Internal Guide – Fire Flow Review for Development Applications

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Objectives

This internal guide is intended to document current practice of providing the Available Fire Flow (AFF) for development applications (mostly Pre-applications (Pes) and Development Permits (DPs) and rationales of methodology, to ensure that all AFF for development applications are provided in a consistent and fair manner.

Process changes for fire flow review

1. Prior to 2017

The evaluation for fire flow by Development Planning is completed if the fire flow requirement is flagged in the Development Permit review process. There is no written rule of which application will require the fire flow calculation or fire hydrant test. Typically for I developments, the requirement is applied, but the requirement is not consistent for residential development.

If the existing water system can't provide adequate fire flow, the upgrade will be the responsibility of the applicant. Development Planning will work with Development Approvals and consultant for upgrade options.

2. Between May 2017 – April 2018

In response to the increased volume of the Development Permit applications and the need to address the fire flow requirement, Water Technical Lead in Development Planning has been working with Development Approvals, Development Engineering sections to work out a fire flow verification and approval process since May 2017, with the additional staffing support from Asset Planning.

Generally, the fire protection in Greenfield is acceptable as newer design standards/practice has been applied when approving the development applications. The fire flow review was part of the water system analysis during LOC plan stage. However, challenges exist for redevelopment area as we are dealing with old infrastructure that was designed based on the old standard, which is less stringent at the time and/or it is adequate for the developments exist at that time. Therefore the fire flow review work was focused on the redevelopment area.

Within Centre City Levy area, which includes downtown and the Beltline area, the system improvement work will be undertaken by Water Resources, so the development application review process is slightly different. A few triggers have been developed for both categories.

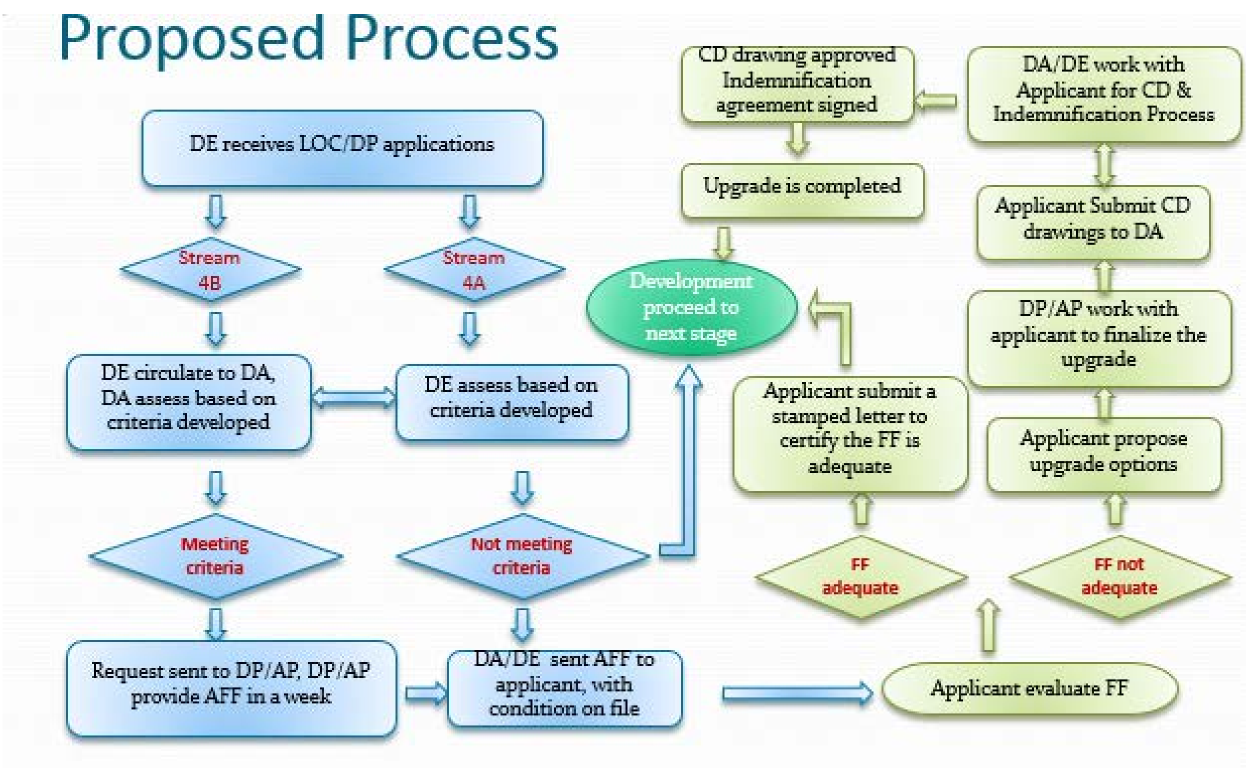
For development applications outside of Centre City Levy area:

a. If the site is located next to water mains that are smaller than 200 mm.
b. If the site is located next to 150 mm water mains that exceed the 250 m maximum length between ties.
c. If the site is located within 10 m from the Top of Zone elevation.
d. If the development is for 5-plex and larger.
e. If the development is ICI, high density residential or Strata type.

For development applications within Centre City Levy area:

a. It the site is located next to water mains that are 100 mm in diameter.
b. If the application is for ICI or Strata type development.
c. If the development is for residential development with more than 50% increase in area.
d. If the development is for 5-plex and larger.

Note: As the City is responsible for the upgrade, the Required Fire Flow (RFF) value needs to be submitted and used to prioritize and plan the upgrade work internally.



3. As of May 1 2018

The new Design Guidelines for Development Site Servicing Plans (DSSP) was published and effective as of May 1 2018. This guide has clearly defined the responsibility between the City and the Engineer of Record.

http://www.calgary.ca/PDA/pd/Documents/urban_development/publications/DSSP-Design-Guidelines.pdf

According to this guideline, "Water Resources will provide the available fire flow at the City's watermain that the development will connect to. It is the responsibility of the Engineer of Record to ensure that the fire flow available in the City's water network is adequate to service the proposed development. "

The internal guideline will focus on the new process and outline the steps to provide Available Fire Flow (AFF) to the application.

Determine the Available Fire Flow (AFF) for DP applications – Step by Step

The request for AFF can be made at either Land Use Change stage (LU), Pre-application (PE) stage or Development Permit (DP) stage.

1. Check the previous LOC/DP comments.
   Different ways to check:
   a. Go to POSSE, use file No. to locate LOC - Detailed Team Review (DTR) Comments.
   b. Go to POSSE, use parcel address to locate LOC - Detailed Team Review (DTR) Comments.
   c. Go to \\Cs5data1\CPAGShared\CPAG Specialist Comments\Development Engineering Specialists to check LOC files or DP files history.

2. Use Total City All Pipe model to run fire flow simulations under Max Day scenario.
   a. Select all hydrants that are within 300 m distance.
   b. Run Single Hydrant Simulation with 15 m residual pressure on average hour of Max Day
   c. Run Multi hydrant simulation with 15 m residual pressure on average hour of Max Day. Need to try different and practical combination of multiple hydrant together then decide the AFF based on majority of the combinations, not the worst case or best-case scenario.

   Note: When selecting candidate hydrants, the hydrants need to be accessible.
   a) Hydrant across from major streets should be avoided.
   b) Public hydrant that needs to be accessed through other private property should be avoided.
   c) Hydrant located in other private properties should be avoided.

3. Based on the result, the Available Fire Flow will be provided in 5000 L/min increments, i.e. 5,000 L/min, 10,000 L/min or 15,000 L/min. The 5000 L/min flow is the design value for one hydrant flow.

4. As the hydraulic modeling results only represent the design condition but do not reflect the main condition, operational changes in the system, as a general rule, the maximum value provided will be 15,000 L/min (which is the minimum required fire flow for ICI and high density residential type of development), with a few exceptions:
   a. The proposed development is located within the Centre City Levy area where the water main network is well gridded and connected. See appendix A for a map of the area.
   b. The water main around the proposed development is relatively new and pipe material is PVC, or PE.
   c. The water around the proposed development is already well sized (200 mm and larger).

Review the Fire Flow Letter provided by applicant/consultant

Per the new DSSP Guideline, **Water Resources does not review the detailed fire flow calculation**. We will review the final value of Require Fire Flow (RFF) done by consultant and determine if the system can provide adequate fire protection.

Note:

The Require Fire Flow (RFF) calculation needs to follow the Water Supply for Public Fire Protection guideline by Fire Underwriters Survey (1999). See Appendix B for the document.
http://www.scm-rms.ca/docs/Fire%20Underwriters%20Survey%20-%201999%20Water%20Supply%20for%20Public%20Fire%20Protection.pdf

The latest document by FUS for applying occupancy factor for different type of building, is listed in Appendix C.

The interpretation of the values used in Part II in the guide should be directed to:
FUS Western Canada Branch office: 1-800-665-5661

1. If Available Fire Flow (AFF) is more than the Require Fire Flow (RFF), then the system can provide adequate fire flow, development can proceed, from the water supply perspective.

2. If Available Fire Flow (AFF) is less than the Require Fire Flow (RFF), then the system can't provide adequate fire flow, the following two options can be perused further by the applicant.

   a. To work with Water Resources with possible system improvement/upgrade options.
   b. To change the building design therefore reduce the Require Fire Flow (RFF) to meet the requirement.

   Note:
   If option 2a is chosen, the applicant needs to work with IP - Development Planning (DP), IP - Development Engineering (DE) and IP - Development Approvals (DA) for an acceptable solution, then work with DE/DA to continue with the Construction Drawing and Indemnification process.

The Fire Flow letter submitted by the applicant or consultant on behalf, should include the following information:

Application number (including all relevant application number, previous DP number)	
Address of the proposed development (including all consolidated parcel addresses)	
Map showing the entire site	
Type of development	
Building Type (wood framed, ordinary or non-combustible)	
Total area (above grade) in m^2	
Total # of units	
If sprinkler system is installed (Yes/No)	
The final value of Required Fire Flow (RFF) in L/min	
Available Fire Flow (AFF) provided by Water Resources	
Assessment of fire flow adequacy	
Proposed mitigation option (attach description and map)	

In addition, A qualified professional engineer's seal and permit to practice stamp is required.

Target review time

The target review time for providing AFF to DA/DE is 5 business days after receiving the request.

In 2018, the average review time is 4 days year to date, compared with average of 3 day in 2017. It is a result of the volume increase and other competing priority work.

- Volume comparison:

2017: 55 in total

2018: 73 in total (as of May 31 2018).

Filing

The fire flow review work, including the work log and modeling simulation info, are saved in Livelink and organized by year. The link is as below:

http://documentmanagement/lldm01/llisapi.dll/open/93529184

Work Staff Contact List

Task	Job Title /Section	Name	Contact
FFR Main Contact	Planning Engineer, Asset Planning	Naorin Wilmshurst	403-268-4414 Naorin.Wilmshurst@calgary.ca
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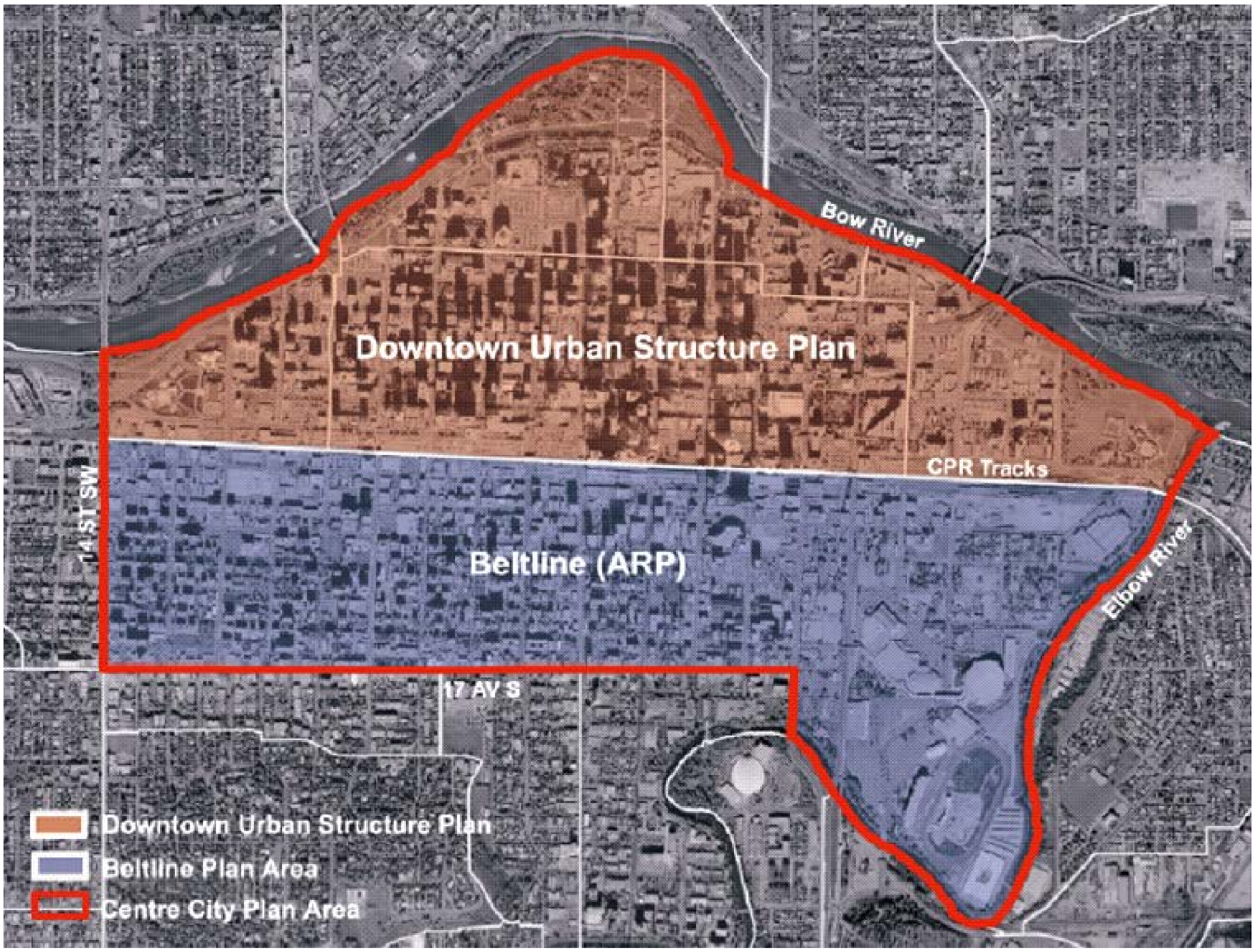
DA Main Contact	Development Engineering Coordinator, Development Approvals	Ben Smith	403-268-6779 Ben.Smith@calgary.ca
DE Main Contact	Leader, Development Engineering	Lawrence Wong	403-268-1714 Lawrence.Wong@calgary.ca

Appendix A: Map of Centre City Levy Area



Appendix B: Water Supply for Public Fire Protection - by Fire Underwriter's Survey (1999)

WATER SUPPLY
FOR
PUBLIC FIRE PROTECTION

1999

FIRE UNDERWRITERS SURVEY

A SERVICE TO INSURERS AND MUNICIPALITIES

For further information on this document or any matters relating to the Fire Underwriters Survey please contact the appropriate offices of CGI Risk Management Services (formerly the Insurers' Advisory Organization) as follows:

Western Canada	CGI Risk Management Services Fire Underwriters Survey 3999 Henning Drive Burnaby BC V5C 6P9	Local: Toll Free: Fax:	604-6841581 1-800-665-5661 604-688-6986
Central Canada	CGI Risk Management Services Fire Underwriters Survey Suite 800, 7015 Macleod Tr. SW Calgary Alberta T2H 2K6	Local: Toll Free: Fax:	403-296-1300 1-800-465-4264 403-296-1316
Quebec	CGI Risk Management Services Fire Underwriters Survey 1611 Crémazie Blvd. East Montreal, Quebec H2M 2P2	Local: Toll Free: Fax:	514-735-3561 1-800-263-5361 514-844-0777
Ontario	CGI Risk Management Services Fire Underwriters Survey Lock Box 200 150 Commerce Valley Drive, West Markham, Ontario L3T 7Z3	Local: Toll Free: Fax:	905-882-6300 1-800-387-4356 905-695-6543
Atlantic Canada	CGI Insurance Business Services Fire Underwriters Survey 238 Brownlow Avenue, Suite 300 Park Place Center Dartmouth, Nova Scotia B3B 1Y2	Telephone: Toll-Free: Fax:	902-423-9287 1-800-639-4528 902-423-7376

FIRE UNDERWRITERS SURVEY is financed by the Canadian Insurance industry and utilizes technical staff of CGI Risk Management Services (formerly the Insurers' Advisory Organization Inc.) Its purpose is to survey fire protection conditions in Canadian communities and municipalities, providing data and advisory services to fire insurance underwriters and public officials concerned.

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WATER SUPPLY FOR PUBLIC FIRE PROTECTION

PREFACE

This guide summarizes the more significant recommendations of Fire Underwriters Survey with respect to fire protection requirements in municipal water works system design. It reflects the manner in which FUS assesses the water supply aspect of a municipality's fire risk potential during surveys on behalf of the Canadian property insurance industry and represents the accumulated experience of many years of study of actual fires. Water supply is one of a number of components evaluated by FUS in the municipal fire protection system. Recommendations applying to the fire departments and code enforcement are covered in other publications of Fire Underwriters Survey. FUS local offices are prepared to assist municipal officials or their consultants with advice on special problems, as time limits permit, in accordance with the intent of this guide. The minimum size water supply credited by FUS must be capable of delivering not less than 1000 L/min for two hours or 2000 L/min for one hour in addition to any domestic consumption at the maximum daily rate. Static suction supplies to fire department pumpers are recognized as a supplement to the piped system.

In the FUS assessment of a water supply system, the major emphasis is placed upon its ability to deliver **adequate** water to control major fires throughout the municipality on a **reliable** basis via sufficient and suitable **hydrants**. What is ultimately available to the fire department is the critical test in this fire protection evaluation.

Rates of flow for firefighting purposes are expressed in litres per minute as this is the adopted unit for the firefighting field.

In this edition all quantities are specified in S.I. units.

PART I

GENERAL

ADEQUACY AND RELIABILITY. An adequate and reliable water supply for firefighting is an essential part of the fire protection system of a municipality. This is normally a piped system in common with domestic potable water service for the community.

A water supply system is considered to be fully adequate if it can deliver the necessary fire flow at any point in the distribution gridiron for the applicable time period specified in the table “Required Duration of Fire Flow” with the consumption at the maximum daily rate (average rate on maximum say of a normal year). When this delivery is also possible under certain emergency or unusual conditions as herein specified, the system is considered to be reliable. In cities of population in excess of 250,000 (or smaller places with high fire incident and severe hazard conditions) it is usually necessary to consider the possibility of two simultaneous major fires in the area served by the system.

Fire flows are amounts of water necessary to control fires. These are determined as shown in Part II. System design should contemplate meeting the required fire flows existing or probable with the possible exception of gross anomalies where there is no fire threat to the remainder of the community. In these cases, the properties should preferably be modified in hazard to reduce the required flow as part of a coordinated community fire protection system.

The protection of buildings by automatic sprinkler systems is a significant contribution to the fire protection of the community and should be encouraged, not penalized by onerous service charges or metering requirements.

In order to provide reliability, duplication of some or all parts of the system will be necessary, the need for duplication being dependent upon the extent to which the various parts may reasonably be expected to be out of service as a result of maintenance and repair work, an emergency or some unusual condition. The introduction of storage, either as part if the supply works or on the distribution system, may partially or completely offset the need for duplicating various parts of the system, the value of the storage depending upon its amount, location and availability.

STORAGE. In general, storage reduces the requirements of those parts of the system through which supply has already passed. Since storage usually fluctuates, the normal daily minimum maintained is the amount that should be considered as available for fires. Because of the decrease in pressure when water is drawn down in standpipes, only the portion of this normal daily minimum storage that can be delivered at a residual pressure of 150kPa at the point of use is considered as available. As well as the quantity available, the rate of delivery of water to the system from storage for the fire flow period is critical to this consideration.

PRESSURE. The principal requirement to be considered is the ability to deliver water in sufficient quantity to permit fire department pumpers to obtain an adequate supply from hydrants. To overcome friction loss in the hydrant branch, hydrant and suction hose, a minimum residual water pressure of 150 kPa in the street main is required during flow. Under conditions of exceptionally low suction losses, a lower residual may be possible. This includes the use of 100 mm and larger outlets for fire department pumper use and hydrants with large waterways.

Higher sustained pressure is of importance in permitting direct continuous supply to automatic sprinkler systems, to building standpipe and hose systems, and in maintaining a water plan so that no portion of the protection area is without water, such as during a fire at another location. Residual pressures that exceed 500 kPa during large flows are of value as they permit short hose-lines to be operated directly from hydrants without supplementary pumping.

SUPPLY WORKS

NORMAL ADEQUACY OF SUPPLY WORKS. The source of supply, including impounding reservoirs, and each part of the supply works should normally be able to maintain the maximum daily consumption rate plus the maximum required fire flow. Each distribution service within the system should similarly support its own requirements. In large cities where fire frequency may result in simultaneous fires, additional flow must be considered in accordance with the potential. Filters may be considered as capable of operating at a reasonable overload capacity based upon records and experience. In general, overload capacity will not exceed 25 percent, but may be higher in well designed plans operating under favourable conditions.

The absolute minimum supply available under extreme dry weather conditions should not be taken as the measure of the normal ability of the source of supply such as supply from wells. The normal or average capacity of wells during the most favourable nine month period should be considered, or the normal sustained flow of surface supplies to the source.

RELIABILITY OF SOURCE OF SUPPLY. The effect on adequacy must be considered for such factors as frequency, severity and duration of droughts, physical condition of dams and intakes; danger from earthquakes, floods, forest fires, and ice dams or other ice formations; silting-up or shifting of channels; possibility of accidental contamination of watershed or source; absence of watchmen or electronic supervision where needed; and injury by physical means. Where there is a risk of disruption, special precautions or alternate supplies should be arranged.

Where the supply is from wells, some consideration should be given to the absolute minimum capacity of the wells under the most unfavourable conditions; also to the length of time that the supply from the wells would be below the maximum daily consumption rate, and the likelihood of this condition recurring every year or only at infrequent intervals. It should be recognized that some water is generally available from wells and that the most extreme conditions are not as serious as a total interruption of the supply, as would be the case in the breaking of a dam or shifting of a channel. The possibility of clogging, salinity, and the need for periodic cleaning and overhauling must be considered. Dependence upon a single well, even where records are favourable, may be considered a feature of unreliability.

Frequent cleaning of reservoirs and storage tanks may be considered as affecting reliability.

Continuity of, and delay in implementing water supplies obtained from systems or sources not under the control of the municipality or utility should be considered also from these aspects.

GRAVITY SYSTEMS. A gravity system delivering supply from the source to distribution directly without the use of pumps is advantageous from a fire protection point of view because of its inherent reliability, but a pumping system can also be developed to a high degree of reliability.

PUMPING

RELIABILITY OF PUMPING CAPACITY. Pumping capacity, where the system or service is supplied by pumps, should be sufficient, in conjunction with storage when the two most important pumps are out of service, to maintain the maximum daily consumption rate plus the maximum required fire flow at required pressure for the required duration. For smaller municipalities (usually up to about 25,000 population) the relative infrequency of fires is assumed as largely offsetting the probability of a serious fire occurring at times when two pumps are out of service. (The most important pump is normally, but not always, the one of largest capacity, depending upon how vital is its contribution to maintaining flow to the distribution system.)

To be adequate, remaining pumps in conjunction with storage, should be able to provide required fire flows for the specified durations at any time during a period of five days with consumption at the maximum daily rate. Effect of normal minimum capacity of elevated storage located on the distribution system and storage of treated water above low lift pumps should be considered. The rate of flow from such storage must be considered in terms of any limitation of water main capacity. The availability of spare pumps or prime movers that can quickly be installed may be credited, as may pumps of compatible characteristics which may be valved from another service.

POWER SUPPLY FOR PUMPS. Electric power supply to pumps should be so arranged that a failure in any power line or the repair or replacement of a transformer, switch, control unit or other device will not prevent the delivery, in conjunction with elevated storage, of required fire flows for the required durations at any time during a period of two days with consumption at the maximum daily rate.

Power lines should be underground from the station or substation of the power utility to water plants and pumping stations and have no other consumers enroute. The use of the same transmission lines by other consumers introduces unreliability because of the possibility of interruption of power or deterioration of power characteristics.

Overhead power lines are more susceptible to damage and interruption than underground lines and introduce a degree of un-reliability that depends upon their location and construction. In connections with overhead lines, consideration should be given to the number and duration of lightning, wind, sleet, and snow storms in the area; the type of poles or towers and wires; the nature of the country traversed; the effect of earthquakes, forest fires, and floods; the lightning and surge protection provided; the extent to which the system is dependent upon overhead lines; and the ease of, and facilities for, repairs.

The possibility of power systems or network failures affecting large areas should be considered. In-plant auxiliary power or internal combustion driver standby pumping are appropriate solutions to these problems in many cases, particularly in small plants where high pumping capacity is required for fire protection service. When using automatic starting, prime 'movers' for auxiliary power supply and pumping should have controllers listed by Underwriters' Laboratories of Canada to establish their reliability.

FUEL SUPPLY. At least a five day supply of fuel for internal combustion engines or boilers used for regular domestic supply should be provided. Where long hauls, condition of roads, climatic conditions, or other circumstances could cause interruptions of delivery longer than five days, a greater storage should be provided. Gas supply should be from two independent sources or from duplicate gas-producer plants with gas storage sufficient for 24 hours. Unreliability of regular fuel supply may be offset in whole or in part by suitable provisions for the use of an alternate fuel or power supply.

BUILDINGS AND PLANT

BUILDINGS AND STRUCTURES. Pumping stations, treatment plants, control centres and other important structures should be located, constructed, arranged, and protected so that damage by fire, flooding, or other causes will be held to a minimum. They should contain no combustible material in their construction, and, if hazards are created by equipment or materials located within the same structure, the hazardous section should be suitably separated by fire-resistive partitions or fire walls.

Buildings and structures should have no fire exposures. If exposures exist, suitable protection should be provided, Electrical wiring and equipment should be installed in accordance with the Canadian Electrical Code. All internal hazards should be properly safeguarded in accordance with good practice. Private in-plant fire protection should be provided as needed.

MISCELLANEOUS SYSTEM COMPONENTS, PIPING AND EQUIPMENT. Steam piping, boiler-feed lines, fuel-piping (gas or oil lines to boilers as well as gas, oil or gasoline lines to internal-combustion engines), and air lines to wells or control systems should be so arranged that a failure in any line or the repair or replacement of a valve, fuel pump, boiler-feed pump, injector, or other necessary device, will not prevent the delivery, in conjunction with storage, of the required fire flows for the specified duration at any time during a period of two days with consumption at the maximum daily rate.

Plants should be well arranged to provide for effective operation. Among the features to be considered are: ease of making repairs and facilities for this work, danger of flooding because of broken piping; susceptibility to damage by spray; reliability of priming and chlorination equipment; lack of semi-annual inspection of boilers or other pressure vessels; dependence upon common non-sectionalized electric bus bars; poor arrangement of piping; poor condition or lack of regular inspections of important valves; and factors affecting the operation of valves or other devices necessary for fire service such as design, operation, and maintenance of pressure regulating valves, altitude valves, air valves, and other special valves or control devices, provision of power drives, location of controls, and susceptibility to damage.

Reliability of treatment works is likely to be influenced by the removal from service of at least one filter or other treatment unit; the reduction of filter capacity by turbidity, freezing or other conditions of the water; the need for cleaning basins; and the dependability of power for operating valves, wash-water pumps, mixers and other appurtenances.

OPERATIONS. Reliability in operation of the supply system and adequate response to emergency or fire demands are essential. Instrumentation, controls and automatic features should be arranged with this in mind. Failure of an automatic system to maintain normal conditions or to meet unusual demands should result in the sounding of an alarm where remedial action will be taken.

The operating force should be competent, adequate, and continuously available as may be required to maintain both the domestic and fire services.

EMERGENCY SERVICES. Emergency crews, provided with suitable transportation, tools and equipment, should be continuously on duty in the larger systems and be readily available upon call in small systems. Spare pipe and fittings, and construction equipment should be readily available. Alarms for fires in buildings should be received by the utility at a suitable location where someone is always on duty who can take appropriate action as required, such as placing additional equipment in operation, operating emergency or special valves, or adjusting pressures. Receipt of alarms may be by fire alarm circuit, radio, outside alerting device, or telephone, but where special operations are required, the alarm service should be equivalent to that needed for a fire station.

Response of an emergency crew should be made to major fires to assist the fire department in making the most efficient use of the water system and to ensure the best possible service in the event of a water main break or other emergency. The increase of pressures by more than 25 percent for fires is considered to increase the possibility of breaks.

PIPING

RELIABILITY OF SUPPLY MAINS. Supply mains cut off for repair should not drastically reduce the flow available to any district. This includes all pipe lines or conduits on which supply to the distribution system is dependent, including intakes, suction or gravity lines to pumping stations, flow lines from reservoirs, treatment plant piping, force mains, supply and arterial mains, etc. Consideration should be given to the greatest effect that a break, joint separation or other failure could have on the delivery of the maximum daily consumption rate plus required fire flow at required pressure over a three day period. Aqueducts, tunnels or conduits of substantial construction may be considered as less susceptible to failure and equivalent to good mains with a long history of reliability.

INSTALLATION OF PIPE. Mains should be in good condition and properly installed. Pipe should be suitable for the service intended. Asbestos-cement, poly-vinyl chloride (PVC), cast and ductile iron, reinforced concrete and steel pipe manufactured in accordance with appropriate Canadian Standards Association or ANSI/AWWA standards, or any pipes listed by Underwriters' Laboratories of Canada for fire service are considered satisfactory. Normally, pipe rated for a maximum working pressure of 1000 kPa is required, Service records, including the frequency and nature of leaks, breaks, joint separations, other failures and repairs, and general conditions should be considered as indicators of reliability. When mains are cleaned they should be lined.

Mains should be so laid as not to endanger one another, and special construction should be provided to prevent their failure at stream crossings, railroad crossings, bridges, and other points where required by physical conditions; supply mains should be valved at one and one half kilometre intervals and should be equipped with air valves at high points and blow offs at low points. Mains should not be buried extremely deep or be unusually difficult to repair, though depths to ten feet may be required because of frost conditions.

The general arrangement of important valves, of standard or special fittings, and of connections at cross-overs, intersections, and reservoirs, as well as at discharge and suction headers, should be considered with respect to the time required to isolate breaks. The need for check valves on supply or force mains and for other arrangements to prevent flooding of stations or emptying of reservoirs at the time of a break in a main should also be considered, as well as the need for relief valves or surge chambers. Accessibility of suitable material and equipment and ease of making repairs should be considered.

Arterial feeder mains should provide looping throughout the system for mutual support and reliability, preferably not more than 1000 metres between mains. Dependence of a large area on a single main is a weakness. In general the gridiron of minor distributors supplying residential districts should consist of mains at least 150mm in size and arranged so that the lengths on the long sides of blocks between intersecting mains do not exceed 200 metres. Where longer lengths of 150mm pipe are necessary 200mm or larger intersecting mains should be used. Where initial pressures are unusually high, a satisfactory gridiron may be obtained with longer lengths of 150mm pipe between intersecting mains.

Where deadends and a poor gridiron are likely to exist for a considerable period or where the layout of the streets and the topography are not well adapted to the above arrangement, 200mm pipe should be used. Both the ability to meet the required fire flows and reliability of a reasonable supply by alternate routing must be taken into account in this consideration.

VALVES. A sufficient number of valves should be installed so that a break or other failure will not affect more than 400 metres of arterial mains, 150 metres of mains in commercial districts, or 250 metres of mains in residential districts. Valves should be maintained in good operating condition. The recommended inspection frequency is once a year, and more frequently for larger valves and valves for critical applications.

A valve repair that would result in reduction of supply is a liability, but because of the probable infrequency of occurrence, it might be considered as introducing only a moderate degree of unreliability even if it resulted in total interruption. The repair of a valve normally should be accomplished in two days. Valves opening opposite to the majority are undesirable and when they do occur they should be clearly identified.

HYDRANTS

SIZE, TYPE AND INSTALLATION. Hydrants should conform to American Water Works Standard for Dry Barrel Fire Hydrants or Underwriters' Laboratories of Canada listing. Hydrants should have at least two 65mm outlets. Where required fire flows exceed 5000 l/min or pressures are low there should also be a large pumper outlet. The lateral street connection should not be less than 150mm in diameter. Hose threads, operating and cap nuts on outlets should conform to Provincial Standard dimensions. A valve should be provided on lateral connections between hydrants and street mains.

Hydrants that open in a direction opposite to that of the majority are considered unsatisfactory. Flush hydrants are considered undesirable because of delay in getting into operation; this delay is more serious in areas subject to heavy snow storms. Cisterns are considered unsatisfactory as an alternative to pressure hydrants. The number and spacing of hydrants should be as indicated in the table titled "Standard Hydrant Distribution".

INSPECTION AND CONDITION. Hydrants should be inspected at least semi-annually and after use. The inspection should include operation at least once a year. Where freezing temperatures occur, the semi-annual inspections should be made in the spring and fall of each year. Because of the possibility of freezing they should be checked frequently during extended periods of severe cold. Hydrants should be kept in good condition and suitable records of inspections and repairs be maintained. Hydrants should be painted in highly visible colours so that they are conspicuous and be situated with outlets at least twelve inches above the grade. There should be no obstruction that could interfere with their operation. Snow should be cleared promptly after storms and ice and snow accumulations removed as necessary.

HYDRANT DISTRIBUTION. Hydrant locations and spacing should be convenient for fire department use. Hydrants should be located at intersections, in the middle of long blocks and at the end of long dead-end streets. To allow for convenient utilization of water supplies, distribution density of hydrants should be in accordance with the required fire flows indicated in the table titled "Standard Hydrant Distribution" (page 16). The maximum recommended spacing of hydrants in commercial, industrial, institutional and multi-family residential areas is 90 metres; in single family residential areas 180 metres is recommended. In areas where fire apparatus have access (e.g. large properties, private developments, etc.), hydrants should be required by bylaw. The planning of hydrant locations should be a cooperative effort between the water utility and fire department.

RECORDS

PLANS AND RECORDS. Complete, up-to-date plans and records essential for the proper operation and maintenance of the system should be available in a convenient form, suitably indexed and safely filed. These should include plans of the source as well as records of its yield and a reliable estimate of the safe yield; plans of the supply works including dams, intakes, wells, pipelines, treatment plants, pumping stations, storage reservoirs and tanks; and a map of the distribution system showing mains, valves, and hydrants. Plans and maps should be in duplicate and stored at different locations.

Detailed distribution system plans, in a form suitable for field use, should be available for maintenance crews. Records of consumption, pressures, storage levels, pipes, valves, hydrants, and of the operations of the supply works and distribution system, including valve and hydrant inspections and repairs should be maintained.

TABLES

STANDARD HYDRANT DISTRIBUTION	
Fire Flow Required (litres per minute)	Average Area per Hydrant (m^2)
2,000	16,000
4,000	15,000
6,000	14,000
8,000	13,000
10,000	12,000
12,000	11,000
14,000	10,000
16,000	9,500
18,000	9,000
20,000	8,500
22,000	8,000
24,000	7,500
26,000	7,000
28,000	6,500
30,000	6,000
32,000	5,500
34,000	5,250
36,000	5,000
38,000	4,750
40,000	4,500
42,000	4,250
44,000	4,000
46,000	3,750
48,000	3,500

REQUIRED DURATION OF FIRE FLOW	
Fire Flow Required (litres per minute)	Duration (hours)
2,000 or less	1.0
3,000	1.25
4, 000	1.5
5,000	1.75
6,000	2.0
8000	2.0
10,000	2.0
12,000	2.5
14,000	3.0
16,000	3.5
18,000	4.0
20000	4.5
22,000	5.0
24,000	5.5
26,000	6.0
28,000	6.5
30,000	7.0
32000	7.5
34,000	8.0
36,000	8.5
38,000	9.0
40,000 and over	9.5

Interpolate for intermediate figures

Area refers to surface area of blocks and bounding streets. For a street without adjacent streets, a depth of one-half block is used.

A water supply system is considered to be adequate for fire protection when it can supply water as indicated above with consumption at the maximum daily rate. Certain types of emergency supplies may be included where reasonable conditions for their immediate use exist. Storage on the system is credited on the basis of the normal daily minimum maintained insofar as pressure permits its delivery at the rate considered.

PART II

GUIDE FOR DETERMINATION OF REQUIRED FIRE FLOW
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N.B. It should be recognized that this is a "guide" in the true sense of the word, and requires a certain amount of knowledge and experience in fire protection engineering for its effective application. Its primary purpose is for the use of surveyors experienced in this field, but it is made available to municipal officials, consulting engineers and others interested as an aid in estimating fire flow requirements for municipal fire protection.

Required Fire Flow may be described as the amount and rate of water application required in firefighting to confine and control the fires possible in a building or group of buildings which comprise essentially the same fire area by virtue of immediate exposure. This may include as much as a city block.

1. An estimate of the fire flow required for a given area may be determined by the formula:

$$F = 220C\sqrt{A}$$

where

F = the required fire flow in litres per minute.

C = coefficient related to the type of construction.

= 1.5 for wood frame construction (structure essentially all combustible).

= 1.0 for ordinary construction (brick or other masonry walls, combustible floor and interior).

= 0.8 for non-combustible construction (unprotected metal structural components, masonry or metal walls).

= 0.6 for fire-resistive construction (fully protected frame, floors, roof).

Note: For types of construction that do not fall within the categories given, coefficients shall not be greater than 1.5 nor less than 0.6 and may be determined by interpolation between consecutive construction types as listed above. Construction types are defined in the Appendix.

A = The total floor area in square metres (including all storeys, but excluding basements at least 50 percent below grade) in the building being considered.

For fire-resistive buildings, consider the two largest adjoining floors plus 50 percent of each of any floors immediately above them up to eight, when the vertical openings are inadequately protected. If the vertical openings and exterior vertical communications are properly protected (one hour rating), consider only the area of the largest floor plus 25 percent of each of the two immediately adjoining floors.

For one family and two family dwellings not exceeding two storeys in height, see **Note J.**

2. The value obtained in No. 1 may be reduced by as much as 25% for occupancies having a low contents fire hazard or may be increased by up to 25% surcharge for occupancies having a high fire hazard. Those may be classified as to contents as follows:

Non-Combustible	-25%	Free Burning	+15%
Limited Combustible	-15%	Rapid Burning	+25%
Combustible	No Charge		

As guide for determining low or high fire hazard occupancies, see the list in the Appendix. The fire flow determined shall not be less than 2,000 L/min,

3. The value obtained in No.2 above may be reduced by up to 50% for complete automatic sprinkler protection depending upon adequacy of the system. The credit for the system will be a maximum of 30% for an adequately designed system conforming to NFPA 13 and other NFPA sprinkler standards. Additional credit of up to 10% may be granted if the water supply is standard for both the system and fire department hose lines required. The percentage reduction made for an automatic sprinkler system will depend upon the extent to which the system is judged to reduce the possibility of fires spreading within and beyond the fire area. Normally this reduction will not be the maximum allowed without proper system supervision including water flow and control valve alarm service. Additional credit may be given of up to 10% for a fully supervised system.

4. To the value obtained in No. 2 above a percentage should be added for structures exposed within 45 metres by the fire area under consideration. This percentage shall depend upon the height, area, and construction of the building(s) being exposed, the separation, openings in the exposed building(s), the length and height of exposure, the provision of automatic sprinklers and/or outside sprinklers in the building(s) exposed, the occupancy of the exposed building(s), and the effect of hillside locations on the possible spread of fire.

   The charge for any one side generally should not exceed the following limits for the separation:

Separation	Charge	Separation	Charge
0 to 3m	25%	20.1 to 30 m	10%
3.1 to 10m	20%	30.1 to 45m	5%
10.1 to 20m	15%		

   The total percentage shall be the sum of the percentage for all sides, but shall not exceed 75%.

   The fire flow shall not exceed 45,000 L/min nor be less than 2,000 L/min.

Notes to Calculation

Note A: The guide is not expected to necessarily provide an adequate value for lumber yards, petroleum storage, refineries, grain elevators, and large chemical plants, but may indicate a minimum value for these hazards.

Note B: Judgment must be used for business, industrial, and other occupancies not specifically mentioned.

Note C: Consideration should be given to the configuration of the building(s) being considered and accessibility by the fire department.

Note D: Wood frame structures separated by less than 3 metres shall be considered as one fire area.

Note E: Fire Walls: - In determining floor areas, a fire wall that meets or exceeds the requirements of the current edition of the National Building Code of Canada (provided this necessitates a fire resistance rating of 2 or more hours) may be deemed to subdivide the building into more than one area or may, as a party wall, separate the building from an adjoining building.

Normally any unpierced party wall considered to form a boundary when determining floor areas may warrant up to a 10% exposure charge.

Note F: High one storey buildings: When a building is stated as 1=2, or more storeys, the number of storeys to be used in the formula depends upon the use being made of the building. For example, consider a 1=3 storey building. If the building is being used for high piled stock, or for rack storage, the building would probably be considered as 3 storeys and, in addition, an occupancy percentage increase may be warranted.

However, if the building is being used for steel fabrication and the extra height is provided only to facilitate movement of objects by a crane, the building would probably be considered as a one storey building and an occupancy credit percentage may be warranted.

Note G: If a building is exposed within 45 metres, normally some surcharge for exposure will be made.

Note H: Where wood shingle or shake roofs could contribute to spreading fires, add 2,000 L/min to 4,000 L/min in accordance with extent and condition.

Note I: Any non-combustible building is considered to warrant a 0.8 coefficient.

Note J: Dwellings: For groupings of detached one family and small two family dwellings not exceeding 2 stories in height, the following short method may be used. (For other residential buildings, the regular method should be used.)

Exposure distances	**Suggested required fire flow**	
	Wood Frame	Masonry or Brick
Less than 3m 3 to 10m 10.1 to 30m Over 30m	See Note "D" 4,000 L/min 3,000 L/min 2,000 L/min	6,000 L/min 4,000 L/min 3,000 L/min 2,000 L/min

If the buildings are contiguous, use a minimum of 8,000 L/min. Also consider Note H.

OUTLINE OF PROCEDURE

A. Determine the type of construction.

B. Determine the ground floor area.

C. Determine the height in storeys.

D. Using the fire flow formula, determine the required fire flow to the nearest 1,000 L/min.

E. Determine the increase or decrease for occupancy and apply to the value obtained in D above. Do not round off the answer.

F. Determine the decrease, if any, for automatic sprinkler protection. Do not round off the value.

G. Determine the total increase for exposures, Do not round off the value.

H. To the answer obtained in E, subtract the value obtained in F and add the value obtained in G.

The final figure is customarily rounded off to the nearest 1,000 L/min.

APPENDIX

TYPES OF CONSTRUCTION

For the specific purpose of using the Guide, the following definitions may be used:

Fire-Resistive Construction - Any structure that is considered fully protected, having at least 3-hour rated structural members and floors. For example, reinforced concrete or protected steel.

Non-combustible Construction - Any structures having all structural members including walls, columns, piers, beams, girders, trusses, floors, and roofs of non-combustible material and not qualifying as fire-resistive construction. For example, unprotected metal buildings.

Ordinary Construction - Any structure having exterior walls of masonry or such non-combustible material, in which the other structural members, including but not limited to columns, floors, roofs, beams, girders, and joists, are wholly or partly of wood or other combustible material.

Wood Frame Construction - Any structure in which the structural members are wholly or partly of wood or other combustible material and the construction does not qualify as ordinary construction.

OCCUPANCIES

Examples of Low Hazard Occupancies:

Apartments
Asylums
Churches
Clubs
Colleges & Universities
Dormitories
Dwellings
Hospitals
Hotels
Institutions
Libraries, except Large Stack Room Areas
Museums
Nursing, Convalescent and Care Homes
Office Buildings
Prisons
Public Buildings
Rooming Houses
Schools
Tenements

Generally, occupancies falling in National Building Code Groups A, B, C and D are of this class.

Examples of High Hazard Occupancies:

Aircraft Hangars	Linseed Oil Mills
Cereal, Feed, Flour and Grist Mills	Match Manufacturing
Chemical Works - High Hazard	Oil Refineries
Cotton Picker and Opening Operations	Paint Shops
Explosives & Pyrotechnics Manufacturing	Pyroxylin Plastic Manufacturing & Processing
Shade Cloth Manufacturing	Solvent Extracting
Foamed Plastics, Storage or use in Manufacturing	Varnish and Paint Works
High Piled Combustibles Storage in excess of 6.5 metres high	Woodworking with Flammable Finishing
	Linoleum and Oilcloth Manufacturing

Other occupancies involving processing, mixing storage and dispensing flammable and/or combustible liquids. Generally, occupancies falling in National Building Code Group F, Divisions 1 and 2 would be in this class.

For other occupancies, good judgment should be used, and the percentage increase will not necessarily be the same for all buildings that are in the same general category - for example "Colleges and Universities": this could range from a 25% decrease for buildings used only as dormitories to an increase for a chemical laboratory. Even when considering high schools, the decrease should be less if they have extensive shops.

It is expected that in commercial buildings no percentage increase or decrease for occupancy will be applied in most of the fire flow determinations. In general, percentage increase or decrease will not be at the limits of plus or minus 25%.

EXPOSURES

When determining exposures it is necessary to understand that the exposure percentage increase for a fire in a building (x) exposing another building (y) does not necessarily equal the percentage increase when the fire is in building (y) exposing building (x). The Guide gives the maximum possible percentage for exposure at specified distances. However, these maximum possible percentages should not be used for all exposures at those distances. In each case the percentage applied should reflect the actual conditions but should not exceed the percentage listed.

The maximum percentage for the separations listed generally should be used if the exposed building meets all of the following conditions:

a. Same type or a poorer type of construction than the fire building.
b. Same or greater height than the fire building.
c. Contains unprotected exposed openings.
d. Unsprinklered.

CONVERSION FACTORS

Multiply	By	To Obtain
Centimetre	0.3937	Inches
Cubic Foot	0.0283	Cubic Metres
Cubic Metre	35.3145	Cubic Feet
Cubic Metre	219.97	Imperial Gallons
Cubic Metre	1.000	Litres
Foot	0.3048	Metres
Horsepower	0.7457	Kilowatt
Imperial Gallon	4.546	Litres
Inch	2.54	Centimetres
Kilogram	2.2046	Pounds
Kilogram of Water	1	Litres
Kilopascal	0.1450	Pounds per sq. inch
Kilowatt	1.341	Horsepower
Litre	0.21997	Imperial Gallons
Litre of Water	1	Kilograms
Metre	3.281	Feet
Metre of Water	10	Kilopascals
Pound	0.4536	Kilograms
Pound per sq. inch	6.89476	Kilopascals
U.S. Gallons	0.8327	Imperial Gallons
Imperial Gallons	1.201	U.S.Gallons

Appendix C: Occupancy Charges for Required Fire Flow Calculations (2011)

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Appendix B

Occupancy Charges for Required Fire Flow Calculations

Occupancy Charge Notes:

1.) All *Occupancy Charges* should be modified accordingly to the specific fire loading and situation that exists in the actual structure.

2.) For *occupancies* other than those listed, please interpolate from the examples given considering fire loading and expected combustibility of *contents* of *occupancy* as compared to those listed.

3.) *Occupancy Charges* should not be made at greater than +25% or less than -25%.

4.) *Occupancy Charges* shown in the examples here can be modified by up to 10% positively or negatively depending on the extent to which the fire loading is unusual for the occupancy type.

C-5 Occupancies

Rapid-burning or flash-burning (C-5)
25% Occupancy Charge

Ammunition
Cereal mills
Combustible hydraulics
Cotton picker and opening operations
Die casting
Explosives and pyrotechnics manufacturing and storage
Feed and gristmills (with > 7 tons of hay & straw)
Fireworks
Flammable compressed gases
Flammable liquid spraying
Flammable liquids
Flour mills
Flow coating/dipping
Highly flammable solids
Linseed oil mills
Manufactured homes/modular building assembly
Matches
Mattress factory
Metal extruding
Nitrocellulose-based plastics
Painting with flammables or combustibles
Plastic processing
Plywood and particle board manufacturing
Printing using flammable inks
Rag storage
Rubber reclaiming
Sawmills
Solvent extracting
Straw or hay in bales
Textile picking
Upholstering shop
Upholstering with plastic foams
Waste paper storage

C-4 Occupancies

Free-burning (C-4)
10-15% Occupancy Charge

Aircraft hangers
Barns and stables (commercial)
Building materials supply storage
Cabinet making
Combustible metals (e.g., Magnesium)
Department stores
Dry cleaner (using flammable fluids)
Exhibition halls, auditoriums, and theatres
Feed store (with > 1/3 ton of hay)
Feed stores (without processing)
Freight terminals
Fur apparel manufacturing
Furniture manufacturing
Kennels
Lumber
Mercantiles
Packaging and crating
Paper and pulp mills
Paper processing plants
Paper products manufacturing
Petroleum bulk-distribution center
Piers and wharves
Repair garages
Rubber products manufacturing and storage
Stables
Tire manufacturing
Tire recapping or retreading
Warehouses, such as those used for furniture, general storage, paint, paper, and woodworking industries
Wax products (candles, etc.)
Woodworking shop

C-3 Occupancies

Combustible (C-3)
0% +/- 15% Occupancy Charge

Amusement occupancies
Auto parts store
Auto repair training school
Bakery
Boat sales (where there is storage, add 15%)
Book store
Bowling establishment
Casino
Clothing manufacturing plants
Cold storage warehouses
Commercial laundry
Confectionery product warehouses
Contractor equipment storage
Department store (where there is storage, add 15%)
Dry cleaner (no flammable fluids)
Farm storage buildings, such as corn cribs, dairy barns, equipment sheds, and hatcheries
Gift shop (where there is storage, add 15%)
Hardware store (where there is storage, add 15%)
Hotel with restaurant
Laundries
Leather goods manufacturing plants
Leather processing
Libraries (with stockroom areas)
Lithography shops
Machine shops
Metalworking shops
Municipal storage building
Nurseries (plant)
Nursery sales outlet store
Pavilion or dance hall
Pet shop
Pharmaceutical manufacturing plants
Photographic supplies
Printer
Printing and publishing plants
Restaurant
Restaurants
Rope and twine manufacturing plants
Sandwich shop
Shoe repair
Sporting goods (where there is storage, add 15%)

C-3 Occupancies

Combustible (C-3)
0% +/- 15% Occupancy Charge

Sugar refineries
Supermarket
Tanneries
Textile manufacturing plants
Theatre
Tobacco barns
Unoccupied buildings
Vacant building
Wearing apparel factory (except furs)

C-2 Occupancies

Limited-combustible (C-2)
-15% Occupancy Charge

Airport, bus, railroad terminal
Apartment
Armories
Artist's studio
Auto repair shop
Auto showroom
Automobile parking garages
Aviary
Barber or beauty shops
Barber shop
Beverage manufacturing plants/breweries
Boiler houses
Brick, tile, and clay product manufacturing plants
Canneries
Cement plants
Churches and similar religious structures
Cold storage warehouse
Dairy products manufacturing and processing plants
Day care center
Doctors' offices
Dormitories, Fraternities and common living spaces
Educational institution
Electronics plants
Foundries
Fur processing plants
Gasoline service station
Gasoline service stations
Glass and glass products manufacturing plants
Greenhouse
Health club
Hotel
Horse stables
Jail
Library
Medical laboratory
Mortuaries
Motel
Municipal buildings
Museum
Nursing home
Office

C-2 Occupancies

Limited-combustible (C-2)
-15% Occupancy Charge

Pet grooming shop
Photographer's studio
Post offices
Radio station
Recreation center
Rooming house
Slaughterhouses
Telephone exchanges
Tobacco manufacturing plants
Undertaking establishment
Watch and jewellery manufacturing plants
Wineries
Watch and jewellery manufacturing plants
Wineries

C-1 Occupancies

Non-combustible (C-1)
-25% Occupancy Charge

Asbestos storage
Clay storage
Clubs
Fire stations
Hospitals
Marble storage
Metal products storage
Offices (including data processing but not combustibles storage)
Police stations
Prisons
Stone storage
Theatres without stages

Appendix D: Acronyms

AFF	Available Fire Flow
PE	Pre-application
RFF	Required Fire Flow
DP	Development Permit
IP- DP	Infrastructure Planning – Development Planning section
IP- DA	Infrastructure Planning – Development Approvals section
IP- AP	Infrastructure Planning – Asset Planning section
IP- DE	Infrastructure Planning – Development Engineering section
CD	Construction Drawing
ICI	Industrial, Commercial and Institutional
LOC	Land Use, Outline Plan and Road Closure
FFR	Fire Flow Review
DSSP	Development Site Servicing Plans
DTR	Detailed Team Review
PVC	Polyvinyl chloride
PE	Polyethylene
FUS	Fire Underwriters Survey