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Assessing Fire Station Response and Coverage Ability in a Pennsylvania Town

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This is to certify that the doctoral study by

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has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
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Abstract

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MA, Park University, 2014

BS, Park University, 2018

Professional Administrative Study Submitted in Partial Fulfillment

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Abstract

There was a gap in fire station response times in a Pennsylvania township. Although there were two fire stations located in the township, one area was contractually serviced by a nearby borough. Stations are staffed by volunteers, which creates problems with coverage and timely responses. The “nine-minute-90%-of-the-time” National Fire Protection Association standard was not always achieved. The purpose of the study was to determine what gaps in fire station response times or coverage existed. A risk-based methodology was used to develop a baseline in standards of coverage. Using a risk methodology with historical data helped in informing issue identification. This resulted in the establishment of identified demand zones. Subject matter expert interviews were conducted to further identify concerns. Findings drawn from collected data, along with analysis, were used to develop courses of action. Using this model assisted authorities and leaders in improving response metrics, which can decrease loss of life and property damage, leading to lower insurance costs, increased property value, future development of the area, and added value to the community. Throughout the study, focus was mainly on response times and coverage; however, it quickly became clear alternatives would need evaluated since the area is comprised of volunteer firefighters. This resulted in a nuance that if a fire station were to be built, staffing would not be available to man the station. The primary finding focused on staffing versus relocation or establishment of a new fire station within the corridor itself. Findings may be used by administrators for positive social change in developing better service for the public.

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Dedication

Dedicated to my wife who encouraged me to take this journey. She inspires me in so many ways. Kind words of support, prompting at just the right moment, humorous thoughts, and her uncanny ability to know when I needed to walk away from this project and refocus my efforts. I could not have succeeded without you by my side.

To the heroes who comprise the many elements of the fire service. As others run away from crisis, you selflessly run towards it. And it is through your efforts our communities are after. Thank you for your service.

Acknowledgments

My initial venture into college was in no small way a burden on my parents. They could not afford it, but somehow, they managed. So, I would be remise not to acknowledge them for what they gave up for me to get ahead. To my older brothers, I say thank you for your encouragement and support. I would also like to thank my family and friends for everything they have contributed. I spent twenty-five years in the greatest military this world has ever known. To my fellow veterans, we share a common bond through our efforts and experiences. You are the fabric that binds this great nation. And lastly, to all my teachers, educators, and professors. Thanks for getting me across the finish line.

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Section 1: Introduction

Introduction

The world is changing at a blistering pace, and there is a real danger that one will not be able to keep up. According to Anderson, there are signs everywhere that we are failing to adapt (2021). This is the reality within the volunteer fire service. Volunteerism is down throughout the nation. Many older fire stations need replacement or renovations. The fire service in this study relies heavily on volunteers. Repairs and/or upgrades to existing stations have been neglected. Members of the fire service are hesitant to relocate, while others believe a new station is warranted. Regardless, there are some that resist change or use incorrect models or methodologies to orient their decisions. Alban wrote (2021) "we have convinced ourselves that we're a business instead of a service, using metrics of our data to chase efficiency instead of effectiveness" (p78). Data and analysis on response times by township fire stations to the corridor was needed to identify gaps which quantify the ability to meet National Fire Protection Association (NFPA) metrics and standards.

The United States (U.S.) Census Bureau projects continue to grow in the township, which leads local officials to believe the volume of emergency response calls will steadily increase. Because of the current geographic locations of the two fire stations, the "nine minute 90% of the time" NFPA standard is not always achieved. Based on these statements, the Authority Having Jurisdiction (AHJ) desired a needs-based assessment to identify gaps in response times and coverage. One concern was the current sighting location for the two existing fire stations. A second concern was the volunteer staffing

model. According to the American Society of Planning Officials (1957), “one properly located fire station can provide more protection than several poorly located stations.” Analysis was therefore needed to validate if a newly sighted station was justified in filling a gap.

An efficient fire service program increases life safety efforts, mitigates risk, and increases the resiliency of the community. Determining how to create an efficient fire service could result in continued business operations, economic development, and stability. The fire services’ existing assets and capabilities can then be aligned to better serve the community’s needs. As a result, the fire service and AHJ can focus on the further development and needs of the community by balancing cost versus risk and provide better access to emergency services and improved quality of life in the community.

Within this section, background, historical, and demographic information will be provided to place the study into context. The purpose of the study, summary of data sources, analysis, definitions, and significance of the study are also outlined. This section concludes with a summation of highlighted points.

Organization Background and Problem Statement

Within the jurisdictional boundaries of the township are two volunteer staffed fire stations. The jurisdiction itself is depicted in figure 1. **Figure 1** Jurisdiction Boundary.

Each station employs a full-time (paid) driver. Citizens Fire Company 1 is in the village of Mt Holly, Pennsylvania (PA). Citizens Fire Company 2 is

in the village of Boiling Springs, PA. Station 2 is in the central portion of the township, while Station 1 is in the eastern portion of the township. Located within the jurisdictional boundaries of the township, the village of Mt Holly (Station 1) is enclaved within but is not part of the township itself. These fire stations represent the township's ethos of providing accessible public services to the community. In a book by Kurt Vonnegut titled the Sirens of Titan, a character states in the book that "I can think of no more stirring symbol of man's humanity to man than a fire truck." Seeing a fire vehicle responding to the scene of an emergency reassures the community that public services are both available and capable of crisis response and containment.

Cumberland County, PA encompasses approximately 550 square miles in the south-central portion of PA. It covers the land mass of the Blue Mountain and North Mountain to the north, South Mountain to the south and the Susquehanna River to the east. There are no major terrain features separating the area to the west. The county is bordered by Perry County (north), Dauphin County (east), Adams and York Counties (south), and Franklin County (west). According to the Cumberland County Historical Society (2014), the county was established in 1750 and originally covered 35,252 square miles. Its present size was established in 1855 when several smaller counties were formed. The United States (U.S.) Geological Survey (USGS) states the county is comprised of 29 townships and 12 boroughs (USGS, 2020). According to the 2020 Decennial Census, the population of Cumberland County was 235,406. In the 2018 Census update, the population grew to 251,423, making Cumberland County the fastest growing community in Pennsylvania by 6.6%. These figures do not include the

temporary or event driven population increases such as car shows. which draw, on average, about half a million visitors annually. The Cumberland Area Economic Development Corporation states events such as car shows, and other festivals contribute approximately $98 million dollars into the local economy (2015). The area is also home to two military installations and several colleges and universities, which further add to the transient population residing in the community.

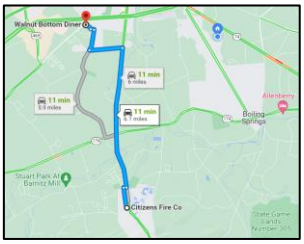
Located within the corridor itself is the 165 bed University of Pittsburgh Medical Center (UPMC) Carlisle Regional Hospital. This facility provides critical care, cardiac and vascular services, medical imaging, pulmonary medicine, stroke center, surgery center, laboratory services, aeromedical evacuation capability, in and outpatient care. It has an annex campus that houses a women's health center, cancer center and wound treatment center. Nearby are numerous medical related specialty facilities, such as a doctor's park, endocrinology center, cardiovascular center, urology services, obstetrics, same day surgery centers, orthodontics, digestive disease care, and orthopedic offices. Several pharmacies and medical support and supply facilities are also located within the corridor. The area contains rehabilitation facilities, memory care, short, and long-term care facilities, and assisted living centers. The corridor is mainly home to several large distribution and logistics platforms. Located adjacent to the hospital is the PA State Police Barracks. Within a five-minute drive are additional shopping, dining, entertainment, other typical community amenities and services, and the Carlisle Regional Airport (owned by the AHJ). The corridor has numerous restaurants (mostly fast food),

fueling stations, grocery stores, shopping and both permanent and transient (lease or rent) housing.

According to the township master development plan, the area is projected for future significant growth in the form of infrastructure improvements, business development, and residential areas. The corridor has its own interstate interchange, which provides ease of access to the area, nearby attractions, and services. Overall, the corridor is within an easy day's drive to Gettysburg (30 minutes), Hershey (45 minutes), Baltimore (one hour), Philadelphia (an hour and a half), Washington, DC (two hours) and New York City (three hours).

The township itself is comprised of rolling hills and farmlands, making it a primarily rural area. The township also has clusters of housing developments and private dwellings. There are numerous manufacturing and agricultural plants, such as the Land 'O Lakes Dairy, and Pittsburgh Plate and Glass Factory; however, the area is more commonly known for distribution, logistics and warehousing. Located within the township are Amazon Fulfillment Corporation, Allen Distribution, YRC Freight, Schneider National, Saia Freight, ABF Freight, Old Dominion Freight Line, and Knight Transportation. In an article published in the Patriot News, there are 96 distribution related warehouses in the local area with a storage capacity of 159 million square feet (Urie, 2019). These warehouses and distribution facilities employ approximately 15,000 people (Urie). One could easily argue that these industries are critical to the economic stability and service needs of the community, as well as a separate demand zone for the fire service.

The problem this study sought to address was determining whether gaps in fire station response times and coverage existed. There are two fire stations located in the AHJ. Station 1 (Figure 1) is in Mt Holly Springs and would take approximately eleven minutes to respond to the corridor. Station 2 (Figure 2) is in Boiling Springs and would take approximately nine minutes to respond to the corridor.



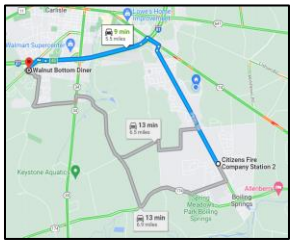


Figure 1 (Far L) Mt Holly Springs station response route. Figure 2 (L) Boiling Springs station response route.

The corridor is contractually serviced by the adjoining government borough. The two stations within the AHJ are staffed by volunteers, creating problems with minimal manning, which affects coverage and response. According to the township manager, the townships' first and most important priority is ensuring the uninterrupted delivery of public services (Adams, 2020). Without adequate fire service coverage, the area is at increased risk for loss of life, property damage, economic instability, and failure to ensure public services are delivered without interruption. There are 40 fire stations located within the county, two of which are federal stations located on military installations.

These two stations have restrictions on mutual aid, and therefore cannot be reliably counted on for services. Within Pennsylvania, 96.8% of fire stations are comprised of volunteers (U.S. Fire Administration, 2022). In Cumberland County, 100% of the fire stations are staffed by volunteers, except for the two federal stations. The nearest career (paid) fire station is in the capitol city of Harrisburg, in neighboring Dauphin County. This station is located 25.3 miles away from the corridor. It would take

approximately 28 minutes to respond without traffic. The physical location of this station presents additional nuances, whereas fire crews would be required to travel over the Susquehanna River via the George N. Wade Memorial Bridge/Interstate (I) 81, Harvey Taylor Memorial Bridge (I-83), or the Pennsylvania Turnpike (I-76). Accessing the turnpike would require traversing through the streets of the capitol city before being able to access the turnpike. Although responses may be faster using this option, it would take extra time just to access this roadway and assuming I-81 or I-83 are unusable, commuters would also revert to using the turnpike as well, creating additional traffic congestion and thus, negating this option. The bridges crossing over the rivers are locally known as bottlenecks, as numerous lanes of traffic are funneled into several smaller lanes of traffic that create gridlock. Due to these increases in traffic, it can take several minutes to cross these one-mile bridges. Once crossed, traffic is further funneled into two lanes of traffic, again creating additional congestion. Based on the time of day (morning or evening commute), the response time would be even further significantly delayed.

Like the adjoining borough, the township fire stations are staffed by volunteers; however, each station employs a paid driver. Upon notification of a call, the driver waits for the full complement of crew members to arrive before responding. The second option is, once notified, the driver responds to the scene without a crew; however, services will not be rendered until the minimum number of firefighters are physically present. This option presents a negative connotation to the public since an apparatus is on scene, but firefighting is not occurring. According to Standard 1720 of the NFPA (2020), the minimum number of firefighters needed to respond to the corridor is four. Should a

response to the UPMC occur (higher demand zone), the minimum number would increase to 15. The NFPA suggests this metric be met 90% of the time (2020). Nearby stations from adjoining jurisdictions can be called upon for assistance; however, they too are manned by volunteers and face similar response and staffing nuances. Ironically, the 2023 National Defense Act requires the Department of Defense to minimally staff each piece of apparats with four crew members before responding to a structural emergency (IAFF, 2022). Although not yet mandated in the local or private sector, it is clear such a standard could become a best practice and therefore mandated.

The AHJ was presented with courses of action (CoA) that are cost-effective and reduce risk, but also begets neighboring communities and jurisdictions abilities to develop modeling solutions having a positive and lasting effect. Fire stations also have the capability and responsibility to identify and create landing zones for aeromedical evacuations. The first and usually most notable sign that it's time to adopt a combination system is an increase in volume call (Jay, 2021). The second symptom is declining numbers in volunteers, while a third symptom is increasing diversity (more technical) in call areas. All three of these signs are evident in the two stations involved in this study.

Just as an addict must admit there is a problem before moving toward recovery, so must a department's leadership (Jester, 2021). Several questions must be posed to begin this conversation. What red flags have been identified? Has or will a failure occur? Failure to evolve before a catastrophic event occurs jeopardizes the very safety of the citizenry served (Jester, 2021). However, one must be cognizant as volunteers are a proud

breed, and the thought of adopting a combination system can be viewed as a failure rather than a natural metamorphosis (Jester, 2021).

Purpose

The purpose of this study was to determine whether gaps existed in fire station response times and coverage existed. Even with the existence of two fire stations located in the AHJ or proximity to it, information was limited regarding the risk accepted by the community and its elected officials, such as liabilities. There was limited data available concerning fire response times to the corridor portion of the township. The purpose of this study was then to provide a descriptive, qualitative assessment depicting potential gaps within the AHJ's fire response times and coverage, relating to the corridor. The major findings (gaps) were identified as (a) response metrics to the corridor using either of the two stations located within the AHJ were not capable of being achieved, (b) establishment of a new station within the corridor is not currently sustainable, (c) reliance on contractual services from an adjourning jurisdiction must continue, and (d) with declining numbers in volunteerism, consideration should be given in evaluating other staffing models (i.e., paid by call, career department, etc.). Completing this study aided in the identification of risk and development of CoA's designed to remediate, reduce, or eliminate risk while adding resiliency, economic worth, and continued growth for the township.

Summary of Data Sources and Analysis

A descriptive, risk-based approach was used. The risk methodology included a listing of likely hazards and threats one could expect to encounter within the township

(ex., flooding, accidents, etc.). This information was obtained via a right to know (RTK) filed through the AHJ. Information on fire related calls, types of incidents (structure fire, vehicle accident, etc.) was needed to obtain data and information on call dispatches and responses. A RTK request was also filed through the PA Sate Police and Local Emergency Planning Committee (LEPC). The LEPC maintains a listing of Toxic Industrial Chemicals (TIC) and Toxic Industrial Materials (TIM) located within the township that could affect fire station responses, as well as the assets needed to effectively manage a hazardous material type of event. It was during this phase where gaps were revealed. Once revealed, a risk assessment was completed to determine whether gaps were deemed to have an unacceptable level of risk. Information gathered from this study has significance in that a gap has far reaching implications affecting neighboring jurisdictions, along with ensuring the needs of the community are fulfilled. When gaps are adequately addressed, similar research models may be used to justify fiscal expenditures or similar type corrective actions.

The problem addressed was to determine if and what gaps in fire station responses and coverage existed in the AHJ as related to the corridor. The township is in one of the largest and most populated counties in Pennsylvania. It is also the fastest growing community. As such, the township expects continued and future growth to accommodate its expansion. The assets located within the corridor portion of the township are important to the community's future development and economic needs. A review of the literature and analysis indicated ample material was available relating to the research. Using a basic conceptual model, a step-by-step process was employed. This process was used to

quantify identified gaps in fire response times and coverage. The initial step consisted of completing an all-hazard threat assessment (AHTA). It was accomplished by obtaining historical data related to fire service calls to identify locations and the nature of required services. These records depict time of notification, when an apparatus departs a station, time of arrival on scene, and time services are initially rendered. This information was instrumental in ascertaining if the NFPA response standards were being met. A RTK request was filed through the AHJ to obtain these records.

A meeting was held with the county LEPC representative. The LEPC representative was the focal point for identifying hazards existing within the community. Hazards such as TIC's and TIM's storage plants, bulk storage facilities or other material(s) considered as hazardous were identified. A meeting with the township emergency manager, engineer and zoning official was also conducted to review locations on assets, infrastructure and resources traversing through the community. Information on railroads, waterways, bridges, pipelines, etc. that could be a nuance or delay in fire responses was also collected. Collectively, hazard and threat information gathered through these sources assisted in identifying initial demand zones based on the probability and severity of occurrence, as related to existing calls for fire service assistance.

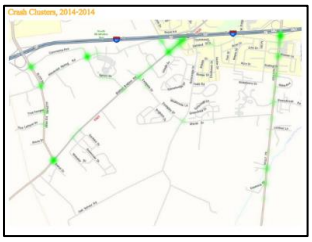
The beginning phase identified the hazards and threats local fire fighters could expect to encounter. This information was derived from open sources, the LEPC, PA State Police, and other cooperative sources. The second phase was to identify what critical infrastructure exists within the township. Meetings occurred with township

representatives to review the master development plan, along with proposed future development projects. This was significant in that it assisted in identifying demand zones.

The third phase was to conduct a capability assessment. Based on the identified hazards and threats, listing of critical assets, infrastructure, and resources, a detailed listing of fire service assets and equipment was developed to determine capability. As an example, an area may be prone to wildfires, yet they have no fire-fighting vehicles capable of traveling off-road. The logical question to then ask was do they have access to this resource through other means or perhaps an agreement with another jurisdiction, agency, or organization to use on short notice. A jurisdiction need not have all the required assets, equipment, or resources, just the identification of need and plan for obtaining the item if needed. Sharing such items is a financial best practice. This is most important during times of fiscal constraints or when costs exceed benefit or a low use requirement. Regardless, such items need to be identified and planned for, hence the capability assessment. This was completed by filing a RTK request though the AHJ to obtain a listing of on-hand, locally available, or through agreements. Once obtained, a meeting with fire service representatives was conducted to validate identified gaps, workarounds, or agreements in place to obtain any missing items.

Phase four identified vulnerabilities based on the hazards and threats, along with how they might affect the critical assets, infrastructure, or resources. This phase specifically identified gaps. In the fifth phase, initial analysis was conducted. Risk was identified along with demand zones, based on historical call records. As an example, most traffic accidents occur on the interstate that traverse through the township.

The area of interest for the study was the Walnut Bottom Corridor area of the township, as depicted in Figure 3. **Figure 1** *Study Area*



The corridor has an annual average daily traffic count of 4,745 to 6,179 vehicles (Baker, 2022). Research indicated most accidents occurred during the morning and evening commutes. It also indicated more accidents occurred on primary routes of travel versus rural routes. Therefore, the area of the interstate is a higher demand zone for medical and rescue responses, while other areas of the township may not. Likewise, this stage infers an engine response would be in higher demand for an industrial area and not on an interstate response. The demand zones, therefore, dictate which piece of fire apparatus has a higher demand for a particular geographic location within the township. If all or most assets are within a certain geographically located fire station, then a gap has been identified.

It was during this phase where most of the statistical analysis, data collection and research was performed. Initial information and data were garnered from reputable peer reviewed journals, government institutions, and township records. Interviews with personnel from the fire companies, township supervisors, and those with firsthand knowledge or a vested interest were invited to participate. Only active or former members of the two fire stations were included in discussions and interviews.

Several sessions were conducted, broken down by rank structure, such as company officers and firefighters. This permitted each group the opportunity to answer and discuss opinions without fear, rebuttal, or retribution. The goal was to identify areas of risk, gauge future infrastructure development, and identify the level of support for the fire service. Moderated discussions were the norm, using previously developed questions. Structured questions were used to keep participants focused and on-track, as participants typically desired to stray into areas they perceived as more important. Using such a model assisted in gaining buy-in from participants. At the conclusion of interviews, projective testing occurred. This type of research sought to answer questions that were purposely vague. Phrasing a question in such a manner permitted participants to voice their own conclusions. Such a methodology provides insight as to how others identify problems and their perceived solutions. This type of information was invaluable and would assist decision makers, who must consider all points of view when developing or implementing a CoA. Analysis was performed to develop statistical theories. Once data gathering and analysis was complete, initial theories were developed that affirmed or rejected the proposed research question on whether a gap exists.

Data collected, analyzed, and used were obtained from archived databases, publicly accessible records, peer reviewed literature, RTK requests, and participant interviews. The study client with the approval of the AHJ consented to this study.

In the final phase of the study, theories, recommendations, and CoA's were developed. These were presented to the client for consideration. Resources used to collect evidence include peer reviewed and scholarly works, government databases and

documents obtained through RTK requests. A risk assessment that identifies hazards and threats (H/T) affecting fire response times, identification of critical assets, infrastructure, and resources (C), and vulnerability (V) concluded in the identification of a risk level (R). Also conducted was a capability assessment that aligned equipment against identified gaps, resulting in an identified level of demand or risk. All assessments were based on a scoring method using the mathematical formula of (H/T x C x V = R).

Definitions

Accident: "An unplanned event that interrupts an activity and sometimes causes injury or damage or a chance occurrence arising from unknown causes; an unexpected happening due to carelessness, ignorance, and the like" (NFPA, 2021).

Authority Having Jurisdiction (AHJ): "An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure" (NFPA, 2021).

All-Hazard: "Any incident or event, natural or human-caused, that warrants action to protect life, property, environment, public health, or safety, and to minimize disruption of government, social, or economic activities" (NFPA, 2021).

Apparatus: "A motor-driven vehicle or group of vehicles designed and constructed for the purpose of fighting fires" (NFPA, 2021).

Arterial Road: "Serve as major centers of metropolitan areas, provide a high degree of mobility and an also provide mobility through rural areas" (U.S. Department of Transportation, n.d.).

Baby Boomer(s): Person born between 1946 and 1964 (Koltai, 2020).

Capability: “Combination of mutually reinforcing controls implemented by technical means, physical means, or procedural means” (U.S. Department of Homeland Security, 2018).

Collector Road: “Gathering traffic from local roads and funneling them to an arterial road network” (U.S. Department of Transportation, n.d.).

Course of Action (CoA): “Time-phased or situation-dependent combination of risk response measures” (National Institute of Standards and Technology, n.d.).

Criticality (C): “Determination of the ranking and priority of assets, inputs, processes, resources, services, or system components, to establish operational thresholds and recovery objectives” (U.S. Department of Homeland Security, 2018).

Engine: “A fire department pumper that has a rated capacity of 750 gallons per minute or more” (NFPA, 2021).

Expressway: “Similar to a freeway, except they are separated by some form of physical barrier and their access and egress points are limited to on and off ramp locations” (U.S. Department of Transportation, n.d.).

Fire: “A rapid oxidation process, which is a chemical reaction resulting in the evolution of light and heat in varying intensities” (NFPA, 2021).

Fire Chief: “Administrative head of the organization, assigned responsibility for management and control of all matters and concerns pertaining to the fire service organization” (NFPA, 2021).

Fire Department: “An organization providing fire suppression, rescue, and related activities” (NFPA, 2021).

Fire Fighter: “Person with knowledge and skills to function as an integral member of a fire-fighting team under direct supervision in hazardous conditions” (NFPA, 2021).

Fire Officer: “Person at the supervisory level, meeting required performance standards” (U.S. Department of Homeland Security, 2018).

Fire Police Officer: “Person officially deployed who provides scene security, directs traffic, and conducts other duties as determined by the AHJ” (NFPA, 2021).

Fire Station: “A place designated for the purpose of loading and unloading passengers, including patron service areas and ancillary spaces associated with the same structure” (NFPA, 2021).

Flood: “General and temporary condition of partial or complete inundation of a land mass due to unusual or rapid accumulation of runoff or surface waters, or overflow of inland or tidal waters” (FEMA, n.d.)

Freeway: “Similar to an expressway, this roadway connects al or nearly all urbanized areas or large urban clustered populations” (U.S. Department of Transportation, n.d.).

Generation X: Person(s) born between 1965 and 1980 (Koltai, 2020).

Generation Z: Person(s) born between 1997 and 2012 (Koltai, 2020).

Hazard (H): “A condition or a physical situation with a potential for loss or damage” (NFPA, 2021).

Highway: "Provides service for trips of moderate length, serves a geographic area, and offers connectivity to higher classification of roadways, such as expressways, freeways, or interstates" (U.S. Department of Transportation, n.d.).

Interstate (I): Designed and constructed with mobility and long-distance travel in mind. Most often consists of multiple directional lanes of traffic (U.S. Department of Transportation, n.d.).

Local Road: "Local roads not intended for use in long distance travel, except at the point of origin or destination end of the trip" (U.S. Department of Transportation, n.d.).

Millennials: Person(s) born after 1981 1964 (Koltai, 2020).

Mobile Water Supply Apparatus, Tanker, Tender: "A vehicle designed primarily for transporting (pickup, transporting, and delivering) water to fire emergency scenes to be applied by other vehicles or pumping equipment" (NFPA, 2021).

Mutual Aid Agreement (MAA): A written intergovernmental agreement between two agencies, jurisdictions, or both, that they assist one another on request by furnishing personnel, equipment, expertise, or a combination in a specified manner (NFPA, 2021).

Off-Gassing: "The event in which the cell case vents due to a rise in internal pressure of the cell" (NFPA, 2021).

Rescue Vehicle: "A special vehicle, also known as a heavy rescue or squad, equipped with tools and equipment to perform one or more types of special rescue such as building collapse, confined space, high angle, vehicle extrication, and water rescue" (NFPA, 2021).

Risk (R): "A combination of the probability and the degree of injury or damage to health in a hazardous situation" (NFPA, 2021).

Silent Generation: Person(s) born between 1925 and 1945 1964 (Koltai, 2020).

Staffing: "The number and level of training of personnel deployed on an emergency call" (NFPA, 2021).

Structure: "That which is built or constructed and limited to buildings and nonbuilding structures as defined herein" (NFPA, 2021).

Threat (T): "Natural or manmade occurrence, individual, entity, or action that has or indicates the potential to harm life, information, operations, the environment, or property" (FEMA, n.d.).

Traditionalist: Person(s) born between 1901 and 1924 1964 (Koltai, 2020).

Truck: "A common fire service term for aerial fire apparatus" (NFPA, 2021).

Vulnerability (V): "Weakness in an information system, system security procedures, internal controls, or implementation that could be exploited or triggered by a threat source" (U.S. Department of Homeland Security, 2018).

Significance

According to the corridor master development plan (Baker, M. 2020) the area is projected to have the highest population growth within the state (p.22). There are no direct routes leading to the corridor from either of the two township fire stations. Delayed response times for fire services appeared to be the norm using contractual services. The corridor portion of the township is covered by the adjoining jurisdiction. This station is geographically located in the center of its jurisdiction.

In a recent study published in Firehouse (Fitzpatrick, 2021), fire departments were provided a listing of equipment and assets and asked which (if any) items on the list they intended to purchase. According to the Fire Safety Research Institute, 73% of respondents replied they were interested in purchasing an apparatus, followed closely by the acquisition of personal protective equipment. However, 40% of respondents stated they had an interest in building a new facility (Fitzpatrick).

Older stations come with a myriad of concerns and risks. One such area is exposure to other people due to proximity. Consider for a moment most firefighters spend half of their career in a firehouse. In essence, a fire station becomes their second home. Yet older stations and sadly, some new stations still use the concept of open sleeping bays, in which multiple beds are in a dormitory style room with little or no privacy or personal space. In 2020, firefighter deaths more than doubled mostly due to COVID-19 exposures, which accounted for the largest share of firefighter deaths (Fahy & Petrillo, 2020). Except for 2021, this marks the highest firefighter death rate since the 1907's (Fahy & Petrillo). Most on-duty deaths were attributed to ground related events, such as a structure or wildland fire. One such death occurred within the AHJ in 2021. Local fire departments responded in 2020 to 1.4 million fires in the U.S. (Ahrens & Evarts, 2021). These fires caused 3,500 deaths, 15,200 reported injuries and an estimated property value damage of more than $21.9 billion dollars (p. 78). Despite these alarming numbers, many believe more can be done to better protect local firefighters. A needs assessment was recently published by the NFPA Research Institute (Messerschmidt, 2021) of the

country's fire service, who noted "little progress has been made in improving fire stations (p21)".

The area is the fastest growing community in Pennsylvania (U.S. Census Bureau, 2020). As part of this expansion and continued growth, the township has developed a master development plan for the continued and future development of the area. Most notably is the corridor; however, what is not noted was consideration/discussion on the fire service. This area contains the most geographic location of assets, businesses, and infrastructure in the township. Collectively, it contains the largest amount of tax base for the community; coupled with the nearby interstate, it has the highest call volume for area fire departments. Despite the importance of this area to the township, fire services are contractually provided by a neighboring jurisdiction since local assets and services cannot meet the NFPA response standards. As a result, the township desired a focused needs-based assessment to validate whether gaps in fire station responses or coverage existed. Assuming a gap was revealed, potential CoA's could be identified to address the finding(s).

Gaps in fire response times or coverage can result in increased costs such as insurance premiums (Fitzpatrick, 2021). In an article highlighting insurance factors, "having a fire department nearby will assist in lowering insurance rates" (Fitzpatrick). In another article discussing insurance ratings, fires are rated as the number one cause of policy claims in the country (Moraga, 2020). Insurance companies use an Insurance Services Office (ISO) rating to determine levels of risk. Ranked one through ten, with one being the best, the Boiling Springs and Borough of Carlisle stations have a rating of

one. The Mt Holly Springs station has a rating of two. In 2022, ISO was replaced by the Verisk Financial Services (VFS) rankings.

In another article discussing insurance ratings, fires are listed as the number one cause of policy claims in the country (Steele, 2016). Having a dedicated fire station in the geographic area of the corridor can lead to cost efficiencies. An additional benefit is that fire services will be available to the region, which is attractive in soliciting future business growth and housing development. Locating a fire station in this area can result in many new benefits including better coverage, decreased response times, decreased insurance premiums, and lowered risk of property damage and loss of life. Additional benefits include the township's goal of ensuring the uninterrupted delivery of public services.

Based on the type of facility design, a fire station could add additional value to the township itself in the form of public meeting space, private meeting venues, township satellite offices, and community-focused or oriented services. A properly sighted and designed facility may also add resiliency and redundancy to the community, ensuring the continued functions of government are maintained during times of crisis or disaster. This would add to the community's continuity of operations and business resiliency efforts.

Without effective fire services, the area remains at risk, costs of services remain high, future area development is curtailed, and increased revenues are negated. More importantly, the NFPA standard response metric will continue not being met. Although ad hoc conversations and discussion have occurred, no formal assessment or research has occurred as related to this study. Existing stations were built on plots of land that negate

the ability of future expansion or growth. Other jurisdictions within Pennsylvania have used a response time-only model to determine the location of a fire station. This model does not address risk, volunteer staffing models, or the type of assets needed most based on an identified demand. Previous peer reviewed and reputable studies have been conducted on the location sighting issues, most notably Erden and Coskun (2010), Savsar (2014) and Yamashita (2000)., all of whom argue for additional risk-based analysis when evaluating fire station sighting.

Summary

Adding to the benefits previously noted, there are potential long-term cost savings due to inefficiencies and avoidable compensations. A properly designed facility will most certainly include energy efficiencies such as insulation, windows and doors, sterile areas, and adequate ventilation of airborne hazards, such as off-gassing. One of the two stations in the AHJ, although grandfathered, is antiquated and fails to meet NFPA Standards. Hazards such as contaminated gear and exhaust fumes (off-gassing) from vehicles result in health care issues like cancer and other diseases. In 2020, 115 firefighters died because of cancer (Badger, 2020). This can result in lifelong payments of medical and disability benefits. Expenditures that can significantly drain an organization's budget. Energy efficiencies reduce the amount spent on utility costs and can contribute towards increased employee satisfaction.

A modernized facility that solicits and incorporates employee ideas can lead to visually idyllic improvements. Infrastructures are the most important aspect of any urban system from disasters (Uddin & Warnitchai, 2020). The urban system largely depends on

the intrinsic network of various facilities, services, and amenities, also known as urban critical infrastructure (Uddin & Warnitchai, 2020). The number and location of fire stations can significantly influence the efficiency of emergency response (Uddin & Warnitchai, 2020). In most countries, the network of fire stations has grown based on demands (Uddin & Warnitchai, 2020).

This section provided insight into the organization and problems the fire service in the AHJ is facing. The purpose was revealed, along with discussion on the data sources and analyzing that occurred. A listing of definitions has been provided for ease of understanding. Collectively, they outline the significance of the study. Section 2 follows with a focus on the strategies and methodologies that were employed throughout the study.

Section 2: Conceptual Framework and Relevant Literature

Introduction

The fire stations within the AHJ responsible for responding to the corridor have a gap in coverage. The AHJ has two volunteer-staffed fire stations. The current station locations and staffing models affect response times and coverage. Without adequate coverage and staffing, the AHJ and community are at elevated risk for loss of life and future economic instability. This section includes discussion on the concepts, models, and theories that were used to assist in informing theory and gap identification.

Literature Search Strategy

The review of literature focused on using peer reviewed, reputable sources. Information from articles, conference papers, journals, statistical information, and websites was first sought via the Walden University Library database. When information could not be obtained or was lacking, information searches were expanded to include the use of the Elton B. Stephens Company (EBSCO), Emerald, and Syskem to Administer Grants Electronically (SAGE) research sites. Further exploration was conducted using the U.S. Department of Homeland Security (DHS), U.S. Fire Administration (USFA), and similar government sites. DHS has the mission of securing the nation from the many hazards and threats the nation faces and maintains numerous databases and analysis on fire responses and issues facing the fire service. The USFA is an organization that falls under the umbrella of the DHS. Their mission is to support and strengthen fire and emergency medical services and stakeholders to prepare for, prevent, mitigate, and respond to all hazards. Like DHS, they maintain databases on fire department response

statics, trends, and issues. Also included were government sponsored or supported think tanks, such as Battelle Memorial Institute and the RAND Corporation. Battelle's focus is on scientific discovery and technological advances that benefit society through education, discovery, and innovation. RAND is a research organization that develops solutions to public policy challenges to assist in making communities safer and more secure.

Collectively, these thinktanks publish a large volume of data on assessments, analysis, and studies. The use of popular search engines, such as Google or Bing, was mostly avoided. When information from these sources was obtained, every effort was made to vet and verify the information before being used in this study. General search terms such as *fire station response* and *fire station coverage* were initially used to delimit the amount of data returned. Later in the research, searches were expanded to include terms like *volunteer fireman staffing*. Statistical information was obtained via RTK requests, historical records, and web-based sources such as the National Institutes of Standards and Technology (NIST) and the U.S. Census Bureau. These services provide quantifiable information through scientific studies. I found no literature directly linked to the fire service as related to response or coverage in the AHJ; however, ample material was found as related to the research question in general.

I reviewed existing literature to identify themes and trends with a nexus to NFPA 1720. I consulted with SME at all levels in the fire service, past and present. Interviews focused primarily on problem solving, gaining perspective, and gathering data to inform this study. Also evaluated was information maintained by the Walden University Library and previously published dissertations. Going back twenty-five years altogether, I mainly

tried to limit the literature to the past ten years to be more current and more relevant. Collectively, the sources used combined with the literature was invaluable to the study and its positive societal implications. One element revealed as part of the literature review and analysis is that additional research on the subject is warranted.

Conceptual Framework

The research question posed was to determine whether gaps existed within the AHJ's fire station responses times and coverage as related to the corridor. A conceptual approach was used incorporating the following.

Table 1 *Conceptual Framework Model*

Concepts	Question
All-Hazards Threats	What fire hazards or threats exist in the community?
Criticality	What infrastructure or key resources are in the community?
Capability	What assets does the community have?
Vulnerability	What are the gaps to be filled?
Analysis	What fire-related hazards or threats exist in the community?
Risk	Identify risk and demand zones.
Recommendations	What are the potential CoAs?

The AHTA was conducted in partnership with the AHJ to identify what hazards and threats existed in the community that would affect fire station response times and coverage. Findings were ranked based on probability and severity of occurrence. The next step was to conduct a critical assessment. This step involved the identification of assets and infrastructure the AHJ deemed important. It was also rank ordered based on the importance to the township's ability to achieve its goals and missions. The third step was to conduct a capability assessment. This step involved obtaining a listing of assets and resources available at the fire stations, and then measuring these inventories against

the NFPA recommended assets and resource listing a volunteer fire station should possess. This step was key in identifying potential shortfalls, as well as identifying the agreements and relationships the two fire stations had with neighboring jurisdictions. The fourth step was to conduct a vulnerability assessment. This step sought to identify what assets, equipment, infrastructure, and resources were vulnerable or lacking based on the identified hazards and threats. Assuming a finding was noted, analysis was conducted to determine if the finding could be eliminated, mitigated, or remediated. The analysis step also served as a risk assessment for the AHJ. The final step of this process was to develop recommendations on those findings, resulting in the assumption of risk.

Literature Review for the Study

The primary goal in this section was to gain insight into what methodologies, insights, and inquiries have previously been conducted as related to fire station coverage and response times. Delimiting the review, only scholarly, peer-reviewed, single source analysis was performed. Primary analysis focused on the research findings themselves, as opposed to the methods that were employed. This approach assisted in informing previously identified outcomes that are applicable to this study, thus aligning theory to application.

This section includes a summation of the literature that was reviewed, relevant analysis, synthesis, and significance as related to this study. For ease in understanding, it is sub-divided into several categorical sections, and concludes with a chapter summary. The review of literature is divided into six areas with its primary focus being on NFPA 1720.

Numerous fire departments and municipal jurisdictions throughout the U.S. are facing the difficult decision of having to evaluate their emergency services. Such decisions are based primarily on either financial or human capitol shortfalls. The constant theme throughout the literature is a rapid response is desired to increase the safety and health of the community being served. Yet the underlying question not being asked is why or what is the relationship between an expedited response and the positive consequences associated with it? The generally accepted theory is that a faster response to a scene, results in decreased loss of life and property damage. Why? In this section, consideration is given to previous assessments, studies, theories, planning efforts, results, and CoA's that were developed to address similar problems facing the fire service.

Staffing

Short staffing is a reality fire department across the nation struggle with daily (Adams, 2021). It is well documented that volunteerism in the fire service has declined dramatically. Since 2015, the number of volunteers has shrunk by approximately 16% (Finger, 2016), whereas volunteers comprise roughly 67% of our nation's fire service. The National Volunteer Fire Council reports volunteer firefighter numbers for 2017 and 2019 are the lowest recorded levels since the NFPA began compiling such data (Rheaume, 2020). The number has declined from roughly 300,000 volunteers during the 1970s to approximately 38,000 in 2018, (Cress, 2022). While the number of volunteers continues to decline, the number of calls has increased. In 2018, 363,000 home structure fires were reported resulting in 2,720 deaths, an increase of 3% (Cress). A recent survey asked respondents about their staffing during a 3–5-year period. Of these, 50% reported a

decline in volunteer staffing, while 28% reported no change and 22% reporting an increase (Firehouse, 2020).

Compounding the staffing issue due to declining numbers of volunteers are the effects on response and coverage. It's hard to get a consistent response with the limited number of qualified staff. On average, there are seven to ten members per call. It's affecting stations locally to the point where there's a core group of people doing the bulk of the work (Cress, 2022). Such thoughts were reinforced by members of the AHJ, who stated "in years past we turned away volunteers who wanted to go out on a call, while today, we have to wait just to fill the minimum staffing" (Cress). It is only a matter of time before staffing becomes unsustainable due to employee burnout.

Adding to the staffing shortages are the additional requirements being levied on the fire service. As building materials and vehicles evolve, along with the required skill sets, so too must the fire service. Single engine apparatus and ladder trucks have morphed into heavy rescue and hazardous material operation platforms. Responses have become more technical (high-rise & electric vehicles) in nature, creating demands for such vehicles and increased proficiency training. In short, the bygone era of rescuing a kitten from a tree has been replaced by more complex responses and rescues. Fire service missions continue to evolve, and departments have truly become all-hazard service providers (Matthews, 2022).

As an example, during the pandemic, some fire stations were used as either COVID testing or vaccination sites, despite the ongoing staffing nuances. What is clear throughout the literature is that the concept of future proofing should be implemented at

every level and at every location associated with the fire service. There was a 6% decrease in volunteer firefighters in 2020, the lowest number of volunteers reported over a ten-year period (Fahy et al., 2022). Due to such declines, volunteer fire stations themselves declined by 10%, from 26,797 to 24,208; such declines mostly occurred in small rural areas serving a population of less than 25,000 (Fahy et al., 2022). Such trends are alarming and can have a negative effect on the communities being served.

Stations

Forty-three percent of fire stations in the U.S. are at least 40 years old, with an estimated $70 to $100 billion cost to repair (Delay, 2022). Fire stations built before 1981 are more likely to have problems that cannot be addressed through repairs or renovations. A large portion of the literature related to fire station response studies focuses on the locations of stations themselves and proximity to their demand zones. Such a methodology is centrist to protection of people and property via an expeditated response; however, the literature reveals it is not as simple as designing and building a station for a jurisdiction's future or continued use. As cities grow and change, facility locations that were optimal when first chosen later to become obsolete and suboptimal, and must be revised periodically (Perez et al., 2015).

Station 2 (Boiling Springs) first opened its doors in 1910 as part of the Walnut St. garage. It remained in operation until 1922 when it relocated to 204 Third St. In 1976, a new station was built and has been in operation ever since. Station 1 (Mt Holly) has a more vibrant history. It operated out of a locally purchased garage on Pine St. from 1911 to 1966. In 1966, the station was moved to an abandoned schoolhouse located at 100

Chestnut St. This station has been modified (never renovated) multiple times over the years to accommodate its missions and requirements. Simply put, it has outgrown its mission and needs extensive renovations and upgrades to meet the demands of the future. The station itself is ill designed, not conducive to fire operations and adds risk to assigned firefighters. During an interview with one of the fire station chiefs it was noted there was mold in the basement and that structural cracks were evident.

A best practice for an efficient facility that lowers risk to its occupants should include a ventilation system to discard off gassing by venting fumes exterior to the facility. A decontamination room should be established as a pass through before entering a clean common area. Such a design keeps firefighters free of toxins they confront while on the job (Petrillo, 2021). Given the area's projected growth, a new station would be a timely addition to the community. But despite this opinion, public emergency services have remained relatively unchanged, including the location of ambulances and firefighting equipment (Perez, et al. 2015). As the demand for services and the expectation for rapid responses increase, so too has the complexity of demand, type of fire vehicles being employed, and construction material used and design of modern structures. Like the fire service itself and the requirement for continual evaluation of station locations and response metrics, consideration must also be given to the evolution and need for advanced fire apparatus that is based on need. Versus a station with multiple assets and apparatus, newer versions of fire vehicles are becoming more multi-purpose and able to respond to a variety of different events. Consider for a moment, one of the

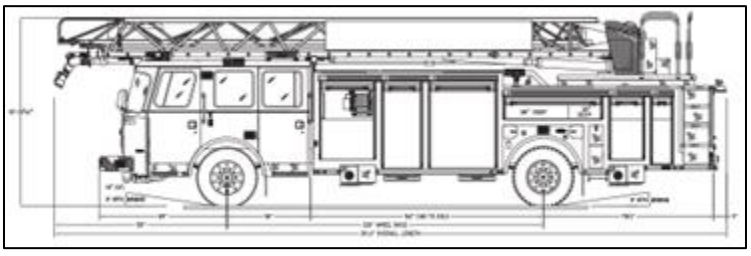
first fire vehicles in the area was a 1929 American-LaFrance Fire Truck, which weighs approximately 2 tons.

Figure 2 *1929 American-LaFrance Fire Truck*

Now imagine the footprint for a 2017 Pierce Velocity Aerial Platform, the newest edition to the area fire service (*image 6*). This vehicle weighs approximately twenty-five tons. In comparison, earlier vehicles on average needed about 80 square feet of floor space while newer vehicles require on average approximately 400 square feet.

Figure 3 *2017 Pierce Velocity Aerial Platform*

Figure 4 *Pierce Schematics*



Additionally, due to weight, floor hardening is also required. A modern fire vehicle placed in an antiquated station would more than likely result in floor cracking and

structural damage. And as previously noted, repairs or renovations would not be cost effective. This was the case in New Philadelphia, Ohio, when a new station had to be built to house the modern apparatus being employed by the city (Nancy, 2017). The antiquated station, built in 1906 was no longer capable of housing these 20-ton vehicles, with cracks and structural damage evident throughout the facility. But the underlying issue here is the requirement for advanced training on these modern apparatuses, technological advancements, and already depleted staffing levels. In short, we are asking more and more from our volunteer firefighter force whose numbers continue to decline. So bad are the staffing numbers, some departments are considering outsourcing services. One such nearby department is now facing this realization and is seriously considering its ramifications and benefits. The decision was based on dwindling volunteer numbers but also on the station's inability to meet NFPA standards. Before implementing the outsourcing process, a jurisdiction must first consider its advantages and risks. Namely, what are the financial benefits and implications. It was noted that on average, 70% to 75% of a fire department's cost is aligned against personnel (Murphy, 2010). These numbers are significant, in that jurisdiction's most costly long-term expense is the payment of benefits and entitlements.

Joint Use Facilities

Throughout the literature, there is a growing trend in the use of joint use facilities. Facilities that house a fire station along with other functions, such as offices, meeting, and training spaces. Such a design can create operational synergies through increased sharing of assets, information, and resources. Improved networking and collaboration can

occur as participants are in proximity with one another, versus only meeting when an in-person need, or incident occurs. Increased training and planning efforts are possible along with cost efficiencies. Often, larger projects (joint use facility) attract more competitive bids, result in better land management, and reduced government real estate footprints (Healy and Carter, 2020). Additional savings can arise from reduced budget expenditures by not duplicating efforts. However, with only expansion in mind, facilities are constructed without cooperative planning (Dickerson, 2010). Often heard or noted in numerous articles are comments or statements such as "we are operating in tough economic times." It is during these times or when such statements are made that public safety services come under intense scrutiny. One must therefore inquire as to what is in the best interest of the community. Paramount should be discussion on benefit versus cost (Dickerson, 2010.), even though the very concept of consolidation or some other change to the fire service are perceived as evil. Along these lines, the procurement of assets, equipment or other resources can quickly erode a jurisdiction's budget. Although there are numerous types of fire apparatus, a fire engine can cost between $300,000 and $1.5 million dollars (Pertz, 2023). Such costs validate the effectiveness and need for Mutual Aid Agreements (MAA) that result in significant savings while ensuring reliable and effective emergency services are available to the community. The sharing of assets and resources according to the Federal Emergency Management Agency (FEMA) is a best practice. Hence, mutual aid agreements are not only a viable and reliable means of ensuring emergency services remain available, but also a significant cost savings through the sharing of assets and resources. And with only expansion in mind, fire stations are

constructed without cooperative planning (Dickerson, 2010). Coordinating projects can assist in reducing fiscal expenditures since duplication of effort is negated. Since the inception of the professional fire service, firefighters have bragged about the size of their departments, number assigned and the amount or type of apparatus and equipment available to them. While such statements make all involved proud, the questions that should be posed are what capabilities we have that can support our community and what is in the best financial interests of those we serve. The phenomenon that perpetuates the former mindset is that tradition incessantly interferes with common sense. The goal should be the mitigation of risk, not the building of an empire. Newly constructed facilities, in addition to fire services, should consider other values and opportunities. Fire related facilities must stand and continue to be ready to play essential roles in their community (Sweet, 2022). The core mission of the fire service is to protect customers and the community from the threat of and significance of unplanned and uncontrolled events (Daley, 2022). Based on these types of comments, opinions and statements, a need to re-evaluate not just response models and metrics or the ethos of getting to the fire as quickly as possible, but rather facility designs that enhance one's ability to respond as expeditiously as feasible. As noted in the literature a properly designed station can afford opportunities for increased operational capabilities such as command centers, emergency operations centers, public information centers, and jurisdictional redundancy in the form of an alternate location of a government office. Such facilities have the potential of offering cost efficiencies through better design, energy savings, reduction of risk(s) through off-gassing, potential contamination, and increased opportunities for the

generation of revenue through meeting and training spaces, which would be available for corporate or public use based on fees. Such a concept increases the interaction between fire service personnel and the public, creating increased awareness and levels of trust. It was revealed through the literature there are dissenting opinions to such designs. When it comes to making changes in the fire service, it is usually met with resistance and discord. Most deterrents come from traditions, firehouse culture and/or the acceptance of that's the way things have always been done (Daley, 2022). When one speaks to "that's how it's been done," it's called tradition – the thoughts, beliefs and actions that are carried from the past (Wilders, 2022). Designed, planned, or newly constructed fire stations have incorporated features that address long term risk concerns, increased insurance costs and the payment of benefits. Off gassing, and cross contamination of gear for example can lead to cancer, breathing problems or other long term medical conditions. Building codes and standards for modern facilities address these issues through proper analysis and facility layout, such as separate apparatus bays, dining/day rooms, office spaces, restrooms, exercise areas, locker rooms, storage areas, etc. (Petrillo, 2021). More importantly, however, modern fire facilities address contamination and other hazards, by separating dirty areas from clean areas and incorporating spaces that mitigate potentially contaminated items from being introduced into clean areas, as well as providing space for decontamination, thereby, increasing safety and addressing the issues insurance, medical concerns, or potential payments of long-term disability benefits. In essence, these properly thought-out designed facilities address risk and more specifically, they lower levels of risk. It's an obligation to remember that risk has a first and last name and that

every strategy and tactic has a risk or cost associated with it. For every name, there is a family, a company and a community that ties back (Wilders, 2022). Regardless of the theories outlined in the literature or the opinions of those involved in this study, both fire stations located within the AHJ lack a sufficient footprint needed for expansion.

Modeling and Metrics

In addition to issues revolving around staffing and station designs, another area affecting the research question is meeting the intent and recommendations for fire response metrics. History tells us the first published edition of NFPA 1720 was in 2001. This initial version was the first attempt at defining fire department response standards for volunteer staffed stations. Coupled with the metrics associated with this standard, stations and fire department leaders were able to clearly articulate the assumption of risk being assumed by the fire service, as well as community leaders. The initial versions of the NFPA made it clear, different standards were needed between a paid station and a volunteer staffed station. In 2004, the second version of NFPA 1720 was published, creating for the first-time quantifiable metrics associated by the type of response as well as demand zones (*see table 2*). As regards the corridor itself, the standard calls for a minimum staffing of 15 within nine minutes of notification, 90% of the time. However, a demand is considered covered if and only if there exists at least one available unit within a specified distance or travel time of its location (Batta and Mannur).

Table 2 *NFPA Staffing and Response Timetable*

Demand Zone *	Demographics	Minimum Staffing to Respond **	Response Time (minutes)***	Meets Objective
Urban Area	1,000+ people per sq. mi.	15	9	90%
Suburban Area	500-1,000 people per sq. mi.	10	10	80%

Rural Area	500 people per sq. mi.	6	14	80%
Remote Area	Travel distance > 8 mi.	4	Depends on travel distance	90%
Special Risks	Determined by AHJ	Determined by AHJ	Determined by AHJ	90%

Note: * Jurisdiction can have more than one demand zone. ** Minimum staffing includes members who respond from the AHJ's department and automatic aid. *** Response time begins upon completion of the dispatch notification and ends at the time interval that's shown in the table

As a point of clarification, the above table is based on a low-hazard level of occupancy such as a 200 square foot, two-story, single-family dwelling. For a larger facility, such as the UPMC Carlisle Regional Medical Center located within the corridor, then a different risk hazard and risk level would be applied. In the 2020 update to the standard, the definition of a volunteer staffed station was changed to better reflect how a volunteer department is manned. A large portion of jurisdictions have a paid driver, whereas most fire personnel are volunteers. The primary change to the 2020 version states a department shall be comprised of at least 85% unpaid to be classified as a volunteer staffed department. The update also incorporated section A.3.3.16.2 (volunteer fire department) into the standard, which permits payment for part-time and on-call members. Such a change was needed to address the continuing volunteer shortages throughout the nation where a member loses wages while away from their primary place of employment. Ultimately, the goal of standard 1720 is to increase the likelihood of the arrival of the first-due unit prior to a flashover (Sohyda, 2021). Expanding on the metrics, modeling is another key factor aligned to the fire service. Some form of quantitative analysis is needed to definitively answer whether existing metrics can be met in accordance with (IAW) the NFPA response metrics. Tangible and intangible criteria that are unique to a given problem is recommended (Badri et al., 1998). Traditional models

mostly address only travel times or travel distances. Such a methodology is flawed as it fails to consider risks or demands. An optimal solution should therefore minimize the sum of losses resulting from a fire while maximizing services and cost efficiencies. In the corporate sector, decision models have changed, arguably for the better. However, the fire service remains focused on response and travel times. Initial models assumed a fire station would almost always be available when a call comes in. Increased demands and the need for more technical services led to redundant coverage demands through multiple stations, known as location, set covering (Badri et al., 1998). One such study by Larson (1974, 1975) used output measures such as vehicle utilization and average response time. Using this method of analysis results in a model that not only validates the type of apparatus and associated response times but optimizes the theory of demand zones and what type of resource is needed most based on a need. Minimizing response and travel times are important, but more vital is getting the right asset to the scene as quickly as possible to save life and property. The literature has revealed a potential nuance, in that not often considered during analysis was the type of fire or its involvement (i.e., contained to first floor, fully involved, etc.). The NFPA assigns involvement levels as (1) confined to object of origin, (2) confined to room of origin, (3) confined to floor of origin, (4) confined to building of origin, and (5) spread beyond building of origin. Again, the size and type of fire were often not considered. Addressing these nuances, a Monte-Carlo type simulation would be useful; however, such analysis is beyond the scope or purpose of this study.

General

Several takeaways are worth noting. In the fire service, consolidation is an evil word. A question one must ask is to determine what the legal ramifications for a jurisdiction are which curtails its fire service. There is no simple or consensus answer, hence additional research is warranted. A fire station supports the needs of the community (Badri et al., 1998). The location of a facility is largely driven by the need to minimize response times. The primary function of a fire station (not counting housing or assets) is therefore to ensure internal response times can be met in accordance with (IAW) the NFPA standards. As fire stations represent a considerable municipal investment, they should be planned to offer long-term services and value to the community (Catay, 2011). Before any new station is considered, additional analysis is needed as to what services would be provided, what is the increased value to the community, and where is the best location to accomplish the fire service mission(s). Likewise, prior to approval on new construction, the fire service should be consulted to ensure timely response and access can be achieved. valuable and complete data is available throughout the literature. The fire service and NFPA specifically, have quantified data by providing definitions and metrics to be used to determine risk.

Conclusions

Throughout the literature, what has become abundantly evident is that an assessment of the performance of current fire staffing and response efforts, identification of areas in need, and the evaluation of risk is warranted. Increased call volumes and longer travel distances, coupled with more shifts employing minimum levels of staffing,

impose an increased risk of not having sufficient resources available to answer a call. The AHJ is concerned about the level of services it provides and is interested in identifying ways to maintain an acceptable service level. Existing studies primarily focused on locations, time and distance traveled, but often failed to consider availability of manning, type of infrastructure involved, or the resulting consequences associated with risk. Questions such as can a station respond without certified, trained or the minimum number of personnel were not considered. Can a station perform its mission or fight a fire without a nearby water source? One should consider how services are rendered when an apparatus fails. How do these performance indicators affect such models and what are the second and third term effects of such failures? The most important requirement that characterizes firefighting services, designed to provide protection of people and property is the need of a rapid response and the simultaneous use of differing types of vehicles (Perez, 2015). Despite such revelations or theories, public emergency services have remained relatively unchanged, including the location of fire stations based strictly upon a location. If increased life safety and the reduction of property losses are the goal, then perhaps staffing and response efforts are not the only areas of efficiency that should be considered. Efforts such as prevention, public education or perhaps code enforcement could assist in reducing loss of life and damage to property. These mitigating programs can be used in advocating for a for a joint use facility, whereas community training, education and modern meeting spaces are conducive to learning and educational efforts. The result is increased awareness of hazards, effective CoA's that can be implemented to combat hazards, coupled with fire station response and staffing efforts can result in a

joint community – fire service effort to mitigate loss. It is clear; however, additional studies on this important issue are necessary before a reliable, general relationship is established (Halpern, Isherwood, and Wand, 1979). So serious is this relationship, the NFPA created performance objectives and standards to quantify risk. Expanding on the theory that faster responses can lower loss of life or property damage, such statements are now aligned against quantifiable factual analysis. Instead of we need to get to the fire as quickly as possible to minimize losses, the question of why is now answered. The longer a fire burns, the more fuel it has (combustible materials), the greater its effects become more evident. If a house fire is reported and an engine arrives on scene quickly, contains and extinguishes the fire, then its effects are limited. If a delay in response and firefighter occurs, the fire could quickly spread throughout the residence, resulting in increased damage and losses. Therefore, the proven correlation is that the faster an apparatus can arrive on the scene of an emergency, the faster services can be rendered, and therefore, risk is reduced. This is the metric that should be employed as evidenced throughout the literature. What has been revealed to be true based on reputable peer reviews is that longer response times are directly tied to increased losses due to a fire having the ability to grow. Decreased response times can result in increased property damage and financial costs. And larger fires increase the risk to firefighters and therefore, the community. It is estimated 80% of calls are medical related. Therefore, 21st century stations should consider how best to address this statistic, but also how to staff, man and equip the emergency medical services arm of public safety. In stark contrast to firefighters, only 13% of EMS members were volunteers (Cash, Rivard, Chrzan, Mercer, Camargo, and

Panchal, 2020). As a sidebar, Emergency Medical Services (EMS) was not part of this study.

Considerations

Some literature, outlining a variety of theories and rationales included discussion of joint use facilities. Although there was no universal definition of what constitutes a joint use facility, most discussion centered on co-locating a fire station with a police department or other agency. Other examples included incorporating local government functions, such as a tax collection office, water department, mayor's office, etc. Such a model was mainly applicable to large metropolitan areas whereas citizens had to traverse greater distances to access public services, or jurisdictions having access to greater financial resources. Although there is a trend towards joint use facilities, no best practices were revealed in advocating for or against such a model, but rather a pro versus con approach that serves in the best interest of the specific community involved. Healy and Carter, 2010) believe combining traditional fire stations with other facilities (government offices, community rooms, etc.) create operational synergy, long-term cost savings, and better use of land management that decreases government and public safety footprints in the community they serve. They also note large construction projects attract competitive bids that can result in cost savings. The DHS maintains a library of lessons learned and best practices. Here, they maintain local governments must have plans for maintaining critical services during incidents that threaten to disrupt normal operations. Jurisdictions must be prepared to continue their operational missions throughout the full spectrum of hazards and threats, while maintaining redundancy and resiliency. As communities grow

and demographics change, it may become necessary to replace existing stations or add more stations to satisfy the increasing needs of emergency services (Catay, 2011). This may be the case as highlighted; however, such models are neither practical nor financially feasible for the AHJ. The community is smaller, a levy or increase in taxes would be necessary, and a new station located in the corridor itself cannot be sustained using the current volunteer staffing model.

Nuances

Among the nuances noted throughout the literature was the surprising revelation of volunteers by generation. Of the generally accepted six generations, it was noted the current generation (millennials) were highly likely to volunteer; however, their preferred method of volunteerism was in the form of financial donations (70%) versus time (28%). From least likely to most likely was the Traditionalist Generation (1901-1924) at 14%, the Silent Generation (1925-1945) at 25%, Generation Z (1997-2012) at 26%, Millennials (1981 to present) at 28%, Baby Boomers (1946-1964) at 31%, and Generation X (1965-1980) at 36%. Such statistics are significant as related to the study in that the fire service in the AHJ relies almost exclusively on volunteers. It was generally known if a volunteer has a family history in the fire service (father, uncle, etc. were firefighters) then they are more likely to volunteer themselves. I was unable to locate a quantifiable statistic or scholarly study that correlates this assumption on generational volunteerism. Likewise, I was unable to locate definitive analysis on the odds of a person volunteering if a member of their family previously volunteered. Within the AHJ, this percentage is greater than 75%; however, additional research would be needed to define a specific percentage.

Looking at the demographic information related to the study, it is the Millennials and older generations that reside in the corridor. These demographics are not typically known for volunteering their time or services, rendering the possibility of a new or satellite station in the corridor unsustainable. Compared to the existing station locations, they have a somewhat stronger pool of volunteers willing to render their time and services.

Summary

The aim of the study was not to develop a location or sighting model, but rather, to determine if fire response standards could be improved with an expansion of services. Factors informing such considerations included functional missions, jurisdictional demographics, response options, infrastructure, geographic functionality, probability, and severity of occurrences. The focus throughout the literature was on NFPA 1720. The review was categorized into six basic paragraphs (staffing, stations, joint use facilities, modeling & metrics, general, conclusions, considerations, and nuances). During the review, the research problem was used to guide and inform theory, reduce risk, and assist in developing effective and efficient CoA's. Additional gaps and nuances were identified, further quantifying the need for additional research. The literature was transparent in that a fire station supports the needs of the community they are in and chartered to serve and are primarily sighted to offer the fastest response times to the areas they are responsible for covering.

Section 3: Data Collection Process and Analysis

Introduction

The research problem posed was to determine whether gaps existed within the AHJ's response times and coverage as related to the corridor. In this section, the practice-focused research question and research design, roles of the researcher (recruitment & participants), methodology, strategy for data analysis, issues of trustworthiness, ethical procedures, will be presented. This section concludes with a summary of the information presented.

Practice-Focused Research Question(s) and Research Design

The purpose of the study was to determine what (if any) gaps exist in a specific township's fire station responses and coverage within the corridor. Information was limited as to the amount of risk assumed by the AHJ. Limited information on response times to the corridor portion of the township was available. Few studies have been conducted on the township's fire services program, resulting in a gap in knowledge and statistical information. As a result, identification of demand zones and community needs was incomplete. Existing stations were either antiquated or required modifications. As an example, one station is an old schoolhouse that is no longer capable of expansion or upgrade. Although grandfathered, this station fails to meet existing NFPA standards. As such, metrics, strategies, and capabilities to address gaps were lacking. Completing such a study assists in the identification of risk and development of CoA's to address findings. Information from the study can also aid in adding resiliency, economic worth, and future growth for the community.

Roles of the Researcher

Leading up to this study, I had no professional or personal relationship with the AHJ or client organization, other than residing in the community being studied. My role was to conduct an assessment for the client organization to determine if gaps in fire station response times or coverage existed. Once a gap was identified, CoA's were developed. I have a laymen's knowledge of the fire service and was previously a law enforcement officer who had extensive interactions with members of the fire service during responses, operations, and events. My current employment is a member of a public safety organization in an adjacent county, which includes the fire department, and is under federal jurisdiction versus the client, which falls under local government jurisdiction. As such, there was no undue influence or interaction between these fire stations or their assigned personnel. No member of my organization was consulted.

During the initial meeting with the AHJ, it was the client organization who broached the concept of evaluating fire response times and coverage, as they had future thoughts related to expansion in the corridor. No biases or conflicts of interest were anticipated or encountered, as I had no preconceived thoughts or knowledge of the fire service or their capabilities. I acknowledge it was difficult to evaluate response options without first understanding the issues associated with volunteer staffing. Study participants and I had differing levels of understanding, as related to the fire service. Once these bridges in knowledge were crossed, a level of trust was established resulting in any biases being negated. The following two paragraphs discuss the methodology used

in conducting the study, as well as the procedures used during the recruitment and selection process, along with the selection and use of participants.

Recruitment

After submission to and receiving approval and concurrence from Walden University's Institutional Review Board (IRB), I contacted the client organization to seek authorization to use the AHJ's facilities and personnel to conduct interviews. A written authorization was provided by the AHJ. Once received, three flyers were disseminated. One flyer sought participation from township officials, while the second was posted in the two township fire stations to solicit interviews from the respective fire chiefs and officers. A third flyer was posted in each of the two township fire stations, soliciting interviews from the firefighters themselves. All interviews were conducted on a volunteer basis without compensation. Only interviews with members previously or presently employed in the fire service, 18 years of age or older were conducted. No participant volunteering to complete an interview was denied an opportunity to participate. No undue influence from township officials, fire chiefs, or fire officers was observed. Those willing to participate were scheduled for one-on-one interviews, which consisted of a pre-developed questionnaire. Participants' personal identities or descriptors were kept confidential. Questions asked were designed to elicit responses that revealed issues and potential solutions that could aid in identifying gaps and developing corrective CoA's.

Participants

Participants for the study were solicited from the township and fire service. From the township, only township officers (emergence manager, zoning officer, township

engineer) were sought, as they had the most knowledge, interaction, and effect of the fire service. Each was presented with a statement of informed consent. Participants were advised that the interview was voluntary, and that no form of compensation was offered. After acknowledging and signing, they were asked a series of pre-scripted questions. At the conclusion of the interview, participants were provided with an opportunity to expound on any issue or question that was presented, as well as general discussion on the study itself. Participants were offered copies of the informed consent and interview questions; all declined.

The second category of participants was the fire chiefs and fire officers. Like the township officers, each was sought as they had the most knowledge of the fire service and the issues being researched. Each was presented with a statement of informed consent. They were advised the interview was voluntary, and that no form of compensation was being offered. After acknowledging and signing, they were asked a series of pre-scripted questions. At the conclusion of the interview, participants were provided with an opportunity to expand on any issue or question discussed, as well as any thoughts or ideas in general related to the study. Participants were offered copies of the informed consent and interview questions, which they declined.

The last category of personnel interviewed was with the firefighters themselves. The same process used by the township officials, fire chiefs, and fire officers was used. Like those previously noted, none of the firefighters desired copies of the questions or informed consent.

The three groups of participants were identified and segregated by category to mitigate any undue influence by a higher level of involvement from a different category of participation. This process also ensured participant confidentiality and mitigated the potential influence of one category of participant over another. Only participants 18 years of age or higher were selected. The only exclusion criteria were that participants had to be former or active members of the township or fire service.

Methodology

All interviews were conducted in a face-to-face, one-on-one setting. Written authorization was sought and received from the AHJ to use the participants' place of work and time while conducting the interviews. Each interview lasted between 30 and 45 minutes in duration. As noted previously, all questions were pre-scripted prior to the interview. All interviews were documented and recorded. As noted in previous sections, solicitation was accomplished by posting flyers seeking volunteers, along with word of mouth within each station. I had no interaction with or knowledge of the participants beforehand. All flyers, pre-scripted questions, and authorizations were provided to the Walden University IRB, who authorized the research to begin. In addition to being advised of the informed consent and participating in a verbal interview, I strived to be respectful of each person's time commitment by limiting the interview to one-hour or less. In most cases, the interview concludes in 30 to 45 minutes. The CoA's recommendations were presented to the client organization in the township administrative building. The Township Chief of Emergency Services and the Township Manager represented the client organization.

Strategy for Data Analysis

I used a risk-management methodology for conducting the study. This process consisted of conducting an AHTA. This step involved identifying the hazards and threats the fire service could expect to encounter. Information was obtained via RTK requests and SME consultations. Conversations with Township officials, LEPC and other interested parties occurred to assist in the identification of the hazards and threats. Once the listing was developed, a numerical score was assigned to each that weighed the probability and severity of occurrence. Once scored, they were ranked with the highest numerical score being listed as one, while lower scores were listed in succeeding order. The second step consisted of performing a criticality assessment. This step involved the identification of assets and infrastructure located within the AHJ that were deemed to be important. Included in this step was the development of a capability assessment, whereas a listing of apparatus and equipment was identified. This step was instrumental in aligning an asset against a need. In doing so, gaps were identified. However, before a true gap could be quantified, verification was conducted to determine if an asset was available and could be obtained through other means, such as contractual services or Mutual Aid Agreements (MAA). The next step was conducting a vulnerability assessment. This step determined how the critical assets and functions were vulnerable based on the identified hazards and threats. It was during this step where gaps were identified. Analysis and additional research were then conducted resulting in a risk assessment which assisted in developing recommended CoA's designed to remediate, mitigate, or eliminate identified levels of residual risk. Also performed were interviews with interested parties and

SME's. Questionnaires were developed with pre-scripted questions using Likert Scales, multiple choice (yes, no, or no opinion), and open-ended interviewing techniques.

Issues of Trustworthiness

Throughout the study, any analysis, conclusions, data, or information gathered, regardless of source was fact checked using peer reviewed reputable sources to ensure its accuracy. Despite these efforts, some judgements and interpretations had to be made. In these situations, personal opinions or pre-judgements were set aside, only using factual or source-based information. If a data point could not be verified or it was based on an opinion or hearsay, it was excluded from the final study, unless verified. Such a methodology ensured the information, recommendations and CoA's remain trustworthy. Validity and trustworthiness were maintained by ensuring ethical standards, conduct, and personal professional accountability was implemented throughout the PAS process. All discussions and interactions were conducted in a transparent, private, and systematic manner.

Ethical Procedures

All efforts were made to ensure ethical standards were maintained throughout the study. Discussions were conducted in secure settings to ensure the privacy of participants. Pre-scripted questions were used to guide discussions which assisted in avoidance of straying into other irrelevant or side-bar topics. Participants were advised and acknowledged the concept of informed consent. They were advised of the purpose of the study and what information was being sought to remain as transparent as possible. The researcher ensured their personal appearance was above reproach, yet casual. This

ensured a professional demeanor and setting was established when interacting with participants. Researchers remained focused throughout the study, especially when interacting with participants by instituting procedures that ensured honesty and trustfulness. This allowed participants to gain a level of trust and therefore, be open to dialog and discussion. All efforts were made to be on time for all scheduled appointments, interviews, or meetings. Researchers remained professional, shying away from personal relationships, storytelling, etc., instead, focusing on the topic at hand. No person volunteering their time was excluded from participating. Researchers ensured all appointments were kept as agreed upon and scheduled. Employing such measures ensured respect for the participants' time, interactions, and opinions.

Prior to beginning any interview, participants were advised of informed consent and that all interactions were voluntary and conducted without compensation. Participants were advised they could withdraw from the study at any time. Participants were advised that any material or notes collected would be stored securely and not shared with other participants or members of the participants organization, ensuring member-checking or other spillage of information was avoided. Researcher conducted all interviews on dates and times suggested by participants that were beneficial to them versus the researcher. Ample time was allotted and respected to conduct interviews, so participants were not rushed and time to ponder and gather thoughts before providing a response was permitted. Researchers remained available to participants throughout the study, ensuring any clarification, changes or additions to interviews could be made.

Participants were advised discussions and interviews would be documented and confidentiality would be maintained throughout.

To ensure risk to participants was mitigated, no personal information other than name and station of assignment was sought. Any inclusion or notation of a person in this study excluded the person's actual demographic information, but rather classified them as a pseudonym such as person one, firefighter one, etc. Such titles were used to ensure the identity of a person was respected and remained confidential. All notes, interviews, data analysis, etc., or otherwise required archived information is stored in password protected PDF files or similar formats, located in a locked container. All documentation as previously noted will be securely maintained for a period of five years.

No harm to any participant occurred. No children or otherwise at-risk or vulnerable population was involved in the study. Only participants 18 years of age or older participated in the study. Only former or current members of the township or fire service were used. Any person or firefighter meeting the selection criteria and willing to participate was permitted to take part in the study. No person was excluded from meeting the study criteria.

Results of the study were shared with the client organization and senior leaders of the fire stations involved. This ensured transparency as well as the integrity of the information presented.

Summary

The problem addressed in this study was determining if gaps in fire related responses of coverage exist. Discussed in this section were the roles of the researcher,

which included recruitment methods, participant selection, and the methodology to conduct this study. The strategy for data analysis, issues of trustworthiness and ethical procedures were revealed. This section expands on the processes and rationales previously reviewed in chapter 1 and 2. The following section (chapter 4) includes expanded discussion data collection, data analysis, findings, CoA's, deliverables and recommendations, and additional evidence of trustworthiness. It concludes with a dialog on the strengths and limitations of the study.

Section 4: Results and Recommendations

Introduction

This section includes information regarding the data collection and data analysis process. Findings, CoA's, deliverables, and recommendations are presented, as well as additional evidence of trustworthiness. The intent of this study was to provide a quantitative assessment in determining if gaps existed in fire station responses or areas of coverage. Data collection and analysis were structured in a manner to quantify any findings or recommendations. All actions performed during the study focused on the central research question (do voids exist in township fire service response and coverage) which guided and assisted in informing the study and its conclusions. This section concludes with a summation for consideration.

Data Collection

The study sample consisted of six participants from the township. Only three participants were initially requested: however, the AHJ desired representation from each township department. With all departments participating, it equated to a 100% return rate. There were two fire chiefs in the AHJ. There was one fire chief in the adjoining borough that provided contractual services to the AHJ. In all, there were three fire chiefs that were invited to participate. All three agreed, resulting in a 100% return rate.

There is no official minimum staffing for each of the two fire stations; however, based on the type and number of apparatuses at each of the stations, and assuming they were fully staffed for each apparatus, 20 firefighters would be present. The Mt. Holly station had two engines (four fighters per vehicle = eight firefighters), a brush truck (two

firefighters), and one aerial platform (four firefighters). The Boiling Springs station had one engine (four firefighters) and a brush truck (2 firefighters). There were 13 firefighters who participated in the study. Overall, the study consisted of 23 participants out of 30 requested, resulting in an overall return rate of 76.6%, which was well within the accepted academic norms of statistical analysis. The pool of participants was consistent with the intended study parameters of being 18 years of age or older and being a former or current member of the fire service or township.

No at-risk populations were used. No harm to any person(s) was noted, and no personal information was revealed. Initial data were obtained through RTK requests, seeking fire station call records. Data obtained were received digitally and in Microsoft Excel format. Notes from meetings and interviews, along with completion of interviews and written surveys, were conducted and archived in permanent document format (PDF). Verbal interviews were recorded with the consent of participants and archived. All analysis and information were archived in PDF and securely stored for the required retention period. The identity of all participants (where applicable) was data-masked to ensure privacy.

Interviews

Of the three fire chiefs interviewed, all were of the same opinion that each station was adequately equipped, staffed, and trained; however, each noted that volunteer staffing was a concern. Based on the time of day and other commitments, having limited staff could be challenging at times. For example, on Friday and Saturday, a paid driver

was available 24 hours. From Sunday through Thursday, the paid driver was only available during the day.

When questioned about recruitment efforts, opinions varied, but it is worth noting that recent and ongoing efforts have reportedly proven successful. Eight junior firefighters had recently joined the service within the past six months. A junior firefighter is a person of age who is only certified for outside usage until additional training and certification occurs. They are not permitted to enter a structure or be used for any form of technical rescue (HAZMAT, confined space, trench, etc.). Of the eight recently hired, six were between the ages of 18-21, which was the target demographic for recruitment.

All three chiefs noted that personal protective equipment (turn-out gear) was adequate, with two of the three stating they were evaluating the implications of the updated NFPA standards that require replacement of PPE based on a defined period. This is an unfunded standard, so volunteer departments will need to develop a purchase plan and incorporate it into their budgeting process. This will likely mean funds used for other areas will need to be diverted to meet this requirement.

All three fire chiefs also highlighted they had standardized training plans in place, and that no gaps existed affecting its execution. All three noted the NFPA response metric could be achieved, assuming manning was readily available. A concern noted by one of the chiefs highlighted the ongoing growth of the township. As additional businesses and housing areas are built, coupled with changes to the roadway network, effects on response metrics and coverage could easily be altered. Two of the three chiefs interviewed stated their existing stations were adequate and met NFPA standards. Both

stated they would like to see changes to the bunkroom areas, allowing for more privacy. The third chief stated a replacement for Station 1 is warranted due to its age and design. As noted, this station was originally a schoolhouse built in the early 1900's, so two additions have been added to the facility over time. These additions do not flow well and are not conducive to an expedited response from its members. It was noted during a walk-through of the facility that mold was evident in the basement area and that structural cracks existed within the facility. All have been evaluated by both environmental and engineering experts and judged to be safe; however, such observations further validate the need for this station to be replaced. When asked about hazard and threat analysis, all agreed with the information presented in the AHTA. All stated they either the assets or resources needed to respond to such scenarios, or that MAA's were in place to obtain required equipment or materials.

Originally, it was requested that three personnel from the township itself partake in the interview process. The emergency manager, zoning official and engineer were requested. The client organization also requested representatives from each of the six departments to participate, as each had information that would be of value to the study. All were advised that the interview was voluntary and would be conducted without compensation. All were presented with a statement of informed consent, which they acknowledged. In addition to the three positions initially requested, these functions included codes enforcement, zoning, community development, and roads department. When asked what they felt was the most important goal of the township, they all agreed it was life safety. When asked what they felt was the most susceptible hazard, high winds

and flooding were most often noted, followed by snow. When asked about most regular threats, they noted crime, vehicle accidents, and fire. Of the hazards and threats highlighted, all aligned with the most probable on the AHTA. All argued they had the sets and resources on-hand, or through an established agreement, to manage or mitigate the listed hazards and threats. When discussing crime, one participant gave a specific example of concern, which was infrastructure in the area, such as electrical distribution platforms and water wells.

The final portion of the interviews involved the firefighters themselves, which were fire service personnel that aren't chiefs or officers. Like the township officials and chiefs, most answers to survey questions aligned with what was previously revealed except for two questions. When presented with a listing of areas the township fire service should focus on in the next five years (Table 3), two of the respondents stated that staffing should be the primary area of concentration. One of the respondents believed an outreach program should be instituted in the area high schools, like military service recruitment. Township officials and the fire chiefs agreed; however, they desired additional funding for recruitment efforts. Although the goal and result were the same (staffing), the method of how to achieve the goal differed.

Table 3

Goal Analysis

Focus Area	1-5 years	5-10 years
Apparatus	N/A	N/A
Expansion	N/A	N/A
Equipment	N/A	N/A
Funding	13 (59%)	15 (68%)
Infrastructure	N/A	2 (9%)

Other	N/A	N/A
Staffing	9 (41%)	5 (23%)
Training	N/A	N/A

The integrity of data collected was verified against authoritative records from government databases, such as the NFPA and State Fire Marshall related standards. Gaps or missing information were sought from interviews or peer reviewed resources. Analysis came after the risk management style assessment was concluded. An AHTA was conducted to identify hazards and threats that could impact fire related responses or coverage. Additionally, a critical assessment was conducted to identify critical assets, infrastructure, and resources within the boundaries of the AHJ. A capability assessment was then performed to determine what agreements, assets, or equipment were on-hand, versus what was needed. A vulnerability assessment was then conducted that identified gaps in fire-related responses and coverage. Analysis was then performed to determine if findings could be eliminated, mitigated, or remediated. The final step of the analysis was to develop CoA's and recommendations.

Data Analysis

The U.S. Department of Transportation, Federal Highway Administration and the 2001 Pennsylvania Act 75, Vehicle Code, classifies roadways into seven broad categories. Beginning with smallest to largest, they consist of collectors, local, arterial, highway, expressway, freeway, and interstate. The township network consists of interstates, highways, arterials, local and connectors. Both fire stations located in the AHJ would use a combination of connectors, local, and perhaps highways to respond from their point of origin (station) to the corridor.

The intersection of Walnut Bottom Drive (Dr) and Stone Hedge Dr is considered the center point of the corridor. At normal speeds, a response from Citizens Fire Company 1 would travel approximately six miles in 11 minutes, while a response from Citizens Fire Company 2 would travel approximately six miles, taking ten minutes. At average speed, neither company would meet the NFPA response standard.

Figure 5 *Station 1 Route*

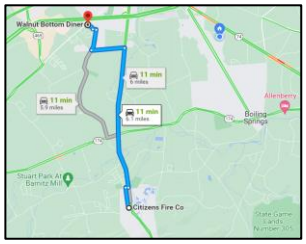
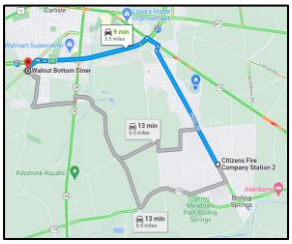


Figure 6 *Station 2 Route*

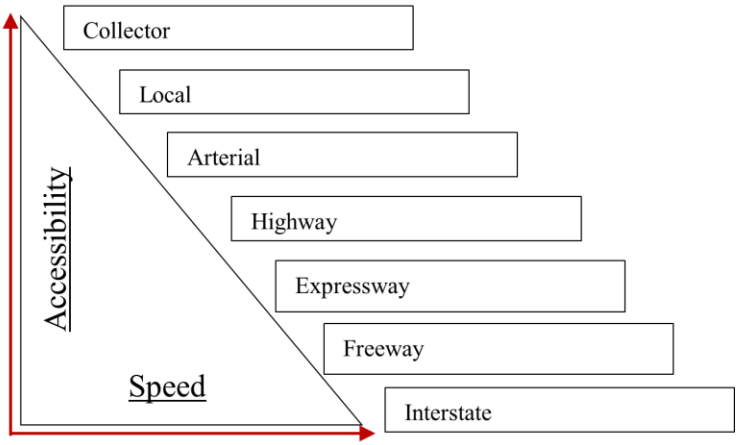


In Pennsylvania, fire vehicles may exceed the prima facie speed limits so long as they do not endanger life or property. The AHJ and associated fire stations have assimilated the State Code. Thus, all vehicles assigned to the fire companies can travel above the posted speed limits within the township. Traveling five and one-half miles in ten minutes equates to an average of 32 Miles Per Hour (MPH), which is well within safe and permissible speed limits. Traveling six miles in 11 minutes equates to an average of 33 mph, which is, again, well within the safe and permissible limits but outside of the nine-minute NFPA metric. Increasing speed to 40 MPH decreases response time to nine minutes, which would meet the NFPA metric; however, safety is of concern as the route of travel encroaches collector, local, and arterial roadways typically consisting of residences and businesses that can often negate high rates of speed. No reportable fire related vehicle accidents have been reported during a ten-year period of analysis. Figure

10 highlights how response times decrease by the type of roadways used; however, as previously mentioned, the roadway network is limited and precludes an increase in responses other than speed, which equates to time.

Figure 7

Roadway Responses



Step one of the risk identification processes consisted of accomplishing an AHTA. This process determined what hazards or threats exist in the local fire service having the highest impact. It categorized natural, technological, and human-caused events. A Microsoft excel sheet was formatted with drop-down repeatable processes (data entry format). The data entries assigned a value to identify and assign an overall probability score for each identified hazard or threat using a binning concept. A scoring subset was developed to determine a probability within each range.

From left to right, the first five columns (Table 4) were free typed using a listing of commonly established or recognized criteria. The sixth column contained a mathematical algorithm that assigned a rating/score based on the probability of occurrence. The seventh column contained a similar mathematical algorithm assigning a

rating/score based on likelihood of occurrence. The final column, also using a mathematical algorithm, provided an overall rating of initial risk after considering probability and likelihood. Ratings consisted of low, moderate, high, or significant. Example scoring criteria and definitions are outlined in Appendix B. Historical analysis was considered which permitted changes to hazards and threats due to changing environmental and societal conditions.

Once populated and tabulated, rating scores were inverted to display the hazards or threats with the highest probability or likelihood of occurring. In all, 609 hazards/threats were evaluated. Of those, only 12 rises to the significant or high level as depicted below.

Table 4 *AHTA*

Hazard Threat	Event Capability	Sub-Category	Justification	Source	Low/Medium/ Significance	Frequency	Score
Hazard	Human Caused	Awkward/Repetitive Movement	Daily	AHJ	High	Constant	1.0
Hazard	Human Caused	Frequent/Improper Lifting	Daily	AHJ	High	Constant	1
Hazard	Human Caused	Slips, Trips & Falls	Daily	AHJ	High	Constant	1
Threat	Human Caused	Theft	N/A	State Police	High	Highly Likely	.90
Hazard	Human Caused	Lack of Qualified Firefighters	N/A	AHJ	High	Highly Likely	.90
Hazard	Meteorological	Motor Vehicle Accident (MVA)	May 22	State Police	High	Highly Likely	.90
Hazard	Meteorological	MVA w/Fatalities	Jul 22	State Police	High	Highly Likely	.85
Hazard	Transportation	Rain	N/A	NWS	High	Highly Likely	.80
Hazard	Transportation	Rain fade (< 2 Hrs.)	Jan 23	NWS	Significant	Fairly Often	.65
Threat	Human Caused	Crime	N/A	State Police	Significant	Fairly Often	.65
Threat	Human Caused	Vandalism	N/A	State Police	Significant	Fairly Often	.60
Hazard	Human Caused	COVID-19/Pandemic	Mar 20	CDC	Significant	Often	.55

The second step consisted of conducting a critical assessment. During the critical phase, a survey of assets and determination of value was made. It identified key assets,

equipment, and infrastructure. Data collected was analyzed to determine the most valued items and to determine the degree of impact should the item be compromised. It is important to note, this step was subjective in nature, and it was difficult to determine the level of loss capability and impact if compromised. Each item was assigned a weighted score of 1-10, based on criteria in Appendix C. During this step, assets, resources, and other identified items were evaluated to determine the level of importance. Any item or area deemed as critical can be assumed to be essential in completing a task or mission in support of the AHJ. Criticality considers importance, effect, recovery, functionality, substitutability, and repairability. The goal of this step was to identify and prioritize assets deemed important to the AHJ.

A Microsoft word sheet to list the assets in the AHJ, their geographic location, and scoring formulas. All populated entries were free typed.

From left to right, the first column listed the asset itself. The second column was the assets' geographic location. The next six columns assigned a numerical rating based on the criteria in Appendix B. The final column was the overall accumulative score. Based on the numerical score, each asset was rated as high, significant, moderate, low, or minimal. Like the AHTA, historical analysis was considered which permitted changes to hazards and threats due to changing environmental and societal conditions.

Once populated and tabulated, rating scores were inverted to display the assets with the highest scores. In all, 1,108 assets were evaluated. Of those, three were listed as high, four listed as significant and 34 listed as moderate as noted below.

Table 5

Asset Listing

Asset	Rating Scores	Significance
Township Electrical Distribution System	29	High
Township Potable Water Supply	28	High
Mt Holly Fire Station	25	Significant
Boiling Springs Fire Station	25	Significant
UPMC Carlisle Regional Hospital	25	Significant
PPL Utilities	24	Significant
Station 1 Command	19	Moderate
Station 1 Engine 136	19	Moderate
Station 1 Engine 236	19	Moderate
Station 1 Brush 136	19	Moderate
Station 1 Truck 36	19	Moderate
Station 1 Traffic 136	19	Moderate
Station 1 UTV 136	19	Moderate
Station 1 Utility 136	19	Moderate
Station 2 Command	19	Moderate
Station 1 Engine 336	19	Moderate
Sunoco Mariner Pipeline	19	Moderate
Station 2 Brush 236	19	Moderate
Station 2 Truck 36	19	Moderate
Station 2 Traffic 236	19	Moderate
Station 2 UTV 136	19	Moderate
Station 2 Utility 236	19	Moderate
Norfolk Southern Railway	17	Moderate
Sunoco Mariner East Pipeline	16	Moderate
MPLZ Liberty Pipeline	16	Moderate
Mariner West Pipeline	16	Moderate
ME-2X Pipeline	16	Moderate
FM 120 Pipeline	16	Moderate
UGI Utilities	16	Moderate
Bell Telephone	14	Moderate
Ameritel	14	Moderate
Township Maintenance Facility	14	Moderate
Township Pumping Stations	14	Moderate
Penn East Pipeline	14	Moderate
Mid-Atlantic Utilities	14	Moderate
T-Mobile Telecommunications Network	14	Moderate
United Telephone	14	Moderate
Verizon Wireless Network	14	Moderate
Township Administrative Facility	13	Moderate
Township Well Houses	13	Moderate

The third step consisted of a vulnerability assessment. This phase identifies findings, gaps, or observations that can be exploited rendering an area or item unusable, based on a hazard or threat. The sheer mention of the word vulnerability can conjure negative thoughts or stoke fears. On a positive front, vulnerabilities can be eliminated, mitigated, or remediated through simple changes in policy or procedures. In some cases, funding may be required. In most all cases though, the risk can be reduced to an acceptable level. Vulnerabilities are assigned a mathematical score based on risk (Appendix D).

This step answers the question of how assets are vulnerable based on the identified hazards and threats. Like criticality, they are based on Accessibility (A), Recognizability (R), Vulnerability (V), Effect on Population (EP), and Recoverability (R). Each category is based on a 1-5 score, with 1 being the lowest and 5 being the highest. Each score within a category is then added for a final score (A+R+V+EP+R=T).

With 609 items listed on the AHTA and 1,108 on the criticality listing, not all assets could be evaluated. Therefore, a cut line was established with only those assets identified as high, significant, or moderate included as outlined in Table 6.

Table 6 *Vulnerability Listing*

Asset	Score
Township Electrical Distribution	45
Township Potable Water	45
UPMC Carlisle Regional Hospital	38
Mt Holly Fire Station	37
Boiling Springs Fire Station	37
PPL Utilities	29
Sunoco Mariner Pipeline	28
Township Pumping Stations	28
UGI Utilities	27
Bell Telephone	27
Ameritel	27
Sunoco Mariner East Pipeline	26
MPLZ Liberty Pipeline	26
Mariner West Pipeline	26
ME-2X Pipeline	26
FM 120 Pipeline	26
Township Maintenance Facility	26
Verizon Wireless Network	26
Station 2 Truck 36	25
Station 1 Engine 136	24
Station 1 Engine 236	24
Station 1 Truck 36	24
Station 1 Engine 336	24
Mid-Atlantic Utilities	24
T-Mobile Telecom Network	24
United Telephone	24
Station 2 Command	23
Norfolk Southern Railway	23
Township Administrative Facility	23
Township Well Houses	23
Penn East Pipeline	22
Station 1 Brush 136	20
Station 1 Traffic 136	18
Station 1 UTV 136	17
Station 1 Utility 136	17
Station 2 Brush 236	16
Station 2 Traffic 236	16
Station 2 UTV 136	16
Station 2 Utility 236	16

The last phase of the assessment process consisted of accomplishing risk analysis. Using the formula noted earlier, risk levels were determined using a quantifiable score. Once tabulated, scoring was inverted to depict the areas of highest risk. It is worth noting, all areas have some degree of risk, but it is up to the AHJ to determine what is an acceptable level of risk to assume. Since time does not permit all areas to be effectively evaluated and assuming the AHJ is willing to accept some level of risk, some items were not assessed.

Table 7 *Risk Scoring*

Asset	V	C	AHTA	R
Township Electrical Distribution	45	29	.65	74.65
Township Potable Water	45	28	.65	73.65
UPMC Carlisle Regional Hospital	38	25	.65	63.65
Mt Holly Fire Station	37	25	1	63
Boiling Springs Fire Station	37	25	1	63
PPL Utilities	29	24	.60	53.6
Sunoco Mariner Pipeline	28	16	.60	52.6
Station 2 Truck 36	25	19	1	45
Station 1 Engine 136	24	19	1	44
Station 1 Engine 236	24	19	1	44
Station 1 Truck 36	24	19	1	44
Station 1 Engine 336	24	19	1	44
MPLZ Liberty Pipeline	26	16	.60	42.6
Norfolk Southern Railway	23	17	.60	40.6

Findings

There are four primary findings revealed while conducting this study as discussed below.

1. Response metrics to the corridor using eighter of the two stations located in the AHJ were not capable of being consistently met.

2. Establishment of a new station in the corridor is not currently sustainable.

3. Reliance on contractual services from the adjoining jurisdiction should continue.

4. With declining numbers in volunteerism, consideration should be given to evaluating other staffing models (i.e., paid by call, career department, etc.)

Deliverables and Recommendations

The major findings (gaps) were identified as (a) response metrics to the corridor using either of the two stations located within the AHJ were not capable of being achieved; (b) establishment of a new station within the corridor is not sustainable; (c) reliance on contractual services from an adjourning jurisdiction must continue; and (d), with declining numbers in volunteerism, consideration should be given in evaluating other models of staffing (i.e., paid by call, career department, etc.).

Finding #1 - Response Metrics

Originally, it was thought neither Station 1 nor Station 2 could meet the NFPA established response metrics. Interviews with the two township fire chiefs believe with ample staffing, they can meet this standard. Research has indicated this finding to be partially correct. Based on time of day, available staffing, traffic, and other contributing factors, the response standard is capable of being met; however, the 90% of the time metric is not always achieved. The adjoining borough of government does consistently meet this metric. Therefore, this finding has validity in that the AHJ cannot consistently meet the nine minute 90% of the time standard.

Finding #2 - Station Sustainability

Should the township desire to establish a fire station in the corridor, it would come with a myriad of additional issues. Primarily, staffing of certified personnel. With existing stations not just in the AHJ, but throughout the nation, opening a new station would be challenging at best. Since area firefighters are comprised of volunteers, a new station located in the corridor would likely not have the citizens near it to be truly effective or efficient. As noted in the study itself, people residing in the corridor area are not typically known to volunteer, making this option statistically unsustainable. This finding is directly correlated to Finding #1 and #4. If located in the corridor and if properly staffed, the NFPA response standard would most certainly be consistently met. However, it would require a different staffing model to maintain.

Finding #3 - Contractual Services

Employing this option ensures the nine minute 90% of the time metric is achieved. Considering Finding #4 and from a cost perspective, this appears to be the best value driven and risk appropriate option to pursue. Although it is a financial obligation the AHJ bears, building, manning, and staffing a new station far exceeds the funds obligated and any associated benefits that would result from terminating contracted services with the neighboring jurisdiction.

Finding #4 - Other Staffing Models

This finding is directly related to the previous three findings. To achieve the nine minutes, 90% of the time response metric, a station in the corridor would be more than capable of achieving and sustaining this metric. Assuming the station was properly

staffed, it would assist in meeting the established standards. If the previous gaps were to be filled, the AHJ would no longer have to primarily rely on contracted services. Collectively, these findings do seem attainable; however, they are rather large hurdles to overcome and from a cost versus benefit perspective, do not align with the township's fiscal responsibility plans. Therefore, additional research is guaranteed to a different staffing model should the township desire to pursue its fire presence in the corridor.

Evidence of Trustworthiness

After completing the prospectus and proposal stages of my capstone experience, I received approval from my committee members and Walden University's IRB to proceed to the data collection and analysis stage as well as writing the PAS. I worked in concert with my committee during this iterative process. I also used Walden's research and library sources throughout this journey. Approval was sought and given during each phase of the capstone process.

All products, documents, questionnaires, and analytical products were pre-approved prior to implementation. Prior to the selection and use of participants, the IRB was consulted to ensure no harm or violations to Walden's ethical or professional research standards would occur. No harm happened to any person(s) and no spillage of confidential or personal information occurred. No at-risk or vulnerable population was used during the study. The response rate for participants was well within the accepted range of a study.

Results of the study are subject to the interpretation and analysis of the researcher. Using a recognized risk management methodology enabled opinions and bias to be

mitigated. Information and analysis were data driven. No ideas, themes, thoughts, or conclusions were pre-conceived. Data developed led to conclusions, versus a conclusion with data being obtained to support the conclusion. Sources of evidence notes, and archival information is encrypted and securely stored. Any information sought was either obtained through an RTK request or through an explicit consent process from the party(s) involved. All forms of an auditability trail have been established. Sources of data and information were obtained from peer reviewed reputable sources.

Numerous sources of information were used throughout the study process and every attempt was made to accurately cite these sources. Tools such as Grammarly and Turnitin were used to vet and verify the accuracy of the information presented. The assigned University Research Reviewer (URR) was also consulted prior to submission and publication of the study.

Strengths and Limitations of the Study

Strengths

The research methods chosen to conduct this study permit ease in replication. A recognized risk identification methodology was employed resulting in quantifiable results that are unbiased and based on empirical evidence. Using the risk management assessment process resulted in better analysis of data and conclusions. Using the analysis and data collection methods ensured facts and findings were easily understood. All the information collected or presented can be considered above reproach. All sources of data analysis were verified to be accurate and authentic. Level of descriptive research was noted by client organization. Information presented to the client organization has value in

determining future CoA's based on fact and designed to be cost effective and risk reducing. Cost(s) associated with conducting this study was minimal. Participation from the client organization and respondents were overwhelmingly positive. Based on the above, credibility has been added to study. Research question was answered in the affirmative, with executable CoA's provided. Additional research is warranted.

Limitations

The number of respondents was limited and focused on a single jurisdiction. Results of assessments were subjective in nature. The type of research did not permit predictive analysis. Information obtained during the interview stage was behaviorally based. Correlation and causation were limited. It was challenging to establish a cause-and-effect relationship.

The primary limitation of the study was the nature and dynamic composition of the fire service within the AHJ. The departments were comprised of volunteers. Therefore, availability of interactions and information was challenging. Within the fire service, there are numerous levels of staffing, from firefighters that were only certified for outside duties, those certified to enter structures, those certified for specific functions, like hazardous materials, confined space, technical rescue, etc. There were also fire officers, supervisors, union officials, support staff, fire captains, and station chiefs. With so many levels of staffing, information gathered had to be evaluated and scrutinized. This study was also limited to the two fire stations located within the AHJ. Emergency Medical Services and Fire-Police (special event traffic enforcement) were not included in the study. Several times, interviews were interrupted when stations were dispatched to a

call. Some appointments were cancelled and later rescheduled when a participant was diagnosed with COVID or influenza like illnesses. Therefore, additional research is warranted to draw any conclusions on the fire service.

The varying levels of experience and knowledge had the potential of skewing the analysis. Inexperienced participants may lack or have incomplete information of the research topic, whereas, experienced and educated participants had SME knowledge. Careful consideration was employed to balance these skill sets. Other limitations included the potential bias of the participants themselves. As noted earlier, firefighters are a proud breed and resistant to changes in culture or climate. Tradition is the norm.

Summary

This section began with an overview of the data collection process and analysis that was conducted. Findings were then discussed using a cause-and-effect process. The deliverables and recommendations were presented, along with the issues of trustworthiness, along with the studies strengths and weaknesses. Section 5 outlines how the study will be presented to the client organization and the study's conclusion.

Section 5: Dissemination Plan and Conclusion

Dissemination Plan

The research question (do voids exist in fire station response and coverage) along with the background, methodology, research, and conclusions, will be presented to the client organization. The presentation will be conducted via an in-person "desk side" meeting. Participants include me as the researcher, Township Emergency Manager, and Township Manager. The Township Board of Supervisors championed the PAS and designated the Township Emergency Manager as the focal point for the study. The Township Manager represents the board in all matters of day-to-day administration and authority. The focus of this study and presentation was the perceived gaps within the township's fire service responses and coverage in the Walnut Bottom Corridor. After reviewing the problem, methodology and analysis, recommended CoA's are to be presented. Client will be advised copies of the final study may be obtained once released by Walden University.

The study has meant to the client that no formal assessment of fire services, as related to response or coverage in the corridor, has been conducted. The township has developed a master development plan that outlines the vision for future growth and planning efforts in the corridor area. This study can be used as a reference or starting point for further discussion. Several gaps were identified during the study. These findings advocate for additional research to be conducted, coupled with the reference point, which can be used as a starting document with analysis and research already performed. The study has value for potential impact and positive social change in that if the

recommended CoA's were to be implemented, there is potential for a reduction in risk, liability, and increased community growth. These areas are in line with the township's goal of delivering uninterrupted public services to the community.

Conclusions

Savings lives, property, and the environment are trademarks of the fire service. Strategically, they understand change is warranted; however, focus on tradition makes them both hesitant and resistant. When the changes were identified, there was no clear consensus on how to make such changes. Ironically, the fire service is extremely good at identifying, evaluating, and implementing risk reduction processes. After conducting a "size-up" of a given situation, they implement a corrective CoA in short order to effectively manage a positive outcome. Input received from those participating revealed that they had positive opinions and thoughts on how to improve fire operations within their stations. These recommendations tended to focus on how existing operations and locations could be improved via efforts to consolidate or expand. One should note though that these recommendations did align with the overall recommendations presented in the study.

Objectively, looking at the fire service within the client's area of responsibility, the fire service can be classified as a sub-set of the public services offered by the township. This is important, as one of the goals of the township is to deliver uninterrupted public services to the community. Firefighters wear many hats and requests for their services have increased significantly within the past ten years. Political and social constraints have also been levied upon them. As noted by one firefighter, "this is

not my father's fire service." Skill sets, certifications, and technical training requirements have expanded, making those who respond to danger rather than running away from it both proud and professional. The overall opinion noted throughout the study was that the local fire stations are well respected and supported by the community. The greatest task facing the fire service within the AHJ is therefore staffing and manning.

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Appendix A: Acronyms

AHJ	Authority Having Jurisdiction
AHTA	All-Hazard Threat Assessment
Ave	Avenue
C	Criticality
CDC	Centers for Disease Control and Prevention
CoA	Course(s) of Action
DHS	Department of Homeland Security
EMS	Emergency Medical Services
FEMA	Federal Emergency Management Agency
H	Hazard
I	Interstate
IAW	In Accordance With
IRB	Institutional Review Board
ISO	Insurance Services Office
LEPC	Local Emergency Planning Committee
MAA	Mutual Aid Agreement
MPH	Miles Per Hour
NFPA	National Fire Protection Association
NIST	National Institute of Science a Standards
NWS	National Weather Service
PA	Pennsylvania

PDF	Portable Document Format
R	Risk
RD	Road
RTK	Right to Know
SME	Subject Matter Expert
SPSS	Statistical Program for Social Sciences
St	Street
T	Threat
TIC	Toxic Industrial Chemicals
TIM	Toxic Industrial Materials
UPMC	University of Pittsburgh Medical Center
URR	University Research Review
U.S.	United States
USFA	United States Fire Academy
USGS	United States Geological Survey
V	Vulnerability
VFS	Verisk Financial Services

Appendix B: AHTA Table

Ranking	Scoring	Definition	Sub-Sets	
High	0.81 – 1.0	Threat has capability and intent, and there is history the asset has been targeted on frequnt basis.	Certain	1.00
		Hazard has demstrated history of occurrence on frequent basis	Highly Likely	0.90
			Very Likely	0.85
Significant	0.51 – 0.80	Threat has capability and intent, there is history asset has been or is being targeted.	Likely	0.75
		Hazard has demonstrated history of occurrence on occasional basis.	Fairly Often	0.65
			Often	0.55
Moderate	0.21 – 0.50	Treat has evidence of intent, but little evidence of capability or history.	Very Possible	0.45
		Hazard has demonstrated history of occuring on infrequent basis.	Possible	0.35
			Somewhat Likely	0.25
Low	0.01 – 0.20	Threat has little credible evidence of capability or intent.	Unlikely	0.20
		Hazard has rare or no history of occurrence.	Highly Unlikely	0.10
			Extremely Rare	0.01

Appendix C: Binning Table

Definitions		Range Subset		
0.81 – 1.0	Greater than 75% disruption to asset. No effective mitigation. Multiple known weaknesses	High	Always Exploitable	1.00
			Exploitable	0.90
			Somewhat Exploitable	0.85
0.51 – 0.80	Graeter than 75% disruption to asset. Some effective mitigation. Substantial weaknesses exist	Significant	Highly Exposed	0.75
			Exposed	0.65
			Somewhat Exposed	0.55
0.21 – 0.50	Mitigation in place. At least one weakness	Moderate	Highly Susceptable	0.45
			Susceptable	0.35
			Somewhat Susceptable	0.25
0.01 – 0.20	No weaknesses	Low	Somewhat Protected	0.20
			Protected	0.10
			Very Protected	0.01

Appendix D: Criticality Scoring Table

Placeholder	Placeholder	Placeholder
Function: Focuses on threat to asset	Asset cannot continue mission until restored	High – 5
	Ability to carry out mission would be significantly impaired	Significant – 4
	50% of assets capability remains	Moderate – 3
	Asset can continue function if compromised, although degraded	Low – 3
	Destruction or disruption has little effect	Minimal - 1
Symbolism: Considers whether asset represents/perceived to be on symbolic value	Location associated with people involved in actions threat actors oppose	High – 5
	Location has historical, religious, or other symbolic significance	Significant – 4
	Location is regarded as cultural significant	Moderate – 3
	Location associated with economic or production capability	Low – 3
	Location is popular social gathering site	Minimal - 1
History: Do threat actors have history of impacting asset	Events against type of asset conducted routinely	High – 5
	Events against asset conducted frequently	Significant – 4
	Events against asset have occurred	Moderate – 3
	Events against asset have been threatened	Low – 3
	Events against asset occur infrequently	Minimal - 1
Accessibility: Asset accessible when threat actors can gain access	Easily accessible	High – 5
	Inside perimeter	Significant – 4
	Inside first floor of building	Moderate – 3
	Inside other floors of building	Low – 3
	Difficulty in gaining access	Minimal - 1
Recognizable: Degree to which asset can be recognized	Clearly recognizable under all conditions	High – 5
	Easily recognizable	Significant – 4
	Difficult to recognize at night/bad weather	Moderate – 3
	Easily confused with other asset(s)	Low – 3
	Cannot be recognized	Minimal - 1
Population: Addresses quantity or people and their demography	Extremely large population >1000	High – 5
	Large population 500+	Significant – 4
	Moderate population 100+	Moderate – 3
	Spares population 10+	Low – 3
	People not present or less than 10	Minimal - 1

Appendix E: Vulnerability Scoring Table

Importance: Value of each item, considering function and monetary value.

9-10	An item more than $2M, critical value-function cannot be performed. High-profile, symbolic, global publicity, loss has catastrophic impact.
7-8	Item value is $1M-$2M, high value-function severely impacted. Prominent symbol, global publicity, loss has serious consequences.
5-6	Item value is $500K to $1M, moderate value-function moderately impacted. Symbolic, limited global publicity, loss has minor consequences.
3-4	Item value is $100K to $500K, low value-some functional impact. Low symbolic value, loss has little consequences.
1-2	Item value less than $100K, little value-minimal impact. Extremely low symbolic value, loss has minimal consequences.

Recoverability: Measures time required for item to be restored, considering availability of assets, equipment, manpower, resources, or redundancies.

9-10	Recovery impractical due to cost or lack of resources.
7-8	Recovery may be accomplished however, at great expense over prolonged time.
5-6	Recovery probable, requires adequate resources and time.
3-4	Recovery readily accomplished; adequate resources available.
1-2	Immediate recovery possible.

Functionality: Measures key positions, functions, equipment, etc.

9-10	Failure until restored.
7-8	Function is significantly impaired.
5-6	Fifty percent degradation.
3-4	Function will continue with some degradation in effectiveness.
1-2	Little effect on ability to function.

Substitutability: Determines if substitutes are available to replicate function.

9-10	No substitutes available.
7-8	Substitutes available but will use will significantly degrade function.
5-6	Substitute available, will result in some function degradation.
3-4	Substitute available, some function degradation in effectiveness.
1-2	Substitute readily available, minimal impact to function.

Repairability: If damaged, can it be repaired or rendered operable?

9-10	Cannot be repaired or time needed exceeds six months or $1M.
7-8	Repairs require one to six months, costs between $500K-$1M.
5-6	Repair require one week to one month, cost less than $100K-$500K.
3-4	Repairs require between 24 hours up to one week, cost less than $100K.
1-2	Same day replacement, negligent cost.

High	45-50
Significant	30-44
Moderate	20-29
Low	10-19
Minimal	0-9

Appendix E: Risk Scoring Table

High	71 – 100
Significant	51-70
Moderate	35-50
Low	20-34
Minimal	0-19