GEOGRAPHIC INFORMATION SYSTEM EMERGENCY SERVICES RESPONSE CAPABILITIES ANALYSIS

Final Report

International Association of Fire Fighters
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Oshawa Fire Services

Oshawa, Ontario

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Executive Summary

This report summarizes the results of a station location, staffing, emergency vehicle travel time analysis, and workload analysis for Oshawa Fire Services at the request of the Oshawa Professional Firefighters Association, IAFF Local 465. Oshawa Fire Services (OFS) operates six fire stations and provides emergency response to the City of Oshawa, including fire prevention and suppression, contractual emergency medical services (EMS) first response, technical rescue including high angle, confined space, trench and water, and hazardous materials response. Additionally, OFS provides specialty services response outside of the city of Oshawa.

OFS regularly staffs fire suppression apparatus with four firefighters, which is the minimum required staffing level as outlined in industry standards. The National Fire Protection Association (NFPA®) Standard 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments* requires that fire suppression apparatus be staffed with a minimum crew size of four firefighters.[1] [2] However, despite the fact that the department meets the minimum objectives of the industry standard, it does not necessarily mean that the city is adequately resourced to meet demand and or address emergencies in certain structure types. Portions of this report are meant to provide information and resources to decision makers regarding the importance of safe staffing levels on apparatus whose primary function is fire suppression.

OFS' newest fire station, Station 6, opened in July 2016 which improved OFS' access to the growing and underserved northern region of Oshawa. To provide and staff a pumper apparatus deploying from Station 6 with four firefighters, OFS re-assigned personnel and apparatus from Station 3, rather than increasing minimum per-shift staffing. As a result, one pumper apparatus (Pumper 211) was placed out of service at Station 1 and one aerial apparatus (Aerial 23) was shifted from Station 3 to Station 1, reducing Station 3 to one staffed suppression apparatus.[3] Previously, the two pumper companies deploying from Station 1 were the busiest in the department, serving the area with the highest call volume. In April of 2017, Aerial 23 was shifted back to Station 3, leaving only a single suppression apparatus, Pumper 21, at Station 1.

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[1] "In jurisdictions with a high number of incidents or geographical restrictions, as identified by the authority having jurisdiction (AHJ), these companies shall be staffed with a minimum of five on-duty members." NFPA 1710, §5.2.3.1.2

[2] "In jurisdictions with tactical hazards, high-hazard occupancies, or dense urban areas, as identified by the Authority Having Jurisdiction (AHJ), these companies shall be staffed with a minimum of six on-duty members." NFPA 1710, §5.2.3.1.2.1 and §5.2.3.2.2.1

[3] For the purposes of this report, as documented in Oshawa dispatch data, OFS began responding from Station 6 in July 2016 and Pumper 211 ceased daily responses in July of 2016. Also, on July 19, 2016 continuing until April 9, 2017 Aerial 23 was moved from Station 3 to Station 1. Prior to July 19, 2016, Pumper 21 and Pumper 211 responded from Station 1 and were each staffed with 4 firefighters at all times. Pumper 23 and Aerial 23 responded from Station 3 and were also each staffed with 4 firefighters at all times. On April 10, 2017 continuing to the present, Aerial 23 was moved back to Station 3, leaving only Pumper 21 at Station 1.

This report examines how this strategy for staffing Station 6, reassigning personnel rather than increasing on-duty staff, effected the department's emergency response capabilities. This report also assessed the risk present within Oshawa to provide necessary context for the analysis of OFS' staffing and deployment configuration and response capabilities, and as a utility to decision makers tasked with maintaining the services that mitigate emergencies in the community.

Response Analysis and Methodology

Analysis was performed to examine the OFS' past workload and response performance. OFS provided computer-aided dispatch (CAD) data for all emergencies responded to by OFS from January 1, 2015 to December 31, 2017. The CAD data contain, but are not limited to, information about the type of emergency, the address and geographic coordinates of the incident, the responding apparatus, the geographic coordinates of the responding apparatus at the time of dispatch, the time the call was received, dispatch time, en route time, time of arrival on location, the returning time, and the in-quarters time. The workload analysis examined the CAD data to assess the call volume, evaluate the department's historical response capabilities, and determine the possible need for additional resources.

The department's workload was evaluated using several parameters, including the total number of incidents and apparatus responses per year, when the highest volume of incidents and apparatus responses occurred throughout the day, the number of times a station's apparatus responded within another station's first-due district, and the 90th percentile travel times of the first arriving OFS apparatus. These factors were examined to determine how changes in deployment and apparatus placement have affected OFS' response capabilities and how performance may be improved through the implementation of staffing and deployment enhancements.

Using Geographic Information Systems (GIS), analysis was performed to evaluate response capabilities under OFS' current staffing and deployment configuration and how OFS' response capabilities may improve if deploying one additional fire suppression apparatus at Station 1, staffed in accordance with NFPA 1710 minimum staffing objectives. Using historical traffic patterns,[4] analysis was performed to examine the department's ability to meet industry standard response requirements such as 4-minute initial unit arrival, the establishment of a minimum of four personnel at an incident scene within 4 minutes, and the assembly of the minimum numbers of personnel required for low-, medium-, and high-hazard structure fires.[5] [6] [7]

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[4] Historical traffic data contained in ESRI's StreetMap Premium, version 17.2.

[5] A "typical, residential structure fire" is one occurring in 2000 sq. ft. (186 sq. m) single-family dwelling without basement and with no exposures.

[6] NFPA 1710 defines medium-hazard structures as open-air strip shopping centers and three-story, garden style apartment buildings.

[7] A "high-hazard occupancy" is one that "presents a high life hazard or large fire potential due to its construction, configuration, or the presence of specific materials, processes, or contents." NFPA 1710, §3.2.28

Key Definitions

As stated above, an examination of the department's historical call volume data (January 1, 2015 to December 31, 2017) was completed to evaluate the OFS' response capabilities and performance. The following definitions were created to identify terminology used in the department's CAD reporting system and specific characteristics used to evaluate the department's performance.

Incident: refers to an emergency to which fire department mobile and personnel resources are dispatched to intervene and mitigate. An incident may require a single or multiple apparatus to respond.

Response: refers to an individual unit, or units, being dispatched and traveling to the scene of an incident.

First-due District: refers to a fixed geographical area established by the department's administration that contains a fire station and that is typically served by the personnel and apparatus assigned to that station.

Call Time: refers to the time when the alarm (request for emergency) is answered by the dispatch center.

Dispatch Time: refers to the time when units and personnel are assigned to an incident.

En Route Time: refers to the time when units and personnel are beginning their travel to the emergency.

On Location Time: refers to the time when the assigned units and personnel arrive at the incident location.

Travel Time: refers to the time interval that begins when a unit is en route to the emergency scene and ends when the unit arrives at the scene.[8]

Response Time: refers to the time interval that begins with call time and ends with on-scene arrival time.

Returning Time: refers to the time when a unit leaves the emergency location.

In-quarters Time: refers to the time when a unit arrives back at the station after response.

[8] NFPA 1710 §3.3.53.7 (2016)

90th Percentile: refers to the value below which 90% of observations fall.

The following definitions were created to identify fire service related terminology used in the some of the literature cited in this document that may differ from terminology typically used in Oshawa.

Company: as defined in NFPA 1710, refers to "A group of members…usually organized and identified as engine companies, ladder companies, rescue companies, squad companies, or multi-functional companies…arriving at the incident scene on fire apparatus." [9] In Oshawa the term "crew" is used for company.

Engine Company: as defined in NFPA 1710, refers to "fire companies whose primary functions are to pump and deliver water and perform basic fire fighting at fires, including search and rescue."[10] In Oshawa the term "pumper" is used for engine.

Ladder or Truck Company: as defined in NFPA 1710, refers to "fire companies whose primary functions are to perform the variety of services associated with truck work, such as forcible entry, ventilation, search and rescue, aerial operations for water delivery and rescue, utility control, illumination, overhaul, and salvage work." [11] In Oshawa the term "aerial" is used for ladder or truck.

Key Findings

- OFS suppression apparatus regularly deploy with four firefighters, the minimum required by industry standards.

- Based on this GIS assessment of the areas within the Oshawa city limits, OFS is only able to respond with a suppression apparatus on 66.7% of roads within Oshawa within 4 minutes. The arrival of the first arriving pumper apparatus within 4 minutes is the standard for safe, effective, and efficient operations at a fire suppression event. NFPA 1710 requires a minimum of four firefighters on each suppression apparatus and that the first arriving apparatus be on scene in 4 minutes or less of travel time to 90% of incidents.[12]

- NFPA 1710 requires a minimum of 14 firefighters and 1 command officer to arrive on the scene of a fire occurring in a typical 186-square meter residential structure within 8 minutes

[9] NFPA 1710 §3.3.13 (2016)
[10] NFPA 1710 §5.2.3.1 (2016)
[11] NFPA 1710 §5.2.3.2 (2016)
[12] Percentages (response capabilities for both existing, and recommended configurations) given in this document are based on a desire to cover one hundred percent of all road segments within a fire department's total response area. These percentages are used as a proxy for the percentage of incidents covered, as it is impossible to predict where all of a jurisdiction's future emergencies will occur. Therefore the emergency response capabilities as are presented herein are represented by the portion of all road segments able to be reached within the specified time parameters.

of travel to 90% of incidents. Currently, OFS is only able to provide for the arrival of 15 firefighters on 53% of roads within the Oshawa within 8 minutes. Pursuant to implementing staffing and deployment recommendations, the department would likely be able to assemble a minimum of 15 firefighters within 8 minutes of travel on 64% of city roads, which equates to a 20.8% increase in response coverage.

- OFS' standard initial alarm for a structure fire consists of 2 pumper apparatus (4 firefighters each), 1 aerial apparatus (4 firefighters), and 1 platoon chief, for a total of 13 firefighters. As stated above, NFPA 1710 requires a minimum of 14 firefighters and 1 command officer to arrive on the scene of a low-hazard structure fire for 90% of incidents. Based on the department's current alarm response to a structure fire, OFS does not dispatch the required minimum 15 firefighters to meet this requirement.

- NFPA 1710 requires a minimum of 26 firefighters and 1 incident commander with an aide to arrive on the scene of a medium-hazard structure fire within 8 minutes of travel to 90% of incidents, for a total of 28 responders. As the department does not provide medical transport, it is responsible for sending a minimum of 26 personnel.[13] Currently, OFS is able to provide for the arrival of 26 firefighters on 2.5% of city roads within 8 minutes of travel. Pursuant to implementing staffing and deployment recommendations, the department would likely be able to assemble a minimum of 26 firefighters within 8 minutes of travel on 13% of city roads, which equates to a 420% increase in response coverage.

- NFPA 1710 requires a minimum of 43 firefighters to arrive on the scene of a high-hazard structure fire within 10 minutes 10 seconds of travel to 90% of incidents. As the department does not provide medical transport, it is responsible for sending a minimum of 39 firefighters.[14] Currently, OFS is not able to provide for the arrival of 39 firefighters on any roads within Oshawa within 10 minutes 10 seconds of travel. Current OFS on-duty minimum shift staffing includes 32 firefighters and 1 platoon chief.

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[13] OFS does not provide medical transport. Therefore, the department would be required to arrive with 24 firefighters, 1 incident commander, and 1 chief's aide to a medium-hazard structure fire. NFPA 1710, §5.2.4.2.1 (9) requires, "The establishment of an initial medical care component consisting of at least two members capable of providing immediate on-scene emergency medical support and transport that provides rapid access to civilians or members potentially needing medical treatment. Where this level of emergency medical care is provided by outside agencies or organizations, these agencies and organizations shall be included in the deployment plan and meet these requirements".

[14] In addition to 39 firefighters, "The provision of a minimum of two crews trained in emergency medical services with on-scene transport capability, each crew with a minimum of two members. At least one of the members shall be trained to the ALS level" NFPA 1710, §5.2.4.4.1.17. Due to emergency medical transport capabilities within Oshawa being provided by an entity other than OFS, the calculation of OFS' response capabilities counted only 39 personnel. Agencies outside of OFS that possess emergency medical transport capabilities should be included in the deployment plan to meet NFPA 1710 High-Rise Initial Full Alarm Assignment requirements.

- From January 1, 2015 to December 31, 2017, there was an approximate 17.8% increase in the total number of incidents[15] and a 19.8% increase in the total number of apparatus responses.[16] The highest volume of incidents and apparatus responses took place between the hours of 8:00 A.M. and 10:00 P.M.

- From January 1, 2015 to December 31, 2017, for each year individually and the three-year span, the highest volume of incidents and apparatus responses occurred in First-due District 1.

- NFPA 1710 states that the first arriving apparatus should be on scene within 4 minutes of travel to 90% of structure fire incidents.[17] From January 1, 2015 to December 31, 2017, the 90th percentile travel time was 6 minutes. Based on these results, OFS did not meet NFPA 1710 travel time requirements during this time period.

- From January 1, 2015 to December 31, 2017 the highest concentrations of incidents where the first arriving apparatus had a travel time greater than 4 minutes were in the southern part of First-due District 1, near the border of First-due District 2. However, incidents where the first arriving apparatus had a travel time greater than 4 minutes occurred throughout the city. Occurrences of such incidents increased during the three-year period in all first-due districts, with the exception of First-due District 6.[18] During this time period, 20.8% of the fire suppression incidents located within OFS' response boundary had a travel time greater than 4 minutes for the first arriving apparatus.

- Occurrences of fire suppression incidents where the first arriving apparatus had a travel time greater than 4 minutes increased in First-due Districts 2 and 3, decreased in First-due Districts 4, 5, and 6, and remained unchanged in First-due District 1. First-due District 1 had the highest volume of fire suppression incidents where the first arriving apparatus had a travel time greater than 4 minutes each of the three years.

- Pumper 21 and Pumper 211, both deploying from Station 1, were engaged in the most responses from January 1, 2015 until Pumper 211 was decommissioned in July of 2016.

- When Pumper 211 was decommissioned in July of 2016, Aerial 23 was shifted from Station 3, reducing Station 3's response capacity from two suppression apparatus, staffed with four firefighters each, to a single suppression apparatus, staffed with four firefighters. During the time period from July 19, 2016 to April 9, 2017, when only a single suppression

[15] Only incidents responded to by OFS were considered when calculating total incidents.
[16] Only responses performed by OFS' apparatus were considered when calculating the total apparatus responses.
[17] "240 seconds or less travel time for the arrival of the first arriving engine company at a fire suppression incident." NFPA 1710, §4.14.2.1(3).
[18] Station 6 did not open until July 2016; therefore, there was not a full set of data on which to base this conclusion.

apparatus deployed from Station 3, substantial increases were seen in responses by units from other stations into Station 3's first-due area. Most of those responses came from Station 1, which increased responses into Station 3's first-due area by 62.9% during this time. Overall, the percent of total responses into First-due District 3 by units from other stations other than Station 3 was 45.4%.

- April 10, 2017, Aerial 23 shifted back to Station 3, reducing Station 1's response capacity from two suppression apparatus, staffed with four firefighters each, to a single suppression apparatus, staffed with four firefighters. During the time period from April 10, 2017 to December 31, 2017, when only a single suppression apparatus deployed from Station 1, substantial increases were seen in responses by units from other stations into Station 1's first-due area. Most of those responses came from Station 2, which increased responses into Station 1's first-due area by 69.8% during this time, and Station 3, which increased responses into Station 1's first-due area by 149%. Overall, the percent of total responses into First-due District 1 by units from other stations was 41.3%.

- As part of the risk assessment, a statistical analysis based on historical incidents and census data identified the characteristics that are associated with areas of having a high likelihood of an incident occurring. The results show that the likelihood of structure fire incidents occurring increases as:
    - The number of buildings built before 1960 *increases*
    - The population of residents with no certificate, diploma or degree *increases*
    - Median Total Income *decreases*
    - The population of renters *increases*
    - The number of private dwellings *increases*

- The analysis results also show that the likelihood of medical emergencies occurring increases as:
    - The number of buildings built before 1960 *increases*
    - The population of residents over the age of 65 *increases*
    - The population of residents with no certificate, diploma or degree *increases*
    - The population of residents who are government transfer recipients *increases*
    - The population of renters *increases*
    - The number of total dwellings *increases*

- The census tracts having the highest populations and highest volume of buildings associated with greater risk probability are all located in Oshawa approximately south of Taunton Road, in the first-due areas of Stations 1, 2, 3, 4 and 5.

Recommendations

- OFS should modify the initial alarm response to a low-hazard structure fire to ensure an initial response of a minimum of 15 firefighters.

- OFS should consider increasing staffing to five or six firefighters on frontline suppression apparatus to meet NFPA 1710 staffing objectives for response to tactical hazards, high-hazard occupancies, and in dense urban areas. [19]

- The IAFF's GIS-based recommendations include adding an additional suppression apparatus staffed with a minimum of **four multi-role firefighters** at all times to Station 1. The addition of this suppression apparatus, staffed with four, will increase on-duty minimum shift staffing to 36 firefighters and 1 platoon chief. The additional suppression personnel will increase OFS' ability to respond in accordance with NFPA 1710 minimum staffing objectives to low- and medium-hazard structure fires.

- OFS should identify where high-hazard structures are located and add additional resources in these areas to possibly increase the department's ability to assemble a minimum of 39 firefighters within 10 minutes and 10 seconds of travel.

- The department and OFS should also address deficiencies in response capabilities in the areas of Oshawa most susceptible to the possibility of future emergency incidents.

- OFS should routinely perform risk and hazard assessments, along with a review of system demand, to identify the potential threats to the community so that stakeholders and decision makers can make informed decisions on how to best mitigate, or at least minimize, these threats.

[19] NFPA 1710, §5.2.3.1.2.1 and 5.2.3.2.2.1.

Executive Summary Conclusion

This analysis assessed the capabilities of Oshawa Fire Services when staffed at current and recommended levels. Geographic assessment of the department's staffing and deployment model demonstrated that resources are not adequately concentrated or distributed to provide emergency response within most areas of Oshawa in and effective and timely manner. OFS' response capabilities do not meet objectives included in the industry standard NFPA 1710 which directs the assembly of 15 firefighters to a low-hazard structure fire and 28 firefighters to a medium-hazard structure fire within 8 minutes of travel, and 43 firefighters to a high-hazard structure fire within 10 minutes 10 seconds of travel, to 90% of incidents. Insufficient numbers of staffed suppression apparatus result in the department's emergency response capabilities being significantly limited. Furthermore, OFS' initial alarm for a structure fire does not dispatch the required minimum 15 firefighters to meet the NFPA 1710 requirement.

Analysis of CAD data detailing OFS responses from January 1, 2015 to December 31, 2017 revealed that the 90th percentile travel time for the first arriving apparatus on scene was 6 minutes. NFPA 1710 states that the first arriving apparatus should be on scene within 4 minutes of travel to 90% of fire suppression incidents. Geographic analysis of the locations of the incidents where the first apparatus on scene had a travel time greater than 4 minutes revealed that the highest concentration of these incidents was in the southern part of Station 1's first-due area. Although the greatest number of these incidents occurred in Station 1's first-due area, such incidents were spread throughout the city. During the three-year study period, Stations 2 and 3 experienced an increase in the number of incidents where the first arriving apparatus had a travel time greater than 4 minutes in their first-due areas.

Analysis of the CAD data indicated that demand on Pumper 23, at Station 3, increased following the opening of Station 6 and the redeployment of Aerial 23 to Station 1. The CAD also indicated that following the reduction of staffed apparatus deploying from Station 3, responses by units from other stations into Station 3's first-due area increased. The greatest such increase was from Station 1, which saw responses into Station 3's first-due area increase by 62.9%. Similarly, analysis of the CAD data indicated that demand on Pumper 21, at Station 1, increased following the redeployment of Aerial 23 to Station 3. The CAD also indicated that following the reduction of staffed apparatus deploying from Station 1, responses by units from other stations into Station 1's first-due area increased. The greatest such increase was from Station 3, which saw responses into Station 1's first-due area increase by 149% during the period when only one suppression apparatus was deployed from Station 1.

The risk assessment performed for this report defined the nature of risk in the Oshawa community. Analysis examined historical incident location, demographic, and building data and identified several demographic and building characteristics that are linked to a high probability of the occurrence of structure fires or medical emergencies occurring in the future. Consideration of the risk assessment results and the historical inability of OFS to meet the objectives of NFPA 1710 suggests that additional suppression capacity should be added to Station 1, so resources and response capabilities are located properly to address the risk in that area. Data shows that Oshawa is a growing city and some areas of the city have higher concentrations of vulnerable populations.

OFS does not currently meet performance objectives outlined in industry standards. This increases risk to the residents of and visitors to Oshawa. The information in this document is designed to help decision makers understand the depth of fire department operations and how proper OFS staffing and deployment can help ensure safe and effective emergency response.

Risk Assessment

A significant part of planning for future fire department deployment is identifying the risks, hazards, and vulnerabilities in the community so that emergency responders and resources are adequately positioned to respond when emergencies inevitably occur. This risk assessment is intended to help create context for an assessment of Oshawa Fire Services' current staffing and deployment configuration, a component in OFS' role of providing safe and effective emergency response for the residents of, and visitors, to Oshawa. The risk assessment itself can be broken into four components:

- An examination of the demographic characteristics of the community.
- A spatial examination of historical response patterns of OFS.
- A statistical risk assessment to calculate risk probability.
- An examination of fatal fire incidents that have occurred in Oshawa.

These four sections, taken as a whole, should serve as a key factor in the process of ensuring that personnel and resources are positioned and deployed adequately to safely and effectively address emergencies occurring throughout Oshawa.

Demographic Profile

Oshawa is approximately 61 kilometers east of Toronto in the province of Ontario, located on the shores of Lake Ontario. Oshawa's census metropolitan area (CMA) had a population of 379,848 in 2016 and was the fourteenth largest CMA in Canada, according to Statistics Canada.[20] The city itself had a population of 159,458 residents in 2016, a land area of 145.64 square kilometers, and an average population of 1,094.9 residents per square kilometer.[21] Since the 2011 census, the population of Oshawa has grown by 6.6%.[22] In 2016, the median age of residents was 41.2 years.

Further assessment of the 2016 census revealed that 22.0% of the population was in a vulnerable category based on age. This category consists of persons under the age of 5 (5.5%) and persons who are 65 years of age and older (16.5%).[23] These populations typically place an increased demand on public safety resources because these groups are at a higher risk of fire-related injury

[20] Statistics Canada. 2017. *Oshawa [Census metropolitan area], Ontario and Ontario [Province]* (table). *Census Profile*. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017. http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed January 31, 2018).
[21] Statistics Canada. 2017. *Oshawa, CY [Census subdivision], Ontario and Durham, RM [Census division], Ontario* (table). *Census Profile*. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017.
http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed January 31, 2018).
[22] Ibid.
[23] Ibid.

and death because of their inability, or reduced ability, to evacuate in an emergency situation. These groups may also be unable to care for themselves or have multiple health issues. Additionally, for the 2015 calendar year, 14.5% of the population was considered low-income based on the low-income measure, after tax (LIM-AT), including 22.5% of the population aged 5 and below, and 9.6% of the population 65 years and over.[24] [25] These are residents who generally lack the means to properly maintain residences which can lead to an increased risk for fire.

The city had a total of 62,595 occupied private dwellings of which 55.6% were single-detached houses, 11.5% were apartment buildings with 5 or more storeys, and 32.9% were other attached dwellings.[26] Of these 62,595 structures, 26.1% were built in 1960 or earlier.[27] Typically, vacant housing and older buildings constructed before fire codes were developed can lead to an increased demand on emergency services.

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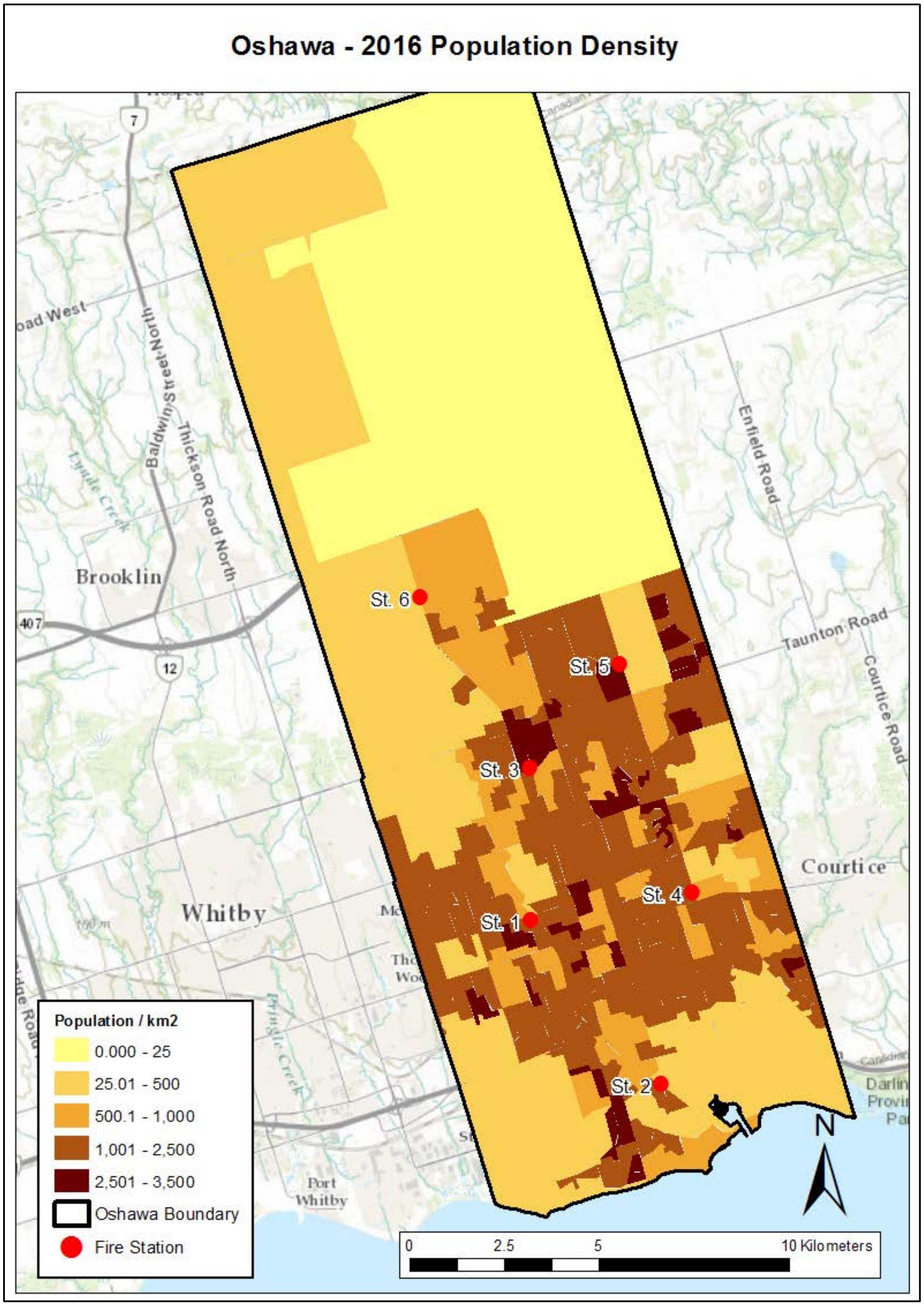
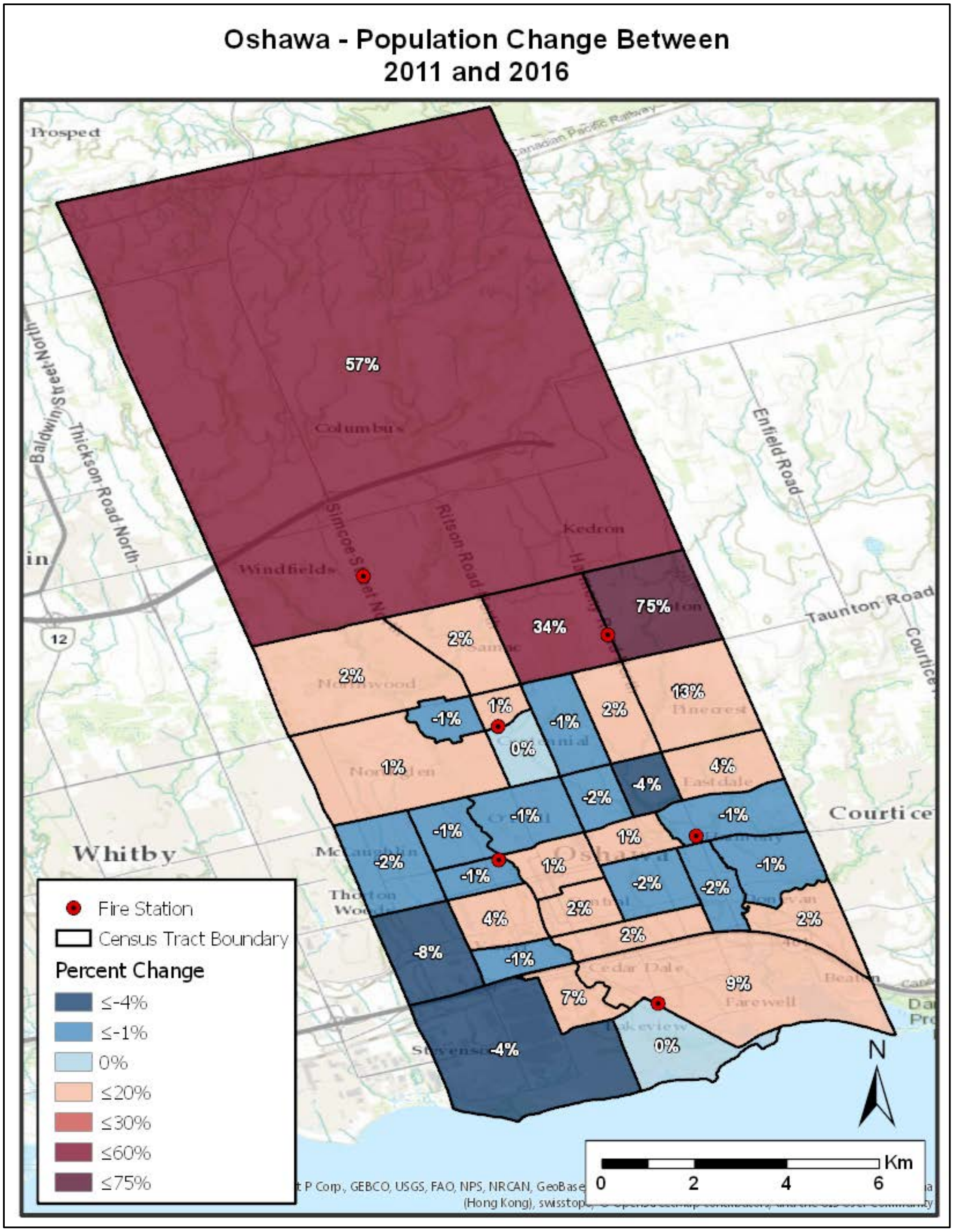
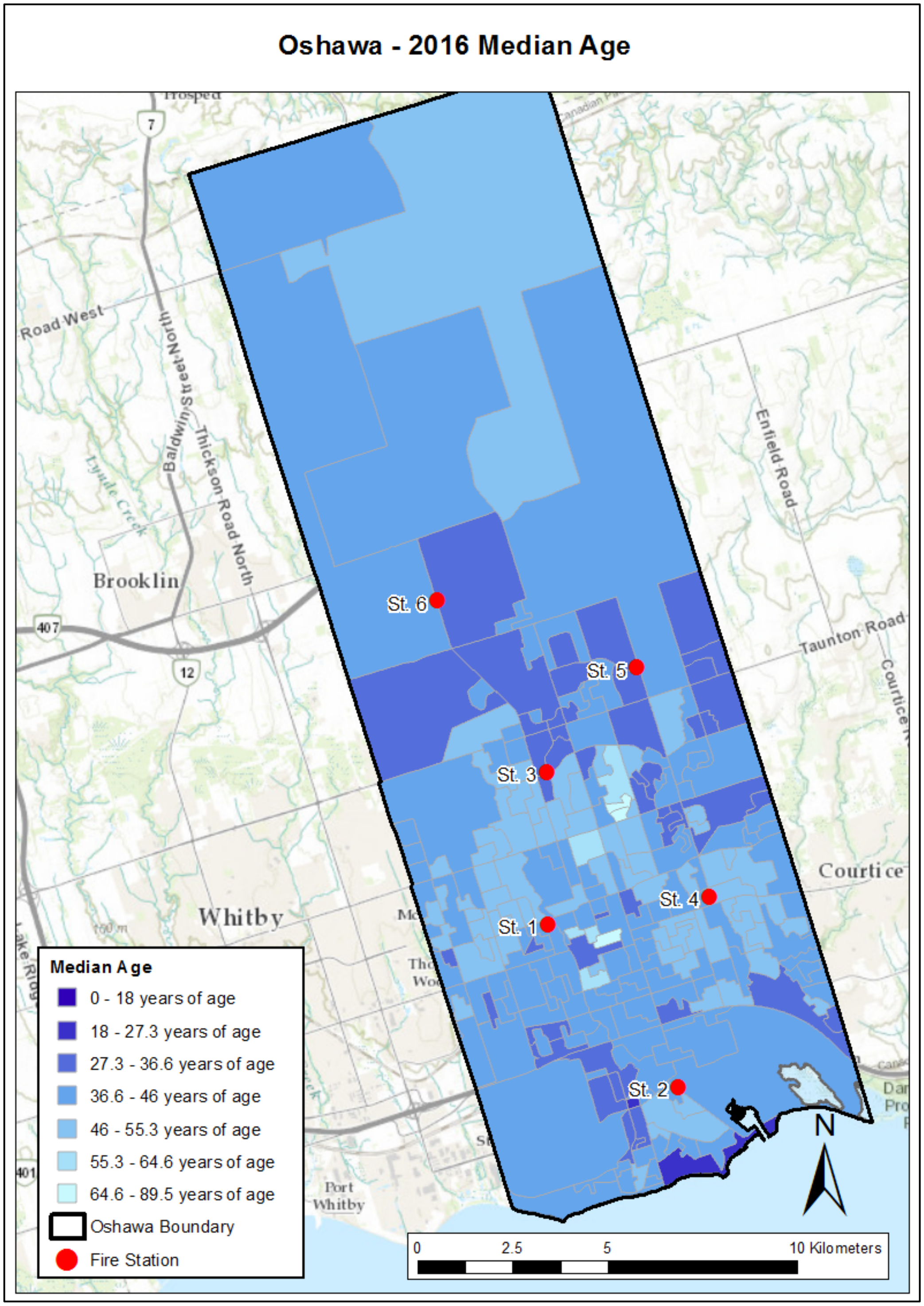
[24] Statistics Canada. 2017. *Oshawa, CY [Census subdivision], Ontario and Durham, RM [Census division], Ontario* (table). *Census Profile*. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017.
http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed January 31, 2018).
[25] Low-income status for the 2016 Census was based on the 2015 calendar year.
[26] Statistics Canada. 2017. *Oshawa, CY [Census subdivision], Ontario and Durham, RM [Census division], Ontario* (table). *Census Profile*. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017.
http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/index.cfm?Lang=E (accessed January 31, 2018).
[27] Ibid.



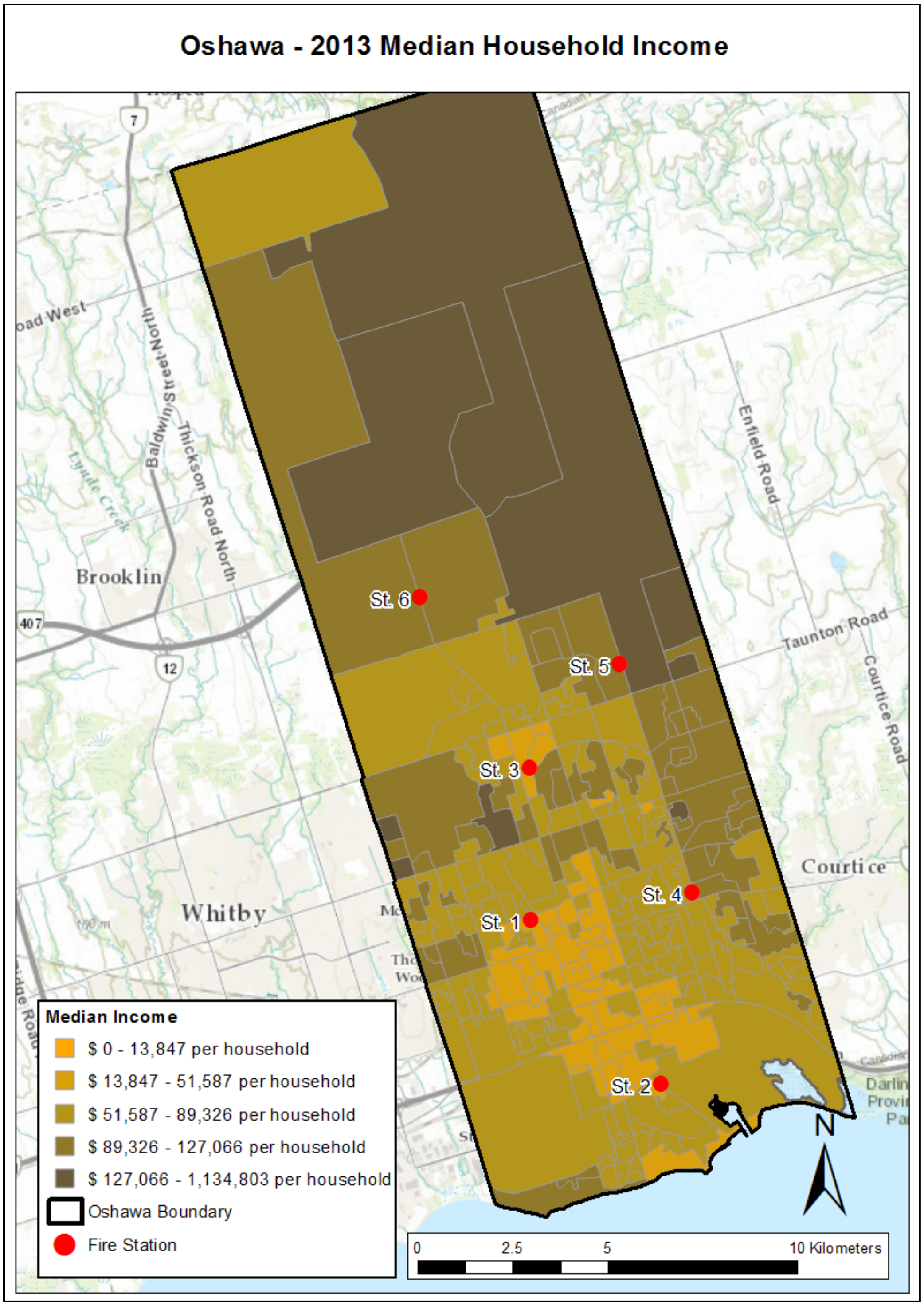
Map 1: Oshawa – 2016 Population Density. Map 1 depicts Oshawa's population per square kilometer based on the 2016 census. The geographic units dividing Oshawa on the map are referred to as census dissemination areas. Also indicated are OFS station locations.



Map 2: Oshawa – Population Change between 2011 and 2016. Map 2 depicts the percent change in the populations of Oshawa census tracts between the 2011 and 2016 censuses. Also indicated are OFS station locations.



Map 3: Oshawa – 2016 Median Age. Map 3 depicts the median age of residents per census dissemination area in Oshawa based on the 2016 census. Also indicated are OFS station locations.



Map 4: Oshawa – 2013 Median Income. Map 4 depicts the median income of Oshawa residents per census dissemination area based on the 2013 census. Also indicated are OFS station locations.

Historical Response

Examination of historical emergency incident locations is a necessary element of assessment of risk in a community. Historical response data is a component used to calculate the probability of incidents occurring in the future. The historical analysis of OFS responses within Oshawa was based on CAD data from January 1, 2015 to December 31, 2017. The data recorded the locations of all incidents to which OFS units responded, the specific OFS units that responded to each incident, and the locations of OFS units at the time of dispatch. Three years of response data is the minimum timespan of dispatch data that is preferred for historical response analysis of a fire department. The following maps are based on the locations of responses as indicated in the CAD data. [28] The section of this report titled "Oshawa Fire Services Workload Analysis" utilizes location parameters as well as additional time-based parameters found in the CAD data to provide perspective on the overall workload of OFS.

[28] The maps included in this section excluded records in the CAD with incident locations that were located outside of the Oshawa city boundary. This section did not exclude CAD records due errors in reporting en route time or on location time.

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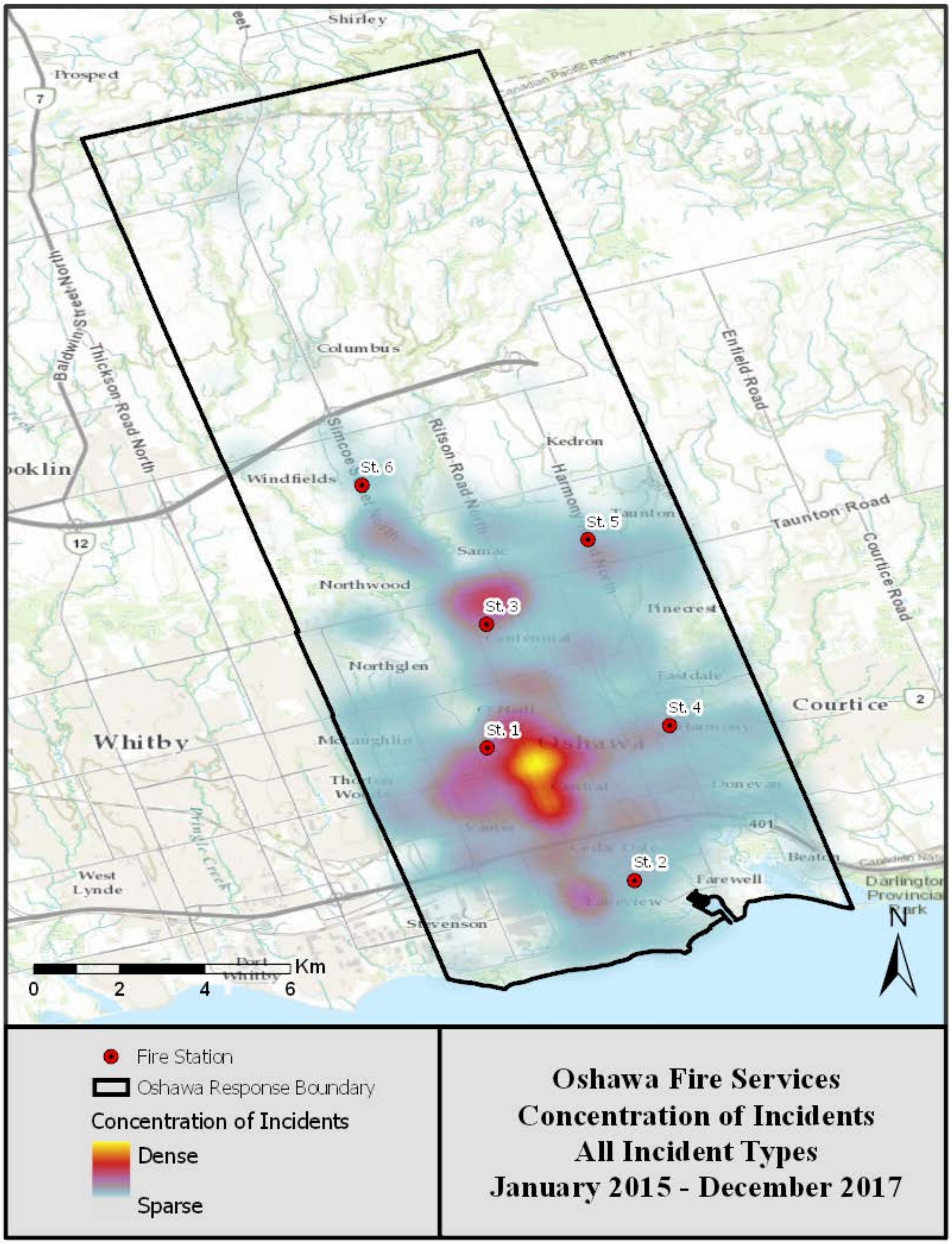
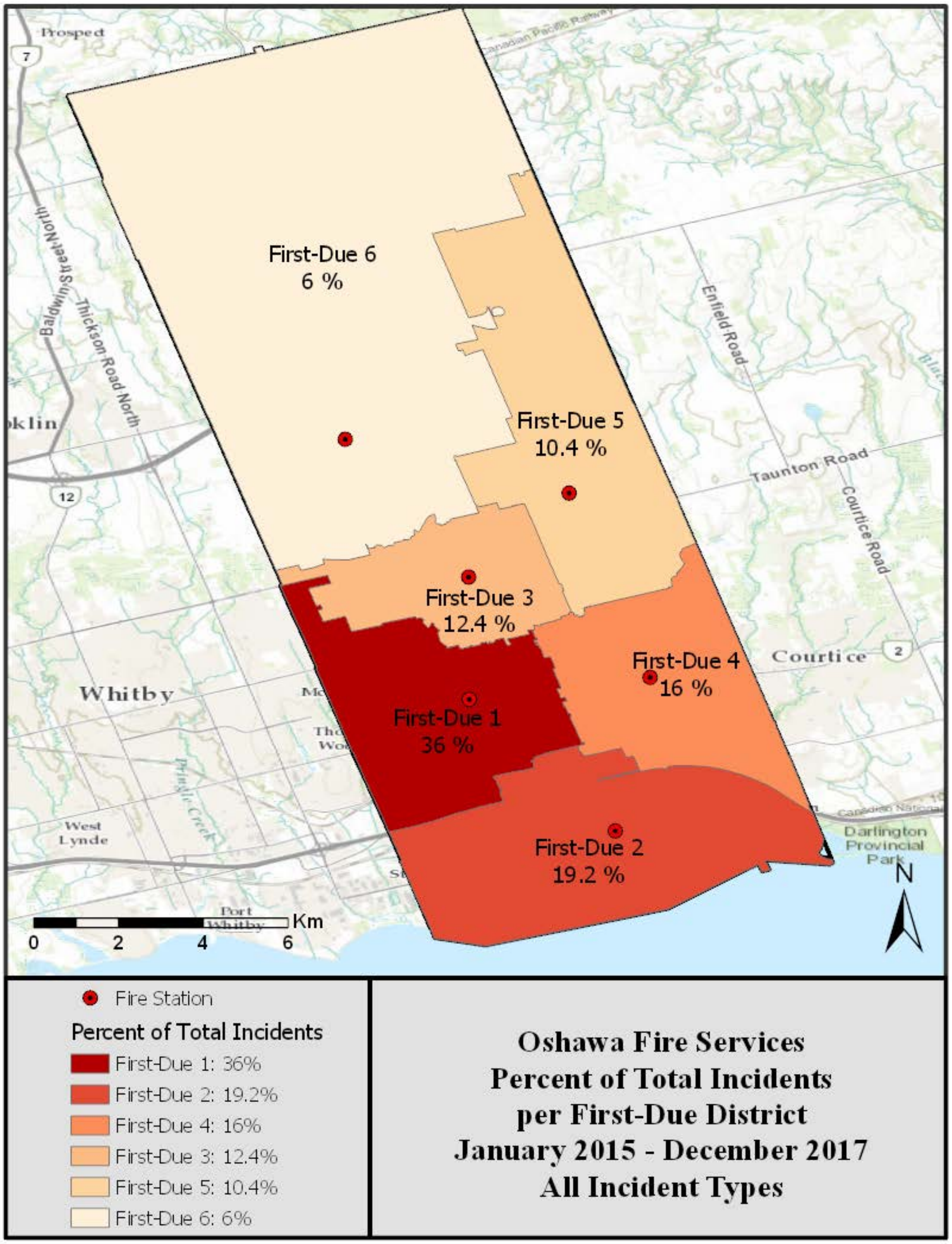
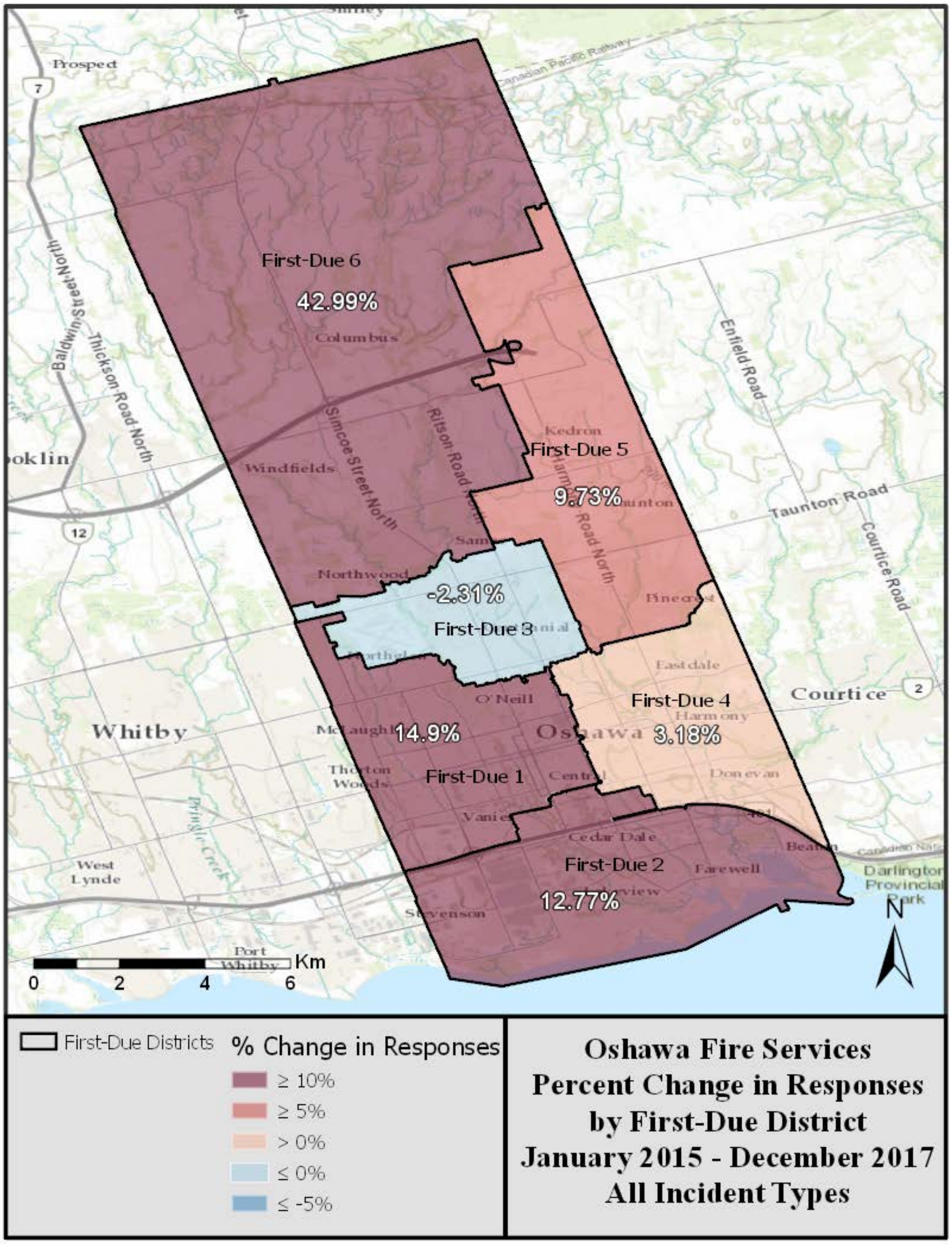


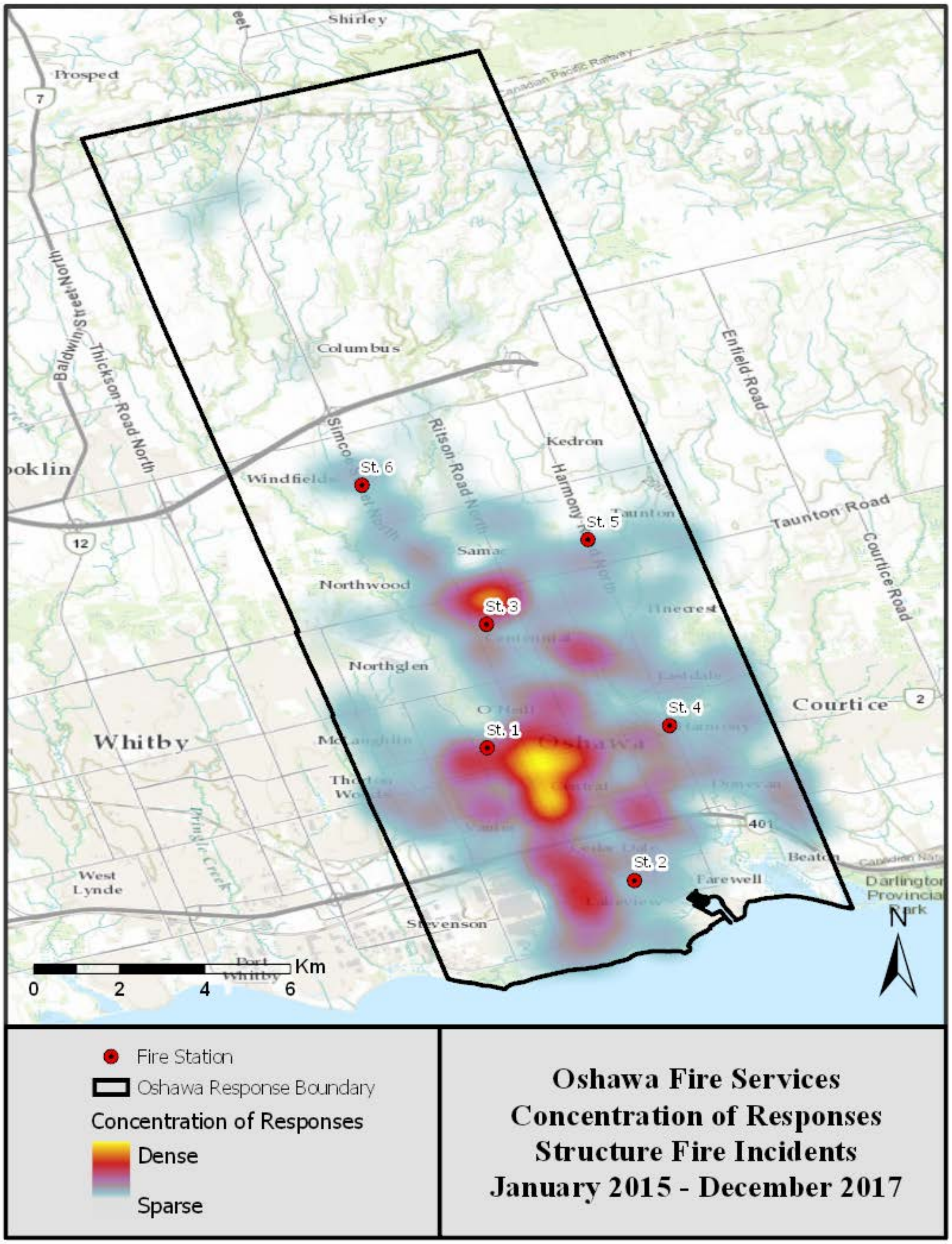
Map 5: Concentration of Incidents, All Incident Types, January 2015 – December 2017. Map 5 depicts the incident density for incidents of all types responded to by OFS units during the three-year period from January 2015 to December 2017.



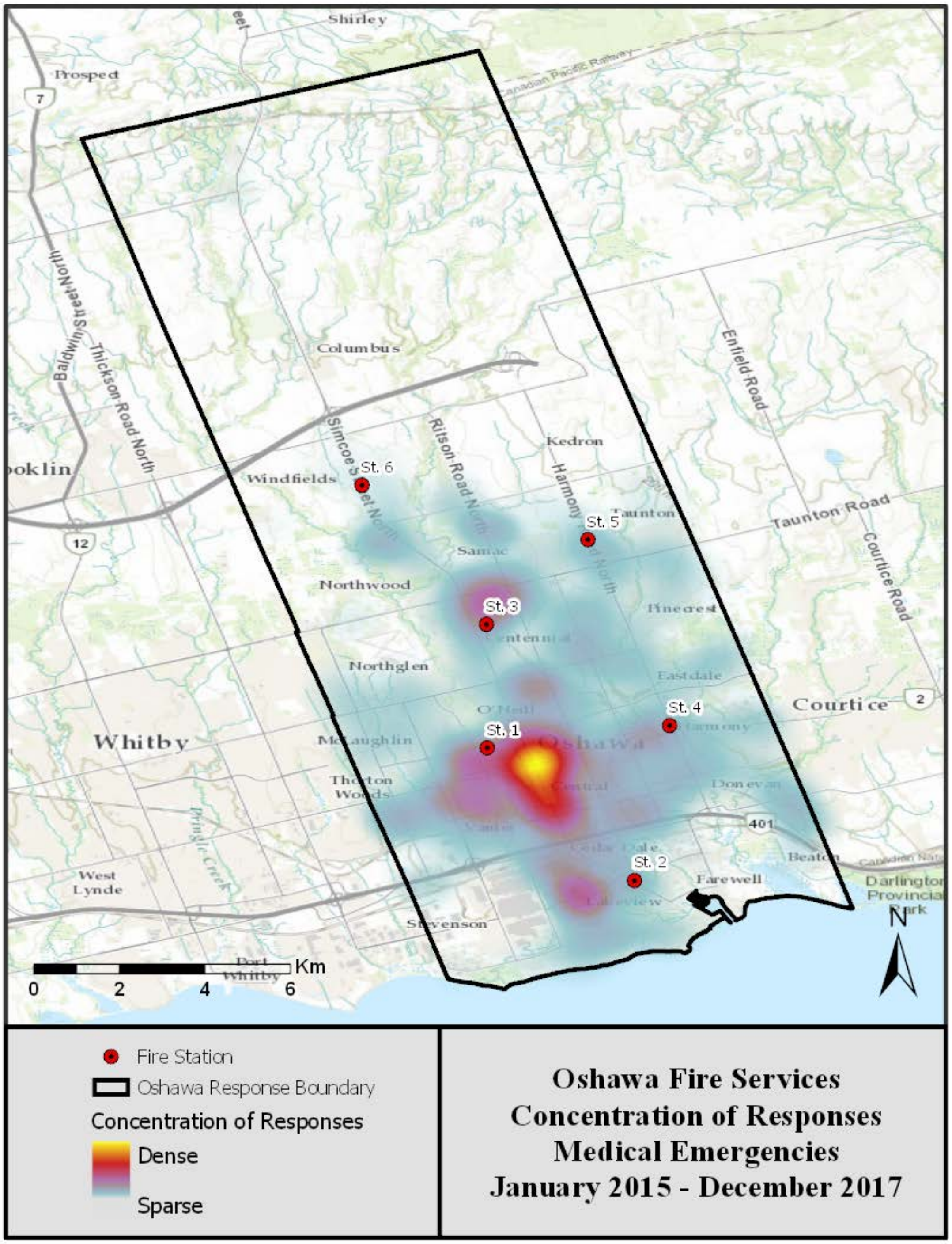
Map 6: Percent of Total Incidents by First-Due District, January 2015 - December 2017, All Incident Types. Map 6 depicts the percent of all incidents that were responded to by OFS units, between January 2015 and December 2017, which occurred in each first-due district. First-Due District 6 had the lowest volume of incidents during this time period while First-Due District 1 had the highest volume of incidents.



Map 7: Percent Change in Responses by First-Due District, January 2015 - December 2017, All Incident Types. Map 7 depicts the percent change, by first-due district, between January 2015 and December 2017 in number of responses for OFS units responding to all incident types. Note that the map depicts the percent change in responses during this time period, not the volume of responses. This map should be viewed together with Maps 5 and 6 on the previous pages that illustrate incident volume. As indicated in Map 7, First-Due District 6, followed by First-Due District 1, experienced the greatest percentage increases of incident occurrences during the study period.



Map 8: Concentration of Responses, Structure Fire Incidents, January 2015 – December 2017. Map 8 depicts OFS' density of responses to structure fire incidents during the three-year period from January 2015 to December 2017. As previously stated, a single incident may result in responses made by multiple apparatus.



Map 9: Concentration of Responses, Medical Emergencies, January 2015 – December 2017. Map 9 depicts OFS' density of responses to medical emergencies during the three-year period from January 2015 to December 2017. As previously stated, a single incident may result in responses made by multiple apparatus.

Risk Probability

Analysis of historical incident locations, demographics and building characteristics were used in a statistical process to determine the probability that incidents may occur in the future. Specifically, characteristics of areas in the community that experienced a high frequency of incidents allows for the identification of what characteristics drive high incident numbers. These characteristics lead to a greater probability of incidents occurring in the future resulting in a higher risk level. With this statistical risk assessment approach, areas where a low number of incidents occurred in the past might still be categorized as high-risk areas. For example, areas in a community with a high number of high-hazard buildings would also be categorized as high risk even if those areas had a low number of incidents in the past.

In this analysis, the level of risk should be interpreted as the probability that an incident may occur in the future. The risk level is also relative: an area which has a low-risk level should not be considered as an area where there is no chance of incidents happening in the future. A low risk level simply means that, compared to other areas in the community, the area in question is less likely to experience incidents, but incidents may still occur. OFS needs to ensure a proper coverage of the entire community, even in low-risk areas. The risk assessment analysis is meant to assist OFS and the city in making decisions that will allow for the appropriate distribution of resources, depending on the different risk levels within the jurisdiction.

Using the CAD data, incidents defined as a structure fire or a medical incident[29] were used to assign each census tract (35 census tracts) a count of how many of those types of incidents occurred within each census tract. The probability of incidents occurring in a given census tract is related to the expected number of incidents in that census tract. Using the CAD data assembled by OFS from January 1, 2015 to December 31, 2017, and the demographic and physical building characteristics of the census tracts where incidents occurred, a statistical analysis can be used to predict the future number of incidents. The predicted number of incidents is used as a proxy for the probability of a particular type of incident in each census tract. For example, if 300 incidents are predicted to occur in a community in a 1-year period, and 200 of those are expected to occur in census tract 1, while 100 are predicted to occur in census tract 2, then at the end of the one-year period, the probability that one of the 300 predicted incidents has occurred in census tract 1 is 200/300 = 66.7%.

The tracts are categorized as low-, moderate- or high-risk, according to the procedure described below. In this analysis, the expected number of incidents, which results in determining the risk assessment classification, are relative only to incidents that will require a response from OFS units. Once the predictions of the number of incidents are made, the census tracts receive a ranking (low, moderate, high) according to the following procedure:

[29] List of incident type classification located in "Appendix B: Risk Analysis Data B.1"

- The census tracts are sorted by the number of predicted incidents, from the lowest to the highest.

- The sum of the predicted incidents of all census tracts defines the total number of predicted incidents.

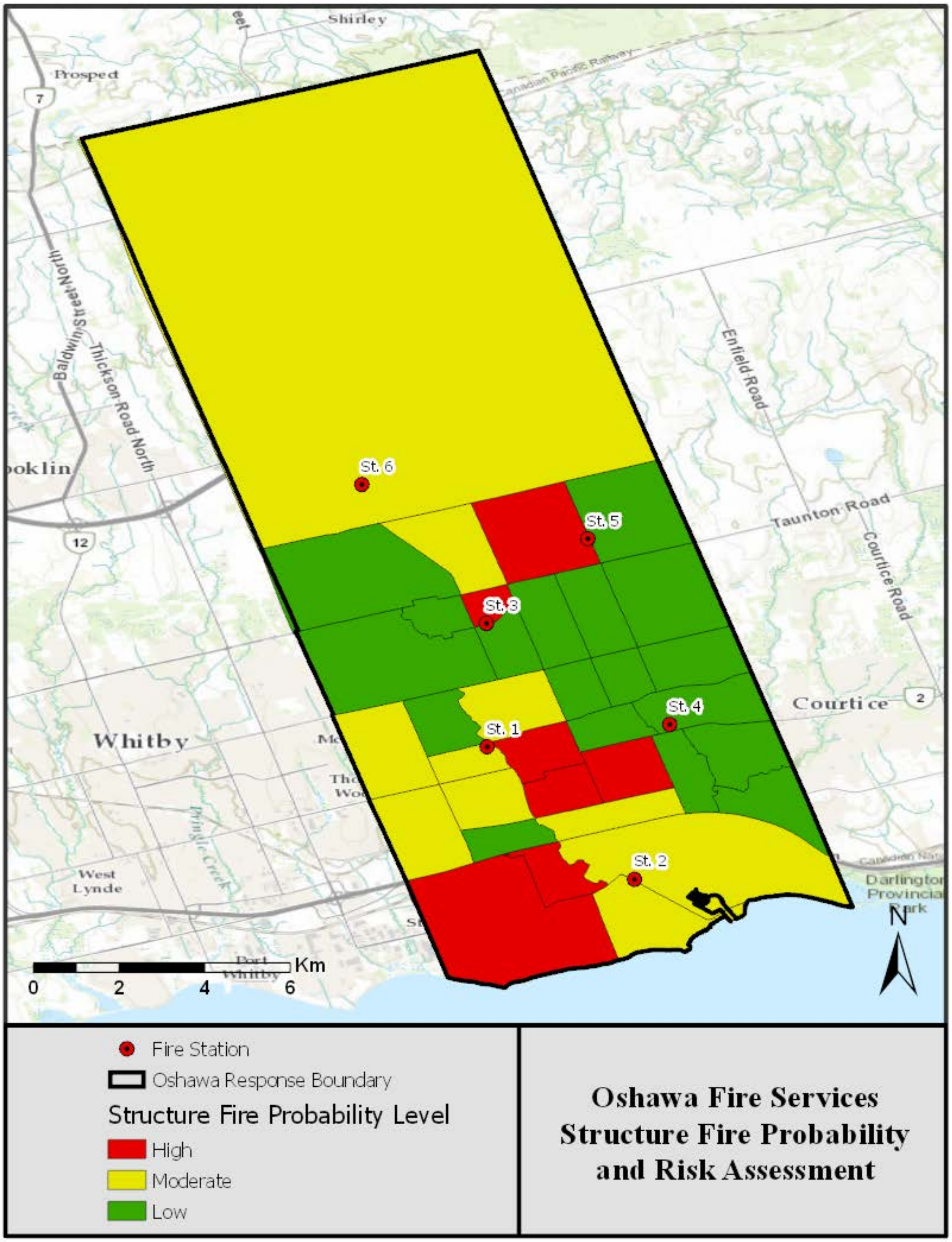
- The cumulative sum of the predicted incidents of each census tract, starting from the census tract with the lowest number of predicted incidents and proceeding towards the highest, defines the risk ranking: *low* for census tracts whose sum of predicted incidents is lower than 33% of the total incidents, *moderate* for tracts whose sum of predicted incidents is greater than 33% and less than 67% of the total, and *high* for the remaining census tracts.

The statistical analysis identified the characteristics that are associated with areas having a high volume of structure fire incident occurrences.[30] Some of these characteristics are expected: the higher the number of private dwellings, the higher the fire risk, simply reflecting that census tracts with many buildings will, on average, experience more structure fires. Other characteristics are more interesting and offer decision makers the possibility to intervene and implement plans to reduce the risk. For example, the regression analysis shows that structure fire incidents are more likely to occur in areas with a lower median income, likely because building conditions and lack of maintenance create a fire risk. The number of renters and the number of people with no certificate, diploma or degree are also risk factors. These variables might be partially related to the median income variable. The age of the buildings is also an important factor, with the risk of fires increasing in census tracts where the number of buildings built before 1961 is higher. The list of variables associated with structure fires risk is listed below. Except for the median income variable, the greater the variable, the higher the risk (e.g. the more buildings built before 1961 the higher the fire risk).

Variables Used in the Structure Fire Risk Analysis[31]
1. Median income[32]
2. Number of private dwellings
3. Number of renters
4. Population with no certificate, diploma or degree
5. Number of buildings built before 1961

Table 1: Variables Used in the Structure Fire Risk Analysis. The above table lists the variables used in the portion of the risk analysis that assessed structure fire risk within Oshawa. The variables are listed in order of significance as determined in the statistical analysis.

[30] The IAFF considered more than 600 variables describing the demographic characteristics of the City of Oshawa. The variables listed in this report are only those that have been found to be associated with a higher risk of medical emergencies and structure fires. Many variables have been excluded either because they are not associated with risk, or because they are significantly correlated and already represented by other variables.
[31] Additional figures in "Appendix B: Risk Analysis Data" further illustrate the relation of these variables to the incidence of structure fires within Oshawa.
[32] Census tracts with a low median income are associated with higher risk.



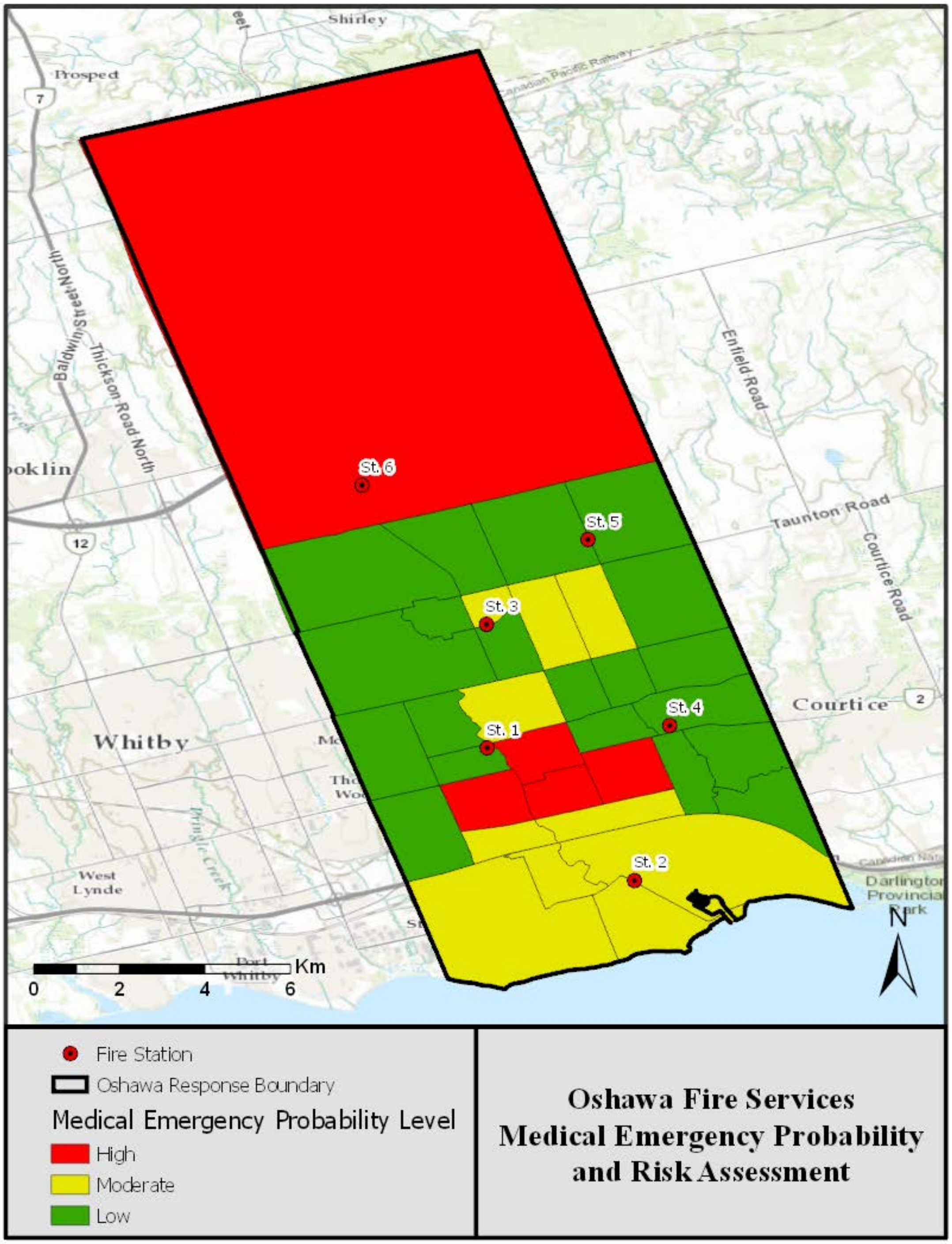
Map 10: Structure Fire Probability and Risk Assessment. Map 10 depicts the probability level for structure fires by census tract. The probability level refers to the likelihood OFS units will respond to a structure fire in the corresponding geographic area in the future.

The statistical regression analysis also identified the characteristics that are associated with areas with a high volume of medical emergencies. The characteristics that were found to be the most associated with higher risk included the number of residents with no certificate, diploma or degree, the number of renters, and building age. This may be a consequence of these variables being correlated with the poverty level, as suggested also by the higher medical incident risk in areas with a larger number of government transfers recipients. The number of residents above 65, a characteristic found in this analysis to be associated with medical higher risk, is a demographic variable typically associated with a higher medical risk. Lastly, the significance of the number private dwellings may be correlated with greater population or greater population density. The list of variables associated with medical incident risk is listed below.

Variables Used in the Medical Risk Analysis[33]
1. Population with no certificate, diploma or degree
2. Number of renters
3. Population 65 years old and over
4. Number of government transfers recipients
5. Number of buildings built before 1961
6. Number of private dwellings

Table 2: Variables Used in the Medical Risk Analysis. The above table lists the variables used in the portion of the risk analysis that assessed the risk of medical emergencies occurring within Oshawa. The variables are listed in order of significance as determined in the statistical analysis.

[33] Additional figures in "Appendix B: Risk Analysis Data" further illustrate the relation of these variables to the frequency of medical emergencies within Oshawa



Map 11: Medical Emergency Probability and Risk Assessment. Map 11 depicts the probability level and risk assessment for medical emergencies in Oshawa. The probability level refers to the likelihood OFS units will respond to medical emergencies in the corresponding geographic area in the future.

The statistical analysis identified the characteristics that are associated with areas of high incident occurrences. The results show that the likelihood of structure fire incidents occurring increases as:

- The number of buildings built before 1960 *increases*
- The population of residents with no certificate, diploma or degree *increases*
- Median Total Income *decreases*
- The population of renters *increases*
- The number of private dwellings *increases*

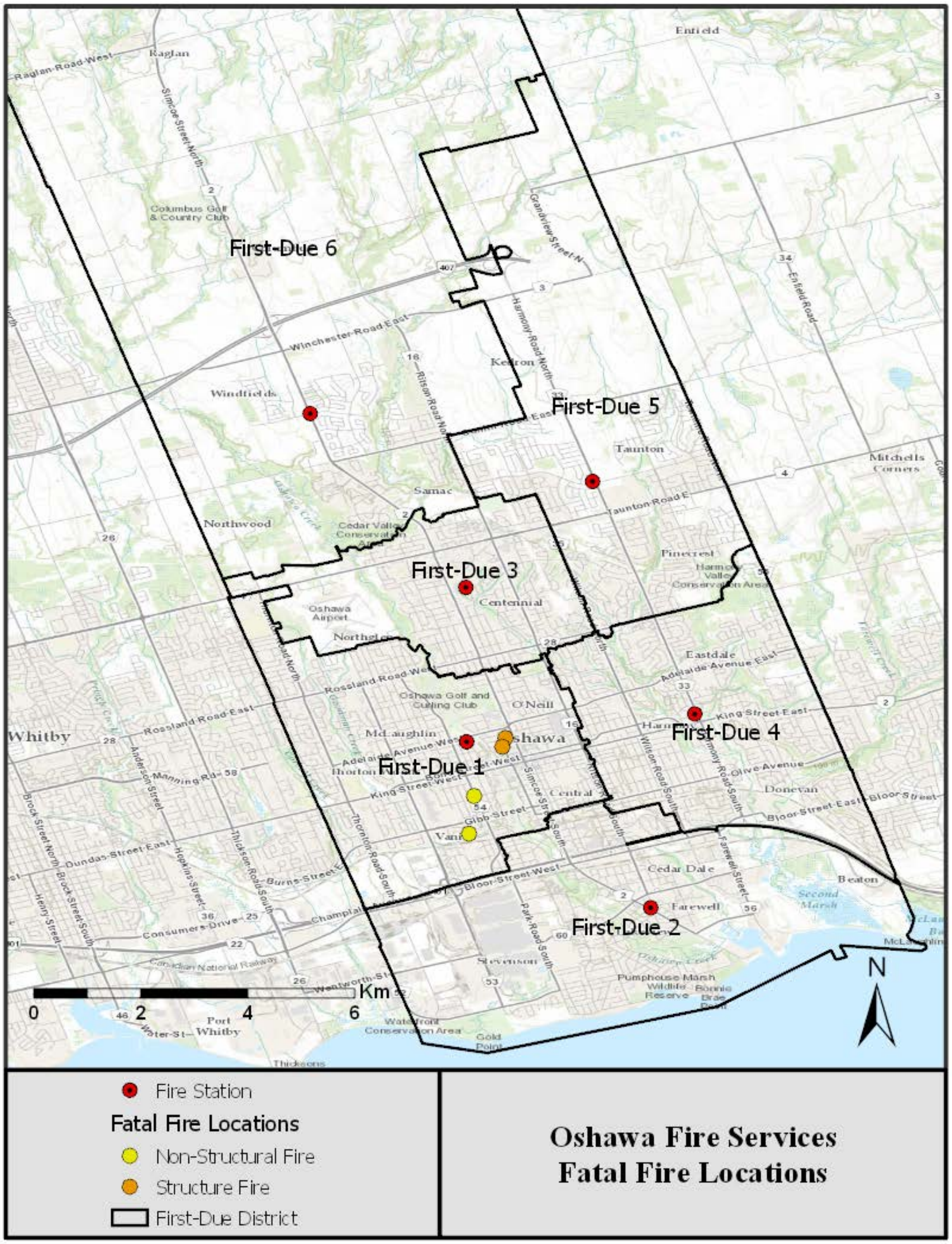
Additionally, the results show that the likelihood of medical emergencies occurring increases as:

- The number of buildings built before 1960 *increases*
- The population of residents over the age of 65 *increases*
- The population of residents with no certificate, diploma or degree *increases*
- The population of residents who are government transfer recipients *increases*
- The population of renters *increases*
- The number of total dwellings *increases*

The OFS and city decision makers should use the information provided in this section to assist in developing data-driven strategies to appropriately position resources and, where possible, implement plans to prevent the occurrence of fires and plans to account for the likelihood of medical emergencies.

Fatal Fires in Oshawa

Four fire incidents in Oshawa between January 1, 2014 and January 31, 2018 resulted in one or more fatalities. The most recent of these fires was a structure fire that occurred on January 8th, 2018 at 116 Centre Street North and resulted in multiple fatalities. Map 12 on the next page shows the locations of each of the four fires.



Map 12: Fatal Fire Locations. Map 12 indicates the locations of fatal fires that occurred in Oshawa between January 1, 2014 and January 31, 2018. Two of the fires, indicated in yellow, occurring on October 1, 2017 and November 9, 2017, were non-structural, and two of the fires, indicated in orange, occurring on February 9, 2017 and January 8, 2018, were structure fires, each in two-storey loft-detached residential structures. All four of the fires were located within the first-due district of Station 1.

When examining these four incidents in context of the risk assessment, it is important to note that the two structure fires were located within areas of Oshawa that have been classified as having the greatest likelihood of structure fire incidents occurring. The most recent of these structure fires occurred on January 8, 2018 at 116 Centre Street North and resulted in multiple fatalities. Another incident, classified in the CAD as a medical incident, was in an area of Oshawa that was classified as having the greatest likelihood of medical emergencies occurring. The remaining fire-related fatality occurred at an incident that was classified in the CAD as “Fire/Explosion: Non-Structural: Other” and does not fall within a category the risk assessment considered in the risk probability analysis. The fact that three of these four historical fatal fire incidents occurred in areas of Oshawa designated as areas having a high likelihood of future incident occurrences underscores the importance of utilizing a risk assessment when planning for the configuration of OFS’ staffing and deployment.

Additional Factors

This document assessed the risk environment in Oshawa based on available data. However, inclusion of at least two additional key datasets directly related to community risk will contribute to a more complete risk assessment. First, data that categorizes the daytime population influx resulting from visitors to Oshawa not reflected in the Census. Second, data that includes a complete inventory of structures within Oshawa describing use, number of storeys, and square meterage. To effectively utilize this inventory for emergency response planning, all structures should be classified as either low-, medium-, or high-hazard occupancies.

Fire Suppression Operations

The business of providing emergency services has always been labor intensive and remains so today. Although new technology has improved firefighting equipment and protective gear, and has led to advances in modern medicine, it is the firefighters who still perform the time-critical tasks necessary to contain and extinguish fires, rescue trapped occupants from a burning structure, and provide emergency medical and rescue services.

A small flame can quickly burn out of control and become a major fire in a short period of time. This is because fire grows and expands exponentially as time passes. In the timeframe of fire growth, the temperature of a fire rises to above 538° Celsius (C). It is generally accepted in the fire service that for a medium growth rate fire[34], flashover—the very rapid spreading of the fire due to super heating of room contents and other combustibles—can occur. Assuming an immediate discovery of a fire, followed by an un-delayed call to 9-1-1, and dispatch of emergency responders, flashover is likely to occur within 8 minutes of fire ignition. However, studies conducted by the Underwriters Laboratory (UL) and the National Institute of Standards and Technology (NIST) have proved that, due to new building construction materials and room contents that act as fuel, flashover may occur much sooner.

At the point of flashover, the odds of survival for unprotected individuals inside the affected area are virtually non-existent. The rapid response of an appropriate number of firefighters is therefore essential to initiating effective fire suppression and rescue operations that seek to minimize fire spread and maximize the odds of preserving both life and property.

This section will explain fire growth and the importance of a fire department response to a low-hazard structure fire. A low-hazard structure fire is defined as a fire that occurs in a typical, 186-square meter, single-family residential home with no basement or exposures. [35]

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[34] As defined in the *Handbook of the Society of Fire Protection Engineers*, a fast fire grows exponentially to 1.0 MW in 150 seconds. A medium fire grows exponentially to 1 MW in 300 seconds. A slow fire grows exponentially to 1 MW in 600 seconds. A 1 MW fire can be thought-of as a typical upholstered chair burning at its peak. A large sofa might be 2 to 3 MWs.

[35] NFPA 1710, 2016 ed. Pg. 1710-19 A.4.1.2.5.1

Fire Growth

The Incipient Phase

The first stage of any fire is the incipient stage. In this stage, a high heat source is applied to a combustible material. The heat source causes chemical changes to the material's surface which converts from a solid and begins to release combustible gases. If enough combustible gases are released, the material will begin to burn freely.

This process is exothermic, which means that it produces heat. The heat being generated raises the temperature of surrounding materials, which in turn begin to release more combustible gases into the environment and begins a chemical chain reaction of heat release and burning. At this point, the fire may go out if the first object completely burns before another begins or the fire can progress to the next stage, which is called the Free Burning Phase.

The Free Burning Phase

The second stage of fire growth is the "free" or "open burning" stage. When an object in a room starts to burn, (such as the armchair in Figure 1, following page), it burns in much the same way it would in an open area. In this phase of a fire, oxygen in the air is drawn into the flame and combustible gases rise to the ceiling and spread out laterally. Simultaneously, the materials that are burning continue to release more heat, which heats nearby objects and materials to their ignition temperature and they begin burning as well. Inside a room, unlike in an open area, after a short period of time, confinement begins to influence fire development. The combustible gases that have collected on the ceiling will eventually begin to support fire and will begin to burn. Thermal radiation from this hot layer begins to heat the ceiling, upper walls, and all the objects in the lower part of the room which will augment both the rate of burning of the original object and the rate of flame spread over its surface.

When this occurs, the structure fire reaches a critical point: either it has sufficient oxygen available to move on to the next stage or the fire has insufficient oxygen available to burn and it progresses back to the incipient stage. However, since structures are not airtight, there is a low likelihood of the fire depleting the available oxygen. During this stage of fire growth, toxic chemicals released by the fire and high heat are enough to burn people in the immediate area and disorient and/or incapacitate people in the structure. Without rapid response and intervention by an adequately staffed fire department, the fire will likely spread to the rest of the structure.

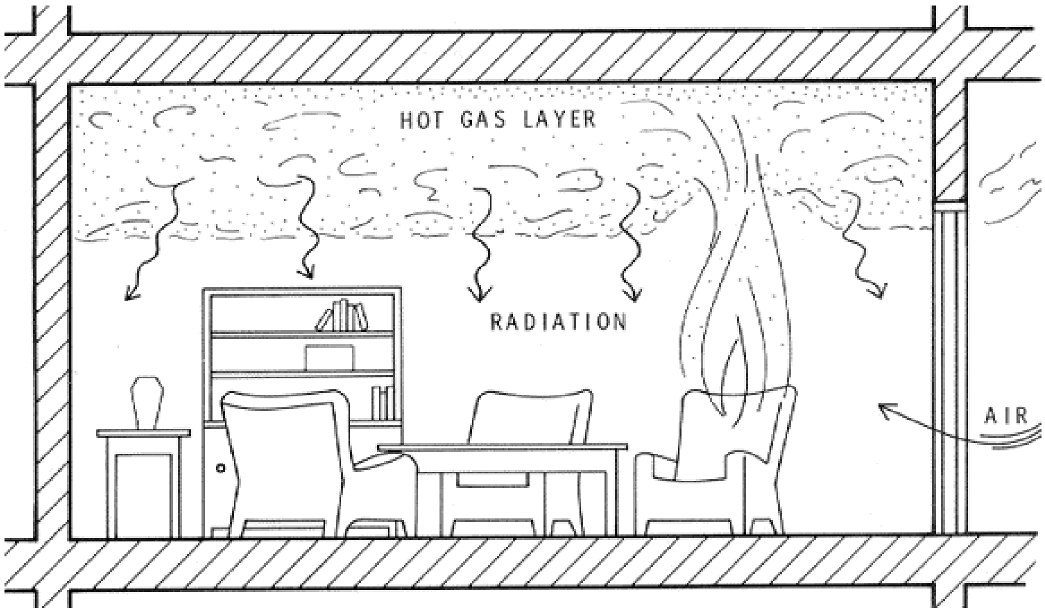

Figure 1: Fire Growth in a Compartment.[36] The above figure depicts the growth of fire in a compartment, which is an enclosed space or room in a building. In a compartment the walls, ceiling, floors, and objects absorb radiant heat produced by the fire. Unabsorbed heat is reflected back to the initial fuel source, which is depicted by the armchair above. This reflected heat continues to increase the temperature of the fuel source and therefore the rate of combustion. Hot smoke, combustible gases, and super-heated air will then rise to the ceiling and spread at first laterally across the ceiling, but later downward towards other fuel sources and the floor of the compartment. As this toxic, super-heated cloud touches cooler materials, the heat is conducted to them, thus increasing their temperature and eventually leading to pyrolysis, which is the process where a fuel source begins to release flammable vapor. This release of flammable vapor leads to further fire growth and eventually flashover. Flashover is the point at which all exposed fuel sources in a compartment ignite.

If there is sufficient oxygen, then the fire will continue to grow and the heating of the other combustibles in the room will continue to the point where they reach their ignition temperatures simultaneously. If this occurs, all combustible materials in the room will spontaneously ignite. This transition from the burning of one or two objects to full room involvement is referred to as flashover.[37]

Flashover

Flashover, when it occurs, is the most significant event during a structure fire. As combustible gases are produced by the two previous stages, they are not entirely consumed and are therefore available fuels. These available fuels rise and form a superheated gas layer at the ceiling that continues to increase, until it begins to bank down to the floor, heating all combustible objects regardless of their proximity to the burning object. In a typical structure fire, the gas layer at the

[36] Image courtesy of University of California at Davis Fire Department
[37] J.R. Mehaffey, Ph.D., Flammability of Building Materials and Fire Growth, Institute for Research in Construction, 1987.

ceiling can quickly reach temperatures of 649° C and higher. With enough existing oxygen at the floor level, flashover occurs, which is when everything in the room ignites at once. The instantaneous eruption of flames generates a tremendous amount of heat, smoke, and pressure. The pressure generated from this explosion has enough force to push fire beyond the room of origin and into the rest of the structure, as well as through doors and windows.

As has been noted, at the time of flashover, windows in the room will break. When the windows break, because of the increased pressure in the room, a fresh supply of air from the outside of the building is available to help the fire grow and spread. Based on the dynamics of fire behavior in an unprotected structure fire, any decrease in emergency unit response capabilities will correlate directly with an increase in expected life, property, and economic loss.

The Importance of Adequate Staffing: Concentration

NFPA 1500 and 1710 both recommend that a minimum acceptable fire company staffing level should be four members responding on, or arriving with, each engine/pumper and ladder/aerial company responding to any type of fire.

A prime objective of fire service agencies is to maintain enough strategically located personnel and equipment so that the minimum effective response force can reach a reasonable number of fire scenes before flashover occurs. [38] Of utmost importance in limiting fire spread is the quick arrival of sufficient numbers of personnel and equipment to attack and extinguish the fire - as well as rescue any trapped occupants and care for the injured. Sub-optimal staffing of arriving units may delay such an attack, thus allowing the fire to progress to more dangerous conditions for firefighters and civilians.

Staffing deficiencies on primary fire suppression apparatus negatively affects the ability of the fire department to safely and effectively mitigate emergencies and therefore correlates directly with higher risks and increased losses, both physically and economically. Continued fire growth beyond the time of firefighter on scene arrival is directly linked to the time it takes to initiate fire suppression operations. As indicated in Table 3, responding apparatus staffed with four firefighters can initiate critical fireground operational tasks more efficiently than those with crew sizes below industry standards.

[38] University of California at Davis Fire Department website; site visited June 7, 2004.
< http://fire.ucdavis.edu/ucdfire/UCDFDoperations.htm >

Engine Company Duties					Ladder Company Duties			
Fireground Tasks	**Advance Attack Line**	**% Change**	**Water on Fire**	**% Change**	**Primary Search**	**% Change**	**Venting Time**	**% Change**
4 Firefighters	0:03:27		0:08:41		0:08:47		0:04:42	
3 Firefighters	0:03:56	12% Less Efficient	0:09:15	6% Less Efficient	0:09:10	4% Less Efficient	0:07:01	32% Less Efficient
2 Firefighters	0:04:53	29% Less Efficient	0:10:16	15% Less Efficient	0:12:16	28% Less Efficient	0:07:36	38% Less Efficient

Table 3: Impact of Crew Size on a Low-Hazard Residential Fire.[39] The above table compares and contrasts the efficiencies of suppression companies in the completion of critical tasks for fire control and extinguishment. The smaller the crew size, the more tasks an individual must complete as a team member, which contributes to the delay in initiating fire attack and contributes to diminished efficiency in stopping fire loss. OFS typically staffs fire suppression apparatus with 4 firefighters.

First-arriving apparatus staffed with four firefighters are more efficient in all aspects of initial fire suppression and search and rescue operations compared to apparatus staffed with two- or three-firefighters. There is a significant increase in time for all the tasks if an apparatus arrives on scene staffed with only three firefighters compared to four firefighters. According to the NIST Report on Residential Fireground Field Experiments, four-person crews are able to complete time critical fireground tasks 5.1 minutes (nearly 25%) faster than three-person crews. The increase in time to task completion corresponds with an increase in risk to both firefighters and trapped occupants.

With four-person crews, the effectiveness of first-arriving pumper apparatus interior attack operations increases by 12% to 29% efficiency compared to three- and two-person crews respectively. The efficacy of search and rescue operations also increases by 4% to 28% with four-person crews compared to three- and two-person crews. Moreover, with a four-person crew, because the first-in unit is staffed with a sufficient number of personnel to accomplish its assigned duties, the second-in crew does not need to support first-in crew operations and is therefore capable of performing other critical fireground tasks that are likely to improve safety and outcomes.

At the scene of a structure fire, the driver/operator of the first pumper apparatus on the scene must remain with the apparatus to operate the pump. This leaves one firefighter to assist the operator in securing a water source from a hydrant and two firefighters to deploy a hoseline and stretch it to the fire. After assisting the operator, the third firefighter should begin to assist the other two firefighters with advancing the hoseline into the building and to the location of the fire. Before

[39] Averill, J.D., e al. Report on Residential Fireground Experiments. NIST Technical Note 1661. National Institute of Standards and Technology; Gaithersburg, MD, April 2010.

initiating fire suppression, the supervising officer of the first arriving pumper apparatus is also responsible for walking around the building to assess the situation, determine the extent of the emergency, and request any additional resources necessary to mitigate the fire.

Similarly, the driver/operator of the first arriving aerial apparatus must remain with the apparatus to safely position and operate the aerial device while the other three firefighters also perform critical fireground tasks such as ventilation and search and rescue. Due to the demands of fireground activities, a fire attack initiated by apparatus staffed with only three or fewer firefighters is not capable of effecting a safe and effective fire suppression and/or rescue operation until additional personnel arrive.

Insufficient numbers of emergency response units or inadequate staffing levels on those units exposes civilians and firefighters to increased risk, further drains already limited fire department resources, and stresses the emergency response system by requiring additional apparatus to respond from further distances. Failing to assemble sufficient resources on the scene of a fire in time to stop the spread and extinguish the fire, conduct a search, and rescue any trapped occupants puts responding firefighters and occupants in a dangerous environment with exponential risk escalation such that it is difficult to catch up and mitigate the event to a positive outcome.

The Importance of Crew Size to Overall Scene Time

Studies have shown that the more personnel that arrive on pumper and aerial apparatus to the scene of a fire, the less time it takes to do complete all tasks associated with fire suppression, search and rescue, and other critical fireground activities. As dispatched units arrive with sufficient numbers of firefighters, the overall time on the scene of the emergency decreases since critical fireground tasks can be completed simultaneously rather than in sequence. This also results in the decrease of on-scene risk levels. In other words, the more firefighters available to respond and arrive early to a structure fire, the less time it takes to extinguish the fire and perform search and rescue activities, thus reducing the risk of injury and death to both firefighters and trapped occupants and reducing the economic loss to the property.

Overall Scene Time Breakdown by Crew Size		
Scenario	**Total Time**	**Efficiency**
4-Person Close Stagger	0:15:44	
3-Person Close Stagger	0:20:30	23% Less Efficient
2-Person Close Stagger	0:22:16	29% Less Efficient
4-Person Far Stagger	0:15:48	
3-Person Far Stagger	0:21:17	26% Less Efficient
2-Person Far Stagger	0:22:52	31% Less Efficient

Table 4: The Relationship between Crew Size and Scene Time. [40] The above table displays how companies staffed with larger crew sizes will be on the scene of an emergency for a shorter time than smaller sized companies. This lag on scene could be translated to mean that emergency resources will be unavailable longer to address other emergencies that may arise. OFS typically staffs fire suppression apparatus with 4 firefighters.

As Table 4 shows, units that arrive with only two firefighters on an pumper or aerial are on the scene of a fire almost 7 minutes longer than units that arrive with four firefighters on each crew. Responding units arriving with only three firefighters on an apparatus are on the scene of a fire 5 to 6 minutes longer than units that arrive with four firefighters on each apparatus. In addition to crew size, the time between the arriving crews matters to overall effectiveness and total on scene time.

In the NIST study on the low hazard residential fire, close stagger was defined as a 1-minute time difference in the arrival of each responding company. Far stagger was defined as a 2- minute time difference in the arrival of each responding company. [41] [42] The results show a consistent pattern of units arriving with four firefighters in a close stagger or far stagger will decrease the overall time at the scene of the emergency compared to units that arrive with two or three firefighters and are more efficient in fire suppression tasks as well.

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[40] Averill, J.D., et al. Report on Residential Fireground Field Experiments. NIST Technical Note 1661. National Institute of Standards and Technology; Gaithersburg, MD, April 2010.

[41] Ibid.

[42] One minute and two minute arrival stagger times were determined from analysis of deployment data from more than 300 U.S. fire departments responding to a survey on fire department operations conducted by the International Association of Fire Chiefs and the International Association of Firefighters.

Physiological Strain on Smaller Crew Sizes

The same NIST study also examined the relationship between crew size and physiological strain. Two important conclusions were drawn from this part of the experiments.

- Average heart rates were higher for members of small crews.
- These higher heart rates were maintained for longer durations.[43]

In 2017 alone, 53% of all firefighter fatalities were related to overexertion.[44] There is strong epidemiological evidence that heavy physical exertion can trigger sudden cardiac events.[45] Smaller crews are responsible for performing several tasks that are designed to be performed by multiple people and frequently in teams of two. This means that firefighters on smaller crews are required to work harder than larger crews to accomplish multiple tasks. Additionally, as discussed earlier, firefighters on smaller crews will also be working longer than larger sized crews. Working harder and longer in high heat and dangerous, stressful environments increases the likelihood of firefighters suffering an injury, or worse dying, because of overexertion.

Charts 1 and 2, on the following pages, highlight the cardiovascular impact on firefighters based on crew size for the first arriving pumper and aerial apparatus. The heart rates of firefighters of crew sizes ranging from 2 to 5 firefighters were measured as they participated in the NIST study. The study was able to conclude that not only do smaller crews work harder and longer than larger crews, their heart rates are also more elevated for longer periods of time as well. This increases the risk of firefighters suffering an injury or death from overexertion. A firefighter suffering a medical emergency on the scene of a working fire, EMS, or rescue incident negatively impacts outcomes and increases the risk to the community, the citizen requiring assistance, and the firefighter.

[43] Averill, J.D. et al. (2010). Report on Residential Fireground Field Experiments. NIST Technical Note 1661. National Institute of Standards and Technology; Gaithersburg, MD, April 2010.
[44] Fahy, R.F., LeBlanc, P.R., Molis, J.L. (June, 2018) Firefighter Fatalities in the United States-2017. NFPA.
[45] Albert, C.A., Mittleman, M.A., Chae C.U., Lee, I.M., Hennekens, C.H., Manson, J.E. (2000) Triggering Sudden Death from Cardiac Causes by Vigorous Exertion. N Engl J Med 343(19):1355-1361

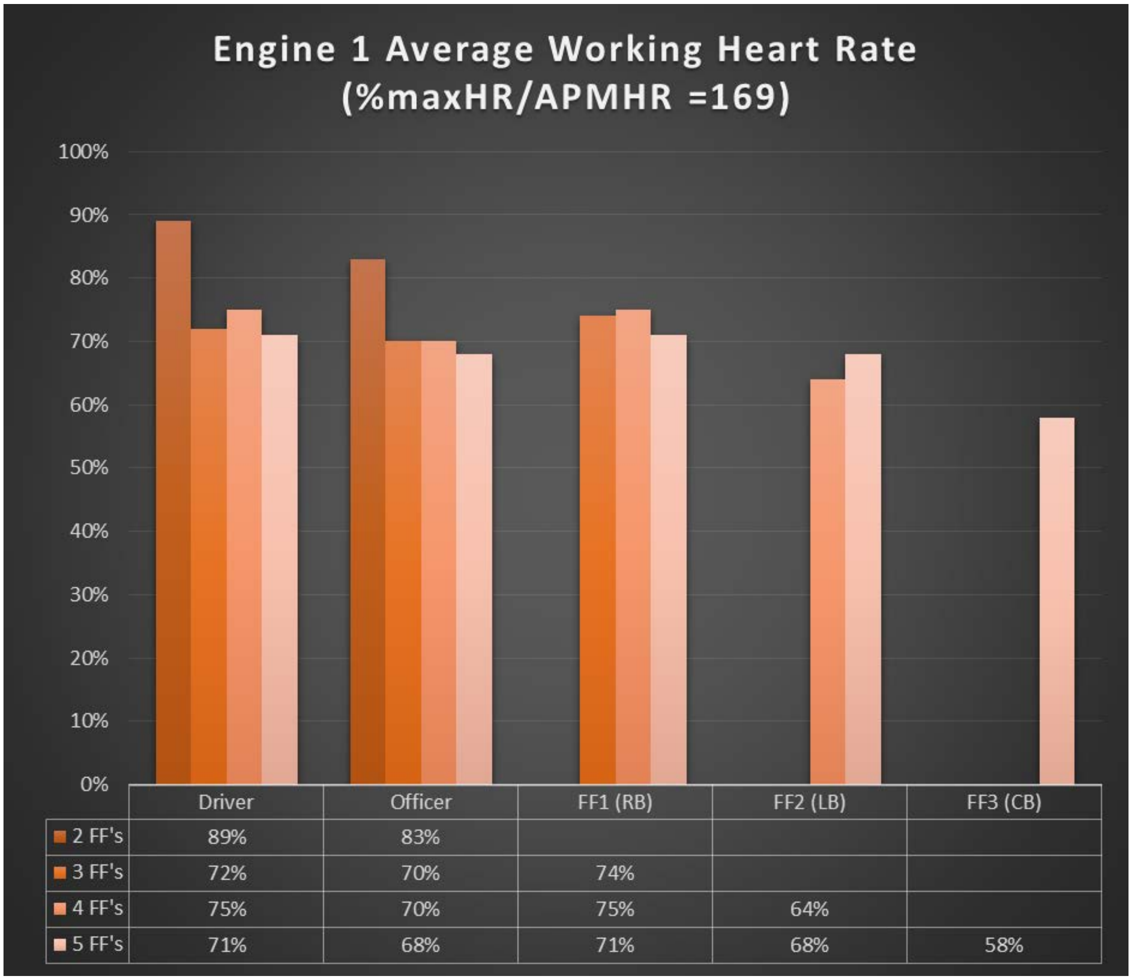

Chart 1: Average Peak Heart Rate of First Engine (E1) with Different Crew Sizes by Riding Position.[46] *In Chart 1, heart rates are expressed as a percent of maximal age-predicted maximal HR.* The average heart rates for firefighters on the first engine crew were above 80% of age-predicted maximum values when only 2 firefighters were working. When staffing was at 2 firefighters, the driver of the apparatus had an average peak heart rate of nearly 90% of the age-predicted maximum. This is largely due to the number of additional tasks the driver must perform to prepare the engine to pump water to the fire and then join the officer to stretch hose to the fire. As can be seen, the larger the crew size, the lower the heart rate.[47] Decision makers could potentially reduce their liability for firefighter injury and death by ensuring staffing is compliant with the minimum recommended industry standards of four firefighters per apparatus.

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[46] Riding position for Chart 1 are as follows: Driver, Officer, Firefighter 1-Right Bucket (RB) seat, Firefighter 2-Left Bucket (LB) seat, Firefighter 3- Center Bucket (CB) seat. A fire company that is staffed with 2 will consist of a Driver and an "Officer."

[47] Smith, D.L., Benedict, R. Effect of Deployment of Resources on Cardiovascular Strain of Firefighters. April, 2010. Pp 5-7

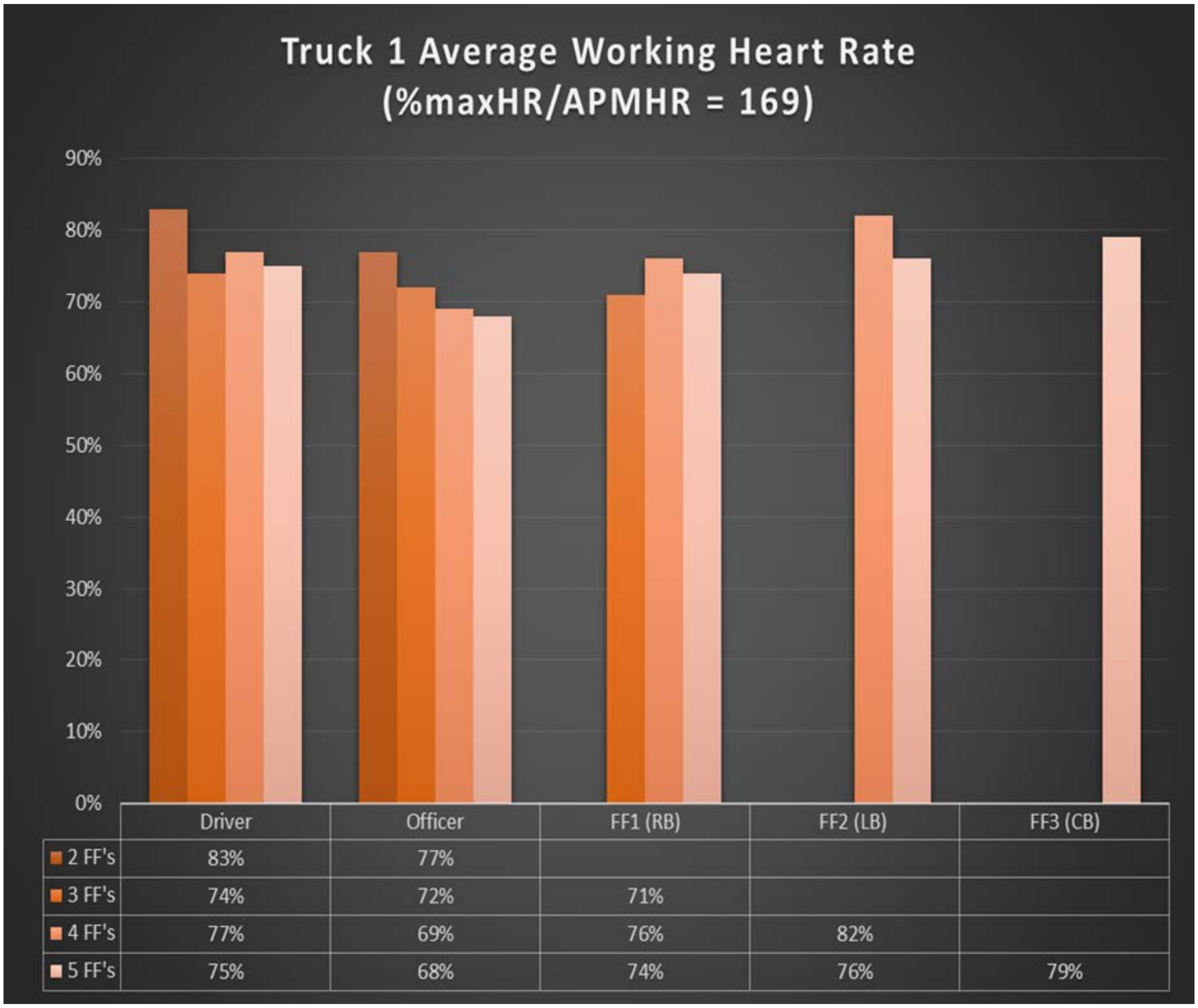

Chart 2: Average Peak Heart Rate of First Truck (T1) with Different Crew Sizes by Riding Position.[48] *In Chart 2, heart rates are expressed as a percent of maximal age-predicted maximal HR.* The average heart rates for firefighters on the first truck company were above 80% of age-predicted maximum values when only 2 firefighters were working.[49] Decision makers could potentially reduce their liability for firefighter injury and death by ensuring staffing is compliant with the minimum recommended industry standards of four firefighters per apparatus.

[48] Riding position for Chart 2 are as follows: Driver, Officer, Firefighter 1-Right Bucket (RB) seat, Firefighter 2-Left Bucket (LB) seat, Firefighter 3- Center Bucket (CB) seat. A fire company that is staffed with 2 will consist of a Driver and an "Officer."

[49] Smith, D.L., Benedict, R. Effect of Deployment of Resources on Cardiovascular Strain of Firefighters. April, 2010. Pp 5-7

The Importance of a Rapid Response

Uncontained fire in a structure grows exponentially with every passing minute. Any delay in the initiation of fire suppression and rescue operations, such as the 5- to 7-minute delay that results from smaller sized crews of firefighters, translates directly into a proportional increase in expected property, life, and economic losses as is shown in Table 5, following page. It warrants emphasizing that if a structure has no automatic suppression or detection system, a more advanced fire may exist by the time the fire department is notified of the emergency and is able to respond. Fires of an extended duration weaken structural support members, compromising the structural integrity of a building and forcing operations to shift from an offensive to defensive mode. [50] As with inadequate staffing, this type of operation will continue until enough resources can be amassed to mitigate the event.

In the NIST study on the low-hazard residential fire, researchers also used fire modeling to mark the degree of the toxicity of the environment for a range of growth fires (slow, medium, and fast). Occupant exposures were calculated both when firefighters arrive earlier to the scene, and when arriving later. The modeling proved that the longer it takes for firefighters to rescue trapped occupants, the greater the risk posed to both the firefighters and occupants by increasing atmospheric toxicity in the structure.

[50] According to the NFPA, "it's important to realize that every 250 GPM stream applied to the building can add up to one ton per minute to the load the weakened structure is carrying."

Rate Per 1,000 Fires			
Fire Extension in Residential Structures:	Civilian Deaths	Civilian Injuries	Average Property Damage
Confined fires (identified by incident type)	0.00	10.29	$218.36
Confined to object of origin	0.65	13.53	$1,611.95
Confined to room of origin, including confined fires by incident type[51]	1.91	23.32	$3,082.79
Beyond the room, but confined to floor of origin	22.73	64.13	$7,668.35
Beyond floor of origin	24.63	60.41	$60,183.93

Table 5: The Relationship between Fire Extension and Fire Loss. [52] [53] The above table displays the rates of civilian injuries and deaths per 1,000 fires, as well as the property damage. Following the far left column from top to bottom, each row represents a more advanced level of fire involvement in a residence. Typically, the more advanced the fire, the larger the delay in suppression. Assuming an early discovery of a fire, companies staffed with larger crew sizes help to minimize deaths, injuries, and property loss. This highlights why a 5- to 7-minute delay in suppression activities by smaller sized crews results in higher economic losses to a residence.

Ontario's Fire Ground Effectiveness Sub-Model

The OFM established the Fire Ground Effectiveness Sub-Model as part of its Comprehensive Fire Safety Effectiveness Model. The Fire Ground Effectiveness Sub-Model defines the necessary components of the delivery of fire ground suppression activities.

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[51] NFIRS 5.0 has six categories of confined structure fires including cooking fires confined to the cooking vessel, confined chimney or flue fires, confined incinerator fires, confined fuel burner or boiler fires or delayed ignition, confined commercial compactor fires, and trash or rubbish fire in a structure with no flame damage to the structure or its contents. Homes include one- and two-family homes (including manufactured housing) and apartments or other multifamily housing. These statistics are national estimates based on fires reported to U.S. municipal fire departments and so exclude fires reported only to federal or state agencies. National estimates are projections. Casualty and loss projections can be heavily influenced by the inclusion or exclusion of one unusually serious fire. Property damage has not been adjusted for inflation.

[52] National Fire Protection Association, NFPA 1710 (2016), Table A.5.2.2.2.1(b) Fire Extension in Home Structure Fires, 2006-2010.

[53] Monetary amounts have been converted from United States Dollars to Canadian Dollars. Annual average conversion rate for the year 2010. Source: < https://www.bankofcanada.ca/rates/exchange/legacy-noon-and-closing-rates >

Within the Sub-Model, the following eleven factors have been identified as having an impact on fire suppression activities:[54]

1. Fire Risk/Fire Demand
2. Response Time
3. Fire Ground Staffing
4. Fire Fighter Performance
5. Fire Ground Command and Control
6. Operational Guidelines
7. Firefighter Safety
8. Apparatus and Equipment
9. Water Supply
10. Availability of Fire Suppression Staffing
11. Fire Prevention and Public Fire Safety

The Fire Ground Staffing element determines activities which may be performed depending on crew size. These activities are "…functions that can be carried out by the crew which is first to arrive and assemble at the scene." [55] According to the OFM, the number of members of the first arriving crew dictate which activities may be initiated.

For a crew of three firefighters, the OFM states, "Interior rescue and suppression operations should not be attempted except in limited circumstances." [56] According to the OFM, a first arriving crew of three firefighters would be capable of performing the following tasks (as dictated by the situation):

- establishment of a water supply from a hydrant (if available)
- establishment of pumper operations
- laying of one hose line to the point of entry into the involved structure
- limited exterior fire fighting including the raising of a ladder beyond the first floor of the structure
- limited exposure protection of surrounding structures
- setting up of a ground monitor

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[54] "Fire Ground Effectiveness Sub-Model." Fire Ground Effectiveness Sub-Model | Ministry of Community Safety and Correctional Services, Office of the Fire Marshal, www.mcscs.jus.gov.on.ca/english/FireMarshal/FireServiceResources/ComprehensiveFireSafetyEffectivenessModel/FireGroundEffectivenessSub-Model/fireground_submodel.html.
[55] "Fire Attack Teams." Fire Ground Effectiveness Sub-Model | Ministry of Community Safety and Correctional Services, Office of the Fire Marshal, www.mcscs.jus.gov.on.ca/english/FireMarshal/FireServiceResources/ComprehensiveFireSafetyEffectivenessModel/FireGroundEffectivenessSub-Model/fireground_submodel.html.
[56] Ibid.

- external rescue using a ladder extended to the point of exit for those persons in the building capable of self-help
- rendering first aid to persons who have exited the involved structure
- forcible entry operations
- shutting off utilities to the structure
- limited ventilation functions
- very limited salvage capability [57]

Additionally, OFM points out that, "some of the foregoing operations, particularly those involving ground ladders, will likely compromise fire ground command and/or pumper operations."[58] The OFM also outlines "**operations which <u>cannot</u> be accomplished safely until such time as additional assistance has arrived on-site.**" [59] These operations include:

- deployment of back-up protection lines
- *conducting interior suppression or rescue operations (except in very limited circumstances)*
- ventilation operations requiring access to the roof of the involved structure
- the use of large (65 mm) hand-held hose lines
- establishment of a water supply from a static source within reasonable time limits [60]

Four-person first arriving crews are also limited in the tasks capable of being accomplished until an external water supply is established. Only *after* an external water supply is established, the following tasks may be accomplished with a four-person crew:

- two-person interior search and rescue with no hand-held back-up line
- two-person interior structure fire fighting with no rescue component and no hand-held back-up line
- limited roof level ventilation operations
- laddering operations
- salvage operations [61]

Some additional tasks are also possible with a four-person first arriving crew, but only to a limited extent. These include:

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[57] "Fire Attack Teams." Fire Ground Effectiveness Sub-Model | Ministry of Community Safety and Correctional Services, Office of the Fire Marshal, www.mcscs.jus.gov.on.ca/english/FireMarshal/FireServiceResources/ComprehensiveFireSafetyEffectivenessModel/FireGroundEffectivenessSub-Model/fireground_submodel.html.
[58] Ibid.
[59] Ibid. Emphasis added
[60] Ibid.
[61] Ibid.

- use of large (65 mm) diameter hand lines
- establishment of a water supply from a static source
- establishment of a second point of entry and approach to the fire location in the structure
- preparing for a second area of search and rescue for person(s) in need of rescue [62]

The size of all suppression crews participating in fireground operations throughout the duration of firefighting operations at the scene of a structure fire is also significant as it relates to fireground efficiency and effectiveness and firefighter health and safety. The fewer members on all crews will require other personnel to work harder and longer, and/or require more resources be dispatched to the scene from farther away. The importance of crew size when conducting firefighting operations in a high-rise structure is discussed later in this document in the "High-Rise Operations" section.

OSHA's "2 In/2 Out" Regulation

Though Ontario fire departments do not have the same legal obligation that United States' fire departments must adhere to the "2 In/2 Out" Regulation, OFS should follow industry standards when assessing and planning for OFS resource deployment.

The "2 In/2 Out" Regulation is part of paragraph (g)(4) of the United States Occupational Safety and Health Administration's (OSHA) revised respiratory protection standard, 29 CFR 1910.134. The focus of this important section is the safety of fire fighters engaged in interior structural firefighting. OSHA's requirements for the number of firefighters required to be present when conducting operations in atmospheres that are immediately dangerous to life and health (IDLH) also covers the number of persons who must be on the scene before firefighting personnel may initiate an interior attack on a structural fire.

An interior structural fire (*an advanced fire that has spread inside of the building where high temperatures, heat and dense smoke are normally occurring*) would present an IDLH atmosphere and, therefore, require the use of respirators. In those cases, at least two standby persons, in addition to the minimum of two persons inside needed to fight the fire, must be present before firefighters may enter the building. [63] [64] This requirement is mirrored in NFPA 1500, which states that "a rapid intervention team shall consist of at least two members and shall be available for rescue of a member or a team if the need arises. Once a second team is assigned or operating in

[62] "Fire Attack Teams." Fire Ground Effectiveness Sub-Model | Ministry of Community Safety and Correctional Services, Office of the Fire Marshal, www.mcscs.jus.gov.on.ca/english/FireMarshal/FireServiceResources/ComprehensiveFireSafetyEffectivenessModel/FireGroundEffectivenessSub-Model/fireground_submodel.html.

[63] According to NFPA standards relating to fire fighter safety and health, the incident commander may make exceptions to these rules if necessary to save lives. The Standard does not prohibit fire fighters from entering a burning structure to perform rescue operations when there is a "reasonable" belief that victims may be inside.

[64] Paula O. White, letter to Thomas N. Cooper, 1 November 1995 (OSHA)

the hazardous area, the incident shall no longer be considered in the 'initial stage,' and at least one rapid intervention crew shall be required."

NFPA Standard 1710 also supports the OSHA Regulation by requiring a minimum of four personnel on all suppression apparatus. Portions of the 1710 Standard recommend that "fire companies whose primary functions are to pump and deliver water and perform basic firefighting at fires, including search and rescue… shall be staffed with **a minimum of four on-duty members**" [65] while "fire companies whose primary functions are to perform the variety of services associated with truck work, such as forcible entry, ventilation, search and rescue, aerial operations for water delivery and rescue, utility control, illumination, overhaul and salvage work… shall [also] be staffed with **a minimum of four on-duty members**."[66]

For either fire suppression company, NFPA 1710 states that "In jurisdictions with a high number of incidents or geographical restrictions, as identified by the AHJ,[67] these companies shall be staffed with a minimum of five on-duty members" and "In jurisdictions with tactical hazards, high-hazard occupancies, or dense urban areas, as identified by the AHJ, these companies shall be staffed with a minimum of six on-duty members."[68]

[65] NFPA 1710, § 5.2.3.1 and § 5.2.3.1.1
[66] NFPA 1710, § 5.2.3.2 and § 5.2.3.2.1
[67] Authority Having Jurisdiction.
[68] NFPA 1710, §5.2.3.1.2, § 5.2.3.1.2.1, § 5.2.3.2.2, and § 5.2.3.2.2.1.

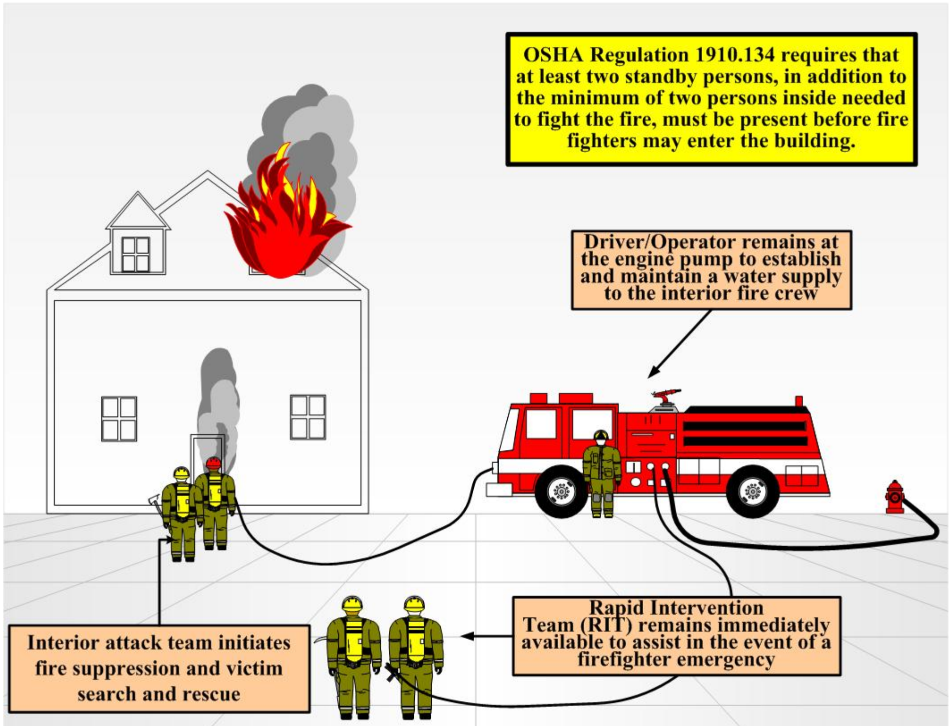

Figure 2: The OSHA "2 In/2Out" Regulation. The above figure depicts the number of firefighters required to meet OSHA regulation 1910.134, which demands one firefighter outside for every firefighter inside. The firefighters outside can support a secondary attack line and facilitate the rescue of trapped or disabled firefighters should the need arise. In this scenario, the driver/operator of the apparatus is not counted towards the total number of firefighters.

A number of incidents exist in which the failure to follow "2 In/2 Out" procedures have contributed to firefighter casualties. For example, in Bridgeport, Connecticut in July 2010, two firefighters died following a fire where the National Institute of Occupational Safety and Health (NIOSH) later found that although a "Mayday" was called by the firefighters, it wasn't responded to promptly as there was no incident safety officer or rapid intervention team (RIT) readily available on scene. In a second case, two firefighters were killed in a fire in San Francisco, California in June 2011. The initial RIT was re-assigned to firefighting duties, and the back-up RIT did not arrive on scene until after the victims were removed.

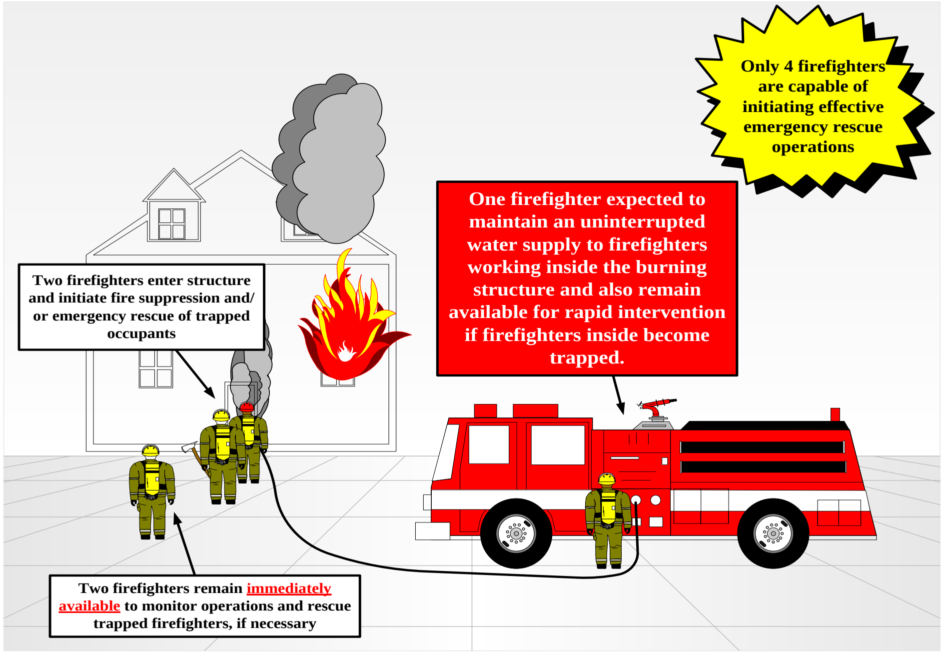

Figure 3: Emergency "2 In/2 Out" Operations. In the emergency model depicted above, the arriving fire apparatus is staffed with a crew of 4 personnel and operates under emergency conditions. In this case the driver/operator of the fire apparatus is also counted as a firefighter, which means that firefighter must be dressed in personal protective equipment (PPE) and be ready to participate in rescue if the need should arise.

When confronted with occupants trapped in a burning structure and a single fire apparatus and crew is on scene, only an apparatus staffed with four firefighters is able to initiate emergency search and rescue operations in compliance with the "2 In/2 Out" Regulation. As indicated in the previous graphic, this requires the complete engagement of every firefighter from the first-in fire apparatus, staffed with four, to participate in the effort, and means that the driver-operator of the apparatus must tend to the pump to ensure the delivery of water to the firefighters performing the initial attack and search and rescue operations and be prepared to make entry with the remaining firefighter should the crew operating inside become trapped.

Regardless, when there exists an immediate threat to life, only an apparatus staffed with a minimum of four firefighters can initiate fire suppression and rescue operations in compliance with the "2 In/2 Out" Regulation, and in a manner that minimizes the threat of personal injury. In crews with fewer than 4 firefighters, the first-in crew must wait until the arrival of the second-in unit to initiate safe and effective fire suppression and rescue operations. This condition underlines the importance and desirability of fire apparatus to be staffed with four firefighters and stresses the benefit of four-person crews and their ability to save lives without having to wait for the second-in apparatus and crew to arrive.

Initial Full Alarm Assignment

Initial Full Alarm Assignment Capability, as outlined in NFPA Standard 1710, recommends that the "fire department shall have the capability to deploy an initial full alarm assignment within a 480-second travel time to 90 percent of the incidents… [and that the] initial full alarm shall provide for the following:

Assignment	*Required Personnel*
Incident Command	1 Officer
Uninterrupted Water Supply	1 Pump Operator
Water Flow from Two Handlines	4 Firefighters (2 for each line)
Support for Handlines	2 Firefighters (1 for each line)
Victim Search and Rescue Team	2 Firefighters
Ventilation Team	2 Firefighters
Aerial Operator	1 Firefighter
Initial Rapid Intervention Crew (IRIC)	2 Firefighters
Required Minimum Personnel for Full Alarm	**14 Firefighters & 1 Scene Commander**

Table 6: NFPA 1710, §5.2.4.1.1. This breakdown of the expected capabilities of a full alarm assignment, in compliance with NFPA 1710, requires a minimum contingent of 15 fire suppression personnel. NFPA 1710 also requires that supervisory chief officers shall be assisted by a staff aide[69] which will increase on-scene staffing to 16 personnel required to arrive at the scene of a structure fire within 8 minutes of travel. Although not specifically discussed in the standard, an industry best practice is to have a second uninterrupted water supply which requires a second dedicated engine pump operator. This second, dedicated pump operator brings the total count of firefighters to 17.

[69] NFPA 1710, § 5.2.2.2.5

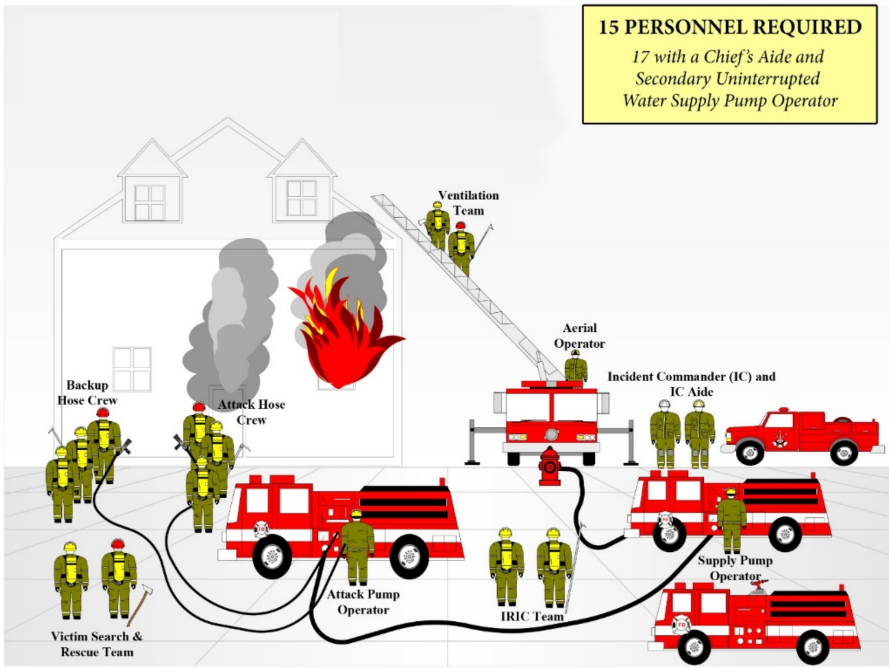

Figure 4: Initial Full Alarm Assignment Deployed Within 8 Minutes. The above figure depicts the full alarm assignment discussed in NFPA 1710, with an additional firefighter to act as the incident commander's aide and another additional firefighter to act as a pump operator for a supply apparatus.

In addition, NFPA 1710, §5.2.4.5.2 states, "The fire department shall have the capability to deploy additional alarm assignments that can provide for additional command staff, members, and additional services, including the application of water to the fire; engagement in search and rescue, forcible entry, ventilation, and preservation of property; safety and accountability for personnel; and provision of support activities…" Oshawa Fire Services has limited capacity to respond to requests for service that require multiple apparatus, as will be seen in the mapping section of this document.

The ability of adequate fire suppression forces to greatly influence the outcome of a structural fire is undeniable and predictable. Each stage of fire extension beyond the room of origin directly increases the rate of citizen deaths, injuries, and property damage.

Fire growth is exponential, growing in a non-linear manner over time. Extending the time for crew assembly by waiting for additional crews to arrive causes on-scene risk to escalate. The higher the risks at the time firefighters engage in fire suppression, the greater the chance of poor outcomes including civilian injury or death, firefighter injury or death, and increased property loss.

High-Rise Operations

Although this section specifically addresses fire response to high-rise buildings, it is important to note that the discussion can be extrapolated to large area buildings such as manufacturing centers, warehouses, grocery stores, schools, and other structures with a high fire load and populations.

The City of Oshawa has a large number of high-rise buildings. Only limited building height data was available for use in this report, so a detailed analysis of OFS response capabilities as it relates to high-rise buildings in Oshawa cannot be completed beyond examining where OFS can assemble an effective response force within the city boundary. [70]

The NFPA 101®, Life Safety Code, 2015 Edition and the International Code Council's International Building Code both define a high-rise structure as a building more than 23 m in height, measured from the lowest level of fire department vehicle access to the bottom of the highest occupied floor. High-rises, which are described in NFPA 1710, §A.3.3.28 as high-hazard occupancies, represent an extraordinary challenge to fire departments and are some of the most challenging incidents firefighters encounter. The Ontario Fire Code does not define high-rise structures.

High-rise buildings may hold thousands of people above the reach of fire department aerial devices, and the chance of rescuing victims from the exterior is greatly reduced once a fire has reached flashover. The risk to firefighters and occupants increases in proportion to the height of the building and the height of the fire above grade level.[71] This is especially true once firefighters are operating above the reach of aerial ladders on aerial apparatus. In these situations, the only viable means of ingress or egress is the interior stairs; extra protection afforded by laddering the building is not possible. Therefore, a sound fire department deployment strategy, effective operational tactics, and engineered fire protection systems cannot be separated from firefighter safety. As in any structure fire, pump apparatus and aerial apparatus operations must be coordinated.

High-rise buildings present a unique threat to the fire service. Fires such as the Alexis Nihon Plaza Fire, Jackson Street Apartments Fire, Wellesley St. E Fire, Interstate Building Fire, One Meridian Plaza Fire, World Trade Center collapse, Cook County Administration Building Fire, and Deutsche Bank Building Fire each represented serious challenges to the operational capabilities of a modern fire department. According to the NFPA, in the United States, between 2009 and 2013, there were an estimated 14,500 reported high-rise structure fires per year that resulted in associated

[70] The City of Oshawa could not provide an inventory of high-rise buildings within Oshawa when requested.
[71] Klaene, B. and Sanders, R. (2007). Structural Firefighting: Strategies and Tactics- High-Rise. Jones and Bartlett 2007.

losses of 40 civilian deaths, 520 civilian injuries, and $154 million in direct property damage. Office buildings, hotels, apartment buildings, dormitories, and health care facilities accounted for almost three-quarters (73%) of these high-rise fires.[72] Although the frequency of fires in high-rise structures is low, they pose a high consequence of loss with regards to injury, loss of life, and property damage.

High-Rise Firefighting Tactics

As has been stated, in a high-rise fire, the risk to firefighters and occupants increases in proportion to the height of the building and the height of the fire above ground level. As the level of the fire floor gets higher, firefighters are required to carry more equipment further and must rely more on the building's standpipe system. A standpipe system is a piping system with discharge outlets at various locations usually located in stairwells on each floor in high-rise buildings that is connected to a water source with pressure supplemented by a fire pump[73] and/or a fire apparatus with pumping capabilities.

A fire in a high-rise building can threaten occupants and responding firefighters. Because of the amount of time it takes firefighters encumbered with equipment to access the involved floors, fire may have expanded well past the area of origin. This means that firefighters can encounter a large volume of fire and darkened conditions when they arrive on the involved floors. This can be further complicated if the building is not equipped with a sprinkler system. Additionally, open-layout floor plans such as office buildings with cubicle farms can challenge both the standpipe's flow capacity and fire department resources in regards to search, rescue, and hoseline deployment. The most effective way to extinguish a high-rise fire is by mounting an offensive attack as early as possible, because in the vast majority of historic high-rise fires the best life safety tactic is extinguishing the fire. Good high-rise firefighting tactics and firefighter/occupant safety cannot be separated. As with a residential structure fire, the first arriving suppression apparatus should be on the scene within four minutes of travel time. However, when responding to any high-rise/high-hazard buildings or structures, **first responding fire apparatus should be staffed with six firefighters per NFPA 1710**, upon determination of the AHJ. OFS does not staff any of its fire apparatus with six firefighters.

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[72] Ahrens, Marty (2016), High-Rise Building Fires. NFPA.

[73] Structural Firefighting Strategy and Tactics 2nd Edition. Klaene B., Sanders R. NFPA 2008

NIST Report on High-Rise Fireground Field Experiments

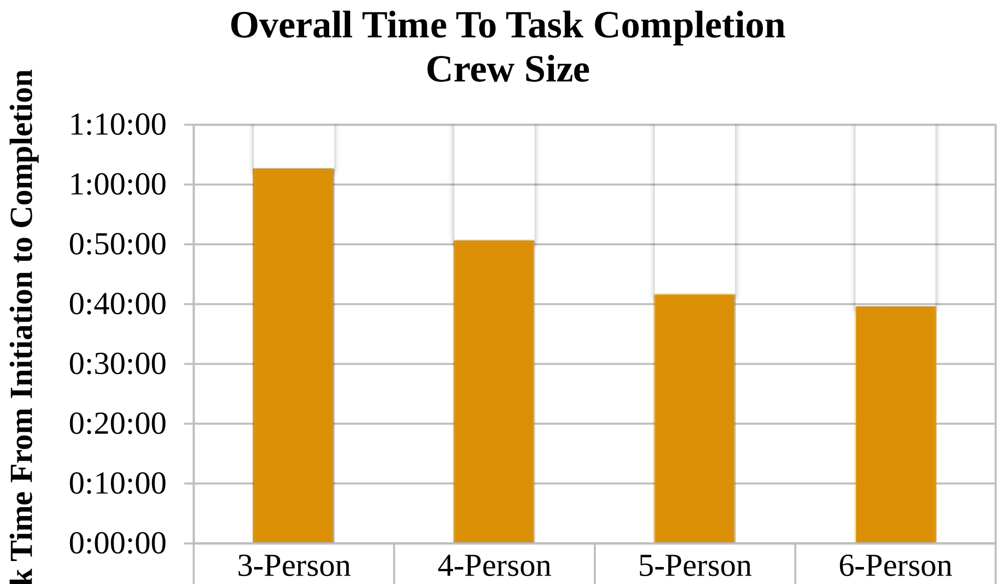
In April 2013, NIST published the "High-Rise Fireground Field Experiment", a report examining the differences in performance time of the completion of critical fireground tasks during a high-rise structure fire. The study compares the performance of 3-person, 4-person, 5-person, and 6-person crews when completing 14 critical fireground tasks. Table 7 displays the 14 critical tasks examined in the NIST study[74].

#	Critical Task:
1	Advance Attack Line
2	Advance Backup Line
3	Fire Out[75]
4	Establish Stairwell Support
5	Search and Rescue- Fire Floor
6	Victim 1 Found- 10th Floor
7	Victim 1 Rescue-10th Floor
8	Victim 1 Descent
9	Search and Rescue- Above Fire Floor
10	Victim 2 Found – 11th Floor
11	Victim 2 Rescue – 11th Floor
12	Victim 2 Descent
13	Advance Line Above Fire
14	All Tasks Complete

Table 7: Critical Task Considered in the NIST Report on High-Rise Fireground Field Experiments. The study measured the time it takes each task to be completed and the total time it takes for all tasks to be completed.

According to the NIST Report on High-Rise Fireground Fields Experiments, six-person crews are able to complete time critical fireground tasks 11 minutes and 59 seconds (19%) faster than four-person crews. The increase in time-to-task completion corresponds with an increase in risk to both firefighters and trapped occupants. Figure 5, on the next page, represents overall time-to-task completion for high-rise fireground tasks based on crew size.

[74] Averill, J.D., et al. Report on High-Rise Fireground Field Experiments. NIST Technical Note 1797. National Institute of Standards and Technology; Gaithersburg, MD, April 2013. Pg. 43.
[75] In the study, "Fire Out" was defined as the time when both the attack and second hose line were in place at the target threshold.



	3-Person	4-Person	5-Person	6-Person
End Time	1:02:33	0:50:34	0:41:36	0:39:35
Duration	1:02:33	0:50:34	0:41:36	0:39:35
Start Time	0:00:00	0:00:00	0:00:00	0:00:00

Figure 5: Impact of Crew Size on a High-Rise Structure Fire. The above figure compares and contrasts the efficiencies of suppression companies in the completion of critical high-rise tasks for fire control and extinguishment. Based on the NIST Report on High-Rise Fireground Fields Experiments, the smaller the crew size, the more tasks an individual must complete as a team member, which contributes to the delay in initiating fire attack and contributes to diminished efficiency in stopping fire loss. **OFS staffs pumpers and aerials with 4 firefighters each.**

Similar to residential structure fires, there are several critical tasks that must be accomplished. However, unlike residential firefighting in a 186-square meter residence, firefighters working at a high-rise fire must travel upwards of more than three stories and carry additional equipment beyond the normal requirements. Additionally, as it takes longer to assemble an effective response force and to access the fire floor, firefighters are likely to encounter a large volume of fire and will therefore have an extended fire attack. Because of this, it is necessary to establish an equipment supply chain to transport equipment and resources up and down the building.

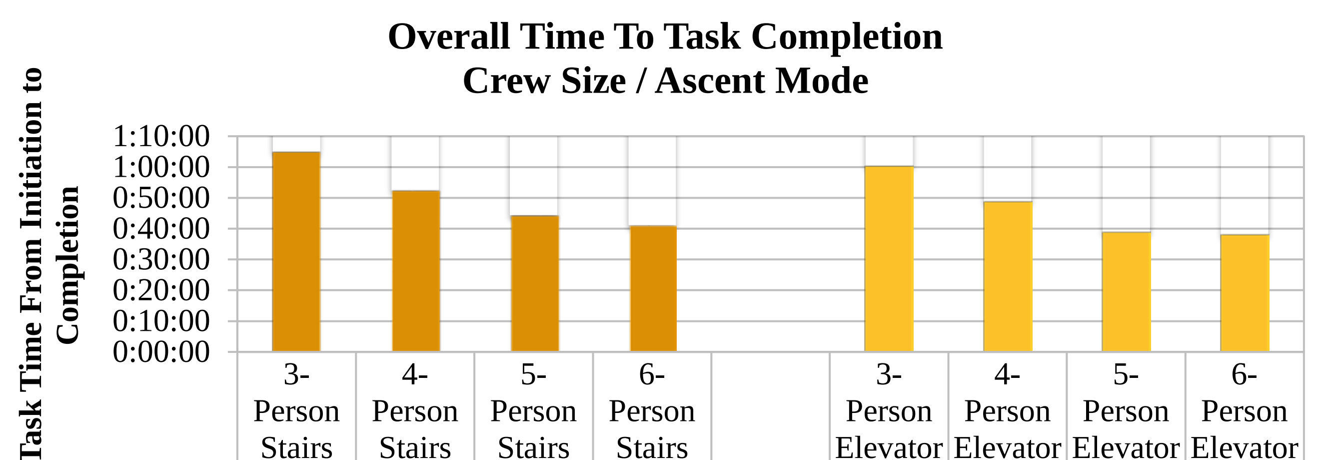
Support

Although the frequency of fires in high-rise structures is low, they pose a high consequence of loss with regards to injury, loss of life, and property damage.

One critical support variable in high-rise fire operations is the availability of reliable elevators. If firefighters can safely use the elevators to move people and equipment, fire-ground logistics may be significantly improved. When the fire is located several floors above ground level, there is a strong inclination to use the elevators. However, fire service access elevators[76] may not be available in all buildings. Therefore, adequate stairways are necessary for firefighters to transport equipment and reach the fire floor for suppression.

Moving supplies and staff up 15, 20, 30, or more stories is an arduous task. If it is not properly managed, firefighters may be exhausted and unable to fight the fire or rescue trapped occupants. Additionally, joint use of stairways by firefighters moving upward and occupants attempting to evacuate may increase the overall evacuation time of the occupants, as well as delay the firefighters' efforts to begin critical tasks such as fire suppression or search and rescue operations. As such, it is important to have multiple firefighters to help carry equipment upstairs and manage resource distribution.

Figure 6, compares total task completion time based on crew size and ascent mode (stairs vs elevator).



	3-Person Stairs	4-Person Stairs	5-Person Stairs	6-Person Stairs		3-Person Elevator	4-Person Elevator	5-Person Elevator	6-Person Elevator
End Time	1:04:52	0:52:24	0:44:25	0:41:07		1:00:14	0:48:45	0:38:47	0:38:04
Duration	1:04:52	0:52:24	0:44:25	0:41:07		1:00:14	0:48:45	0:38:47	0:38:04
Start Time	0:00:00	0:00:00	0:00:00	0:00:00		0:00:00	0:00:00	0:00:00	0:00:00

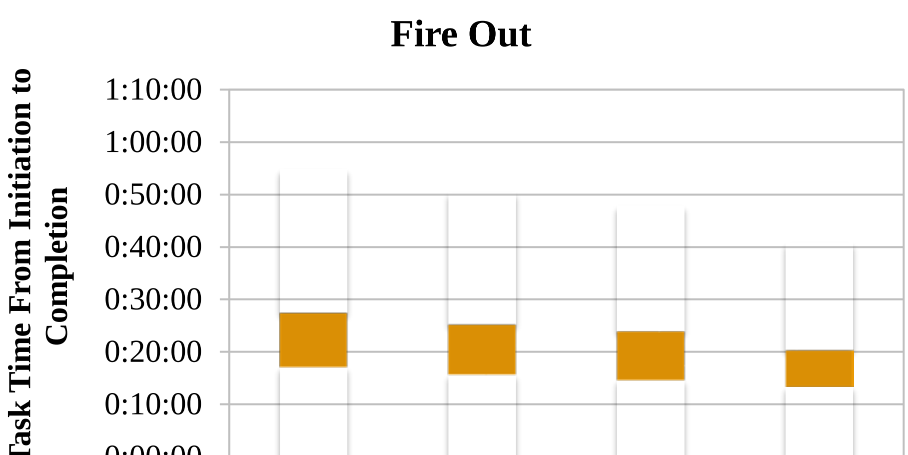
Figure 6: Impact of Crew Size and Ascent Mode in a High-Rise Structure Fire. The above figure compares and contrasts the efficiencies of suppression companies in the completion of critical high-rise tasks (Table 7) for fire control and extinguishment based on crew size and ascent mode. Based on the NIST Report on High-Rise Fireground Fields Experiments, for any given crew size, the reduction in time to complete all tasks attributed to ascent mode was roughly in the 3-minute to 5-minute range when the elevator was used. The smaller the crew size the more tasks an individual must complete as a team member, which contributes to the delay in initiating fire attack and contributes to diminished efficiency in stopping fire loss. **OFS staffs pumpers and aerials with 4 firefighters each.**

[76] A fire service elevator is engineered to operate in a building during a fire emergency and complying with prescriptive building code requirements and the American Society of Mechanical Engineers (ASME) A 17.1 safety standard for elevators.

Fire Extinguishment

Fire extinguishment is a critical factor, since the intensity and size of the fire will determine the extent to which combustion gases are heated and how high they will rise inside the building. Building suppression systems, both active and passive, can impact fire growth, occupant safety, and firefighter safety and effectiveness. Such features include active fire detection and automatic sprinkler systems and are designed to either extinguish the fire or contain it until firefighters arrive.

Once firefighters are on scene, they will complete a series of fire confinement and extinguishment tasks. Firefighters access the structure, locate the fire, locate any avenues of spread, place hoselines, and establish a water supply. Once a water supply is established, water should be placed at the seat of the fire or in the compartment containing the fire to extinguish it. Unlike residential structure fires where hoselines can be stretched from the fire apparatus into the structure, high-rise structures require the use of standpipes systems to combat fire. This requires firefighters to carry multiple sections of hose to the affected floors and connect into the system to fight fire. Minimally, firefighters must deploy two hoselines to the involved floor and one hoseline to the floor above the fire. The third hoseline supports a number of critical tasks in the suppression effort. Principally, it is used to protect search and rescue teams, but also to stop the spread of fire as a result of conduction and convection through exposed pipes, metal framing, and ventilation systems. Figure 7 represents the time it took to extinguish the fire compared to crew size and the task time from initiations to completion of the “fire out” task.



	3-Person	4-Person	5-Person	6-Person
End Time	0:27:26	0:25:12	0:23:57	0:20:24
Duration	0:10:09	0:09:18	0:09:06	0:06:53
Start Time	0:17:17	0:15:54	0:14:50	0:13:31

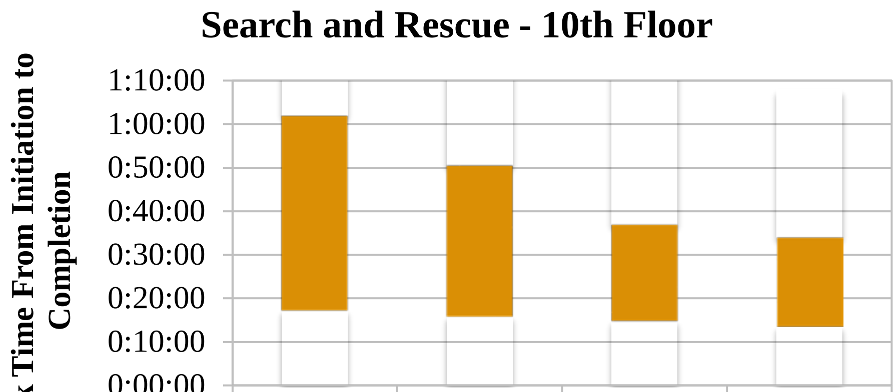
Figure 7: Critical Task “Fire Out”. The fire out task was defined as having both the attack line and the second hose line in place. **OFS staffs pumpers and aerials with 4 firefighters each.**

Search and Rescue

Search and rescue are critical fireground tasks that comprise a systematic approach to locating possible victims and removing those victims from known danger to a safe area. In a residential structure fire, searches are normally conducted by a crew of a minimum of two firefighters, supplemented by an attack or ventilation crew. However, high-rise structures pose challenges regarding search and rescue that are not typically encountered in residential housing. For commercial high-rises and wide-area structures, large open areas and cubicle farms require additional search and rescue teams so that thorough searches can occur over a larger area than found on most residences because conscious victims may retreat to areas in an attempt to find shelter from the heat and smoke. These areas may differ from places where they are typically seen by coworkers, making locating them difficult if they are unaccounted for.

In residential high-rises, apartments typically lack two exits and usually share a common hallway for egress. Doors left open by victims fleeing fire can allow fire and smoke to spread into the hallway and impact escape attempts. Firefighters will be slowed in their search since they will be required to force their way into numerous apartments to search for victims. For this reason, regardless of commercial or residential, it is essential for there to be multiple search and rescue teams operating per involved floor to quickly locate victims in large surface areas. It is also necessary for additional search and rescue teams to search the floors above the fire and the highest floor of the building, due to how fire and smoke spread to the rest of the building. Search and rescue teams should also be supplemented with evacuation management teams to assist injured or disabled victims down the stairwells so searching can continue. Because of the larger search area, NFPA 1710 requires a minimum of four firefighters for searching and a minimum of four firefighters for evacuation management teams.

The NIST study scenario for the search and rescue tasks took place on the fire floor, and the floor above. The fire floor was a 2,800 sq. m area containing 96 cubicles. Figure 8, on the next page, summarizes the amount of time it took each crew size to start and complete the search on the fire floor.



	3-Person	4-Person	5-Person	6-Person
End Time	1:01:50	0:50:29	0:36:56	0:33:59
Duration	0:44:29	0:34:30	0:22:00	0:20:23
Start Time	0:17:22	0:15:59	0:14:55	0:13:36

Figure 8: Critical Task Search and Rescue: The critical task of search and rescue consisted of a complete search of the fire floor, which for this experiment, was a 2800 sq. m area containing 96 cubicles. **OFS staffs pumpers and aerials with 4 firefighters each**

Ventilation

Ventilation affects both search and rescue and fire extinguishment. Ventilation may be implemented at any time during the operation, but it should be coordinated with suppression and interior rescue activities. Ventilation is used to channel and remove heated air, smoke, fire gases, and other airborne contaminants. Applying proper ventilation at the right time and place is key to firefighter and occupant safety. Venting at the wrong time or place can draw active fire toward fresh air, which will injure or kill anyone in its path. In instances of high-rise fire suppression, adequate and appropriate ventilation is important to keep stairways free of smoke and noxious gases for victims who are evacuating.

Because of the size of high-rise buildings and high-hazard structures in general, a larger number of firefighters is required for a ventilation team than would be for a residential structure. NFPA 1710 requires a minimum of four firefighters to be assigned to ventilation.

To accomplish the critical fireground tasks associated with high-rise firefighting and meet the minimum staffing objectives for task completion, NFPA 1710 recommends the following crew sizes for the first arriving unit(s) on the scene within four minutes of travel time for response to high-hazard structures:

- In jurisdictions with a high number of incidents or geographical restrictions, as identified by the AHJ, these companies shall be staffed by a minimum of five on-duty members.[77]

- In jurisdictions with tactical hazards, high-hazard occupancies, or dense urban areas, as identified by the AHJ, these fire companies shall be staffed with a minimum of six on-duty members.[78]

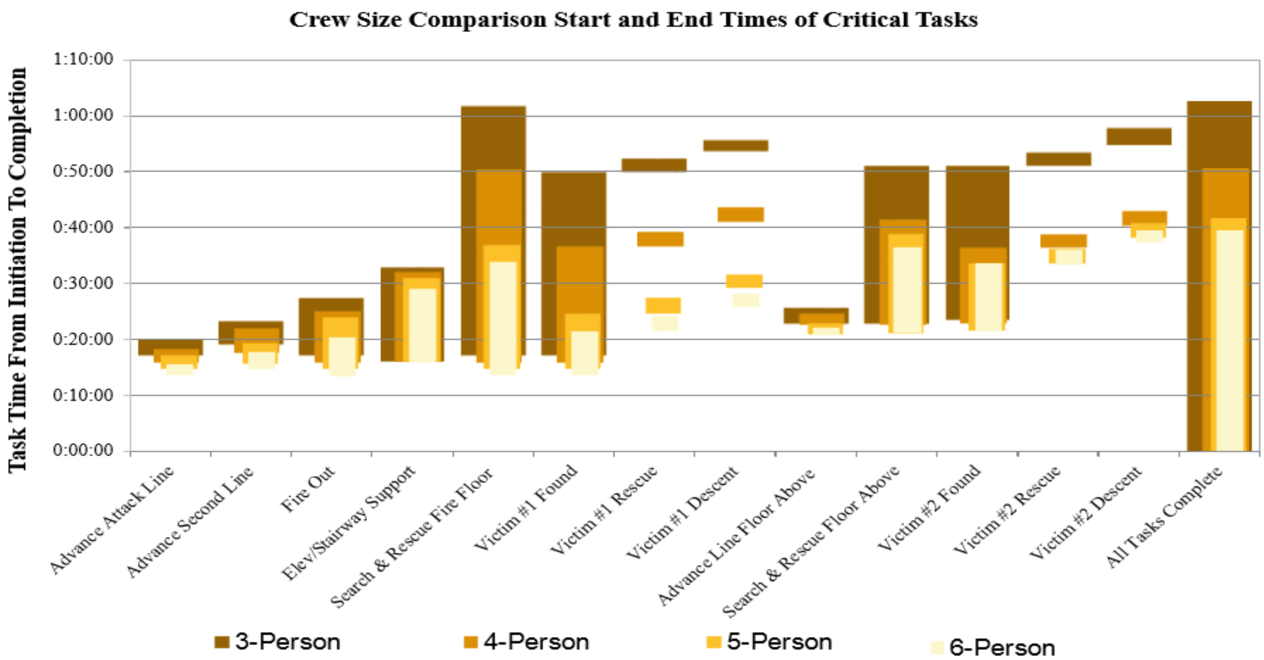


Figure 9: The Relationship between Crew Size and Completion of Critical Fireground Tasks.[79] The above figure displays how companies staffed with larger crew sizes will be on the scene of a high-rise emergency for a shorter time than smaller sized companies. Figure 9 represent the 14 critical tasks measured in the NIST Report on High-Rise Fireground Field Experiment. This lag on scene could be translated to mean that emergency resources will be unavailable longer to address other emergencies that may arise. **OFS staffs pumpers and aerials with 4 firefighters each.**

[77] NFPA 1710. §5.2.3.1.2
[78] NFPA 1710. §5.2.3.1.2.1, §5.2.3.2.2, and §5.2.3.2.2.1.
[79] Averill, J.D., et al. Report on Residential Fireground Field Experiments. NIST Technical Note 1661. National Institute of Standards and Technology; Gaithersburg, MD, April 2010.

As indicated by the tasks that must be accomplished on a high-rise fireground, understanding the required resources is critical. The number of firefighters needed to safely and effectively combat a high-rise fire may be large. Although an offensive fire attack is the preferred strategy whenever conditions and resources permit, a defensive attack that limits operations to the outside of a building and generally results in more property damage must be considered when risks to firefighter safety are too great and benefits to building occupants are negligible. The offensive vs. defensive decision is based on a number of factors: fireground staffing available to conduct an interior attack, a sustained water supply, the ability to conduct ventilation, and risk vs. benefit analysis regarding firefighter and occupant safety. Table 8, following page, displays the minimum number of firefighters required to arrive as part of the initial full alarm assignment to a high-rise fire.

Assignment	***Required Personnel***
Incident Command	1 Incident Commander 1 Incident Command Aide
Uninterrupted Water Supply	1 Building Fire Pump Observer 1 Fire Engine Operator[80]
Water Flow from Two Handlines on the Involved Floor	4 Firefighters (2 for each line)
Water Flow from One Handline One Floor Above the Involved Floor	2 Firefighters (1 for each line)
Rapid Intervention Cre (RIC) Two Floors below the Involved Floor	4 Firefighters
Victim Search and Rescue Team	4 Firefighters (2 per team)
Point of Entry/Oversight Floor	1 Officer 1 Officer's Aide
Point of Entry/Oversight Floor Above	1 Officer 1 Officer's Aide
Evacuation Management Teams	4 Firefighters (2 per team)
Elevator Management	1 Firefighter
Lobby Operations Officer	1 Officer
Trained Incident Safety Officer	1 Officer
Staging Officer Two Floors Below Involved Floor	1 Officer
Equipment Transport to a Floor Below Involved Floor	2 Firefighters
Firefighter Rehabilitation	2 Firefighters
Vertical Ventilation Crew	1 Officer 3 Firefighters
External Base Operations	1 Officer
2 EMS ALS Transport Units[81]	4 Firefighters
Required Minimum Personnel for Full Alarm	**36 Firefighters** **1 Incident Commander** **6 Officers** **Total Personnel: 43**

Table 8: Number of Firefighters for an Initial Full Alarm to a High-Rise Fire. High-rise firefighting poses many unique obstacles and challenges above those that are not found in a residential structure fires. Hose cannot be deployed directly from fire apparatus and needs to be carried, with other equipment, to the location of the fire. Search and rescue is impacted by large areas and accessibility concerns. Additionally, because of delays in access, firefighters are likely to encounter a high volume of fire which will necessitate a supply chain to equip ongoing

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[80] If connecting to building's fire pump.

[81] NFPA 1710. §5.2.4.4.1 Provision of a minimum of two members to manage member rehabilitation. At least one of the members shall be trained to the ALS level. Provision of a minimum of two crews trained in emergency medical services with on-scene transport capability, each crew with a minimum of two members. At least one of the members shall be trained to the ALS level. . Where this level of emergency medical care is provided by outside agencies or organizations, these agencies and organizations shall be included in the deployment plan and meet these requirements

suppression efforts. A single alarm response to a high-rise building requires a minimum of 43 responders, consisting of 36 firefighters, 1 incident commander, and 6 officers.

It should be noted that although the OFS does not provide ALS response or transport, the intent of this section of the NFPA 1710 high-rise standard is to provide a means of rehabilitation for firefighters to minimize the risk of injury and death. OFS should require the provincial EMS agency to provide two ALS ambulances staged outside of the structure. Two firefighters should be stationed inside the building in the staging area to monitor firefighters for signs of exhaustion, dehydration, and other signs and symptoms of a medical emergency. As the rehab area is on the interior of the building, it is advisable that firefighters perform this critical task, as provincial EMS workers lack the training or personal protective equipment to operate in or near an IDLH environment. As such, allowing provincial EMS workers to operate in the building and mere floors below the floor or floors that are on fire creates an unnecessary risk to everyone operating at the scene of a high-rise fire.

Fire Department Deployment

Before discussing the staffing and deployment analysis of Oshawa Fire Services' resources it is imperative to understand the intricacies of distribution and concentration. Although adequate staffing is a key element contributing to positive outcomes, fire station location and apparatus deployment are equally important.

The Importance of Adequate Resources: Distribution

Distribution involves locating geographically distributed, ideal first-due resources for all-risk initial intervention. Distribution describes first due arrival. Station locations are needed to assure rapid deployment for optimal response to routine emergencies within the response jurisdiction. Distribution can be evaluated by the percentage of the jurisdiction covered by the first-due units within adopted public policy service level objectives.[82] In this case, distribution is measured by the percentage of roads that are covered from each fire station within 4- and 8- travel times to adhere to NFPA 1710 standards.

Distribution study requires geographical analysis of first due resources. Distribution measures may include:[83]

- Population per first-due apparatus
- Area served per first-due apparatus (square kilometers)
- Number of total road kilometers per first-due apparatus
- Dwelling unit square meterage per first-due apparatus
- Maximum travel time in each first-due apparatus' protection area
- Catchment areas (4-minute road response from all fire stations) to determine gap areas and overlaps of first-due resources
- Areas outside of actual performance
    1. Population not served
    2. Area not served (square kilometers)
    3. Road kilometers not served
    4. Dwelling unit square meterage not served
- First-due unit arrival times (Pumper, Aerial, etc.)

[82] Commission on Fire Accreditation International, 5th Edition. 2008. Page 52.
[83] Ibid.

A major item to be considered in the distribution of resources is travel time. It should be a matter of public policy that the distribution of fire stations in the community is based on the element of travel time and the response goal. Travel time should be periodically sampled and analyzed to determine whether or not the fire department is achieving a reasonable response performance to handle emergencies.[84]

Evaluating a small number of incidents for response time performance does not reflect the true performance of the department. Analyzing incident demand measured over a 3-5 year period will provide a more accurate assessment of the delivery system performance. Completing the same analysis over a period of time will allow for trend analysis as well.[85]

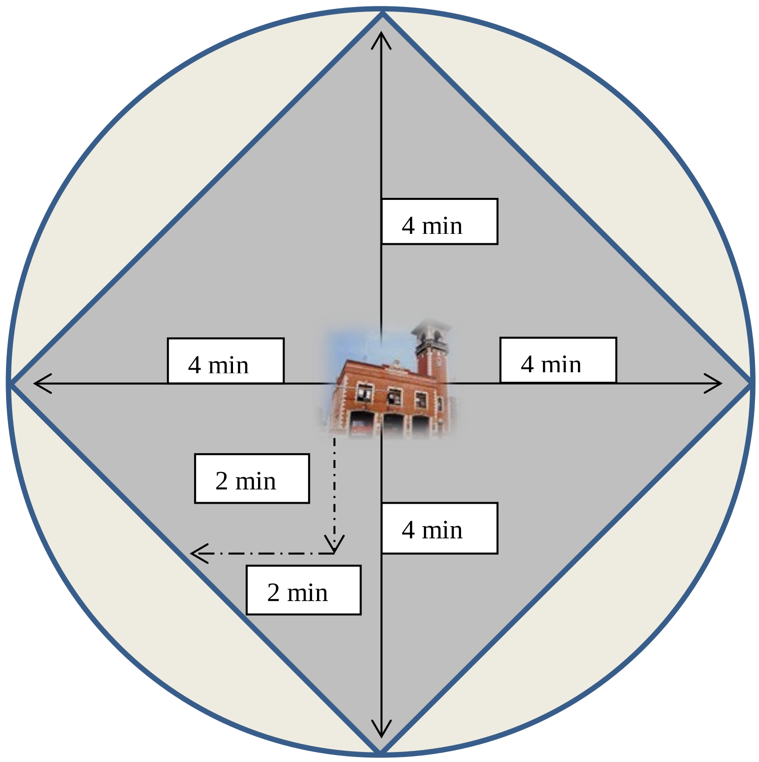

Figure 10: Normal Distribution Model for an Initial 4-Minute Response Area.[86] As depicted in the above figure, fire stations and emergency resources should be distributed throughout a community so that citizens receive equitable coverage and protection. However, there are additional points of concern when modeling a response district such as road network, traffic patterns, and building occupancies.

Distribution strives for an equitable level of outcome: Everyone in the community is within the same distance from a fire station. Distribution is based on probabilities that all areas experience equal service demands, but not necessarily the same risk or consequences as those demands for

[84] Commission on Fire Accreditation International, 5th Edition. 2008. Page 53
[85] Commission on Fire Accreditation International, 5th Edition. 2008. Page 53
[86] Derived from Commission on Fire Accreditation International, 5th Edition. 2008. Page 53

service in other areas. For example, suburban communities in a city may have the same service demand as an industrial factory area, but the level of risk is very different. This can have an impact on fire station locations as placement would probably put the stations near high risk areas with shorter travel times. Additionally, EMS response times based on medical emergencies will drive equal distribution in the community and negate distribution based on risk, as the risk is equal.

First unit arrival times are the best measure of distribution. It should be noted that if an area experiences fire unit arrival times outside the adopted performance measure, in this case 4-minute travel time per NFPA 1710, it does not necessarily mean it has a distribution issue.[87] Other issues occur such as reliability, call processing times and turnout times, and traffic which can affect the overall performance of response times.

An effective response force for a fire department is impacted not only by the spacing of fire stations but also by the type and amount of apparatus and personnel staffing the stations. To assemble the necessary apparatus, personnel, and equipment within the prescribed timeframe, all must be close enough to travel to the incident, if available upon dispatch. The placement and spacing of specialty equipment is always challenging.[88] Specialty units tend to be aerials, rescue units, hazmat, or Battalion personnel. Most often there are less of these types of equipment and personnel compared to the first-line response of pumpers. Selecting where to put specialty units requires extensive examination of current and future operations within the fire department and a set goal of response time objectives for all-hazards emergencies within the city.

Distribution vs. Concentration

Major fires have a significant impact on the resource allocation of any fire department. The dilemma for any fire department is staffing for routine emergencies and also being prepared for the fire or emergency of maximum effort. This balancing of distribution and concentration staffing needs is one that almost all fire agencies face on an ongoing basis.

The art in concentration spacing is to strike a balance with respect as to how much overlap there should be between station areas. Some overlap is necessary to maintain good response times and to provide back-up for distribution when the first-due unit is unavailable for service or deployed on a prior emergency.

Concentration pushes and pulls distribution. Each agency, *after risk assessment and critical task analysis*, must be able to quantify and articulate why its resource allocation methodology meets the governing body's adopted policies for initial effective intervention on both a first-due and multiple-unit basis.[89]

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[87] Commission on Fire Accreditation International, 5th Edition. 2008. Page 55
[88] Commission on Fire Accreditation International, 5th Edition. 2008. Page 62
[89] Commission on Fire Accreditation International, 5th Edition. 2008. Page 62-63

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Mapping Analysis of Oshawa Fire Services

In creating this document, it was important to ascertain where stations were located and if they were located to provide safe and effective coverage to the citizens. To make this assessment, the IAFF created maps of Oshawa Fire Services response area and plotted the fire station locations.

Computer modeling was then used to determine the distance apparatus could travel in 4 and 8 minutes. The following table specifies the locations of the current six stations.

Station	Address	Apparatus	Typical Staffing
1	199 Adelaide Avenue West	Pumper 21 Car 25	**3 Firefighters, 1 Captain** **1 Platoon Chief**
2	1111 Simcoe Street South	Pumper 22 Aerial 22	**3 Firefighters, 1 Captain** **3 Firefighters, 1 Captain**
3	50 Beatrice Street East	Pumper 23 Aerial 23 Tanker 23	**3 Firefighters, 1 Captain** **3 Firefighters, 1 Captain** **Cross-staffed**
4	50 Harmony Road North	Pumper 24	**3 Firefighters, 1 Captain**
5	1550 Harmony Road North	Pumper 25 Rescue 25	**3 Firefighters, 1 Captain** **Cross-staffed**
6	2339 Simcoe Street North	Pumper 26	**3 Firefighters, 1 Captain**

Table 9: Current Fire Station Locations. The above table displays where apparatus are housed and typical on-duty staffing.

Travel times were modeled using ESRI ArcGIS Pro version 2.1.0. Fire stations were identified on Geographic Information System (GIS) maps as starting points with vehicles traveling at posted road speeds.

Prior to drawing conclusions from the mapping analysis, the following issues should be taken into consideration:

- Modeled travel speeds are based on historical traffic speeds occurring on Wednesdays at 5:00 P.M.[90] Actual response speeds may be slower, and the associated travel times greater, with any unpredictable impedances including, but not limited to:
    - Traffic Incidents: Collisions and vehicle breakdowns causing lane blockages and driver distractions.

[90] Historical traffic data as contained in ESRI's StreetMap Premium, Version 17.2.

- Work Zones: Construction and maintenance activity that can cause added travel time in locations and times where congestion is not normally present.
- Weather: Reduced visibility--road surface problems and uncertain waiting conditions result in extra travel time and altered trip patterns.
- Special Events: Demand may change due to identifiable and predictable causes.
- Traffic Control Devices: Poorly timed or inoperable traffic signals, railroad grade crossings, speed control systems, and traveler information signs contribute to irregularities in travel time.
- Inadequate Road or Transit Capacity: The interaction of capacity problems with the aforementioned sources causes travel time to expand much faster than demand.[91]

- Larger emergency vehicles are generally more cumbersome and require greater skill to maneuver. Therefore, response by these vehicles may be more negatively affected by weight, size, and in some cases, inability to travel narrow surface streets.

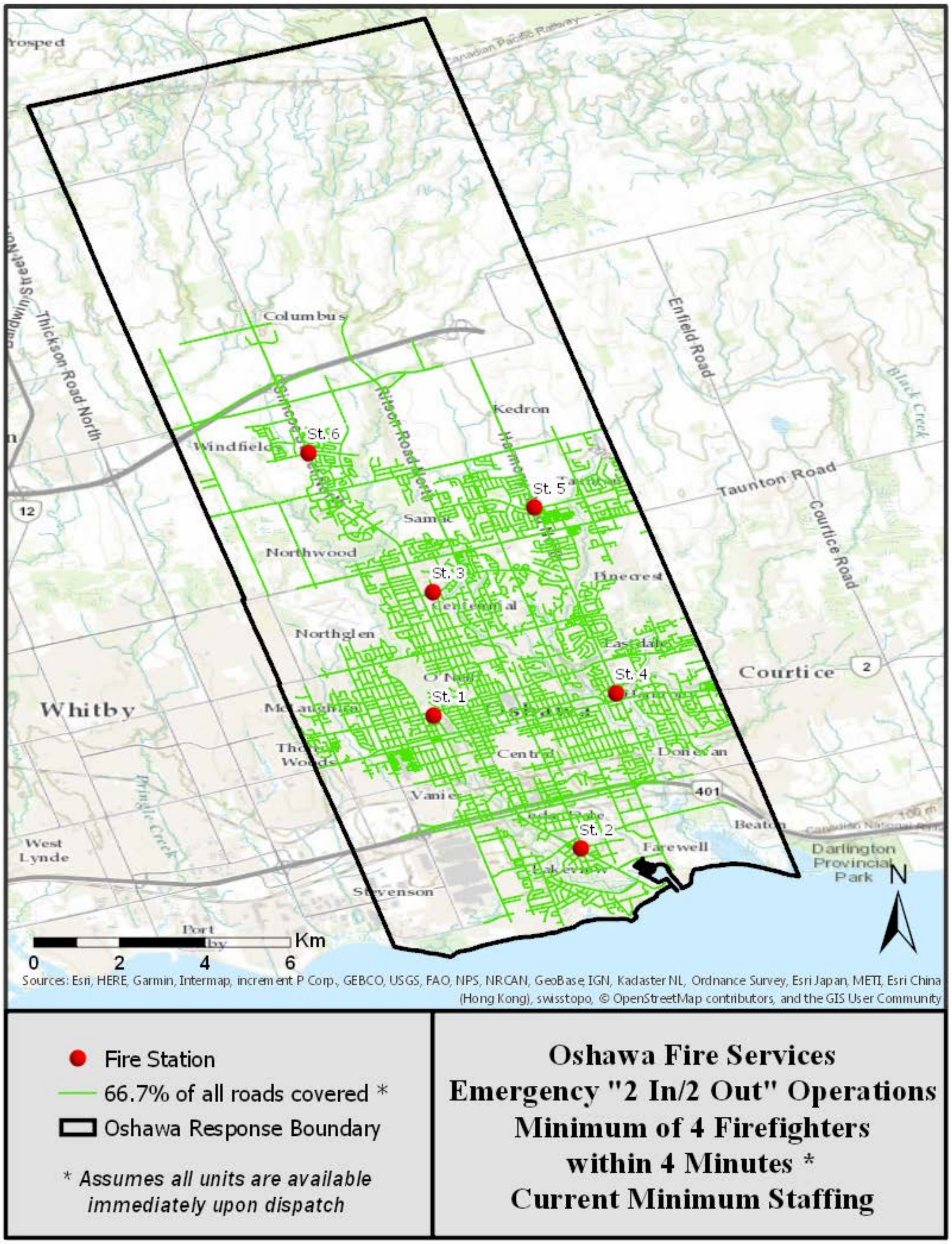
- Computer modeling only considers travel time of apparatus. Decision makers should understand that once apparatus and personnel arrive on the incident scene there are other essential tasks that must be completed which require additional time before access, rescue, and suppression can take place. Tasks such as establishing a water supply, forcible entry (access), and deployment of an attack line are not considered in the computer modeling.

- The reliability of a community's hydrant system to supply water to fire apparatus.

- Weather conditions

[91] David Shrank and Tim Lomax, The 2003 Urban Mobility Report, (Illinois Transportation Institute, Illinois A&M University: September 2003).

Current Emergency Response Capabilities



Map 13: Emergency "2 In/2 Out" Operations, Minimum of 4 Firefighters within 4 Minutes, Current Minimum Staffing. Map 13 identifies those roads where a minimum of 4 firefighters can assemble on scene within 4 minutes of travel under minimum staffing conditions. Currently, OFS can assemble at least 4 firefighters on 66.7% roads within Oshawa within 4 minutes, assuming apparatus are staffed and available for immediate response.

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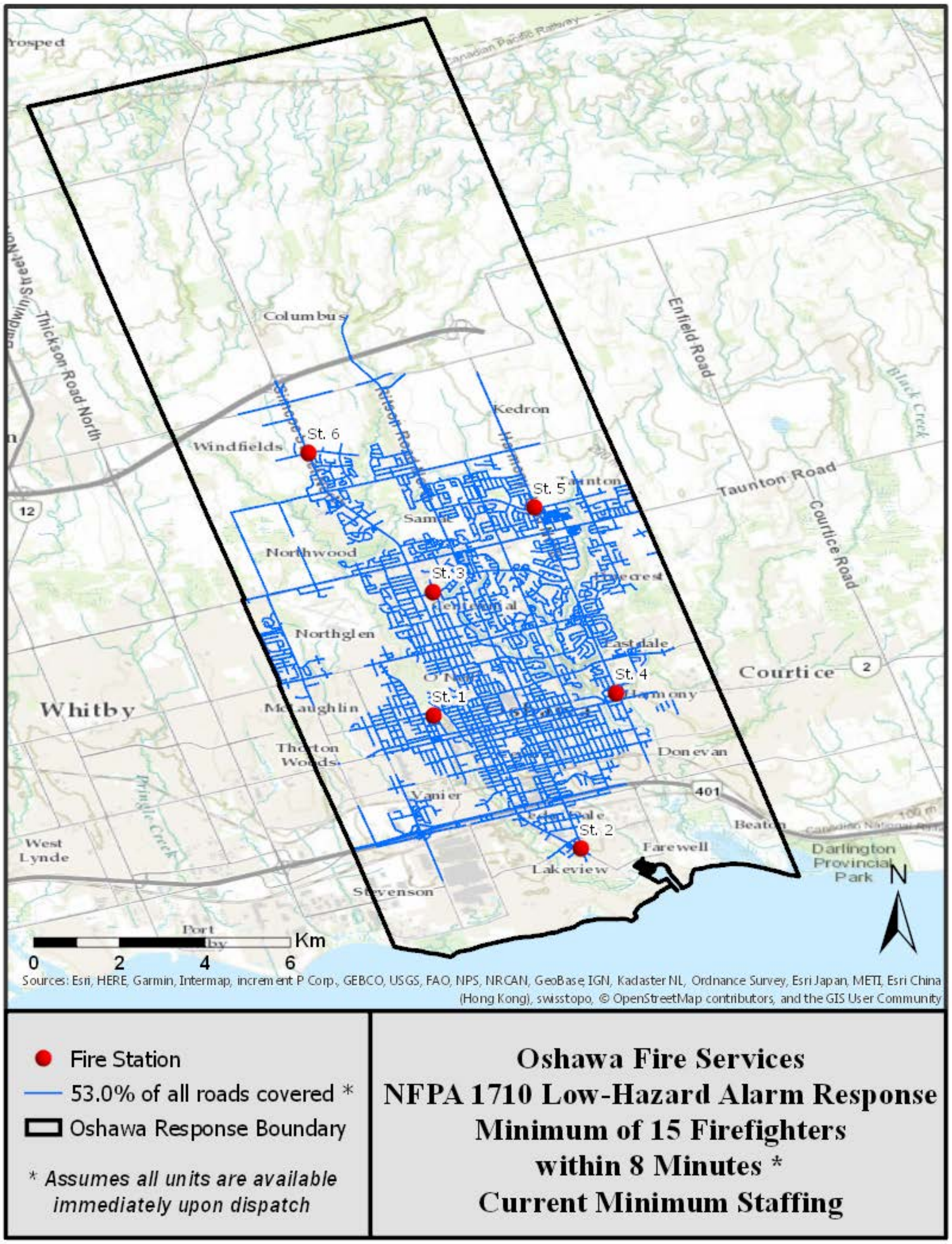
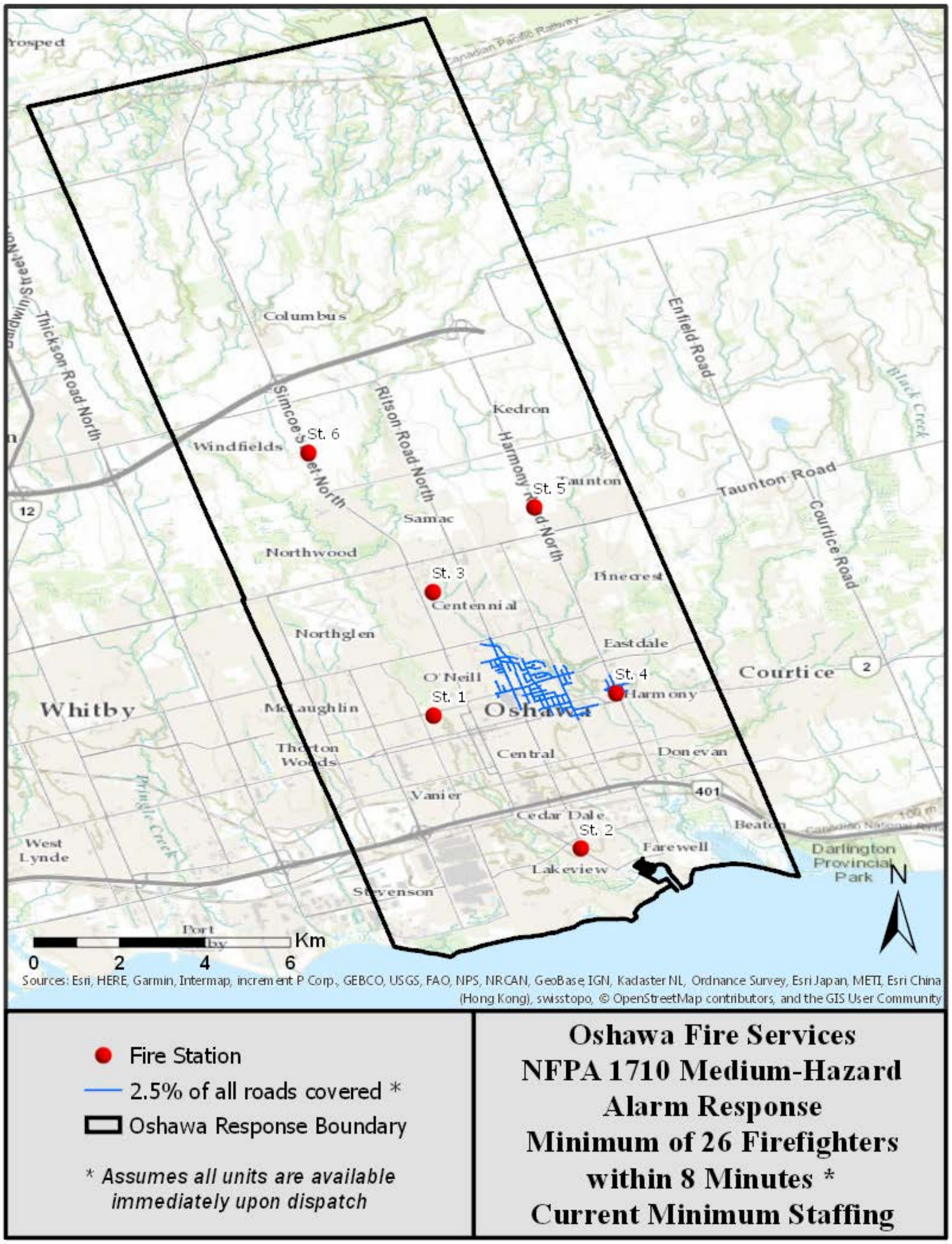
OFS' Structure Fire Alarm Response

OFS' standard initial alarm for a structure fire consists of 2 pumper apparatus (4 firefighters each), 1 aerial apparatus (4 firefighters), and 1 platoon chief, for a total of 13 firefighters. NFPA 1710 requires a minimum of 14 firefighters and 1 command officer to arrive on the scene of a low-hazard structure fire for 90% of incidents. Based on the department's current alarm response to a structure fire, OFS does not dispatch the required minimum 15 firefighters.

The following maps examine the current ability of OFS to respond to a structure fire occurring in a low- or medium- hazard structure as required by NFPA 1710 performance objectives. **Under the current staffing and deployment configuration, OFS in unable to assemble a minimum of 39 firefighters on any roads within the city to meet NFPA 1710's minimum response requirements to a high-hazard structure fire.**



Map 14: NFPA 1710 Low-Hazard Alarm Response, Minimum of 15 Firefighters within 8 Minutes, Current Minimum Staffing. Map 14 identifies those roads where a minimum of 15 firefighters can assemble on scene within 8 minutes of travel. Currently, OFS is capable of assembling a minimum of 15 firefighters on 53% of roads within Oshawa within 8 minutes, assuming all units are available immediately upon dispatch.



Map 15: NFPA 1710 Medium-Hazard Alarm Response, Minimum of 26 Firefighters within 8 Minutes, Current Minimum Staffing. Map 15 identifies those roads where a minimum of 26 firefighters can assemble on scene within 8 minutes of travel. Currently, OFS is capable of assembling a minimum of 26 firefighters on 2.5% of roads within Oshawa within 8 minutes, assuming all units are available immediately upon dispatch.

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Oshawa Fire Services Workload Analysis

The analysis of OFS' response capabilities is based on the assumption that all units are available to respond immediately upon dispatch, which allows for a general evaluation of the department's response capabilities. However, instances when all units are available for dispatch at the same time rarely happen. To more accurately evaluate the department's workload, incident data must be examined on a smaller scale.

OFS provided historical CAD data for all OFS emergency responses from January 1, 2015 to December 31, 2017. The CAD data include, but are not limited to, details such as type of incident, responding apparatus, the geographic location of responding units at the time of dispatch, the location of incident, time the call was received, dispatch time, en route time, time of arrival on location, the returning time, and the in-quarters time. CAD data have the necessary information needed to: determine the total number of incidents and apparatus responses per year, determine when the highest volume of incidents and apparatus responses occur throughout the day, determine pumper demand throughout the year, calculate the 90th percentile travel times for the first arriving apparatus, and identify which units are responding into which first-due districts.

Using these findings, the department will be able to determine how workload, increased call volume, and changes in staffing, deployment, and apparatus placement have affected OFS' response capabilities. It will provide decision makers with the information to better allocate resources to ensure OFS provides effective and efficient emergency response.

Data Parameters

CAD data provided by OFS list all incidents responded to by the department's personnel and resources from January 1, 2015 to December 31, 2017. Parameters were created to accurately examine the department's workload and past performance. Below are the parameters used when analyzing the data:

- Records with errors in reporting en route time, arrival time, and/or incidents that were cancelled before the first apparatus arrived on scene were excluded from the travel time analysis.[92]

- An apparatus response was not counted if the record did not have both en route and arrival times. Records where both en route and on location times were not entered could be examples of an apparatus being cancelled before it started to respond to the incident.

[92] 23.5% of responses were excluded due errors in reporting en route time, arrival time, or were cancelled before arriving on scene.

- Incidents that were not located within OFS' response boundary or could not be geographically located due to inaccurately entered latitude/longitude and/or address information were excluded from the travel time and district demand analyses.[93]

Call Volume Analysis

An important parameter to consider is the number of incidents compared to the number of apparatus responses. Incidents may, and frequently do, require responses from multiple apparatus. It is also important to understand at what times during the day most incidents and apparatus responses take place. Examining the number of responses performed by each OFS apparatus will assist in determining the workload of each apparatus.

From January 1, 2015 to December 31, 2017, OFS experienced an increase in the number of incidents and apparatus responses. During this time period, there was a 17.8% increase in the number of incidents[94] and a 19.8% increase in the number of apparatus responses.[95] The highest volume of incidents and apparatus responses took place between the hours of 8:00 AM and 10:00 PM. The department experienced its lowest call volume between 11:00 PM and 8:00 AM. While call volume may be lower during the overnight hours, the risk for civilian fire fatalities peaks during these hours. According to a study of Ontario fatal fires from 2007 to 2016 by the Ontario Office of the Fire Marshal and Emergency Management, 42% of residential fatal fires occurred between 10:00 PM and 6:00 AM.[96] Additionally, according to a 2017 study performed by the U.S. Fire Administration (USFA), 51% of U.S. civilian fire fatalities in residential buildings occurred between the hours of 11:00 PM and 7:00 AM.[97] Even though OFS experienced a lower call volume during the overnight hours, the department must be equipped appropriately in order to have the necessary resources and personnel available to respond to all types of incidents and hazards at all times. Figure 12 on Page 79 details the volume of OFS incidents and apparatus responses by hour of day.

[93] 1.8% of incidents were excluded from the cover incident analysis portion of the report due to being located outside of OFS's response boundary or couldn't be geographically located due to errors in reporting the latitude/longitude or address in the CAD.
[94] Only incidents responded to by OFS were considered when calculating total incidents.
[95] Only responses performed by OFS' apparatus were considered when calculating the total apparatus responses.
[96] "Ontario Fatal Fires: 10 years, 2007 – 2016". "The Office of the Fire Marshal and Emergency Management (OFMEM) investigates fatal fires in Ontario", December 2017. OFMEM, http://www.mcscs.jus.gov.on.ca/english/FireMarshal/MediaRelationsandResources/FireStatistics/OntarioFatalities/FatalFiresSummary/stats_fatal_summary.html.
[97] https://www.usfa.fema.gov/downloads/pdf/statistics/v18i4.pdf

During the three-year period (2015-2017), Pumper 21 and Pumper 22 executed the most responses. Additionally, during its only full year in service in 2015[98] out of the three-year period studied, Pumper 211 was the second busiest unit. Refer to Table 10 on Page 80 for the response totals for primary OFS apparatus during the three-year period.

Map 5, on Page 19, in the section titled "Historical Response", can be referred to for a view of the spatial concentration of all responses made by OFS apparatus during the three-year study period, with no individual unit distinction. Additionally, Map 6 on Page 20 in the same section, can be referred to in order to view the percent increases of incidents located in each first-due district during the three-year study period.

[98] On July 19 of 2016, when Station 6 opened, Pumper 211 ceased daily responses and Aerial 23 was moved from Station 3 to Station 1. The response capability of Station 3 was reduced from 2 suppression apparatus, staffed with 4 firefighters each to one suppression apparatus, staffed with 4 firefighters. Prior to July 19, 2016 Pumper 21 and Pumper 211 responded from Station 1 and were each staffed with 4 firefighters at all times. After July 19, 2016 until present, Pumper 21 has been staffed with 4 firefighters and Pumper 211 is a reserve apparatus.

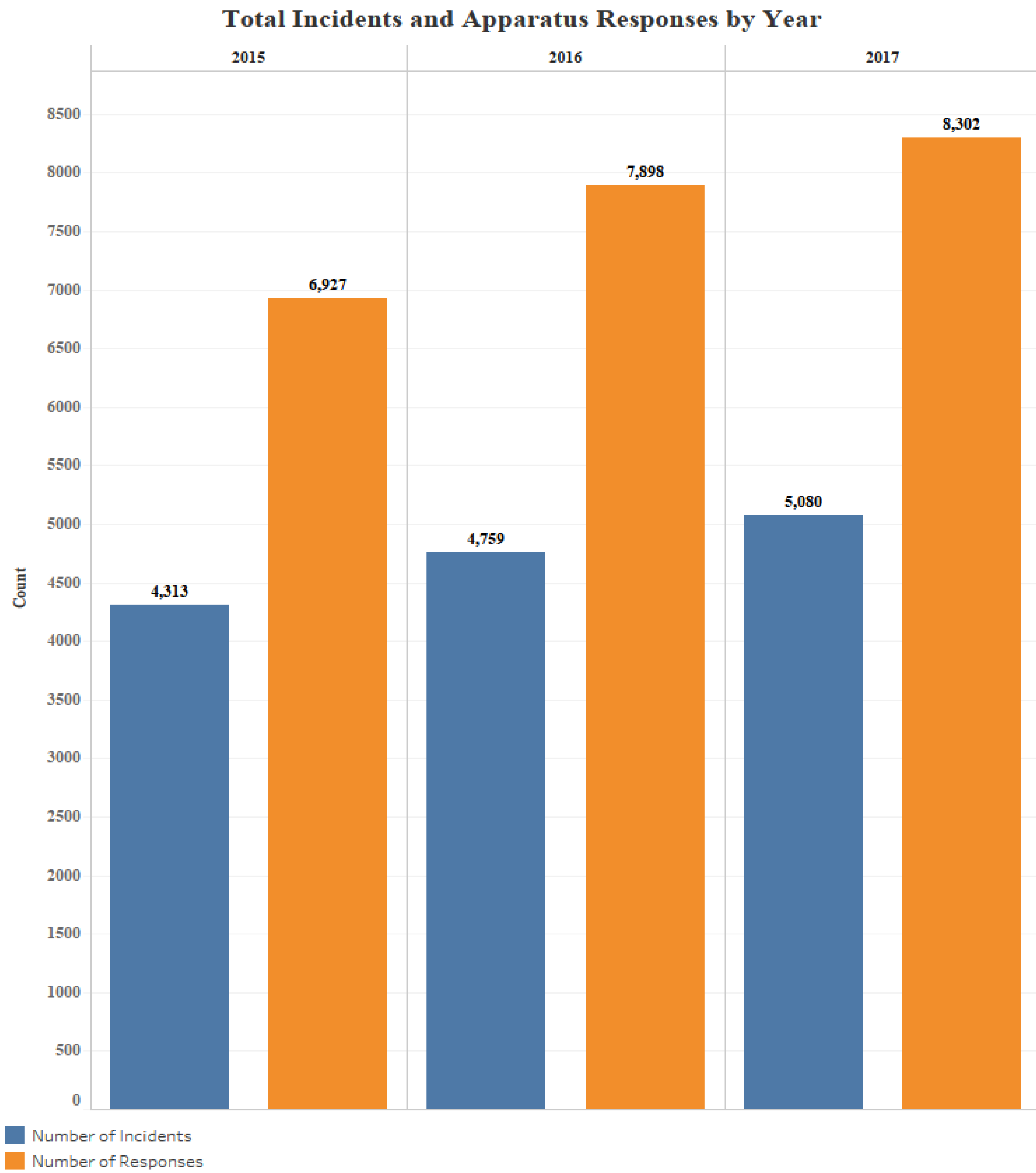


Figure 11: Total Incidents and Apparatus Responses by Year. Figure 11 depicts the total number of incidents and apparatus responses executed by OFS in 2015, 2016, and 2017. From January 1, 2015 to December 31, 2017 there was a 17.8% increase in the number of incidents and a 19.8% increase in the number of apparatus responses. Responses to many incident types can be labor intensive and frequently require personnel from multiple units to complete critical tasks simultaneously.

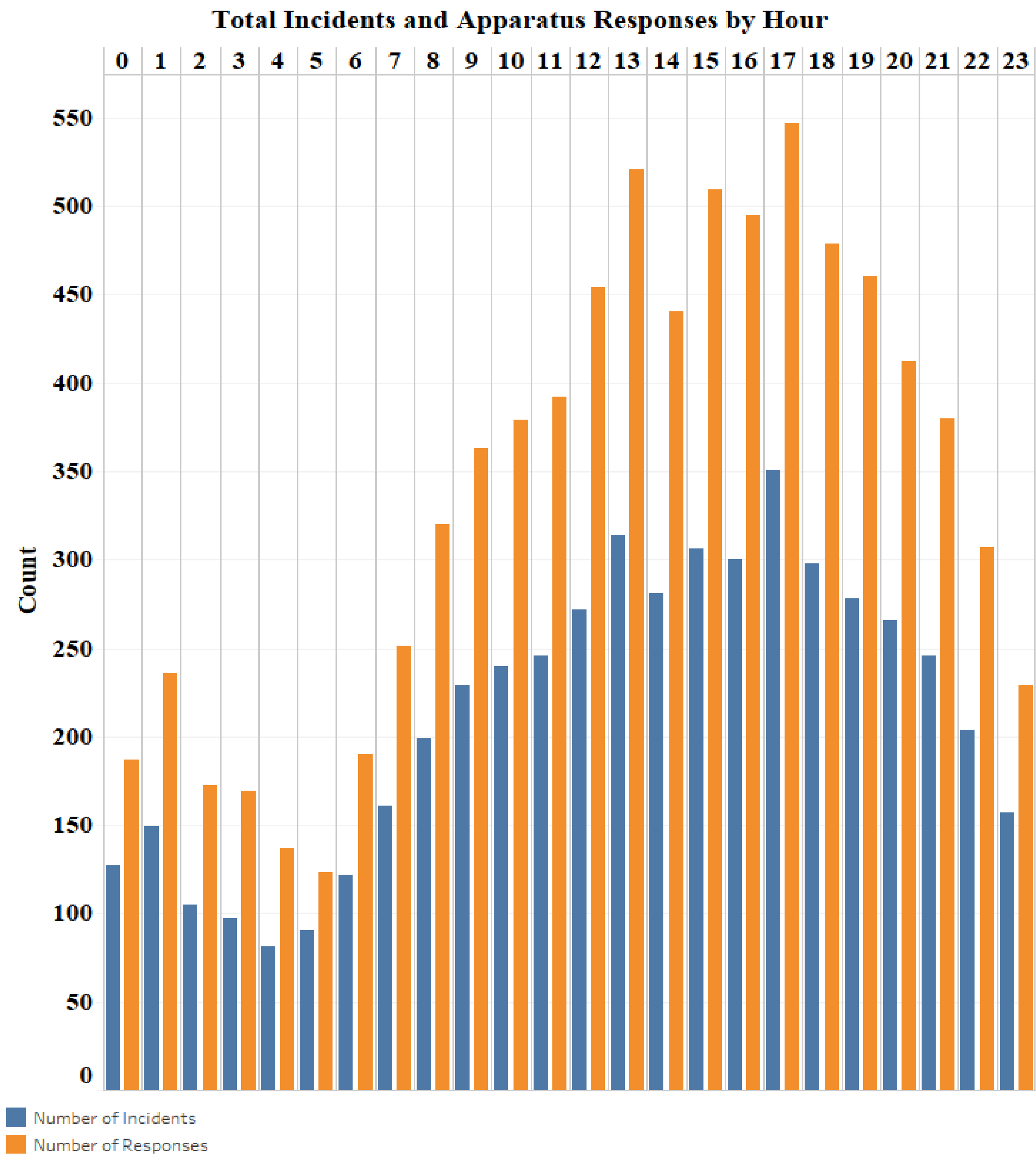


Figure 12: Total Incidents and Apparatus Responses per Hour.[99] Figure 12 depicts the total number of incidents (blue bars) and apparatus responses (orange bars) executed by OFS for each hour in the day (the 0 -23 horizontal axis at the top). From January 1, 2015 to December 31, 2017, the highest volume of incidents and apparatus responses took place between 8:00 AM and 10:00 PM.

[99] List of number of incidents and responses per hour are located in "Appendix B Workload Data B.2"

Apparatus	2015	2016	2017	Total
Aerial 22	605	627	654	1,886
Aerial 23	576	807	808	2,191
Aerial 211	4	2	8	14
Pumper 21	1,293	1,692	1,921	4,906
Pumper 211	1,120	699	6	1,825
Pumper 22	946	1,066	1,370	3,382
Pumper 23	764	907	1,068	2,739
Pumper 24	810	1,033	1,149	2,992
Pumper 25	670	694	682	2,046
Pumper 26	N/A	232	481	713
Pumper 212	N/A	8	N/A	8
Pumper 222	N/A	N/A	2	2
Pumper 233	2	N/A	2	4
Rescue 25	113	114	127	354
Tanker 23	24	16	23	63
Total	**6,927**	**7,898**	**8,302**	**23,127**

Table 10: Total Apparatus Responses. Table 10 depicts the total number of responses performed by OFS apparatus from January 1, 2015 to December 31, 2017. Over this three-year period, Pumper 21 and Pumper 22 responded to the most incidents. Pumper 211 was the second busiest apparatus in 2015. The sharp reduction in the number of responses by Pumper 211 in 2016 and 2017 reflects the fact that after July 2016, it was only deployed as a reserve apparatus.

District Demand Analysis

Tracking how responses into first-due districts change over time can be useful for identifying trends in how demand on individual OFS stations is accommodated. Examining these responses can be used to provide insight into how the 17.8% increase in the number of incidents and the 19.8% increase in the number of apparatus responses by OFS over the 3-year period (2015-2017) impacted the resources from individual stations. Analysis of the CAD reveals how frequently a station’s units were required to respond within another station’s first-due district. This sort of analysis can reveal how OFS units were forced to shift response to accommodate the reduction of Station 3’s response capabilities between July 19, 2016 and April 9, 2017, and the reduction of Station 1’s response capabilities from April 10, 2017 to the end of the study period.

Over the 3-year study period, responses within Station 1’s first-due area increased by 14.9%. Inevitably, OFS units from stations other than Station 1 have increased responses into Station 1’s first-due area because of the increasing incident occurrence and of Station 1’s reduction in response capabilities starting in April of 2017.

As can be seen in the results below, First-Due District 1 and First-Due District 3 experienced significant increases (indicated in bold) in the number of times apparatus from other stations responded to incidents within First-Due Districts 1 and 3 when staffed apparatus were removed from Stations 1 and 3.

The following results detail the percentage of responses into a first-due district from apparatus located in other first-due districts:

- First-due District 1:
  - January 1, 2015 – July 18, 2016: 23.9%
  - July 19, 2016 – April 9, 2017: 24.4%
  - **April 10, 2017 – December 31, 2017: 41.3%**

- First-due District 2:
  - January 1, 2015 – July 18, 2016: 23.8%
  - July 19, 2016 – April 9, 2017: 23.2%
  - April 10, 2017 – December 31, 2017: 24.7%

- First-due District 3:
  - January 1, 2015 – July 18, 2016: 31.9%
  - **July 19, 2016 – April 9, 2017: 45.4%**
  - April 10, 2017 – December 31, 2017: 28.6%

- First-due District 4:
  - January 1, 2015 – July 18, 2016: 35.5%
  - July 19, 2016 – April 9, 2017: 34.6%
  - April 10, 2017 – December 31, 2017: 36.5%

- First-due District 5:
  - January 1, 2015 – July 18, 2016: 36.8%
  - July 19, 2016 – April 9, 2017: 37.3%
  - April 10, 2017 – December 31, 2017: 37.5%

- First-due District 6:
  - January 1, 2015 – July 18, 2016: 100%
  - July 19, 2016 – April 9, 2017: 51.9%
  - April 10, 2017 – December 31, 2017: 45.5%

Additionally, Stations 2 and 3 had the greatest increases in responses into First-due District 1 as Station 1 was reduced to 1 staffed suppression apparatus in April of 2017:

- Station 2 increased responses into First-Due District 1 by 69.8% in this time period.
- Station 3 increased responses into First-Due District 1 by 149% in this time period.

Also, Station 1 had the greatest increase in responses into First-Due District 3 when Station 3 was reduced to 1 staffed suppression apparatus in July of 2016:

- Station 1 increased responses into First-Due District 3 by 62.9% in this time period.

These results indicate that additional resources and personnel may be needed at Station 1 to accommodate increasing demand. The reduction of Station 1's capacity to respond has corresponded with increasing responses from other stations into Station 1's first-due area. The results also indicate that resources and personnel should not be transferred from other OFS stations. In the time period when Station 1 was reduced to 1 staffed suppression apparatus, the majority of additional responses into Station 1's first-due area came from Station 3. In the time period when Station 3 was reduced to 1 staffed suppression apparatus, the majority of additional responses into Station 3's first-due area came from Station 1.

The following 6 figures show the percent of responses into each station's first-due district and the stations those responses came from in each of three distinct timeframes within the three-year study period.

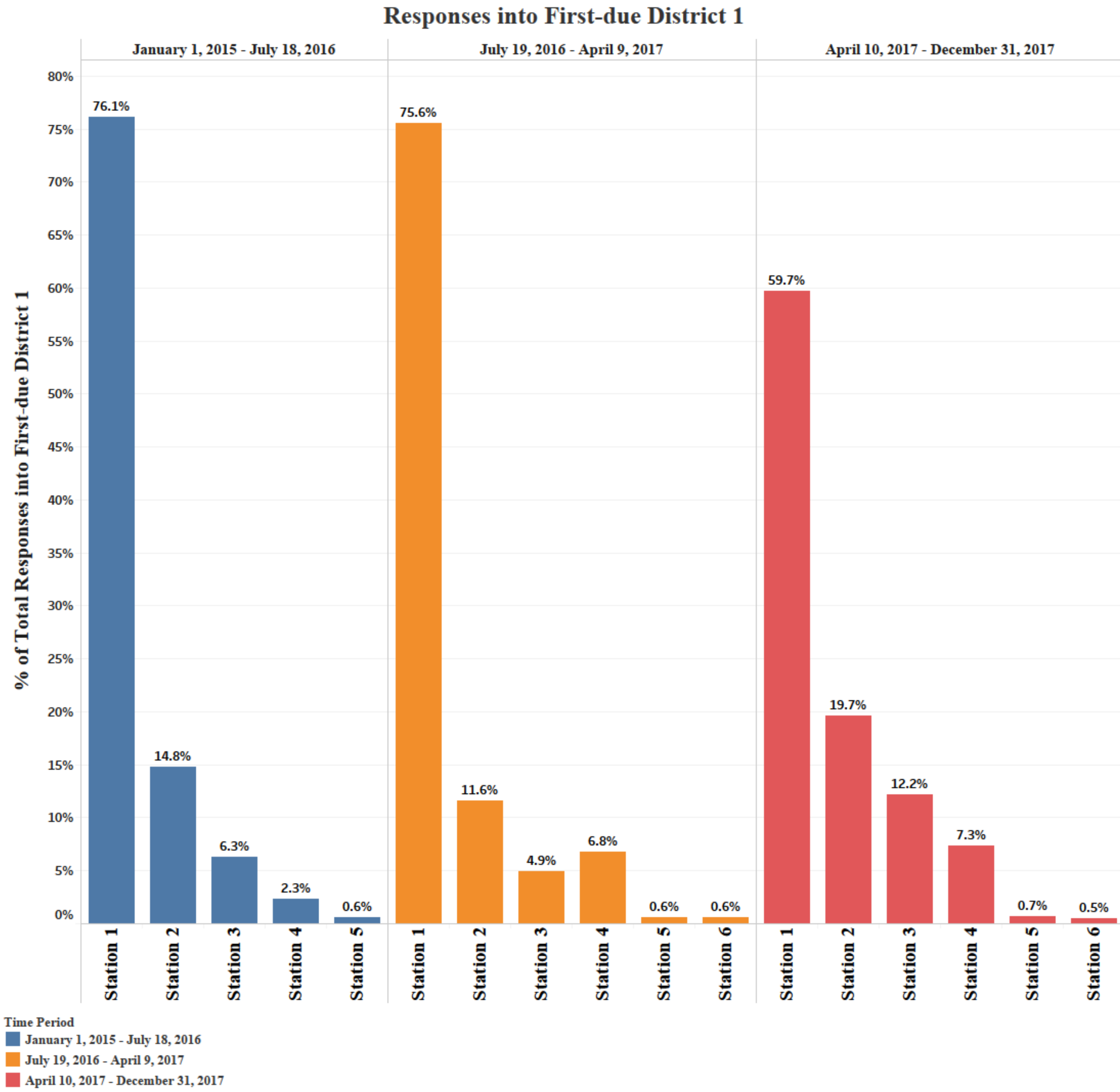


Figure 13: Responses into First-Due District 1. Figure 13 depicts the percent of responses into First-Due District 1 by units from each station, for each of the three time periods designating dates when apparatus and personnel were shifted between Stations 1 and 3. It should be noted that Stations 2 and 3 had a large increase of responses into First-due District 1 after April 10, 2017. Station 2 increased such responses by 69.8%. Station 3 increased such responses by 149%. Overall, the percent of total responses into First-due District 1 that came from stations other than Station 1 shifted from 23.9% and 24.4% in the two time periods before the loss of a suppression apparatus in April of 2017, to 41.3% after.

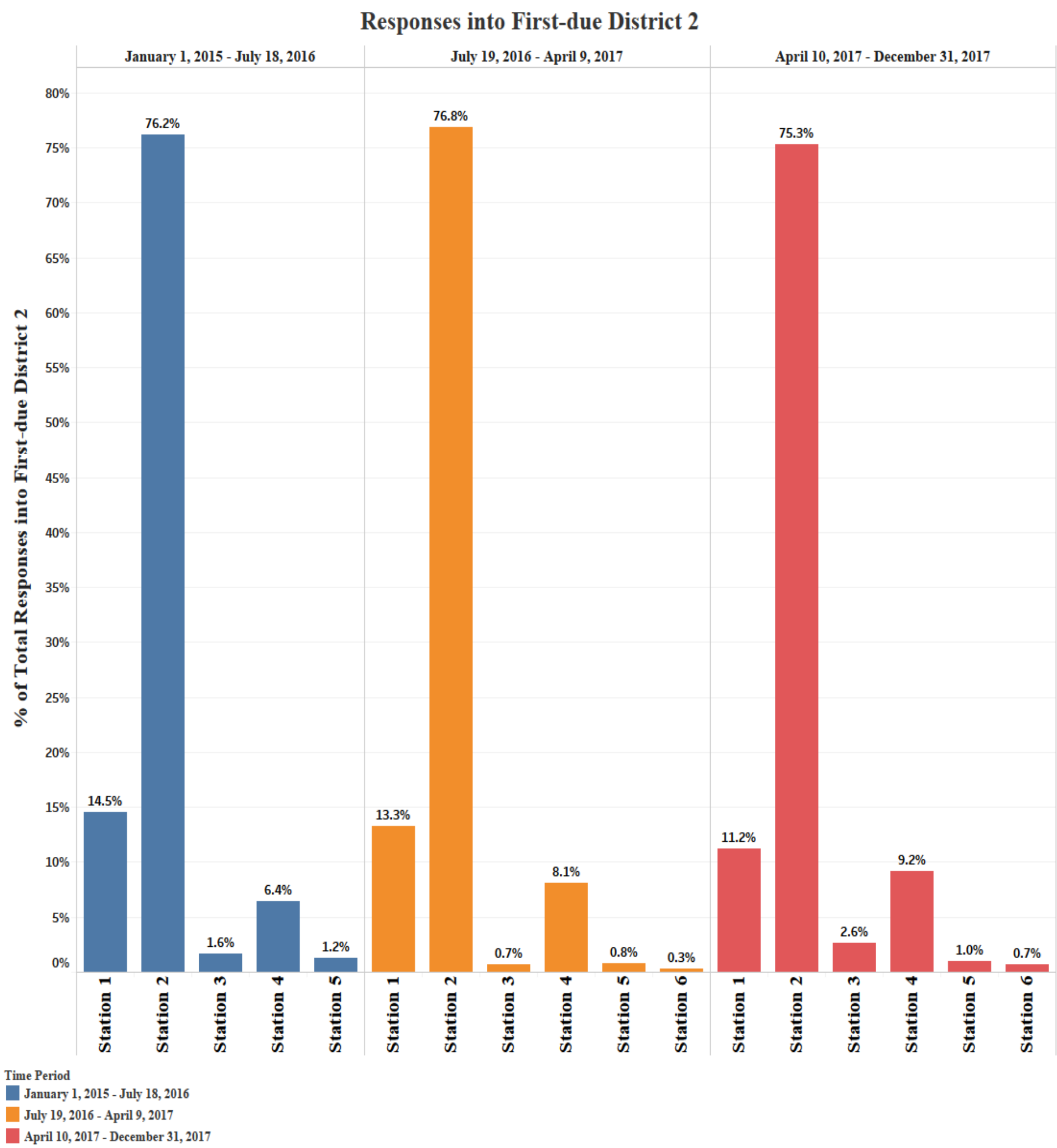


Figure 14: Responses into First-Due District 2. Figure 14 depicts the percent of responses into First-due District 2 by units from each station, for each of the three time periods designating dates when apparatus and personnel were shifted between Stations 1 and 3. Unlike in First-Due Districts 1 and 3, the percent of total responses into First-Due District 2 that came from stations other than Station 2 remained consistent over the three time periods at 23.8%, 23.2% and 24.7%.

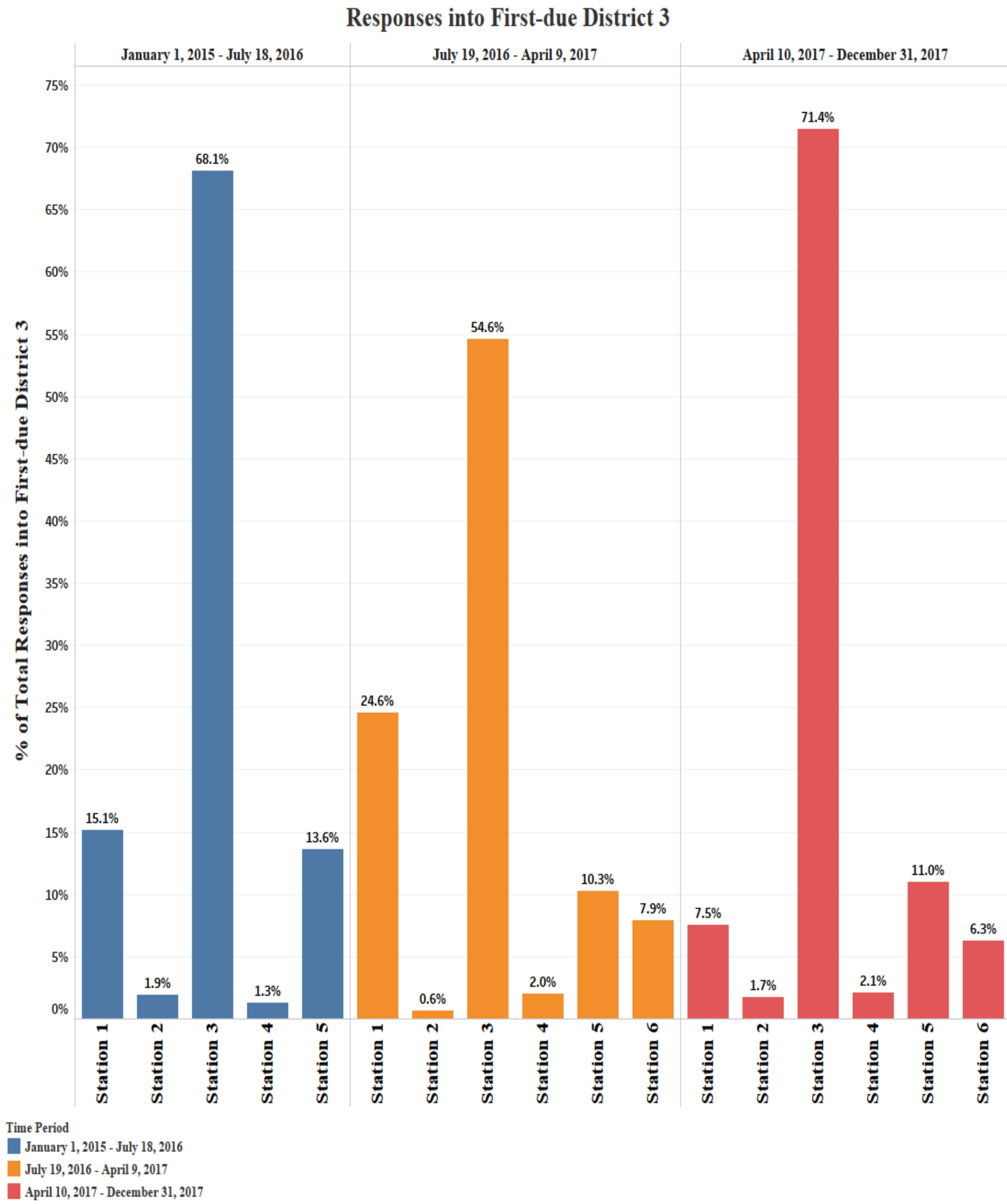


Figure 15: Responses into First-Due District 3. Figure 15 depicts the percent of responses into First-Due District 3 by units from each station, for each of the three time periods designating dates when apparatus and personnel were shifted between Stations 1 and 3. It should be noted that Station 1 increased responses into First-Due District 3by 62.9% after July 19, 2016 when apparatus and personnel were shifted from Station 3. Overall, the percent of total responses into First-Due District 3 that came from stations other than Station 3 increased from 31.9% before the loss of a suppression apparatus in July 2016, up to 45.4% in the time periods when it only had one apparatus and decreased to 28.6% after April of 2017.

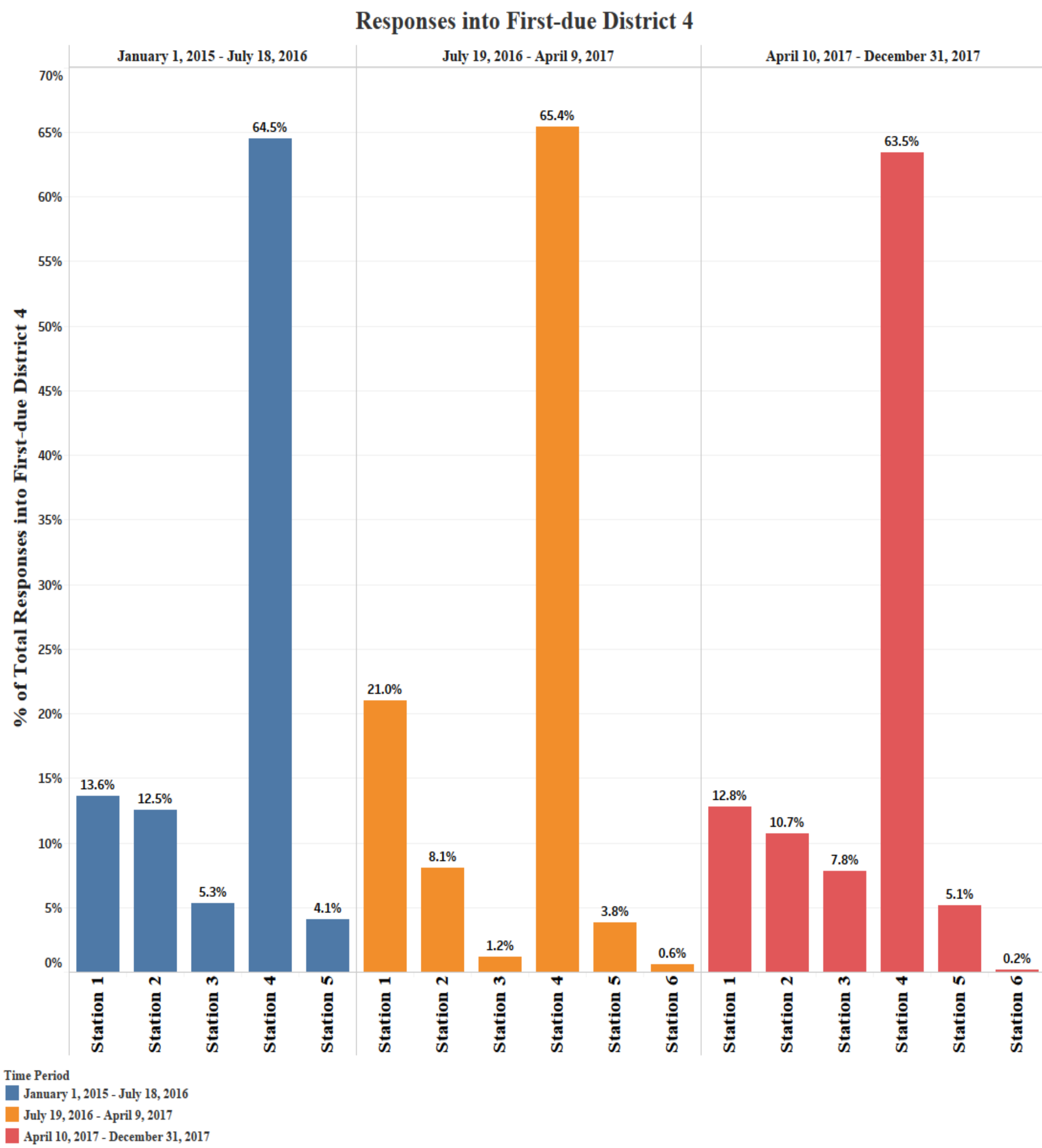


Figure 16: Responses into First-due District 4. Figure 16 depicts the percent of responses into First-Due District 4 by units from each station, for each of the three time periods designating dates when apparatus and personnel were shifted between Stations 1 and 3. Unlike in First-Due Districts 1 and 3, the percent of total responses into First-due District 4 that came from stations other than Station 4 remained consistent over the three time periods at 35.5%, 34.6% and 36.5%.

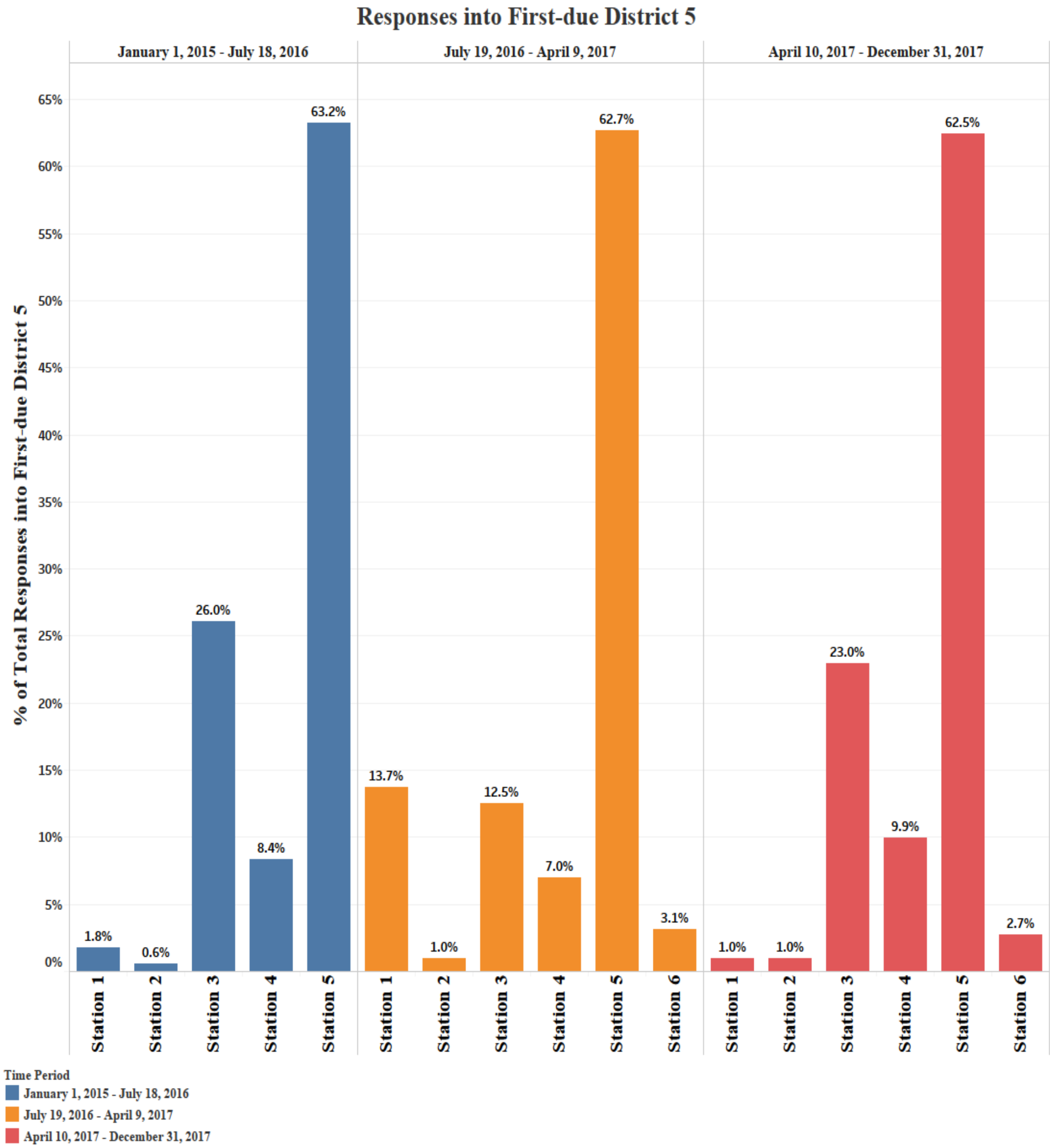


Figure 17: Responses into First-Due District 5. Figure 17 depicts the percent of responses into First-Due District 5 by units from each station, for each of the three time periods designating dates when apparatus and personnel were shifted between Stations 1 and 3. Unlike in First-Due Districts 1 and 3, the percent of total responses into First-Due District 5 that came from stations other than Station 5 remained consistent over the three time periods at 36.8%, 37.3% and 37.5%.

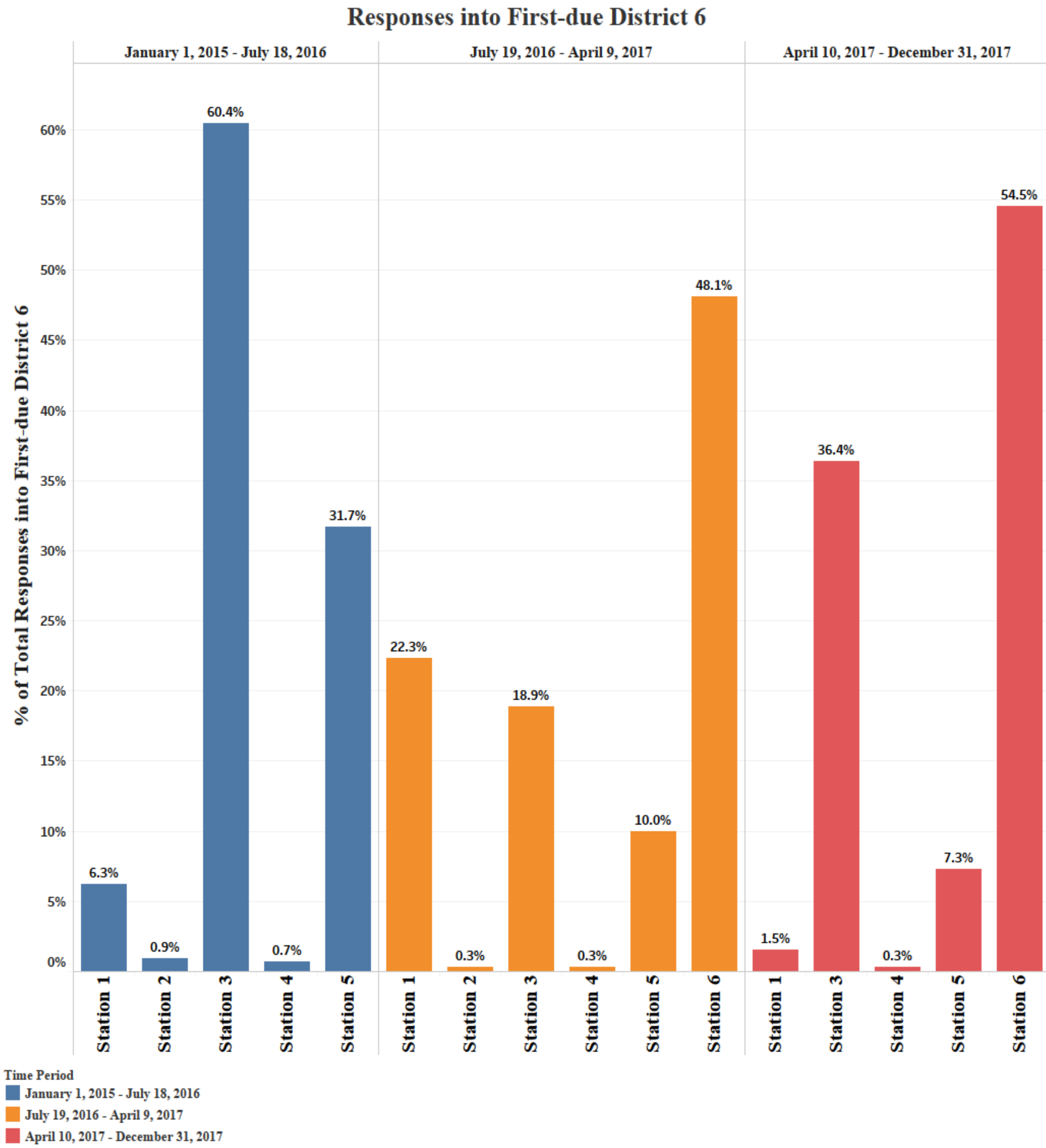


Figure 18: Responses into First-Due District 6. Figure 13 depicts the percent of responses into First-Due District 6 by units from each station, for each of the three time periods designating dates when apparatus and personnel were shifted between Stations 1 and 3. Note that in the year 2015 and the first half of 2016, Station 6 did not exist and responses indicated in this figure that were into First-Due District 6 during these times were into the geographic area that would later become Station 6's first-due area. The percent of total responses into First-Due District 6 that came from stations decreased to 51.9% and 45.5% in the two time periods after Station 6 opened.

Travel Time Analysis [100]

Travel times for the first arriving apparatus were calculated using the en route and arrival on location times included in the CAD. NFPA 1710 states that the first arriving apparatus should be on scene within 4 minutes (240 seconds) or less of travel to 90% of fire suppression incidents. Travel times that are consistently higher than this benchmark suggest that the department may need additional resources. Furthermore, areas of Oshawa that experience a greater concentration of responses that are consistently higher than this benchmark suggest that additional resources may be needed in those areas.

Analysis examined the department's overall 90th percentile travel times as well as individual apparatus' 90th percentile travel times for the first arriving apparatus. From January 1, 2015 to December 31, 2017, the 90th percentile travel time was 6 minutes.[101] [102] Based on the results of the 90th percentile travel time analysis, OFS did not meet NFPA 1710 travel time objectives during this time period.

Year	90th Percentile Travel Time
2015	0:06:00
2016	0:06:00
2017	0:06:00

Table 11: First Arriving Apparatus' 90th Percentile Travel Times by Year. Table 11 depicts the first arriving apparatus' 90th percentile travel times for fire suppression incidents from January 1, 2015 to December 31, 2017. NFPA 1710 states that the first arriving apparatus should be on scene within 4 minutes or less of travel for 90% of fire suppression incidents. Overall, from January 1, 2015 to December 31, 2017, the 90th percentile travel time of the first arriving apparatus to arrive on scene was 6 minutes.

[100] The travel time analysis performed by the IAFF is limited by the fact that the time stamps provided in the CAD files made available to the IAFF specify only hour of the day and minutes, but not seconds (for example: 12:30:00). The IAFF is not aware if these times are rounded to the nearest whole minute or if the seconds are just dropped. For example, if a unit arrives on scene at 12:30:50 the time stamp could be reported as 12:30:00 or rounded to 12:31:00. In the absence of this information, there is a 60 seconds uncertainty on the time stamps. This caveat should be kept in mind, as it may affect interpretation of analysis results.

[101] This analysis excluded CAD entries where the en route and/or arrival on scene times are missing or inaccurately reported, as well as incidents that where the location was outside of Oshawa city limits or inaccurately reported.

[102] This analysis included only CAD entries with incident types having the Fire/Explosion designation.

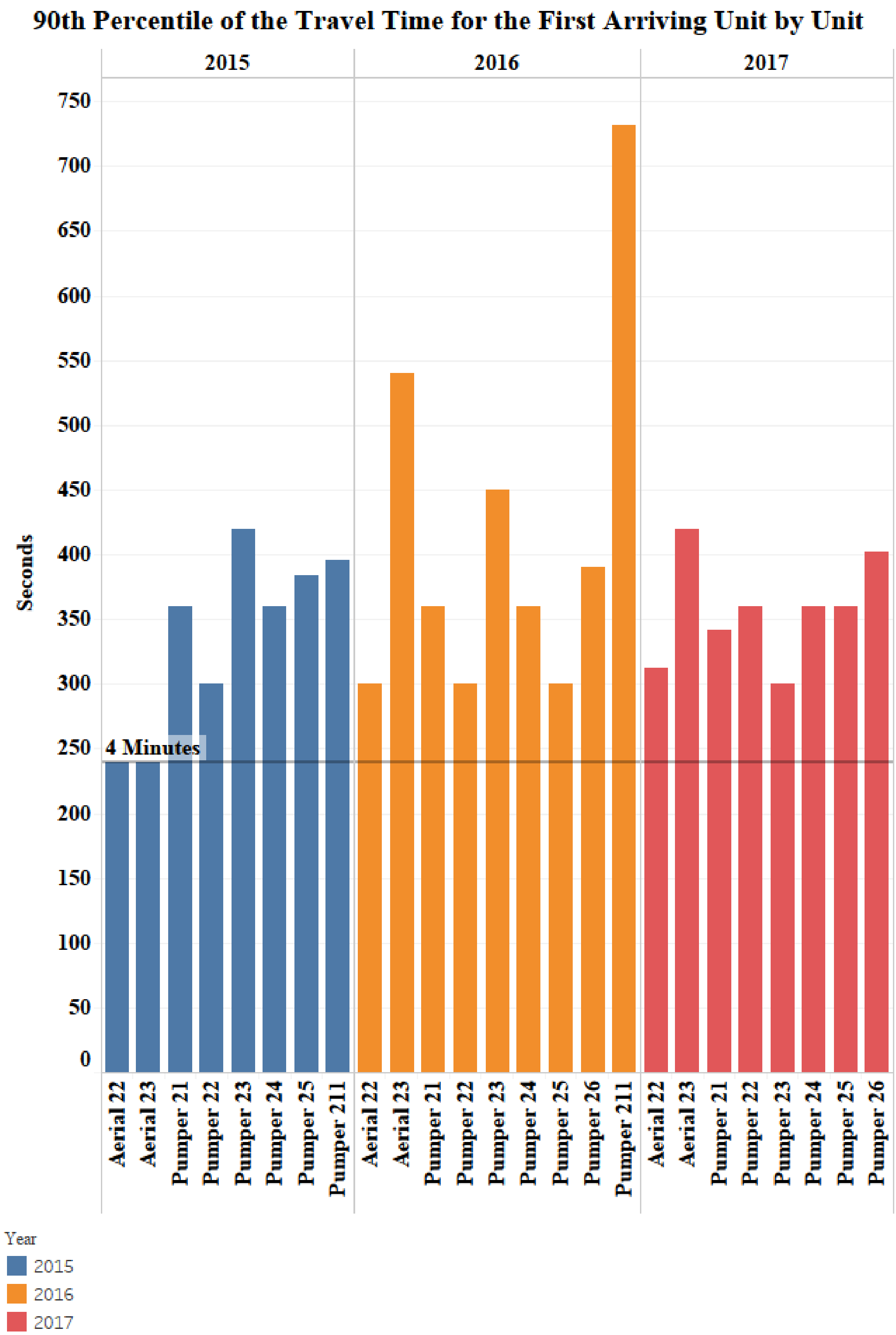


Figure 19: 90th Percentile of the Travel Time for the First Arriving Apparatus by Unit. Figure 19 depicts the 90th percentile travel times by unit for the first arriving apparatus at the scene of a fire suppression incident. The horizontal line across the figure designates the 90th percentile benchmark of 4 minutes (240 seconds) for the first arriving apparatus.

Year	2015	2016	2017
First-Due District	90th Percentile Travel Time	90th Percentile Travel Time	90th Percentile Travel Time
1	0:06:00	0:06:00	0:06:00
2	0:05:00	0:05:00	0:06:00
3	0:04:00	0:05:00	0:05:00
4	0:06:00	0:05:54	0:05:06
5	0:06:00	0:05:00	0:06:00
6	0:09:12	0:09:54	0:07:00

Table 12: Travel Time for Responses into a First-Due District. Table 12 depicts the first arriving apparatus' 90th percentile travel times for fire suppression incidents occurring in the specified first-due districts from January 1, 2015 to December 31, 2017. NFPA 1710 states that the first arriving apparatus should be on scene within 4 minutes of travel for 90% of incidents.

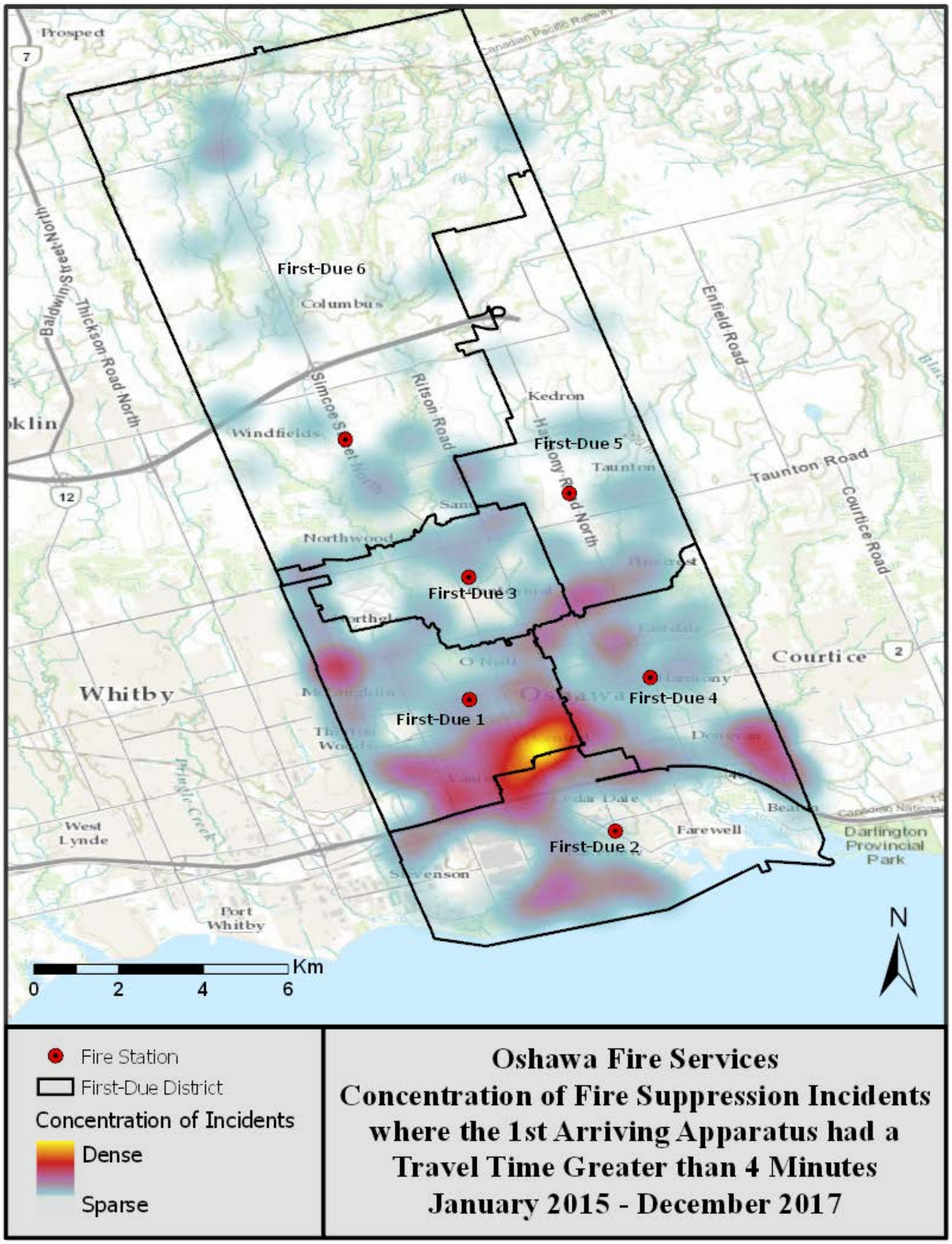
The travel time analysis also examined where the highest concentrations of incidents that had a first arriving apparatus with a travel time greater than 4 minutes were located. The highest concentrations of incidents where the first arriving apparatus had a travel time greater than 4 minutes were the south and southeastern areas of First-Due District 1. However, such incidents were also distributed widely throughout all first-due districts, accounting for 20.8% of fire suppression incidents during the three-year study period. Fire stations near areas with a high concentration of incidents where the first arriving apparatus' travel time is greater than 4 minutes, but within the range of OFS' 4-minute travel capabilities, should be considered for additional resources. Positioning additional resources at those fire stations will increase the likelihood apparatus will be in station and available to respond immediately to incidents within the corresponding first-due districts, resulting in shorter travel times.

Additionally, the travel time analysis examined how the concentration of incidents where the first arriving apparatus had a travel time greater than 4 minutes shifted during the three-year study period. First-Due Districts 4, 5 and 6 each had a decrease in the number of these incidents during the three-year study period. [103] First-Due District 1 experienced the same number of these incidents in 2017 as in 2015. First-Due Districts 2 and 3 experienced an increase in the number of these incidents, the greatest of which was First-Due District 3 with an increase of 71.4%.

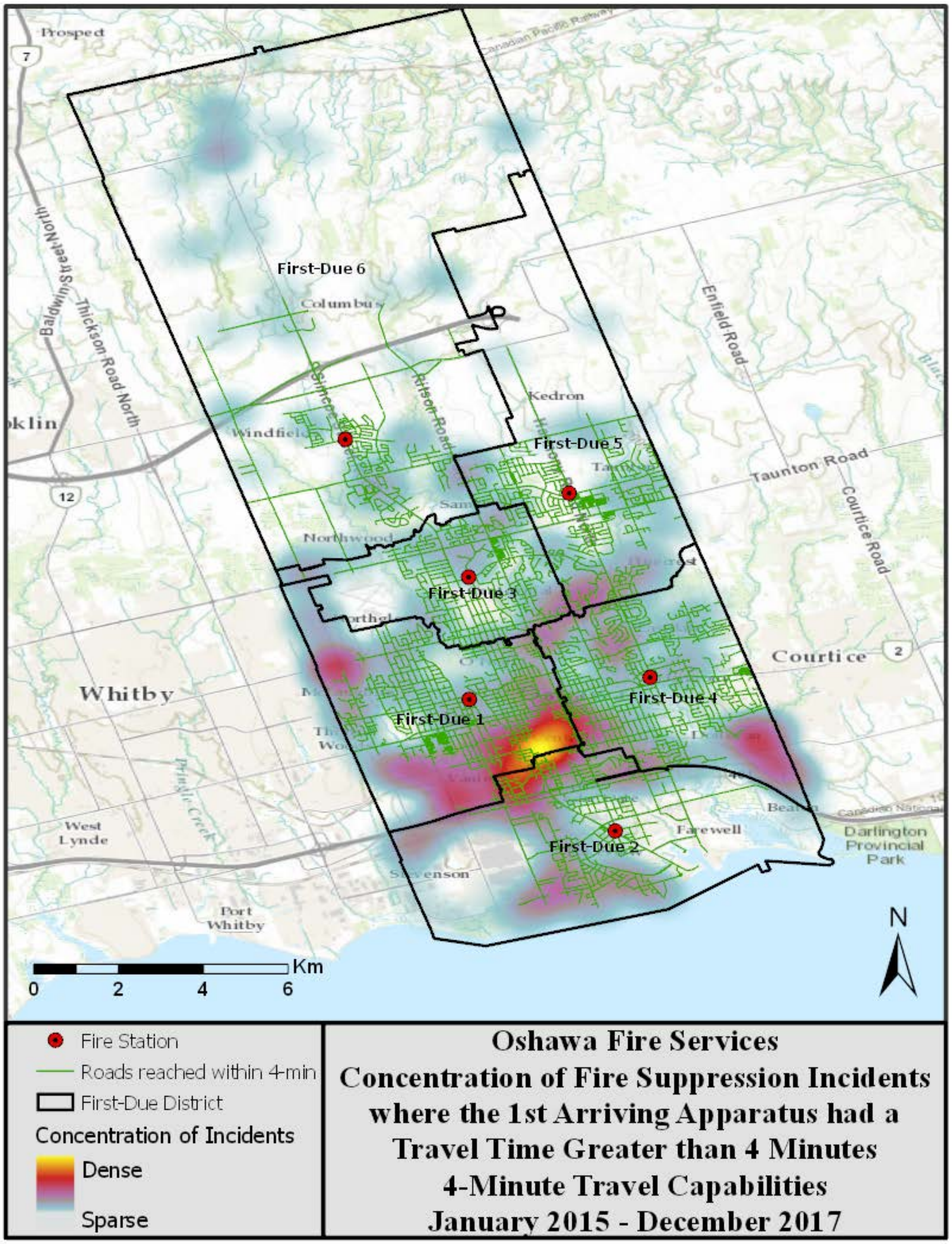
The shifting of personnel and apparatus between Stations 1 and 3 in the time since Station 6 opened has changed the response capabilities of these two stations over time. From April 10, 2017 until

[103] Fire Station 6 opened in 2016. For the purposes of this workload analysis, for the 2015 year, all incidents in the CAD that were located within the geographic area corresponding to First-Due District 6 were assigned to First-Due District 6 even though such a district did not exist until 2016.

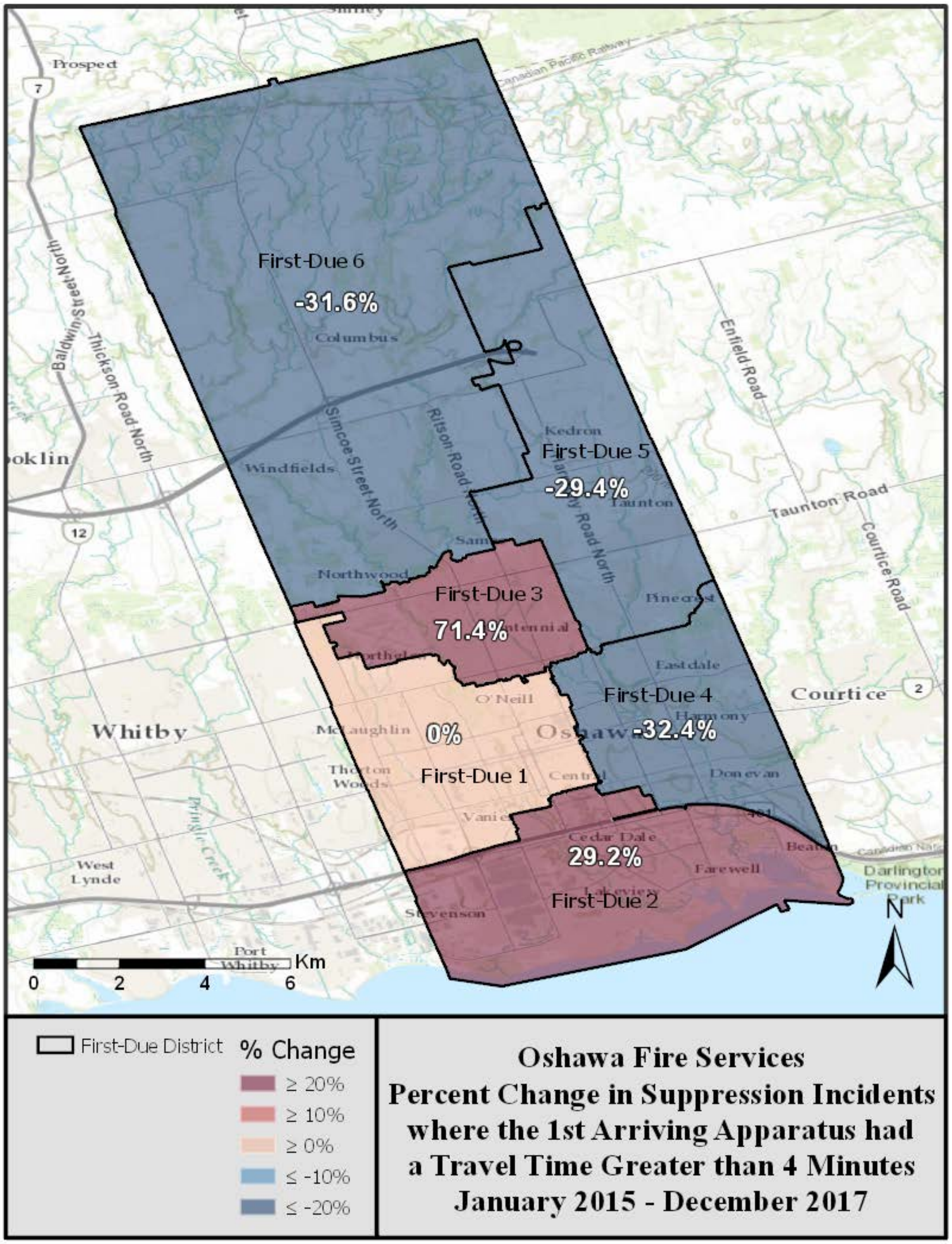
the end of the three-year study period, Station 1, the station with the highest call volume in an area of Oshawa with the highest volume of incidents, operated with only one staffed pumper. This likely changed the volume and locations of incidents where the first arriving apparatus had a travel time greater than 4 minutes. Since April 10, 2017 units from other stations have had to increase responses into Station 1's first-due area, with most of those responses coming from Station 3. This occurred with the backdrop of increasing call volume in not only that area of Oshawa, but throughout the city. During the three-year study period, First-Due District 1 experienced a 14.9% increase in responses and OFS overall experienced a 19.8% increase in responses. These factors have likely contributed to the increase in the number of incidents where OFS has been unable to meet NFPA 1710 travel time objectives for the first-arriving apparatus.



Map 16: Concentration of Fire Suppression Incidents where the 1st Arriving Apparatus had a Travel Time Greater than 4 Minutes, January 2015 – December 2017. Map 16 depicts the concentration levels of fire suppression incidents from January 1, 2015 to December 31, 2017 where the first arriving apparatus had a travel time greater than 4 minutes. NFPA 1710 states that the first arriving apparatus should be on scene within 4 minutes of travel for 90% of incidents. The highest concentrations of fire suppression incidents where the first arriving apparatus had a travel time greater than 4 minutes were located along the border of First-Due Districts 1 and 2, but such incidents were also spread throughout Oshawa. Throughout Oshawa, during the three-year study period, the first arriving apparatus had a travel time of greater than 4 minutes for 20.8% of fire suppression incidents.



Map 17: Concentration of Fire Suppression Incidents where the 1st Arriving Apparatus had a Travel Time Greater than 4 Minutes, 4-Minute Travel Capabilities, January 2015 – December 2017. Map 17, as in the previous map, depicts the concentration levels of fire suppression incidents from January 1, 2015 to December 31, 2017 where the first arriving apparatus had a travel time greater than 4 minutes. The roads indicated in green on the map show roads that OFS units can reach within 4 minutes of travel, assuming all units are in station and are available immediately upon dispatch.



Map 18: Percent Change in Suppression Incidents where the 1st Arriving Apparatus had a Travel Time Greater than 4 Minutes, January 2015 – December 2017. Map 18 depicts the percent change in the number of fire suppression incidents from January 1, 2015 to December 31, 2017 where the first arriving apparatus had a travel time greater than 4 minutes. NFPA 1710 states that the first arriving apparatus should be on scene within 4 minutes of travel for 90% of fire suppression incidents. First-Due District 3 experienced the greatest increase of such incidents during the three-year period.

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NFPA 1710 Recommended Minimum Staffing and Deployment

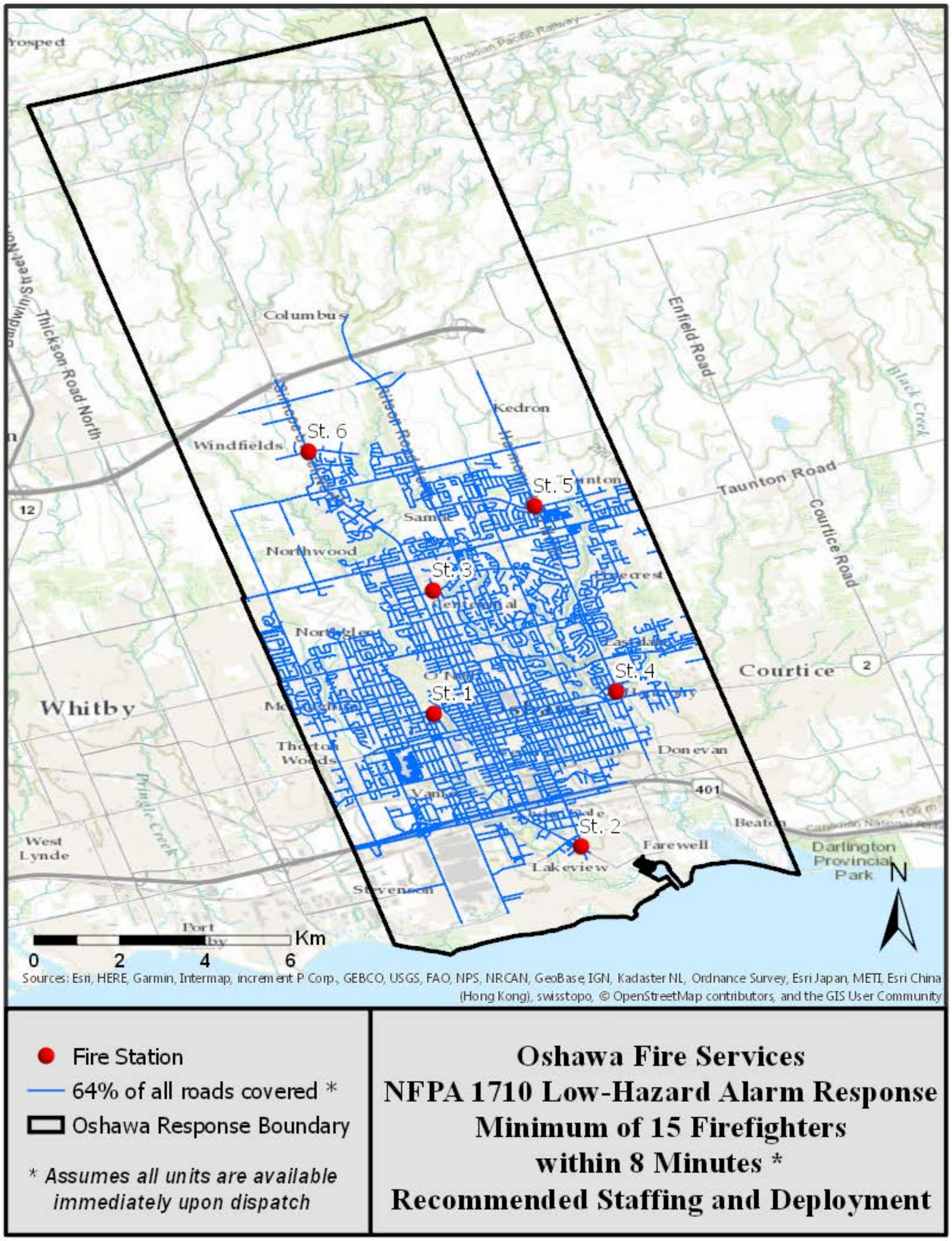
Additional staffing and resources are required in order to bring Oshawa Fire Services closer to meeting industry standard performance objectives and to allow for safer and more effective firefighting operations. It is recommended that 1 additional suppression apparatus, staffed with at least 4 firefighters at all times, be deployed from Station 1. Pursuant to the recommended staffing increases, minimum on-duty per shift staffing would be increased to 36 firefighters and 1 platoon chief.

Station	Address	Apparatus	Suggested Staffing
1	199 Adelaide Avenue West	Pumper 21 *Pumper 211* Car 25	**4 Firefighters** ***4 Firefighters*** **1 Platoon Chief**
2	1111 Simcoe Street South	Pumper 22 Aerial 22	**4 Firefighters** **4 Firefighters**
3	50 Beatrice Street East	Pumper 23 Aerial 23 Tanker 23	**4 Firefighters** **4 Firefighters** **Special Request**
4	50 Harmony Road North	Pumper 24	**4 Firefighters**
5	1550 Harmony Road North	Pumper 25 Rescue 25	**4 Firefighters** **Special Request**
6	2339 Simcoe Street North	Pumper 26	**4 Firefighters**

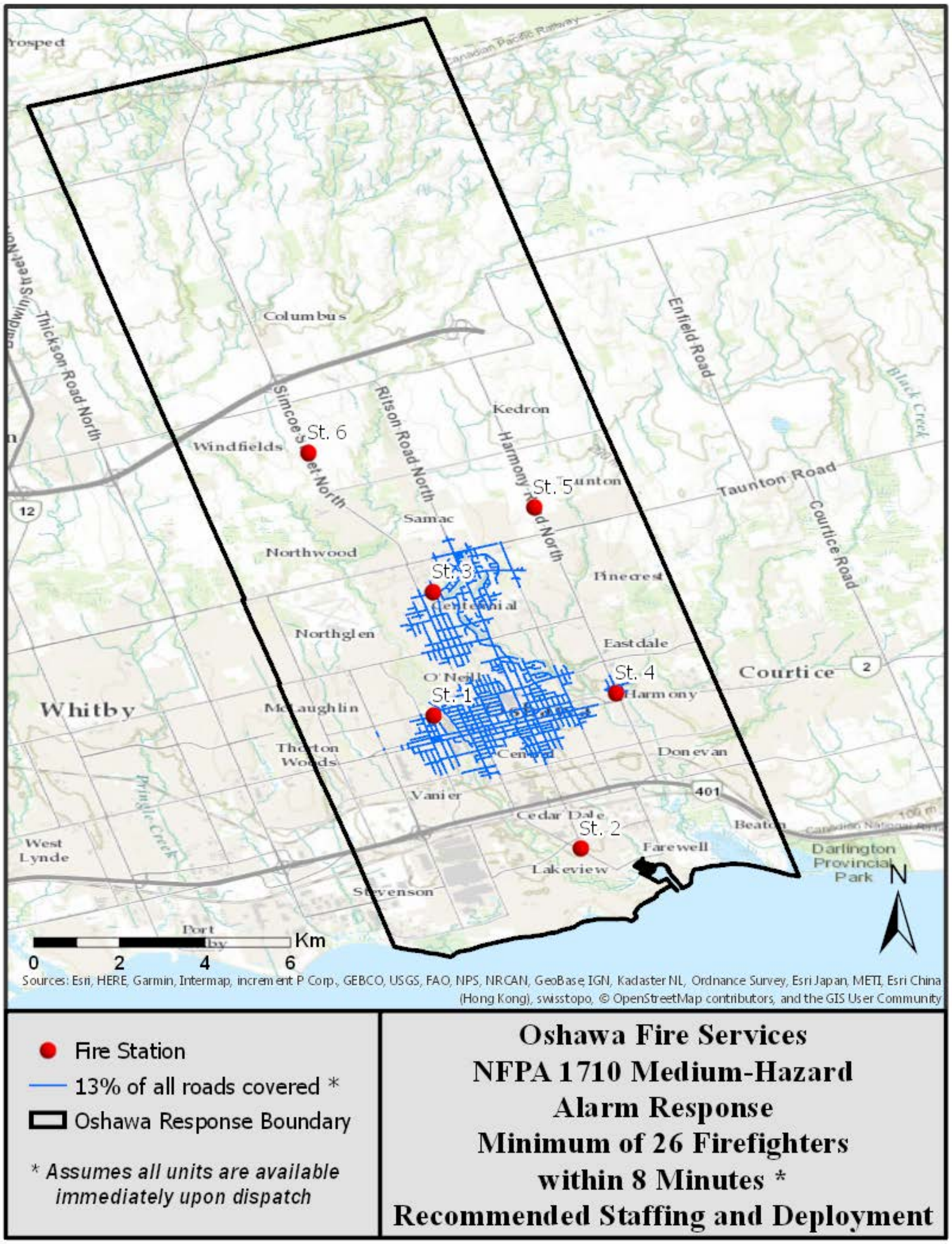
Table 13: NFPA 1710 Recommended Minimum Staffing Levels. The above table displays where apparatus would be housed and the recommended minimum on-duty staffing.

The following GIS maps present the anticipated response capabilities analysis of Oshawa Fire Services pursuant to implementation of the staffing and deployment configuration described in Table 13. The following maps represent travel times of 8 minutes.

Emergency Response Capabilities, Recommended Staffing and Deployment



Map 19: NFPA 1710 Low-Hazard Alarm Response, Minimum of 15 Firefighters within 8 Minutes, Recommended Staffing and Deployment. Map 19 identifies those roads where a minimum of 15 firefighters will likely have the ability to assemble on scene within 8 minutes of travel. Pursuant to implementing the recommended staffing and deployment, OFS will likely be capable of assembling a minimum of 15 firefighters on 64% of roads within Oshawa within 8 minutes. This translates to a 20.8% *increase* in response capabilities above current capabilities when all units are available for response.



Map 20: NFPA 1710 Medium-Hazard Alarm Response, Minimum of 26 Firefighters within 8 Minutes, Recommended Staffing and Deployment. Map 20 identifies those roads where a minimum of 26 firefighters will likely have the ability to assemble on scene within 8 minutes of travel. Pursuant to implementing the recommended staffing and deployment, OFS will likely be capable of assembling a minimum of 26 firefighters on 13% of roads within Oshawa within 8 minutes. This translates to a 420% *increase* in response capabilities above current capabilities when all units are available for response.

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Conclusion

In conclusion, regardless of the type of response, Oshawa Fire Services does not currently deploy a sufficient number of staffed fire suppression apparatus to meet the objectives of industry standards for safe, efficient, and effective response to fires or rescue situations. Deficiencies in staffing and apparatus utilization contribute to delays in fire suppression, rescue, and response. These deficiencies should be remedied to improve response and enhance service to the citizens. It is essential that departmental resources are able to meet demand and address risk.

In recent years, even as demand has been increasing, Oshawa Fire Services has moved personnel and resources out of areas with the highest demand and highest population of vulnerable residents. The department's existing workload and current insufficiencies indicate the need for additional fire suppression personnel and resources, specifically at Station 3 in the past, and presently at Station 1. As resources become scarce as demand increases, performance will worsen. Analysis has indicated that in areas of Oshawa that experienced the highest call volume, the number of times when units have had to provide response into other stations first-due areas has increased. Additionally, occurrences of incidents where the arrival time of the first arriving unit is greater than 4 minutes have increased. This increases the risk of death or injury due to fire for both citizens and firefighters in Oshawa. It also increases the risk of considerable property loss for housing units in many areas of the city.

Currently, under typical staffing conditions, only 66.7% of Oshawa roads are served by four fire fighters assembling on the scene of a fire within four minutes. Additionally, OFS is only able to assemble 15 firefighters within 8 minutes on 53% of Oshawa roads and 26 firefighters within 8 minutes on 2.5% of Oshawa roads. Furthermore, OFS is not able to assemble the NFPA 1710 required minimum of 39 firefighters on the scene of a high-hazard structure fire within 10 minutes and 10 seconds anywhere in Oshawa. The addition of at least one suppression apparatus, staffed with a minimum of four firefighters at all times, will enhance OFS' ability to respond to low- and medium-hazard structure fires safely and effectively.

While it is impossible to predict where most of a jurisdiction's fire and medical emergencies will occur, the regression analysis that was conducted as part of the Oshawa risk assessment in this document identified areas in Oshawa where structure fires and medical emergencies have a high likelihood of occurring in the future. Additionally, OFS should examine where emergencies have typically occurred in the past and make efforts to ensure these areas continue to enjoy the same level of coverage, while adjusting resources and deployment in an effort to achieve complete compliance with NFPA Standard 1710. Areas with accelerated development and population growth will require additional coverage in the future, though expanding coverage in some areas should not come at the cost of reducing the level of coverage available in other areas. Any projected increase in emergency response demands should also be considered before changes are implemented, focusing on associated hazard types and planned response assignments. In the future, if additional fire stations are opened in Oshawa, steps should be taken to study the ramifications of redeploying existing personnel rather than increasing overall on-duty staffing, the strategy that was used when Station 6 was opened.

As explained by the Commission on Fire Accreditation International, Inc. in its Creating and Evaluating Standards of Response Coverage for Fire Departments manual, "If resources arrive too late or are understaffed, the emergency will continue to escalate…What fire companies must do, if they are to save lives and limit property damage, is arrive within a short period of time with adequate resources to do the job. To control the fire before it reaches its maximum intensity requires geographic dispersion (distribution) of technical expertise and cost effective clustering (concentration) of apparatus for maximum effectiveness against the greatest number and types of risks." Optimally, there needs to be a balance between both elements.

It is generally accepted that a municipality has the right to determine the overall level of fire protection it wants. However, regardless of the level of fire protection chosen by the citizens, neither they nor their elected representatives have the right to jeopardize the safety of the employees providing those services. Citizens pay for protection of life and property through their tax dollars, and they assume that their elected and appointed officials will make informed decisions regarding that protection. Too often, however, that decision-making process has been based solely on budgetary expedience. Irrespective of the resources provided, citizens continue to believe that firefighters are prepared to provide an aggressive interior assault on fires, successfully accomplishing victim rescue, fire control, and property conservation. They do not expect firefighters to take defensive actions- to simply surround and drown a fire- because to do so would be to concede preventable loss of both life and property

Considering the ramifications of deficient staffing levels as they pertain to the loss of life and property within a community, is essential when considering modifications to a fire department's deployment configuration. A fire department should be designed to adequately respond to a number of emergencies occurring simultaneously in a manner that aims to minimize the loss of life and the loss of property that the fire department is charged to protect. Any proposed changes in staffing and deployment should be made only after considering the historical location of calls, response times to specific target hazards, compliance with departmental Standard Operating Procedures, existing industry standards, including NFPA 1500 and NFPA Standard 1710, and the citizens' expectation of receiving an adequate number of qualified personnel on appropriate apparatus within acceptable time frames to make a difference in their emergency.

Appendix A: Performance Standards

The National Fire Protection Association (NFPA) produced NFPA 1710 *Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*. NFPA 1710 is the consensus standard for career firefighter deployment, including requirements for fire department arrival time, staffing levels, and fireground responsibilities.[104]

Key Sections included in the 1710 Standard that are applicable to this assessment are:

- 4.3.2
    - The fire department organizational statement shall ensure that the fire department's emergency medical response capability includes personnel, equipment, and resources to deploy at the first responder level with AED or higher treatment level.

- 5.2.3
    - **Operating Units**. Fire company staffing requirements shall be based on minimum levels necessary for safe, effective, and efficient emergency operations.

- 5.2.3.1 & 5.2.3.1.1
    - Fire companies, whose primary functions are to pump and deliver water and perform basic firefighting at fires, including search and rescue… shall be staffed with a minimum of four on-duty members

- 5.2.3.2 & 5.2.3.2.1
    - Fire companies whose primary functions are to perform the variety of services associated with truck work, such as forcible entry, ventilation, search and rescue, aerial operations for water delivery and rescue, utility control, illumination, overhaul and salvage work… shall be staffed with a minimum of four on-duty members.

[104] NFPA 1710, 2016

- 5.2.3.1.2.1 & 5.2.3.2.2.1
    - In jurisdictions with tactical hazards, high hazard occupancies, high incident frequencies, geographical restrictions, or other factors as identified by the AHJ[105], these companies shall be staffed with a minimum of five or six on-duty personnel.

- 4.1.2.1(3) and 4.1.2.4
    - The fire department's fire suppression resources shall be deployed to provide for the arrival of an engine company within a 240-second travel time to 90 percent of the incidents.

- 4.1.2.1(4)
    - For other than high-rise, the fire department shall have the capability to deploy an initial full alarm assignment within a 480-second travel time to 90 percent of the incidents.

- 4.1.2.1(5)
    - For high-rise, the fire department shall have the capability to deploy an initial full alarm assignment within a 610-second travel time to 90 percent of the incidents.

[105] AHJ- Authority Having Jurisdiction

- 5.2.4.1.1
  - The initial full alarm assignment to a structure fire in a typical 2000 ft^2 … two-storey single-family dwelling without basement and with no exposures shall provide for the following

Assignment	***Minimum Required Personnel***
Incident Command	1 Officer
Uninterrupted Water Supply	1 Pump Operator
Water Flow from Two Handlines	4 Firefighters (2 for each line)
Support for Handlines	2 Firefighters (1 for each line)
Victim Search and Rescue Team	2 Firefighters
Ventilation Team	2 Firefighters
Aerial Operator	1 Firefighter
Initial Rapid Intervention Crew (IRIC)	2 Firefighters
Required Minimum Personnel for Full Alarm	**14 Firefighters & 1 Scene Commander**

- 5.2.4.2.1 & 5.2.4.3.1
    - The initial full alarm assignment to a structure fire in a typical open-air strip shopping center ranging from 13,000 ft^2 to 196,000 ft^2 (1203 m^2 to 18,209 m^2) in size and the initial full alarm assignment to a structure fire in a typical 1200 ft^2 (111 m^2) apartment within a three-story, garden-style apartment building shall provide for the following:

Assignment	***Minimum Required Personnel***
Incident Command	1 Incident Commander 1 Incident Command Aide
Uninterrupted Water Supply (2)	2 Firefighters
Water Flow from Three Handlines	6 Firefighters (2 for each line)
Support for Handlines	3 Firefighters (1 for each line)
Victim Search and Rescue Teams	4 Firefighters (2 per team)
Ladder/Ventilation Teams	4 Firefighters (2 per team
Aerial Operator	1 Firefighter
Rapid Intervention Crew (RIC)	4 Firefighters
EMS Transport Unit[106]	2 Firefighters
Required Minimum Personnel for Full Alarm	**27 Firefighters** **1 Incident Commander**

[106] The Standard further states, "Where this level of emergency care is provided by outside agencies or organizations, these agencies and organizations shall be included in the department plan and meet these requirements."

- 5.2.4.4.1
    - Initial full alarm assignment to a fire in a building with the highest floor 23 m (75 ft.) above the lowest level of fire department vehicle access shall provide for the following:

Assignment	***Required Personnel***
Incident Command	1 Incident Commander 1 Incident Command Aide
Uninterrupted Water Supply	1 Building Fire Pump Observer 1 Fire Engine Operator
Water Flow from Two Handlines on the Involved Floor	4 Firefighters (2 for each line)
Water Flow from One Handline One Floor Above the Involved Floor	2 Firefighters (1 for each line)
Rapid Intervention Crew (RIC) Two Floors Below the Involved Floor	4 Firefighters
Victim Search and Rescue Team	4 Firefighters (2 per team)
Point of Entry/Oversight Fire Floor	1 Officer 1 Officer's Aide
Point of Entry/Oversight Floor Above	1 Officer 1 Officer's Aide
Evacuation Management Teams	4 Firefighters (2 per team)
Elevator Management	1 Firefighter
Lobby Operations Officer	1 Officer
Trained Incident Safety Officer	1 Officer
Staging Officer Two Floors Below Involved Floor	1 Officer
Equipment Transport to a Floor Below Involved Floor	2 Firefighters
Firefighter Rehabilitation	2 Firefighters (1 must be ALS)
Vertical Ventilation Crew	1 Officer 3 Firefighters
External Base Operations	1 Officer
2 EMS ALS Transport Units	4 Firefighters
Required Minimum Personnel for Full Alarm	**36 Firefighters** **1 Incident Commander** **6 Officers**

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Appendix B: Risk Analysis Data

B.1 Incident Type Classification

Medical
Medical: Emergency
Structure Fire
Fire/Explosion: Structural: Barn
Fire/Explosion: Structural: Commercial
Fire/Explosion: Structural: Electrical Substation
Fire/Explosion: Structural: Industrial
Fire/Explosion: Structural: Institutional: Hospital
Fire/Explosion: Structural: Institutional: Nursing Home
Fire/Explosion: Structural: Institutional: Retirement Home
Fire/Explosion: Structural: Institutional: School/Church
Fire/Explosion: Structural: Other
Fire/Explosion: Structural: Residential: Apartment/Townhouse
Fire/Explosion: Structural: Residential: Highrise
Fire/Explosion: Structural: Residential: House

Table B.1: Incident Type Classification. Table B.1 lists the incident types selected from the CAD data that were used in the risk analysis.

B.2 Regression Analysis Variables – Structure Fires

Figure B.2: Number of Structure Fire Incidents in Relation to the Variables Used in the Regression Analysis. Figure B.2 depicts the number of structure fires in each census tract in relation to the five variables used in the regression analysis. These five variables are referred to as explanatory variables in the regression analysis and were selected from over 600 categories of demographic data available for the City of Oshawa. Each blue circle represents one of the 35 census tracts within Oshawa. The lines represent the result of the linear regression if each variable was the only explanatory variable. These lines are shown for visualization purposes only, to highlight the relation between the variables and the number of incidents. However, the regression analysis was conducted by simultaneously considering the entire set of variables.

B.3 Regression Analysis Variables – Medical Emergencies

Figure B.3: Number of Medical Emergency Incidents in Relation to the Variables Used in the Regression Analysis. Figure B.3 depicts the number of medical emergencies in each census tract in relation to the six variables used in the regression analysis. These six variables are referred to as explanatory variables in the regression analysis and were selected from over 600 categories of demographic data available for the City of Oshawa. Each blue circle represents one of the 35 census tracts within Oshawa. The lines represent the result of the linear regression if each variable was the only explanatory variable. These lines are shown for visualization purposes only, to highlight the relation between the variables and the number of incidents. However, the regression analysis was conducted by simultaneously considering the entire set of variables.

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Appendix C: OFS Operating Guideline Number 1-29

Oshawa
Prepare To Be Amazed
Fire Services

Operating Guidelines
Policy

DATE REVISED: 2017 03 28 | **NUMBER 1-29**

STAFFING FIRE VEHICLES & RESPONSE ASSIGNMENTS

DATE ISSUED: 1992 09 15 | **Page: 1 of 3**

PURPOSE

The purpose of this policy is to establish safe staffing levels for Oshawa Fire Services emergency vehicles.

SCOPE

This policy is for all personnel responsible for staffing emergency vehicles.

POLICY

	HEADQUARTERS			STATION 2		STATION 3		STATION 4	STATION 5		STATION 6
Staff	Car 25	Pump 21	Pump 211 Aerial 21	Pump 22	Aerial 22	Pump 23	Aerial 23	Pump 24	Rescue 25	Pump 25	Pump 26
✧41	1	5	4	4	4	4	4	4	2	4	5
✧40	1	4	4	4	4	4	4	4	2	4	5
✧39	1	4	4	4	4	4	4	4	2	4	4
✧38	1	4	4	4	4	4	4	4	1	4	4
37	1	5	Reserve	4	4	4	4	4	2	4	5
36	1	4	Reserve	4	4	4	4	4	2	4	5
35	1	4	Reserve	4	4	4	4	4	2	4	4
34	1	4	Reserve	4	4	4	4	4	1	4	4
*33	1	4	Reserve	4	4	4	4	4	Reserve	4	4
32	1	4	Reserve	4	3	4	4	4	Reserve	4	4
31	1	4	Reserve	4	2	4	4	4	Reserve	4	4
30	1	4	4	5	O/S	4	O/S	4	Reserve	4	4
29	1	4	4	4	O/S	4	O/S	4	Reserve	4	4
28	1	4	3	4	O/S	4	O/S	4	Reserve	4	4
27	1	4	2	4	O/S	4	O/S	4	Reserve	4	4

✧ If Appropriate Vehicle available
* **Minimum** Staffing Level (As determined by the Fire Chief)

NOTE: Tank 21 will only be replaced with a tanker vehicle.

The following protocol shall be observed for initial response to all emergency incidents.

1. In all circumstances the nearest available unit shall be dispatched. If delays are expected or encountered, the next nearest apparatus will also be dispatched.
2. If responding unit[s] do not have appropriate staff or equipment, the next nearest appropriate unit shall also be dispatched to assist.

Dc ✧ jk DISTRIBUTION: * CO Fire
PO 29 Staffing

3. The Platoon Chief will monitor all incidents (1 & 2 vehicle responses) and adjust responses accordingly. The Platoon Chief will respond to all responses where 3 or more units are dispatched and any 1 & 2 vehicle responses of a serious nature or where required/requested.
4. First arriving Officer shall initiate command and assess the situation immediately, and stage or release subsequent responding vehicles as the situation dictates.
5. The Platoon Chief shall clarify vehicles in service and vehicle complement with Communications staff at the beginning of each shift.
6. Communications staff may increase a response at their discretion based on information received.
7. Overtime is authorized when staffing falls below 33. OG #1-13 provides callback procedures.
8. At Staffing levels 33 and below the Platoon Chief will assign a driver when needed to T21.
9. At Staffing levels between 38 & 42, P211 or Aerial 21 will be staffed with 4, only if an appropriate vehicle is available.
10. When any truck is committed for a period of 10 minutes or more for any reason (including fueling trucks, meetings etc.) where there are no trucks remaining in the hall, Platoon Chiefs shall provide a fill in where available.
11. At staffing levels of 38 and above, fill in for P24 or P25 will be P211 or A21, whichever is in service.

RESPONSE TYPE	QUINT [4 STAFF]
Semi/Detached Residential	2P – 1A
Medium & High Risk	2P – 1A
Out of Hydrant Area (Structure fire)	2P & 1A - 1T
Vehicle Fire	1P or A
Vehicle Fire Hwy 401	2P
Vehicle Fire Out of Hydrant Area	1P or A & 1T
MVC	2P or 1P & 1A
MVC on Hwy 401 - See OG 2-15	2P
Hazmat	2P or A
911 Unknown	1P or A
Medical Assist	1P or A
Elevator Rescue	1P or A
Carbon Monoxide w/symptoms	1P or A + EMS
Carbon Monoxide w/o symptoms	1P or A

12. OUTSIDE BOUNDARY RESPONSE

12.1 Oshawa Fire Services will respond with Whitby FD to the westbound lanes of 401, west of the Oshawa City limits to Thickson Road.

12.2 Whitby Fire Dept. will respond with Oshawa Fire Services to the eastbound lanes of 401, east of Whitby City limits to Stevenson Road.

12.3 Oshawa Fire Services will respond with Clarington FD to the eastbound lanes of 401, east of Oshawa City limits to Courtice Road.

12.4 Clarington FD will respond with Oshawa Fire Services to the westbound lanes of 401, west of Courtice Road to Harmony Road.

12.5 The first Fire Department receiving the call will be responsible for notifying the alternate Fire Department.

12.6 The first arriving Fire Department will advise the second responding Fire Department of the situation and location.

13. MUTUAL AID

13.1 TANKER: [Mutual Aid] two operational personnel will respond with Tanker if deemed necessary by Platoon Chief due to considerations such as weather, time of day, location of water supply. Otherwise driver only shall respond.

13.2 MINOR VEHICLE FIRE: e.g. car, motorcycle, 10 minute operation: extinguish fire and upon returning to station notify proper department of fire and damage for their records.

13.3 LARGER FIRES: e.g., house, truck, trailer, etc., more than 10 minute operation: Immediately request that proper department be notified and dispatched. Save life and property by rescue and firefighting until their arrival.

14. CARBON MONOXIDE

14.1 DANGER OF ILLNESS PRESENT: full station emergency response with Ambulance backup.

14.2 ACTIVATION OF CO DETECTOR ONLY AND NO DANGER: station pumper only in a non emergent mode as in 17.1.

15. BOMB THREAT RESPONSE

15.1 Respond to the area and position units a safe distance from incident location.

15.2 The station in the area of the incident location will respond.

16. STAFFING TANKER

16.1. The Tanker shall be staffed as indicated in the above table. The Platoon Chief may assign a second firefighter to the vehicle at staffing numbers of 35 and above, for conditions described in 13.1.

16.2. The Tanker will only respond inside the hydrant areas when requested by the on duty Platoon Chief or Incident Commander on scene.

17. NON EMERGENT RESPONSES

17.1. Responses to incidents such as carbon monoxide alarms without symptoms, 911 Unknown, EMS lift assists or alarm resets should be treated as non-emergent and therefore lights and sirens should not be used. Vehicles will respond within the normal flow of traffic. Officers shall use discretion when determining if a response is being treated as non-emergent and notify communications accordingly. Officer's Crisys notes are to include if a non-emergent response was utilized.

RESPONSIBILITY

It is the responsibility of the Platoon Chief or Incident Commander to follow this policy.

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