APPENDIX 1-C

IMPACTS OF FIRE FLOW DEMAND ON WATER QUALITY TECHNICAL MEMORANDUM

CITY OF GREATER SUDBURY WATER AND WASTEWATER MASTER PLAN

TECHNICAL MEMORANDUM: IMPACTS OF FIRE FLOW DEMANDS ON WATER QUALITY

CITY OF GREATER SUDBURY

DRAFT

PROJECT NO.: 121-23026-00
DATE: MARCH 2016

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1 INTRODUCTION

The City of Greater Sudbury (City) retained WSP Canada Inc. (WSP) to complete a Water and Wastewater Master Plan that includes computer modelling to predict the Available Fire Flow (AFF) for different Communities and/or zoning; now and for future Scenarios based on planning forecasts. This document explains the Required Fire Flow (RFF) targets used in this Master Plan, based on a framework that is:

— Informed by current Ontario guidelines and trends in similar municipalities;
— Calculated to contribute to public safety without adding an excessive additional flow to reduce property damage; and,
— Balanced against the need to avoid a negative impact on water age and quality that can result from over-sizing distribution mains to provide larger fire flows.

2 REQUIRED FIRE FLOWS FOR THE GREATER SUDBURY MASTER PLAN

In this section, WSP provides its recommendation regarding the RFF for residential and institutional, commercial and industrial (ICI) zones within the City. A justification of the recommended rates is also provided based on an analysis of RFF and AFF for existing and significant buildings in the City.

Please note that the RFF targets are used to evaluate the current state of the system in terms of its ability to supply the AFF, by producing maps that compare the AFF for each property to the RFF based on zoning. The overall goal is to rationalise and improve the system over a period of years to decades, improving the level of service and the AFF to multiple properties on a cost-benefit and prioritisation basis. The objective of the Master Plan is not to comment on specific properties or to impose requirements on a lot-by-lot basis.

2.1 RECOMMENDED RESIDENTIAL FIRE FLOWS

For residential FFR, WSP recommends using a rate of 75 L/s. This recommended rate is in-line with the City's Engineering Design Manual which stipulates a required fire flow of 75 L/s, including local demand at the node(s) where the fire occurs. The corresponding fire duration for this amount of fire flow needed is approximately 2 hours, per the Water Supply for Public Fire Protection (Fire Underwriters Survey (FUS), 1999). A fire flow rate of 75 L/s is commonly used for residential zones and is in line with the FUS which suggests a range of 67 to 83L/s for a modern residential subdivision.

It is important to note that if the residential dwelling units are attached townhouse groups or apartment buildings, the required fire flow can increase to rates between 100 to 167 L/s or more. For new buildings, the RFF can be reduced significantly by increased building separation, an all-brick envelope and/or 2-hour fire walls between some units – these decrease the exposure risk and total Building area considered by FUS.

Since new building designs can limit the RFF and most existing areas already have this level of service, WSP recommends using the residential fire flow of 75L/s for all residential development.

In computer modeling analyses of the City's water systems undertaken to date, as part of the City's Master Plan, a RFF of 75L/s has been used as the baseline against which AFFs, simulated using the City's water model, have been compared for residential zones. The following numerical categories have been used for the maps and statistics in this Master Plan:

- Less than 65L/s – Needs Improvement (typically occurs at dead-ends or high ground). New mains and/or loops may increase the AFF for key areas.
- 65 to 75L/s – May be achievable by improved operations or maintenance. Relining existing mains or replacing sections with new, larger water mains may also be required.
- 75L/s or above – Meets City Design Criteria and Master Plan objectives.

Based on the gap reports and modelling for the Town of Sudbury and the Valley area, about 75% of residences already have this fire flow capacity, e.g.: AFF is equal to or greater than $RFF_{residential}$. Many of the residential areas not meeting the require fire flows are supplied by a single main along a dead-end and/or located at the high end of their zone elevation. In such instances, lower AFF are often unavoidable.

2.2 RECOMMENDED INSTITUTIONAL, COMMERCIAL OR INDUSTRIAL FIRE FLOWS

Since the City's Engineering Design Manual does not specify a RFF for ICI zones, other sources were considered. The FUS 1999 provides general estimates for Institutional/Commercial/Industrial (ICI) buildings, as follows (brackets show WSP comments):

- Institutional building: 83 to 250L/s (can be reduced using sprinklers and fire separations)
- Commercial building: 233-417L/s (larger values are for older business districts only)
- Industrial building/park: 233L/s (can be calculated for each Building to avoid over-sizing mains)

For each of these, a case-by-case calculation may reduce RFF, and fire mitigation in building design may significantly reduce RFF for new construction. The ICI RFF criterion should not strive to reflect older buildings in a municipality but should instead focus on future buildings. For example, sprinklers or fire-resistive construction are now common for large buildings. The rationale in taking this approach is to avoid requiring excessive pipe sizes (increased water age) and/or zone pressure to supply an occasional (rare) fire flow.

Based on WSP's review of existing and future development in the City, a RFF of 150 L/s is recommended for ICI zones. This recommendation is based on calculations for typical buildings provided in Section 1.3 and is achievable for modern Commercial and Industrial developments; as well as being about mid-way along the FUS range for Institutional buildings.

In all modeling analyses of the City's water systems undertaken to date as part of the City's Master Plan, an average RFF of 150 L/s has been used as the baseline against which AFFs, simulated using the City's water model, have been compared against for ICI zones. The following numerical categories have been used for the maps and statistics produced to date for this Master Plan:

- Less than 130L/s – Needs Improvement (typically occurs at dead-ends or high ground). New mains and/or loops may increase the RFF for key areas. May be acceptable for small buildings.
- 130 to 150 L/s – May be achievable by improved operations or maintenance and/or sufficient on-site fire protection, based on a detailed calculation of the RFF for individual buildings. Sprinkler or foam systems can greatly reduce RFF for specific building types, often below 150 L/s.
- 150 L/s or above – Meets or exceeds the Master Plan criterion for ICI fire flows.

2.3 ZONE-SPECIFIC FIRE FLOW REQUIREMENTS BASED ON FUS CALCULATIONS

The City has constructed and operated its water supply and distribution system over decades, resulting in an existing capacity to supply fire flows to each location in its system. To scrutinise the RFF targets recommended in Sections 2.1 and 2.2, WSP undertook a comparison of RFF and AFF for critical buildings (i.e. buildings that would present a 'worst case fires') in Sudbury. The RFFs are based on calculations per the FUS 1999 and the AFFs are based on the City's water model for the Master Plan. If the AFFs met the RFFs, it would suggest that the recommended RFF rates presented in Sections 2.1 and 2.2 are acceptable for these existing properties.

To gather real-world examples in Sudbury, representative buildings were selected and their respective RFFs were calculated using FUS 1999. The criteria for selecting critical buildings that would present a 'worst case' fire in each zone were that the buildings had to be:

1. Remotely situated from the source of supply or from large mains; and/or,
2. Located at high elevations

The Required Fire Flow Worksheet found in **Appendix B** provides the calculated RFF for each location, shown in Figure 2-1.

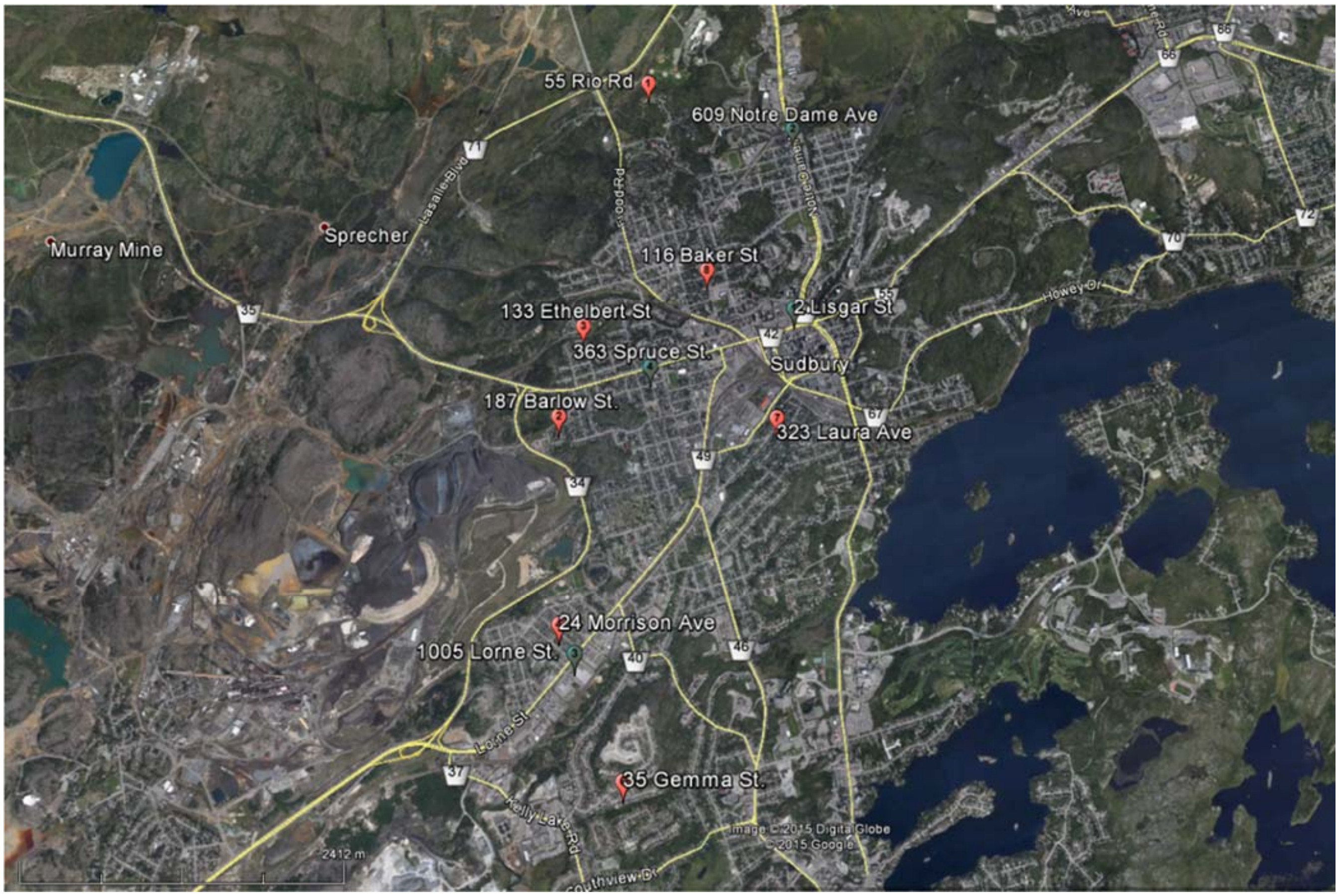

Figure 2-1 Representative Fire Flow Locations[1]

The available fire flow simulated using the City's water model was compared to the representative RFF, revealing that flows in the system currently meet fire flow requirements in most areas of the CGS and that, where they do not meet the RFFs, AFFs are often within 10 L/s. The results from the exercise support the proposed residential (75L/s) and ICI (150L/s) RFF targets presented in Sections 2.1 and 2.2, respectively.

It is important to note; however, that some of the areas with older mains, as well as areas along 150 mm diameter watermains typically do not have the capacity to deliver the required fire flows to meet the recommended fire flows. This is a consequence of the hydraulic conveyance capacity of such smaller mains operating at typical water system pressures.

To improve the FFA in such existing areas, the pipes can be re-lined, additional looping can be provided or (in rare cases) zone pressure can be increased during a fire by using larger pumps. Such measures will be evaluated in the Alternatives report for the Master Plan.

[1] WSP has also identified each representative fire flow location using GoogleEarth Pro file (Sudbury_FireFlow.kmz), enabling anyone with an internet connection to visualize the key locations listed in the RFF worksheet.

3 CONCLUSIONS AND RECOMMENDATIONS

3.1 IN THE SHORT TERM

Based on the calculations and simulations described herein, WSP makes the following conclusions and recommendations;

1. A target fire flow of 75 L/s is recommended for residential zoning, consistent with the City's Engineering Design Manual. This is a basis for comparing computer model predictions and its main purpose is to guide the development of Master Plan alternatives.
2. An overall target fire flow of 150L/s is recommended for institutional, commercial and industrial (ICI) areas. This is a basis for comparing computer model predictions and its main purpose is to guide the development of Master Plan alternatives.
3. The Master Plan provides CGS an opportunity to select a required fire flow calculation method for the subject area – to balance the need for everyday water quality against occasional uses to preserve life and property. This could take the form of an interpretive note for FUS 1999, as discussed in the Appendix, allowing ISO or other references to determine the RFF parameters.

3.2 IN THE LONGER TERM

The following recommendations are based on WSP's review of the criteria used to determine RFF and their governing framework, summarised in Appendix A. In the future, the City may consider the following:

1. Review current by-laws and/or the existing development review process, with a focus on the linkages between the Planning, Building, Public Works and Fire Departments. This review should consider increasing level of detail of different studies prepared in support of water system management and development control. For example:

— At the Master Plan or district plan level, trunk and secondary mains should enable the system to supply the required fire flow while maintaining the best water quality possible, using right-sized mains and looping whenever possible.

— At the Subdivision or Operations plan level, distribution mains (smaller pipes) should ensure distribution Operators will end-up with a system that can maintain good water quality. The RFF should attempt to meet the Master Plan targets using Building separations and/or design features. The modelling report may also include efficient flushing procedures that meet or exceed a shear stress criterion. The net results is to ensure pipes are not too large (e.g.: reduce water age and help maintain its quality) or too small (e.g.: supply the fire flow target or more).

2. Update the development review process to manage the required fire flow targets for each land use. If a proponent's RFF exceed the Master Plan targets and/or the AFF based on a hydrant flow test (whichever is greater), consider adapting Building separations and/or construction methods and enclosing or providing new distribution system loops instead of over-sizing the proposed mains. This can be accomplished in a number of complementary ways:

— Review areas with residential zoning to compare worst-case (capped) fire demands to available fire flows, obtained from computer models. If the predicted "available fire flows" are significantly greater than 75L/s, then consider reducing main diameters in this area when relining or replacing them over the next few decades.

    — The CGS can check that new Buildings' construction and/or fire suppression methods will limit the required fire demands to the target or AFF, whichever is greater;

— Consider implementing a general requirement for 2-hour fire rated walls between groups of no more than 4 dwellings. Alternatively, consider capping the largest residential fire flow to 150L/s. Appendix A shows this has been done in Ottawa and Vancouver; and,

— Buildings requiring fire flows greater than those provided above can be designed with supplemental provisions, such as private sprinkler systems, fire-breaks, etc.

In the context of the Sudbury Water Master Plan, important discussions have already taken place to determine the appropriate level of service and fire flow targets, as documented herein. The target fire flows are benchmarks used to evaluate Alternatives that will improve the "level of service" going forward, balancing the cost of water system improvements to the community and the needs of future developments.

SELECTED BIBLIOGRAPHY

1 MOE Design Guidelines for Drinking Water Systems – 2008;
2 Water Supply for Public Fire Protection, Fire Underwriters Survey (FUS) Guideline – 1999;
3 Water Supply for Public Fire Protection, Fire Underwriters Survey (FUS) Guideline – 1991[2];
4 National Building Code of Canada – 2012;
5 Ontario Building Code – 2013;
6 City of Ottawa Technical Bulletin ISDTB-2014-02;
7 Fire Flow requirements of other municipalities; and,
8 U.S. Fire Administration: Water Supply Systems and Evaluation Methods Volume 1: Water Supply System Concepts – October 2008.
9 Ontario Association of Fire Chiefs Position Paper: "Residential Fire Sprinklers"

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2 The 1991 FUS Guideline makes general recommendations for various types of buildings and establishments which were not included in the most current FUS-1999 document.

APPENDIX

A

CRITERIA FOR REQUIRED FIRE FLOWS

Construction and long term maintenance of underground watermains constitutes a significant portion of municipalities' infrastructure budgets. Watermains are designed to provide two services: i) deliver potable water for domestic use; and, ii) provide flows that are large enough to fight fires.

Part 9 of the Ontario Building Code does not require water be supplied from hydrants to fight fires in "Housing and Small Buildings". Distribution systems are primarily concerned with providing potable water to residents. Fire is secondary to safe drinking water.

Generally, main size is governed by the larger flows required for firefighting and not by peak domestic demand. Although "bigger is better" for fire flows, the result is larger-diameter mains that are costly to maintain and may have negative impacts on water age (and consequently on water quality). The optimal watermain size is a double-bounded problem: the right pipe diameter is neither too small nor too large.

Given that many factors need consideration, designing an optimum distribution system only for fire flow is not possible; however, it is practical to define the minimum acceptable standard for fire protection. It is therefore important to use an "adequate" method of calculating the required fire flows since this will be the governing factor when determining water main diameters.

Determining an adequate fire flow is governed by three (3) hierarchical considerations:

1. Search and Evacuation Flows, to suppress fire and temperature during rescue personnel entry;
2. Defensive Flows, to prevent the spread of fire to neighbouring buildings; and,
3. Offensive Flows, to protect property and to extinguish the fire.

In Ontario, two key documents are used in the determination of the required fire flow: 1) Ontario Building Code (Appendix 3.2.5.7); and, 2) Fire Underwriters Survey (FUS). The focus and limitations of these two documents are briefly described below.

ONTARIO BUILDING CODE (OFFICE OF THE FIRE MARSHAL – ONTARIO)

In Ontario, the only legislated fire flow calculation method is the Ontario Building Code (OBC) Method. This method was developed by the Office of the Fire Marshal for Ontario, based on input from various water distribution supply authorities such as the American Water Works Association (AWWA), Insurers Advisory Organization, and the Ministry of Housing - Building Branch to name only a few. An important fact that should be noted however is that the OBC method only requires that water be supplied to Part 3 Buildings for firefighting. Buildings described in Part 9 of the Code: "Housing and Small Buildings" are not subject to code compliance and do not require "adequate water supply for firefighting".

Furthermore, the OBC method identifies that its primary purpose is to provide "adequate fire protection water supply to support evacuation and fire department search and rescue operations during a fire, and prevent fire spread to other buildings." These are the first two considerations when providing fire flow.

The OBC and Fire Marshal's Office clearly state that with regard to firefighting, their method is "not intended to provide the optimum for property protection", and that since it is focused on establishing a minimum requirement for search and evacuation procedures, those concerned with water supply for the protection of property or the potential for significant environmental impacts should consider alternative calculation methods, such as the Fire Underwriters Survey (see next section).

FIRE UNDERWRITERS SURVEY (FUS)

The Fire Underwriters Survey (FUS) publishes the most common method for the calculation of the required fire flow in Ontario since it is used as a basis for setting insurance rates in Ontario Municipalities. The FUS method is also endorsed by reference in the Ontario Building Code and the Ministry of the Environment Design Guidelines for Drinking Water Systems. The latest version of the FUS Guidelines is 1999.

The FUS method is primarily based on a method developed by the Insurance Services Office (ISO). The ISO method was derived from empirical data gathered from an analysis of 32,000 fires in the late 1960's and early 1970. The ISO method provides a flowrate that is primarily designed to confine a fire to the building of origin, but not to necessarily to attack the fire. Modifications to the ISO procedure by the FUS include additional flow compensation for exposures.

Depending on the engineer and/or municipal bylaws and/or reviewer, different interpretations of the FUS Guideline can result in significant variations in the required fire flows. In extreme cases, calculated fire flows cannot be obtained from the existing water system and hydrants without significant upgrades.

DISCUSSION

The Ontario Building Code method is the only legally enforceable method for calculating minimum required fire flows. With the exception of local municipal by-laws and/or policies, there is no other legislated requirement to provide fire protection for buildings from distribution system hydrants. As stated above, the primary purpose of a municipal system is to distribute potable water for consumption.

Interest in providing protection to one's property, especially in the case of commercial properties, and or instances where significant environmental impacts could result from fire, has led many municipalities to incorporate the delivery of fire flows to all buildings into their by-laws as a means to provide additional service to their residents and businesses; however, this additional feature competes with the basic purpose of the distribution system: to provide high quality potable water.

If water is to be provided for firefighting purposes, it is incumbent on each municipality to determine what it deems to be an "adequate" provision for fire flows without compromising the primary need to maintain high water quality standards. In the real-world, that means limiting the fire protection 'wish' to avoid excessively large watermains in order to maintain the highest water quality possible and practical.

BALANCING FIRE AND DOMESTIC DEMANDS

The smallest practical watermain diameter is optimal for best water quality but it must typically be up-sized to convey the required fire flow. Each standard watermain size (diameter) adds an exponentially-greater amount of cross-sectional area and volume, reducing velocities and increasing water age in that part of the system. There is a practical limit to the amount of additional flow that is 'optimal' overall.

The practicalities affect the assumptions and/or the parameter selections used in the calculations used to determine the required fire flow using FUS or other methods. Key factors are discussed separately below.

BUILDING CONSTRUCTION

In its prescriptive standards on fire protection, the Ontario Building Code (OBC) makes certain assumptions regarding the firefighting ability of a municipality. By its own declaration (OBC Appendix A, Section A-3, pg15) the code acknowledges that firefighting capability can vary from municipality to municipality.

Similarly, the OBC was not developed with any particular required fire flow method in-mind, including the FUS method, and as a result, confusion exists within the Ontario design community. For example, in the determination of fire areas, the FUS references the use of 2-hour fire rated walls as defined by the National Building Code (NBC) of Canada – not the OBC.

Whereas the OBC requires that 2-hour fire rated walls be provided to subdivide townhomes into areas no greater than 600m2, the *building area* in the OBC is defined as "*the greatest horizontal area of a building above grade*", whereas the FUS calculation method evaluates the total area above grade. The result is that in some cases, the area used for calculation of the required fire flow can reach up to 1,800m2 which by FUS calculations would require an enormous amount of water (>330L/s with exposures).

Architects are generally unaware of the FUS calculation method and, in following the OBC, they are trying to design a fire-safe building; however, OBC design criteria can result in excessive fire flow requirements.

CAPPING FIRE FLOW REQUIREMENTS

As a practical matter, a municipality can decide the level of service it will provide over-and-above mandated provincial regulations, if any. With respect to fire flow requirements, higher levels of protection against property loss can be achieved in one of two ways:

1 Require the owner/developer to improve the building design (additional firewalls, reduced size, sprinkler systems, etc…); or,
2 Provide large pumps and mains or additional firefighting capacity (fire stations, trucks and/or personnel …).

A municipality can review each building application and determine whether construction can proceed or, if the calculated required fire flows are excessive, whether some form of concession is required in the form of building improvements to limit the required fire flow so it can be delivered by existing water distribution infrastructure and its planned expansion into a new service area, if any.

CITY OF OTTAWA EXAMPLE

Like many fast-growing Ontario municipalities, the City of Ottawa struggled to bridge the gap between required fire flows (as calculated by the FUS method) and their goal of maximising water quality. Recognizing the need to limit the size of mains to avoid excessive water age, the City did two things to safely reduce the required fire flows (see appendix):

1. It specified additional construction criteria for single detached dwellings and traditional side-by-side town and row houses and, if these conditions are met, limited the required fire flow for these dwellings to 167 L/s or 10,000L/min[3];
2. If the above buildings could not meet the 167L/s criterion, their design was to be modified such that their required fire flows be satisfied by mains with a nominal diameter no greater than 200mm.

The balance between what any one municipality considers "adequate" fire protection for search and evacuation (or more), and their responsibility to provide safe drinking water is not easy. For the City of Ottawa, capping residential mains to 200mm provides "adequate" fire protection.

CITY OF VANCOUVER EXAMPLE

In a position paper on: "Residential Fire Sprinklers", the Ontario Association of Fire Chiefs cites the enactment of by-law by the City of Vancouver requiring residential sprinklers in all residential buildings, including low-density housing. The paper also states that 220 North American jurisdictions have provisions that require residential sprinklers in residential buildings.

The rationale is that sprinklers lower the temperature inside a building on fire, directly supporting the first two objectives stated in Section 1: search-and-rescue and prevention of spread. A sprinkler-equipped building receives a credit that reduces its required fire flow, using the FUS method. This enables designers to safely reduce some watermain diameters.

[3] 167 L/s is a typical fire flow rate achievable with a 200 mm diameter main and the required fire flow recommended in the 1991 FUS Guide for modern row townhouses.

APPENDIX

B REQUIRED FIRE FLOW WORKSHEET

121-23026-00

REQUIRED FIRE FLOW WORKSHEET

Building Information				System Type							Contents Information		Exposure Charge[2]									Unadjusted Flow (F=220C sqrt A)			Correction Factors				Required Fire Flow (RFF)	
													East		West		North		South											
ID: Building	Footprint Area (m^2)	# of Storeys[1]	Construction Class	NFPA 13 Sprinkler	Credit (%)	Standard Water Supply	Credit (%)	Fully Supervised	Credit (%)	**Total Credits (%)**	Contents Factor	**Contents Charge**	Distance (m)	Charge (%)	Distance (m)	Charge (%)	Distance (m)	Charge (%)	Distance (m)	Charge (%)	**Total Charges[3]**	C	A (m^2)	F (L/min)	Occupancy	FF Adjusted for Occupancy	Sprinkler Decrease	Exposure Charge	**L/min**	**L/s**
Res1: 58 Nicolet St.	130	2	WF	NO	0	NO	0	NO	0	**0**	LC	**-15%**	3.1 to 10	20	3.1 to 10	20	30.1 to 45	5	over 45	0	**45%**	1.5	260	**5000**	-750	4250	0	1913	**6000**	**100**
Res2: 187 Barlow St.	124	2	WF	NO	0	NO	0	NO	0	**0**	LC	**-15%**	30.1 to 45	5	30.1 to 45	5	3.1 to 10	20	3.1 to 10	20	**50%**	1.5	248	**5000**	-750	4250	0	2125	**6000**	**100**
Res3: 133 Ethelbert St.	142	1	WF	NO	0	NO	0	NO	0	**0**	LC	**-15%**	20.1 to 30	10	30.1 to 45	5	3.1 to 10	20	3.1 to 10	20	**55%**	1.5	142	**4000**	-600	3400	0	1870	**5000**	**83**
Res4: 24 Morrison Ave`	145	1	WF	NO	0	NO	0	NO	0	**0**	LC	**-15%**	30.1 to 45	5	30.1 to 45	5	0 to 3	25	3.1 to 10	20	**55%**	1.5	145	**4000**	-600	3400	0	1870	**5000**	**83**
Res6: 242 Gold Street	153	2	WF	NO	0	NO	0	NO	0	**0**	LC	**-15%**	0 to 3	25	0 to 3	25	30.1 to 45	5	over 45	0	**55%**	1.5	306	**6000**	-900	5100	0	2805	**8000**	**133**
Res7: 323 Laura Ave	156	2	WF	NO	0	NO	0	NO	0	**0**	LC	**-15%**	30.1 to 45	5	20.1 to 30	10	0 to 3	25	0 to 3	25	**65%**	1.5	312	**6000**	-900	5100	0	3315	**8000**	**133**
Res8: 116 Baker St.	145	2	WF	NO	0	NO	0	NO	0	**0**	LC	**-15%**	30.1 to 45	5	3.1 to 10	20	30.1 to 45	5	20.1 to 30	10	**40%**	1.5	290	**6000**	-900	5100	0	2040	**7000**	**117**
Ind1: 2 Lisgar St (National Bank)	816	2	OC	YES	30	YES	10	YES	10	**50**	LC	**-15%**	over 45	0	10.1 to 20	15	30.1 to 45	5	20.1 to 30	10	**30%**	1	1632	**9000**	-1350	7650	3825	2295	**6000**	**100**
Ind2: 609 Notre Dame Ave (Hobby Depot)	136	2	WF	YES	30	YES	10	NO	0	**40**	LC	**-15%**	over 45	0	30.1 to 45	5	10.1 to 20	15	3.1 to 10	20	**40%**	1.5	272	**5000**	-750	4250	1700	1700	**4000**	**67**
Ind3: 1005 Lorne St.	11518	2	NC	YES	30	YES	10	YES	10	**50**	LC	**-15%**	over 45	0	10.1 to 20	15	10.1 to 20	15	over 45	0	**30%**	0.8	23036	**27000**	-4050	22950	11475	6885	**18000**	**300**
Ind4: 363 Spruce St (Spruce St. Pinto)	318	2	WF	YES	30	YES	10	NO	0	**40**	LC	**-15%**	10.1 to 20	15	0 to 3	25	20.1 to 30	10	3.1 to 10	20	**70%**	1.5	636	**8000**	-1200	6800	2720	4760	**9000**	**150**
Inst1: Confederation Secondary School	8946	1	WF	YES	30	YES	10	NO	0	**40**	LC	**-15%**	30.1 to 45	5	30.1 to 45	5	30.1 to 45	5	30.1 to 45	5	**20%**	1.5	8946	**31000**	-4650	26350	10540	5270	**21000**	**350**

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

F = required fire flow in litres per minute.
C = correction for construction, contents and exposure.
A = Total building floor area in m^2 (excluding basements).

Calculation Notes:
1 Includes all storeys, but excluding basements at least 50%
2 Length-Height of the exposure Building is the length of the facing wall (feet) times the height (storeys), if applicable.
3 Maximum exposure charge = 75%
4 Round to Nearest 1,000 L/min.

Construction Class

WF wood frame construction
OC ordinary construction
NC non-combustible construction
FC fire-resistive construction

Contents Factor

NC non-combustible
LC limited combustible
C combustible
FB free burning
RB rapid burning

* Three interpretations of the Fire Underwriters Survey Guideline (Methods A, B, and C) result in a different Required Fire Flow (RFF). The 133L/s RFF in the Master Plan corresponds to the minimum value of 8,000L/min for contiguous buildings (FUS-1999,

**Calculations resulting in similar RFF as those used in the Water Supply and Distribution Operation Master Plan (WSDOMP) for Breslau. Master Plan (3) corresponds to Res5: 483-497 Beaumont Cr., for which 3 alternative caclulations are shown.