THE UNIVERSITY of TENNESSEE

MUNICIPAL TECHNICAL ADVISORY SERVICE

HENDERSONVILLE, TENNESSEE
Fire Station Prioritization Study

March 2017

Dennis Wolf, Fire Management Consultant
The University of Tennessee, Institute for Public Service
Municipal Technical Advisory Service

Table of Contents

List of Tables

List of Figures

Introduction and Scope of Work

This study was conducted at the request of Mr. Scotty Bush, Fire Chief for the City of Hendersonville. A written request to MTAS from Chief Bush authorized MTAS to conduct an official fire department study.

In January 2017, Chief Bush contacted MTAS and requested assistance in prioritizing the order in which new fire stations should be built in Hendersonville. The city has an imminent need for at least one fire station now, and the fire department has identified the need for at least three additional stations (including the one needed now) as growth occurs. The specific question asked of MTAS was, "Where should we build the next fire station?" Therefore, the scope of this project is to prioritize the order in which the city should add fire stations. The study will suggest general areas for fire stations, but will not recommend exact locations for additional fire stations.

Background

The City of Hendersonville is the largest city in Sumner County in Middle Tennessee, and the 11th largest city in Tennessee. Hendersonville is located on Old Hickory Lake, near the cities of Goodlettsville and Gallatin. Hendersonville is governed by a Mayor-Aldermanic form of government, with a mayor and twelve aldermen. The board sets policy and evaluates the management of the city. The mayor oversees all operational activities.

Fire protection and staffing is a local policy issue, and a community must balance local resources against acceptable risk. The Hendersonville Fire Department is a career fire department recognized by the State of Tennessee. The department is supported and funded by the City of Hendersonville. The fire department operates six engine companies and two truck companies from six fire stations located throughout 32 square miles. In addition, the fire department protects 26 miles of shoreline on Old Hickory Lake with a fireboat that is staffed as needed using an on-duty fire engine crew.

The City of Hendersonville has a very good fire department. It is well managed, well trained, and well equipped. Hendersonville residents and business owners enjoy an Insurance Services Office (ISO) Public Protection Classification (more commonly called the ISO Rating) of Class 4/9, which places Hendersonville in the top 22% of communities nationwide, and in the top 23% in Tennessee, in terms of fire protection. Only 82 communities in Tennessee have a better ISO rating, which indicates that Hendersonville has made good decisions in planning for community fire protection.

During the last ISO evaluation, Hendersonville received just 48.5% credit for having an adequate number of fire stations covering the community, which indicates that the city does need to add more fire stations. In the report to the city, ISO stated, "The FSRS indicates that a minimum of 7 engine companies are needed in the fire district to suppress fires in structures with a Needed Fire Flow of 3,500 gpm or less." Hendersonville needs "7 engine companies to provide fire suppression services to areas with a reasonable number of properties without a responding fire station within 1½ miles." The need to add stations is long overdue. The map in Figure 1 shows the current city limits and the areas in green are within 1½ miles of an engine company. The map in Figure 2 shows the future, potential size of the city with the planning area and urban growth boundary areas added to the existing city limits.

ISO's recommendations are based on the polygon model of fire station planning. Under ideal conditions, which includes an interconnected road network with no geographical barriers, a single fire station can cover 4.5 square miles. Based on the city's size of 32 square miles, Hendersonville needs at least 7.11 fire stations. The travel distance for a ladder or service company is 2½ miles, so under ideal conditions Hendersonville needs at least 2.6 ladder or service companies. The road network is not ideal, and the shape and topography of the area affect travel time, but it is apparent that the city needs to add fire stations and staff the service company to be able to continue to provide adequate fire protection.

Community Risk – General Overview

Hendersonville covers 32 square miles, had a population of 40,620 according to the 2010 census, and has a current population of 51,372 as of 2016 (TNECD), a 26.47% increase in sixteen years. In fact, the city has more than doubled in size since 1990, with the population increasing by 59.6%. There is significant future growth either underway or in the planning stages. Currently, there is no fire station located north of Vietnam Veterans Boulevard, so all fire response comes from existing stations south of the major highway. The city is growing, and the fire department needs to grow as well to continue to provide the level of fire protection the community desires, and maintain the ISO Rating.

Community risk refers to the location where a fire or other emergency may occur, and includes factors such as type of construction, occupancy classification, number of occupants, and exposures (other properties close to the property at risk). Residential areas are considered low risk, while commercial areas are considered to be medium risk, and dense development or industrial development is considered high risk. The greater the risk, the greater the amount of fire resources needed.

In order to make prioritization recommendations, MTAS looked at several factors, including where growth is occurring, geographical limitations, the road network, the level of risk by occupancy type, and future annexation plans.

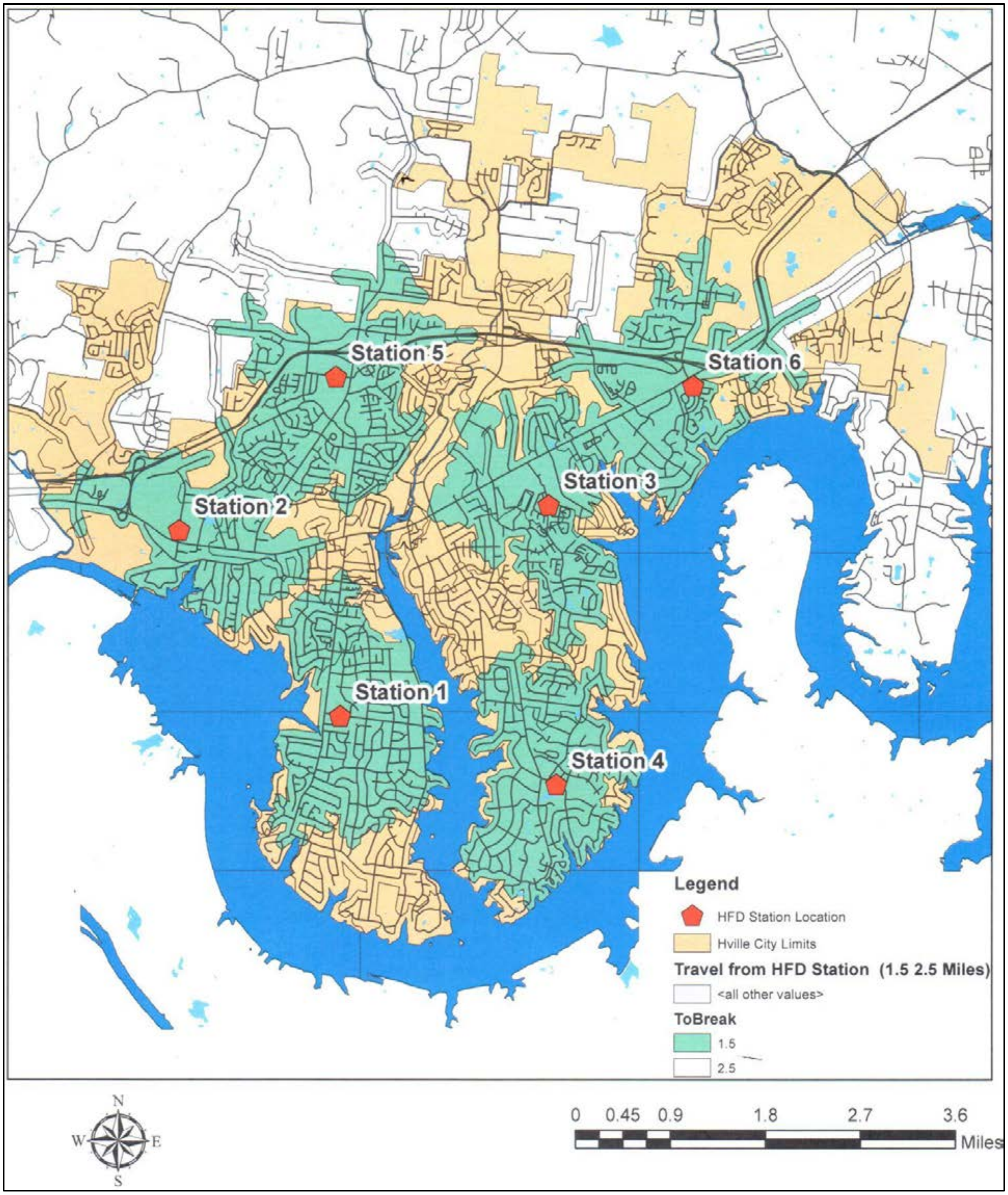

Figure 1 – 1½-mile Travel Distance Coverage of Existing Fire Stations

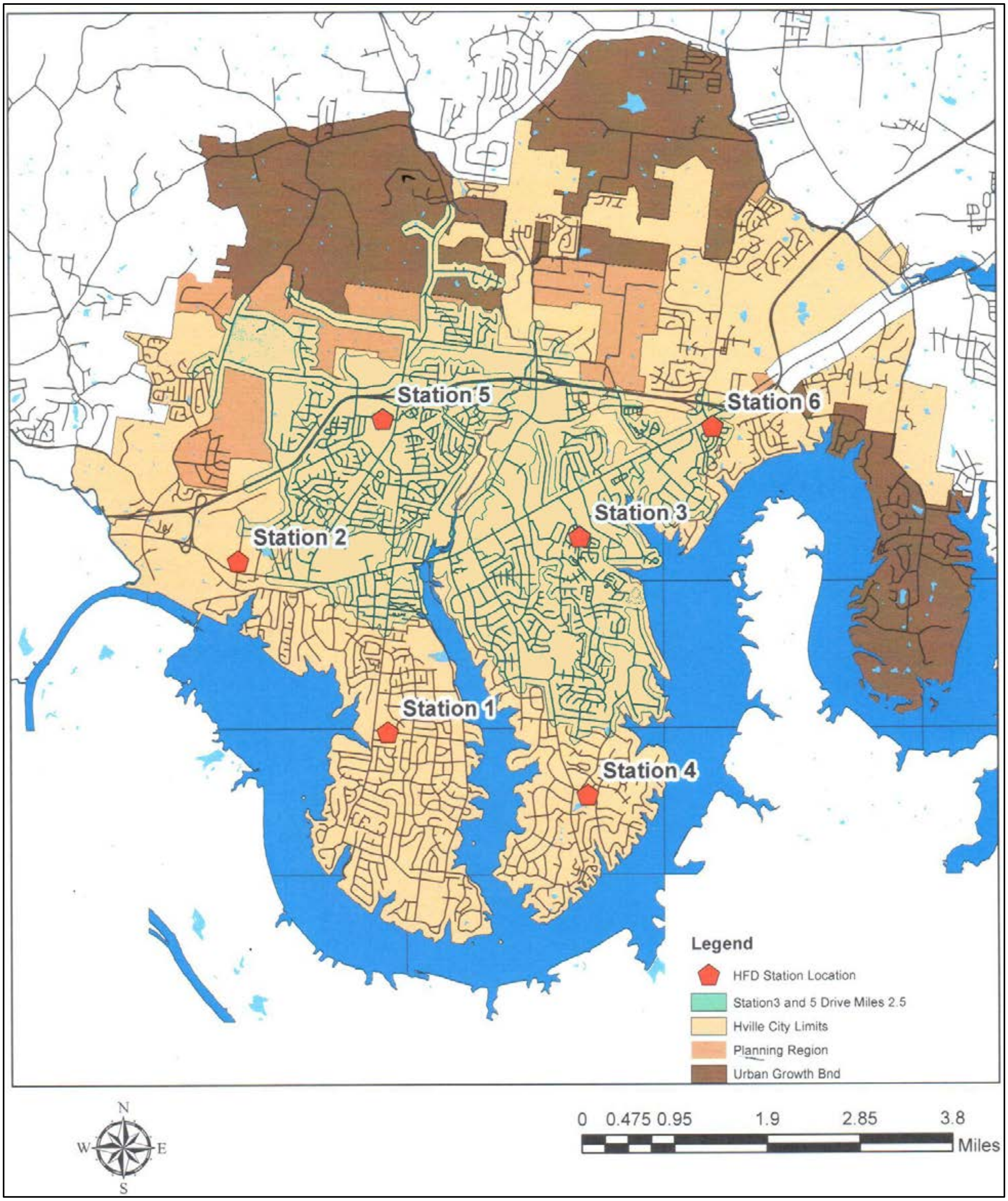

Figure 2 – City Limits, Planning Region, and Urban Growth Boundary

Where is Growth Occurring?

Growth is occurring throughout the area north of Vietnam Veterans Boulevard. New schools have been built, and additional schools are planned. Many subdivisions have been built, and others are under construction or in the planning stages. A large city park, Volunteer Park at Arrowhead, is open and being expanded. Commercial and retail development will occur to provide needed amenities for those living in the area. All of this development will require adequate fire protection commensurate with the level of risk.

Single-family residential subdivisions with 10-foot or more side yard setbacks will require the response of at least two engines and a ladder or service company. MTAS observed that many subdivisions have large homes of 3,000 square feet or more, and many lots are sloped so that a home that looks like a two-story home in the front actually has three and even four stories in the rear. For this reason, MTAS recommends that the fire department respond an aerial ladder company to this area for the added reach of the aerial ladder over ground ladders.

Denser residential development, such as zero lot line, apartments, and townhomes, will require the response of at least three engines and a ladder company.

Light commercial, mercantile, and hotel development will require the response of at least three engines and a ladder company.

Geographical Limitations

The rural road network does not allow fire apparatus to obtain safely response speeds typically achievable in suburban settings.

There are no fire stations north of State Route 386 (Vietnam Veterans Boulevard), and limited access points to cross SR-386 for apparatus responding from existing fire stations.

The bridge at Stop 30 Road and Drakes Creek was damaged by the flooding that occurred in May 2010 and will not bear the weight of fire apparatus. This bridge should be repaired as soon as possible to provide maximum flexibility for the fire department on response routes.

Station Location, Response Time, and Fire Loss

It is important to understand the relationship between the placement of fire stations and how that affects response time. Fast response times are important because there is a direct relationship between putting water on a fire quickly and fire loss: the faster fire suppression operations start, the lower the fire loss. Insurance companies recognize this relationship and quote lower rates for higher levels of fire protection. Also, quick response times contribute to a better outcome on fire related injuries, and improve the chance of a successful rescue of trapped occupants. Response time has been studied for decades, and there are two sources to consult for guidance on what constitutes an adequate response time: the ISO Fire Suppression Rating Schedule, and National Fire Protection Association Standard 1710.

A fast response is also important for emergency medical calls. A person who has a heart attack whose heart stops beating will begin to suffer brain damage in four minutes unless CPR or advanced life support is started. Brain damage increases as time passes, and at the ten minute mark, brain damage is certain and brain death is imminent. A quick response time decreases morbidity and mortality for trauma and cardiac patients.

The first source is the Insurance Services Office (ISO) Fire Suppression Rating Schedule. Section 560 of the schedule covers the deployment of engines and ladder-service companies and states: “The built-upon area of the city should have a first-due engine company within 1½ miles and a ladder-service company within 2½ miles.”

The second resource is the National Fire Protection Association (NFPA). NFPA addresses the number of fire stations needed in an indirect way based on minimum response times. NFPA Standard 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*, 2016 edition, Section 4.1.2.1, allows 240 seconds (4 minutes) of travel time for the first arriving engine company. Using an empirical model called the piece-wise linear travel time function, based upon studies done by the RAND Corporation estimating that the average response speed of fire apparatus is 35 mph, one can determine that the distance a fire engine can travel in 4 minutes is approximately 1.97 miles.

Travel Time of Fire Apparatus

There is an old saying in the fire service that seconds saved are minutes earned, which is why a fast response time contributes to a better outcome on any emergency. Travel time is one of the components of total response time for an incident. On most emergency incidents, fire apparatus respond from fixed locations (fire stations) rather than from somewhere within the response district, so the ability to predict travel time has value for planning and evaluating fire protection in a community.

ISO Evaluation of Travel Time

The ISO Fire Suppression Rating Schedule (FSRS) has always evaluated the distribution of fire resources through the community based on a fixed travel distance of 1½ miles for an engine company and 2½ miles for a ladder/service company. Beginning in 2013, ISO uses an alternative to the fixed distance and will credit the results of a systematic performance evaluation of travel time using “computer-aided dispatch (CAD) history to demonstrate that, with its current deployment of companies, each fire department meets the time constraints for initial arriving engine in accordance with the general criteria of in NFPA 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*." Thus, two methods are available for Hendersonville to receive credit for the deployment of fire resources in the fire protection area, a fixed distance measurement, or a performance measurement. Unfortunately, the road network and rural road design does not provide fast enough travel times to meet the requirements specified in NFPA 1710, as discussed below. This means that having an adequate number of fire stations strategically located in essential for good response times and service levels.

The RAND Institute Travel Time Equation

Over forty years ago, the RAND Institute conducted research on the travel time of various types of fire apparatus. One of the results of this research was the determination that the average speed of a fire engine on an emergency response was 35 miles-per-hour (MPH) over average terrain, with average traffic and weather conditions, and slowing for intersections. Another result was the equation commonly referred to as the RAND travel time equation. The equation that is used by ISO and many others is:

$T = 0.65 + KD$

The components of the travel time equation are:

T	travel time in the nearest 1/10 of a minute
0.65	an acceleration constant over the first 2,000 feet of travel
K	defined constant based on the average speed of a given apparatus over a 5 mile course
D	travel distance to nearest 1/10 of a mile

Table 1 – RAND Travel Time Equation

The values for K are shown in the following table. As mentioned above, the RAND studies determined that the average speed for a fire engine was 35 mph, so most people, and ISO, use the K value of 1.7 as a constant.

K Values	
Rate of Speed (mph)	**K value**
60	1.0
55	1.1
50	1.2
45	1.3
40	1.5
35	1.7
30	2.0
25	2.4
20	3.0

Table 2 – RAND Equation K Values

NFPA 1710 Travel Time and ISO

NFPA 1710 § 4.1.2.1(3) establishes a travel time of 240 seconds or less for the arrival of the first arriving engine company at a fire suppression incident. Using the equation $T = 0.65 + 1.7D$, where D equals 1.5 miles, ISO determined that the travel time for the first arriving engine is 192 seconds (3.2 minutes, or 3:12). As mentioned above, in Sections 510A and 540 of the FSRS, ISO will consider an alternative to the 1.5 miles travel distance with demonstrated proof that the first company can arrive on the scene within 240 seconds or less travel time on 90% of responses. Using the RAND equation, 240 seconds is equal to about 1.9 miles, a potential 26% improvement in the size of the response district. The key to using the alternative evaluation method for deployment analysis is having accurate data.

Practical Uses of the Travel Time Equation

However, not all fire apparatus is equal is size, weight, acceleration, response speed, and maneuverability. For example, a tanker may be slower than an engine, and a large ladder truck may be slower than an engine. The RAND studies used the Fire Department of New York as the model for the study, so response territory that is markedly different from an urban city can affect travel time. Still, the K value of 1.7 has proven very reliable over time, but a fire official can use a different K value for his or her community if needed.

Community officials can use the equation when making decisions about where to locate, or relocate, a fire station, and to verify response time data from computer aided dispatch (CAD) systems. ISO does not measure or use actual response times of individual communities as most departments lack reliable data, so the fire official can use the equation to verify the accuracy of local data.

Application of the RAND Formula in Hendersonville

MTAS toured the service areas north of Vietnam Veterans Parkway to ascertain the actual and potential fire protection risks, and to gauge the travel time of fire apparatus. The area is of rural character, with subdivisions replacing pasture and farm land while retaining the existing road network. The main roads feeding the area are of a rural cross-section: two lanes with no curbs or gutters. The topography of rolling hills means the road network has grades and curves that restrict the speed of traffic. As such, fire apparatus are not able to travel at the speeds commonly used in suburban developments. MTAS estimates that fire apparatus is more likely to average 30 MPH during a response rather than the 35 MPH typically used. Therefore, the use of a K factor of 2.0 is more appropriate than using 1.7, which means that travel times will be longer. For example, using the same distance of 1.5 miles, a K factor of 1.7 estimates a travel time of 3.2 minutes (3:12), and a K factor of 2.0 estimates a travel time of 3.65 minutes (3:39).

Responses to the West from Existing Stations

From Station 2 to 162 Trail Ridge (a far point on the western portion of the area), the travel distance is 4.1 miles, and the estimated travel time is 8:51

From Station 5 to 162 Trail Ridge, the travel distance is 3.5 miles, and the estimated travel time is 7:39.

The travel times from the two closest existing fire stations exceed the desired travel time of 4 minutes or less. This indicates that this area needs an additional fire station to provide good response times.

Responses to the East from Existing Stations

From Station 6 to 208 Crooked Creek Lane (a far point on the eastern portion of the area), the travel distance is 2.9 miles, and the estimated travel time is 6:27

From Station 5 to 208 Crooked Creek Lane, the travel distance is 6.2 miles, and the estimated travel time is 13:03.

The travel times from the two closest existing fire stations exceed the desired travel time of 4 minutes or less. This indicates that this area needs an additional fire station to provide good response times.

Responses to the North from Existing Stations

From Station 6 to 206 Carly Close East (a far point on the northern portion of the area), the travel distance is 4.5 miles, and the estimated travel time is 9:39

From Station 5 to 206 Carly Close East, the travel distance is 5 miles, and the estimated travel time is 10:39.

The travel times from the two closest existing fire stations exceed the desired travel time of 4 minutes or less. This indicates that this area needs an additional fire station to provide good response times.

Responses from Proposed Location of Drakes Creek and Anderson

The fire department identified a possible fire station site at Drakes Creek and Anderson. MTAS will use this location as the starting point for travel time examples to existing addresses on the far west, east, and north of the fire protection area.

Going west, the estimated travel time to 162 Trail Ridge, which is 6.8 miles from this location, is 14:15. However, to show the difference that a better road network has on travel times, using Vietnam Veterans Parkway, the travel distance is 8.4 miles, 1.6 miles farther, but the travel time is ten seconds faster at 14:05.

Going east, the estimated travel time to 208 Crooked Creek, which is 5.6 miles from this location, is 11:51.

Going north, the estimated travel time to 206 Carly Close East, which is 1.7 miles from this location, is 4:03.

The travel times from this location to the east and west exceed the desired travel time of 4 minutes or less, and are right at 4 minutes to the northern most location.

Analysis of Travel Time Estimates

The estimated travel times indicate that the entire area north of Vietnam Veteran’s Parkway is in need of at least three additional fire stations. Fire stations represent a significant cost to any community, which means adequate funds must be available to begin construction. With limited funds, the city cannot afford to build three stations at the same time, so the city must prioritize the order of construction for additional fire stations.

The fire department has identified potential fire station sites to the west, middle, and east portions of this service area, and none of the proposed locations are adequate to provide service to the entire area because of the size of the area to be served. While growth is occurring throughout the area, most of the growth is occurring in the middle portion. Also, an additional fire station in the middle portion can respond to the furthermost west and east locations with somewhat “proportional” travel times of 11:51 to the east and 14:05 to the west, whereas a fire station located to the east or west would have disproportional response times to the other area.

Recommendations

Hendersonville should plan to add at least three fire stations in future years. The city should build, equip, and staff the fire stations as soon as adequate funds are available.

The first station should be built in the center of the service area north of Vietnam Veteran's Parkway. This location is where most of the significant growth is occurring, and will provide a proportional response time to the west and east of the service area.

The second station should be built in the west area, near the vicinity of approximately Center Point Road and Hunts Road.

The third fire station should be built in the Cages Bend peninsula. This area is in Hendersonville's urban growth boundary and is not yet part of the city. This area does have some high value residential development, and there is a large amount of undeveloped land as well. The closest Hendersonville fire station is Station 6, and it is 5.2 miles from Station 6 to the end of the peninsula at 3049 Cages Bend, a travel time of 11:03. An ideal location for a fire station would be on Cages Bend between Douglas Bend Road and Grassland Drive, as this is between 1.7 and 1.5 miles from the end of the peninsula. Though currently outside the city limits, annexation of the area is planned. The city may want to secure property now for a future fire station before good sites are taken for other development projects.

Appendix A – Estimated Travel Times and Total Response Time in Minutes

Distance To Travel in Miles	Estimated Travel Time	Ring Time	Call Processing Time	Fire Dept. Turnout Time	Total Response Time
0.25	01:09	00:15	01:00	01:20	03:44
0.50	01:39	00:15	01:00	01:20	04:14
0.75	02:09	00:15	01:00	01:20	04:44
1.00	02:39	00:15	01:00	01:20	05:14
1.25	03:09	00:15	01:00	01:20	05:44
1.50	03:39	00:15	01:00	01:20	06:14
1.75	04:09	00:15	01:00	01:20	06:44
2.00	04:39	00:15	01:00	01:20	07:14
2.25	05:09	00:15	01:00	01:20	07:44
2.50	05:39	00:15	01:00	01:20	08:14
2.75	06:09	00:15	01:00	01:20	08:44
3.00	06:39	00:15	01:00	01:20	09:14
3.25	07:09	00:15	01:00	01:20	09:44
3.50	07:39	00:15	01:00	01:20	10:14
3.75	08:09	00:15	01:00	01:20	10:44
4.00	08:39	00:15	01:00	01:20	11:14
4.25	09:09	00:15	01:00	01:20	11:44
4.50	09:39	00:15	01:00	01:20	12:14
4.75	10:09	00:15	01:00	01:20	12:44
5.00	10:39	00:15	01:00	01:20	13:14

Notes:

- Travel time was calculated using the RAND formula of $T = 0.65 + 2.0D$ to estimate travel time, where T is time and D is the distance to be covered expressed in miles.
- A K factor of 2.0, rather than 1.7, was used because of the rural nature of the road network in the proposed service area.
- The 15-second ring time, 60-second call processing time, and 80-second turnout time are based on recommendations found in NFPA Standard 1710, and the total response times indicated are a best-case estimate. If the actual times for these processes are longer in the local community, then the estimated response times will be longer as well. For example, if the actual call processing time is 90 seconds, then the total response time for a 1.5 mile response will increase from 6:14 minutes to 6:24 minutes. It is important to know what the actual, local ring time, call processing, and turnout times are, and to adjust the estimated total response time accordingly.

Appendix B – Existing Fire Station Locations and Apparatus

Station	Address	Apparatus
1	173 Luna Lane	Engine 1
2	225 Freehill Road (Admin. Offices)	Engine 2, Rescue Truck
3	179 Bonita Parkway	Engine 3, Truck 3, Special Ops, DC
4	511 Indian Lake Road	Engine 4, Reserve engine
5	1166 Forest Retreat Road	Engine 5, Truck 5, Dive Team
6	1003 Winston Hills Parkway	Engine 6

References

Compton, Dennis and John Granito, eds. (2002). *Managing Fire and Rescue Services (2nd ed)*. Washington, DC: The International City/County Management Association (ICMA).

Cote, Arthur, Grant, Casey, Hall, John, Solomon, Robert (Eds.). (2008). *Fire Protection Handbook, 20th Edition*. Quincy, MA: National Fire Protection Association (NFPA).

Insurance Services Office. (2012). *Fire Protection Rating Schedule (edition 2012)*. Jersey City, NJ: Insurance Services Office (ISO).

National Fire Protection Association. (2016). *NFPA 1710, Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*. Boston, MA: National Fire Protection Association.