ultimately spread to the 16th floor, where it was held by the LAFD. An isolated fire occurred from heated products of combustion on the 27th floor via an HVAC duct. This fire, in a storage closet, burned itself out. Simultaneous fire attack was underway via four interior stairways on as many as four floors. The large number of stairway doors opened contributed to heavy smoke contamination of the stairwells.

The building was undergoing maintenance work on its sprinkler system, and only part of the building was equipped with sprinklers. The system was not operational at the time of the fire, and maintenance personnel were on the scene. Fire pumps were not activated until a sprinkler contractor returned to the scene after being rescued from the roof of the building by a police helicopter. Pressure reducing valves were not set properly and permitted pressures as high as 400 psi to be supplied to handlines, creating a hazard from bursting hoselines. The building is shown in figure 1.

Additional problems were encountered with elevators, in-building communication systems, and overloaded radio frequencies. The Incident Command organization for this fire is shown in figure 2.

A total of 383 fire service personnel responded. Four fire department helicopters operated at the incident, in addition to five people rescued form the roof by police helicopters early in the incident. There were 14 firefighter injuries.

Figure 1 -- First Interstate Bank Building – note fire damage on lower floors (LAFD photo).

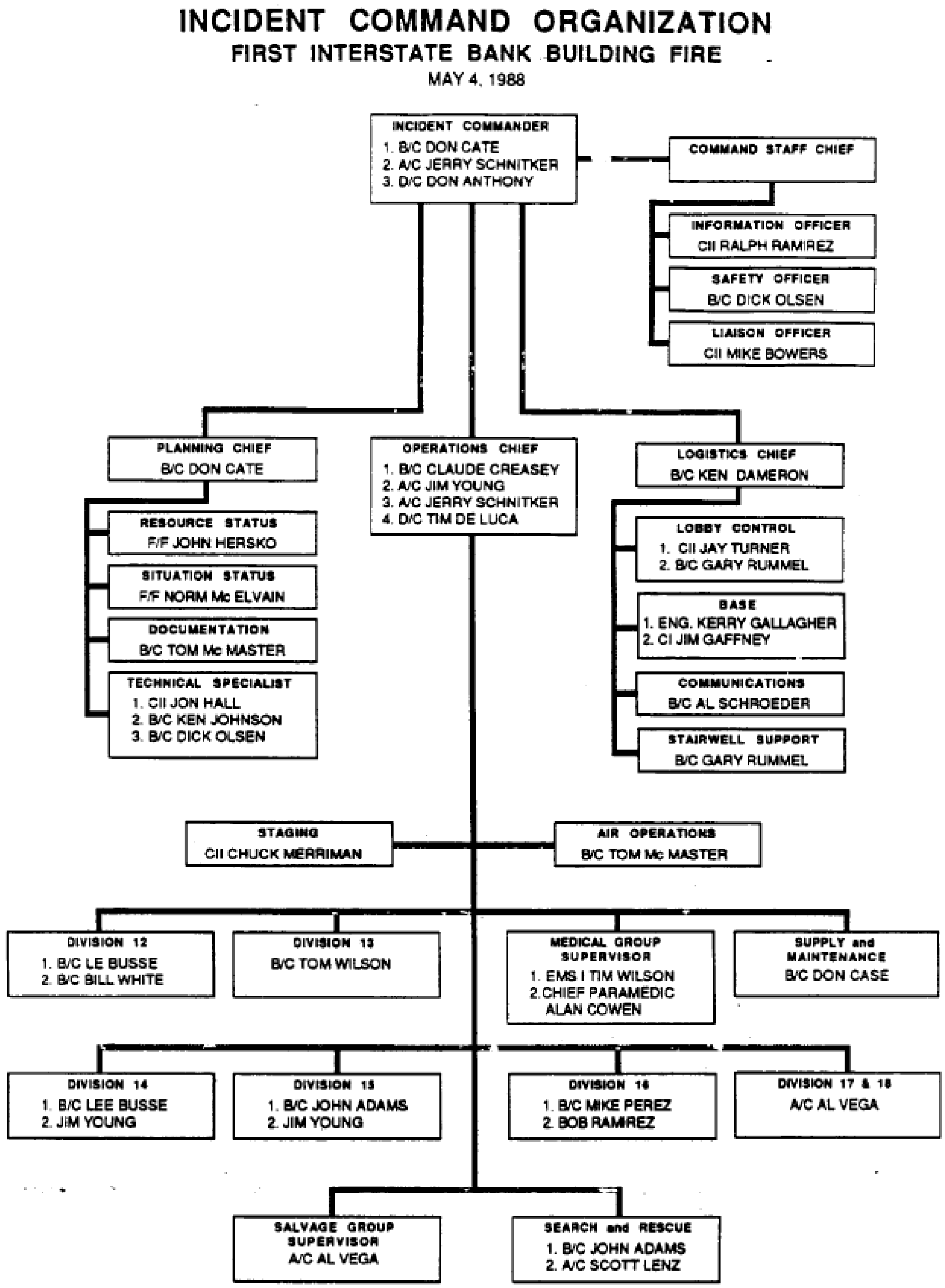


Figure 2 -- Incident Command Organization for First Interstate Bank fire (1988).

5-Fatality Office Building Fire (1989)

The next incident we will review is the Peachtree 25th fire (1989). This fire occurred in a ten-storey office building in Atlanta, GA. An electrical fire originating on the sixth floor killed five people, and injured 23 civilians and six firefighters. One woman had jumped from a sixth floor window prior to the fire department's arrival and was seriously injured. Firefighters removed approximately 14 people over aerial ladders and rescued five others from the interior of the building.

The electric closet where the fire started opened directly onto the exit corridor. When the fire erupted, it immediately blocked the corridor, keeping most victims away from the two exits serving the floor. Fire drills practiced by occupants of the building were credited with the safe evacuation of everyone not on the fire floor. The four people who died did so in offices on the fire floor. Breaking windows was positively correlated with survival in this incident, although there were fatalities in offices where people congregated and broke windows. The fifth fatality was an electrician who was standing at the electrical panel when the arc occurred.

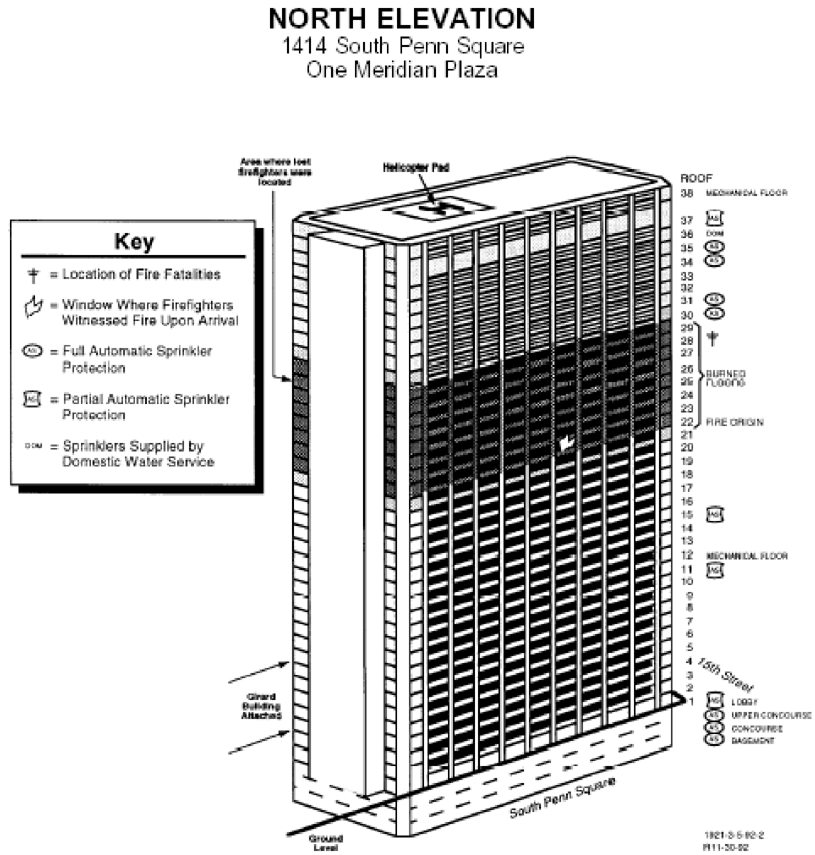
The Atlanta Fire Department received the initial alarm via a manual pull station. An initial assignment of 3 engines, 2 ladders, a medical unit, and battalion chief were dispatched. Shortly thereafter, approximately 20 additional calls were received reporting a serious fire with people trapped. The fire escalated to three alarms in 14 minutes after the first dispatch. Six firefighters were injured. Smoke spread from the 4th to 10th floors, and handlines were advanced on three floors.

Figure 3 -- Peachtree 25th Building (Charles Jennings).

One Meridian Plaza (1991)

The partially-sprinklered 38-story building was struck by fire after hours. Security personnel failed to report an activated smoke detector on the 22nd floor. An employee investigated by riding up in the elevator and was trapped. He was able to be rescued when the elevator was recalled by another building staff member in the lobby. The central station alarm company that services the building delayed sending the alarm until it was verified by building staff. The first report of the fire came from a passerby who reported fire showing from upper story windows.

As the first company was ascending in an elevator, a power failure stranded them. The building's emergency generator failed. As the fire progressed, it was determined that pressure reducing valves had been set at pressures incompatible with the 1.75 inch hose lines equipped with combination fog nozzles. The PRVs were unfamiliar to the fire department, and could not be field adjusted without special tools.



Figures 4 and 5 -- One Meridian Plaza (Charles Jennings, USFA graphic).

Doors locked from the stairwell side required forcible entry, further delaying firefighting. Unable to get adequate pressure to attack the fires, a 5-inch line was hand-laid up the stairway. The fire spread through a combination of autoexposure and via floor penetrations, from the 22nd to the 30th floor over the course of 18-19 hours. It was the largest high-rise fire in US history at the time.

During the fire, an engine company sent to open roof hatches became disoriented when they ran low on air. They transmitted a distress call, and requested permission to break a window to obtain air. The crew reported the wrong location, frustrating efforts to find them. Ultimately, they were located with the assistance of a medevac helicopter that was on scene. The members were removed from the floor before the fire progressed to their location, but the entire crew of three firefighters were dead.

Interior fire operations were ceased after 11 hours, after losing 3 members and facing visible structural damage to the building. Ten sprinkler heads activated on the 31st floor, and stopped the fire from extending. The partial sprinkler system, with supplemental supply from fire service pumpers, was effective.

The building suffered structural damage, with floors sagging, and some exterior façade panels becoming dislodged. Fire hoses were severed by falling glass, which also injured a firefighter. Over 300 firefighters responded to this incident, which also resulted in 24 firefighter injuries. After years of litigation, the building was demolished.

North York, Ontario Apartment Building (1995)

This 1995 fire in a 30-storey residential high-rise caused the deaths of 6 residents. The fire started around 5 a.m. in a sofa in a fifth-floor apartment. When the occupants of the fire apartment discovered the fire, they evacuated, but the door to their unit was left in the open position. A fire alarm activated throughout the building. Smoke spread throughout common areas and into some apartments on upper floors.

Residents who evacuated immediately were successful. The fire breached eventually one of two exit stairways, and the other was rendered ineffective when used for fire attack. No announcements were made on the building PA system until late in the incident, and those announcements may not have been audible due to design or maintenance limitations of the PA system.

Numerous residents, faced with a confirmed fire and ringing alarms, decided to evacuate. Many of these occupants were stranded in smoke. Some pounded on apartment doors of neighbors to gain shelter. Six were overcome by smoke in common areas. Ironically, each unit in the building was equipped with a balcony that could have provided safety for most residents.

Cook County Administration Building (2003)

The Cook County administration building was a 36-floor building containing offices in part of a government complex. The building was not equipped with sprinklers, but had smoke detection that consisted of coverage in common areas and return air ducts. Duct detectors were designed to stop the air handling system and activate the building's fire alarm. The building was a mix of "open plan" and private offices floor by floor. Two stairways were located on opposite sides of the building. One of these stairwells was arranged as a smokeproof tower, with a design that relied on a vertical shaft separating the corridor doorway from the stairwell via a short walkway. A heat-activated louver was intended to open in the event of an elevated temperature at the vestibule or nearby. Stairwell doors were arranged to lock from the stairwell side. A PA system served the entire building, with two-way fire service intercoms located every fifth floor in the stairwells.

Just before 5 p.m. a fire was discovered in a supply closet on the twelfth floor. A smoke detector activated, sounding an alarm. A building engineer went to the 12th floor to investigate using an elevator, stopping 1-2 floors below the reported fire to walk up. He was met by employees from the 12th floor who confirmed a fire. He radioed this information to an employee at the lobby desk and ordered an evacuation of the 9th through 15th floors. He then proceeded up to the 12th floor, and was knocked over by a blast of heat when he opened the stairwell door. He then advised the lobby desk to order a complete building evacuation.

The Chicago Fire Department arrived within five minutes, and began an attack on the fire from the 12th floor. A second alarm was sounded within five minutes of CFD's arrival, and companies were directed to search the 9th through 12th floors.

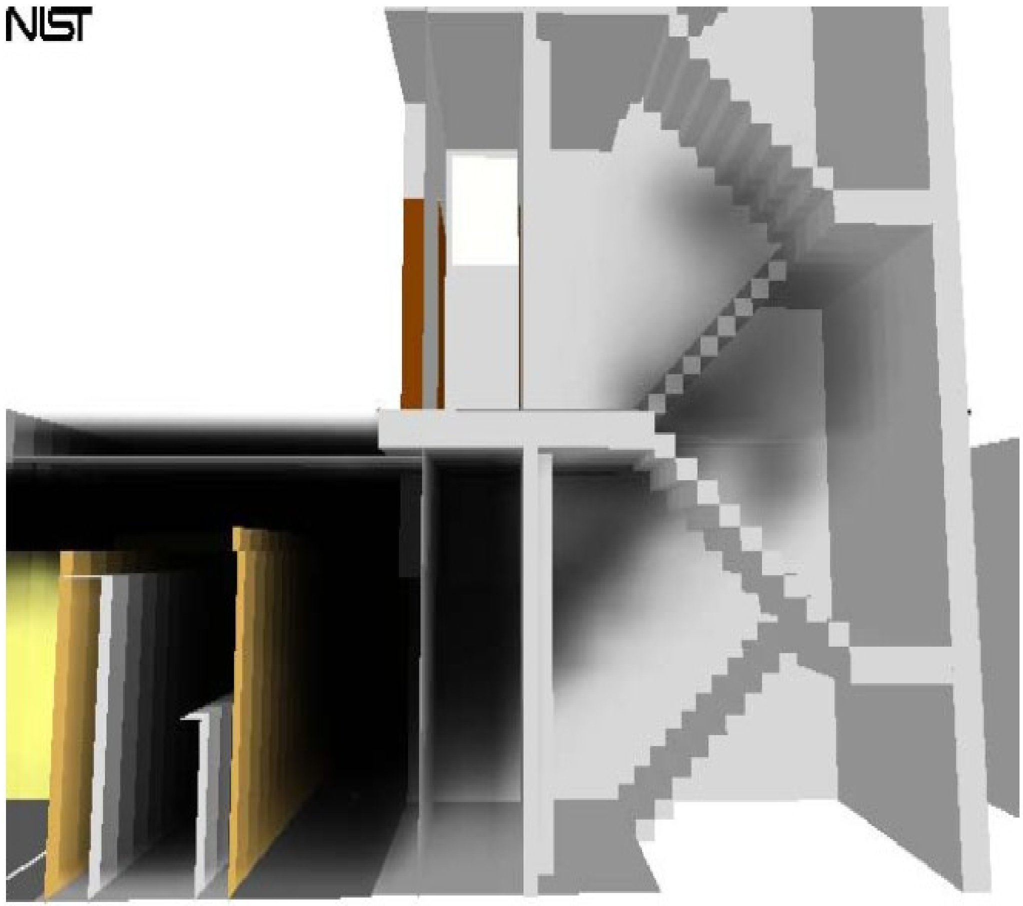


Figure 6a -- Cook County office building schematic showing infiltration of smoke from fire floor to stairwell. (NIST Graphic).

Within an hour, three additional alarms were sounded, and an exterior attack was used via ladder pipe to knock down fire which had extended through a third or more of the 12th floor. After this, companies moved in with handlines to complete extinguishment within 20 minutes of the exterior attack.

Occupants evacuating via the stairs encountered light smoke conditions until the CFD forced the door on the 12th floor to initiate fire attack. Occupants coming down the stairs at that time were not allowed to pass and reportedly told to "go back upstairs." Because stairwell doors were locked, an indeterminate number of people were trapped in smoke and heat-charged stairways above the 12th floor. A 9-1-1 call was received via cell phone from someone requesting assistance in the stair used for fire attack about 12 minutes after the interior attack commenced. Dispatchers told the callers that "help was on the way."

A large group of occupants successfully re-entered an unlocked door on the 27th floor, where they called for assistance via 9-1-1. Firefighters were sent up via the non-attack stairway and removed these people via stairway. Due to limited air supply, firefighters did not search the upper levels of the attack stair. Shortly thereafter a victim was discovered in the attack stair, and a full building search was ordered (about the time the fire was extinguished completely). Thirteen people were found overcome in the attack stair, of which six died.

Lessons Reinforced from Selected High-Rise Incidents

These incidents are a mere sample of the negative outcomes that have been realized in high-rise fires. As is evident, the problem transcends the capabilities of manual fire suppression, and requires simultaneous attention to building features and operations, fire suppression operations and staffing, and occupant behavior.

Life safety systems in high-rise buildings are often compromised during fire events. The reliability record of elevators, stairwell pressurization, standpipe systems, and other equipment is far from flawless. Elevators routinely fail under fire conditions, even when under Phase II operation. Smoke and water infiltration of elevator shafts and maintenance defects can cause cars to stall or be called to the fire floor.[1]

As the Chicago case amply demonstrates, even when an aggressive, well-staffed fire attack is initiated by a large and experienced department, failure to properly understand building features and manage occupants can produce undesired outcomes. “Good enough” isn't good enough to assure the safety of high-rise buildings.

In the next section we turn our attention to the need for a systems approach to high-rise fire safety.

[1]Dunn, Vincent. “Dunn’s Dispatch: Deadly Elevators.” Fire Engineering, December 2007.

SYSTEMS APPROACHES TO THE HIGH-RISE PROBLEM

A system can be conceived of as a larger group of components operating with some degree of interdependence (structure) to achieve some outcome. The rules for a system are thus:[2]

1. A system does something
2. Addition or removal of components changes the system
3. A component is affected by its inclusion in the system
4. Components are perceived to be related in hierarchical structures
5. There are means for control and communication which promote system survival
6. The system has emergent properties, some of which are difficult to predict
7. The system has a boundary
8. Outside the boundary is a system environment which affects the system
9. A system is owned or valued by someone

A system of fire incidence and fire loss in residential structures was developed by Jennings (see Figure 7). One of the contributions of this model is that it shows the distinction between fire initiation and fire loss. Fire initiation is a fire starting – for example through careless cooking. Fire loss is the toll of death, injuries, and dollar loss caused by the fire. We can compare two fires with an identical fire initiation and end up with two totally different fire losses because of a number of mitigating factors. These factors include the building stock (is the fire in a single family dwelling or apartment), and social and demographic variables (numbers of people present, type of housing unit, etc.).

We can use the conceptual model to design interventions to reduce the toll of fires. Public education can be targeted at reduction of incidence (general fire prevention) or reduction of losses (home escape planning), for example.

We can conceive of the high-rise fire problem in the same fashion. Policies or programs can be thought of as interventions in the system that will influence the outcomes in terms of losses from high-rise fires.

For high-rise fires, we will emphasize 3 key components to the system:

1. Building Construction/Code Enforcement
2. Public Education
3. Fire Suppression

Each element MUST be addressed in order to be effective. Any single area in isolation can not achieve success by itself.

We will use this systems conception of the high-rise fire problem to guide us in targeting interventions to reduce the fire problem. We must balance these interventions against the limited resources available to address them, as well as their likelihood of success given regulatory, legal, and technical constraints.

[2] Waring, Alan. Practical Systems Thinking. London: Thomson Learning, reprinted 2003, pp. 25-26.

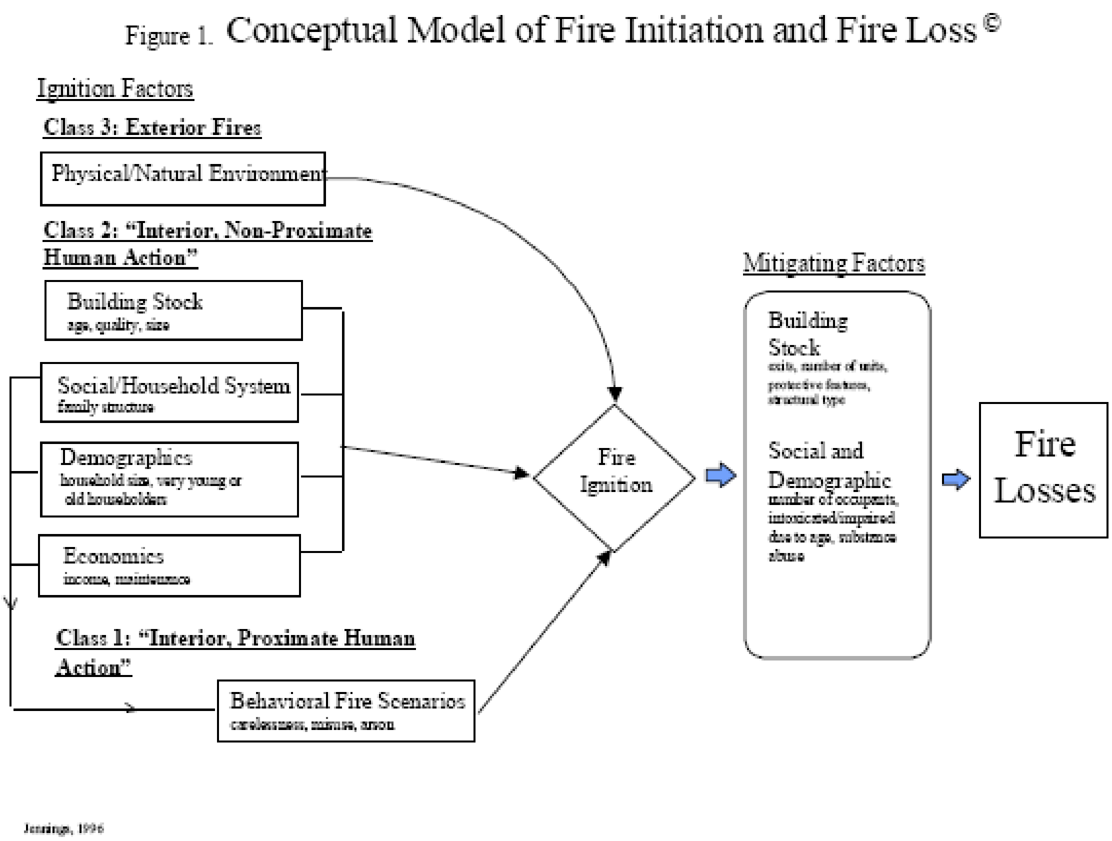


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Figure 7 -- Conceptual model of residential fire initiation and loss.

Given our knowledge of Surrey's high-rise problem, and an understanding of high-rise challenges from North American fire experience, we can identify specific recommendations for addressing vulnerabilities identified through our analysis of the local situation.

SURREY HIGH-RISE FIRE EXPERIENCE

As part of this study, a comprehensive review of incident-related information was used to gather data on Surrey's fire experience in high-rise buildings. This data consisted of incident reports, CAD data, and limited data from Provincial and US sources for comparison purposes. Manitou uses a novel approach to understanding risk in different property types, and we applied this method to Surrey, as will be explained later in this chapter.

Surrey has a relatively small number of high-rise buildings. These buildings are almost entirely residential. A list of current high-rises in Surrey is in the table below. Most high-rises are concentrated in the Whalley and Guildford areas (Figure 8).

Table 1 -- Existing High-Rise Buildings, January 2008, Surrey

Street Name	Street Number	Floors (AG)	Building Name
100	13618	36	INFINITY TOWER B
101	13880	21	ODYSSEY TOWERS
101	13880	1	ODYSSEY TOWERS - CLUB HOUSE
101	15030	16	GUILDFORD MARQUIS
101	15038	16	GUILDFORD MARQUIS
101	15090	8	LEN SHEPHERD MANOR
102	13450	25	CENTRAL CITY TOWER
103A	14881	22	SUN WEST ESTATES
104	13435	17	MAYFLOWER APARTMENT
104	14820	22	CAMELOT
104	15269	22	SHERATON INN GUILDFORD
108	13353	18	CORNERSTONE BLDG 2
108	13383	20	CORNERSTONE BLDG 1
134	10523	16	GRANDVIEW COURT
148	10082	22	STANLEY / GUILDFORD PARK PLACE
151A	10608	13	SANDMAN SUITES
KING GEORGE	9835	16	SURREY VILLAGE HI RISE
KING GEORGE	9850	6	DAYS INN
OLD YALE	13350	21	KUHN HIGH RISE
OLD YALE	13352	8	KUHN LOW RISE
WHALLEY RING	9830	15	BALMORAL COURT
WHALLEY RING	10899	23	OBSERVATORY @ GATEWAY LEN

Surrey's population of high-rise buildings is changing rapidly. As part of its development strategy, the City is encouraging additional high-rise development as a “smart growth” initiative. Generally, these newer high-rise buildings are equipped with sprinklers and other features to make them much less likely to experience a major fire, but their sheer number and increased complexity places demands on the fire services.

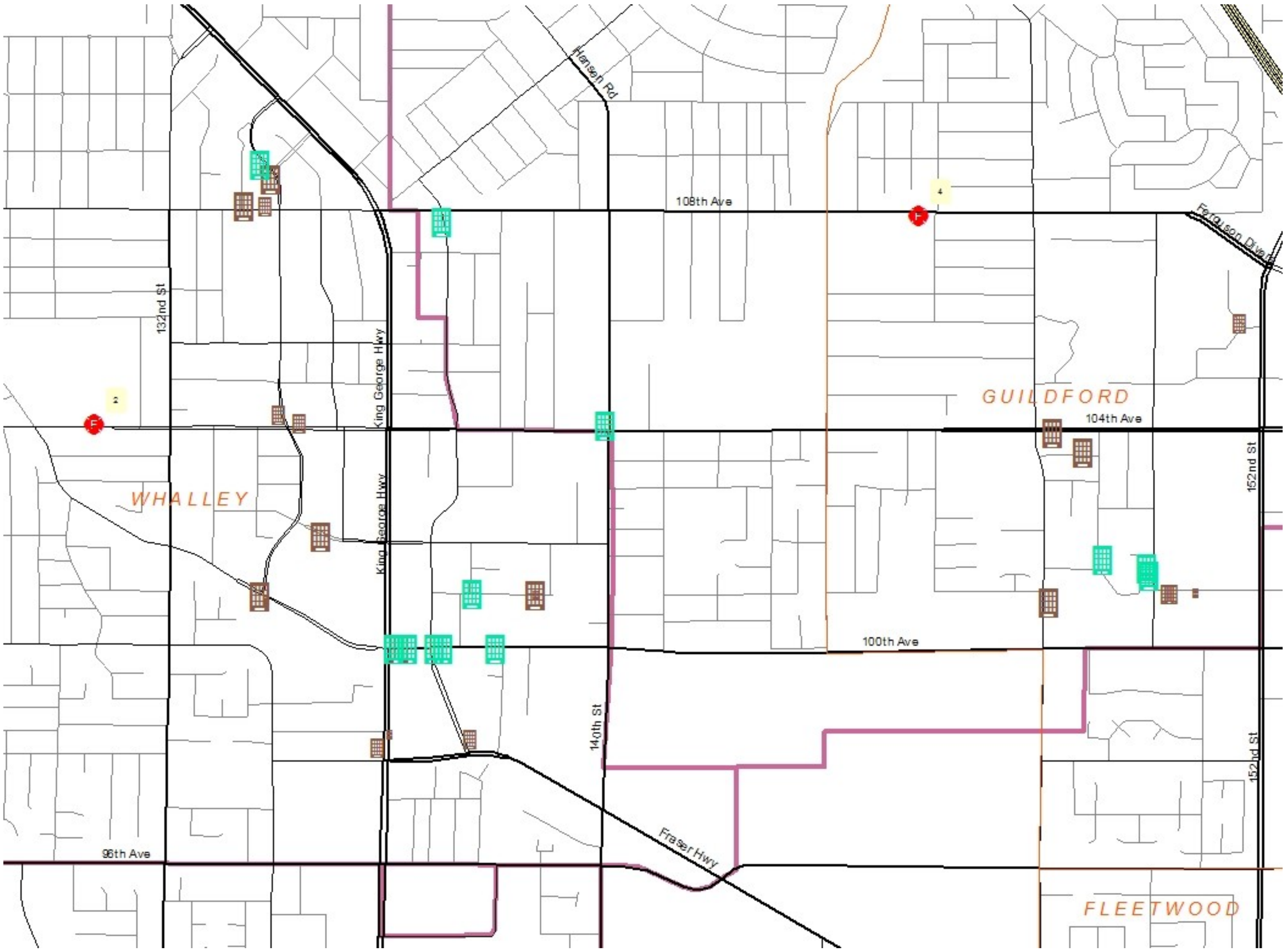

Figure 8 – Concentration of high-rise buildings

High-rise buildings currently make up a small portion of the number of structures and the floor area. The majority of high-rise (81 percent) buildings were built between 1980 and 2000. As shown in the figure above where brown markers represent the existing buildings. There are over 28 proposed high-rise apartments being planned for the Whalley and western Guildford areas in the coming years. Most of the proposals are along 100th Avenue near King George Highway and in Guildford near 150th Street and 100th Avenue.

The City's Department of Planning and Development has identified 18 different locations, ten of which are slated to be double towers. Most of the projects are apartments. This will double the number of structures that current suppression units have to address and require strategies to pull adequate resources together to ensure appropriate cover for these new developments, many of which will be between 25-40 storeys.

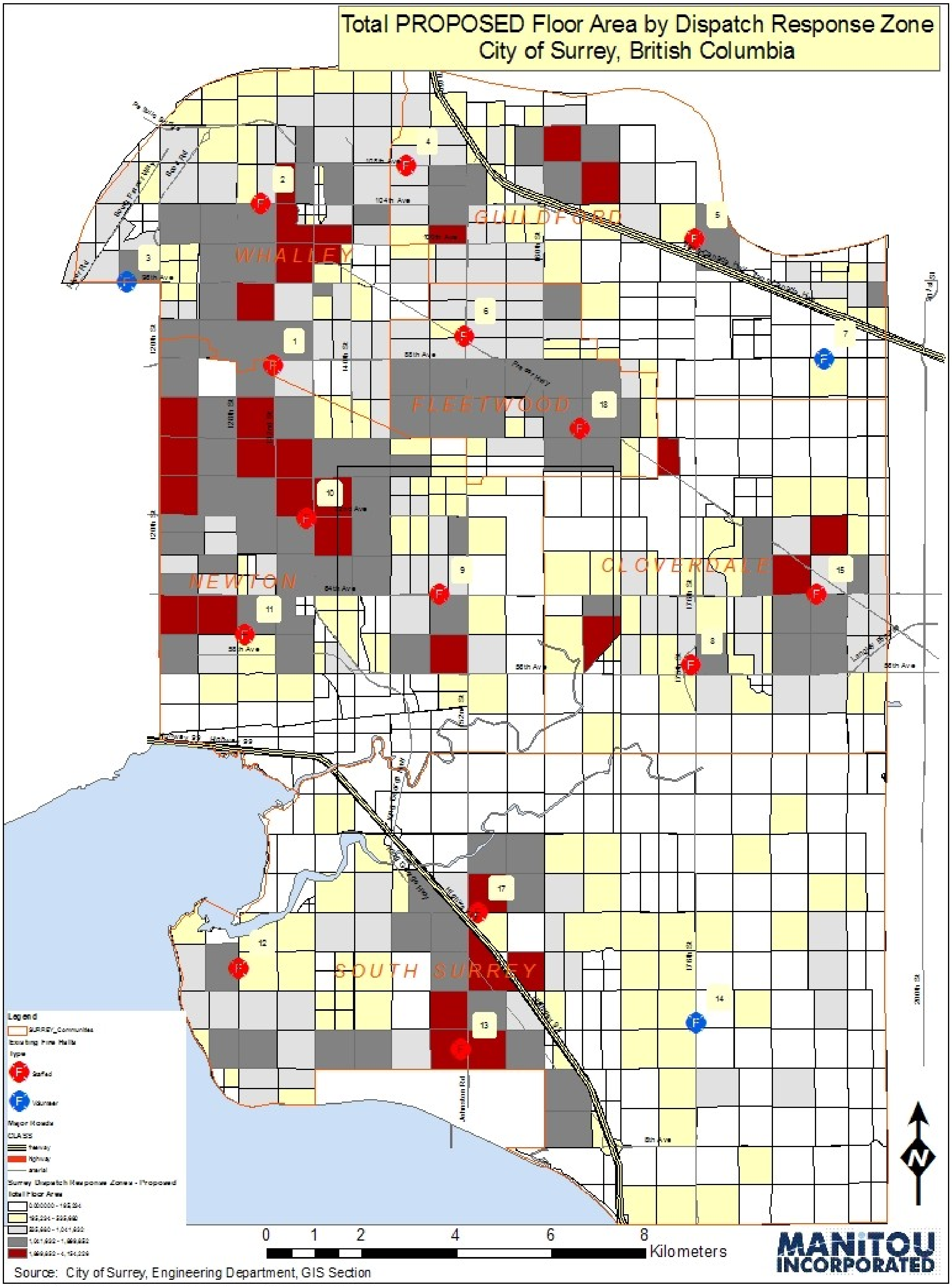

Figure 9 -- Proposed High-rise floor area, City of Surrey.

Fire Incident Data

We began with almost 20 years of incident data. This initial set of incidents numbered in excess of 70,000, which included fires, emergency medical calls, and all other incident types. Because we are interested in structure fires, we removed non-structural fires from the analysis. This left us with 4,758 structure fires over the 1988 (partial) to 2007 time period.

We engaged a process for defining high-rise fires from among this set in a number of steps. In 2004 there was a change in coding schemes for fire incident reports. Consequently, we converted codes post-2004 to the previous code scheme for those data elements used in the analysis.

The detailed process was as follows:

1. Convert codes to be compatible (only for items used in the analysis).
2. Remove incidents with incident types VC, PS, OU (2004-2007)
3. Remove incidents with property use type
    1. Vehicle PT003
    2. Outdoor Area PT006
    3. Waterfront, Wharf PT008
4. Remove Incidents with "General Construction" equals GC009 (Vehicle, outside area) or
5. Remove incidents with property class codes
    1. Outdoor property
    2. Trailer or houseboat
    3. Mine
    4. NA, not in structure
    5. Car park
    6. City park (checked to remove mobile homes and trailers only, outbuildings remained in)
    7. Federal or other park
    8. Campsite (checked to remove mobile homes and trailers only, outbuildings remained in)
6. Removed incidents with "property type" indicating mobile equipment.

As stated, this reduced the data set to 4,758 incidents over a 19.29 year period.[3] Annualized, this represents 247 structure-related fires annually. Of these 4,758 structure fires, 60 were in high-rise buildings. This indicates limited local fire experience in high-rise buildings. There does appear to be a trend toward increasing numbers of fires in high-rise buildings, however (see Figure 11).

Figure 10 -- The New face of "Downtown" Surrey.

[3] The data starts in mid-September 1988 and goes through 2007.

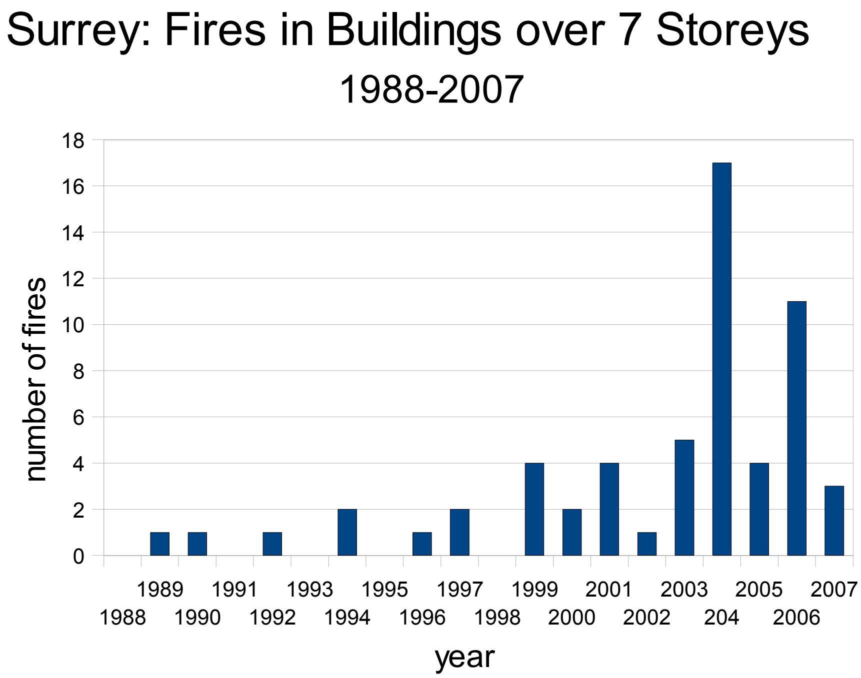

Figure 11 -- High-rise fires per year 1988-2007.

The high-rise fires were mainly in residential occupancies. The remaining fires were in mixed-use, hospital, or parking garages (Table 2).

Table 2 -- High-Rise Fires by Occupancy (Property Use Types (Fires only))

Property Use	Number of Fires (19.26 Years)
Amusement, Recreation Place	1
Hospital	2
Dwelling (311) miscoded, should be Apartment	3
Apartment 3-20 Units with Business	4
Apartment 3-20 Units w/o Business	2
Apartment, > 20 Units	46
Clothing Store	1
Parking Garage	1

It is interesting to contrast high-rise with non-high-rise fires in terms of loss and other characteristics. Over the almost 20 years of data, there were 475 injuries and 33 deaths from 1988 through 2007. This equates to an average of 24.6 injuries and 1.7 deaths annually. High-rise incidents produced 6 of these injuries.

As a means of comparing Surrey's high-rise fire experience with other communities, we obtained data from the British Columbia Office of the Fire Commissioner. This data was restricted to fire incidents in the Province where the reported with a building height greater than 7 storeys.

This data, for 2004-2007, showed a record comparable to the City of Surrey. Losses were limited, with 262 incidents producing a total of 17 injuries and 2 deaths. The number of fires in a year ranged from 34 to 75. Of course, the OFC data does not include all incidents, but should be useful in the aggregate for drawing comparisons.

Table 3 -- BC High-rise data 2004-2007

Year	Number of Fires	Property Loss ($1,000)	Contents Loss ($1,000)	Total Loss ($1,000)	Injuries	Fatalities	Injuries per fire	Casualties per fire
2004	75	2087.2	1366.7	3453.8	1	0	0.01	0.01
2005	34	1660.7	1275.2	2935.9	9	2	0.26	0.32
2006	47	1052.4	220.4	1272.8	6	0	0.13	0.13
2007	90	2214.2	1238.2	3452.4	1	0	0.01	0.01
Totals	262	7059.4	4122.7	11182.0	17	2	0.06	0.07
Loss per Incident		$26944	$15735	$42680	0.06	0.01		

A study by the United States Fire Administration found that high-rise fires in the United States had an overall rate of casualties (injuries plus deaths) of 0.07,[4] which agrees very closely with British Columbia data (Table 4).

Table 4 -- Casualties per fire: US, BC, and Surrey

	Fires	Injuries	Deaths	Casualties per fire
Surrey	59	6	0	0.1
BC	262	17	2	0.07
US	na			0.07

Surrey's data is consistent with that, but also it is slightly higher at 0.1 casualties per incident. One possible explanation for this finding is that Surrey's population of high-rise buildings is almost exclusively residential, which was shown to have casualty rates which were higher than office occupancies. Of course, because of the small number of incidents, 1-2 injuries could place Surrey well above or below data based on a much larger sample of incidents.

We then examine the differences between the high-rise and non-high-rise fire experience in Surrey. Comparing differences between high-rise and non-high-rise buildings can be useful for better understanding the effectiveness of code interventions as well as identifying the characteristics of the existing high-rise population.

The first measure we look at is the date of last inspection. This element gives a window on the

4 U.S. Fire Administration. Topical Fire Report Series High-Rise Fires. Volume 2 Issue 18, January 2002.

relationship between inspection frequency and the incidence of fire. High-rise buildings are inspected annually, and this is largely born out by the data showing that high-rise buildings show a much greater likelihood of being inspected than the general population of buildings (which includes single family dwellings, which would not be subject to inspection.

Table 5 -- Date of Last Inspection v. Building Type

Last Inspected	Non-High-rise	High-rise	Percent Non-High-Rise	Percent High-rise
Blank	1429	35	30.4%	59.3%
Cannot Be Determined	214	4	4.6%	6.8%
Less than 30 Days Prior	46	3	1.0%	5.1%
31 to 60 Days	50	1	1.1%	1.7%
61 to 90 Days	73	2	1.6%	3.4%
91 to 180 Days	101	2	2.1%	3.4%
6 to 12 Months	191	3	4.1%	5.1%
13 to 24 Months	161	3	3.4%	5.1%
25 to 36 Months	37	1	0.8%	1.7%
Over 36 Months	18	0	0.4%	0.0%
Not Applicable	2379	5	50.6%	8.5%
Total	4699	59		

This data element was not used from 2004 on, and has a great deal of missing (blank) values across the previous years.

The next element examined was casualties, which was defined as the sum of injuries and deaths per incident. The greatest number of injuries in a high-rise incident was 1, versus 6 for non-high-rise fires. The incidence of injuries is approximately the same for fires in both types of buildings, however (Table 6).

Table 6 -- Casualties by Incident and Building Type

Casualty	Non-HR	High-Rise	Total
0	4285	53	4338
1	352	6	358
2	46		46
3	9		9
4	5		5
5	1		1
6	1		1
Total	4699	59	4758

Another factor of interest is the role of detection and suppression systems in fires. We expect that high-rise buildings would have a higher rate of having working fire detection or suppression systems. We begin with smoke detectors (Table 7). Most tellingly, there were no smoke detectors installed in 5 percent of high-rise incidents, versus 30 percent for non-high-rise buildings. Overall, smoke detectors activated in 64 percent of high-rise fires, as opposed to 17 percent of non-high-rise buildings. This reflects the code compliance that exists for high-rise buildings.

Interestingly, smoke detectors sounded, but occupants were unable to react in 28 percent of high-rise incidents, versus less than one percent in the non-high-rise buildings. This may be explained by the presence of smoke detectors in high-rise occupancies including hospitals, but also indicates that vulnerable populations may be more likely to be found in high-rise buildings. This has some important implications for pre-emergency planning and incident response, and is worthy of further exploration. The "alarm activated" unknown cause is lower in high-rise buildings, which indicates that maintenance of these systems is good, when compared to the entire population of buildings.

Table 7 -- Smoke Detection Status by Building Type

Smoke Detection	Non-HR	High-Rise	Total incidents	Percent of Non-HR	Percent of High-Rise
No SD installed	1429	3	1432	30.4%	5.1%
Alarm activated – assisted occupants	575	16	591	12.2%	27.1%
Alarm activated -- inaudible	14		14	0.3%	0.0%
Alarm activated – occupants unable to respond	26	17	43	0.6%	28.8%
Alarm activated – unnecessary to evacuate	115	4	119	2.4%	6.8%
Alarm activated – occupant action unknown	70	1	71	1.5%	1.7%
Alarm not activated, unsuitable location	127	2	129	2.7%	3.4%
Alarm not activated – no or dead battery	67		67	1.4%	0.0%
Alarm Not activated – no AC power	62	1	63	1.3%	1.7%
Unclassified	12		12	0.3%	0.0%
Alarm Not Activated – unknown cause	215	1	216	4.6%	1.7%
NA	396	1	397	8.4%	1.7%
SD099	1231	9	1240	26.2%	15.3%
Alarm Not Activated – unknown cause	360	4	364	7.7%	6.8%
Total	4699	59	4758		

We next examine sprinkler protection in high-rise and non-high-rise buildings. As expected, high-rise buildings are much more likely to have sprinkler systems installed (Table 8). Over 60 percent of high-rise buildings had complete sprinkler systems installed, versus less than 4 percent of the non-high-rise buildings.

Table 8 -- Sprinkler Protection by Building Type

Sprinkler Protection	Non-High-rise	High-rise	Percent Non-High-rise	Percent High-rise
Undetermined	126		2.7%	0%
Complete Spkr., Supervised	175	32	3.7%	54.2%
Complete Spkr., Alarm to FD	57	4	1.2%	6.8%
Complete Spkr., unsupervised	47		1.0%	0%
Partial Spkr, supervised	27	4	0.6%	6.8%
Partial Spkr, Alarm to FD	14	3	0.3%	5.1%
Partial Spkr, unsupervised	59	2	1.3%	3.4%
No Sprinklers	4028	14	85.7%	23.7%
NA	162		3.4%	0%
unclassified	4		0.1%	0%
Total	4699	59	4758	

When considering casualties and sprinklers, for high-rise buildings, two-thirds of the casualties occurred in buildings with no sprinklers. In non-high-rise buildings, 95 percent of casualties occurred in unsprinklered buildings. This suggests that in high-rise buildings, the larger numbers of people present creates an opportunity for injuries even when sprinklers are installed.

Finally, we look at the extent of flame damage. This measure is valuable because it can be measured fairly unequivocally, and is a good measure of the severity of a fire, independent of cost or casualties. Ideally, the extent of flame damage would be measured on arrival of fire services and after extinguishment. This would pose a challenge, but would be possible.

In this table (Table 9), we should look at the percentages cumulatively, to see the percentage of incidents that are at or below a specified threshold. The most commonly used threshold is the percentage of fires contained to the room of origin. For non-high-rise buildings, this was 51.6 percent of all fires. For high-rise buildings, it was 81.3 percent. This high degree of fire containment may be attributable to the compartmentation present in residential high-rises. Four high-rise fires were shown to have extended beyond the building of origin, which is questionable. This could indicate a possible error in completing the incident reports.

Table 9 -- Fire extension by building type

Fire Extension	Non-High-rise	High-rise	Percent Non-High-rise	Percent High-rise
Can not be determined	77	0	1.6%	0.0%
Confined to object of origin	707	16	15.0%	27.1%
Confined to part of room of origin	1018	22	21.7%	37.3%
Confined to room of origin	701	10	14.9%	16.9%
Confined to floor of origin	489	5	10.4%	8.5%
Confined to Building of origin	1414	2	30.1%	3.4%
Extended beyond building of origin	214	4	4.6%	6.8%
Confined to Roof	22	0	0.5%	0.0%
Not applicable	23	0	0.5%	0.0%
Undetermined	34	0	0.7%	0.0%
Total	4699	59		

The method of extinguishment is an important measure, and is closely tied to the workload and staffing demands necessary for high-rise fires. Using incident report information, we compared the method of extinguishment in non-high-rise and high-rise buildings. A hoseline (either from fire service apparatus or a standpipe system) was used to extinguish two-thirds of non-high-rise fires, versus 27 percent of high-rise fires. Interestingly, when sprinklers are examined, we see that 40 percent of high-rise fires were extinguished by sprinklers, versus only 1.3 percent of fires in non-high-rises. When the hoselines and sprinklers are added, the percentages of fires extinguished by water (either hoseline or sprinkler system) for both building types is equal (Table 10).

Table 10 -- Extinguishment Method by Building Type

	Non-High-rise	High-rise	Percent Non-High-rise	Percent High-rise
undetermined	279	2	5.9%	3.4%
Hand Extinguishers	445	5	9.5%	8.5%
Standpipe Hoseline	39	1	0.8%	1.7%
Makeshift Means	477	4	10.2%	6.8%
Fire Service Water Application	3087	15	65.7%	25.4%
Fire Service Other than Water	7	0	0.1%	0.0%
Sprinklers	62	24	1.3%	40.7%
Fixed Systems other than sprinklers	7	0	0.1%	0.0%
Burned out	137	0	2.9%	0.0%
Miscellaneous	159	8	3.4%	13.6%
Total	4699	59		

To get more detail on hoselines used, we looked at the hoseline and nozzle information reported (Table 11). Only one high-rise fire is shown as being extinguished by a standpipe line using supplied 1.5 inch hose with a smooth bore nozzle. For fire service hoselines, the most common method was a one inch or less hoseline, essentially tied with the combination of either 1.5 and 2.5 inch hoselines, or more than two hoselines. For high-rise fires, the most common hoselines used were two 1.5 or 1.75 inch lines. The second most common hoseline for high-rise fires was reported as a one inch or smaller hoseline, which appears to contradict the equipment carried by the Surrey Fire Service.

Table 11 -- Hoseline Used by Building Type

	Non-High-rise	High-rise	Percent Non-High-rise	Percent High-rise
Standpipe				
1.5 inch hose, smooth bore	14	0	2.7%	0.0%
1.5 inch hose, combination nozzle	16	1	3.1%	20.0%
2.5 inch hose, smooth bore	6	0	1.2%	0.0%
2.5 inch combination nozzle	2	0	0.4%	0.0%
standpipe hose, other	1	0	0.2%	0.0%
Fire service hoseline				
one inch or less	131	1	25.4%	20.0%
one 1.5 or 1.75 inch line	58	0	11.2%	0.0%
two 1.5 or 1.75 inch lines	98	2	19.0%	40.0%
one 2.5 or 3-inch hoseline	1	0	0.2%	0.0%
two 2.5 or 3-inch hoselines	14	0	2.7%	0.0%
combinations of hoselines	129	0	25.0%	0.0%
master stream device	4	0	0.8%	0.0%
other fire service water	42	1	8.1%	20.0%
Total	516	5		

“Other fire service water” was used in 20 percent of high-rise fires, versus only 8 percent in non-high-rises, but this was based on only one high-rise fire.

As we can see, high-rise buildings are distinct in terms of their life safety performance and protective systems installed. Given the similar injury rates for both high-rise and non-high-rise fires, it is clear that enhanced requirements for systems are appropriate given the larger numbers of people at risk, and the challenges fire services face in terms of delayed access to fires and the difficulties of relaying on building equipment.

Fire Incidence and Probability

We sought to determine the incidence rates for fires in different types of structures. To accomplish this, it was not enough to have incident reports. We needed to have information on the numbers and size of buildings in the City. With data provided by the Long-range Planning Section of the Department of Planning and Development, we were able to obtain counts for buildings by type and square footage within the City.[5]

For determining probability of fire by type of building, “unclassified, and cannot be determined” fires were included in the overall incidence of fires, but were not included in any particular category of building use. Because of the large numbers of buildings involved, it was felt that the effect would be minimal, especially since it would not be appropriate to distribute the “other” category across all of the existing uses.

The 4758 fires divided by 93,954 structures in the City's records yields a fire incidence rate of 0.0026 fires per building annually, or 2.6 fires per 1,000 structures per year. Fires can also be thought of as a “380-year event” for the “average” structure. While interesting, these aggregate numbers do not have much power for use in policy *in isolation*. By monitoring these numbers and how they change over time, they can provide a useful indicator of where the fire problem is most prevalent in the City.

The following three tables (Tables 12, 13, and 14) present information on the incidence of fires by building and by square footage for the City. Although they are presented as “2007” data, in reality, more precise estimates could be obtained by matching building counts with fires on a narrower time frame. As presented, there is probably some undercounting of incidence, because of the rapid growth in numbers of buildings over the duration of the fire incidence data. By the same token, choosing too small a time frame would cause the numbers to fluctuate excessively from observation to observation. In short, the current precision is fine for our purposes.

5 This is the third time that such estimates have been prepared on a citywide basis.

Table 12 -- Fires per Building Type and Square Footage, Surrey 2007

Use Categories	Sq. Footage	Fires	Buildings	Fires/Bldg/ Year	Fires/10,000 Sq Ft/Year
Assembly	189823	52	18	0.15	0.142
Education	7906546	116	170	0.04	0.008
Farm	15187276	65	586	0.01	0.002
Government/Institutional	2230326	16	115	0.01	0.004
Health Related	1139200	11	7	0.08	0.005
Industrial/Utility	34450171	215	1807	0.01	0.003
Office	4919845	25	201	0.01	0.003
Retail/hotel	23001657	1241	1830	0.04	0.028
Residential	289481666	2757	89220	0	0.005

Table 13 -- Fires per Building and Square Footage – Residential v. Non-Residential

Use Category	Sq. Footage	Fires	Buildings	Fires/Bldg/ Year	Fires/10,000 Sq Ft/Year
Non-residential	89019476	2001	4734	0.02	0.012
Residential	289481666	2757	89220	0	0.005

Table 14 -- Fires per Building and Square Footage – Residential Breakdown

Residential Breakdown	Fires	Buildings	Fires/Bldg/ Year	Sq. Feet	Fires/10,000 Sq Ft/Year
1 and 2 family	2042	81729	0.001	219829033	0.005
Townhouse	312	6935	0.002	104224376	0.002
Apartments (all)	403	555	0.038	102323680	0.002
Apartments High-rise*	54	12	0.234	1,776,289	0.016

RECOMMENDATIONS

Based on an analysis of Surrey's existing situation, and the planned development of additional high-rises, we offer the following recommendations. Each recommendation is referenced so that an implementation schedule can be developed. The recommendations are divided according to functional area of the Surrey Fire Service. As we have indicated, the recommendations should be pursued as a "system" -- they will not work in isolation.

DISPATCH AND INCIDENT COMMUNICATIONS

Dispatch is the critical beginning of any high-rise fire response. The normal functions of dispatch take on added significance because of the large size and complex layout of buildings; the likelihood of multiple callers, and sometimes conflicting information. At the other extreme, some major office building fires were first reported by people outside the building, or by automatic alarm systems.

Determining the appropriate response is important, because of delays in getting personnel and equipment to the upper floors of the building, sending too few resources can leave crews playing "catch up" on an advancing fire situation.

Figure 12 -- Modern automatic alarm systems can be a vital source of initial information on high-rise incidents.

The Surrey Fire Service recently procured and implemented a new Computer Aided Dispatch (CAD) system. This system permits tailoring of standard alarm assignments to specific addresses. With the Department's existing pre-plan information, dispatching can be adjusted to reflect the unique vulnerabilities of different buildings. We recommend that sprinkler systems be used to distinguish between buildings. There was some discussion of residential (compartmented) versus office (open plan) as the decision criteria, but sprinklers have been demonstrated to be effective in high-rise buildings of both commercial and residential type, while significant fires have developed in unsprinklered buildings of both residential and commercial use.

The best argument against increasing the numbers of resources sent on an initial alarm would be if the existing workloads were so high that the added responses would result in actual emergencies receiving reduced service. A review of citywide utilization rates for fire companies does not indicate that this is a concern now or in the near future. Surrey currently dispatches one engine on automatic alarms and two engines and one aerial on reported fires in high-rise buildings.[6]

Given the well-established high-rise fire record and the potential for major incidents demanding excess resources, we recommend increasing the initial alarm levels for high-rise buildings as follows in Tables 15 and 16:

Table 15 -- Recommended Alarm Response: Sprinklered High-Rise

	Engines	Aerial	Chief	Support
Automatic Alarm	1	1		
Reported Structure Fire	3	1	Battalion Chief	
Confirmed Fire	2		Staff Chief	Rehab Unit, Communications Van

Table 16 -- Recommended Alarm Response: Unsprinklered High-Rise

	Engines	Aerial	Chief	Support
Automatic Alarm	2	1		
Reported Structure Fire	3	2	Battalion Chief	
Confirmed Fire	2		Staff Chief	Rehab Unit, Communications Van

Initial alarm assignments -- The thrust of these changes is that two companies will be sent to any possible fire incident in a high-rise building. For automatic alarms in unsprinklered buildings, two pumping appliances and one aerial device are dispatched. This recognizes the possibility of a working fire, and allows for establishment of a water supply for the initial engine crew who would go to the fire floor.

For a full response to a reported structural fire, a sprinklered building would get three engines and one aerial device. An unsprinklered building would add an additional aerial device to provide staffing for additional rescue or occupant control tasks or possible deployment of an aerial device.

In addition, in the case of a "confirmed" working fire (multiple calls, smoke or fire showing from exterior, or units on scene) a second alarm would be struck immediately. In addition to the two engines now sent on a second alarm, a staff chief should respond, along with the rehab unit and

[6] O.G. 2.05.04 Incident Response and Alarm Levels.

communications van. These resources are necessary in the event that the incident does escalate, and if it does not, it places needed relief crews and command support on the scene more quickly.

Develop procedure for large numbers of calls -- The dispatch facility should also develop a policy and procedure to document and relay communications between the dispatchers and incident command staff. In a sustained incident, it is likely that multiple calls will be received requesting direction or reporting people requesting assistance. Some of these calls may even come from third parties and relatives of people in the building.

Documentation of people requesting assistance is important to establish. Uncertainties in relaying information from occupants of the building has been implicated in numerous incidents.

Staffing – The dispatch facility reports that they can usually dedicate one person to handle a working incident. However, additional dispatch-trained staff would be necessary. Provisions should be formalized to track dispatch-trained on-duty firefighters who might be brought in to supplement staff until off-duty personnel can arrive. In a major incident, these resources may not be available, however.

Review and expand pre-arrival instructions for occupants of high-rise buildings – The CAD system should be relied upon for details of the buildings (height, protective systems in place, special occupancy, etc.). This should reduce some of the current questions asked which are not necessary. In their place, more directed questions should be asked. Building on the existing system for "shelter in place" buildings, a set of clear instructions should be developed for advising occupants in the early stages of an incident, but also for soliciting information that may be useful to responders. Such information may include:

- Callers location in building.
- Do they hear alarms?
- What is on fire?
- Is there smoke or flame in their floor/unit?
- Have they attempted to evacuate?
- Do they see smoke or flames from their window?
- Can they remain in their location comfortably?

FIRE SUPPRESSION

Fire suppression usually receives the most attention in the high-rise fire problem. Basic issues such as hoseline selection, staffing, and operational procedures are critical to the outcome of fire incidents. However, time after time it has been demonstrated that a fire suppression response, even when large, can not guarantee life safety in a high-rise environment.

During our meetings with the Steering Committee, the use of Class A foam as a high-rise extinguishing agent was raised. While there is some discussion of this possibility in the literature, there is presently not a reliable way to deliver the proper foam solution in a high-rise because of the complications of working through a standpipe or combination sprinkler/standpipe system. At present the most reliable method for generating foam would be to use a manual educator positioned at the standpipe valve. We do not see the benefits gained as being worthwhile given the demands this would place on initial attack crews.

Figure 13 -- High-rise fires require the fire services to depend on building systems.

Standardize hose loads – The standpipe pack should be standardized across the City. At present there is some variation between companies. Additional suggestions to accomplish this are given in the paragraphs that follow.

Nozzles – It is beyond the scope of this report to specify nozzles for use in standpipe applications. However, a review of currently available nozzles was undertaken with an eye toward identifying characteristics of a desirable nozzle for high-rise standpipe pack usage. Because Surrey has buildings with standpipe systems operating at low (65 psi) and high (100 psi) pressures, a single nozzle solution requires careful consideration.

Examples of nozzles that have received good reviews include the Vindicator Heavy Attack by 1st Strike technologies, and dual pressure automatic nozzles (Dual Force) by Task Force tips and Akron Brass. Smooth bore nozzles can also be included as part of this package.

Fire and environmental conditions can also require adaptation and variance of standard operating guidelines. It is the objective to anticipate all credible contingencies during the planning stage, but an understanding of the underlying dynamics of high-rise buildings under fire conditions is essential to be effective in achieving desired outcomes – fire extinguishment and protection of occupants.

Hoselines – The minimum hoseline size to be used for high-rise buildings should be 1.75 inches. There will be fire conditions in which a larger line is entirely appropriate. Depending on conditions, crews should feel empowered to elect to use a larger diameter attack line. Selecting a hoseline size is a balance between effort required to place the line in service and the needed fire flow. The most important thing is for crews to understand the importance of flow versus pressure, and to routinely stage a larger line for quick deployment should the initial attack be ineffective or a large body of fire is encountered.

There is an emerging consensus that all hoselines of a given diameter are not equal. Kinking, friction loss, and weight all play a role. However, these concerns are generally of a "second-order" importance, and will be deferred as an "important" rather than an "essential." Some fire department testing results are available on the web, but it is difficult to unconditionally endorse any particular findings because of possible inconsistencies in test procedure and lack of outside verification.

Other hoseline appliances -- Consideration should be given to equipping standpipe lines with in-line pressure gauges. This will be critical to understanding appropriate nozzle selection, and potential issues with fire flows delivered during an incident.

Evaluate large-flow portable light weight device for use inside high-rise buildings -- The Department should test and procure portable, lightweight, high-flow master stream devices capable of being deployed on upper floors of a high-rise building. Develop procedure for staging this device and an appropriate length of 2.5 inch hose on working fires.[7]

In the case of a well-developed fire and/or impaired water supply, this device could potentially be supplied by two 2.5 inch outlets to develop an effective stream even under reduced pressure scenarios.

Figure 14 -- Surrey's pilot standpipe pack relies on 1.75 inch hoseline with combination nozzle. Removal of nozzle tip creates a smooth bore pattern.

Develop a standard high-rise 2.5 inch hose package to be brought in on any working fire response – this pack should include the necessary lengths of hose, appliances, nozzles and related equipment necessary to place a line in service from the standpipe system. It is expected that the hose would be made up as needed, while the nozzles and related equipment would be packed in a "kit" to be carried

7 The Task Force Tips, inc. *Blitzfire* is an example of such a device. It can deliver up to 500 gpm and is designed to be operated by 1-2 people in close quarters. It has a safety valve that will interrupt flow in the event the device moves suddenly or becomes elevated.

upward.

Develop strategically-placed caches of equipment to be deployed on a suspected "working" high-rise fire – The specialized equipment described in this section is not something that will be used everyday. A limited amount of ready-made kits could be assembled and strategically located such that a full assignment anywhere in the City would see this equipment on scene.

Develop a citywide high-rise familiarization training program -- all personnel need exposure to refresher training on topics to include 1) overview of high-rise fire problems; 2) standpipe evolutions and water supply issues; 3) occupant behavior; 4) fire protection systems; 5) elevators; 6) wind-driven fires and PPV; 7) systems approach to high-rise fire problems and company role.

Command Support – (see dispatch section) -- an additional chief officer and the communications vehicle responding at the early stages of an incident should provide much smoother operations and allow for more timely implementation of accountability systems. They will also free the initial responding Battalion Chief to mange the incident and leave supporting functions and activities to the next arriving chief officer.

Helicopter operations -- Helicopters have been shown to be valuable tools for the fire service at high-rise fires. Some jurisdictions with their own helicopter fleets have elaborate operational guidelines for roof rescue and for depositing firefighters on the roof of a building to initiate operations above a fire. Los Angeles City, for example, requires new high-rise buildings to have helicopter landing facilities.

In Surrey a surveillance function is probably the most valuable function to be provided by a helicopter (RCMP). Helicopters, due to media reports and dramatic portrayals, often lead people to evacuate upward during a fire, which is contrary to advice in most places. In fact, numerous deaths have been documented among people ascending through smoke-filled stairwells only to reach a rooftop door locked for security purposes.[8]

A policy should be developed to utilize this asset, with these caveats in mind. The greatest "regular" use of a helicopter would be to conduct surveillance of a high-rise, identifying people in distress, fire progress, and possibly using a PA system to address occupants. A protocol should be developed that would call for the helicopter to respond on request and 1) establish a common operating frequency that will permit direct communication with the incident command post; 2) develop a protocol for conducting a systematic perimeter survey of the building, using the number of storeys from the roof as a means to establish whereabouts of items of interest.

Provisions could be made for a command officer to be picked up and to ride in the helicopter, but this is probably not feasible in the early stages of an incident. If the helicopter is equipped with video downlink capabilities, arrangements for getting access to these transmissions in real time should be pursued, either through equipment in the Communication Van, or through use of RCMP equipment.

CODES AND ENFORCEMENT

Codes and enforcement are crucial to the management of the high-rise fire problem. Not only must proper codes be implemented, but they must be enforced. The BC Fire Code, in Division B, section 3.2.6, sets out special requirements for high-rise buildings. The Provincial structure for codes is such that local amendments must be approved by the Province. Effectively, this creates a "mini-max" code situation, in which localities are restricted from enacting code provisions that are responsive to their

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[8] The World Trade Center 1993 and 2001, as well as North York, ON (1995) come to mind.

unique challenges.

Faced with this challenge, fire services may enact local by-laws, provided that they can be structured in such a way as to not interfere with Provincial code requirements. The Surrey Fire Service has been proactive and creative in this regard, and this trend should be encouraged. Some of these recommendations will require the approval of Provincial authorities, but are thought to be achieveable.

Exercise and establish time standards for relay of alarms from high-rise buildings monitored – Operators of central station alarm services should be subject to periodic testing to verify that alarms are being transmitted to the fire services in a timely fashion.

Consider local bylaw to require retrofit of PA systems into existing high-rise buildings – We understand that all existing high-rise buildings are equipped with one-way public address capability. This feature should be expanded retroactively to two-way capability for unsprinklered buildings with alarms that do not permit staged evacuation. This two-way PA capability could be accomplished through call boxes placed in stairwells (at regular intervals) and elevator lobbies. This PA system is separate and distinct from the fire service intercom systems. Appropriate signage must be installed in buildings without 24-hour lobby staff to provide guidance on system usage. Los Angeles City and Chicago both have this requirement, and supporting materials are included in the attachments.

Elevator issues – Standardize keys for Phase I recall and Phase II (Firemen's service). This could be done through a local by-law. We also understand that this may be a provision of the future Canadian elevator code. Standardizing elevator keys (for Phase I and II operation (not for hoistway doors)) will simplify operations and allow personnel to carry their own elevator keys. This reduces reliance on building supplies, and allows multiple personnel to take control of elevators as necessary during fires or other emergencies such as EMS incidents.

Continue to pursue video monitoring of common areas – the use of video monitoring of common areas enabling real-time viewing by fire services is an excellent means of supporting awareness of conditions on upper storeys of a high-rise building. Our understanding is that these images would not be recorded. The addition of such a rich source of data points to need for command support, so that these video feeds can be viewed consistently. For larger buildings, it may be difficult to maintain watch over multiple cameras due to human or equipment limitations. Some consideration should be given to establishing a replay capability, perhaps through a digital recorder that would recycle on a set interval (30 minutes).

Self-certification -- The Surrey Fire Services have moved to a system where building owners are required to retain a professional party to do acceptance testing of fire protection systems. This is a wise move, consistent with practice in large jurisdictions. However, the fire service needs to verify the diligence of these companies, and should therefore do periodic checks of inspections to confirm that equipment is in working order.

A disadvantage of a private, third-party certification system is that fire services personnel may not have the opportunity to observe these systems under construction, or during acceptance testing. The SFS should require notification of acceptance testing, and this information should be relayed to local fire companies, who may attend and witness the testing. This could be a valuable learning opportunity for personnel, and would likely improve confidence in the systems as they go on-line.

Develop standardized method for reporting of fire protection deficiencies discovered during routine operations in high-rise buildings – Although personnel in Surrey appear to be conscientious, past incidents in other locations have shown that defects and equipment that may be out of service are not always brought to the attention of code enforcement personnel. Fire companies have an opportunity to observe fire protection features during routine activity such as EMS calls and automatic alarms. A formal process should be developed to document deficiencies such as fire alarms in trouble, elevators malfunctioning, or damaged standpipe valves.

Pressure reducing valves (PRVs) – PRVs and other pressure regulating devices have been identified as possible impediments to establishing needed fire flows in some major high-rise losses. There are several recommendations relating to these devices.

a. Specify that only field-adjustable valves be used in Surrey. We understand that this is possible in the development review process. Having the ability to manually adjust valve settings can be crucial. Appropriate documentation and any specialized tools should be kept at the FCAC, and instructions noted in pre-fire plans. Only one type of valve should be used within a building or project.

Figure 15 -- PRVs should be marked with the pressure settings and documentation should be kept on site.

b. We understand that pre-fire plans are being amended to show a profile of the building with notations for pressure settings on the standpipe system.

c. Pressure settings should be marked on PRVs so that companies will not have to rely on memory. A semi-permanent marking could be used and applied by installers or testing agencies.

d. A documentation package should be developed for each installation including 1) instructions for setting pressures; 2) acceptance testing and certification data.

e. Review existing code requirements and plan review practices to minimize the use of PRVs. Procedures for partially opening standpipe valves may need to be introduced in cases where high outlet pressures may be encountered.

Develop stairway and vertical shaft designations – Each stairway and vertical shaft should have a unique alphabetic designation. These designations should appear on pre-plans, evacuation diagrams, and on each level of the stairways themselves on both the inside (stair side) and outside (tenant side). Model stairway signage designation is included in the supplemental material.

Develop "model" announcements for PA systems – Public address systems are critical to control of building occupants. The PA system should be a regular part of operations in high-rise buildings.

Figure 16 -- Older, non-sprinklered residential high-rise.

SUGGESTED TEXT FOR RESIDENTIAL BUILDINGS PUBLIC ADDRESS ANNOUNCEMENTS ATTENTION PLEASE, (pause 5 seconds) ATTENTION PLEASE, THIS IS THE SURREY FIRE SERVICE. WE ARE INVESTIGATING a) ___________ ON THE ___ FLOOR. IF YOU OBSERVE SMOKE OR FIRE ON YOUR FLOOR, PLEASE EVACUATE BY STAIRWAY b) _______. ALL OTHERS SHOULD REMAIN IN PLACE AND STAND BY FOR FURTHER INSTRUCTIONS. ELEVATORS ARE OUT OF SERVICE. a) – activated smoke detector, report of smoke, report of fire b) – designated evacuation stairway FOLLOW UP ANNOUNCEMENT (no problem) ATTENTION PLEASE . . . THIS IS THE SURREY FIRE SERVICE. THE ALARM ON THE ___ FLOOR WAS CAUSED BY ____. THERE IS NO EMERGENCY, PLEASE RETURN TO YOUR NORMAL OPERATIONS. THE FIRE SERVICES WILL BE LEAVING THE BUILDING SHORTLY. ELEVATORS WILL RETURN TO SERVICE SOON. THANK YOU FOR YOUR COOPERATION. FOLLOW UP ANNOUNCEMENT (stable problem) ATTENTION PLEASE . . . THIS IS THE SURREY FIRE SERVICE. WE HAVE A c) ______ ON THE ____ FLOOR. WE ARE INVESTIGATING. THERE IS NO NEED TO EVACUATE AT THIS TIME. STANDY BY FOR MORE ANNOUNCEMENTS. FOLLOW UP ANNOUNCEMENT (unstable problem) ATTENTION PLEASE . . . THIS IS THE SURREY FIRE SERVICE. WE HAVE A c) ______ ON THE ____ FLOOR. WE ARE CONTROLLING THE SITUATION NOW. RESIDNETS OF THE ____ FLOOR SHOULD REMAIN IN THEIR UNITS. RESIDENTS OF THE ___ FLOORS SHOULD STAND BY FOR POSSIBLE EVACUATION VIA STAIRWAY ____. STANDY BY FOR MORE ANNOUNCEMENTS.

Table 17 – Suggested PA Announcements

For buildings with selective notification, the announcements would be tailored to the floors hearing an audible alarm, and the whole building. A less specific announcement should be given for the entire building.

For office buildings, the City currently requires full evacuation. While this is appropriate for selective notification alarm systems, we believe it is unworkable in the long term for full-building evacuations. Based on local decisions, an announcement should be developed using the residential model.

Pre-plans need to be expanded – They should integrate information on building systems, shelter-in-place, and appropriate recommendations for public address announcements. Much of this is already in progress.

Require minimum qualifications for a responsible party required to be on scene for certain high-rise buildings – At present the code-defined position of Fire Safety Director* is an administrative title with mostly record-keeping responsibilities. Leading organizations have moved to require a competent person be on site and be knowledgeable of both the building and fire protection features and capable of supporting the fire service. New York, Seattle, San Francisco, and Los Angeles all require an examination and presence of a competent person on-site under various circumstances of occupancy. The Surrey Fire Service should explore the possibility of enacting such a requirement through the Provincial Fire Code.

PUBLIC EDUCATION

Public education for occupants and residents of high-rise buildings is a challenge. While the code rightfully places the primary burden on property management, the fire services should provide assistance in the form of periodic presentations, development of model materials and guidelines, and monitoring compliance.

Fire experience shows that the public must be included as their behaviour is critical to the success of any intervention. Despite popular perceptions to the contrary, the public can and should receive honest, timely information about the hazards they face in advance of an incident as well as instruction during an event.

The provision of information to building occupants reinforces confidence in the systems in place, and alleviates the cumulative weakening of attention paid to building alarms and warnings. This effect, called the False Alarm Effect, appears to be an apt description of occupant response to repeated false alarms. When occupants receive no or incomplete information, they *assume* that any alarms are false and lose confidence in the system.[9]

The public must be educated on high-rise building fire safety and protocols – Separate programs should be developed for residential and non-residential high-rise buildings. These programs should be capable of being adapted by building management to suit their particular building. A challenge is to keep this material broad enough that each building can work from a common starting point.

This task can be facilitated by developing a building by building matrix of protective systems, 1) sprinkler; 2) zoned alarm; 3) PA capability. Develop corresponding messages to be delivered as education for the occupants.

Make policy on mixed use buildings – A preferred sequence of operation for fire alarm, evacuation/relocation protocols and occupant education should be developed for complex, mixed-use projects that are becoming more common in the City. Consistency of these sequences should be maintained, and they should be available on-site for reference by responding companies. Programmable fire alarms raise the possibility that an error during system maintenance could alter the desired sequence of operation.

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[9] Jennings, Charles. “High-rise office building evacuation planning: human factors versus “cutting edge” research. *Journal of Applied Fire Science,* vol. 4, no. 4, 1995.

TRAINING FOR SURREY FIRE SERVICE

Training occupies a critical position in translating the preceding recommendations into effective action. Only if personnel are familiar with and proficient in the policies, procedures, and techniques implied in the other recommendations will they be effective. Training can not be done in some of these areas until internal questions are resolved and formal procedures are developed. In other areas, general familiarity and information is the goal, and efforts to begin training can begin immediately.

Some items under this section would probably fall across multiple divisions of the Surrey Fire Services, and thus should be shared responsibilities.

High-rise familiarization – there is a need for department-wide refresher training in high-rise firefighting to include: 1) fire protection systems; 2) philosophy of occupant movement and control; 3) fire and smoke behavior.

ICS for high-rise -- Specialized training in incident command systems for high-rise buildings should be undertaken. This training could be combined with training on a revised high-rise guideline. This training should also include use of public address systems.

Training in standpipe systems, PRVs, and hydraulics. – This training should ideally include demonstrations of PRVs installed in the City, and should be documented for sharing by personnel throughout the Department. Consideration should be given to procuring or developing a mock-up that can be used in demonstrations.

Positive pressure ventilation for high-rise fires – This training would be developed based on study and adaptation of recent research on PPV use in the high-rise environment published by the US-based National Institute for Standards and Technology. This report is included in the supplementary materials.

Exercises -- Conduct an operational exercise in a nearly-completed high-rise building to test procedures and assess staffing requirements for high-rise operations. These exercises should involve neighboring fire services as observers, as a means to gain better familiarity and reinforce working relationships.

Work with allied agencies on high-rise table-top exercises – planning should be initiated with BC Ambulance and the RCMP on incident command at high-rise incidents. An understanding of needs and issues likely to arise at a significant fire event should be reviewed. This planning activity should also include non-fire emergencies including violent, terrorist, or other criminal scenarios in a high-rise building.

MUTUAL AID AND COMMON OPERATING PROCEDURES

Fire experience in high-rise buildings clearly demonstrates the potential for utilizing large numbers of personnel to mitigate the incident. While Surrey maintains a relatively large on-duty personnel strength, this number is not sufficient to handle a conceivable well-developed high-rise fire in an unsprinklered building, or a fire in which the sprinklers system was not effective.

Mutual aid is not commonly used by the Surrey Fire Service, and there is a perception that some of its neighboring departments do not have sufficient resources to offer much assistance.

However, the regional dispatching arrangements in greater Vancouver offer the basis for readily mobilizing resources should they be required. A higher degree of communications interoperability exists in the Vancouver region than in many areas. This should be leveraged to facilitate a more robust mutual aid system.

Figure 17 -- E-Comm Radio System can facilitate mutual aid

Recommendation -- Surrey should conduct interoperability planning and exercises with neighboring as well as regional assets. Ideally, a regional plan to extend the existing mutual aid agreement should be developed. Given the nature of threats to communities, the potential for sustained incidents, and seismic risk in the area, mutual aid should be advanced on a regional basis so that large-scale incidents can be dealt with effectively.

An example high-rise guideline from the metropolitan Washington, DC fire departments is included. This guideline unites multiple agencies and ensures a common incident approach at major incidents.

CONCLUSIONS

No amount of preparation can guarantee absolute safety in a high-rise building, or any other setting. The Surrey Fire Service has chosen to step forward and embrace the challenge of a burgeoning number of high-rise buildings. While these new buildings are equipped with numerous fire safety features, there is no room for complacency – existing buildings, particularly those without sprinklers, zoned evacuation capability, and in-building communication systems, pose a real threat. Human error, mechanical failure, and natural or man-made disaster also threaten high-rise buildings.

The systems approach advocated in this report can form the basis for addressing this situation and ensuring an improved level of safety in all high-rise buildings for both the public and responders. By moving forward on recommendations in each of these areas, the likelihood of a major event is decreased, and the ability of the Surrey Fire Services to handle an incident is improved.

As indicated previously – a sustained effort should be undertaken to achieve these goals and to see that the gains made are maintained.

BIBLIOGRAPHY

Bush, Reade and J. Gordon Routley. *Operational Considerations for High-rise Firefighting*. Emmitsburg, Md.: US Fire Administration Technical Report Series TR-082.

DeVries, David. “Chicago Office High-Rise Fire: Lessons Learned” American Society of Safety Engineers 2005 Professional Development Conference, Session 605.

Dunn, Vincent. “Dunn’s Dispatch: Deadly Elevators” Fire Engineering, December 2007.

Fire Investigation Summary: North York Residential High-Rise January 6, 1995. NFPA Fire Investigations Department.

Jennings, Charles. "High-Rise Office Building Evacuation Planning: Human Factors versus "Cutting Edge" Technologies." *Journal of Applied Fire Science*, Vol. 4, no. 4. Reprinted in DeCicco, Paul. Ed. *Evacuation from Fires.* (Applied Fire Science in Transition Series, volume 2). Amityville, N.Y.:Baywood Press, 2001.

Jennings, Charles. “Five Fatality High-rise Office Building Fire -- Atlanta, GA. Report 033 in United States Fire Administration Technical Report Series, 1989.

Madrzykowski, D. and W. D. Walton. *Cook County Administration Buildnig Fire, 69 West Washington, Chicago, Illinois, October 17, 2003: Heat Release Rates Experiments and FDS Simulations.* NIST Special Publication SP-1021, July 2004.

Routley, J. Gordon, Charles Jennings, and Mark Chubb. "Highrise Office Building Fire, One Meridian Plaza, Philadelphia, Pennsylvania, February 1991." Report 049 in United States Fire Administration Technical Report Series, 1993.

Shin, Paul H.B. “Evacuation Training Called a Key Factor in Survival.” New York *Daily News.* September 20, 2001. Online at http://www.nydailynews.com/archives/news/2001/09/20/2001-09-20_evacuation_training_called_a.html

U.S. Fire Administration. Topical Fire Report Series *High-Rise Fires*. Volume 2 Issue 18, January 2002.

Waring, Alan. *Practical Systems Thinking*. London: Thomson Learning, reprinted 2003.

APPENDICES

High-Rise Operations

Incident Management

FIRESCOPE – FIRESCOPE, the California-based incident command organization, remains highly active in refining high-rise incident command procedures and policies. A copy of its high-rise guide, reflecting revisions through 2007, is included on the reference CD. It also has detailed position guides for high-rise ICS functions. For further information, please go to . . .

http://www.firescope.org/working-groups/high-rise/working-high-rise.htm

Another reference of interest is the National Fire Service Incident Management System *Model Procedures Guide for High-Rise Firefighting.*

Positive Pressure Ventilation

Recent testing has resulted in some definitive guidance for use of positive pressure ventilation (PPV) for high-rise environments. This guidance, contained in a report included for reference purposes, suggests that PPV fans can be deployed on upper storeys of high-rise buildings to pressurize stairways.

Figure A1 -- NIST testing of PPV in high-rise environments.

Wind-Driven Fires

NIST has also recently completed preliminary testing on the subject of wind-driven fires. These are high-rise fires in which a prevailing wind pushes combustion products back into the fire compartment. Depending on the intensity of the winds and the timing of fire attack, these incidents have caused serious injuries and deaths to firefighters, and created conditions on the fire floor that exceed the extinguishing capability of hoselines.

Working with the New York City Fire Department, the use of a flame-resistant blanket lowered from an upper storey to obstruct the window has been investigated. Initial results appear promising. The report is currently in preparation. This is a development that should be carefully monitored.

Figure A2 -- NIST Testing of Wind-driven fires.

Code Approaches from Leading Agencies

Code excerpts from leading agencies are included in the supplementary material. This material includes information from Phoenix, Las Vegas, Los Angeles, San Francisco, Seattle, Chicago, and other jurisdictions.

Emerging Code Approaches

Video Monitoring

The Surrey Fire Service submitted a proposal to national building code officials to consider adding video monitoring of elevator lobbies for fire service use during emergencies. This is a progressive step, and deserves serious consideration.

Coincidentally, the National Fire Protection Association's High-Rise Building Safety Advisory

Committee (HRB-SAC)[10] has recommended video monitoring of stairwells at the Fire Command Station, as a means to enable the incident commander to have real-time awareness of conditions in stairwells and the flow of occupants from upper storeys of a building. The proposal has not been incorporated into any NFPA standards at this time.

Its recommendation and a technical committee response is reproduced here verbatim, for reference purposes.

The following quote is from the compilation of recommendations made available to other NFPA committees in mid-2006.

"13 (b) Closed Circuit Television.
Affected NFPA TC's should consider the use of closed circuit television in exit stairs and elevator lobbies to provide real time situational awareness for emergency responders, for immediate assessment during and after the incident and for further research regarding occupant behavior. The system should provide for back-up data off site during emergency incidents and have information available for emergency responders in real time. HRB-SAC is requesting input on this subject from NFPA's Technical Committees.HRB-SAC specifically requests that threshold conditions under which such systems are to be used be established, and that design, installation, operational and maintenance criteria be developed. This proposal is partially in response to recommendations #13, #14 and #15 of NIST's World Trade Center Disaster study. *(Jan 06* ballot)"

Committee Meeting Action: Reject

Committee Statement: Information gathering on occupant movement is not substantiated for inclusion as a Code mandate. Cameras are impractical and invasive from a normal operations standpoint. The presence of cameras and monitoring equipment for other than security purposes might lead to a false sense of security. The threshold of 4000 persons might capture non-high rise buildings with multiple exits such that no egress route is used for an extended period of time.

It is the author's opinion that video monitoring can be a great benefit to maintaining situation awareness in a high-rise environment. The fire record has amply demonstrated the usefulness of such systems, and the market for video systems as a component of building security will render such debates moot in the next 5-10 years, as fire and security systems begin to merge.

Methodology for Spatial Analysis

Manitou has developed a unique method for exploiting the potential for utilizing large municipal data sets for analysis of socioeconomic and building stock dimensions of the fire problem. Using GIS software and database analysis, we "joined" Surrey Fire Services data with Growth and Development data from the City of Surrey Department of Planning and Development (see Figure A3).

[10]This Committee provides review, assistance and recommendations to NFPA technical committees, and to other activities within the NFPA system, on the very broad range of subjects that encompass the tall building environment. This includes, but is not limited to: reviewing and developing proposals/comments on NFPA documents; studying external information to assist with determining its relevance to an NFPA program or committee project; referring pertinent information to the Public Education Division for their consideration; recommending research activities for consideration by the FPRF; and providing implementation or other advice related to recommendations of the NIST-WTC investigation. The NFPA Standards Council will assign the membership and scope of this committee and the committee shall provide an annual report to the Council of its activities.

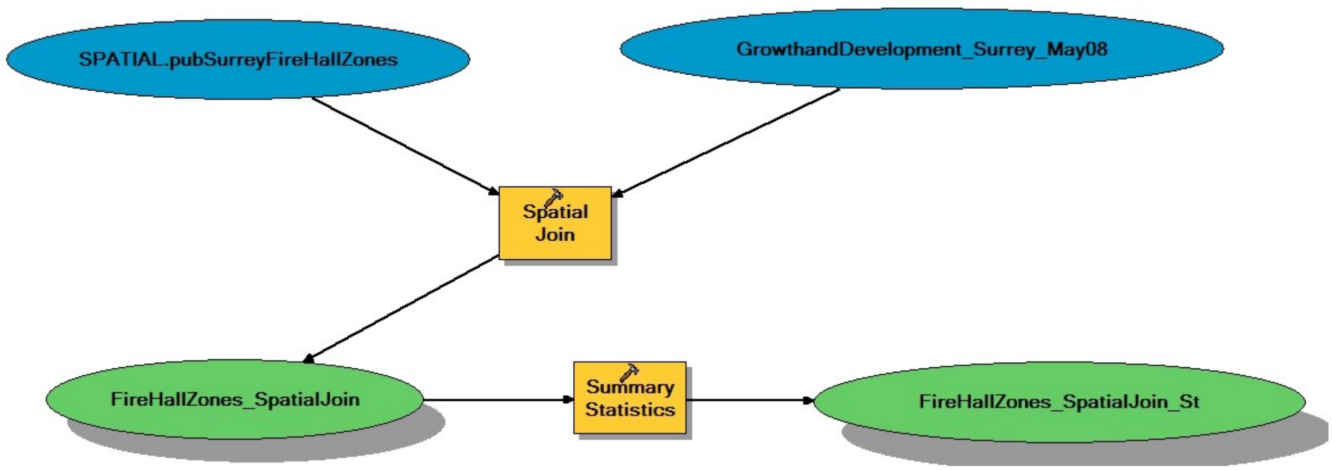

Figure A3 -- Spatial analysis methodology

This process, represented schematically in figure A3, enabled us to calculate the current future projected square footage of high-rise buildings by fire response zone and station first-due areas. It also forms the basis for being able to conduct further analyses incorporating socioeconomic data from Census Canada as well as other municipal and Provincial data sources.