GEOGRAPHIC INFORMATION SYSTEM EMERGENCY SERVICES RESPONSE CAPABILITIES ANALYSIS

FINAL REPORT

International Association of Fire Fighters
1750 New York Ave NW
Washington, DC 20006

WEST BEND FIRE DEPARTMENT

West Bend, Wisconsin

September 2021

Dedication

This Report is Dedicated to the Citizens of West Bend, the Town of West Bend, and the Town of Barton who Deserve the Most Efficient and Effective Fire, Rescue, and Emergency Medical Services Available.

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Executive Summary

This report summarizes the results of a station location, staffing, workload, and emergency vehicle travel time analysis for the West Bend Fire Department (WBFD) at the request of the West Bend Professional Firefighters, International Association of Fire Fighters (IAFF) Local 2025. To make data-driven recommendations, this study assessed WBFD's current response capabilities against the industry standard, the potential need for additional personnel, fixed and mobile resources and WBFD's potential response capabilities pursuant to modifying fire station locations. WBFD currently operates three fire stations and provides emergency response services to the City of West Bend including fire prevention and suppression, rescue, and emergency medical services (EMS) first response and transport at the Advanced Life Support (ALS) level. Further, WBFD provides ALS first response and transport to portions of the Town of West Bend and the Town of Barton.

WBFD staffs fire suppression apparatus with three firefighters, which is less than the minimum staffing level 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. Studies have shown that the smaller the crew size, the more tasks an individual must complete, which contributes to diminished efficiency and delays in initiating fire attack and containing fire. [1]

WBFD also engages in the practice of cross-staffing. Cross-staffing is a practice whereby the same crew is used to operate different units (e.g., medic unit or engine), dependent upon the type of incident. For example, Engine 1, housed in Station 1, is cross staffed by the same crews that staff Med 11. If Engine 1 was dispatched to an incident, the medic unit would be left unstaffed and unable to respond to the same incident or to other incidents that might occur at the same time, reducing the response capabilities of the department.

Additionally, the number of firefighters per shift and the number of available staffed suppression apparatus are not adequate to meet industry standards for safe, efficient, and effective response to fires occurring within low-, medium-, or high-hazard occupancies anywhere in West Bend.

The failure to maintain enough resources to meet demand in a timely manner exposes civilians and firefighters to increased risk. It also drains fire department resources and stresses the

[1] NIST Report on Residential Fireground Field Experiments and NIST Report on High-Rise Fireground Field Experiments. < https://www.nist.gov/sites/default/files/documents/el/fire_research/Report-on-Residential-Fireground-Field-Experiments.pdf > and < https://www.nist.gov/publications/report-high-rise-fireground-field-experiments >

emergency response system. This report addresses the current deficiencies within the WBFD by examining several metrics including the call volume, travel time performance per apparatus and district, the 90th percentile travel times of apparatus arriving at the scene of fire suppression and emergency medical incidents, and locations of first-unit arrivals that did not meet NFPA 1710 travel time performance objectives. Through analysis of computer-aided dispatch (CAD) data, the use of geographic information systems (GIS) mapping software, this report will inform West Bend decision makers on the negative impact that current staffing and deployment practices have on daily operations and how increasing resources will improve the efficiency of the WBFD and the safety residents.

Key Findings

GIS Analysis

- WBFD's suppression (engine and truck) companies regularly deploy with fewer than four firefighters. Apparatus not staffed with a minimum of four firefighters do not meet the company staffing objectives outlined in NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program* and NFPA 1710. Because units are not staffed with four, firefighters must rely on supplemental personnel arriving later before making entry into environments that are immediately dangerous to life and health (IDLH), such as structure fires, in order to meet objectives outlined in industry standards and Occupational Safety and Health Administration (OSHA) rules and regulations. [2]

- WBFD can respond with four firefighters on only 19.8% of roads[3] within four minutes when at typical staffing levels, assuming all units are available immediately upon dispatch. Pursuant to implementing staffing and deployment recommendations, the department would likely be able to assemble a minimum of four firefighters within four minutes of travel on 77.7% of roads, which equates to a 291.5% **increase** in response coverage.

    - Pursuant to implementing staffing and deployment recommendations and the four-station configuration, the department would likely be able to assemble a minimum of four firefighters within four minutes of travel on 97.8% of roads, which equates

[2] 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 firefighters 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.

[3] Percentages (response capabilities for current 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.

to a 392.8% **increase** in response coverage over current conditions and a 25.9% **increase** over conditions where the current three stations are staffed pursuant to staffing and deployment recommendations.

- WBFD can respond with an engine company on 40.6% of roads within four minutes, assuming all units are available immediately upon dispatch. [4]

    - Pursuant to implementing staffing and deployment recommendations and the four-station configuration, the department would likely be able to respond with an engine company within four minutes of travel on 47.4% of roads, which equates to a 16.7% **increase** in response coverage over current conditions.

- Modeling of response capabilities showed that with current station locations, if all units are in station and available to respond, 82.1% of the incidents that occurred from 2016 to 2020 are reachable from current fire stations within four minutes of travel. If the recommend four-station configuration is implemented, 92.0% of the incidents would be reachable within four minutes of travel.

- WBFD is not able to respond with a truck company, staffed with a minimum of four firefighters, on any roads within six minutes at typical staffing levels, assuming all units are available immediately upon dispatch. Pursuant to implementing staffing and deployment recommendations, the department would likely be able to respond with truck company, staffed with a minimum of four firefighters, within six minutes of travel on 56.2% of roads. [5]

    - Pursuant to implementing staffing and deployment recommendations and the four-station configuration, which relocates Station 2, the department would likely be able to respond with truck company, staffed with a minimum of four firefighters, within six minutes of travel on 60.3% of roads, which equates to a 7.3% **increase** over conditions where the current three stations are staffed pursuant to staffing and deployment recommendations.

- WBFD is not able to provide for the arrival of 17 firefighters on any roads within eight minutes at typical staffing levels. Pursuant to implementing staffing and deployment recommendations, the department would likely be able to assemble 17 firefighters within

[4] "The fire department shall establish the following objectives…240 seconds (4 minutes) or less time for the arrival of the first engine company at a fire suppression incident." NFPA 1710, §4.1.2.1(3).
[5] "The fire department shall establish the following objectives…360 seconds (6 minutes) or less time for the arrival of the second company with a minimum staffing of 4 personnel at a fire suppression incident." NFPA 1710, §4.1.2.1(4). Although not explicitly stated, it is recommended that this apparatus be the ladder truck or a company that will be assigned to truck duties.

eight minutes of travel on 58.2% of roads. The arrival of 17 firefighters within eight minutes is the standard for safe, effective, and efficient operations at a typical, residential structure fire.[6] [7]

- Pursuant to implementing staffing and deployment recommendations and the four-station configuration, the department would likely be able to assemble 17 firefighters within eight minutes of travel on 89.6% of roads, which equates to a 53.9% **increase** in response coverage over conditions where the current three stations are staffed pursuant to staffing and deployment recommendations.

- WBFD is not able to provide for the arrival of 28 firefighters on any roads within eight minutes at typical staffing levels, assuming all units are available immediately upon dispatch. The arrival of 28 firefighters within eight minutes is the standard for safe, effective, and efficient operations at a typical garden-style apartment building or open-air strip shopping center structure fire.[8] [9]

- WBFD is not able to provide for the arrival of 43 firefighters on any roads within ten minutes, ten seconds at typical staffing levels. The arrival of 43 firefighters within ten minutes, ten seconds is considered to be the standard for safe, effective, and efficient operations at a fire occurring at a high-hazard occupancy.[10] [11] [12]

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[6] A "typical, residential structure fire" is one occurring in 2000 sq. ft. (186 sq. m), two-story single-family dwelling without basement and with no exposures. NFPA 1710, §5.2.4.1.1

[7] A 17th firefighter is needed to operate an aerial device. Even if an aerial device is not in use, a ground ladder will likely be in use at a typical residential structure fire and a 17th firefighter will be needed to maintain the ground ladder while firefighters traverse the ladder and crews operate on the roof.

[8] A "typical, open-air strip shopping center fire" is one occurring in a 13,000 ft^2 to 196,000 ft^2 (1,203 m^2 to 18,209 m^2) open-air strip shopping center. A "typical apartment" structure fire is one occurring in a 1,200 ft^2 (111 m^2) apartment within a three-story, garden style apartment building. NFPA 1710, §5.2.4.2.1 and NFPA 1710, §5.2.4.3.1

[9] WBFD is required to arrive with a total of 28 personnel (26 firefighters, one incident commander, one chief's aide), to a medium-hazard structure fire. Because WBFD provides medical transport, this count includes two firefighters, as 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 transportation that provides rapid access to civilians or members potentially needing medical treatment."

[10] 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, §3.3.36

[11] A "high-rise" is an occupancy "with the highest floor greater than 75 ft (23 m) above the lowest level of fire department vehicle access." NFPA 1710, §5.2.4.4.1. Although this standard addresses fire response to high-rise buildings, it is important to note that the designation 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.

[12] Because WBFD provides medical transport, four of the 43 firefighters are required for, "The establishment of an initial medical care component consisting of a minimum of two crews with a minimum of two members each with one member trained to the ALS level capable of providing immediate on-scene emergency medical support, and transport that provides rapid access to civilians or members potentially needing medical treatment." NFPA 1710, §5.2.4.4.1(18).

- WBFD is able to respond with ALS transport capabilities on 90.9% of roads within the EMS response area within eight minutes, assuming all medic units are available immediately upon dispatch. Because WBFD cross-staffs medic and fire suppression units, this also assumes that all fire suppression units will be unable to respond. [13] [14]

    - Pursuant to implementing staffing and deployment recommendations and the four-station configuration, the department would likely be able to respond with ALS transport capabilities within eight minutes of travel on 99.6% of roads, which equates to a 9.5% **increase** in response coverage over current conditions. Also, pursuant to these recommendations, all fire suppression units would be available to respond to fires when medic units are already deployed.

Workload Analysis

- WBFD responded to 3,903, 4,088, 4,264, 4,283, and 4,382 incidents in 2016, 2017, 2018, 2019 and 2020, respectively.

- Those incidents required the response of 5,136, 5,242, 5,455, 5,244, and 5,474 WBFD units in 2016, 2017, 2018, 2019, and 2020, respectively.

- From 2016 to 2020, incident volume grew by 12.3% and response volume grew by 6.6%.

- From 2016 to 2020, Meds 11, 31, and 21 were the first, second, and third busiest WBFD units, respectively.

    - Overall, from 2016 to 2020, medic units accounted for 75.8% of all in service time for WBFD units.

- WBFD's 90th percentile travel time for the first-arriving engine at a fire suppression incident exceeded NFPA 1710 travel time objectives each of the five years from 2016 to 2020. It was 4 minutes and 52 seconds (4:52), 4:38, 4:47, 5:25, and 4:33 in 2016, 2017, 2018, 2019 and 2020, respectively.

    - During the five years, the first-arriving engine on scene at 20.4% of fire suppression incidents had a travel time of greater than four minutes.

[13] "The fire department shall establish the following objectives…240 seconds (4 minutes) or less travel time for the arrival of a unit with first responder with automatic AED or higher level of capacity at an emergency medical incident." NFPA 1710, §4.1.2.1(7)

[14] "The fire department shall establish the following objectives…480 seconds (8 minutes) or less travel time for the arrival of an advanced life support (ALS) unit at an emergency medical incident, where this service is provided by the fire department provided a first responder with an AED or BLS unit arrived in 240 seconds or less travel time." NFPA 1710, §4.1.2.1(8)

- During the five years, 41.3% of these greater than four minute first-responses were by Engine 1, deploying from Station 1.

- WBFD's 90th percentile travel time for the first-arriving unit at an emergency medical incident exceeded NFPA 1710 travel time objectives each of the five years from 2016 to 2020. It was 5 minutes and 35 seconds (5:35), 5:43, 5:37, 5:54 and 6:10 in 2016, 2017, 2018, 2019 and 2020 respectively.

    - 29.9% of emergency medical incidents during the five years had the first-arriving unit with a travel time of greater than four minutes.

    - During the five years, 44.7% of these greater than four minute first-responses were by Med 11, deploying from Station 1.

    - The percentage of emergency medical incidents where the first arriving unit had a travel time greater than four minutes increased from 29.5% in 2016, to 32.2% in 2020.

Recommendations

The recommendations listed below are based on the performance objectives in NFPA 1710, the findings of the GIS evaluation of the current staffing and deployment practices of WBFD and optimal fire station locations for WBFD, and the findings of the workload analysis of the WBFD CAD data from 2016 to 2020. It is recommended that:

- WBFD should discontinue the practice of cross-staffing fire suppression apparatus and medic units.

- WBFD should staff all frontline fire suppression apparatus with a minimum of four firefighters at all times to meet the minimum staffing objectives stated in NFPA 1500 and NFPA 1710.

- WBFD should staff all frontline medic units with a minimum of two firefighters at all times to meet the minimum staffing objectives stated in NFPA 1500 and NFPA 1710.

- WBFD should relocate Station 2 near the intersection of S. River Road and Whitewater Drive.

- WBFD should build a fourth fire station near the intersection of W. Washington Street and Wildwood Road that deploys one engine, staffed with four firefighters at all times, and one medic unit, staffed with at least two firefighters at all times.

- Given the relocation of Station 2 and the building of a fourth fire station in the approximate locations described above, when Stations 1 and 3 are rebuilt or replaced, they should be rebuilt at or as near as possible to their present locations.

Executive Summary Conclusion

WBFD's fire suppression apparatus are staffed with less than four firefighters. Suppression apparatus not staffed with a minimum of four firefighters do not meet minimum staffing objectives outlined in NFPA 1500 and NFPA 1710. Staffing suppression apparatus in this manner makes firefighters working at the scene of emergencies less efficient and effective, and increases the chance of injury to firefighters and residents. Physiological strain placed on firefighters working on the fireground increases with three-firefighter companies compared to four-firefighter companies. Additionally, WBFD cross-staffs fire suppression apparatus and medic units at each station. This limits the ability of the fire department to respond effectively to emergencies.

Based on geographic analysis of the positioning of WBFD resources and evaluation of historical CAD data, fire suppression resources are not deployed adequately to provide for the arrival of the first-arriving unit within four minutes of travel to 90% of fire suppression incidents, and WBFD resources are not deployed adequately to provide for the arrival of the first-arriving unit within four minutes of travel to 90% of emergency medical incidents. As the fire department experiences increasing demand, performance will worsen if available resources are not increased.

WBFD's response capabilities do not meet objectives included in NFPA 1710 which require the assembly of 17 firefighters to a low-hazard structure fire within eight minutes of travel to 90% of incidents, the assembly of 26 firefighters at a medium-hazard structure fire within eight minutes to 90% of incidents, or the assembly of 39 firefighters to a high-hazard structure fire within 10 minutes and 10 seconds to 90% of incidents. Geographic assessment demonstrated that the current level and distribution of fire department resources is not adequate to meet these objectives put forth in industry standards. Increasing the number of staffed suppression apparatus and fire stations, and staffing all suppression apparatus with a minimum of four firefighters, and discontinuing the practice of cross-staffing so each station will be capable of responding both a suppression company and a medic unit at all times, will increase the department's ability to assemble the required effective response forces at low-hazard structure fires and increase the department's ability to meet minimum travel time objectives for response to fire suppression and medical incidents. Geographic and workload analysis identified areas where WBFD response capabilities need to be enhanced.

In addition to increasing staffing to meet the minimum objectives of NFPA 1710, WBFD should increase the number of fire stations and adjust Station 2's current location in order to address demand in West Bend and the contract areas. As demand has increased over time, WBFD has not adequately increased response capacity.

A fire department should be designed to adequately respond to several emergencies occurring simultaneously in a manner that aims to minimize the loss of life and property that the fire department is charged to protect. Staffing and deployment decisions should be made in conjunction with consideration of historical locations of calls, response times to target hazards, compliance with departmental Standard Operating Procedures (SOPs), existing industry standards, including NFPA 1500 and NFPA 1710, and the citizens' expectations of receiving an adequate number of qualified personnel on appropriate apparatus within acceptable time frames to make a difference in their emergency.

The provision of fire protection and EMS response are essential services that governments must provide. However, for these services to be effective and efficient, they must be positioned appropriately to address emergencies in an equitable manner, as they occur. All residents should receive equitable coverage from WBFD. Currently, many areas of the city do not receive timely coverage. The fire department's staffing and deployment configuration is not consistent with a goal of providing equitable coverage to all West Bend residents. The findings in this report will provide the department and city officials with information on how the department's present response capabilities compare to industry standards and how the lack of resources negatively affects the WBFD's ability to appropriately respond to incidents in some areas of West Bend.

Background

The International Association of Fire Fighters (IAFF) Headquarters was engaged by of the West Bend Professional Firefighters, IAFF Local 2025, to create a data-driven document for West Bend city and fire department administrators to assist with informed decisions regarding West Bend Fire Department (WBFD) emergency response.

Currently, the department maintains three fire stations. All suppression apparatus are staffed with a minimum of three fire fighters each at all times, which is less than the minimum staffing level outlined in industry standards. The frontline suppression apparatus – Engine 1, Engine 3, and Truck 2 – are cross-staffed with the three medic units, which have the highest call volume of any department units. This practice severely limits WBFD response capacity. The three existing fire stations do not make it possible for WBFD to provide adequate four-minute coverage in many areas of West Bend. Additional fire stations, personnel, and staffed suppression and medic units are required in order for the department to meet the performance objectives of NFPA 1710 for response to fires and emergency medical incidents.

City and fire department administration, and Local 2025, have identified the need for a comprehensive evaluation and analysis of current WBFD response capabilities and historical performance that can be measured against industry standards.

The information provided in this document is designed to help decision makers understand the depth of fire department operations and how low staffing levels and inadequate resource distribution can negatively impact responders and residents in West Bend and the Towns of West Bend and Barton.

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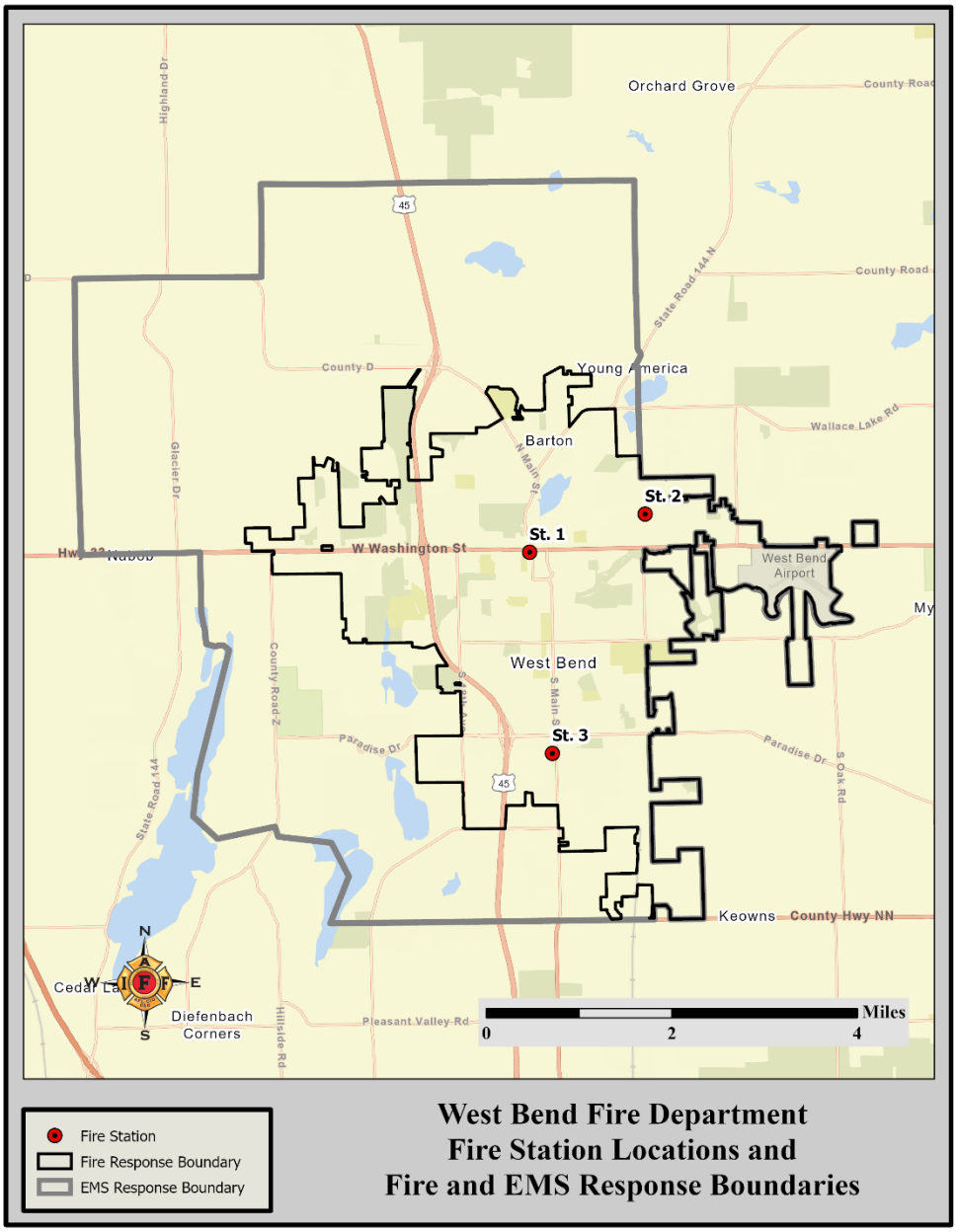
Risk Characteristics

West Bend is a city in Washington County, Wisconsin. The city has an area of 15.1 square miles. WBFD is responsible for responding to all of West Bend. WBFD also provides ALS first-response and transport to portions of the Town of West Bend and the Town of Barton, both to the west of West Bend.



Map 1: Fire Stations, Fire Districts and Response Boundary. Map 1 depicts the WBFD fire station locations, fire response boundary, and EMS response boundary. The EMS response boundary encompasses all of the city of West Bend and portions of the Towns of West Bend and Barton.

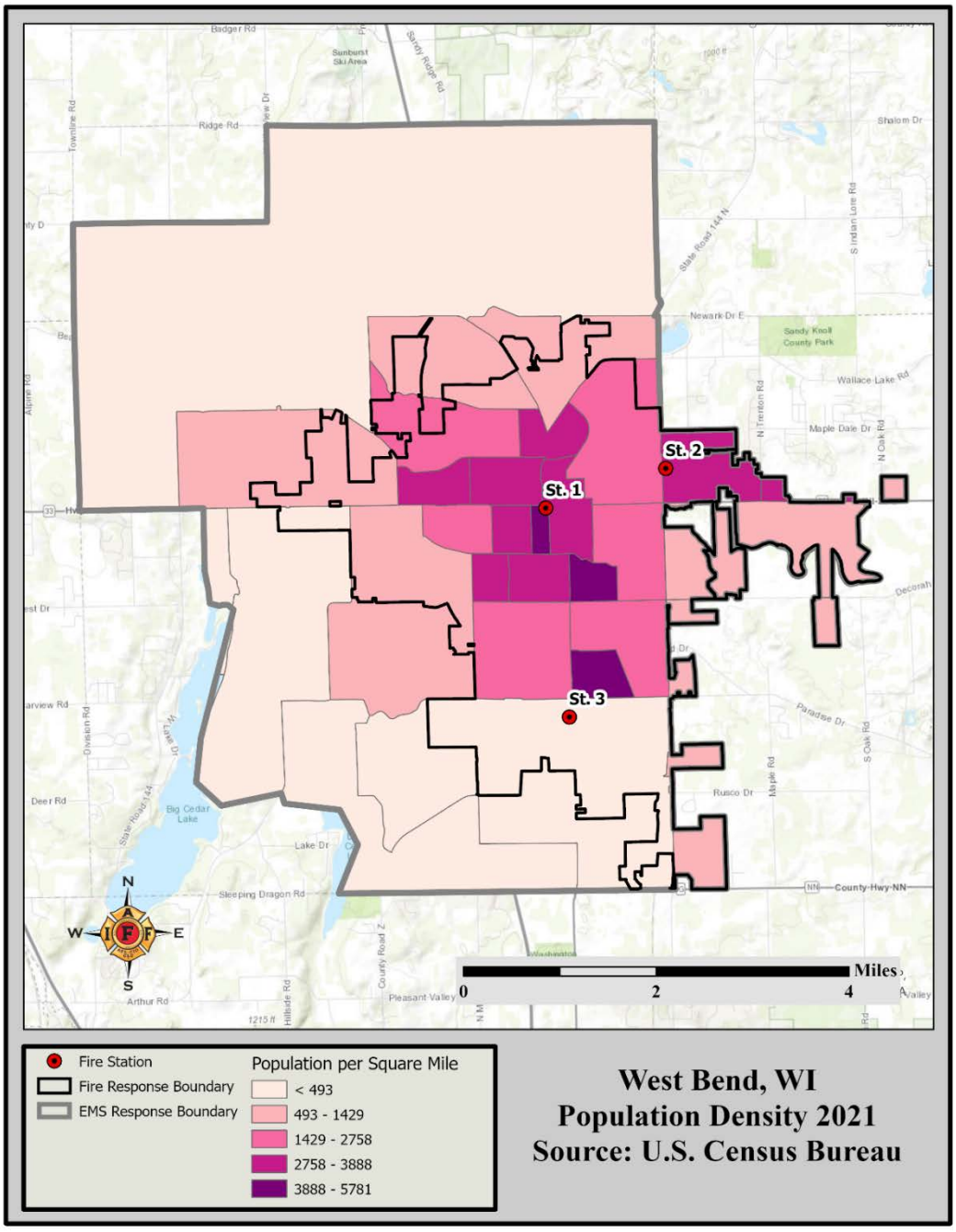
West Bend had a population of 31,596 and overall population density of 2,092.5 residents per square mile according 2019 estimates. [15] Between the 2010 and 2019, the population of West Bend grew by 2.7%.[16]

Further assessment of the 2019 American Community Survey revealed that 23.1% of the population was in a vulnerable category based on age. This category consists of persons under the age of 5 (5.7%) and persons who are 65 years of age and older (17.4%).[17] These populations typically place an increased demand on public safety resources because these groups are at a higher risk of fire-related injury 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, 6.9% of the population was living at or below the poverty level. [18] Those living in poverty may generally lack the means to properly maintain residences which can lead to an increased risk for fire.

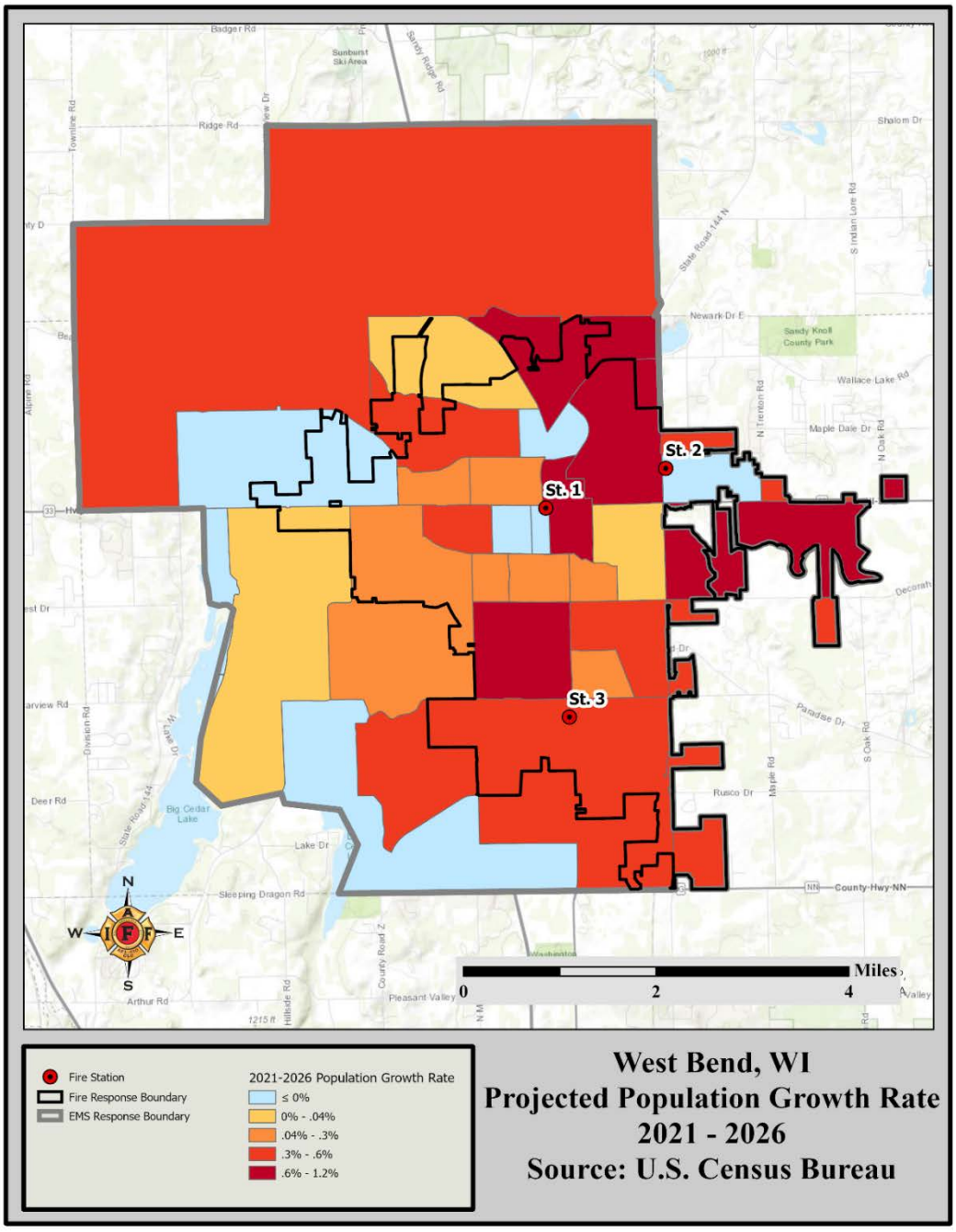
The city had a total of 13,890 housing units in 2019 of which 52.2% were single family homes, 47.7% were multifamily structures (2 to 20+ units), and 0.1% were mobile homes.[19] Of these structures, 36.3% were built before 1970, 12.4% were built before 1940, and 3.1% were vacant.[20] Typically, vacant housing and older buildings constructed before current fire codes were developed can lead to an increased demand on emergency services.

The following maps depict various demographic and physical characteristics of West Bend.

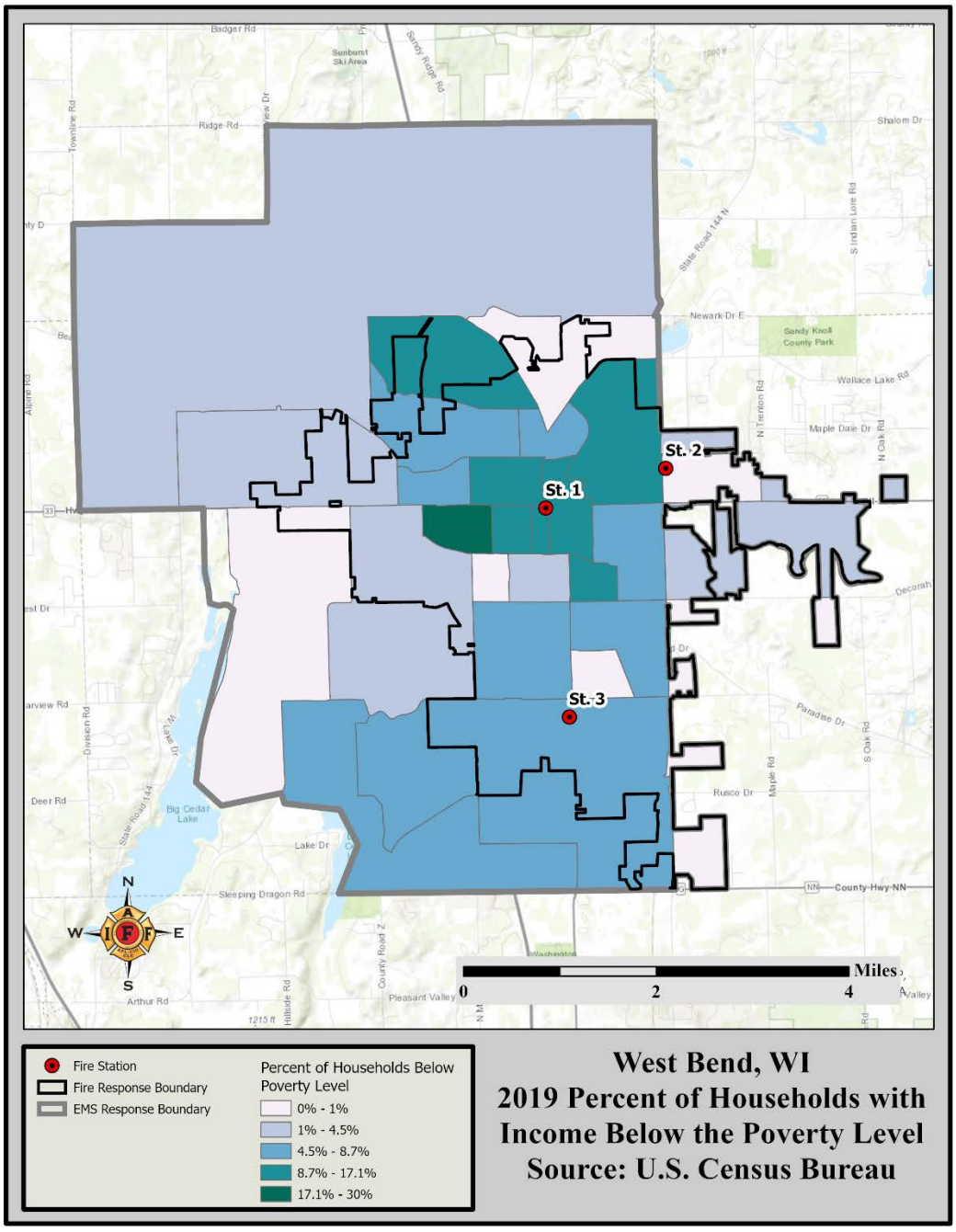
[15] West Bend city, Wisconsin, Population estimates 2019, American Community Survey 1-Year Estimates.
[16] West Bend city, Wisconsin, Population Estimates Program (PEP), U.S. Census Bureau.
[17] West Bend city, Wisconsin, Selected Economic Characteristics 2019, American Community Survey 5-Year Estimates.
[18] Ibid.
[19] West Bend city, Wisconsin, Selected Housing Characteristics 2019, American Community Survey 1-Year Estimates.
[20] Ibid.



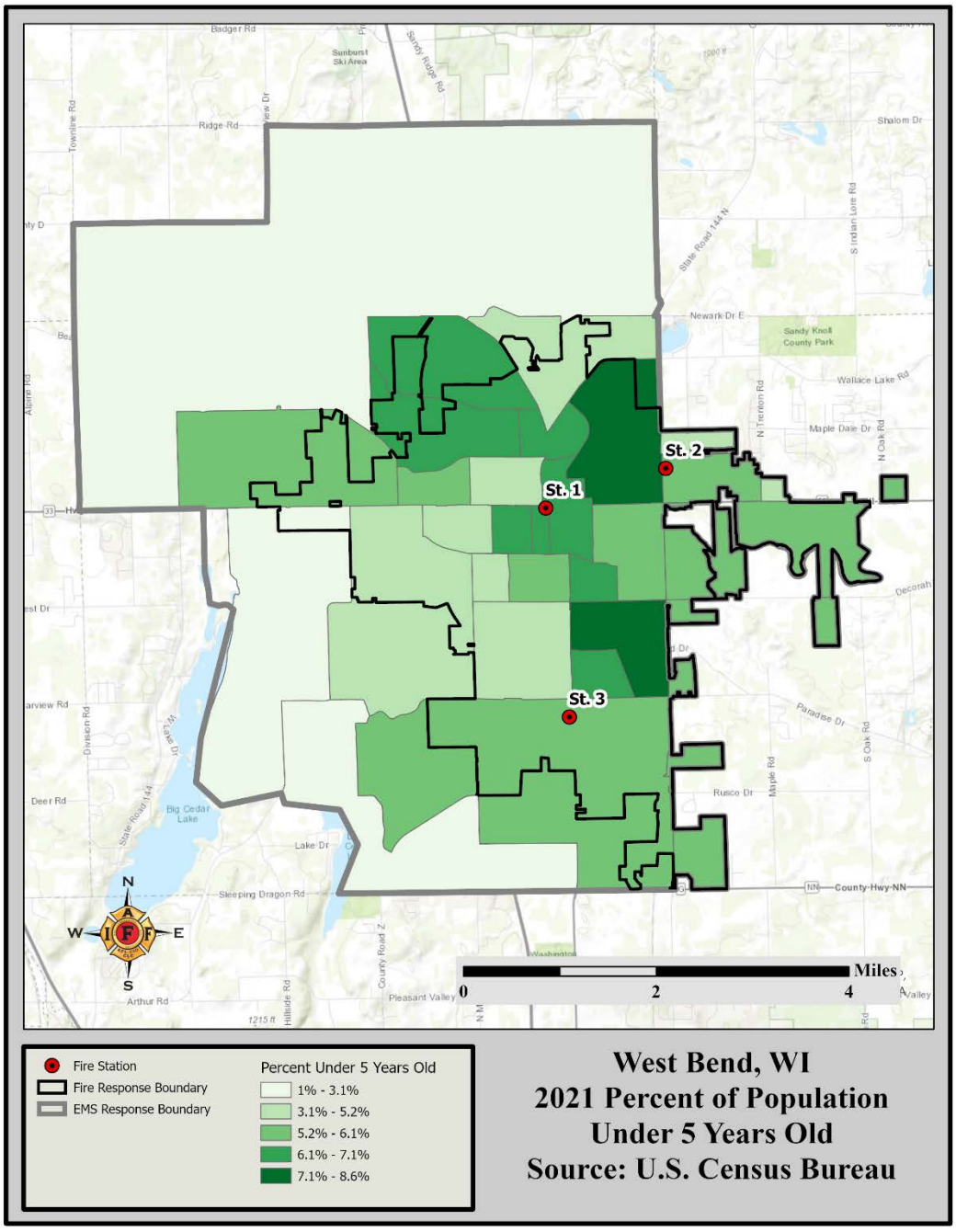
Map 2: Population Density 2021. Map 2 shows West Bend's 2021 population density in people per square mile by census block group. Demand on emergency units is expected to be greater in areas with higher population density.



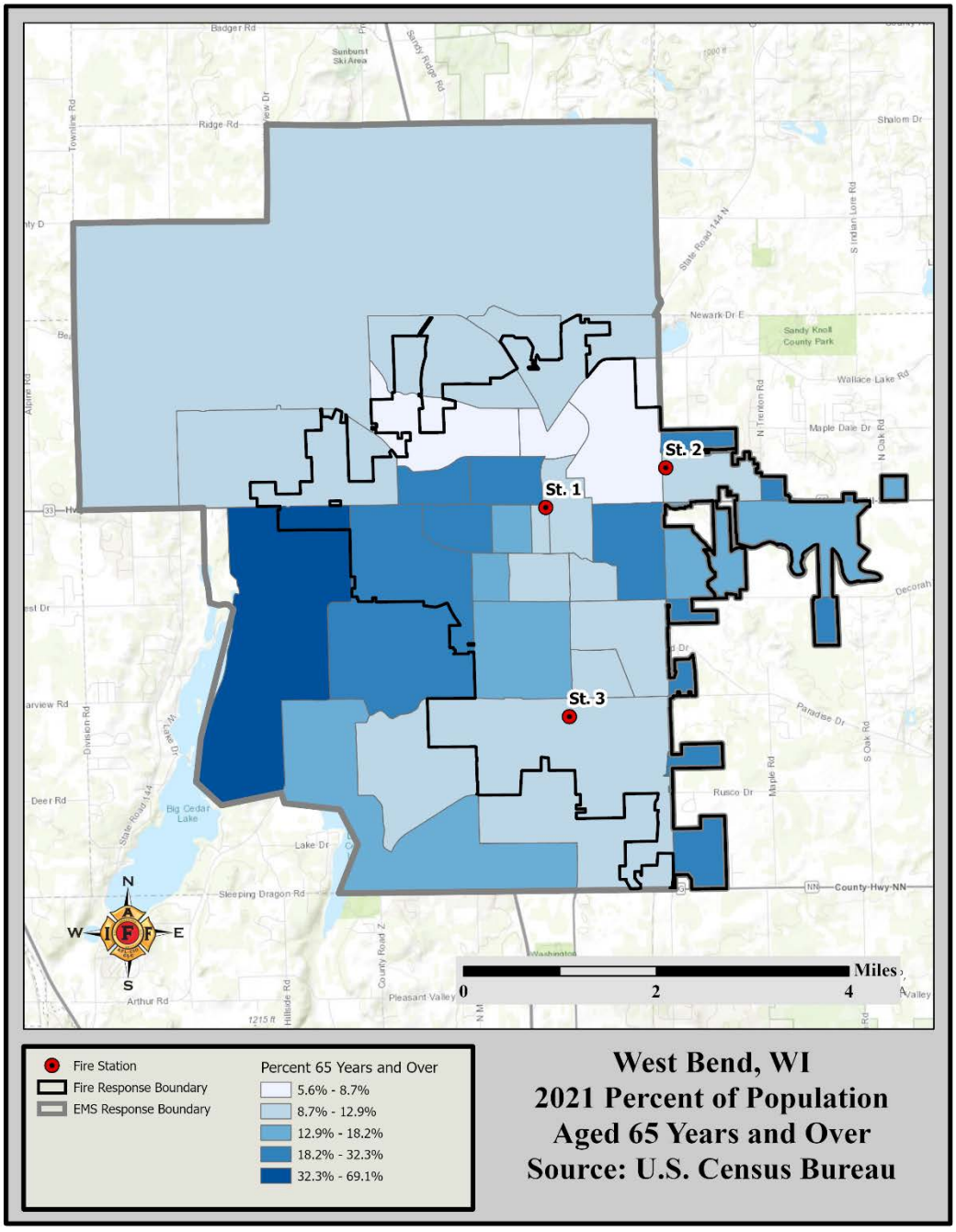
Map 3: Projected Population Growth Rate, 2021 - 2026. Map 3 depicts the projected population growth rate from 2021 to 2026 per census block group. Based on these projections, most of West Bend will experience growth. Typically, as population increases, so does demand. WBFD should continue to monitor population growth as an indication of where additional resources may be needed in the future.



Map 4: 2019 Percent of Households with Income Below the Poverty Level. Map 4 depicts the percentage of the population that lives below the poverty line. In the U.S. overall, 14.5% of the population lives below the poverty line. Typically, people that live at or below the poverty line are at a higher risk for medical complications due to the lack of a primary care physician and or having a fire in their residence due to overcrowding, unsafe heating source, and/or the lack of fire alarms resulting in fire-related injury or death.

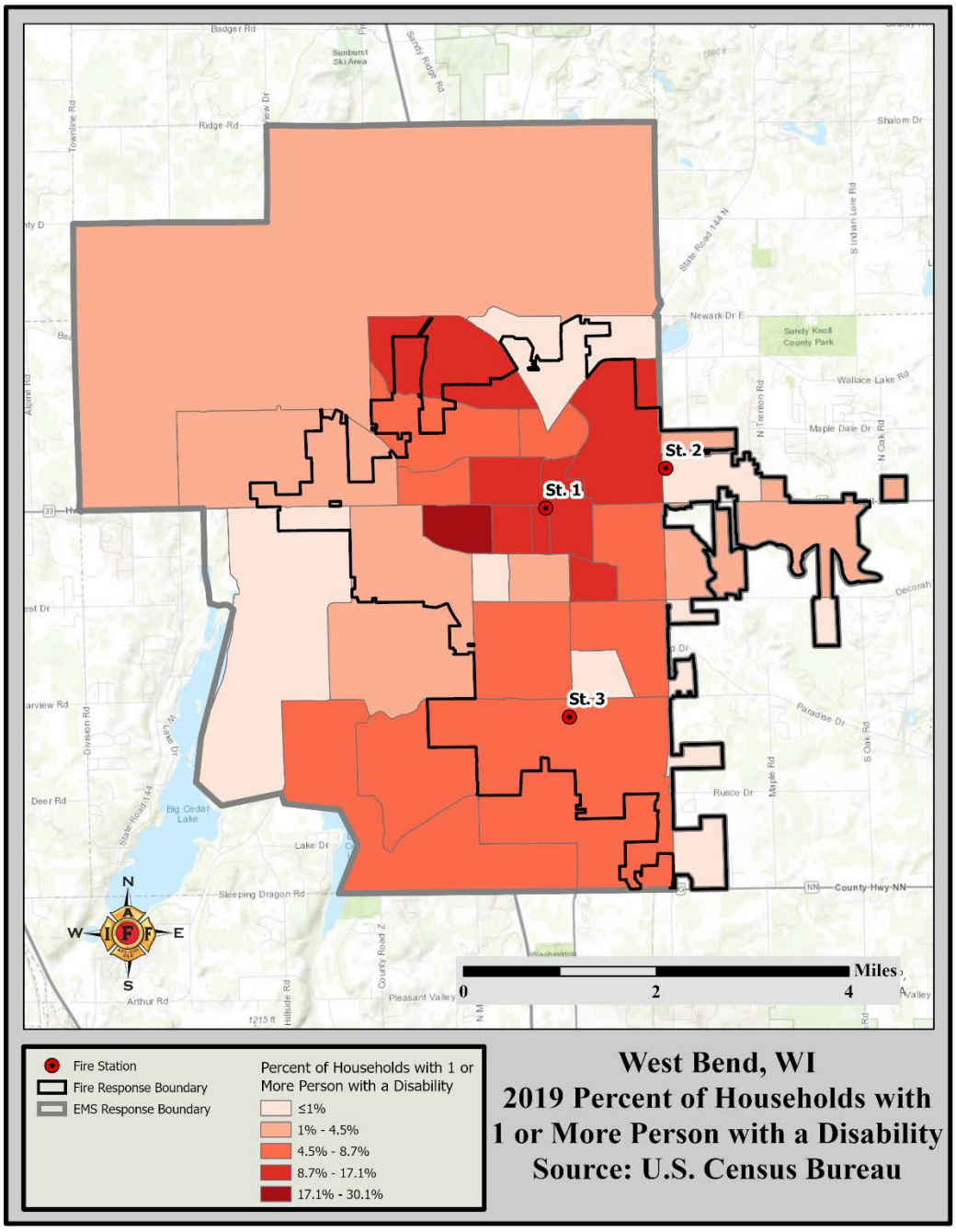


Map 5: 2021 Percent of Population Under 5 Years Old. Map 5 depicts the percentage of the total population under five years old by census block group. Typically, people under five years old are at a higher risk for injury or death because of their inability or reduced ability to evacuate in an emergency. This age group also tends to place an increased demand on emergency medical services. Thus, this map identifies potential areas of vulnerability in the community that will most likely need assistance before, during and after a hazardous event.

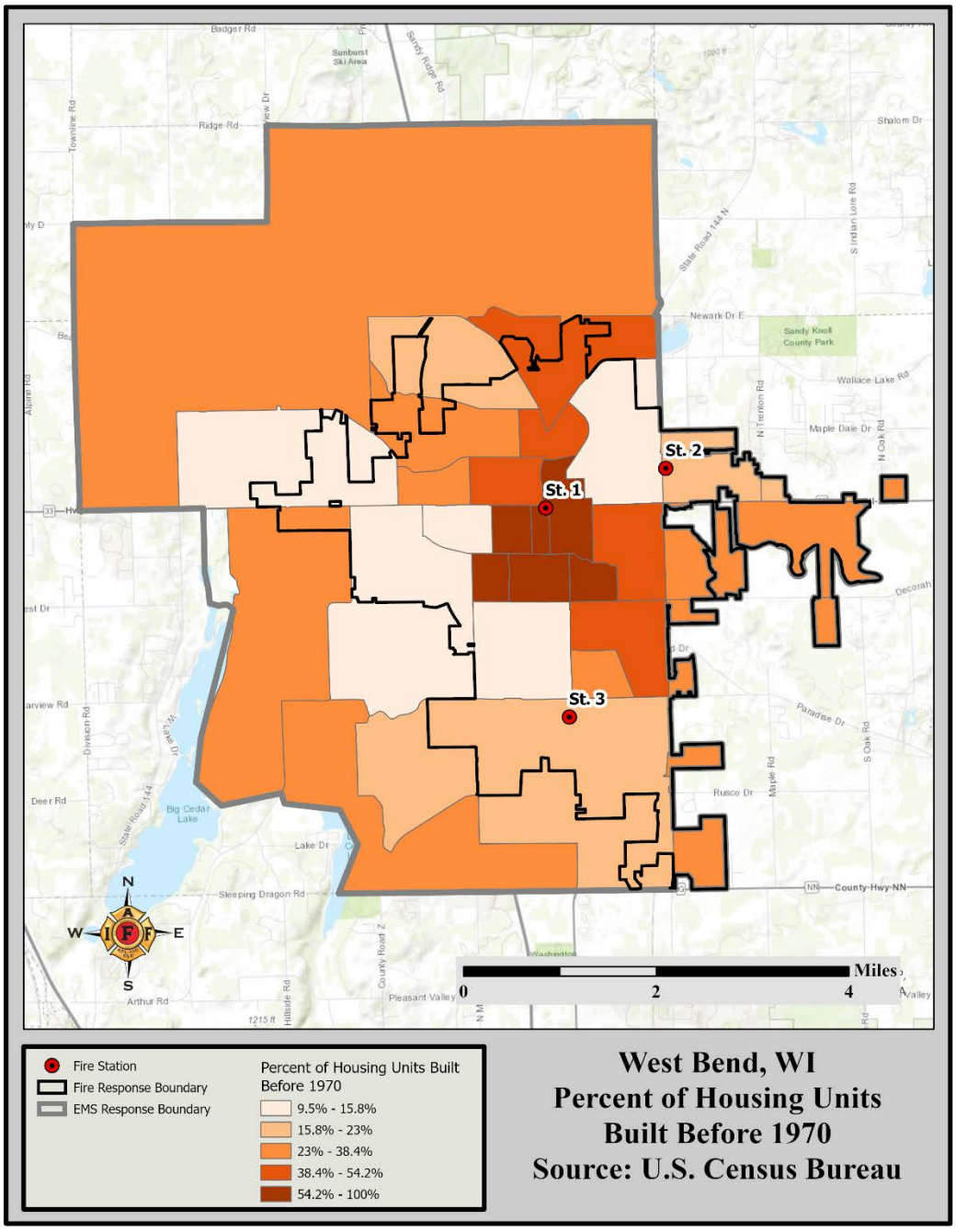


Map 6: 2021 Percent of Population 65 Years and Over. Map 6 depicts the percentage of the total population aged 65 years and older by census block group. Typically, people aged 65 and older are at a higher risk for injury or death because of their inability or reduced ability to evacuate in an emergency. According to a 2018 NFPA study, "Home Fire Victims by Age and Gender" [21], the age groups of 65 to 74, 75 to 84, and over 84, have 15.2, 21.2, and 26 home fire death and injury rates per million, respectively. For all age categories, the overall rate in the United States is 7.9. Thus, this map identifies areas of vulnerability in the community that will most likely need assistance before, during and after a hazardous event.

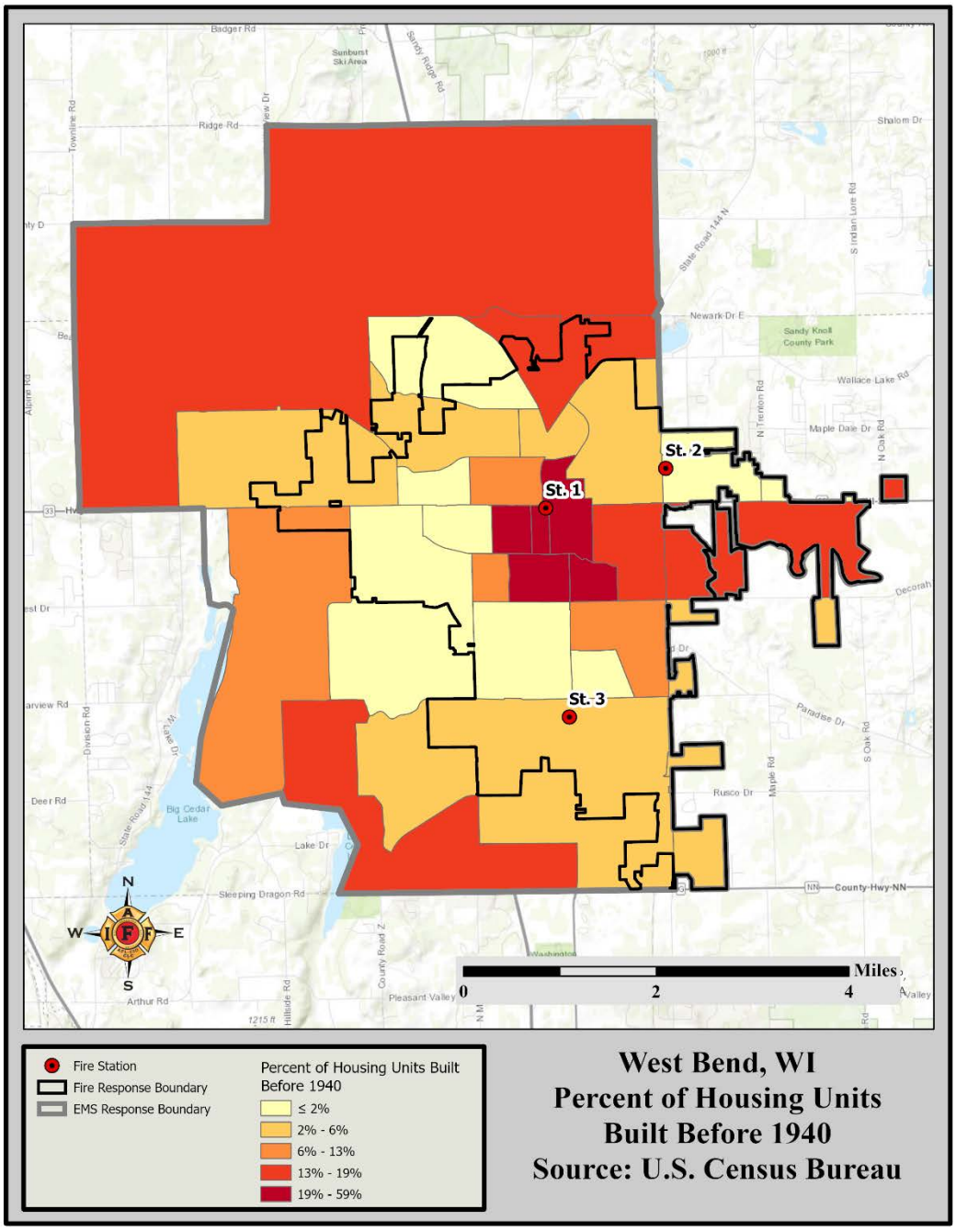
[21] Marty Ahrens, Home Fire Victims by Age and Gender, NFPA, December 2018.



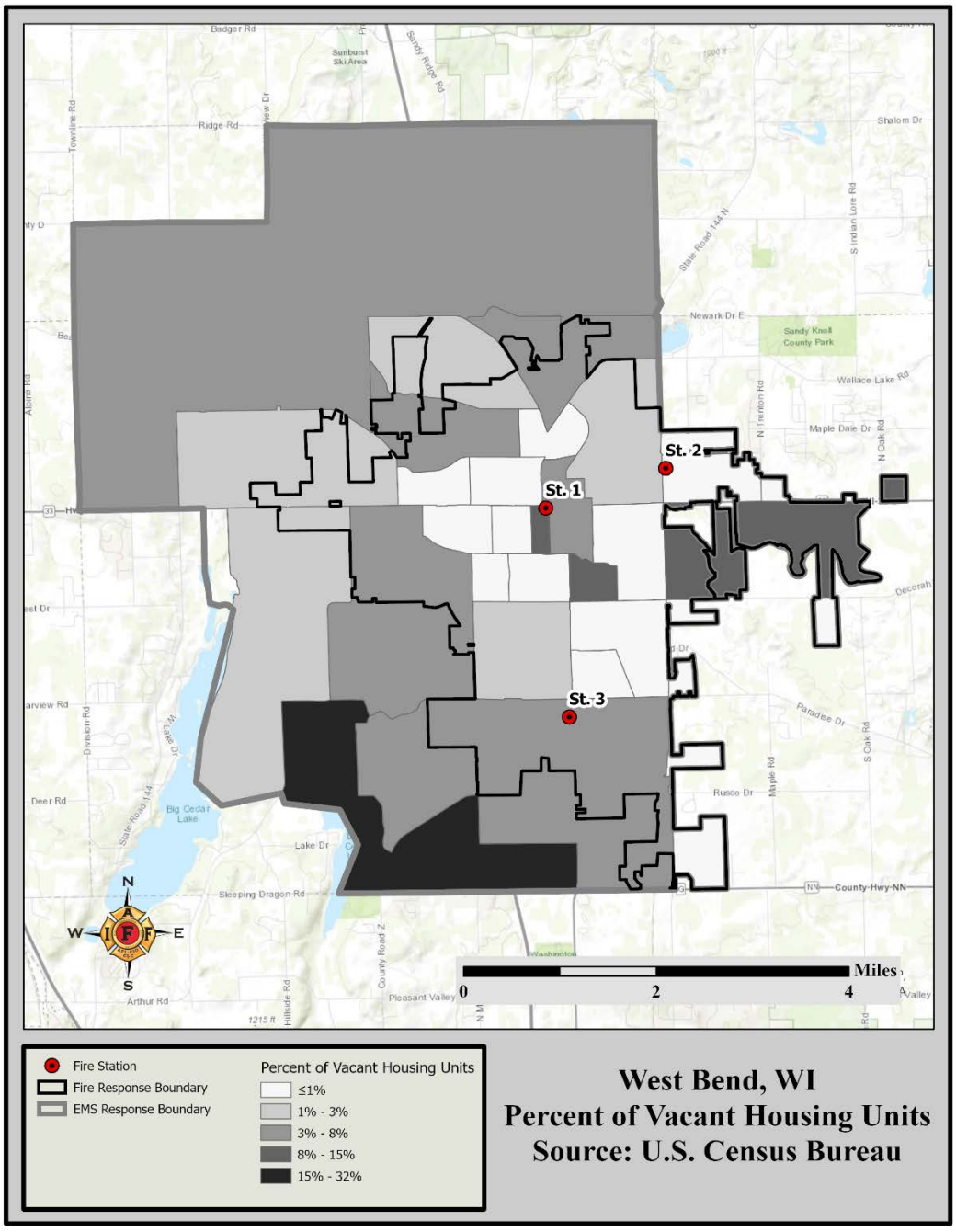
Map 7: 2019 Percent of Households with 1 or More Person with a Disability. Map 7 depicts the percentage of households with one or more person with a disability by census block group. Individuals with a disability may have a higher risk of injury or death because they may have difficulty or inability to evacuate in an emergency. Thus, this map identifies areas of vulnerability in the community that will most likely need assistance before, during and after a hazardous event.



Map 8: Percent of Housing Units Built Before 1970. Map 8 depicts the percentage of housing units built before 1970. Typically, when there are high numbers of older buildings constructed before many current fire codes were developed, and poorly maintained properties, there is an increased demand on emergency services.



Map 9: Percent of Housing Units Built Before 1940. Map 9 depicts the percentage of housing units built before 1940. Typically, when there are high numbers of older buildings constructed before many current fire codes were developed and poorly maintained properties, there is an increased demand on emergency services.



Map 10: Percent of Vacant Housing Units. Map 10 depicts the percentage of vacant housing units. According to ACS 2019 5-year estimates 4.5% of housing units in West Bend were vacant. Wisconsin's average vacancy rate is 12.4%. Based on an April 2018 NFPA study, over 50% of all structure fires in vacant buildings are intentionally set. Structure fires in vacant structures are approximately three times more likely to spread beyond the structure of origin compared to overall structure fires, and 13% of firefighter injuries occurred in vacant building fires.[22]

[22] Marty Ahrens, Fires in Vacant Buildings, NFPA, April 2018.

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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 time frame of fire growth, the temperature of a fire rises to above 1,000° Fahrenheit (F). It is generally accepted in the fire service that for a medium growth rate fire,[23] 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 eight 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 fire department response to a low-hazard structure fire. A low-hazard structure fire is defined as a fire that occurs in a typical, 2000 square foot, single-family residential home with no basement or exposures.[24]

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

[23] 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.

[24] NFPA 1710, 2020 ed. Pg. 1710-20 A.4.1.2.5.1

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 as it would in an open area. In this phase of the 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, the 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 aggressive intervention by an adequately staffed fire department, the fire will likely spread to the rest of the structure.

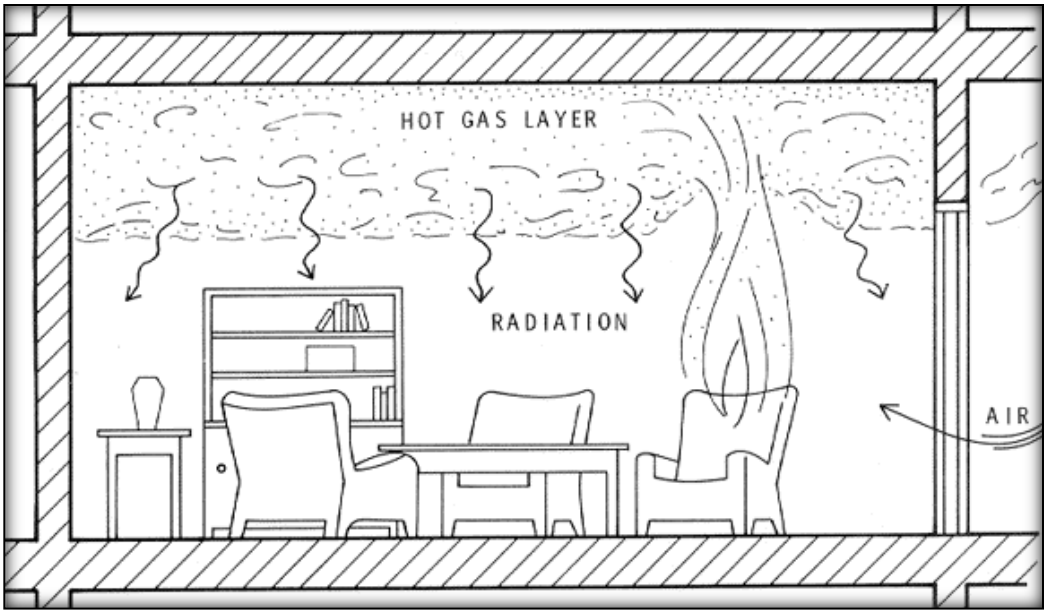


Figure 1: Fire Growth in a Compartment.[25] The above figure depicts the growth of fire in a compartment, which is an enclosed space or room in a building. In a compartment the walls, ceiling, floors, and objects absorb radiant heat produced by the fire. Unabsorbed heat is reflected back to the initial 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 more or less 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. [26]

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 super-heated 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

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

ceiling can quickly reach temperatures of 1,200˚ F 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 these windows break, as a result 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 and ladder 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 firefighting force can reach a reasonable number of fire scenes before flashover occurs. 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 1, responding companies staffed with four firefighters are capable of initiating critical fireground operational tasks more efficiently than those with crew sizes below industry standards.

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 1: Impact of Crew Size on a Low-Hazard Residential Fire.[27] 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.

First-arriving companies staffed with four firefighters are more efficient in all aspects of initial fire suppression and search and rescue operations compared to two- or three-person companies. There is a significant increase in time for all the tasks if a company 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 engine company 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 company, because the first-in unit is staffed with a sufficient number of personnel to accomplish its assigned duties, the second-in company does not need to support first-in company 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 engine company 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 initiating fire suppression, the supervising officer of the first arriving engine company 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.

[27] 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.

Similarly, the driver/operator of the first-arriving ladder company 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 companies 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. It also 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 engine and ladder truck companies to the scene of a fire, the less time it takes to 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 2: The Relationship between Crew Size and Scene Time.[28] 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.

As Table 2 shows, units that arrive with only two firefighters on an engine or ladder truck are on the scene of a fire almost seven 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 five to six 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.[29] [30] 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.

[28] 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.
[29] Ibid.
[30] 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.[31]

In 2018 alone, 44% of all firefighter fatalities were related to overexertion.[32] There is strong epidemiological evidence that heavy physical exertion can trigger sudden cardiac events.[33] Smaller crews are responsible for performing a number of 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, as a result of overexertion.

Charts 1 and 2, on the following pages, highlight the cardiovascular impact on firefighters based on crew size for the first arriving engine and ladder company. The heart rates of firefighters of crew sizes ranging from two to five 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.

[31] 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.
[32] Fahy, R.F., Molis, J.L. (June, 2019) Firefighter Fatalities in the United States-2018. NFPA.
[33] 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

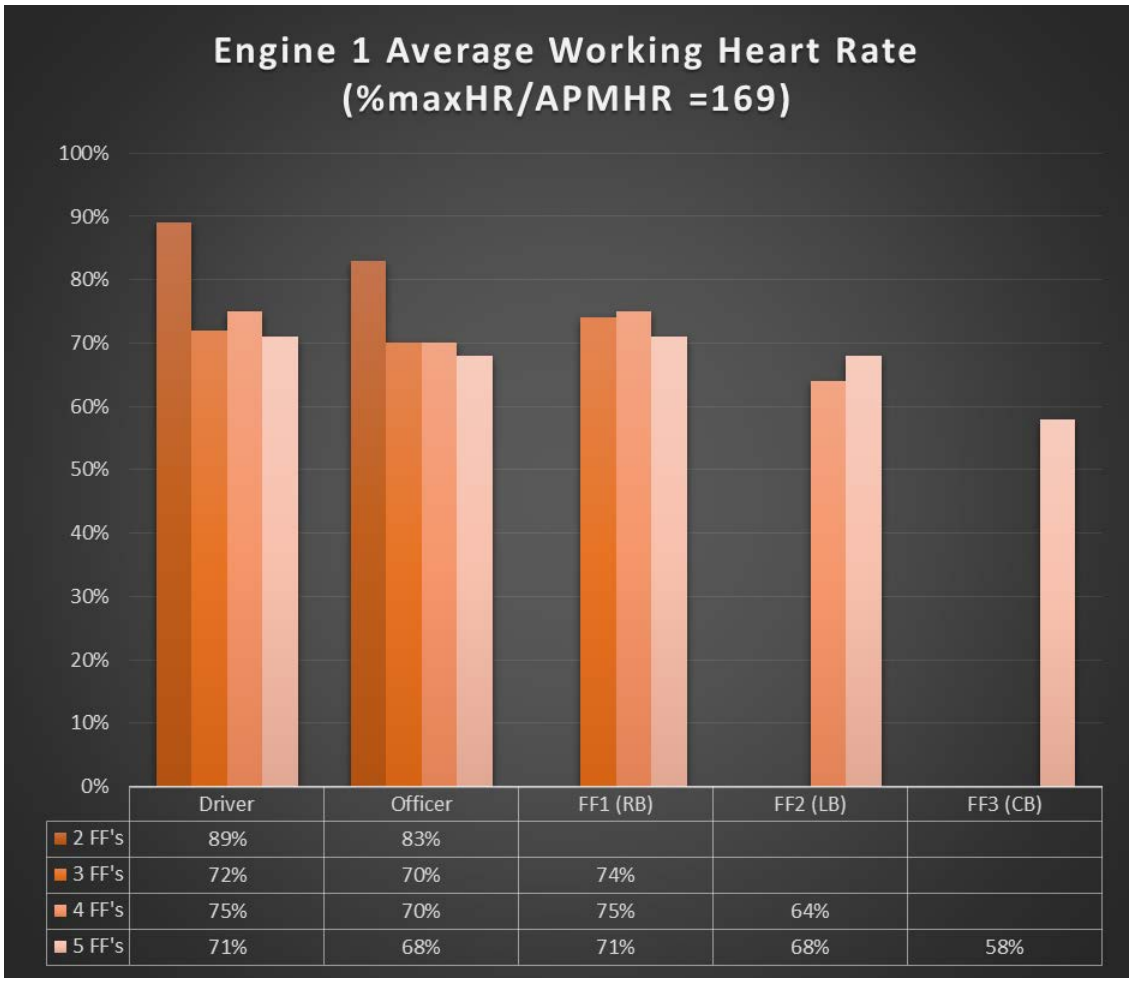
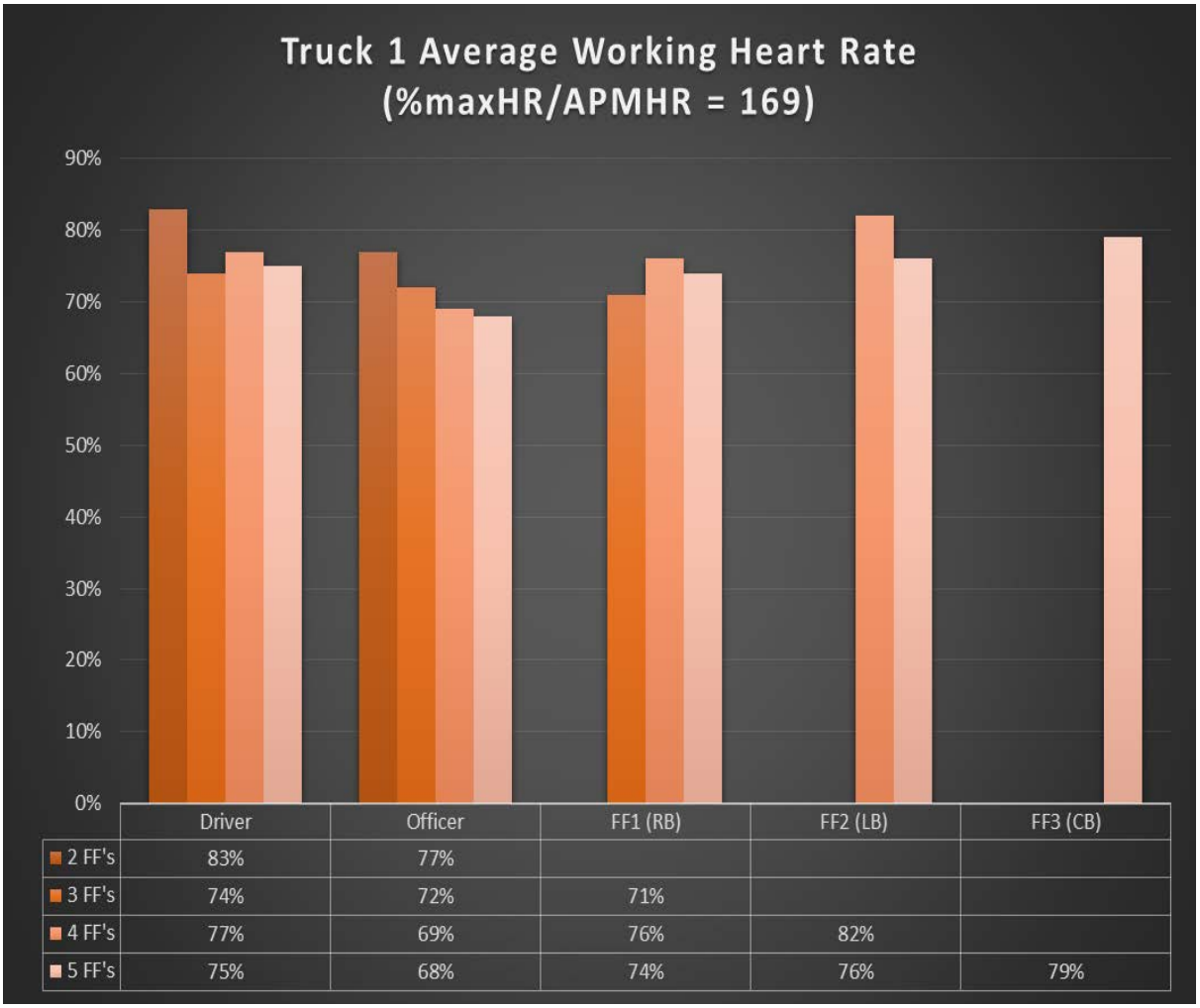


Chart 1: Average Peak Heart Rate of First Engine (E1) with Different Crew Sizes by Riding Position.[34] *In Chart 1, heart rates are expressed as a percent of maximal age-predicted maximal HR.* The average heart rates for firefighters on the first engine company were above 80% of age-predicted maximum values when only two firefighters were working. When staffing was at two 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.[35] 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.

[34] 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."

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



	Driver	Officer	FF1 (RB)	FF2 (LB)	FF3 (CB)
2 FF's	83%	77%			
3 FF's	74%	72%	71%		
4 FF's	77%	69%	76%	82%	
5 FF's	75%	68%	74%	76%	79%

Chart 2: Average Peak Heart Rate of First Truck (T1) with Different Crew Sizes by Riding Position.[36] *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 two firefighters were working.[37] 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.

[36] 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."

[37] 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 3, 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.[38] 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 showed 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.

[38] 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			
Flame Spread:	**Civilian Deaths**	**Civilian Injuries**	**Average Dollar Loss per Fire**
Confined fires (identified by incident type)	0.00	8.7	$200
Confined to object of origin	0.4	11.1	$1,200
Confined to room of origin, including confined fires by incident type[39]	1.8	23.8	$4,000
Beyond the room, but confined to floor of origin	16.2	76.3	$35,000
Beyond floor of origin	24.6	55.0	$65,900

Table 3: The Relationship between Fire Extension and Fire Loss.[40] The above table displays the rates of civilian injuries and deaths per 1,000 fires, as well as the average 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.

OSHA's "2 In/2 Out" Regulation

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 firefighters 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 environment and, therefore, require the use of respirators. In those cases, at least two standby persons, in addition to the minimum of two persons inside

[39] NFIRS 5.0 has six categories of confined structure fires, including cooking fires confined to the cooking vessel, confined chimney or flue fire, confined incinerator fire, confined fuel burner or boiler fire or delayed ignition, confined commercial compactor fire, 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.

[40] National Fire Protection Association, NFPA 1710 (2020), Table A.5.2.2.2.1 Fire Extension in Residential Structures, 2012-2016.

needed to fight the fire, must be present before firefighters may enter the building.[41] [42] 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 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**,"[43] 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, ladder 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**."[44]

However, the number of personnel required per fire suppression apparatus increases with risk and demand. NFPA 1710, 2020 edition states that engine and ladder companies that are assigned to first-due districts that have a high number of incidents, geographic restrictions[45], geographic isolation[46], or areas considered to be urban[47] with regards to population density, all as identified by the AHJ, should be staffed with a minimum of five firefighters. First-due districts that have tactical hazards, high hazard occupancies, or densely populated urban areas[48], as identified by the AHJ, shall have companies that are staffed with six firefighters.[49]

[41] 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.
[42] Paula O. White, letter to Thomas N. Cooper, 1 November 1995 (OSHA)
[43] NFPA 1710, § 5.2.3.1 and §5.2.3.1.1.
[44] NFPA 1710, § 5.2.3.2 and §5.2.3.2.1.
[45] Geographic Restriction is a defined condition, measure, or infrastructure design that limits response and/or results in predictable response delays to certain portions of the jurisdiction.
[46] Geographic Isolation is a first-due response zone or jurisdiction with staffed resources where over 80% of the response area is outside of 10-minute travel time from the next closest staffed suppression apparatus.
[47] An urban area is an incorporated or unincorporated area with a population over 30,000 people and /or a population density over 1,000 people per square mile but less than 2,999 people per square mile.
[48] A dense urban area is an incorporated or unincorporated area with a population density of over 200,000 people and/or a population density of over 3,000 people per square mile.
[49] 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.

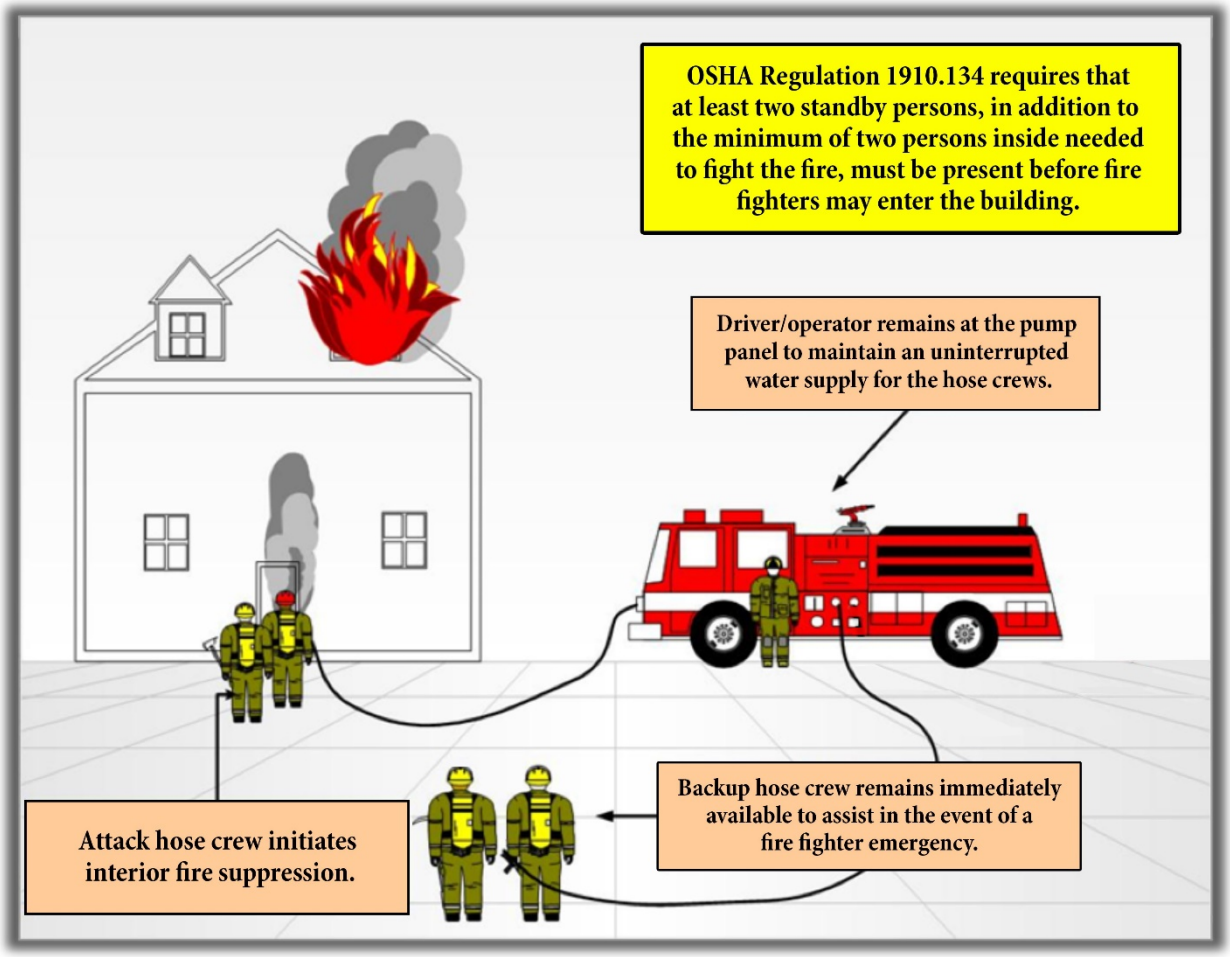


Figure 2: The OSHA "2 IN/2 Out" Regulation. The above figure depicts the number of firefighters required to meet OSHA regulation 1910.134, which demands one firefighter outside for every firefighter inside. The firefighters outside can support a secondary attack line and facilitate the rescue of trapped 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.

Several examples of incidents exist in which the failure to follow the "2 In/2 Out" regulation have contributed to firefighter casualties. For example, in Bridgeport, Connecticut in July 2010, two firefighters died following a fire where 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.

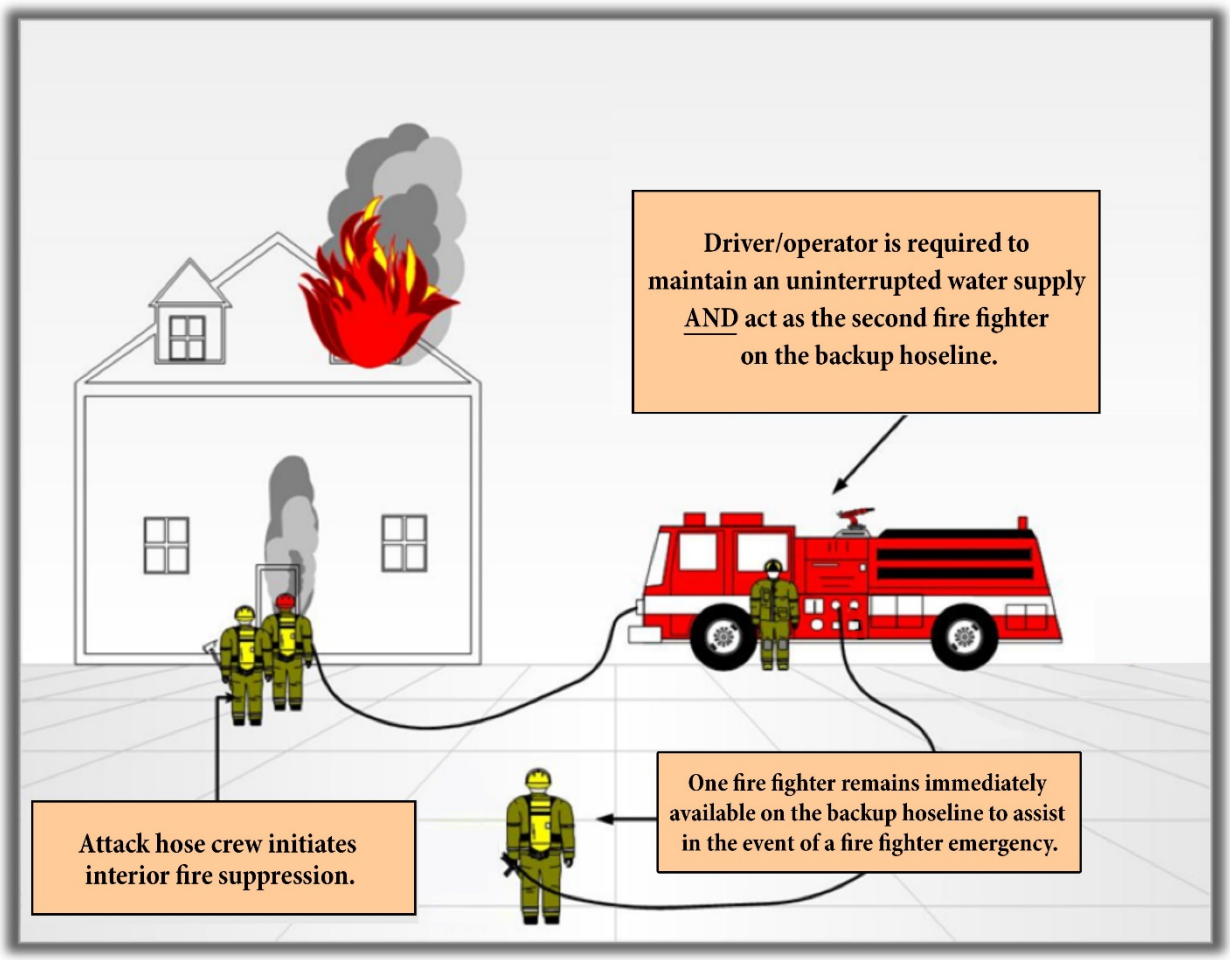


Figure 3: Emergency "2 In/2 Out" Operations. In the emergency model depicted above, the arriving fire apparatus is staffed with a crew of 4 personnel and operates under emergency conditions. In this case the driver/operator of the fire apparatus is also counted as a firefighter, which means that firefighter 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 company is on scene, only a company staffed with four firefighters can 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 company, 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 a company of four firefighters can initiate fire suppression and rescue operations in compliance with "2 In/2 Out" Regulation, and in a manner that minimizes the threat of personal injury. In crews with fewer than four firefighters,

the first-in company 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 companies to be staffed with a minimum of four firefighters and stresses the benefit of four-person companies and their ability to save lives without having to wait for the second-in company 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)	4 Firefighters
Required Minimum Personnel for Full Alarm	**16 Firefighters & 1 Scene Commander**

Table 4: 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 17 fire suppression personnel

In addition, NFPA 1710, §5.2.4.6.2 states, "The Fire Department shall have the capability for 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…"

In the initial full alarm assignment, one firefighter is designated to operate an aerial device if one is in use at the incident. However, even if an aerial device is not used, in order to maintain safe operations, the use of a ground ladder requires one firefighter to maintain (heel) the ladder while

firefighters traverse the ladder and while crews operate on the ladder or roof. Also, depending on the length of the ground ladder, three or more firefighters may be required to raise and properly position the ladder. [50] One such example of the failure to follow this practice occurred in Saint-Sulpice, Quebec in December 2012. [51] Two firefighters were injured when operating off an unheeled ladder, using a chainsaw to ventilate a roof. The ladder butt was unsecured and the ladder slipped, causing both firefighters to fall.

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[50] IAFC, NFPA, Firefighting Skills and Hazardous Materials Response, Canadian Fourth Edition. April 2019. P 401.
[51] Structure fire in Saint-Sulpice, Quebec. December 2012. Incident footage: <https://www.youtube.com/watch?v=2nt0DT0nXq8>.

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 civilian deaths, injuries, and property damage.

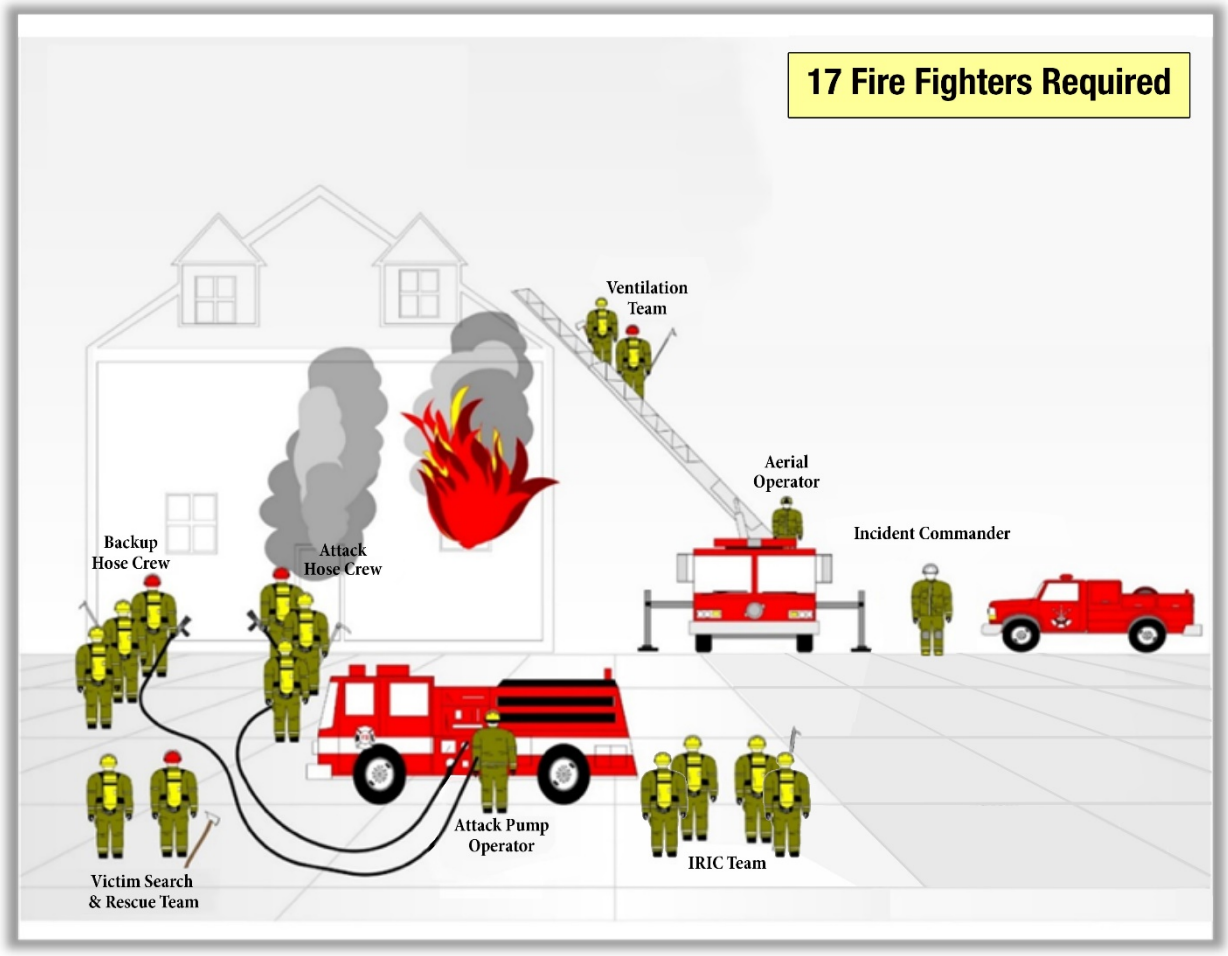

Figure 4: Initial Full Alarm Assignment Deployed Within Eight Minutes, 17 Firefighters Required. The above figure depicts the full alarm assignment required by NFPA 1710 as discussed in Table 4.

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.

Overview of High-Rises

High-rise buildings were once found exclusively in urban cities. However, today they are commonly found in small and mid-sized suburban communities as well. Many high-rise buildings in suburban areas are newer, shorter, and protected by automatic sprinkler systems, although this is not always a guarantee. 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 75 ft. (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.3.3.36 as high-hazard occupancies, represent an extraordinary challenge to fire departments and are some of the most challenging incidents firefighters encounter.

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 risks to firefighters and occupants increase in proportion to the height of the building and the height of the fire above grade level.[52] This is especially true once firefighters are operating above the reach of aerial ladders on truck companies. In these situations, the only viable means of ingress or egress is the interior stairs. 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, engine company and truck company operations must be coordinated.

High-rise buildings present a unique threat to the fire service. Multi-floor fires such as the 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, between 2007 and 2011, there were an estimated 15,400 reported high-rise structure fires per year that resulted in associated losses of 46 civilian deaths, 520 civilian injuries, and $219 million in

[52] Klaene, B. and Sanders, R. (2007). Structural Firefighting: Strategies and Tactics- High-Rise. Jones and Bartlett 2007.

direct property damage. Office buildings, hotels, apartment buildings, and health care facilities accounted for nearly half of these high-rise fires.[53]

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. Even if a department does not respond to high-rise buildings at present, it may in the future as urban sprawl continues and/or jurisdictional border restrictions and population growth require taller buildings to meet residential needs.

High-Rise Firefighting Tactics

As has been stated, in a high-rise fire the risks 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[54] located in the building 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, the 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 regarding 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 most 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.

Like residential structure fires, there are several critical tasks that must be accomplished. However, unlike residential firefighting in a 2,000 square foot 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 firefighting force and to access the fire floor, firefighters are likely to encounter a large volume of

[53] Hall, J.R. (2013), High-Rise Building Fires. NFPA.
[54] Structural Firefighting Strategy and Tactics 2nd Edition. Klaene B., Sanders R. NFPA 2008

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.

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 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 in most residences. In addition to these larger areas, search and rescue can be further complicated because conscious victims may retreat to areas to find shelter from 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. It should be noted that in regard to high-rise fire suppression, crews larger than four performed searches faster than crews of four, thus minimizing a person who is trapped exposure to fire and toxic gases.

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 that 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 standpipe 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.

Ventilation

Ventilation affects both search and rescue and fire extinguishment. Coordinated 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.

Support

As has been discussed, fire suppression in a high-rise or high-hazard structure requires the establishment of a supply chain to shuttle equipment to different locations. Additionally, with increased resources and personnel, there is an increased need for additional supervision and accountability.

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, fireground 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[55] 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 10, 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

[55] 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.

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.

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 company sizes for the first arriving unit(s) on the scene within four minutes of travel time for response to high-hazard structure:

- In first-due response areas with a high number of incidents, geographical restrictions, geographical isolation, or urban areas, as identified by the AHJ, these companies shall be staffed by a minimum of five on-duty members.[56]

- In first-due response areas 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.[57]

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 several 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 5, on the next page, displays the minimum number of firefighters required to arrive in the first full alarm assignment to a high-rise fire.

[56] NFPA 1710. §5.2.3.1.2 and §5.2.3.2.2
[57] NFPA 1710. §5.2.3.1.2.1 and §5.2.3.2.2.1.

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 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[58]	4 Firefighters
Required Minimum Personnel for Full Alarm	**36 Firefighters** **1 Incident Commander** **6 Officers**

Table 5: Number of Firefighters for an Initial Full Alarm to a High-Rise Fire. Table 5 is a breakdown of the expected capabilities of a full alarm assignment to a high-rise structure fire, in compliance with NFPA 1710. Fighting fire in high-rise structures poses many unique obstacles and challenges other than are found in a residential structure fire. 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 suppression efforts. A single alarm response to a high-rise building minimally requires 43 responders, consisting of 36 firefighters, one incident commander, and six officers.

[58] 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."

Fire Department EMS Operations

In recent years, the provision of EMS has progressed from an amenity to a citizen-required service. More than 90% of career and combination fire departments provide some form of emergency medical care, making fire departments the largest group of prehospital EMS providers in North America. In many fire departments that deliver prehospital care, EMS calls can equate to over 75% of total call volume.

There are six main components of an EMS incident from start to finish.[59] These are (1) detection of the incident, (2) reporting of the incident to a 9-1-1 center, (3) response to the incident by the appropriate emergency resources, (4) on scene care by emergency response personnel, (5) care by emergency personnel while in transit to a medical care facility, and (6) transfer of the patient from emergency response personnel to the medical care facility. Not all EMS events will necessitate all six components, as when a patient refuses treatment, or is treated at the scene and not transported.

In an analysis of data from over 300 fire departments in the United States, first responder units, which are typically fire engines, arrived prior to medics approximately 80% of the time.[60] This is likely due to the fact that fire stations housing first responder units, which are equipped and staffed with dual-role firefighter/emergency medical service technicians and supplies, are more centrally located and are able to effect a quicker response and provide life-saving procedures in advance of a medic. This reinforces why it is in the best interest of the public good for the fire department to provide EMS transport as well as first response.

The benefit of supporting EMS transport within fire department operations is that fire departments are already geared towards rapid response and rapid intervention. Strategically located stations and personnel are positioned to deliver time-critical response and effective fire suppression and are therefore equally situated to provide effective response to time critical requests for EMS service. Both fire suppression and EMS response are required by industry standards to have adequate personnel and resources operating on scene within four minutes. In both fire suppression and EMS incidents, time is directly related to the amount of damage, either to the structure or the patient.

When medic response is prolonged, a patient will be further delayed in reaching a medical facility to receive definitive care. This is especially dangerous for incidents of chest pain, stroke, and survivable cardiac arrest. Many times, patients experiencing symptoms associated with these

[59] The Star of Life, designated by Leo R. Schwartz, Chief of EMS Branch, National Highway Traffic Safety Administration (NHTSA) in 1997.
[60] Moore-Merrell, L. et al. (2010) Report on Residential EMS Field Experiments, Fire Fighter Safety and Deployment Study; Washington, DC, September 2010.

events may not recognize the onset indicators and immediately call for assistance.[61] [62] [63] [64] Acute Coronary Syndrome (ACS), or heart attack, is the number one leading cause of death in the United States. Experts agree that an ACS event should receive definitive care from a hospital within one hour of onset of symptoms. One study found that definitive care for ACS within one hour of onset improves survivability by 50% and 23% if definitive care was given within 3 hours.[65]

Strokes, which are the number three cause of death in the U.S., as well as a leading cause of disability, also benefit from expedient treatment in definitive care. Ischemic stroke, which is a stroke caused from a blood clot, can be effectively treated if definitive care is received within 3 to 4.5 hours[66] of onset of symptoms. The sooner a patient receives definitive treatment from onset of symptoms, the less likely a patient is to suffer disability from this type of stroke. However, it is important to emphasize that before the time-critical treatment can be administered to the patient in the hospital, there is a time intensive assessment that must be performed to ensure the patient is qualified to receive the treatment. The current benchmark for an ischemic stroke patient "door to needle"[67] is less than or equal to 60 minutes. However, Steps Against Recurrent Stroke (STARS) registry shows that the median door to needle time is 96 minutes or one hour and 36 minutes.[68]

In two-tiered EMS systems that deploy with sufficient resources, there is an increased likelihood that a patient will receive a medic unit and a first responding fire apparatus in not only a timely manner, but also frequently at the same, or close to the same time. This is extremely beneficial to the patient as most EMS responses, particularly the previously mentioned conditions, are labor intensive. Patients suffering from ACS should not perform any form of exertion as to minimize any damage that is occurring. Patients suffering from strokes are frequently unable to exert due to physical disabilities caused by the incident. An adequately sized crew is able to provide simultaneous interventions while assessment is being performed, thereby reducing the on-scene

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[61] American Heart Association, *Heart Disease and Stroke Statistics-2005 update,* Dallas, TX: AHA 2005

[62] Time from Symptom Onset to treatment and outcomes after thrombolytic therapy. Newby LK, et al. *J Am Coll Cardiol.* 1996:27:1646-1655

[63] An International Perspective on the Time to Treatment of Acute Myocardial Infarction. Dracup, K. et al. *J Nurs Scholarsh* 2003;35:317-323

[64] Prehospital and In-hospital Delays in Acute Stroke Care. Evanson, KR, et al. *Neuroepidemiology* 2001;20:65-76

[65] Association of patient delays with symptoms, cardiac enzymes, and outcomes in acute myocardial infarction. Rawles, JM. Et al. *Eur Heart J.* 1990; 11:643-648.

[66] Thrombolysis with Alteplase 3 to 4.5 Hours after Acute Ischemic Stroke. Hacke, W. et al. *N Engl J Med*. 2008;359:1317-1329

[67] "Door to Needle" is an industry specific term that refers to the time the patient entered the emergency department to the time the received the treatment. A drug named recombinant tissue plasminogen activator (rt-PA) is utilized to dissolve the thrombosis causing the stroke. Current FDA approvals limit this drug's use to 3-4.5 hours from initial symptoms and require a CT scan and labs before administration.

[68] Improving Door-to-Needle Times in Acute Ischemic Stroke: The Design and Rational for the American Heart Association/American Stroke Association's Target: Stroke Initiative. Fonarow, Gregg, et al. *Stroke* 2011;42:00-00

time. Following completion of critical tasks, the crew can then facilitate a safe removal of the patient to the medic unit and minimize the risk of injury to patient and provider.[69]

One of the most labor intensive and time critical requests for EMS response is cardiac arrest, which globally affects 20-140 out of every 100,000 people. Traditionally, the American Heart Association (AHA) taught a method of cardiac resuscitation that involved single rescuer performance of prioritized action.[70] However, there was a gap between instruction and practice which led to confusion and may have potentially reduced survival. In reality, providers respond and function in teams larger than two.

The AHA's guidelines for cardiac resuscitation focus on a team-centric approach. Evidence-based research suggested that the manner in which CPR was being performed was inherently inefficient and only provided 10-30% of the normal blood flow to the heart and 30-40% to the brain.[71] [72] This was linked to provider fatigue from administering chest compressions, and as such, these studies indicate that providers should be rotated to ensure effective depth and rhythm of chest compressions. Consensus documents from the AHA recommend that providers should rotate with every two-minute cycle of CPR. It is also recommended that requests for EMS service for cardiac arrest also have a team leader to organize priorities and direct resources as they arrive or are needed. The team leader would also be responsible for identifying symptoms of fatigue and making appropriate assignment adjustments to ensure maximally efficient CPR.

Although the AHA and other researchers have not identified what an optimally sized crew for effective team-centric CPR should be, some consensus literature from AHA has mentioned that five providers were best suited to perform resuscitation. However, providers may be required to perform multiple tasks. Industry best practices, through the guidance of Medical Directors, have suggested six providers would be most successful in minimizing confusion and redundancy.

An EMS crew consisting of six personnel would require four personnel arriving with the first responding fire apparatus and two with the medic unit.[73] For an all-ALS system, two of the six should be Paramedics, with a minimum of one assigned to each of the responding apparatus. Some ALS systems require two Paramedics on the medic unit and a minimum of one on the first responding fire apparatus. However, these deployment options are determined by State directive or Medical Director's discretion. Regardless of the make-up of the EMS certification level of the

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[69] Moore-Merrell, L. et al. (2010) Report on Residential EMS Field Experiments, Fire Fighter Safety and Deployment Study; Washington, DC, September 2010.
[70] Highlights of the 2010 American Heart Association Guidelines for CPR and ECC
[71] Determinants of Blood Flow during Cardiac Resuscitation in Dogs. Halperin, HR et al. *Circulation* 1986;73:539-550
[72] Increased Cortical Cerebral Blood Flow with LUCAS, a New Device for Mechanical Chest Compressions Compared to Standard External Compressions during Experimental Cardiopulmonary Resuscitation. Rubertson S, et al. *Resuscitation*. 2005;65:357-363
[73] NFPA 1917: Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments

providers on scene, an ALS integrated cardiac arrest response should provide for the following: a lead provider, an airway manager, two providers to interchangeably deliver chest compressions, a provider to establish an intravenous medication line and administer medications, and a provider to operate the monitor.

Fire Department Deployment

Before discussing the staffing and deployment analysis of fire department resources, it is imperative to understand the intricacies of distribution and concentration.

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.[74] In this case, distribution is measured by the percentage of roads that are covered from each fire station within four-[75], six-[76], eight-minute[77], 10-minute and 10 second[78] travel times, and to adhere to NFPA 1710, 2020 edition. Four minutes of travel time is the allowable maximum travel time for the first arriving apparatus at the scene of a fire or the first responding unit to an EMS incident.

Distribution study requires geographical analysis of first due resources. Distribution measures may include:[79]

- Population per first-due company
- Area served per first-due company (square miles)
- Number of total road miles per first-due company
- Dwelling unit square footage per first-due company
- Maximum travel time in each first-due company's protection area

[74] Commission on Fire Accreditation International, 5th Edition. 2008. Page 52.
[75] Four minutes of travel time is the allowable maximum travel time for the first arriving apparatus at the scene of a fire, first responding unit to an EMS incident, and BLS ambulance if there is not a first responding unit already on the scene.
[76] Six minutes of travel time is the maximum amount of travel time permitted for the second arriving apparatus. Although not explicitly stated, it is recommended that this apparatus be the ladder truck or a company that will be assigned to truck duties.
[77] Eight minutes of travel time is the maximum amount of travel time permitted for a low-, or medium-hazard alarm assignment.
[78] Ten minutes and ten seconds of travel time is the maximum amount of travel time permitted for a high-hazard alarm assignment.
[79] Commission on Fire Accreditation International, 5th Edition. 2008. Page 52.

- Catchment areas (four-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 miles)
    3. Road miles not served
    4. Dwelling unit square footage not served

- First-due unit arrival times (Engine, Ladder, BLS unit, etc.)

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 the fire department is achieving a reasonable response performance to handle emergencies.[80]

Evaluating a small number of incidents for response time performance also does not reflect the true performance of the department. Analyzing tens of thousands of incidents measured over three to five years will provide a more accurate assessment of the delivery system performance. Completing the same analysis over a period will allow for trend analysis as well.[81]

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 the probability that all areas experience equal service demands, but not necessarily the same risk or consequences as those demands for service in other areas. For example, suburban communities in a jurisdiction 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 to provide 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.

[80] Commission on Fire Accreditation International, 5th Edition. 2008. Page 53
[81] Ibid.

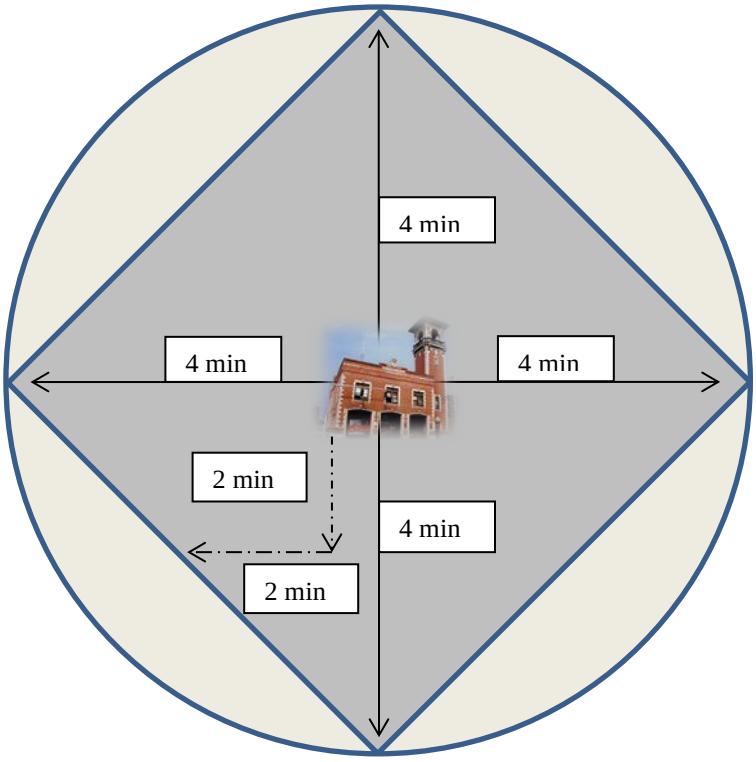


Figure 5: Normal Distribution Model for an Initial 4-Minute Response Area.[82] As depicted in the above figure, fire stations and emergency resources should be distributed throughout a community so that citizens receive equitable coverage and protection. However, there are additional points of concern when modeling a response district such as road network, traffic patterns, and building occupancies.

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 four-minute travel time per NFPA 1710, it does not necessarily mean it has a distribution issue.[83] 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.[84] Specialty units tend to be trucks, 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 engine units. Selecting where to put specialty

[82] Derived from Commission on Fire Accreditation International, 5th Edition. 2008. Page 53
[83] Commission on Fire Accreditation International, 5th Edition. 2008. Page 55
[84] Commission on Fire Accreditation International, 5th Edition. 2008. Page 62

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 a jurisdiction.

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.[85]

[85] Commission on Fire Accreditation International, 5th Edition. 2008. Pages 62-63

Mapping Analysis of West Bend Fire Department

In creating this document, it was important to ascertain where stations were located and if they were located to provide fair and equitable coverage to the citizens. In order to make this assessment, the IAFF created maps of the department's response area and plotted the fire stations.

Computer modeling was then used to determine the distance apparatus could travel in four and eight minutes. WBFD is not currently capable of assembling 17, 26, or 39 firefighters anywhere within West Bend within eight minutes or ten minutes, ten seconds to meet the objectives of NFPA 1710 for response to a fire occurring in a low-, medium-, or high-hazard occupancy; therefore, this section does not contain any maps showing eight minute or ten minute, ten second response.

Table 6 specifies the current locations of the WBFD fire stations and typical staffing.

Station	Address	Apparatus	Typical Staffing
1	325 N. 8th Avenue	Engine 1	**3 Firefighters (FF)/Medics**
		Med 11	**Cross-staffed**
		Truck 1	**Cross-staffed**
		Intercept 1	**Cross-staffed**
		Tender 1	**Cross-staffed**
		Brush Rig	**Cross-staffed**
		Tech Rescue	**Cross-staffed**
		Engine 12	**Reserve**
		Med 12	**Reserve**
		Battalion	**1 Battalion Chief**
2	901 N. River Road	Truck 2	**3 FF/Medics**
		Med 21	**Cross-staffed**
		Intercept 2	**Cross-staffed**
3	2100 S. Main Street	Engine 3	**3 FF/Medics**
		Med 31	**Cross-staffed**
		Intercept 3	**Cross-staffed**
		Hazmat Trailer	**Special Request**
		Mass Casualty Trailer	**Special Request**

Table 6: Current Fire Station Locations and Staffing. The above table displays where apparatus are housed and how they are typically staffed.

Travel times were modeled using ESRI ArcGIS Pro, version 2.8. Fire stations were identified on Geographic Information System (GIS) maps as starting points with vehicles' speeds based on historical traffic.

When generating the maps, several assumptions needed to be addressed prior to drawing conclusions from the analysis. These assumptions are as follows:

- Modeled travel speeds are based on historical traffic speeds occurring on Wednesdays at 5 pm.[86] 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.
    - 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.[87]

Note that the historical traffic data incorporates historical instances of impedances from above list that have occurred within West Bend in the past. The relevance of the list relates to the consideration of travel times in the *future* and unpredictable impedances that may occur in the *future*.

In addition, it is reasonable to suggest that because larger emergency vehicles are generally more cumbersome and require greater skill to maneuver, their response may be more negatively affected by their weight, size, and in some cases, inability to travel narrow surface streets.

As discussed, 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

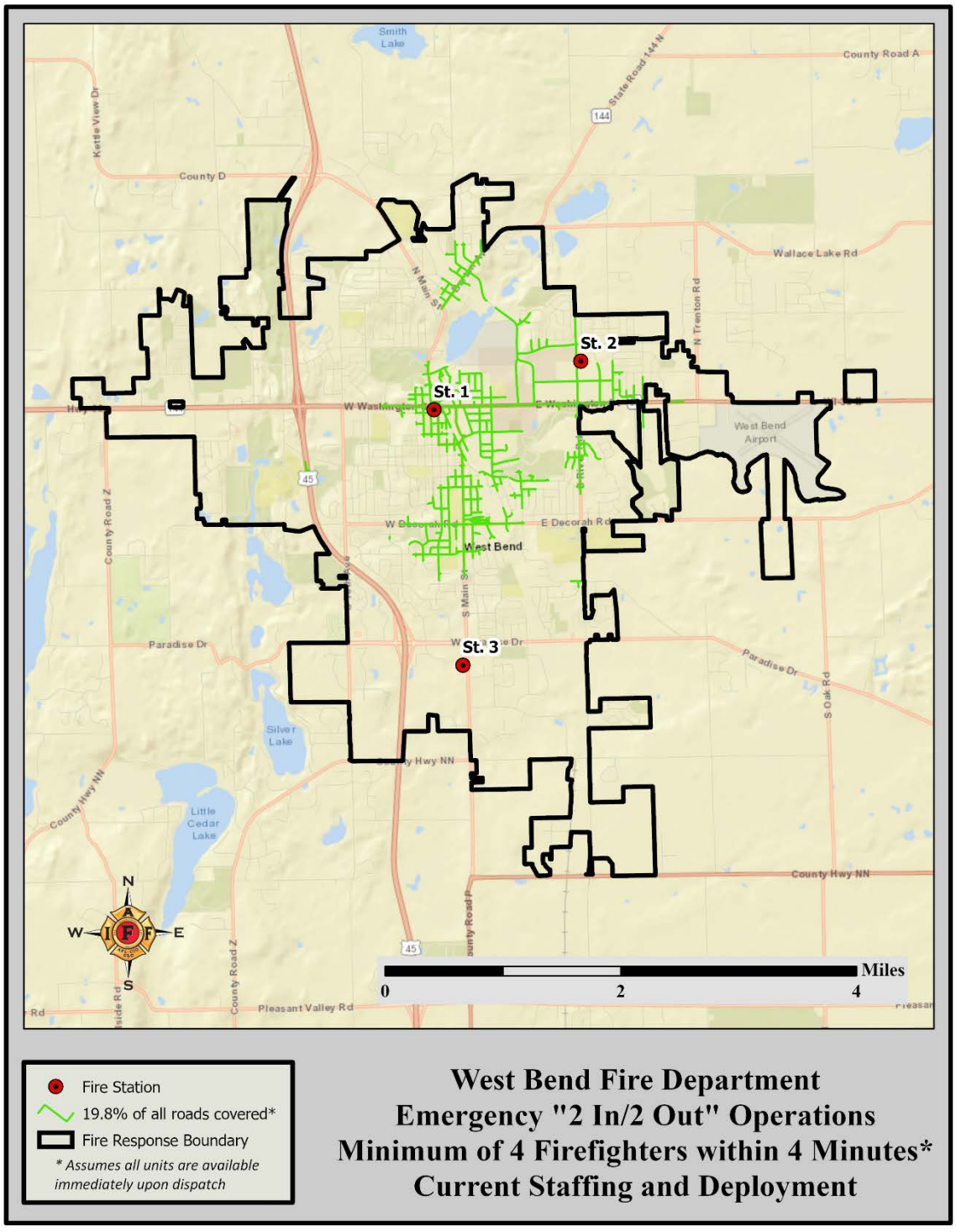
[86] Historical traffic data as contained in ESRI's StreetMap Premium, Version 21.1.
[87] David Shrank and Tim Lomax, The 2003 Urban Mobility Report, (Illinois Transportation Institute, Illinois A&M University: September 2003).

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. Other additional factors also include:

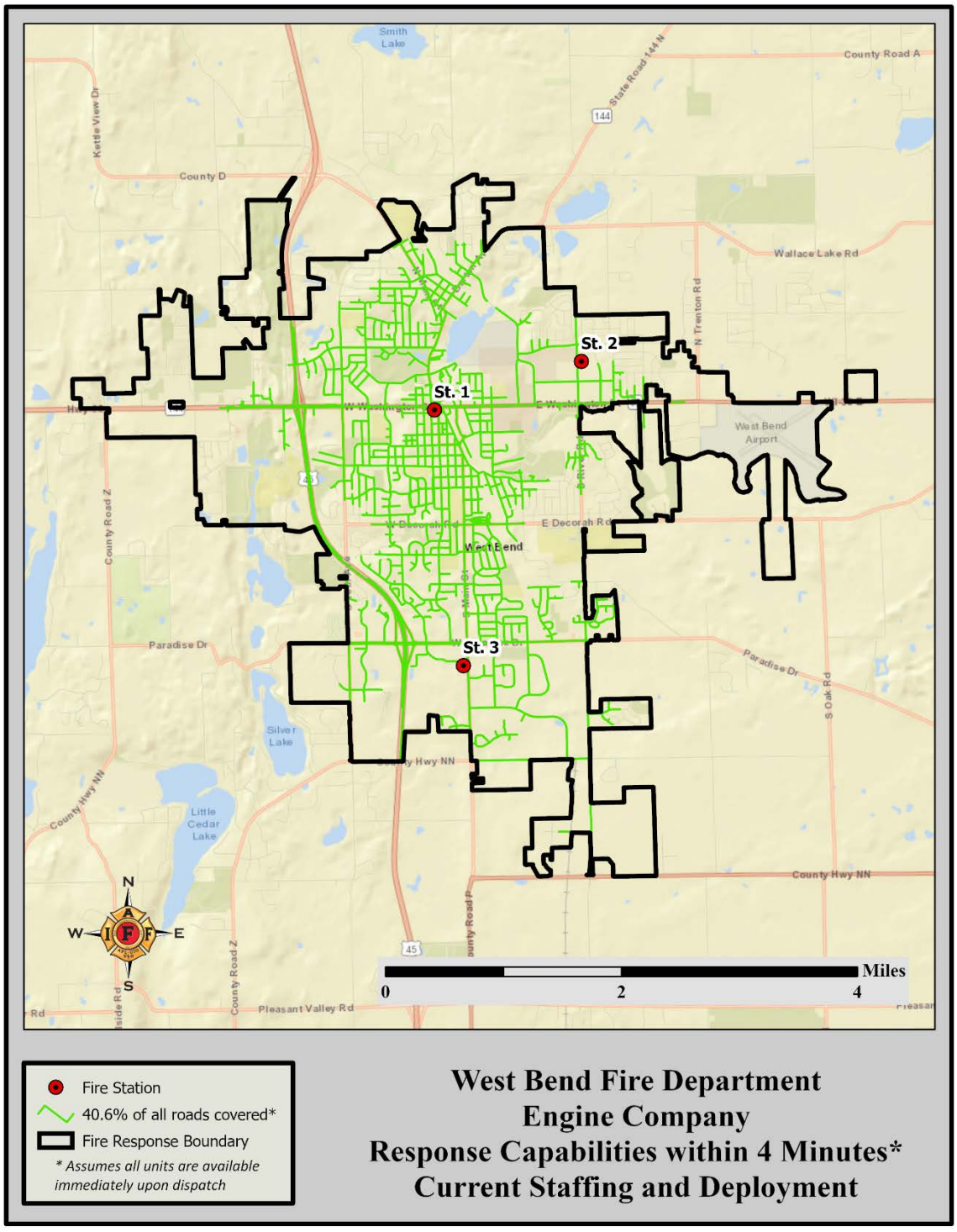
- The time from arrival of the apparatus to the onset of interior fire operations (access interval) must be considered when analyzing response system capabilities.
    - The access interval is dependent upon factors such as distance from the apparatus to the task location and the elevation of the incident and locked doors or security bars which must be breached.
    - Impediments like these may add to the delay between discovery of a fire and the initiation of an actual fire attack.
- The reliability of a community's hydrant system to supply water to fire apparatus.
- Weather conditions

Emergency Response Capabilities: Current Staffing Levels

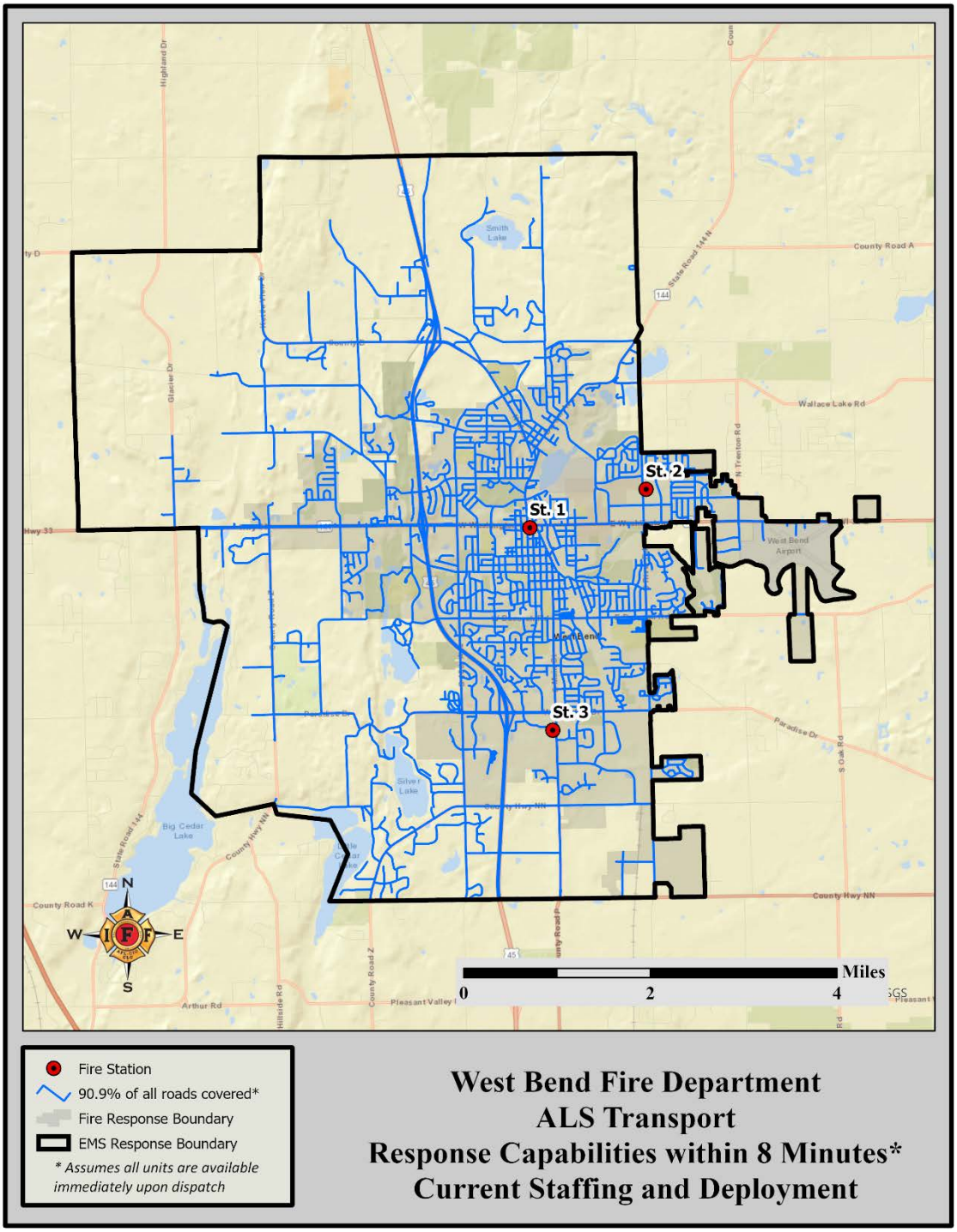
The following GIS maps present the results of a response capabilities analysis of the WBFD. The staffing and deployment configuration examined in this section includes typical daily staffing levels as described in Table 6.



Map 11: Emergency "2 In/2 Out" Operations, Minimum of 4 Firefighters within 4 Minutes, Current Staffing and Deployment. Map 11 identifies those roads where a minimum of four firefighters can assemble on scene within four minutes of travel when at typical staffing levels at each station. Assuming all units are in service and available to respond at the time of dispatch, the WBFD can respond with four firefighters on 19.8% of roads within West Bend within four minutes.



Map 12: Engine Company Response within 4 Minutes, Current Staffing and Deployment. Map 12 identifies those roads where WBFD can respond with an engine within four minutes of travel when at typical staffing levels at each station. These roads showing engine coverage also depict the areas where WBFD can respond with BLS capabilities. Assuming all units are in service and available to respond at the time of dispatch, the WBFD can respond with an engine company on 40.6% of roads within West Bend within four minutes.



Map 13: ALS Response within 8 Minutes, Current Staffing and Deployment. Map 13 identifies those roads where WBFD medic units can respond with ALS capabilities within eight minutes of travel when at typical staffing levels at each station. **The findings shown in this map assume that, because of cross-staffing, no fire suppression apparatus, including Engine 1, Engine 3, and Truck 2, are available to respond**. Assuming all medic units are in service and available to respond at the time of dispatch, the WBFD can respond with ALS transport capabilities on 51.8% of roads within WBFD EMS response boundary within eight minutes.

West Bend Fire Department Workload Analysis

In order to more accurately evaluate the fire department's workload, incident and response data must be examined on a smaller scale. The WBFD provided historical CAD data for emergency responses from January 1, 2016 to January 22, 2021. The CAD data include, but are not limited to, details such as incident identifier number, type of incident, location of incident, responding apparatus, reporting time, dispatch time, en route time, arrive time, and the time when apparatus and personnel have returned to the station. CAD data have the necessary information needed in order to determine the total number of incidents and apparatus responses, 90th percentile travel times of the first-arriving unit, and the percentage of responses to incidents that fall above and below NFPA 1710 travel time thresholds.

Using these findings, the fire department will be able to determine how workload, call volume, and the locations of resources have affected WBFD's response capabilities. It will provide decision makers with the necessary information to better allocate resources to ensure the fire department provides effective and efficient emergency response.

Key Definitions

The following definitions were created to identify terminology used in the 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.

Call: synonymous with "incident" above. These terms are used interchangeably in this report.

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

Fire District, District, or First-due District: refers to a fixed geographic 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. This is also commonly known as a first-due area.

First-Due Unit: refers to a unit that is responding inside of the fire district corresponding to the unit's station of origin.

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 Scene 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.[88]

In Service Time: refers to the time interval that begins with dispatch time and ends with clear time.

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

Available Time or Clear Time: refers to the time after an emergency response when a unit is available again to respond.

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

Data Metrics

Metrics were created to accurately examine the department's workload and past performance. Below are the metrics used when analyzing the data:

- Engine companies were considered when evaluating travel times of the first-arriving unit at a fire suppression incident. All companies were considered when evaluating travel times of the first-arriving unit at an emergency medical incident.

- Records that were duplicates, were located outside of the WBFD response boundary, or with errors in reporting en route, arrive time, and/or incidents that were cancelled before the first apparatus arrived on scene were excluded from the travel time analysis.[89]

[88] NFPA 1710 §3.3.64.7 (2020)
[89] 33.1% of records were excluded in this category.

- Records that were duplicates, could not be geocoded or that were outside of the WBFD response boundary excluded from the travel time analysis and analysis of the concentration of incidents.[90]

Call Volume Analysis

An important parameter to consider is the number of incidents compared to the number of apparatus responses. Responses to all incident types can be labor intensive and frequently require personnel from multiple apparatus to complete critical tasks simultaneously. Examining the number of responses performed by each WBFD unit will assist in determining the workload of each unit. Also, identifying where past incidents happened will assist the department in better allocating resources in those areas with a high call volume.

From 2016 to 2020, WBFD's units responded to 20,920 incidents and performed 26,551 responses. During that time span incident and response volume grew by 12.3% and 6.6%, respectively.

Chart 3 on the next page shows the count of incidents responded to by WBFD and the count of unit responses each year from 2016 to 2020.

[90] 30.0% of records excluded in this category.

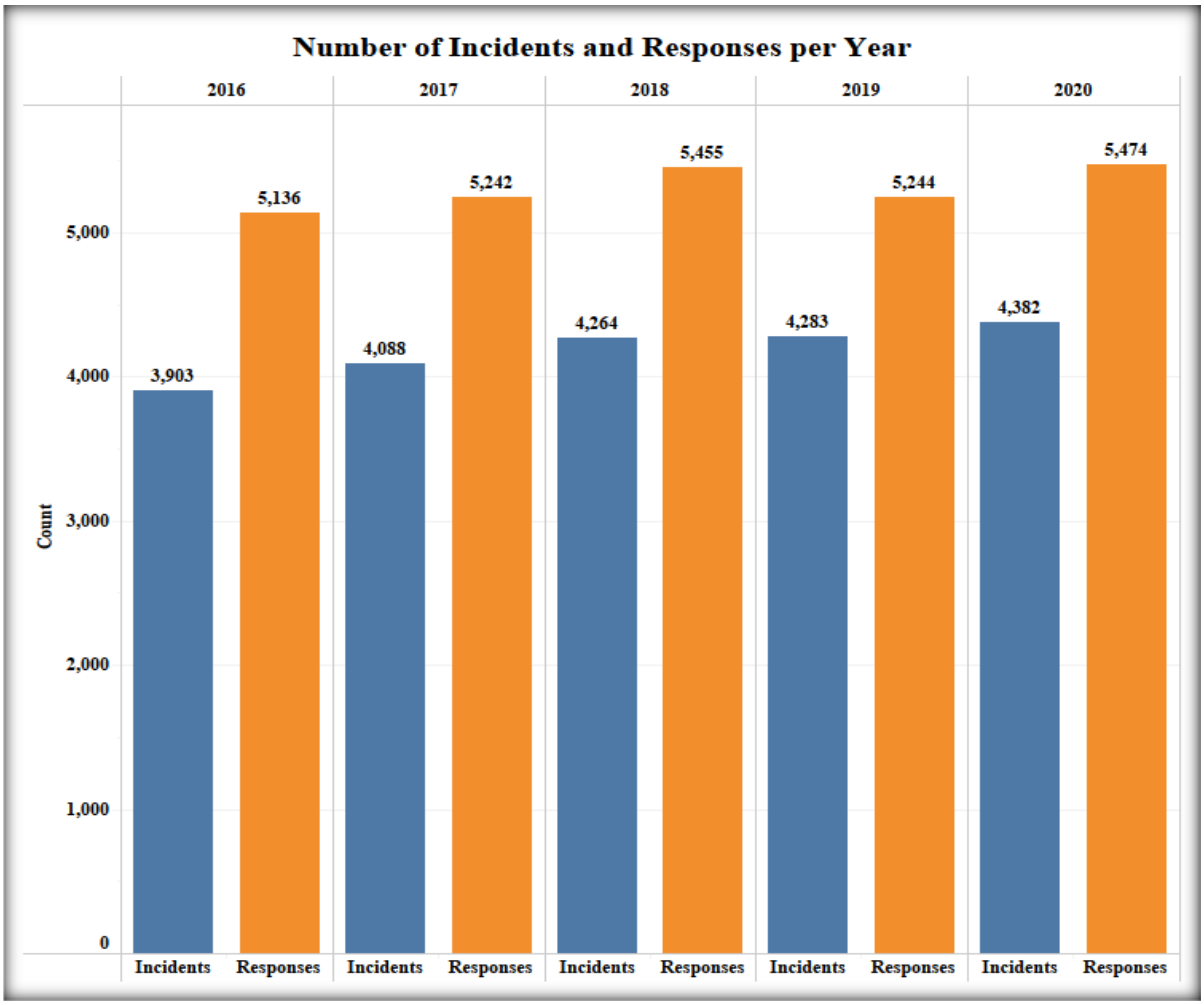


Chart 3: Number of Incidents and Responses per Year. This chart shows the number of incidents to which WBFD responded and the number of total responses to these incidents from 2016 to 2020. Incident and response volume increased over the time period, with incidents increasing by 12.3% and responses increasing by 6.6% from 2016 to 2020. As West Bend's population is projected to continue growing, WBFD call volume is likely continue the upward trend seen during these years.

Chart 4 on the next page details the number of responses by individual units in order of response volume. The three primary medic units were the three busiest WBFD units. Overall, from 2016 to 2020, medic units accounted for 75.8% of all in service time for WBFD units.

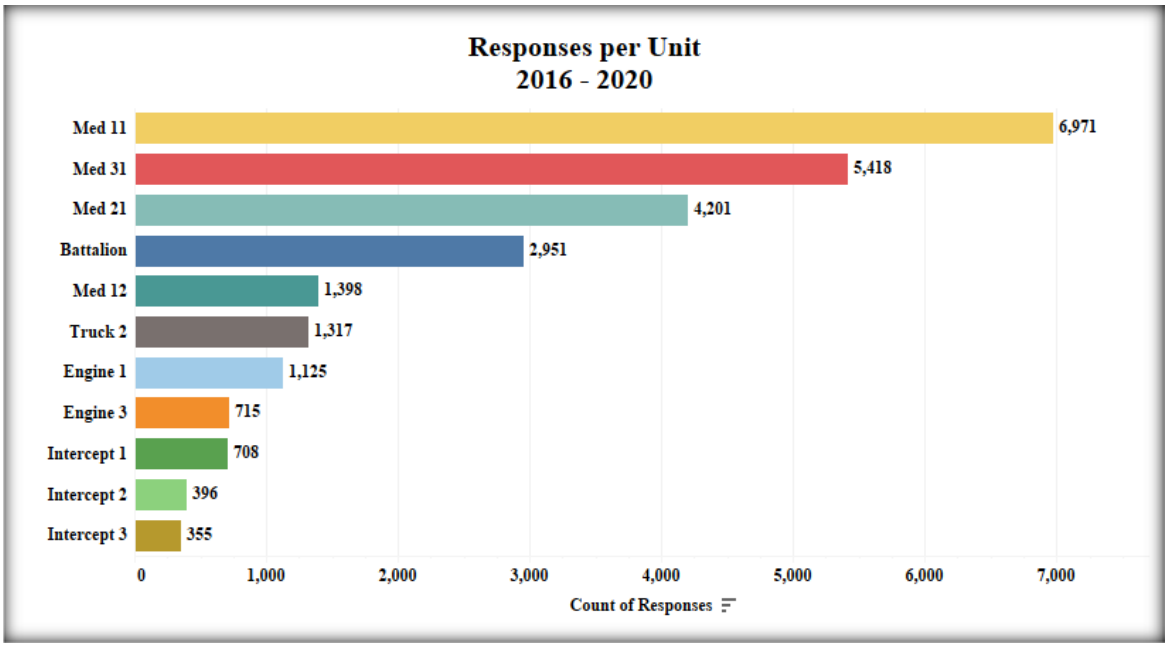
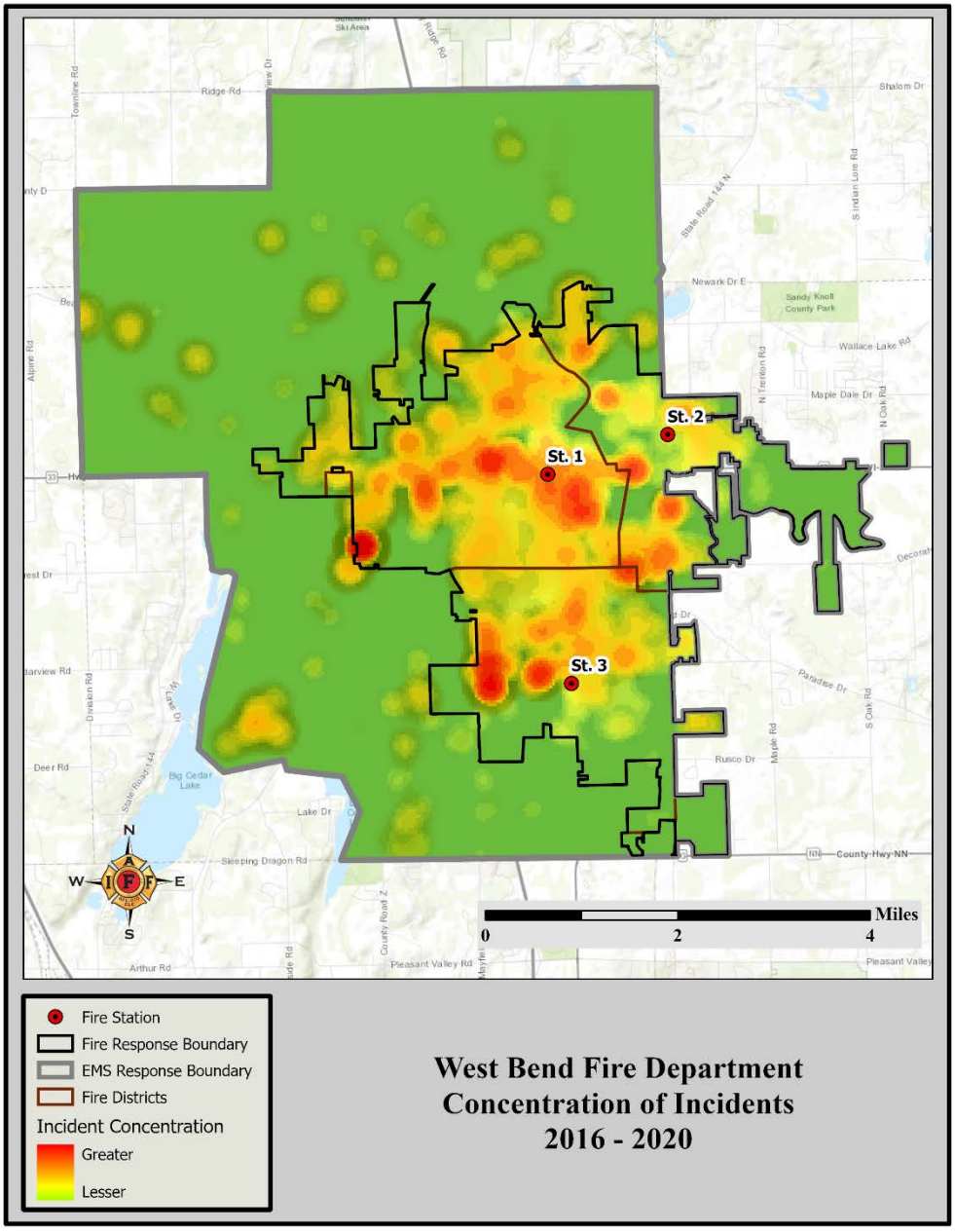


Chart 4: Responses per Unit, 2016 - 2020. Chart 4 depicts the total number of responses by individual WBFD units. Individual units are listed in descending order of response volume. Med 11 conducted the most responses during the five-year period with 6,971 total responses and its responses increased by 40.1%. Overall, for all WBFD units during the five years, medic units accounted for 75.8% of all in service time.

Map 14 on the next page shows the distribution of incidents of all types in West Bend that WBFD responded to from 2016 to 2020. The call volume were distributed throughout the West Bend, with some pockets of higher concentration. Outside of the city limits, in the Towns of West Bend and Barton where WBFD provides EMS first-response, call volume was less concentrated. WBFD should provide additional resources in areas where units are experiencing high call volumes, while providing equitable coverage throughout the city and contract areas. As will be seen in the Travel Time section of this, some areas of West Bend, particularly the western portion of the city, do not have adequate spatial distribution of resources to respond to emergencies in a timely manner.



Map 14: Concentration of Incidents, 2016 - 2020. Map 14 depicts the concentration levels of incidents of all types from 2016 to 2020. Incidents were widely distributed throughout the West Bend city limits, with the highest volume in Station 1's first-due district. Incidents occurred much less frequently in the Towns of West Bend and Barton, which are more rural. Population growth is projected in most areas of the city, as well as the contract areas. Additional population will create greater future call volumes.

Chart 5, on the next page, shows the volume of incidents that were spatially located within each first-due district from 2016 to 2020. It is helpful to compare this chart to Map 14. Station 1's first-due district had the highest call volume, and all districts experienced increasing call volume during the five years. The WBFD is unable to meet NFPA 1710 four-minute travel time

objectives throughout the city. To address this deficiency additional stations, personnel and resources should be considered. As stated earlier, all residents deserve equitable, timely and effective response. The Travel Time Analysis section will further explore this issue.

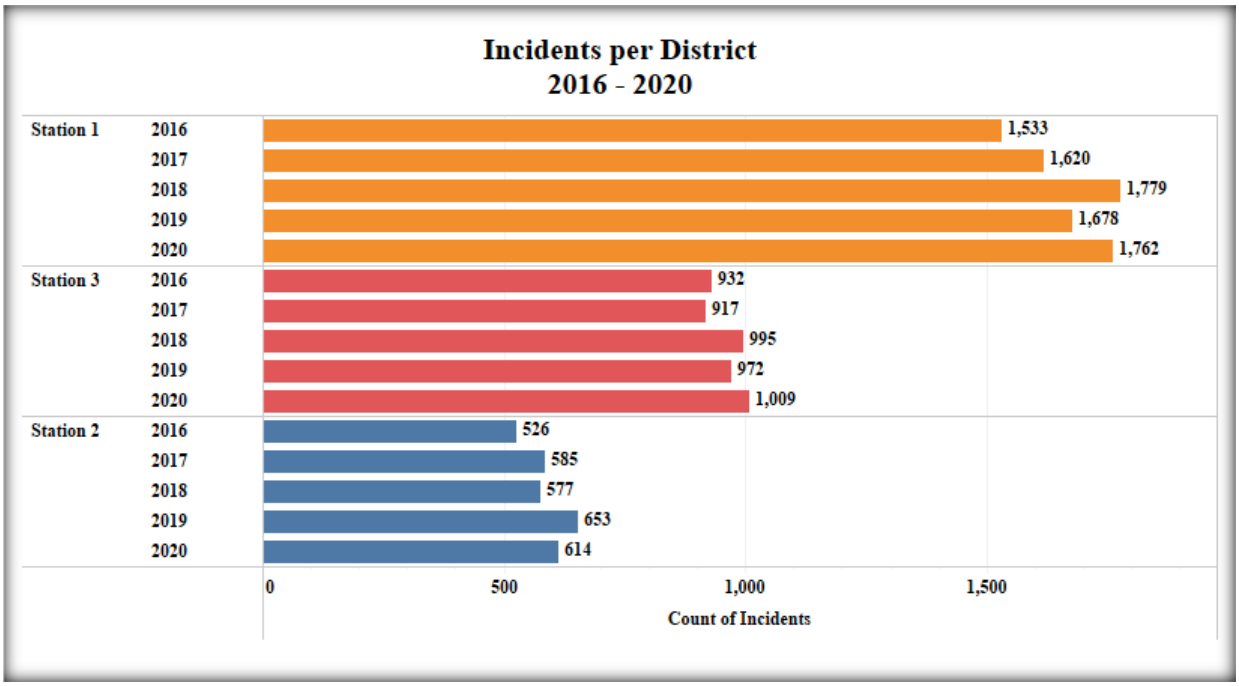


Chart 5: Incidents per District. Chart 5 depicts the total number incidents that occurred in each WBFD fire district in the City of West Bend per year and lists the districts in descending order according to incident volume. All three districts experienced increasing incident volume from 2016 to 2020. The greatest incident volume was in Station 1's first-due district, which increased by 14.9% during the five years. Incident volume for Station 3's first-due district, increased by 8.3%. Incident volume for Station 2's first-due district increased by the highest percentage at 16.7%.

Travel Time Analysis [91]

The travel time analysis examined the en route and arrival on scene times included in the CAD data to calculate the travel times for WBFD apparatus responding to incidents within West Bend. NFPA 1710 requires a travel time of four minutes (240 seconds) or less to 90% of fire suppression incidents for the first arriving engine company, and a travel time of four minutes for the first arriving unit with BLS or greater capable units to 90% of emergency medical incidents. Industry standards aim for the first unit to arrive at the scene of fire and medical emergencies rapidly because delays of even seconds may result in death or injury and may make controlling a fire more difficult.

Analysis examined WBFD's 90th percentile travel times for the first-arriving engine to fire suppression incidents, the 90th percentile and travel times for the first-arriving unit to emergency medical incidents. The travel time analysis also examined the performance of individual WBFD units, and the areas of the WBFD response jurisdiction where the highest concentrations of fire suppression and emergency medical incidents with a first-arriving unit travel time greater than four minutes were located. Travel times that are consistently higher than this benchmark suggest that the department may need additional resources, including personnel, apparatus, and stations.

Specifically, this analysis found that:

- WBFD's 90th percentile travel time for the first-arriving engine at a fire suppression incident exceeded NFPA 1710 travel time objectives each of the five years. It was 4 minutes and 52 seconds (4:52), 4:38, 4:47, 5:25, and 4:33 in 2016, 2017, 2018, 2019 and 2020, respectively.
    - 20.4% of fire suppression incidents during the five years did not have a first-arriving suppression unit within four minutes.
        - 41.3% of these greater than four minute responses were by Engine 1, deploying from Station 1.
- WBFD's 90th percentile travel time for the first-arriving unit at an emergency medical incident exceeded NFPA 1710 travel time objectives each of the five years. It was 5 minutes and 35 seconds (5:35), 5:43, 5:37, 5:54 and 6:10 in 2016, 2017, 2018, 2019 and 2020 respectively.

[91] This analysis excluded CAD entries where the unit was canceled or the en route and/or arrival on scene times are missing or inaccurately reported (18.1% of entries), as well as incidents that where the location was outside of West Bend city limits or inaccurately reported (0.9%).

- 29.9% of emergency medical incidents during the five years had the first-arriving unit with a travel time of greater than four minutes.
    - 44.7% of these responses were by Med 11, deploying from Station 1.
- During the five-year study period, the percentage of emergency medical incidents where the first arriving unit had a travel time greater than four minutes was 28.6%, 29.5%, 29.0%, 30.1%, and 32.2% in 2016, 2017, 2018, 2019 and 2020, respectively

These results demonstrate that WBFD does not have adequate resources to meet NFPA 1710 travel time objectives. Mapping the concentration of incidents where WBFD did not meet NFPA 1710 travel time objectives will help identify where additional resources are needed. In West Bend, the majority of these incidents occurred in the western half of the city, and were responded to by Station 1 units. Additional fixed and mobile resources are needed to address such deficiencies and will reduce travel times. Opening a fourth fire station west of Station 1 would result in shorter travel times for WBFD units responding in the areas where, historically, WBFD has not met NFPA 1710 travel time objectives. Any delays to response can have a negative impact on the outcome of medical and fire emergencies, increasing risk for the community.

Fire Suppression Incidents

Chart 6, on the next page, shows the 90th percentile travel times of the first arriving engine at fire suppression incidents each year from 2016 to 2020. The chart shows that 90th percentile travel times exceeded the NFPA 1710 objective of four minutes (240 seconds) each year.

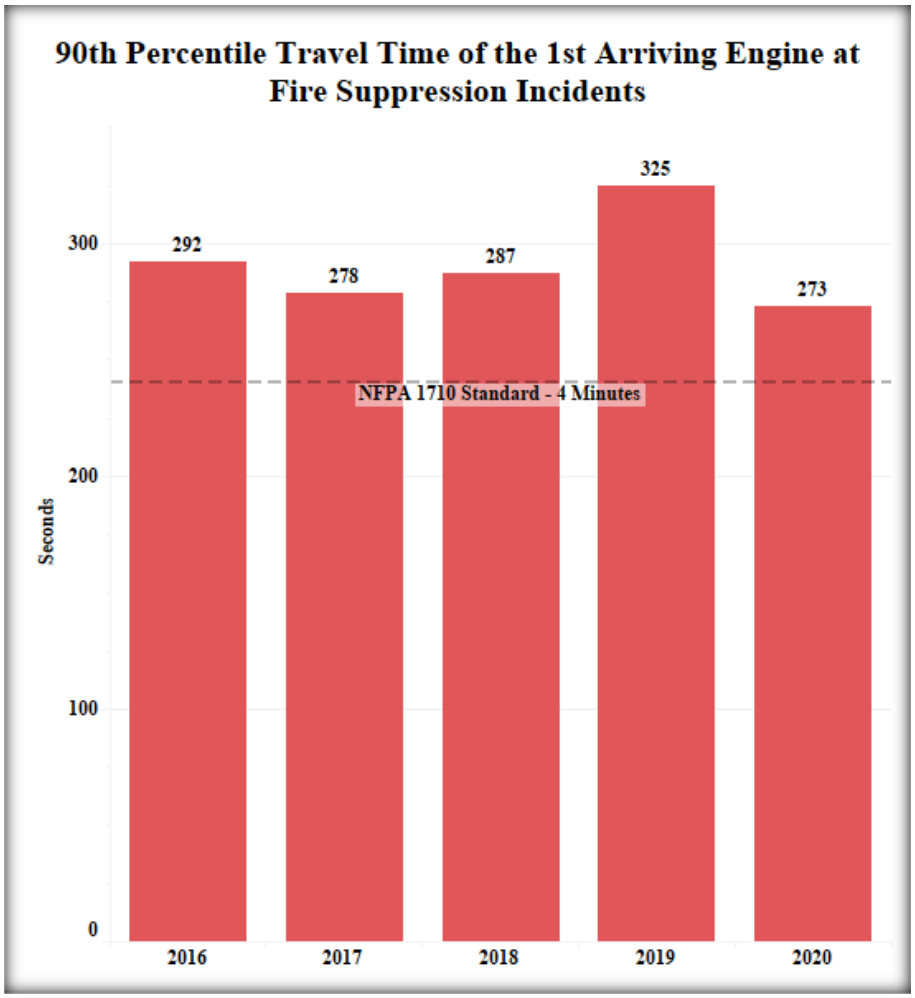
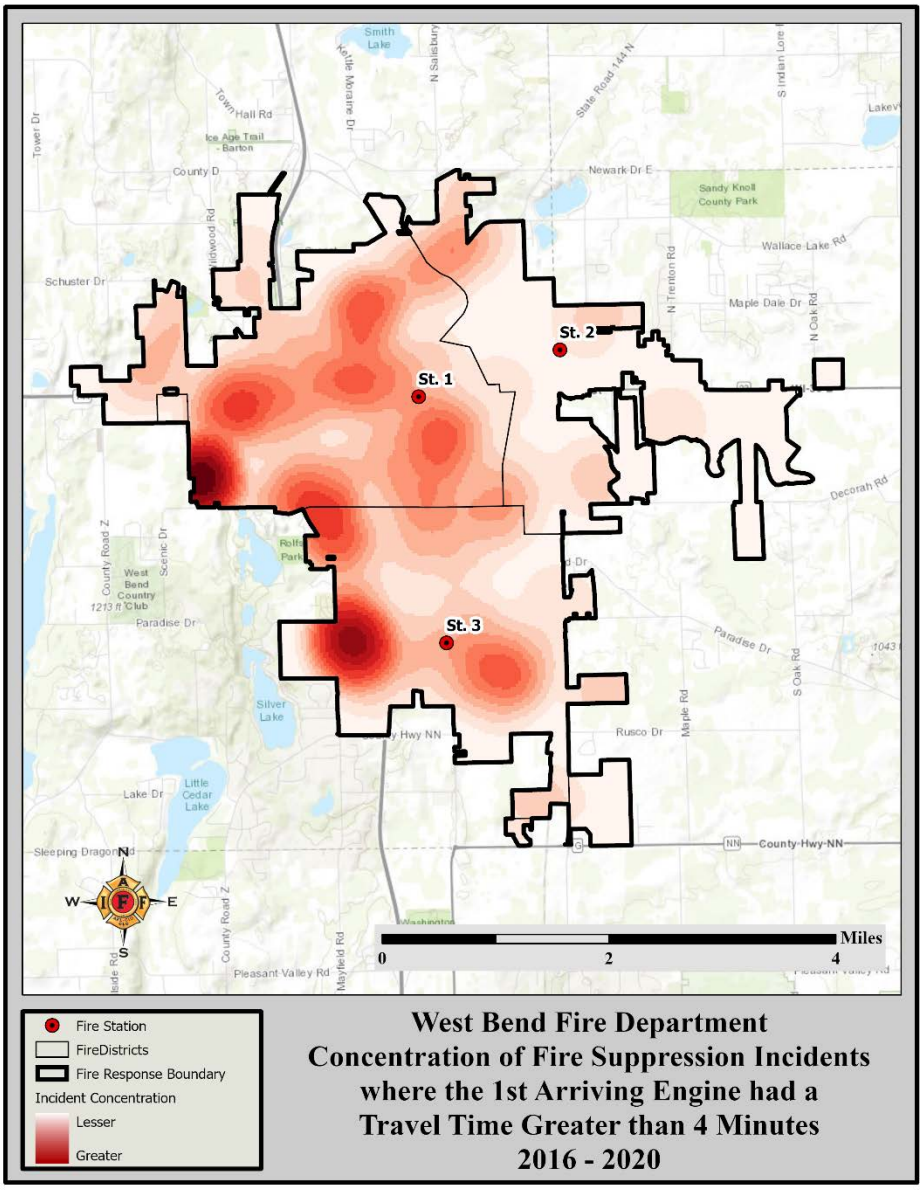


Chart 6: Travel Time of 1st Arriving Engine at Fire Suppression Incidents. Chart 6 depicts the first-arriving engines' 90th percentile travel times for all fire suppression incidents from 2016 to 2020. NFPA 1710 states that the first-arriving unit should be on scene within four minutes (240 seconds) or less of travel for 90% of incidents. During this time, the 90th percentile travel time of the first-arriving engine exceeded four minutes each year. Delays in response to fires can increase the chances of a fire spreading throughout a structure or flashing over and increase the difficulty of finding and rescuing trapped victims.

Mapping the concentration of incidents where WBFD did not meet NFPA 1710 travel time objectives, as shown in Map 15 on Page 71, will help identify where additional resources are needed. In West Bend, most of these incidents occur in the west half of the city, in Station 1's first-due area. Engine 1 is the suppression unit with the greatest number of responses to fires and the greatest number of late responses. Locating a new fire station west of Station 1 would enable WBFD provide more timely response.



Map 15: Concentration of Fire Suppression Incidents where the 1st Arriving Engine had a Travel Time Greater than 4 Minutes, 2016 - 2020. Map 15 depicts the concentration levels of fire suppression incidents from 2016 to 2020 where the first-arriving engine had a travel time greater than four minutes. NFPA 1710 states that the first-arriving engine should be on scene within four minutes of travel for 90% of incidents. For the five years, 20.4% of the fire suppression incidents located within WBFD's response boundary had a first-arriving engine travel time longer than four minutes. Out of these incidents 52.5% occurred within Station 1's first-due district; 41.3% of the late responses were from Engine 1. These findings indicate a need for additional fire stations and fire suppression resources in West Bend. This lack of ability of WBFD to provide timely first-engine response to fires results in a delay of the initiation of fire suppression and rescue operations, and increases risk to residents and firefighters. Even seconds of delay can allow increased fire spread and can translate directly into losses of life and property.

Map 15 supplemented Chart 6 with detail about where NFPA 1710 travel time objectives for responding to fires are not being met. These findings demonstrate that WBFD does not have adequate quantity or distribution of resources to meet these travel time objectives. 52.5% of fires with a late arriving first engine occurred within Station 1's first-due area, but they also occurred throughout West Bend.

Most areas of West Bend are growing and WBFD is experiencing increasing call volumes, which will reduce the likelihood that all units are available to respond at any given time and degrade the fire department's ability to rapidly respond. Adding fire stations, personnel, and suppression apparatus – without displacing current personnel or resources – will increase rapid response capabilities and lower the chance of fire spread, which will reduce risk to the community and to firefighters.

Emergency Medical Incidents

Chart 7 below shows the 90th percentile travel times of the first arriving unit at emergency medical incidents each year from 2016 to 2020. The chart shows that 90th percentile travel times that are over five minutes (300 seconds) each year, exceeding the standard by more than one minutes.

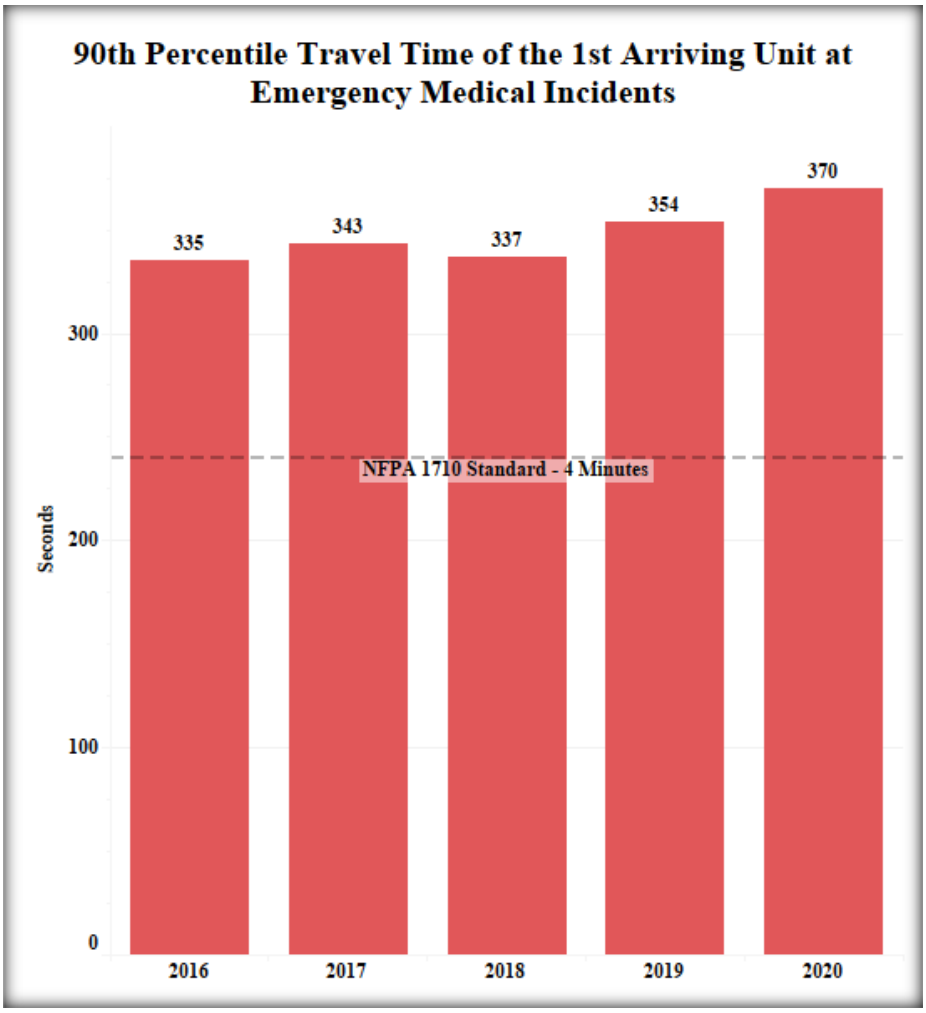
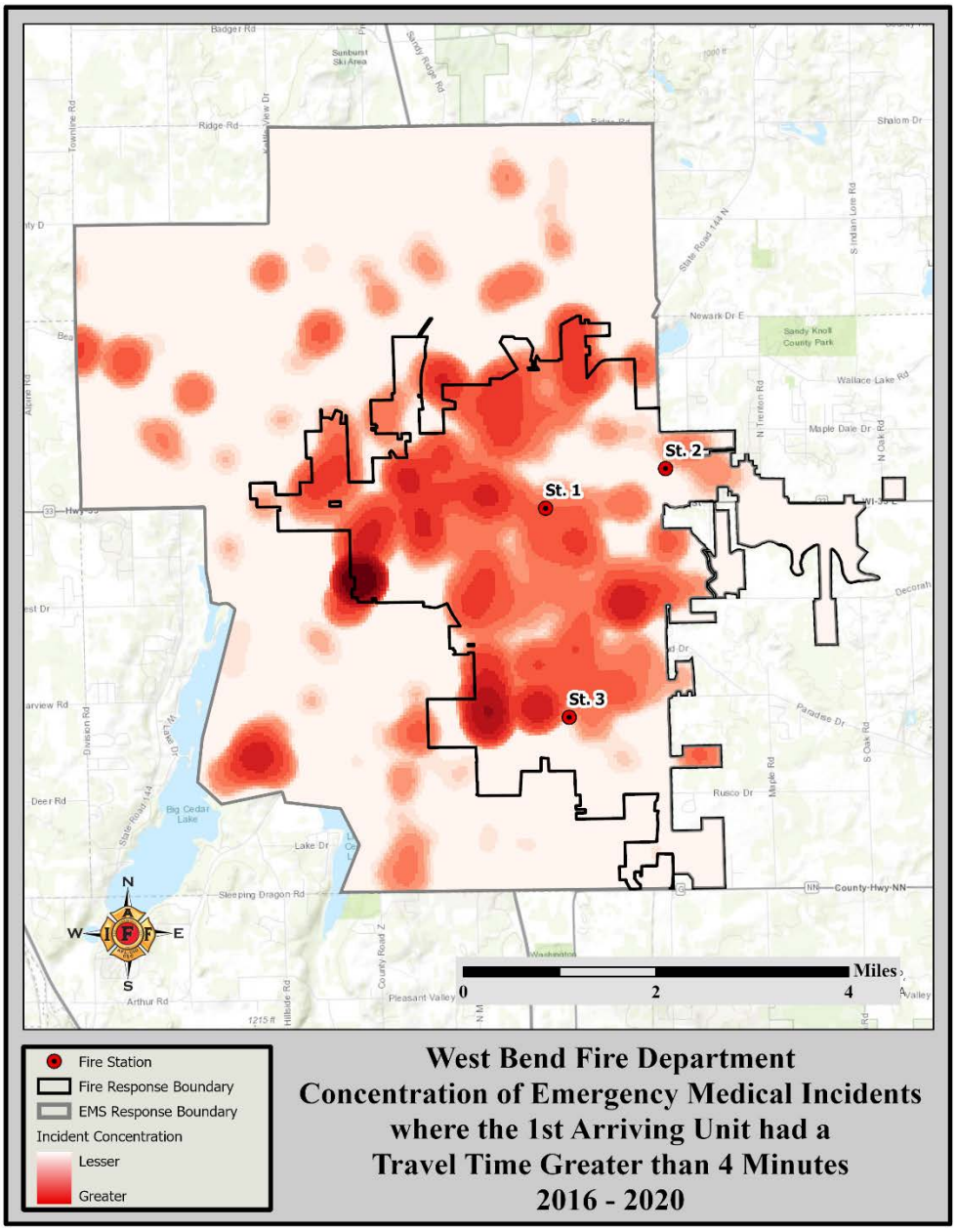


Chart 7: 90th Percentile Travel Time of 1st Arriving Unit at Emergency Medical Incidents. Chart 7 depicts the first-arriving units' 90th percentile travel times for all emergency medical incidents from 2016 to 2020. NFPA 1710 states that the first-arriving unit should be on scene within four minutes (240 seconds) or less of travel for 90% of incidents. WBFD exceeded this performance objective each of the five years with a 90th percentile travel times over five minutes from 2016 to 2019, and over six minutes in 2020.



Map 16: Concentration of Emergency Medical Incidents where the 1st Arriving Unit had a Travel Time Greater than 4 Minutes, 2016 - 2020. Map 16 depicts the concentration levels of emergency medical incidents from 2016 to 2020 where the first-arriving unit had a travel time greater than four minutes. NFPA 1710 states that the first-arriving unit should be on scene within four minutes of travel for 90% of incidents. Overall, during the five years, 29.9% of the emergency medical incidents located within WBFD's response boundary had a first-arriving unit travel longer than four minutes. The majority (75.0%) of these incidents with late first-arriving units occurred within West Bend city limits. Within West Bend, Station 1's first-due area had 44.6% of all late first-arrivals. While the WBFD EMS contract areas outside of West Bend had a much smaller incident volume, 81.3% of these incidents had a late first-arriving unit. These findings indicate a need for additional fire stations in West Bend. A new fourth fire station located west of Station 1 will increase WBFD's ability to provide timely response within West Bend and in the contract areas. Even seconds of delay to initiating medical care can negatively impact patient survivability.

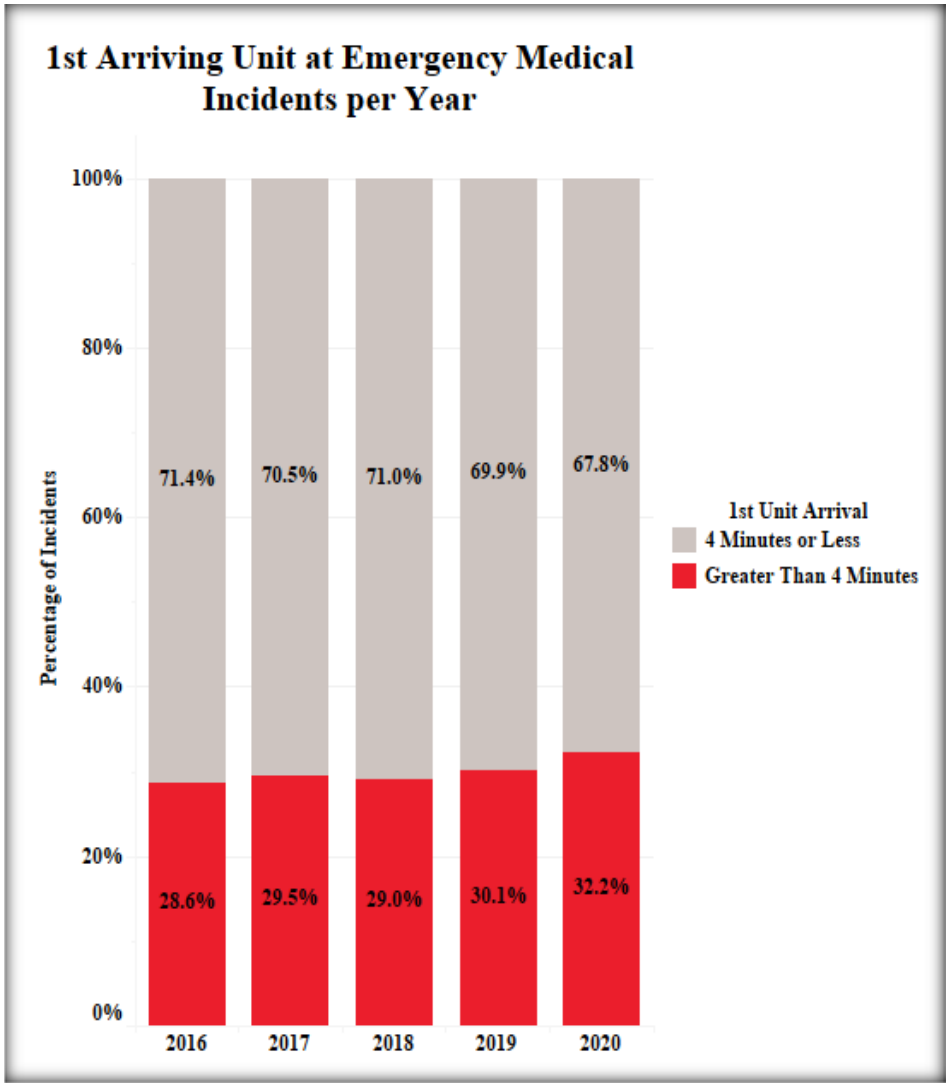


Chart 8: 1st Arriving Unit at Emergency Medical Incidents per Year. Chart 8 shows the percentage of emergency medical incidents in each year where the first arriving unit had a travel time within or longer than four minutes. The red bars indicate incidents where the first-arriving unit had a travel time longer than four minutes. The proportion of incidents with late first-arriving units ranged from 28.6% in 2016 to 32.2% in 2020. This decrease in travel time performance over this time period is an indication that the current level of WBFD resources are not keeping up with increasing demand. Residents expect and deserve rapid response from WBFD, but many emergencies receive delayed response. Additional units should be placed in areas experiencing high concentrations of incidents where the first unit did not arrive within four minutes of travel. Delays of even a few seconds can have a negative impact on the outcome of medical emergencies, creating a significant risk for the community.

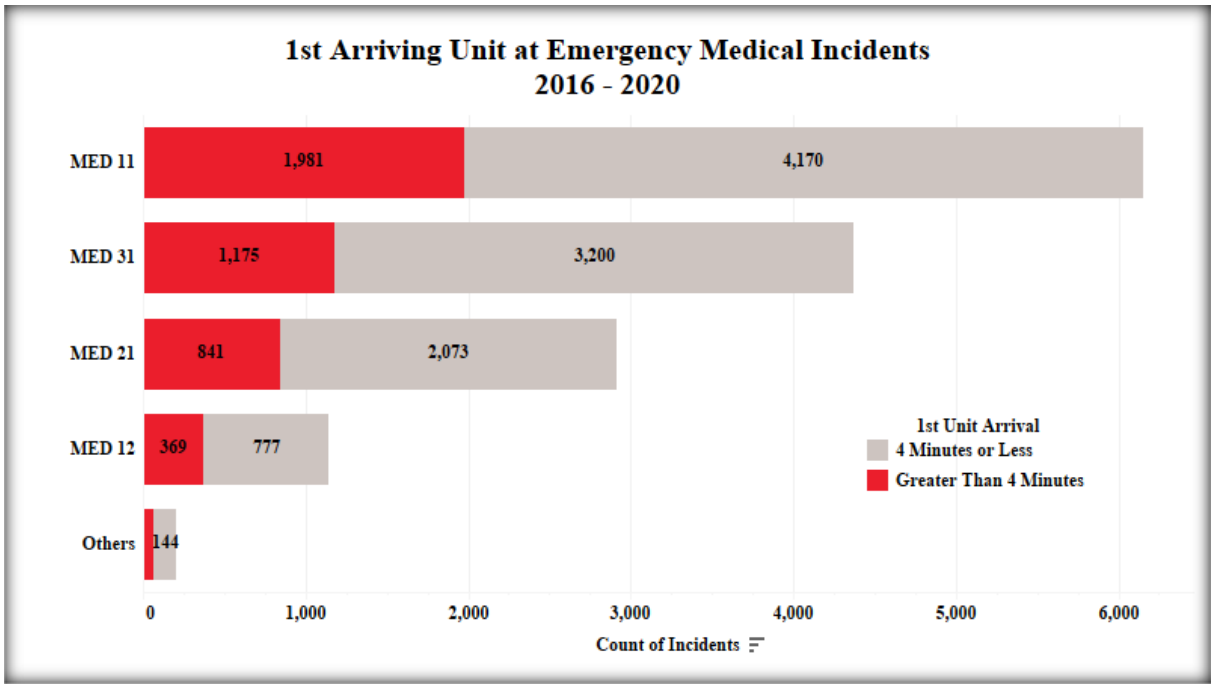


Chart 9: 1st Arriving Unit at Emergency Medical Incidents, 2016 - 2020. Chart 9 shows the total count of first-arriving responses at emergency medical incidents of WBFD units. The red bars indicate responses where the unit had a travel time greater than four minutes. The quantities in red correspond to the incident concentrations displayed in Map 16. Medic units were the first on scene for the vast majority of emergency medical incidents, and the proportion of late responses ranged from 26.9% for Med 31 to 32.2% for Med 11. Med 11 was the busiest of all WBFD units during the five years, and Med 11's late first-arrivals account for 44.7% of all first arrivals that did not meet NFPA 1710 travel time objectives. This underscores the fact that the current number and distribution of WBFD fire stations is not adequate to provide timely response to emergencies. Regardless of where in the city they live, residents deserve equitable services from WBFD.

Charts 8 and 9 detailed the first arriving unit response to emergency medical incidents per year and by unit. During the five-year study period WBFD was not able to meet NFPA 1710 travel time objectives that require the arrival of the first unit at an emergency medical incident within four minutes travel to 90% of incidents. WBFD does not have adequate quantity or distribution of resources to meet these objectives. Overall, during the five-year study period, 29.9% of emergency medical incidents did not receive a unit within four minutes travel. Most of these, 75.0%, occurred within West Bend city limits. Even though incident volume was much lower in the contract areas outside of West Bend, 81.3% of these incidents did not receive a responding unit within four minutes travel. These findings suggest that additional stations and resources are needed to improve WBFD's ability to rapidly respond within West Bend and within the contract areas.

As West Bend continues to grow, call volumes will increase, which will make the likelihood that all units are available to respond at any given time rarer, further reducing WBFD's ability to

rapidly respond. Based on the findings of this analysis, WBFD requires additional fire stations, personnel, and apparatus in order to come closer to meeting industry standards for responding to emergencies, and to respond safely and effectively. Delays of even a few seconds can have a negative impact on the outcome of medical and fire emergencies, creating a significant risk for the community.

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Recommended Minimum Staffing Levels

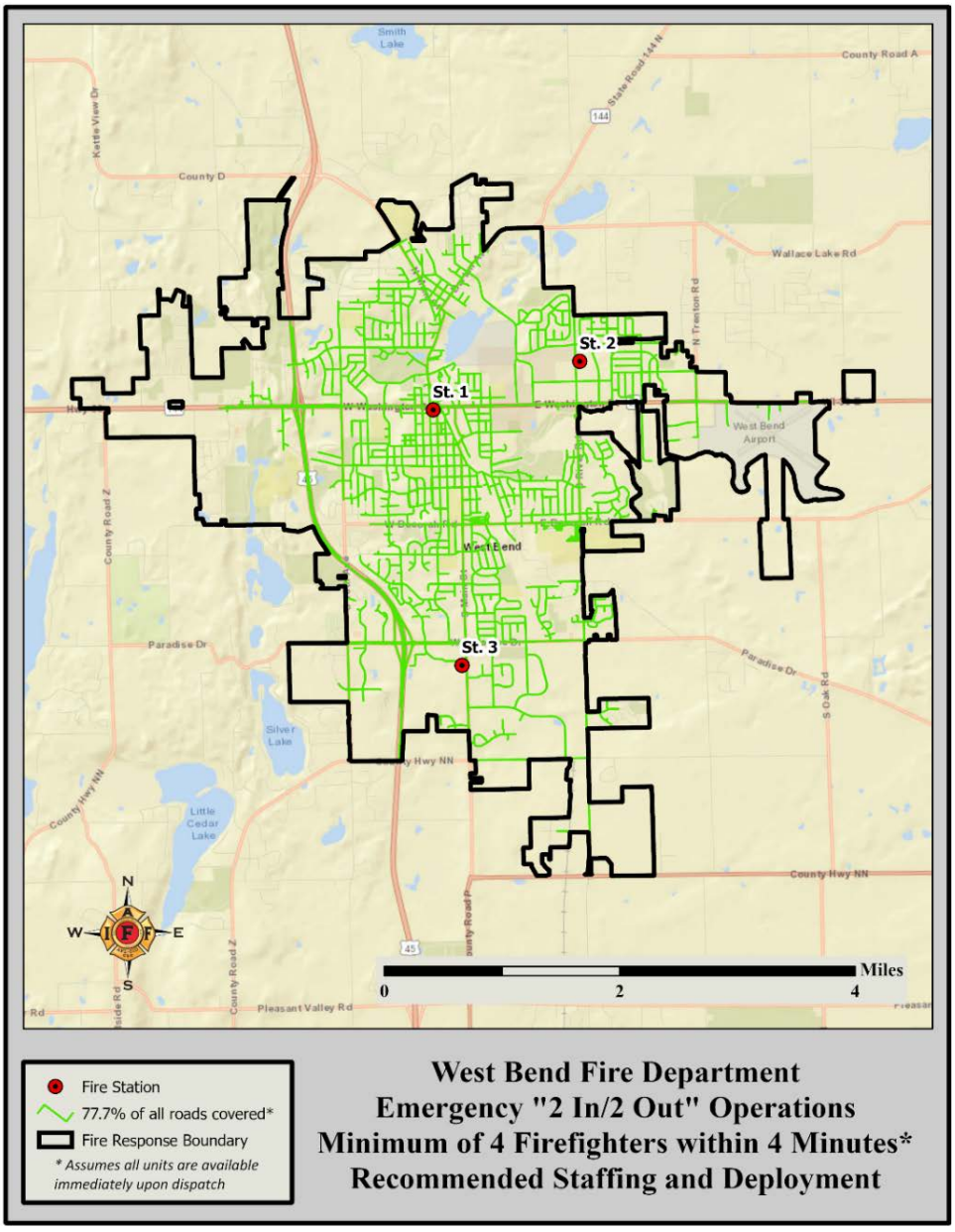
Additional personnel, staffed suppression apparatus, and stations will allow ensure rapid response to emergencies in West Bend and safer and more effective firefighting operations. The increased availability and travel reach of suppression and EMS resources will bring WBFD closer to meeting industry standards. This section will examine expected response capabilities pursuant to increasing staffing to meet the objectives of NFPA 1710 at the current station locations and at a recommended four-station configuration.

Recommended Staffing and Deployment – Current Three Stations

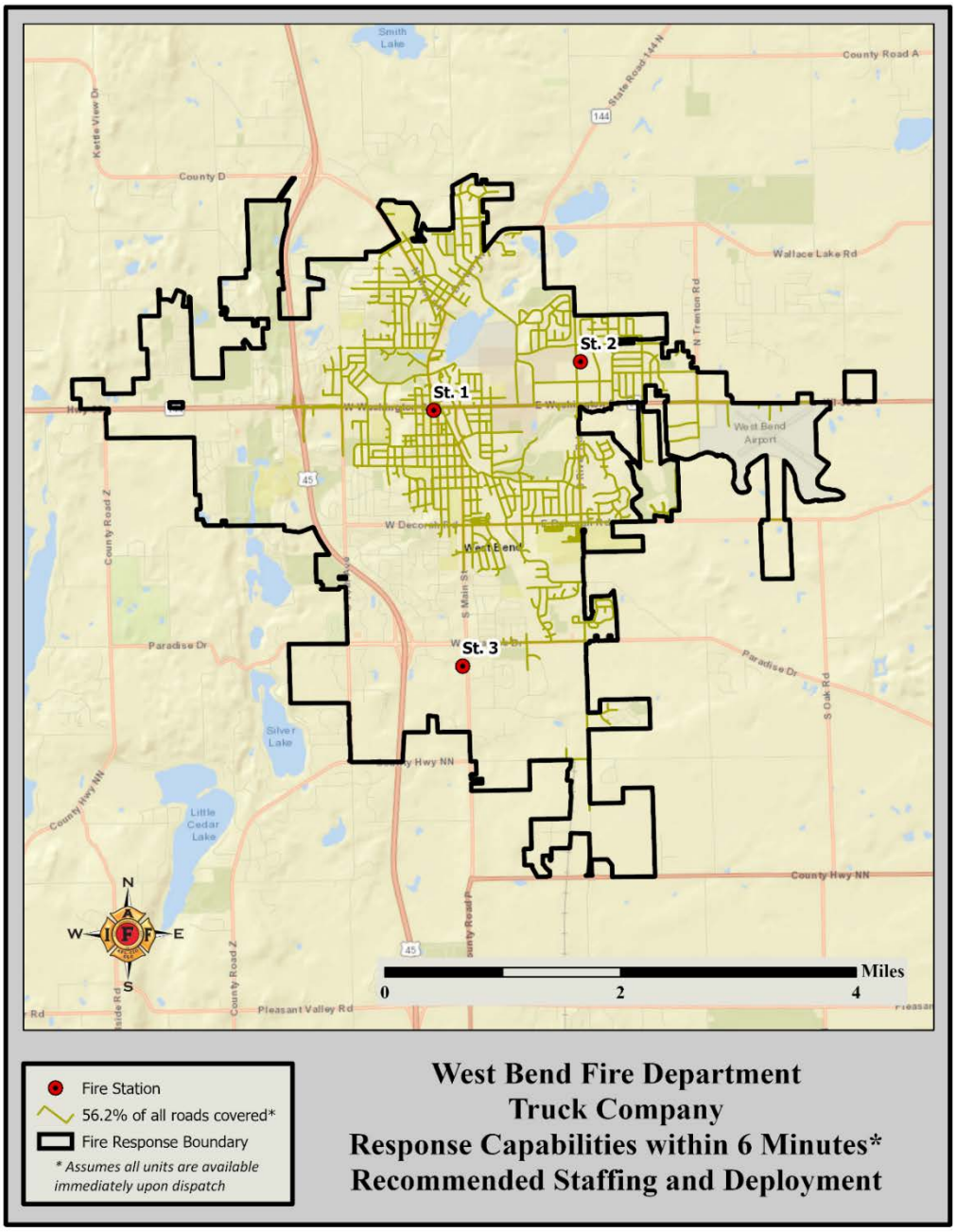
The following GIS maps present the results of a response capabilities analysis of the WBFD pursuant to increasing staffing at its current three fire stations as they are presently located. In this scenario the practice of cross-staffing suppression apparatus and medic units is discontinued. Each frontline suppression apparatus – including Engine 1, Engine 3, and Truck 2 – is staffed with four firefighters at all times, and each medic unit – including Med 11, 21, and 31 – is staffed with two firefighters at all times. Minimum staffing will increase by nine firefighters per shift. The staffing and deployment configuration examined in this section includes daily staffing levels as described in Table 7 below.

Station	Address	Apparatus	Typical Staffing
1	325 N. 8th Avenue	Engine 1	**4 Firefighters (FF)/Medics**
		Med 11	**2 FF/Medics**
		Truck 1	**Special Request**
		Intercept 1	**Special Request**
		Tender 1	**Special Request**
		Brush Rig	**Special Request**
		Tech Rescue	**Special Request**
		Engine 12	**Reserve**
		Med 12	**Reserve**
		Battalion	**1 Battalion Chief**
2	901 N. River Road	Truck 2	**4 FF/Medics**
		Med 21	**2 FF/Medics**
		Intercept 2	**Special Request**
3	2100 S. Main Street	Engine 3	**4 FF/Medics**
		Med 31	**2 FF/Medics**
		Intercept 3	**Special Request**
		Hazmat Trailer	**Special Request**
		Mass Casualty Trailer	**Special Request**

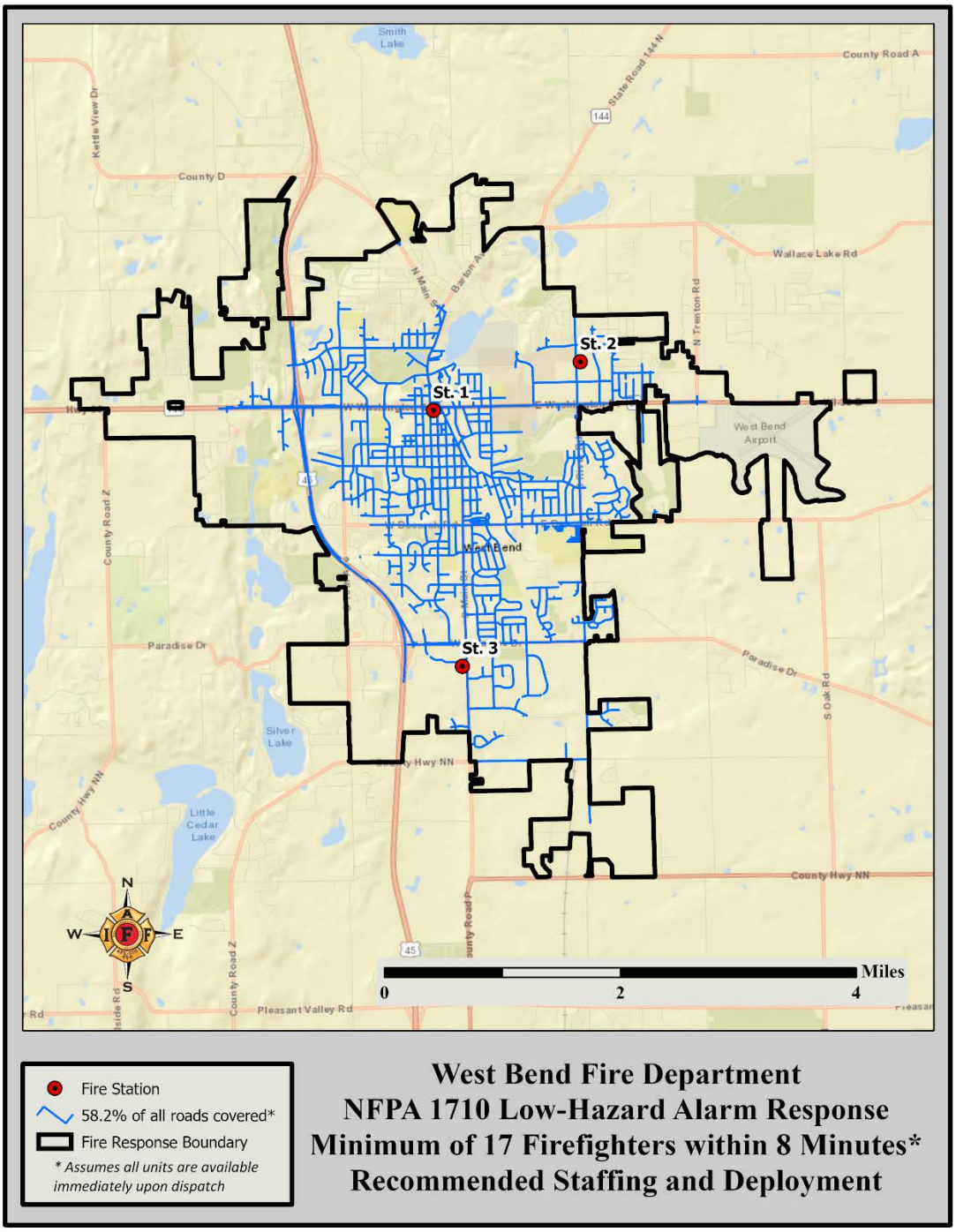
Table 7: Current Fire Station Locations and Recommended Staffing. The above table displays where apparatus are housed and recommended staffed.



Map 17: Emergency "2 In/2 Out" Operations, Minimum of 4 Firefighters within 4 Minutes, Recommended Staffing and Deployment. Map 17 identifies those roads where a minimum of four firefighters could assemble on scene within four minutes if staffing is increased on suppression and medic apparatus pursuant to recommendations. Assuming all units are in service and available to respond at the time of dispatch, the WBFD will likely be capable of responding with four firefighters on 77.7% of roads within West Bend within four minutes. This translates to a 291.5% ***increase*** in response capabilities above existing conditions. In addition to the increase in percentage of roads covered, the essential benefit of staffing suppression apparatus with four firefighters is that multiple apparatus are no longer required to engage in "2 In/2 Out" operations. Under this scenario, WBFD does not have to wait for the arrival of a second apparatus to initiate fireground or search and rescue operations. Furthermore, first-arriving companies staffed with four firefighters are more efficient in all aspects of initial fire suppression and search and rescue operations compared to three-person companies.



Map 18: Truck Company Response Capabilities within 6 Minutes, Recommended Staffing and Deployment. Map 18 identifies those roads where a second suppression company that is a truck could likely respond within six minutes of travel pursuant to implementing staffing and deployment recommendations. Assuming all units are in service and available to respond at the time of dispatch, the WBFD will likely be capable of responding with a second suppression company that is a truck on 56.2% of roads within West Bend within six minutes. Currently, WBFD cannot meet NFPA 1710 minimum staffing objectives that require suppression apparatus to be staffed with a minimum of four firefighters.



Map 19: NFPA 1710 Low-Hazard Alarm Response, Minimum of 17 Firefighters within 8 Minutes, Recommended Staffing and Deployment. Map 19 identifies those roads where a minimum of 17 firefighters will likely be able assemble on scene within eight minutes pursuant to implementing staffing and deployment recommendations. Assuming all units are in service and available to respond at the time of dispatch, the WBFD will likely be capable of assembling at least 17 firefighters on 58.2% of roads within West Bend within eight minutes. Currently WBFD is unable to respond with a minimum of seventeen firefighters anywhere in West Bend within eight minutes.

ArcGIS Location-Allocation Tool

Within the ArcGIS Network Analyst toolset, the Location-Allocation tool can identify suitable location(s) for a facility or multiple facilities that provide a service within a community. Different facilities require different locations based on the services they provide and whom they serve. In the case of locating fire stations, a community must carefully place fire stations to reach the most people within the shortest amount of time and the right number of resources. This tool was utilized to find the optimal number and locations of WDFD fire stations.

Depending on what scenarios are input while setting up the Location-Allocation tool, different locations can result. For example, entering travel times of four minutes, six minutes, or eight minutes may result in different station location outputs. Changing demand point criteria may also result in different station location recommendations. The Location-Allocation tool uses demand points as features that are to be allocated to each individual fire station. For WBFD historical incident locations from January 1, 2016, to January 22, 2021, were used as demand points.

The Location-Allocation tool helps decision makers answer questions; however, it is not a tool that *completely* answers the questions; it is only a starting point. The software outputs a recommendation of a location or locations based on travel time requirements and demand points. Other factors may play a role in final station locations that go beyond GIS capabilities such as anticipated community risk, frequency of simultaneous calls for service, level of service demanded by the community, and available land. The fire department (both administration and frontline personnel) and the community should all have input and come to an agreement on where to place any new fire stations within the jurisdiction. The locations recommended in this report are approximations of best locations based on the location-allocation, and not any indication of land availability.

For West Bend, the Location-Allocation tool was used to determine the optimal number of stations for reaching demand points within a four-minute travel time, and the optimal positioning of the chosen number of stations. As the result of this process, it is recommended that: (1) a fourth fire station be opened west of Station 1, near the intersection of W. Washington Street and Wildwood Road, and (2) Station 2 be relocated to the south, near the intersection of S. River Road and Whitewater Drive. It is also recommended that Stations 1 and 3, if rebuilt, be rebuilt at or as near as possible to their present respective locations.

It was not within the scope of this report to examine whether or not any West Bend fire station physically should be rebuilt, but rather to examine optimal positioning and quantity of fire stations.

Recommended Staffing and Deployment – Four Station Configuration

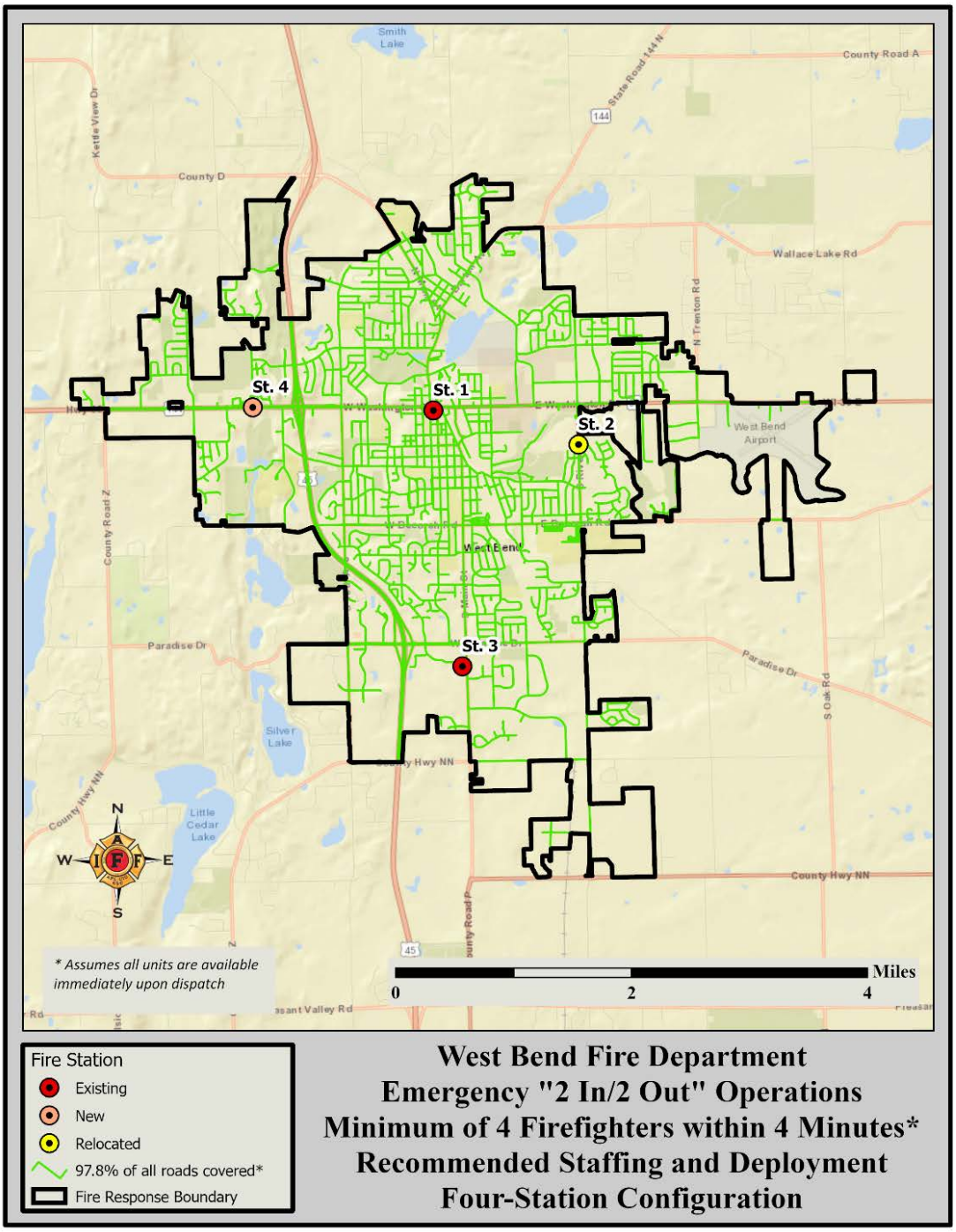
The following GIS maps present the results of a response capabilities analysis of the WBFD pursuant to:

- Relocating Station 2 to the south, near the intersection of S. River Road and Whitewater Drive.
- Opening a new fire station, Station 4, near the intersection of W. Washington Street and Wildwood Road that deploys one engine, staffed with four firefighters at all times, and one medic unit, staffed with two firefighters at all times.
- Discontinue the practice of cross-staffing suppression apparatus and medic units.
- Increase staffing to meet the objectives of NFPA 1710 by staffing each frontline suppression apparatus – including Engine 1, Engine 3, and Truck 2 – with four firefighters at all times, and each medic unit – including Med 11, 21, and 31 – with two firefighters at all times.

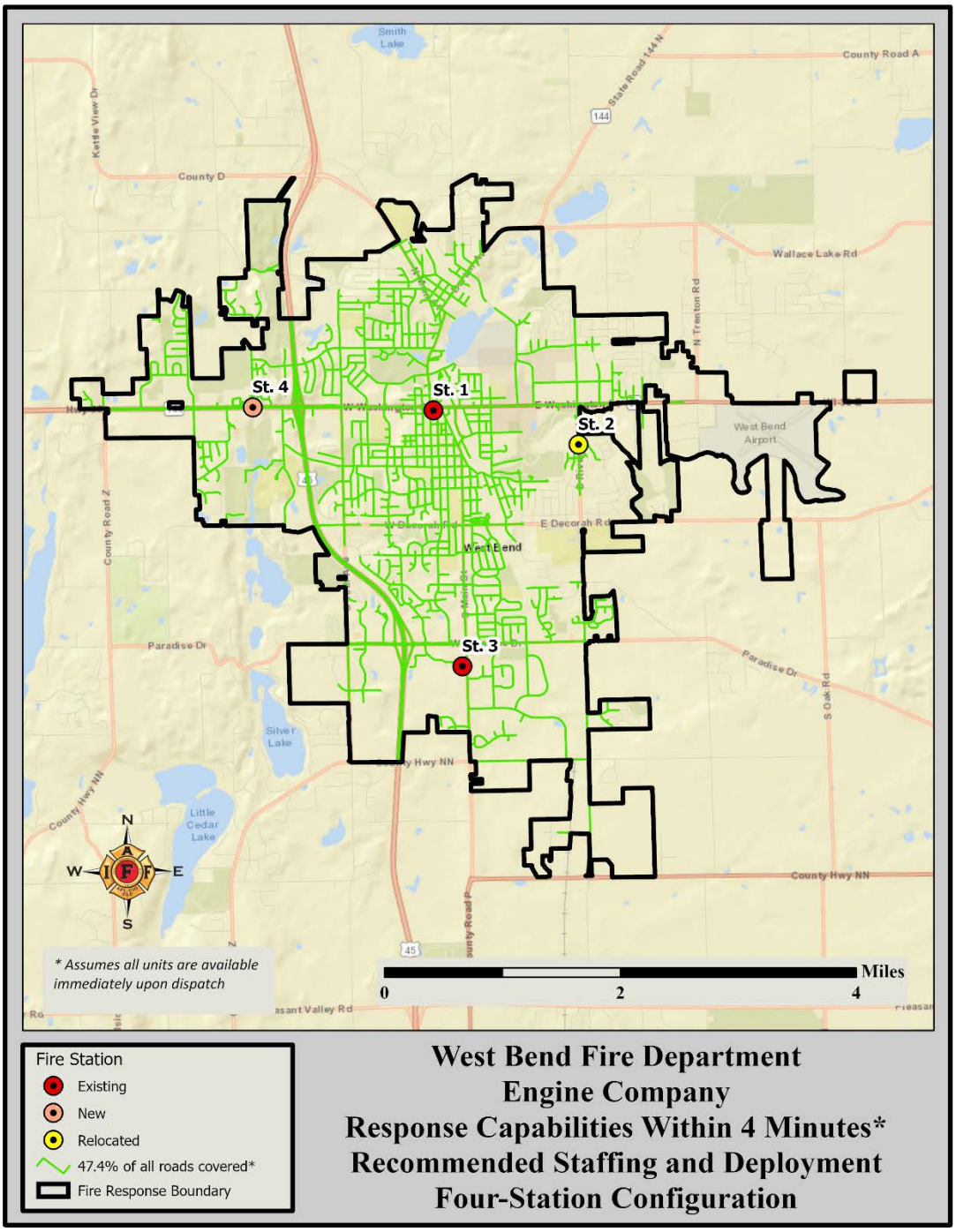
Minimum staffing will increase by 15 firefighters per shift. The staffing and deployment configuration examined in this section includes daily staffing levels as described in Table 8 below.

Station	Address	Apparatus	Typical Staffing
1	325 N. 8th Avenue	Engine 1 Med 11 Truck 1 Intercept 1 Tender 1 Brush Rig Tech Rescue Engine 12 Med 12 Battalion	**4 Firefighters (FF)/Medics** **2 FF/Medics** **Special Request** **Special Request** **Special Request** **Special Request** **Special Request** **Reserve** **Reserve** **1 Battalion Chief**
Relocated 2	Intersection of S. River Road and Whitewater Drive	Truck 2 Med 21 Intercept 2	**4 FF/Medics** **2 FF/Medics** **Special Request**
3	2100 S. Main Street	Engine 3 Med 31 Intercept 3 Hazmat Trailer Mass Casualty Trailer	**4 FF/Medics** **2 FF/Medics** **Special Request** **Special Request** **Special Request**
New 4	Intersection of W. Washington Street and Wildwood Road	Engine Med	**4 FF/Medics** **2 FF/Medics**

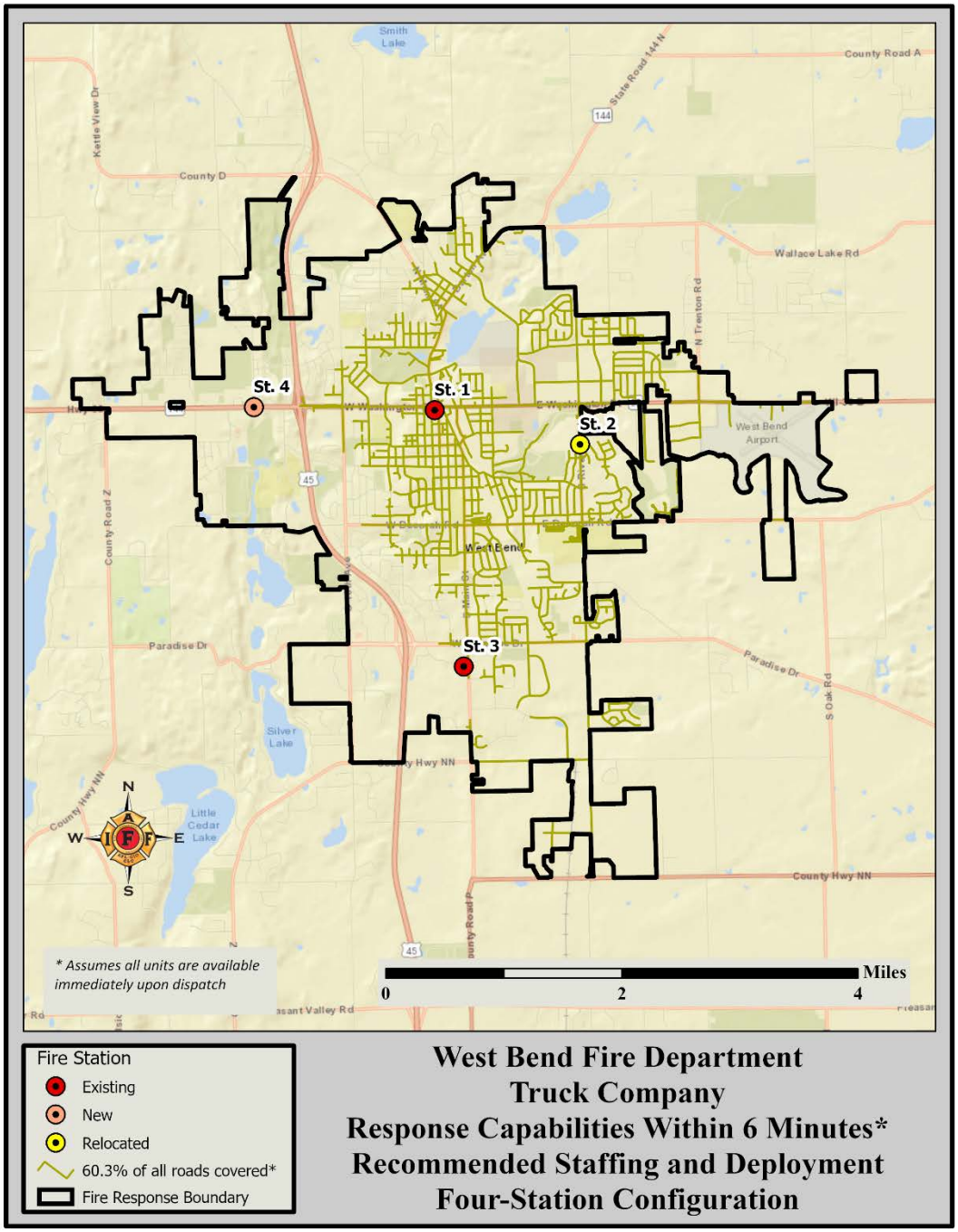
Table 8: Recommended Fire Station Locations and Staffing. The above table displays recommended station locations and apparatus staffing.



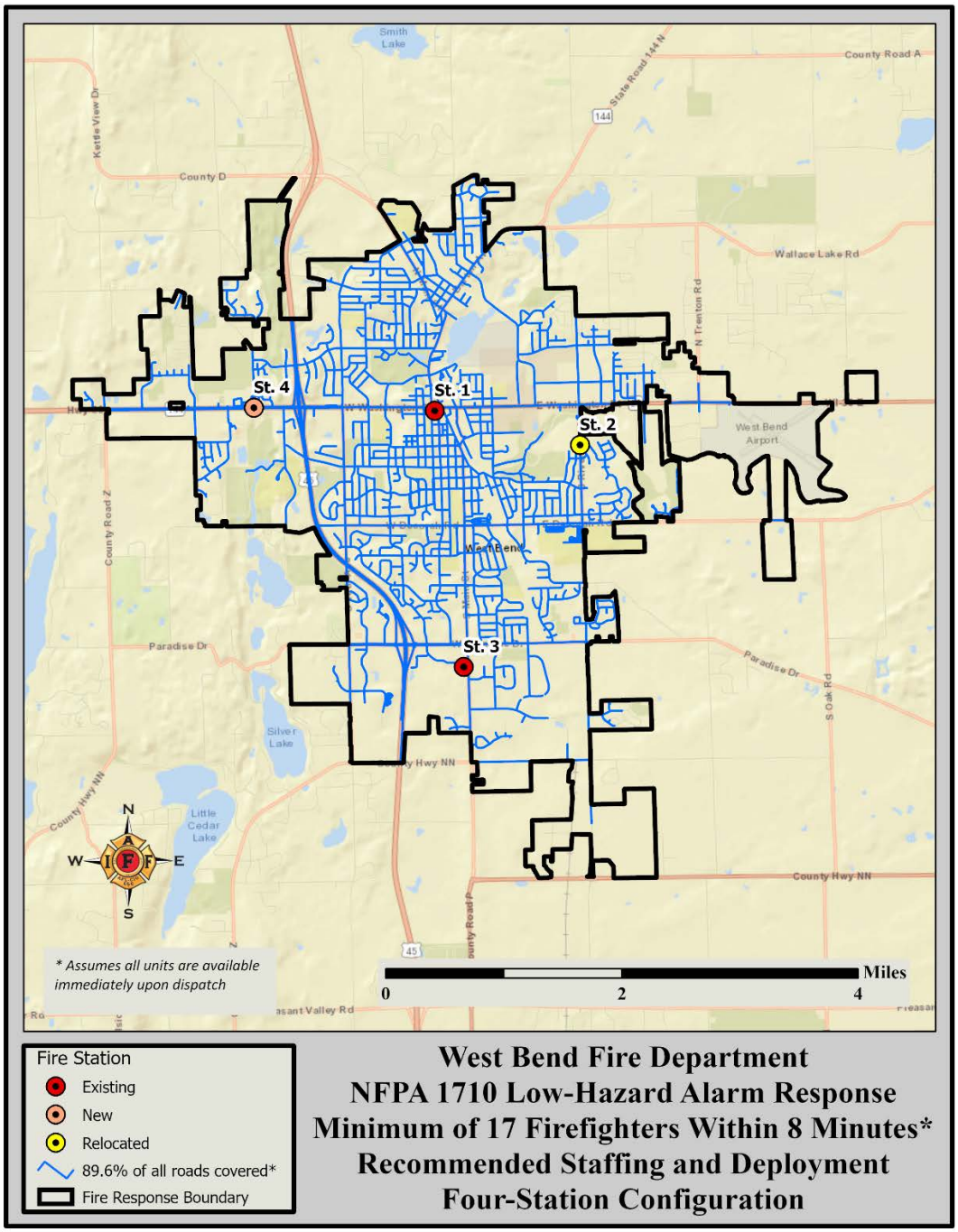
Map 20: Emergency "2 In/2 Out" Operations, Minimum of 4 Firefighters within 4 Minutes, Recommended Staffing and Deployment, Four-Station Configuration. Map 20 identifies those roads where a minimum of four firefighters could assemble on scene within four minutes if staffing is increased on suppression and medic apparatus pursuant to recommendations, and station locations are modified as identified in the map. Assuming all units are in service and available to respond at the time of dispatch, the WBFD will likely be capable of responding with four firefighters on 97.8% of roads within West Bend within four minutes. This translates to a 392.8% ***increase*** in response capabilities above existing conditions, and a 25.9% ***increase*** in response capabilities above recommended staffing at the three current stations.



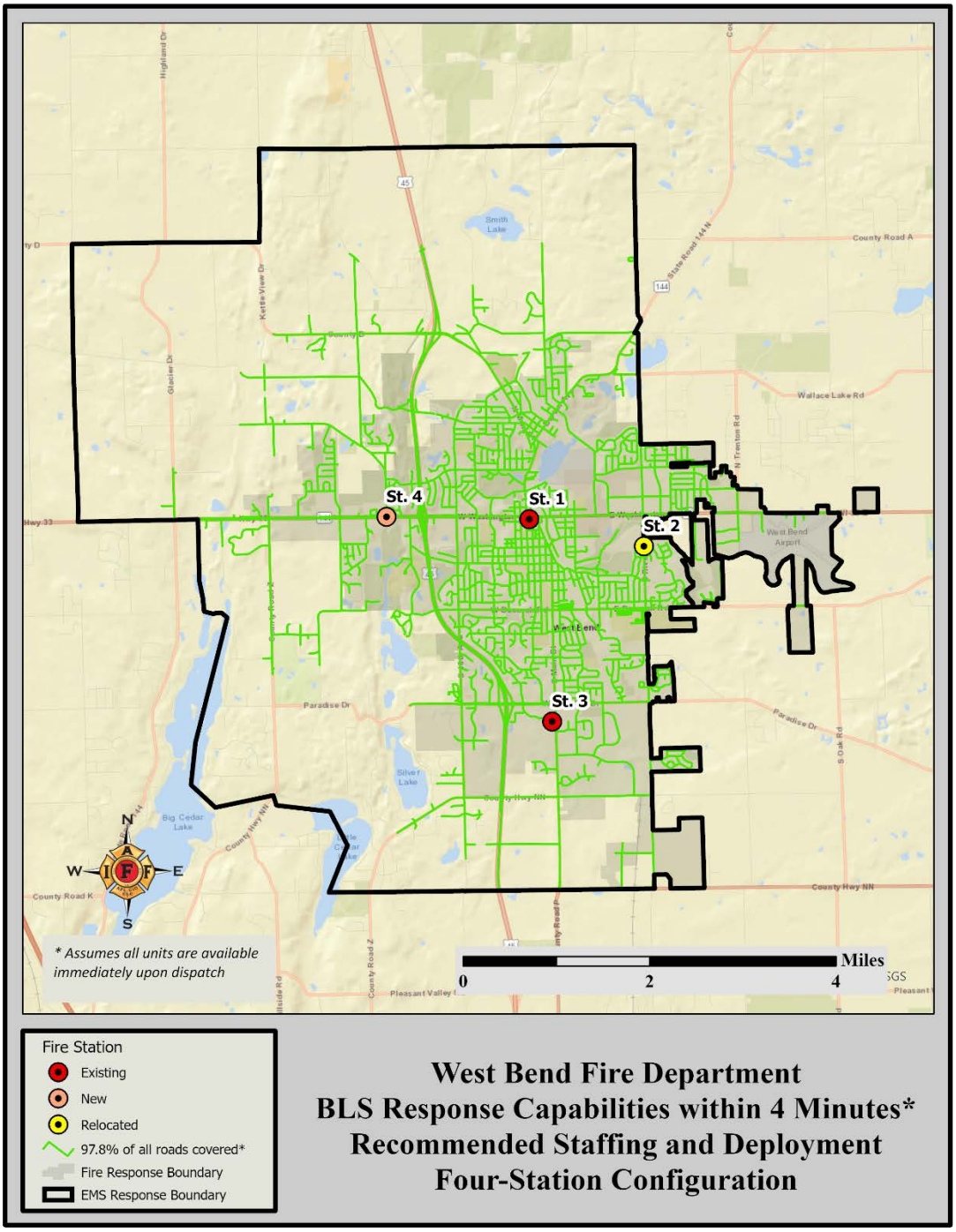
Map 21: Engine Company Response Capabilities within 4 Minutes, Recommended Staffing and Deployment, Four-Station Configuration. Map 21 identifies those roads where WBFD could likely respond with an engine within four minutes pursuant to implementing the four-station configuration, and staffing and deployment recommendations. Assuming all units are in service and available to respond at the time of dispatch, the WBFD will likely be capable of responding with an engine on 47.7% of roads within West Bend within four minutes. This translates to a 16.7% ***increase*** in response capabilities above existing conditions.



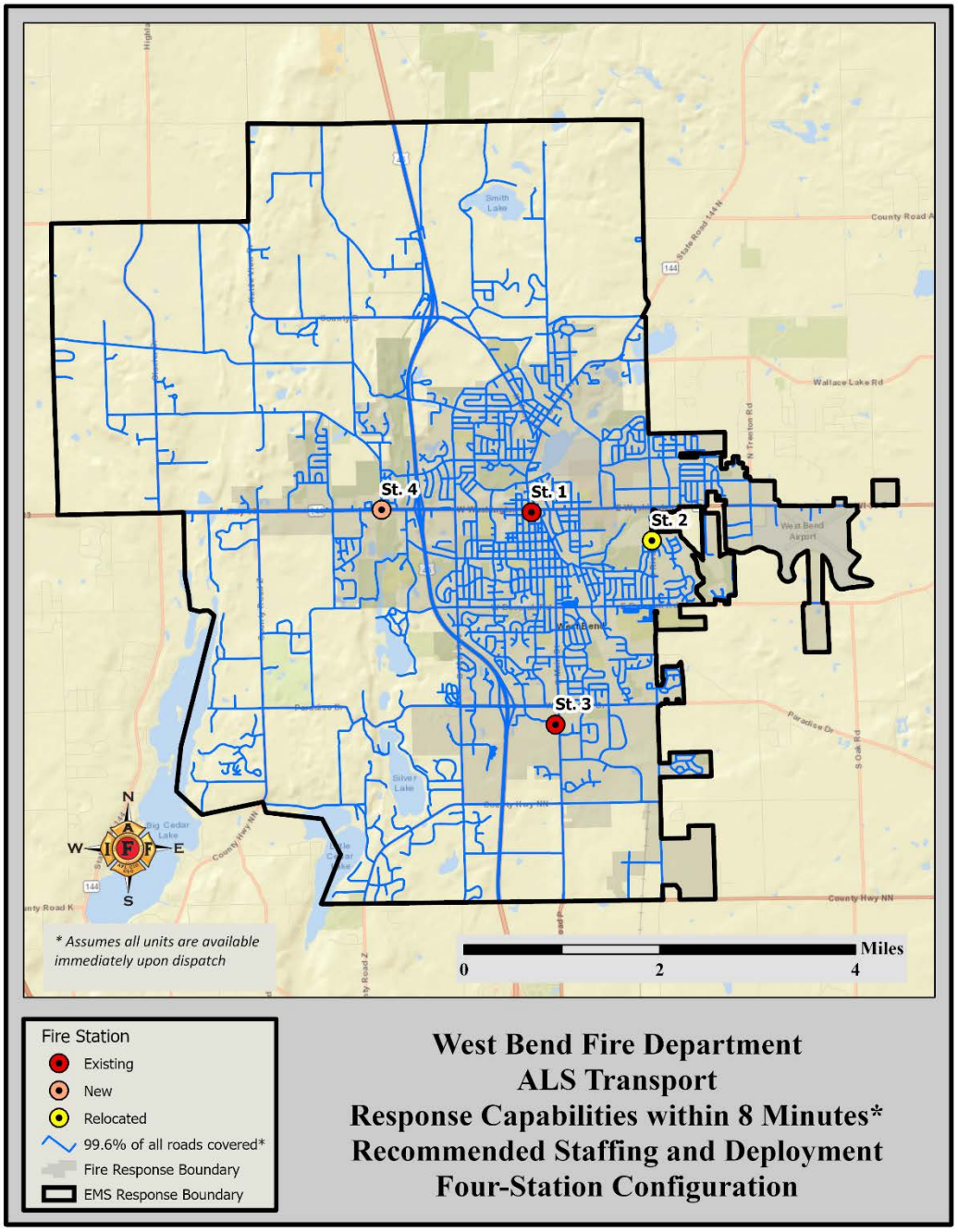
Map 22: Truck Company Response Capabilities within 6 Minutes, Recommended Staffing and Deployment, Four-Station Configuration. Map 22 identifies those roads where a second suppression company that is a truck could likely respond within six minutes of travel pursuant to implementing the four-station configuration, and staffing and deployment recommendations. Assuming all units are in service and available to respond at the time of dispatch, the WBFD will likely be capable of responding with a second suppression company that is a truck on 60.3% of roads within West Bend within six minutes. Currently, WBFD cannot meet NFPA 1710 minimum staffing objectives that require suppression apparatus to be staffed with a minimum of four firefighters; furthermore, this translates a 7.3% ***increase*** in response capabilities above recommended staffing at the three current stations.



Map 23: NFPA 1710 Low-Hazard Alarm Response, Minimum of 17 Firefighters within 8 Minutes, Recommended Staffing and Deployment, Four-Station Configuration. Map 23 identifies those roads where a minimum of 17 firefighters will likely be able assemble on scene within eight minutes pursuant to implementing the four-station configuration, and staffing and deployment recommendations. Assuming all units are in service and available to respond at the time of dispatch, the WBFD will likely be capable of assembling at least 17 firefighters on 89.6% of roads within West Bend within eight minutes. Currently WBFD is unable to respond with a minimum of seventeen firefighters anywhere in West Bend within eight minutes; furthermore, this translates a 53.9% ***increase*** in response capabilities above recommended staffing at the three current stations.



Map 24: BLS Response Capabilities within 4 Minutes, Recommended Staffing and Deployment, Four-Station Configuration. Map 24 identifies those roads WBFD will likely be able respond with BLS capabilities within four minutes, pursuant to implementing the four-station configuration. The recommended Station 4 expands the ability of WBFD to respond within four minutes in western West Bend and the contract areas of the Town of West Bend Town and the Town of Barton. Assuming all units are in service and available to respond at the time of dispatch, the WBFD will likely be responding with BLS capabilities on 97.8% of roads within WBFD EMS response boundary within four minutes. This translates a 25.9% ***increase*** in response capabilities above the current three-station configuration.



Map 25: ALS Transport Response Capabilities within 8 Minutes, Recommended Staffing and Deployment, Four-Station Configuration. Map 25 identifies those roads WBFD will likely be able respond with ALS capabilities within eight minutes, pursuant to implementing the four-station configuration, and staffing and deployment recommendations. With its current practice of cross-staffing suppression and medic units, WBFD is not able to respond to a fire with a suppression apparatus when a medic unit is already out on response. Assuming all units are in service and available to respond at the time of dispatch, the WBFD will likely be responding with ALS capabilities on 90.9% of roads within WBFD EMS response boundary within eight minutes, where the first unit can arrive within four minutes. This translates a 9.5% ***increase*** in response capabilities above current capabilities.

Conclusion

In conclusion, regardless of the type of response, the WBFD staffs suppression apparatus with fewer than four firefighters, which is the minimum number required for efficient and effective fireground operations. The WBFD does not have an adequate number of firefighters per shift, an adequate number of staffed apparatus, or an adequate number of fire stations to provide emergency response that meets the objectives of industry standards for safe, efficient, and effective response to fires, medical emergencies, or rescue situations.

Currently, four firefighters are only able to assemble on 19.8% of roads within four minutes and WBFD is only able to accomplish this when *two companies* arrive on scene in the small area of four-minute overlap between West Bend fire stations. Deployment of fire department resources is not consistent with a goal of providing equitable coverage to all West Bend residents. Additional personnel, staffed suppression apparatus, and fire stations are vital to ensure that WBFD increases performance to meet the needs of the community and their expectation of fast response times. At a minimum, it is recommended that the fire department discontinue the practice of cross-staffing suppression and medic units, and increase staffing on all suppression apparatus to at least four firefighters at all times, and on all medic units to at least two firefighters at all times. Demand has been steadily increasing for the fire department the additional staffing at current stations will help enhance response capabilities. If the recommended enhancements to the current staffing and deployment model are implemented, WBFD with likely able to respond with four firefighters on 77.7% of city roads within four minutes.

Increasing the amount of staffing and fully staffed suppression apparatus will also likely increase the WBFD's ability to assemble an effective response force to fires occurring in low-hazard occupancies as required by NFPA 1710. Under current staffing conditions, the WBFD cannot respond with 17 firefighters to a low-hazard structure fire within eight minutes anywhere within West Bend. If the recommended enhancements to the staffing and deployment model are implemented, WBFD will likely be capable of responding with 17 firefighters on 58.2% of roads within West Bend within eight minutes.

Currently, WBFD is only capable of responding with an engine company to 40.6% of roads in West Bend within four minutes. Engine and ladder companies are cross-staffed with medic units, the three of which are the busiest units in the department – frequently leaving WBFD unable to respond in large portions of the city, and increasing risk. Analysis of CAD data from 2016 to 2020 confirms that the WBFD is not able to meet NFPA 1710 travel time objectives that require a travel time of four minutes or less to 90% of fire suppression incidents for the first arriving engine company, or that require a travel time of four minutes for the first arriving unit with BLS

capable units to 90% of emergency medical incidents. From 2016 to 2020, the first-arriving unit at 20.4% of fires and 29.9% of emergency medical incidents had a travel time greater than four minutes. Engine 1 and Med 11, both deploying from Station 1, had the greatest proportion of these late first-arrivals with 41.3% and 44.7%, respectively. Based on the dynamics of fire behavior in an unprotected structure fire, any delays in response will correlate directly with an increase in expected life, property, and economic loss.

Deficiencies in staffing and apparatus utilization contribute to delays in fire suppression, rescue, and response. Response delays are likely to increase as available apparatus decrease, and apparatus are unable to immediately respond. This increases the risk of death or injury due to fire for both residents and firefighters of West Bend. It also increases the risk of considerable property loss for housing units and businesses in many areas of the city. It is essential that departmental resources are able to meet demand. The fire department's current insufficiencies indicate the need for additional resources.

While it is impossible to predict where most of a jurisdiction's fire and medical emergencies will occur, the WBFD 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 as needed to achieve complete compliance with industry standards. West Bend is experiencing some growth, and areas with accelerated development and population growth will require additional coverage in the future. Any projected increase in emergency response demands should also be considered before changes are implemented, focusing on associated hazard types and planned response assignments.

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.

The ramifications of insufficient resource levels, as they pertain to the loss of life and property within a community, are essential when considering a fire department's deployment configuration. A fire department should be designed to adequately respond to several 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, deployment and station locations 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.

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Appendix

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.[92]

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

- **4.1.2.1** The fire department shall establish the following performance objectives for the first-due response zones that are identified by the AHJ:
  - (3) 240 seconds or less travel time for the arrival of the first engine company at a fire suppression incident[93]
  - (4) 360 seconds or less travel time for the arrival of the second company with a minimum staffing of 4 personnel at a fire suppression incident
  - (5) For other than high-rise, 480 seconds or less travel time for the deployment of an initial full alarm assignment at a fire suppression incident
  - (6) For high-rise, 610 seconds or less travel time for the deployment of an initial full alarm assignment at a fire suppression incident
  - (7) 240 seconds or less travel time for the arrival of a unit with first responder with automatic external defibrillator (AED) or higher-level capability at an emergency medical incident
  - (7) 240 seconds or less travel time for the arrival of a unit with first responder with automatic external defibrillator (AED) or higher-level capability at an emergency medical incident
  - (8) 480 second or less travel time for the arrival of an advanced life support (ALS) unit at an emergency incident, where this service is provided by the fire department provided a first responder with an AED or basic life support (BLS) unite arrived in 240 seconds or less travel time.

[92] NFPA 1710, 2020
[93] All travel time objectives are to be achieved 90% of the time

- **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 Engine Companies.** Fire companies, whose primary functions are to pump and deliver water and perform basic firefighting at fires, including search and rescue, shall be known as engine companies shall be staffed with a minimum of four on-duty personnel.
    - 5.2.3.1.1 These companies shall be staffed with a minimum of four on-duty personnel.
    - 5.2.3.1.2 In first-due response zones with a high number of incidents, geographical restrictions, geographic isolation, or urban areas, as identified by the AHJ, these companies shall be staffed with a minimum of five on-duty members.
    - 5.2.3.1.2.1 In first-due response zones 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.

- **5.2.3.2 Ladder/Truck Companies.** Fire companies whose primary functions are to perform the variety of services associated with truck work, such as forcible entry, ventilation, search and rescue, ladder operations for water delivery and rescue, utility control, illumination, overhaul and salvage work, shall be known as ladder or truck companies… shall be staffed with a minimum of four on-duty personnel.
    - 5.2.3.2.1 These companies shall be staffed with a minimum of four on-duty personnel.
    - 5.2.3.2.2 In first-due response zones with a high number of incidents, geographical restrictions, geographic isolation, or urban areas, as identified by the AHJ, these companies shall be staffed with a minimum of five on-duty members.
    - 5.2.3.2.2.1 In first-due response zones 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.

- **5.2.4.1** The initial full alarm assignment to a structure fire in a typical 2000 ft^2 … two-story single-family dwelling without basement and with no exposures 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)	4 Firefighters
Required Minimum Personnel for Full Alarm	**16 Firefighters & 1 Scene Commander**

- **5.2.4.2 Open-Air Strip Shopping Center Initial Full Alarm Assignment Capability**
  - 5.2.4.2.1 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

- **5.2.4.3 Apartment Initial Full Alarm Assignment Capability**
  - 5.2.4.3.1 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[94]	2 Firefighters
Required Minimum Personnel for Full Alarm	**27 Firefighters** **1 Incident Commander**

[94] 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 High-Rise Initial Full Alarm Assignment Capability.**
  - 5.2.4.4.1 Initial full alarm assignment to a fire in a building with the highest floor 75 ft. (23 m) 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
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 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[95]	4 Firefighters

[95] 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."

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