GEOGRAPHIC INFORMATION SYSTEM EMERGENCY SERVICES RESPONSE CAPABILITIES ANALYSIS

International Association of Fire Fighters
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CITY OF TERRE HAUTE FIRE DEPARTMENT

TERRE HAUTE, INDIANA

NOVEMBER 29TH, 2006

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ABSTRACT

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In November of 2005, the International Association of Fire Fighters (IAFF) was contacted by the Terre Haute Firefighters, IAFF Local 758, to perform a Geographic Information System (GIS) analysis of the City of Terre Haute, Indiana Fire Department. Local 758 requested that the GIS study evaluate the 4- and 8-minute response capabilities of fire department units deploying from existing fire station locations, and include an examination of staffing conditions that prevail in the department. The City of Terre Haute Fire Department requested that the results of the GIS mapping be assessed against existing National Fire Protection Association (NFPA) professional standards and Occupational Safety & Health Administration (OSHA) safety regulations, including compliance with NFPA 1710 staffing performance objectives and the OSHA "2 In/2 Out" regulation. The procedures involved in this analysis consisted of the generation of GIS mapping response scenarios under existing and planned staffing and deployment configurations, a statistical analysis of fire department response capabilities, and an evaluation of GIS outcomes measured against NFPA standards and OSHA regulations.

Findings

Analysis of the City of Terre Haute Fire Department reveals that, engine fire suppression companies deploy with three fire fighters, out of compliance with industry standards. Apparatus not staffed with four firefighters do not meet compliance with the company staffing objectives outlined in NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, and 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*.

The City of Terre Haute Fire Department requires a minimum of one Battalion Chief to supervise each shift.[1] The department does not staff an Assistant Chief's Aide on full alarm assignments. Therefore, the City of Terre Haute Fire Department is not currently deployed with sufficient resources to perform incident oversight in the most efficient manner. An Assistant Chief's Aide plays a critical role in ensuring emergency incident oversight, including fire fighter accountability, and their absence contributes to the likelihood of fire fighter injuries.

The primary Medic Companies have the fewest amount of road coverage within 4-minutes compared to any other primary apparatus in the Fire Department. At the same time, the EMS related emergencies comprise of nearly 70% of the total emergency calls within a year.

In addition, all Medic Companies- each of which is staffed with 2 firefighters cross-trained in the delivery of advanced medical support (ALS)- are deployed in compliance with the fire services' professional standards for the safe and effective delivery of emergency medical services. NFPA 1710 recommends that, "units that provide ALS transport shall be staffed with a minimum of two members providing patient care that are trained to emergency medical technician-Paramedic (EMT-P) level."[2]

[1] NFPA 1710, §5.2.1.2.3*

[2] NFPA 1710, 5.3.3.3.2.2

Recommendations

The IAFF's GIS-based recommendations include staffing all Engine and Ladder companies with *at least* four multi-role fire fighters, in compliance with NFPA 1710 and NFPA 1500.

An Assistant Chief Aide should be assigned full time to accompany and assist the existing Assistant Chief on full alarm assignments in compliance with NFPA 1710 section 5.2.1.2.5.

The IAFF's GIS-based recommendations include adding an additional primary medic unit comprised of 2 firefighters cross-trained in the delivery of advanced medical support (ALS).

The practice of staffing all Medic Companies with 2 firefighters cross-trained in the delivery of advanced medical support (ALS) should be maintained.

EXECUTIVE SUMMARY

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This report summarizes the results of a station location, staffing, and emergency vehicle response time analysis for the City of Terre Haute Fire Department and IAFF Local 758. This computer-based analytical study examines predicted response times and geographic coverage areas for emergency response units deployed from existing fire stations in the City of Terre Haute.

The City of Terre Haute Fire Department- the primary provider of fire, rescue, and disaster and emergency services in the City of Terre Haute, Indiana - does not currently meet the company staffing objectives of national industry standards. Industry standards require all fire suppression companies (i.e., engines and trucks) to deploy with *at least* four-person crews. Currently, all engine companies are staffed with 3 firefighters. The proposed staffing and station realignment maintains staffing the engine companies with 3 firefighters. The practice of staffing fire companies with *less than* four fire fighters puts public safety at a greater risk for the loss of life and property. Assessment of the critical tasks required for an interior fire attack establishes the impact that reduced staffing has on the effectiveness of fireground operations involving a single-family residential structure.

TABLE 1:

IMPACT OF CREW SIZE ON FIRE ATTACK IN A RESIDENTIAL STRUCTURE[3]
(First Alarm Assignment)

Apparatus	1st Engine Company		2nd Engine Company		Ladder Company		
Fireground Tasks	Charge Initial Interior Line and Advance	Locate and Rescue Victim	Charge Interior Support Line and Advance	Charge Exterior Line and Advance	Roof Ventilation	Search & Rescue	Check Exposures for Fire Extension
5 Firefighters	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
4 Firefighters	**84.7%**	**96.1%**	**77.9%**	**72.9%**	**79.0%**	**90.3%**	**80.2%**
3 Firefighters	**71.3%**	**82.8%**	**0.0%**	**0.0%**	**0.0%**	**79.6%**	**0.0%**

"First-arriving" engine companies that consist of three firefighters are only 71% efficient in initiating an interior fire attack, and 83% efficient in locating and rescuing a fire victim. "Second-in" companies also staffed with three firefighters are completely unable to initiate additional interior or exterior operations because they must support the understaffed operations of the first-in company.

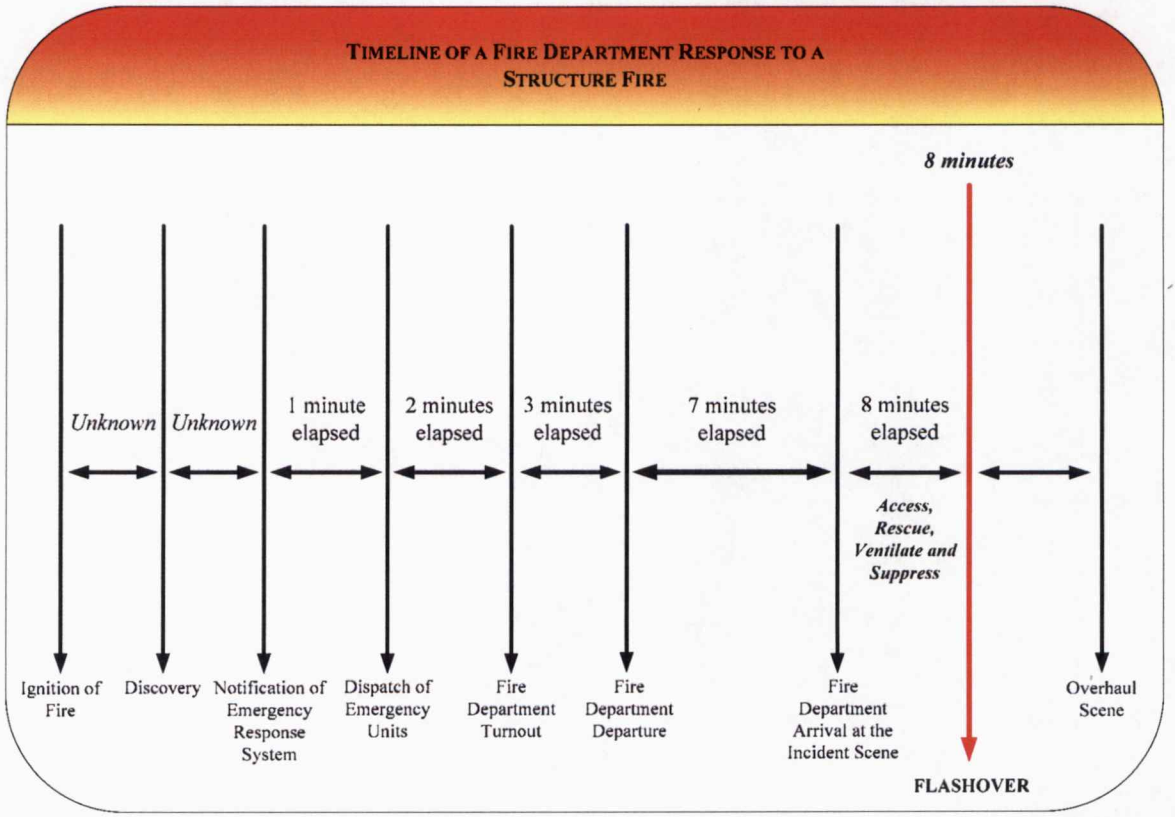
With four person staffing, the effectiveness of first-arriving company interior attack operations *increases* by 14%, to 85% efficiency. The efficacy of engine company victim search and rescue operations also *increases* by 13% with four-person staffing. Moreover, with a four-person company, because the first-in unit is staffed with a sufficient number of personnel to accomplish its assigned duties, the second-in company does not need to support first-in operations, and is therefore capable of performing critical second-in duties.

[3] McManis Associates and John T. O'Hagan & Associates, Dallas Fire Department Staffing Level Study, (June 1984); pp. 1-2 and II-1 through II-7; Richard C. Morrison, Manning Levels for Engine and Ladder Companies in Small Fire Departments, (1990)

Current staffing deficiencies negatively impact the ability of the Fire Department to safely and effectively mitigate emergencies and correlate directly with an increase in expected life, property, and economic losses. Fire growth- the rate of spread and the intensity of the fire- is directly linked to the time it takes to initiate fire suppression operations. As is indicated in Table 1 on the previous page, companies staffed with four firefighters are capable of initiating critical fire ground tasks more efficiently than those staffed below national standards.

As a rule, a fire doubles in size for every minute that passes without the application of aggressive fire suppression measures. In less than 30 seconds a small flame can rage completely out of control and turn into a major fire. During fire growth, the temperature of a fire rises to between 1,000° and 1,200° F. It is generally accepted in the fire service that flashover- the very rapid spreading of the fire due to super heating of room contents and other combustibles- occurs in less than 10 minutes. As there is a potential delay between fire ignition, discovery, and the transmission of an alarm it may be said that **flashover is likely to occur within 8 minutes of firefighters receiving the alarm.** (It is worth noting, however, that flashover may occur in a burning room within four minutes, depending upon its contents.) At the point of flashover, the odds of survival for individuals inside the structure- both victim and rescuer alike- are virtually non-existent. The rapid response of an appropriate number of firefighters is therefore essential to initiating effective fire suppression and rescue operations that seek to minimize flame spread and maximize the odds of preserving both life and property.

FIGURE 1:

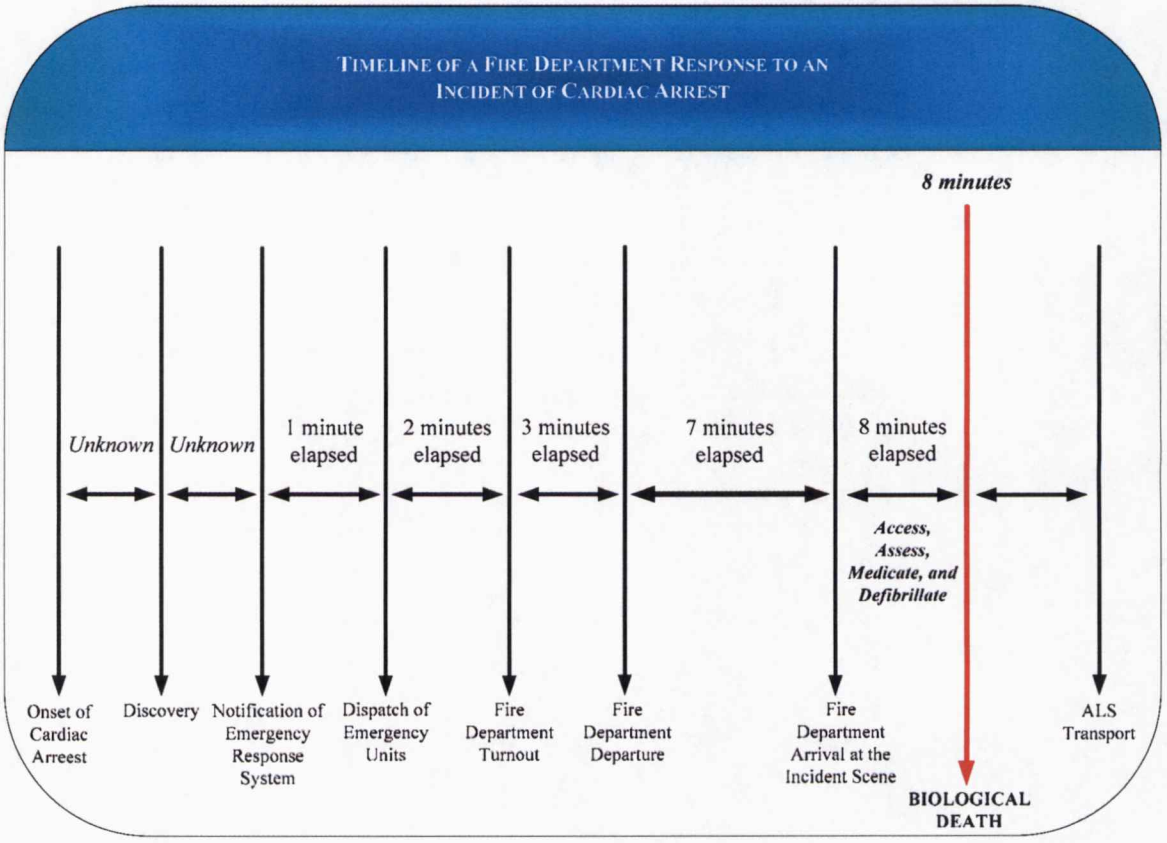


Any decrease in emergency unit response capabilities correlates directly with an increase in expected life, property, and economic losses. Fire growth - the rate of spread and the intensity of the fire- is directly linked to the time it takes to initiate fire suppression operations. In less than 30 seconds a small flame can rage completely out of control and turn into a major fire. As rule, a fire doubles in size for every minute that passes without the application of aggressive fire suppression measures. In five minutes a room can get so hot that everything in it ignites at once, a condition known as "flashover." At this point, the odds of survival for individuals inside the structure- both victim and rescuer- are virtually non-existent.

The unavailability of fire department units, or inadequate staffing levels on those units, exposes citizens to increased risk, drains limited fire department resources, and stresses the emergency response system by requiring additional apparatus to respond with an additional number of personnel. Independent studies performed by private consultants, industry trade groups, emergency service associations and individual fire departments across the United States and Canada all validate similar findings: adequately staffed fire suppression companies responding in a timely fashion are able to initiate and perform emergency scene operations more safely, more effectively, and with greater success than under-staffed companies. Due to the staffing of all engine companies with only three firefighters, the conclusion drawn from analysis of the City of Terre Haute's Fire Department staffing and deployment arrangement is that the fire department does not meet compliance with existing national standards and federal health and safety regulations.

The response to medical emergencies such as a cardiac arrest (one of the most common types of medical emergencies) mirrors the time-temperature curve for fire growth. Cardiac arrest is one of the most time-critical medical emergencies that can be treated in the field. The highest hospital discharge rate has been achieved in patients in whom CPR was initiated within 4 minutes of arrest and advanced cardiac life support within 8 minutes. Fast emergency medical response is therefore essential not only in initiating fire suppression and rescue operations, but in improving survival rates of medical emergencies, as well.

FIGURE 2:



Human Resources vs. Mobile Resources

Emergency units staffed with less than four firefighters also drain limited Fire Department resources, as an increased number of emergency units are allocated to an incident in an effort to achieve appropriate on-scene staffing. The allocation of a greater number of mobile resources (i.e., fire engines and ladder trucks) to an incident in an effort to assemble an appropriate number of human resources (i.e., firefighters) stresses the emergency response system by reducing the number of units available to respond to simultaneously occurring emergencies. Simultaneously occurring emergencies are a regular and expected occurrence in any city that a well-designed emergency response system should be designed to anticipate. The allocation of a greater number of mobile resources to an incident in an effort to assemble an appropriate number of human resources is a direct result of inadequate staffing. In the City of Terre Haute, such conditions may be exacerbated by current cross-staffing practices, and could be further compounded by response delays due to unit unavailability.

Innumerable studies validate similar findings: adequately staffed fire suppression companies responding in a timely fashion are able to initiate and perform emergency scene operations more safely, more effectively, and with greater success than under-staffed companies. And, as will be demonstrated throughout this analysis, adequately-staffed emergency units maintain the overall integrity of the response system by ensuring that sufficient resources, both mobile and human, are available to respond to multiple incidents occurring simultaneously. Insufficient resources, as exist currently in the Terre Haute Fire Department, result in rapid resource depletion, stressing the emergency response system and increasing the risk of the loss of life and property.

The primary conclusion drawn from analysis of the City of Terre Haute Fire Department's staffing and deployment arrangement is that the Fire Department does not fully meet compliance with existing national standards. Consequently, fire fighters and the community they protect are at an increased risk for the loss of life and property. Policies which seek to reduce fire department resources from existing levels would result in further non-compliance with professional standards, and would negatively impact the ability of emergency personnel to provide the safe and effective delivery of fire suppression and rescue services.

Specific recommendations begin on Page 12 of this report.

RECOMMENDATIONS

RECOMMENDATIONS

Based on the findings discussed in this document, the following recommendations are made:

- **It is the recommendation of this analysis that the City of Terre Haute Fire Department should make efforts to staff *all* engine companies on a 24-hour basis with *at least* four multi-role fire fighters cross-trained as emergency medical service (EMS) providers.**[4] NFPA Standard 1710 recommends "fire companies, whose primary functions are to pump and deliver water and perform basic fire fighting at fires, including search and rescue… shall be staffed with a minimum of four on-duty personnel."[5] Industry studies indicate that four fire fighters are capable of performing the rescue of potential victims 80% faster than a crew of three fire fighters. *Currently, not all engine companies are staffed in compliance with NFPA 1710 company staffing objectives.*

- **It is the recommendation of this study that a fire department Battalion Chief deploy with an Assistant Chief's Aide.** NFPA Standard 1710, Section 5.2.1.2.5, states that, "supervisory chief officers shall have staff aides deployed to them for purposes of incident management and accountability at emergency incidents."

- **It is the recommendation of this study that the City of Terre Haute Fire Department add an additional primary Medic Company to the proposed scenario.** The future scenario the Fire Department has created shows an additional fire station and additional fire suppression apparatus with appropriate personnel to the existing stations. However, the Fire Department *does not* add additional Medic Companies to any of the proposed station locations. Existing Basic Life Support assignment covers the least amount of 4-minute road coverage compared to any other 4-minute apparatus or current assignment. In addition, the city boundary and amount of roads will increase in the future scenario as the city of Terre Haute will annex additional areas. Therefore, the 4-minute Medic Company road coverage will decrease. EMS related emergencies comprise of nearly 70% of the total emergencies the City of Terre Haute Fire Department responds to on a yearly basis.

These measures will work to ensure that the City of Terre Haute Fire Department remains in compliance with established OSHA regulations and NFPA industry standards. Furthermore, it promotes safer and more effective fire suppression and disaster incident mitigation, while expediting the delivery of essential emergency medical services to those residing in and visiting the City of Terre Haute.

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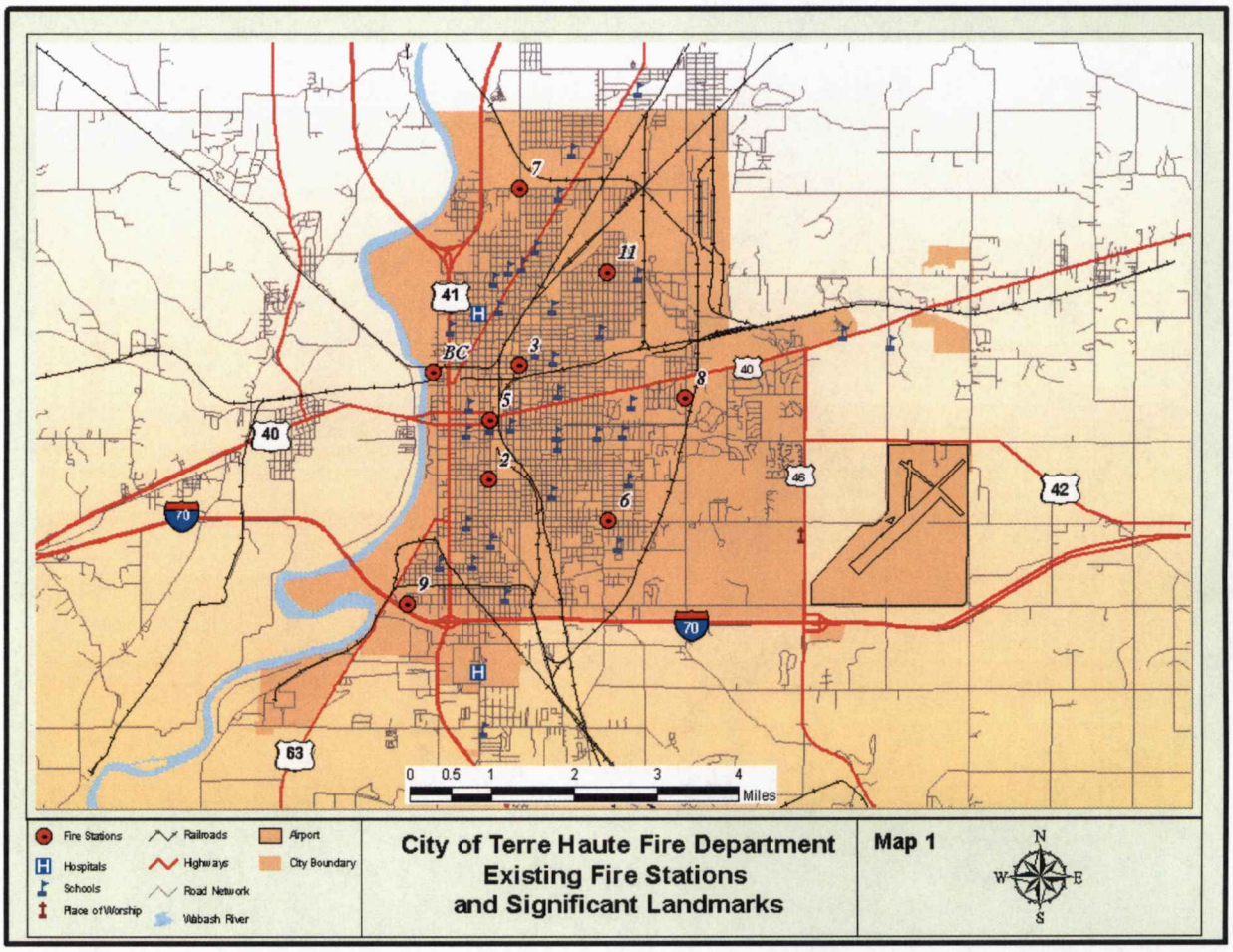
[4] NFPA Standard 1710, §5.2.2.1.2 and §5.2.2.2.2, recommends that, "In jurisdictions with tactical hazards, high hazard occupancies, high incident frequencies, geographical restrictions, or other pertinent factors as identified by the authority having jurisdiction, these companies shall be staffed with a minimum of five or six on-duty members."

[5] NFPA 1710, §5.2.2.1 and §5.2.2.1.1

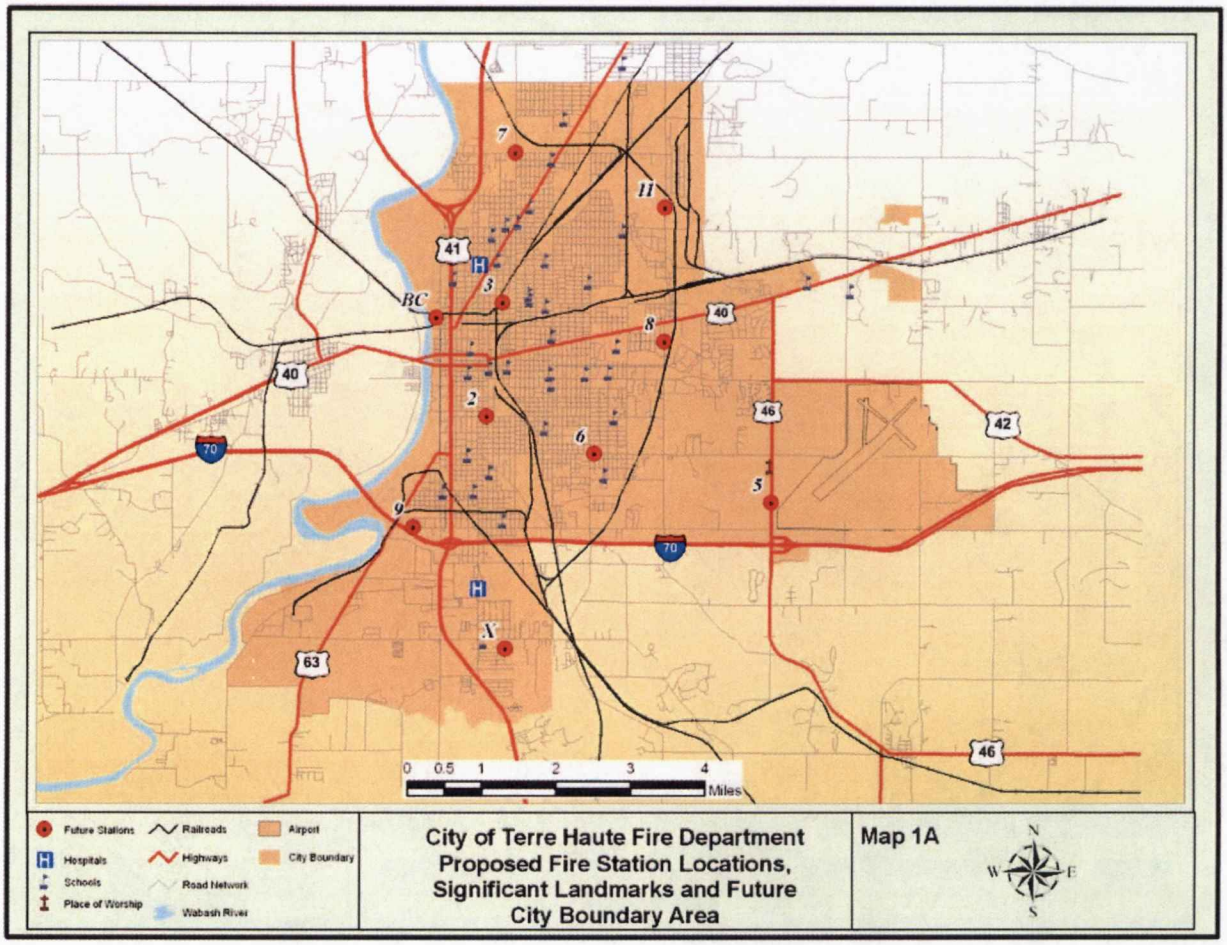
CITY OVERVIEW

MAP 1



Map 1 indicates the City of Terre Haute Fire Department noting major roads and highways, waterways, and the locations of significant area landmarks and existing fire stations. 'BC' is a label for mapping purposes only. The symbol identifies the location of the Battalion Chief. The Battalion Chief does not deploy from a fire station, nor is there any fire apparatus that deploys from the location. The location is identified on each map, because the Battalion Chief responds to full alarm assignments. In this study the Battalion Chief is counted as 1 firefighter. Therefore, the Battalion Chief is designated as an available crew member for the OSHA "2 In/2 Out" regulation and the NFPA Standard 1710 Full Alarm 8-minute response compliance.

MAP 1A



Map 1A indicates the proposed fire station locations in the city of Terre Haute along with the changes to the city boundary area. The proposed station locations and city boundary were updated as of September, 2006. Station 'X' is a label for mapping purposes only. The station has not been designated with a number at this time.

GEOGRAPHY[6]

The City of Terre Haute is located near Indiana's western boarder with Illinois. As of the 200 census, the city had a total of population of 60,614. Terre Haute is intersected by Interstate 70 and Highway 41. Terre Haute is located 77 miles southwest of Indianapolis and within 185 miles of Chicago, St. Louis, Louisville, and Cincinnati. According to the United States Census Bureau, the city has a total of area of 32.1 miles. Terre Haute sits along the Wabash River. The river forms the western border of the city.

[6] Wikipedia. http://en.wikipedia.org/wiki/Terre_Haute,_IN Site last visited on June 28, 2006

FIRE DEPARTMENT OVERVIEW

OVERVIEW OF FIRE DEPARTMENT OPERATIONS

The City of Terre Haute's Fire Department maintains minimum staffing of 34 firefighters, and 1 Battalion Chief for each shift. There are 9 primary (a.k.a., "frontline") fire suppression apparatus (i.e., Engines, Trucks, and Ambulances). All Ambulances are staffed by two firefighters. All Engines are staffed by 3 firefighters, and the Ladder trucks are staffed by four firefighters. The single primary Support Vehicle is staffed by one firefighter. Fire suppression units are stationed at 8 fire houses strategically located throughout the City of Terre Haute. The Battalion Chief is not stationed in any of the fire houses. The members of the City of Terre Haute Fire Department who staff these emergency response units provide fire suppression, special operations, and essential emergency medical services 24 hours a day, 7 days a week.

The primary emergency services provided by the City of Terre Haute Fire Department include:

1. Fire Suppression
2. Emergency Medical Services
3. Special Operations (*inclusive of hazardous materials*)

Each operational program, as described below, has unique responsibilities that support the overall function of the City of Terre Haute's Fire Department.

FIRE SUPPRESSION

According to the U.S. Fire Administration, on average, fire departments in the United States respond to 2 million fire calls each year. On a per capita basis, the American fire problem is one of the worst in the industrial world. Each year, thousands of Americans die, tens of thousands more are injured, and property losses reach into the billions of dollars. The indirect costs of fire- which may be as much as 8 to 10 times higher than the direct costs of fire- are equally as significant, and include temporary lodging, lost business, medical expenses, psychological damage, and more. The USFA puts this into context by noting that **"the annual losses from floods, hurricanes, tornadoes, earthquakes, and other natural disasters combined in the United States average just a fraction of those from fires."**[7]

[7] U.S. Fire Administration, Fire in the United States: 1992-2001, 13th Ed. (Washington, D.C.: October 2004) < http://www.usfa.fema.gov/downloads/pdf/publications/fa-286.pdf >

TABLE 2:
"THE U.S. FIRE PROBLEM"[8]

YEAR	TOTAL FIRES	CIVILIAN DEATHS	CIVILIAN INJURIES	FIREFIGHTER DEATHS	FIREFIGHTER INJURIES	DIRECT PROPERTY DAMAGE[9]
1980	2,988,000	6,505	30,200	138	98,070	$6,254,000,000
1981	2,893,500	6,700	30,450	136	103,340	$6,676,000,000
1982	2,538,000	6,020	30,525	127	98,150	$6,432,000,000
1983	2,326,500	5,920	31,275	113	103,150	$6,598,000,000
1984	2,343,000	5,240	28,125	119	102,300	$6,707,000,000
1985	2,371,000	6,185	28,425	128	100,900	$7,324,000,000
1986	2,271,500	5,850	26,825	120	96,450	$6,709,000,000
1987	2,330,000	5,810	28,215	131	102,600	$7,159,000,000
1988	2,436,500	6,215	30,800	136	102,900	$8,352,000,000
1989	2,115,000	5,410	28,250	118	100,700	$8,655,000,000
1990	2,019,000	5,195	28,600	107	100,300	$7,818,000,000
1991	2,041,500	4,465	29,375	108	103,300	$9,467,000,000
1992	1,964,500	4,730	28,700	75	97,700	$8,295,000,000
1993	1,952,500	4,635	30,475	79	101,500	$8,546,000,000
1994	2,054,500	4,275	27,250	104	95,400	$8,151,000,000
1995	1,965,500	4,585	25,775	97	94,500	$8,918,000,000
1996	1,975,000	4,990	25,550	96	87,150	$9,406,000,000
1997	1,795,000	4,050	23,750	98	85,400	$8,525,000,000
1998	1,755,500	4,035	23,100	91	87,500	$8,629,000,000
1999	1,823,000	3,570	21,875	112	88,500	$10,024,000,000
2000	1,708,000	4,045	22,350	103	84,550	$11,207,000,000
2001	1,734,500	6,196[10]	21,100[11]	439[12]	82,250	$44,023,000,000
2002	1,687,500	3,380	18,425	97	80,719	$10,337,000,000
2003	1,584,500	3,925	18,125	105	78,750	$12,327,000,000
2004	*Unknown*	*Unknown*	*Unknown*	110[13]	*Unknown*	*Unknown*

Every year, fires injure more than 20,000 people, and every year more than 3,000 Americans die in building fires. According to the NFPA, "Every 20 seconds, a fire department responds to a fire somewhere in the nation. A fire occurs in a structure at the rate of one every 61 seconds, and in particular a residential fire occurs every 79 seconds. Fires occur in vehicles at the rate of 1 every 101 seconds, and there's a fire in an outside property every 42 seconds."[14]

There occurred 18,125 civilian fire injuries in 2003 (the last year for which data is available), a decrease of 1.6% from the previous year. It should be noted, however, that this only an

[8] NFPA survey, NFPA's Fire Incident Data Organization (FIDO).
[9] Direct property damage figures do not include indirect losses, like business interruption, and have not been adjusted for inflation.
[10] This includes 2,451 civilian deaths that occurred from the events of 9/11/01.
[11] This includes 800 civilian injuries that occurred from the events of 9/11/01.
[12] Includes 340 firefighters at the World Trade Center, September 11, 2001.
[13] USFA website, < http://64.233.167.104/search?q=cache:zjVfQizVfRAJ:www.usfa.fema.gov/downloads/pdf/04-fatality-summary.pdf+A+Provisional+Report+of+On-Duty+Firefighter+Fatalities&hl=en >, "A Provisional Report of On-Duty Firefighter Fatalities in the United States: 01/01/2004 to 12/31/2004 (rev. 1/31/05)." Site visited March 30, 2005.
[14] Michael J. Karter Jr., Fire Loss in the United States During 2003, National Fire Protection Association (Quincy, MA: October 2004), i.

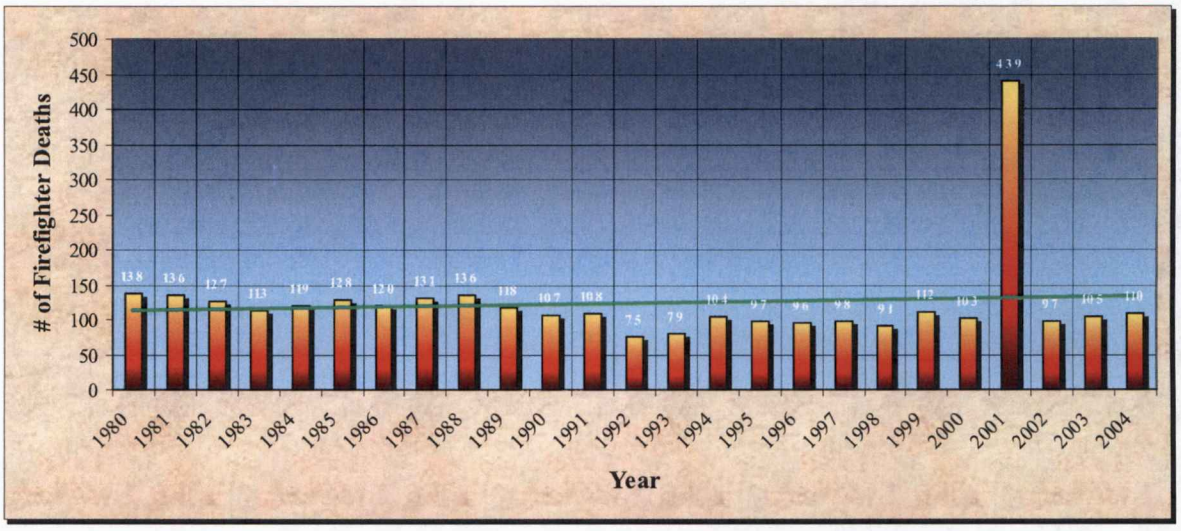
estimation. According to the NFPA, the figure for civilian injuries is on the low side due to under-reporting of civilian injuries to the fire service. Of these injuries, 14,075 occurred in residential properties, while 1,525 occurred in nonresidential structure fires. **Nationwide, there was a civilian fire injury every 29 minutes.**[15]

There occurred 3,925 civilian fire deaths in 2003, an *increase* of 16.1% from a year ago. Of these, 3,145 (about 80% of all fire deaths) occurred in the home – an *increase* of 17.8%, and back to the 2000 and 2001 levels. An additional 220 civilians died in nonresidential structure fires. This includes 100 civilians that died in the Station Nightclub Fire in Rhode Island, and 31 civilians who died in nursing home fires in Connecticut and Tennessee. **Nationwide, there was a civilian fire death every 134 minutes.**[16]

Furthermore, each year in the United States and its protectorates, approximately 100 firefighters are killed while on-duty, and tens of thousands more are injured. According to the Federal Emergency Management Agency:

> **Despite a downward dip in the early 1990s, the level of firefighter fatalities is back up to the same levels experienced in the 1980s. If the firefighter deaths at the World Trade Center are included in the 2001 data, the number rises to 23.1 firefighter fatalities per 100,000 fires.**[17]

FIGURE 1:
"ON-DUTY FIRE FIGHTER FATALITIES"
(1980 – 2004)



To effectively respond to emergencies occurring in the City of Terre Haute, all firefighters are trained in the latest fire suppression techniques, hazardous material recognition, medical first response and basic rescue techniques. A firefighter's base of knowledge must cover the areas of building construction, hydraulics, medical treatment, fire sprinkler design, safe driving

[15] Michael J. Karter Jr., Fire Loss in the Unites States During 2003, National Fire Protection Association (Quincy, MA: October 2004), ii.
[16] Ibid.
[17] Firefighter Fatalities in the United States in 2002, Federal Emergency Management Agency (Washington, D.C.: July, 2003), 8.

practices, vehicle extrication techniques, and more. Each one of these areas is continually changing with new research and technology utilized in the public and private sectors. Rigorous, comprehensive, and continuous training enables the fire department to deliver water rescue, high & low angle rope rescue, heavy rescue, structural collapse rescue, confined space rescue, and trench rescue.

During 2005, the City of Terre Haute Fire Department reported a total of 3365 Fire/EMS incidents. The following table shows the incidents by type of response.

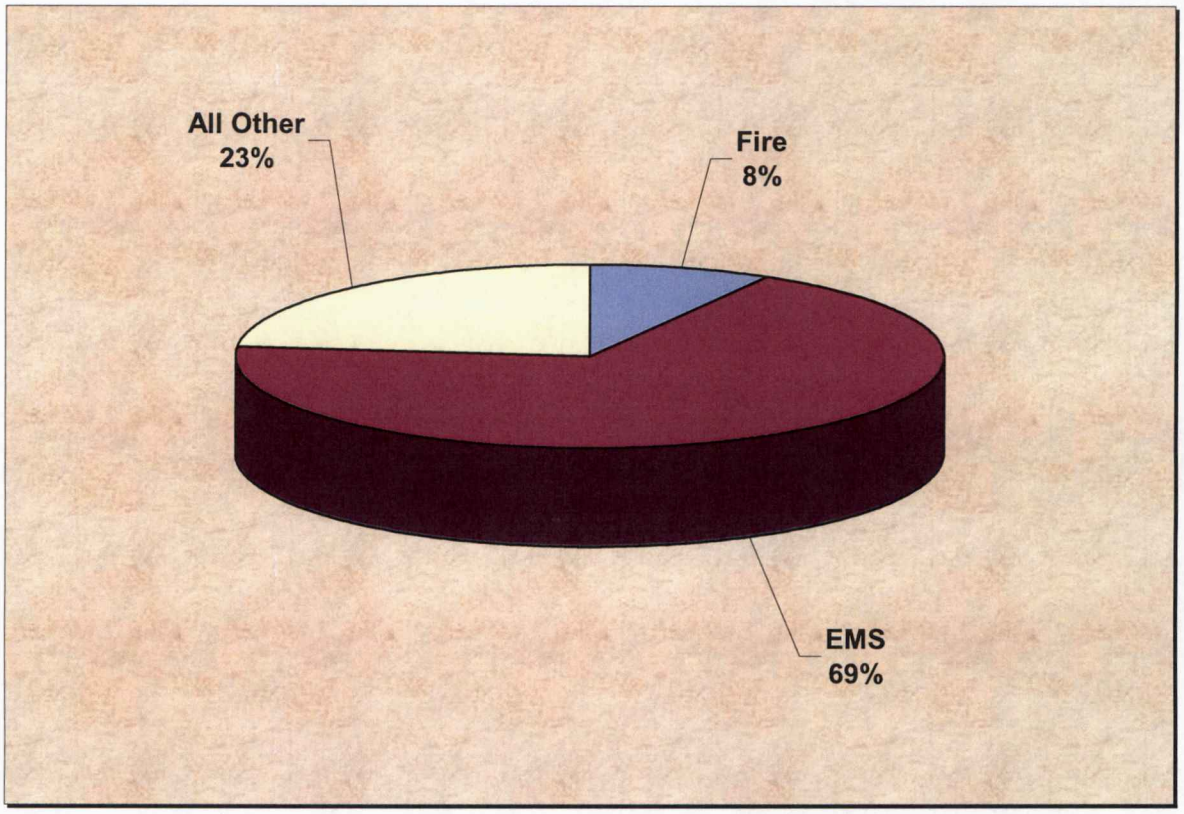
TABLE 3:
REPORTED INCIDENTS BY TYPE[18]
(Year 2005)

Incident Type	Total
Fire Related Calls for Service	283
EMS Calls for Service	2296
All Other Calls for Service	786
Total	3365

Based on 2005 response statistics, these figures are detailed as percentages in the following graphic. *(See following page)*

[18] Data collected from the York, Pennsylvania Financial Management Study and the Matrix Consulting Group.

FIGURE 2:
BREAKDOWN PERCENTAGES OF TOTAL REPORTED INCIDENTS
(Year 2005)



FIRE PREVENTION, CODE ENFORCEMENT, PUBLIC EDUCATION & FIRE INVESTIGATION

Fire prevention is an important component in all aspects of fire department operations, including education, training, fire cause investigation and determination, support for the preparation of litigation pertaining to arson, and victim assistance. As noted in a recent study, "Some of the greatest value delivered by the U.S. fire service comes in activities that prevent fire and other emergencies from occurring or that moderate their severity when they do occur."[19]

Fire prevention encompasses the performance of mandatory inspections at hospitals, child/adult care facilities, correctional institutions, hotels and motels, foster homes, preschool facilities, health spas and any businesses that, by decree of state law, require inspection.

Fire prevention efforts pursued by the City of Terre Haute Fire Department are aimed at reducing the factors which contribute to the cause and spread of fire. These efforts include consultations with the public, the issuance of permits, and public education programs targeted towards schoolchildren and seniors.

[19] National Fire Protection Association/U.S. Fire Administration, A Needs Assessment of the U.S. Fire Service: A Cooperative Study Authorized by U.S. Public Law 106-938, (Washington, D.C.: December 2002), 49.

The Value and Purpose of Fire Inspection & Prevention Programs

Fire prevention consists of three elements: codes and code enforcement, fire prevention inspections, and fire education. The American Insurance Association lists the value and purpose of fire department inspections and fire prevention programs as follows:

1. *To obtain proper life safety conditions.* Life safety inspections call for attention to the adequacy of exits, obstructions to rapid and orderly egress at time of fire, the adequacy of building evacuation plans, and the determination of the number of occupants permitted in a place of public assembly.

2. *To keep fires from starting.* Fire inspectors are specifically trained to identify fire hazards and can point out hazardous conditions and explain their seriousness to those who work among materials or situations which are hazardous.

3. *To keep fires from spreading.* Most people have little appreciation of the value that structural features (stair and elevator enclosures, fire doors and fire partitions) have in preventing the spread of fire. Inspectors educate owners and occupants in the value of proper maintenance of such structural members and have additional features installed, when necessary.

4. *To determine the adequacy and maintenance of fire protection equipment.* Private fire protection equipment such as extinguishers, standpipes, hose systems, automatic sprinkler systems, private water supplies, and alarm systems are installed to alert and protect building occupants and to aid in fire department operations. Under normal conditions this equipment is seldom used. Frequent inspections therefore are necessary to insure that the equipment will always be in proper working order.

5. *To pre-plan fire fighting procedures.* The "pre-fire plan" of a particular building calls for a knowledge of the building's fire hazards, fire protection equipment, construction features affecting the spread of fire, exposures, and exit facilities. Pre-planning is necessary for the protection of fire fighters as well as the occupants, and aids in efficient extinguishment. Fire department personnel conduct inspections and incident pre-planning on specific residential properties, including triplexes and larger dwellings, in addition to all commercial businesses in the community. Personnel are responsible for checking business licenses in all commercial occupancies during the course of their regular building inspection tours, and for checking permits for hazardous processes, special occupancies and any activity that may produce conditions hazardous to life or property. Regular inspections and pre-planning provide for the systematic inspection of all commercial occupancies, and help to reduce the loss of life and property due to fire and other hazards.

6. *To stimulate cooperation between the fire department and owners and occupants.* Inspectors provide valuable advice on problems of fire protection and prevention. Such advice fosters cooperation between the community and the fire

department, and serves to increase the standing of the department within the community.

7. *To assure compliance with fire codes, laws, and regulations.* Inspectors are trained to recognize and correct violations, and are empowered to enforce fire code regulations.[20]

Arson Investigation

According to the United States Fire Administration, arson is the leading cause of fire in the United States. The general public typically views arson as an insurance concern – primarily a "paper" crime of fraud mostly affecting insurance companies. Each year, an estimated 267,000 fires are attributed to arson, which result in $1.4 billion in property loss.

Arsonists, however, injure and kill both civilians and firefighters, causing over 2,000 injuries and nearly 500 deaths per year.[21] Increasingly, set fires motivated by spite and revenge are used as weapons. Such fires tend to be more deadly because they are targeted specifically to inflict personal harm. According to the USFA, "firefighters are 3 times more likely to be injured or killed while responding to arson versus a non-arson fire."[22]

The City of Terre Haute Fire Department pursues investigations should the fire cause be "undetermined" or "suspicious in origin," "incendiary in origin," or result in serious injury or death. The fire department coordinates with local law enforcement agencies to aggressively prosecute individuals who commit the crime of arson.

Public Education

The City of Terre Haute Fire Department realizes that the most effective way to reduce the tragedies due to fire is to provide the proper fire safety tools to the community. The fire department strives to achieve this by conducting station tours to different groups within the community and by targeting education programs to children in local schools, where educational programs that teach children what to do in a fire situation. In addition, educational programs for school age children address the risks involved in playing with fire and the dangers of playing with matches and lighters,[23] as children are naturally curious about fire. Some studies suggest that interest in fire develops even before age three.[24] The U.S. Fire Administration characterizes the problem of juvenile fire setting as follows:

> Whether a child actually sets fires depends on a variety of factors, including their exposure to fire and the availability of fire supplies. Although some children who set fires are unaware of the potentially tragic consequences of their actions and are simply curious, others are fully aware of the ramifications of their actions and purposely intend

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[20] James F. Casey, ed., Fire Prevention, Fire Chief's Handbook, 4th ed., (Saddle Brook, N.J., 1987), 530-532.

[21] John R. Hall, Jr., Intentional Fires and Arson, National Fire Protection Association (Quincy, MA: March 2005). <http://www.nfpa.org/catalog/services/customer/downloadmemberonlypdf.asp?pdfname=OS%2Earson%2Epdf&src=nfpa >

[22] USFA Press Release, United States Fire Administration Announces Arson Awareness Week Theme for May 5-11, 2002, (Washington, D.C.: May 3, 2002). < http://www.usfa.fema.gov/inside-usfa/media/2002releases/02-042.shtm >

[23] These efforts re part of NFPA's *Risk Watch®* curriculum, which incorporates elements from the earlier *Learn Not to Burn® Curriculum.*

[24] D.J. Kolko and A.E. Kazdin, "A Conceptualization of Fire-setting in Children and Adolescents," Journal of Abnormal Child Psychology, 14, (1), 49-61, 1999.

> to cause damage. Regardless of the motivations underlying juvenile fire-setting, it is a widespread problem that affects not only those children and their families, but all of society.[25]

According to the NFPA, "In 2002, an estimated 13,900 child-playing structure fires were reported in the U.S., with associated losses of 210 civilian deaths, 1,250 civilian injuries, and $339 million in direct damage."[26] For the ninth straight year, juvenile fire-setters accounted for at least half (50%) of those arrested for arson in 2003 (the last year for which data is available). The percentage of arson arrestees under age 10 (3% in 2003) is much higher than for any other crime the FBI tracks.[27] These facts underline the importance of community fire prevention programs, especially in the community's younger population.

EMERGENCY MEDICAL SERVICES

The City of Terre Haute Fire Department also provides the citizens of and visitors to the City of Terre Haute with high-quality pre-hospital emergency medical care. Each apparatus in the fire department is equipped with basic life support equipment, including automatic external defibrillators (AEDs) and oxygen. All firefighters in the City of Terre Haute Fire Department are certified, at a minimum, to the level of "Basic" emergency medical technicians (EMT-Bs). ALS and ambulance transport services are provided by 3 primary ambulances that deploy from Stations 7, 8, and 9. Reserve ambulances are stationed at Stations 2, 6, 7, and another at Station 9. Two firefighters deploy on each ambulance. One firefighter is certified, at a minimum, as an EMT-P (Paramedic). The second firefighter is certified as an EMT-A.

In 2005, the City of Terre Haute Fire Department responded to 6,009 emergency medical calls for service. 4,385 of those were transports which is 73% of the total calls for service. The total amount of EMS related calls for service has been steadily increasing in the past 5 years in the City of Terre Haute. *See chart on the following page.*

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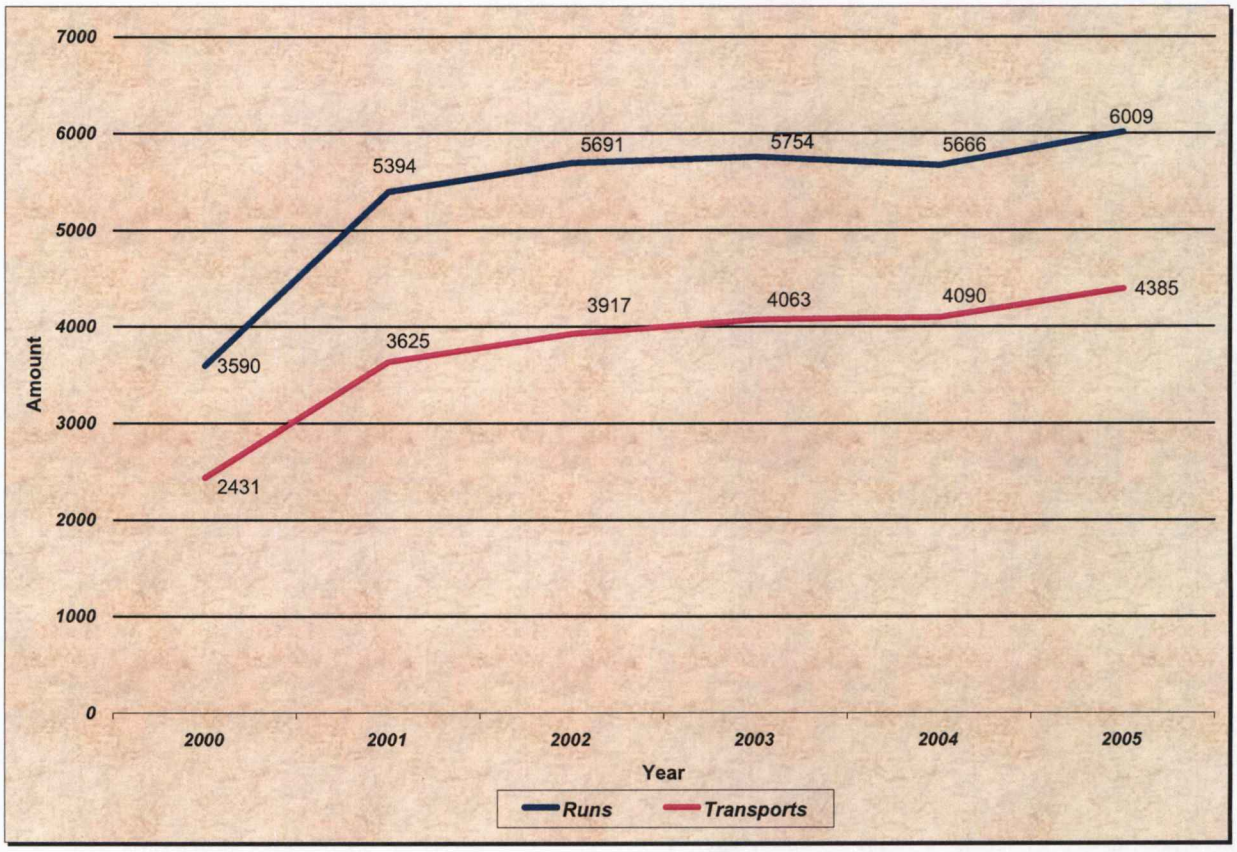
[25] U.S. Fire Administration, "Children and Fire," Topical Fire Research Series, vol. 1, issue 6 (Washington, D.C.: December, 2001).

[26] John R. Hall, Jr., Children Playing with Fire, National Fire Protection Association, (Quincy, MA: March 2005), i. <http://www.nfpa.org/itemDetail.asp?categoryID=281&itemID=18271&URL=Research%20&%20Reports/Fact%20sheets/Home%20safety/Children%20playing%20with%20fire&cookie%5Ftest=1>

[27] John R. Hall, Jr., Intentional Fires and Arson, National Fire Protection Association (Quincy, MA: March 2005).

FIGURE 3:
EMS CALLS FOR SERVICE BY YEAR



SPECIAL OPERATIONS

The City of Terre Haute Fire Department continues to provide all risk emergency response to the citizens of the city. This includes the best quality fire protection, fire prevention, fire safety education, emergency medical service, and other emergency response services.

Hazardous Materials Program (HazMat)

The importance of a rapid response to a hazardous materials incident cannot be overstated. Responding personnel must arrive as promptly as possible to allow for sufficient time to identify the hazards involved and initiate a plan of action that ensures the safety of the community and the on-scene personnel before attempting to rescue and treat any victims.

A hazardous materials incident involves the intentional or accidental release of toxic, combustible, illegal or dangerous nuclear, biological or chemical agents into the environment. Hazardous materials incidents are generalized under three categories: Intentional Releases, Accidental Releases, and Domestic Terrorism.

Intentional Releases

The intentional release of hazardous materials occurs when "individuals and/or companies knowingly and illegally emit or dump toxic waste into landfills, waterways, the atmosphere and the environment in general. An example of such a release would be the illegal 'cooking' of methamphetamine in clandestine drug labs."[28] Drug labs present a serious health and safety issue to a community. A significant amount of time and resources are required to safely dismantle drug labs, decontaminate the area, and mitigate the incident.

Domestic Terrorism

Domestic terrorism involving hazardous materials can be defined as the intentional and malicious release of deadly biological or chemical agents into the general population. Terrorist activities that have occurred in past years– the bombing of Murrah Federal Building in Oklahoma City, the release of a deadly nerve gas (sarin) in a Tokyo subway system, terrorist attacks in New Terre Haute City and Washington, DC, anthrax attacks along the eastern seaboard, and, most recently, the delivery of ricin to the U.S. Capitol– have prompted the expansion of hazardous materials preparedness and response capabilities, both nationally and internationally.

[28] Seattle Fire Department website: < http://www.ci.seattle.wa.us/fire/text/firefighting/operations/t_hazMat.htm >; site visited September 2, 2004.

GIS ANALYSIS METHODOLOGY

METHODOLOGY

OVERVIEW

Once the domain of cartographers, computer-assisted drawing technicians, mainframes, and workstations, geographic information systems (GIS) mapping has migrated to the desktop. With ArcView, a user can create intelligent, dynamic maps, using data from virtually any source and across most popular computing platforms to display information that has a geographic aspect. The ArcView GIS software, a product of ESRI, Inc., allows desktop users to work simultaneously with maps, database tables, charts, and graphics, and is an effective tool for conducting computerized system analysis and management.

Geographic information systems are used by government agencies, nonprofit organizations, and businesses to describe and analyze the physical world. Simply put, a GIS combines layers of information about a geographic region to give you a better understanding of that region. Layers of information can be combined depending on the purpose of the study, forming a computer model of a jurisdiction on which many types of analysis can be made. In the public safety sector, and for the purposes of this analysis, GIS software uses geography and computer-generated maps as an interface for integrating and accessing location-based information. For example, the location of fire stations can be layered on a jurisdiction's geography including the road network, water features, building footprints, or any other feature that has been digitized and assigned a location. In this manner, GIS allows public safety personnel to effectively plan for emergency response, determine mitigation priorities, analyze historical events, and predict future events. GIS can also be used to provide critical information to emergency responders upon dispatch or while en route to an incident to assist in tactical planning.

NFPA 1710 AND GIS ANALYSIS

While modern science has been well integrated into many areas of emergency response, it has been glaringly absent in the area of fire-rescue organization and deployment. Fire growth and behavior are scientifically measurable, as are the expected outcomes associated with untreated cardiac arrest, and the specific resource requirements to control fires, reduce fire-related injuries, and prevent deaths. Despite these facts, many communities maintain an *ad hoc* approach fire-rescue organization and deployment.

The Role of the National Fire Protection Association (NFPA)

The mission of the NFPA is to reduce the worldwide burden of fire and other hazards on the quality of life by providing and advocating scientifically-based consensus codes and standards, research, training, and education, and recommends that all fire departments establish a policy of providing and operating with "the highest possible levels of safety and health for all members."[29]

The recommendations and analysis contained in this study are guided by NFPA standards for two important reasons. First, NFPA standards provide fire departments with a measure of "interoperability." Interoperability enables fire service personnel in the chain of command to speak the same language and conform to the same operational guidelines. NFPA standards provide the fire service with a common language, common definitions, and common

[29] NFPA Mission Statement

requirements that are meant to foster the *safe* and *effective* delivery of fire suppression, rescue, EMS, and special services to a given community. Second, NFPA standards are formulated via consensus development. Development of NFPA standards are the result of scientific research, empirical studies, and consensus among technical experts and the organizations with which they are affiliated. Combined, these factors legitimate NFPA standards as the yardstick by which fire departments are measured internationally.

On account of their emphasis on safe and effective fire suppression and rescue operations, the two standards that will be referenced most often throughout this analysis are NFPA 1500 and NFPA 1710. NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, specifies (1) the minimum requirements for a fire department's occupational safety and health program, and (2) the safety procedures for members involved in rescue, fire suppression, and related activities. This standard addresses organization, training and education, vehicles, equipment, protective clothing, emergency operations, facilities, medical and physical criteria, and member assistance programs. NFPA 1500 recommends that a "**minimum acceptable fire company staffing level should be four members responding on or arriving with each engine and each ladder company responding to any type of fire**."

The purpose of 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*, is "to specify the minimum criteria addressing the effectiveness and efficiency of the career public fire suppression operations, emergency medical service, and special operations delivery in protecting the public of the jurisdiction and the occupational safety and health of fire department employees."[30] The standard recommends "fire companies, whose primary functions are to pump and deliver water and perform basic fire fighting at fires, including search and rescue… shall be staffed with a **minimum of four on-duty personnel**.[31] Fire companies whose primary functions are to perform the variety of services associated with truck work, such as forcible entry, ventilation, search and rescue, aerial operations for water delivery and rescue, utility control, illumination, overhaul and salvage work… shall [also] be staffed with a **minimum of four on-duty personnel**.[32] In jurisdictions with tactical hazards, high hazard occupancies, high incident frequencies, geographical restrictions, or other pertinent factors as identified by the authority having jurisdiction, these companies shall be staffed with a minimum of five or six on-duty members."[33]

The NFPA 1710 Standard is important because it applies the documented and proven science of fire behavior and emergency medicine to the basic resource requirements for effective fire and emergency service deployment. Coupled with GIS analysis, this application allows a community to determine if the resources allocated for the different types of fires, emergencies, medical calls and other incidents are sufficient to effectively control the incident and protect lives and property. NFPA 1710 sets forth in concise terms the recommended resource requirements for fires, emergencies and other incidents. The standard requires, and GIS analysis facilitates, the emergency response organization to evaluate its performance and report it to the authority having jurisdiction. The approach embodied by NFPA 1710, and supported

[30] NFPA 1710, § 1.2.1
[31] NFPA 1710, § 5.2.2.1 and § 5.2.2.1.1
[32] NFPA 1710, § 5.2.2.2 and § 5.2.2.2.1
[33] NFPA 1710, § 5.2.2.1.2 and § 5.2.2.2.2

by GIS analysis, makes communities and fire fighters safer and responders more effective and enhances efficiency.

NFPA 1710 and the Law

NFPA standards protect communities against liability. In the United States, by law- specifically, the General Duties clause of the Occupational Safety and Health Administration Act- if Congress fails to pass legislation setting industry safety standards, municipal governments nationwide are mandated to follow standards promulgated by an industry-wide trade group, such as the NFPA. Many NFPA standards have been enacted into law at the federal, state, provincial and local levels. Although jurisdictions having authority are not required to automatically enact a particular NFPA standard, courts frequently rely upon NFPA standards to determine the "industry standard" for fire protection and safety measures. Judicial reliance on NFPA doctrines is most frequently found in common law negligence claims. To prevail in a common law negligence claim, the plaintiff must show that the defendant owed a duty of care to the plaintiff, that the defendant breached this duty of care and that this breach was the cause of the plaintiff's injury. Hence**, the NFPA 1710 standard could be found highly relevant to the question of whether a jurisdiction has negligently failed to provide adequate fire or emergency medical protection to an individual harmed in a fire or medical emergency. Furthermore, any local government that fails to follow the NFPA 1710 Standard is subject to liability claims in the event of fire fighter injuries or death.**

ArcView 3.3 and Network Analyst Geographic Information Systems

ArcView's Network Analyst is an extension, or software tool, that manipulates the network data incorporated into a GIS. Networks are interconnected line features, visually represented as roads, rivers, pipelines, or trails. From this data, it is possible to determine the best route between two spots or amongst several points, calculate travel cost in distance or time, find the closest facility to an address, or model service areas.

Travel speed is based on road type, as assigned by the U.S. Census Bureau. The ArcView 3.3 software Network Analyst extension uses the Tele Atlas® v8.0™ street database, which offers the most accurate and comprehensive U.S. street and address data available today.

Assigned Road Speeds

A great deal of geographic street data originates from the US Census Bureau TIGER files. One of the attributes extracted from these files is the Census Feature Classification Code (CFCC), which describes street characteristics, among others. The CFCC is a three-character code: the first character is a letter describing the feature class; the second character is a number describing the major category; and the third character is a number describing the minor category. Based on the CFCC codes, a GIS user employing the ArcView Network Analyst extension is able to calculate the driving time for each line segment in a road network (i.e., the roads in a city, county, or other jurisdiction). The designated CFCC codes for each road type, as assigned by the U.S. Census Bureau, are indicated on the following pages.

Primary Highways *With* Limited Access – 55 mph

Interstate highways and some toll highways are in this category (A1) and are distinguished by the presence of interchanges. These highways are accessed by way of ramps and have multiple lanes of traffic. The opposing traffic lanes are divided by a median strip.

A11 Interstate highway, un-separated
A12 Interstate highway, un-separated, in tunnel
A13 Interstate highway, un-separated, under-passing
A14 Interstate highway, un-separated, with rail line in center
A15 Interstate highway, separated
A16 Interstate highway, separated, in tunnel
A17 Interstate highway, separated, under-passing
A18 Interstate highway, separated, with rail line in center

Primary Roads *Without* Limited Access – 45 mph

This category (A2) includes nationally and regionally important highways that do not have limited access as required by category A1. It consists mainly of US highways, but may include some state highways and county highways that connect cities and larger towns. A road in this category must be hard-surface (concrete or asphalt). It has intersections with other roads, may be divided or undivided, and have multi-lane or single-lane characteristics.

A21 US highways, un-separated
A22 US highways, un-separated, in tunnel
A23 US highways, un-separated, under-passing
A24 US highways, un-separated, with rail line in center
A25 US highways, separated
A26 US highways, separated, in tunnel
A27 US highways, separated, under-passing
A28 US highways, separated, with rail line in center

Secondary and Connecting Roads – 35 mph

This category (A3) includes mostly state highways, but may include some county highways that connect smaller towns, subdivisions, and neighborhoods. The roads in this category generally are smaller than roads in Category A2, must be hard-surface, and are usually undivided with single-lane characteristics. These roads usually have a local name along with a route number and intersect with many other roads and driveways.

A31 State highways, un-separated
A32 State highways, un-separated, in tunnel
A33 State highways, un-separated, under-passing
A34 State highways, un-separated, with rail line in center
A35 State highways, separated
A36 State highways, separated, in tunnel
A37 State and county highways, separated, under-passing
A38 State and county highway, separated, with rail line in center

Local, Neighborhood, and Rural Roads – 25 mph

A road in this category (A4) is used for local traffic and usually has a single lane of traffic in each direction. In an urban area, this is a neighborhood road and street that is not a thoroughfare belonging in categories A2 or A3. In a rural area, this is a short-distance road connecting the smallest towns; the road may or may not have a state or county route number. Scenic park roads, unimproved or unpaved roads, and industrial roads are included in this category. Most roads in the Nation are classified as A4 roads.

A41 Local street, un-separated
A42 Local street, un-separated, in tunnel
A43 Local street, un-separated, under-passing
A44 Local street, un-separated, with rail line in center
A45 Local street, separated
A46 Local street, separated, in tunnel
A47 Local street, separated, under-passing
A48 Local street, separated, with rail line in center

Vehicular Trails – 1 mph

A road in this category (A5) is usable only by four-wheel drive vehicles, is usually a one-lane dirt trail, and is found almost exclusively in very rural areas. Sometimes the road is called a fire road or logging road and may include an abandoned railroad grade where the tracks have been removed. Minor, unpaved roads usable by ordinary cars and trucks belong in category A4, not A5.

A51 Vehicular trail, 4WD only, un-separated
A52 Vehicular trail, 4WD only, un-separated, in tunnel
A53 Vehicular trail, 4WD only, un-separated, under-passing

Road with Special Characteristics – 20 mph (or less)*

This category (A6) includes roads, portions of a road, intersections of a road, or the ends of a road that are parts of the vehicular highway system and have separately identifiable characteristics.

A61 Cul-de-sac
A62 Traffic circle, roundabout
A63 Access ramp
A64* Service drive on highway (5 mph)

Road as Other Thoroughfare – 5 mph (or less)*

A road in this category (A7) is not part of the vehicular highway system. It is used by bicyclists or pedestrians, and is typically inaccessible to mainstream motor traffic except for private-owner and service vehicles. This category includes foot and hiking trails located on park and forestland, as well as stairs or walkways that follow a road right-of-way and have names similar to road names.

A71* Walkway or trail for pedestrians (1 mph)
A72* Stairway for pedestrians (1 mph)
A73 Alley, road for service vehicles
A74 Driveway, service, or access road, usually privately owned

ASSUMPTIONS

Several key assumptions must be addressed prior to drawing any conclusions from this analysis:

- Modeled travel speeds are based on reasonable and prudent road speeds, as defined by the U.S. Census Bureau. **Actual response speeds may be slower, and the associated travel times greater, with any traffic congestion or any other unpredictable impedances including, but not limited to:**

  ✓ ***Traffic Incidents***: collisions and vehicle breakdowns causing lane blockages and driver distractions.

  ✓ ***Work Zones***: construction and maintenance activity that can cause added travel time in locations and times where congestion is not normally present.

  ✓ ***Weather***: reduced visibility, road surface problems and uncertain waiting conditions result in extra travel time and altered trip patterns.

  ✓ ***Demand Changes***: traffic volume varies from hour-to-hour and day-to-day and this causes travel time, crowding and congestion patterns to disappear or to significantly worsen for no apparent reason in some locations.

  ✓ ***Special Events***: an identifiable case of demand changes where the volume and pattern of the change can frequently be predicted or anticipated.

  ✓ ***Traffic Control Devices***: poorly timed or inoperable traffic signals, drawbridges, railroad grade crossing signals or traveler information systems contribute to irregularities in travel time.

  ✓ ***Inadequate Road or Transit Capacity***: the urban areas are not adding enough capacity, improving operations or managing demand well enough to keep congestion from growing larger.[34]

[34] David Schrank and Tim Lomax, The 2005 Urban Mobility Report, (Texas Transportation Institute, Texas A&M University: May 2005).

Assumptions for Railroad Crossings

ArcView can only change road segment designations as passable or impassable and model the outcome. The City of Terre Haute has many roads that cross busy railroad tracks; therefore railroad crossings directly impact the time it takes for an apparatus from the fire department to reach an emergency. However, ArcView can not model the number of trains that use the tracks in a day, the length of the trains, or the speed at which the trains travel. All these factors would change the travel time in the cost analysis and could further change the service areas from each station. Therefore, the coverage areas defined on the maps do not show service coverage if an apparatus is blocked by a train.

TABLE 4:
"EXISTING STATION LOCATIONS & DEPLOYMENT CONFIGURATION"

STATION	ADDRESS	APPARATUS	PERSONNEL
Station 2	875 College St.	Engine 2 Reserve 1 (Ambulance) MCI Trailer	**3 FF** (2 EMT- B, 1 EMT- P)
Station 3	701 N. 13th St	Engine 3	**3FF** (EMT-B)
Station 5	28 S. 9th St.	Ladder 5 Support 5	**4FF** (EMT-B) **1FF** (EMT-B)
Station 6	2600 Hulman St	Engine 6 Reserve 4 (Ambulance)	**3 FF** (EMT-B)
Station 7	1300 Ft. Harrison Rd	Engine 7 Medic 7 Reserve Engine Reserve 2 (Ambulance)	**3FF** (2 EMT-B, 1 EMT-P) **2FF** (1 EMT-A, 1 EMT-P)
Station 8	240 S. Fruitridge Ave	Ladder 8 Tanker 8 Medic 8	**4FF** (EMT-B) **2FF** (1 EMT-A, 1 EMT-P)
Station 9	559 W. Margaret Ave	Engine 9 Medic 9 Unit 9-11 (Haz-mat, WMD) Haz-Mat Decon Unit & Hovercraft Reserve 3 (Ambulance)	**3FF** (EMT-B) **2FF** (1 EMT-A, 1 EMT-P)
Station 11	2601 Maple Ave	Engine 11	**3FF** (EMT-B)
Battalion Chief	25 Spruce Ct.	Battalion Chief Vehicle	**1FF** (EMT –B)

Existing On-duty Staffing: 34

TABLE 5:
"PROPOSED STATION LOCATIONS & DEPLOYMENT CONFIGURATION"

STATION	ADDRESS	APPARATUS	PERSONNEL (EMS LEVE
Station 2	875 College St.	Engine 2 Ladder 2	**4 FF** **4 FF**
Station 3*	N 13th St/Locust St.	Engine 3	**4 FF**
Station 5*	46th St/Margaret Ave.	Engine 5 Support 5	**4 FF** **1 FF**
Station 6	2600 Hulman St	Engine 6	**4 FF**
Station 7	1300 Ft. Harrison Rd	Engine 7 Ladder 7 Medic 7	**4 FF** **4 FF** **2 FF**
Station 8	Rte 46/Poplar Dr.	Engine 8 Ladder 8 Medic 8	**4 FF** **4 FF** **2 FF**
Station 9	559 W. Margaret Ave	Engine 9 Medic 9 Unit 9-11 (Haz-mat, WMD) Haz-mat Decon Unit & Hovercraft	**4 FF** **2 FF**
Station 11*	38th St./Maple Ave.	Engine 11/New Training Tower	**4 FF**
Station 'X'*	Future Annex Area	Engine	**4 FF**
Battalion Chief	25 Spruce Ct.	Battalion Chief Vehicle	**1FF**

Proposed On-duty Staffing: 56

**Stations that will move from existing locations or will be built in the future.*

- **If primary units are unavailable, for any reason** (e.g., simultaneous emergencies, scheduled training, or as a result of mutual aid obligations), **to respond to an emergency, travel times will be greater as more distantly-located secondary apparatus will be required to respond to an emergency in the primary unit's stead, and with potential delays.**

- **The time from arrival of the apparatus to the onset of interior fire suppression operations and/or initiation of critical emergency medical interventions by that crew** (access interval) **must be considered when analyzing response system capabilities.** In reality, the access interval is dependent upon factors including, but not limited to, distance from the apparatus to the task location and the elevation of the fire or EMS location (i.e., high rise structures). Locked doors or security bars which must be breached also act as

impediments to access, as do traumatized family members, crowds, whether or not the scene is secured by police, parked cars, and a host of other unpredictable conditions. Impediments like these may add to the delay between the discovery of a fire and implementation of an actual fire attack, and to the delay between the discovery of an individual in medical distress and the initiation of emergency medical care.

Input information including station locations, apparatus deployment, incident data, and staffing minimums, were provided by the IAFF, Local 758. The report that follows is a "best estimate" response time model of those roads expected to receive coverage by the City of Terre Haute's Fire Department.

IDENTIFICATION OF EXISTING EMERGENCY RESOURCE RESPONSE CAPABILITIES

SUMMARY

The following series of maps indicate the existing response capabilities of City of Terre Haute Fire Department emergency apparatus when responding from existing station locations (reference p. 31). **The indicated response capabilities for individual units, and the resources designated to respond as part of an alarm assignment, assume that all units and the personnel assigned to staff and respond these units are available to respond immediately upon dispatch.**

Understanding the several components of an emergency response is an important part of understanding how to interpret the following series of maps. To follow are some key terms that the reader should understand.

- ***Alarm Time*** is defined as "The point of receipt of the emergency alarm at the public safety answering point to the point where sufficient information is known to the dispatcher to deploy applicable units to the emergency."[35]

- ***Dispatch Time***, also referred to as *call processing time*, is "The point of receipt of the emergency alarm at the public safety answering point to the point where sufficient information is known to the dispatcher and applicable units are notified of the emergency."[36]

- ***Turnout Time*** is "The time beginning when units acknowledge notification of the emergency to the beginning point of response time."[37] Per NFPA 1710, turnout time should not exceed one minute.[38]

- ***Response Time*** is defined as "The time that begins when units are en route to the emergency incident and ends when units arrive at the scene."[39]

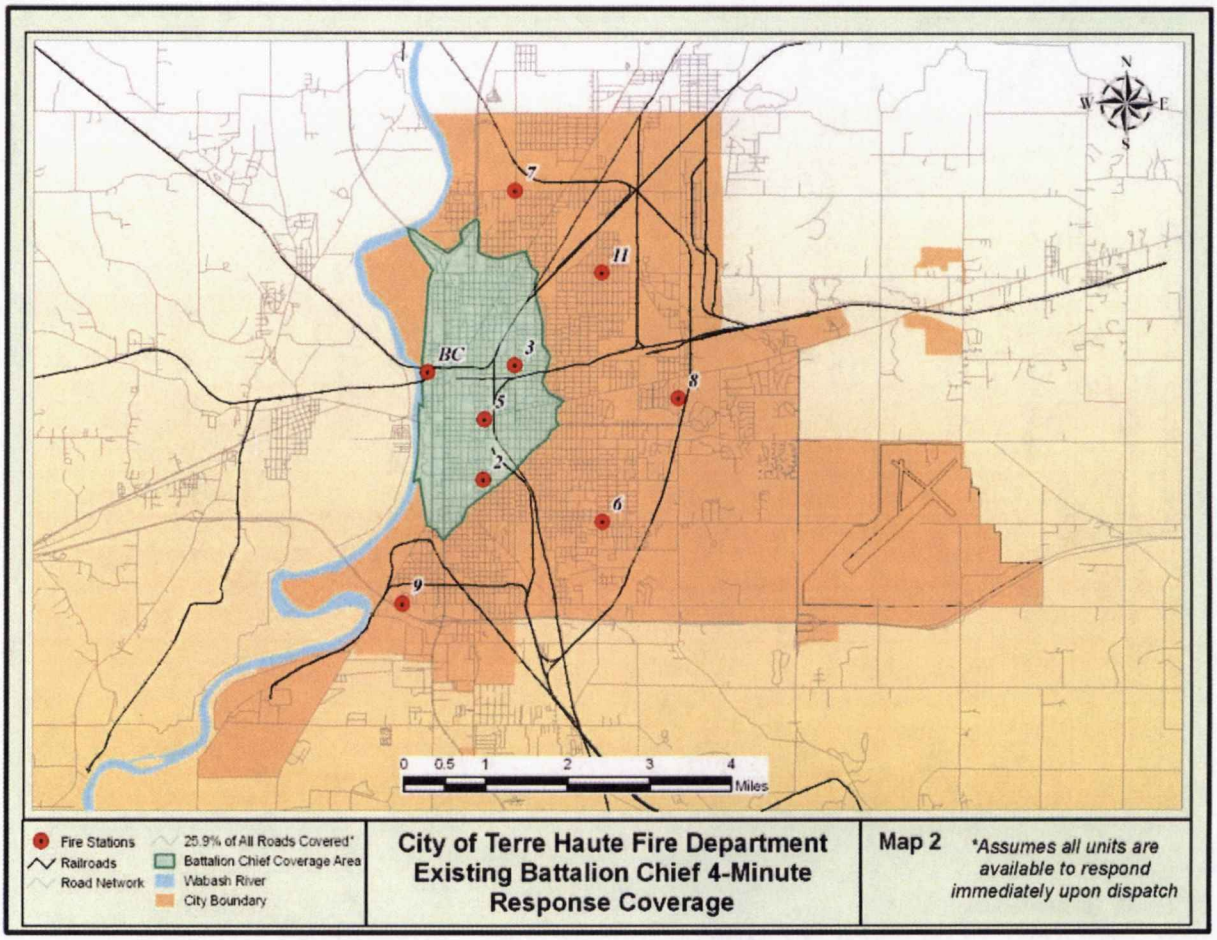
It is critical to understand that the response capabilities indicated in the following series of maps reflect ***response time only***. That is to say, the following series of maps indicate how far an emergency vehicle traveling on the existing road network in the City of Terre Hautecan travel within 4 and 8 minutes. **Dispatch time and turnout time are not considered as part of this analysis, and may add as much as two minutes to overall call-to-arrival time. Actual response speeds may be slower, and the associated travel times greater, with any traffic congestion or any other unpredictable impedances.**

If any unit is unavailable for any reason, travel times will be greater as more distant apparatus will be required to respond, with potential delays. Impediments to access may add to the delay between the discovery of a fire and implementation of an actual fire attack (resulting in *increased* fire growth)**, and to the delay between the discovery of an individual in medical distress and the initiation of emergency medical care** (resulting in *decreased* patient survivability)**.**

[35] NFPA 1710, §3.3.42.1
[36] NFPA 1710, §3.3.42.3
[37] NFPA 1710, §3.3.42.5
[38] NFPA 1710, §4.1.2.1.1
[39] NFPA 1710, §3.3.42.4

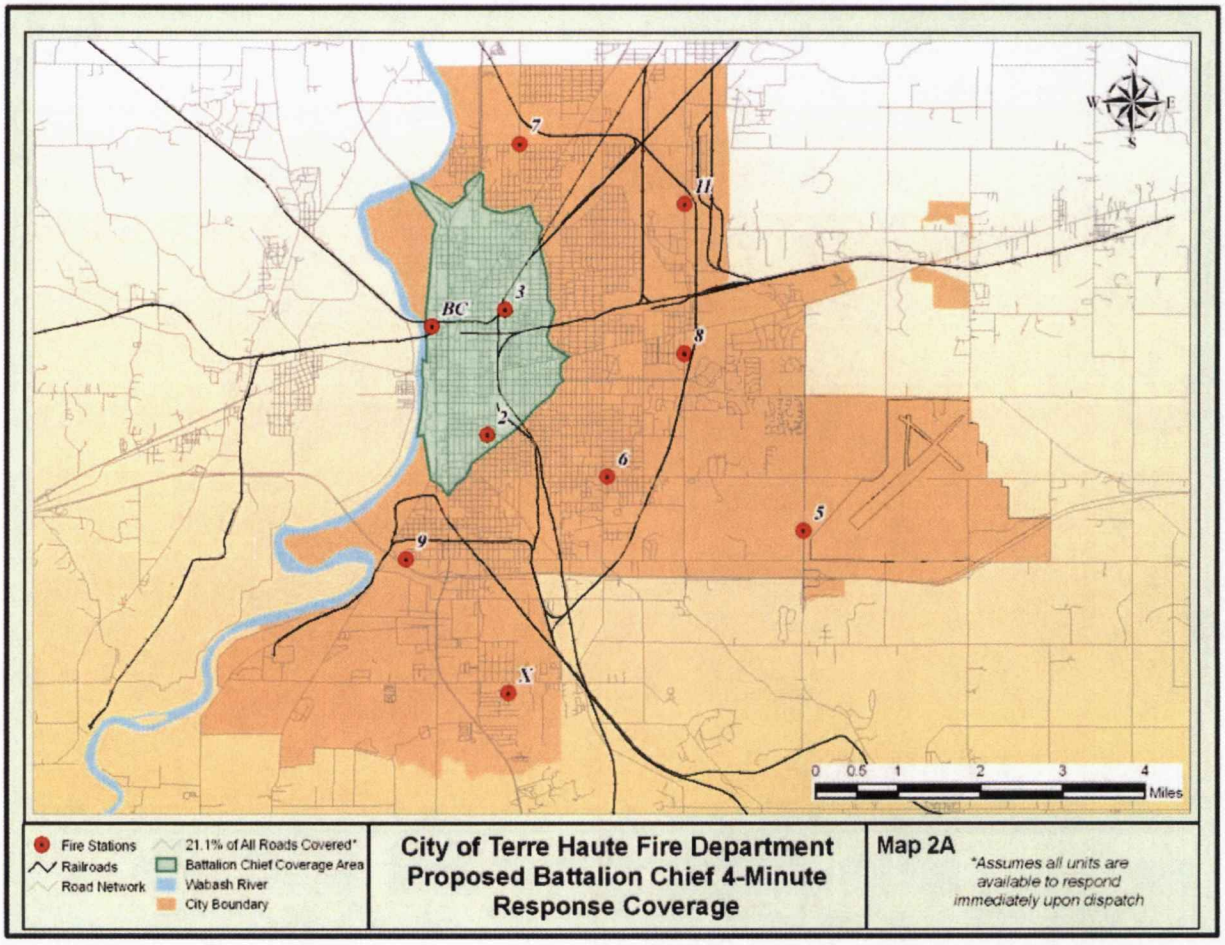
Additionally, the computer model is unable to accurately portray the response of "callback" fire fighters responding in private vehicles from distant locations to an incident scene. Inasmuch as "callback" personnel are not available on a regular basis to respond emergency units immediately upon dispatch- and it is impossible to quantify the amount of time it takes for those individuals to respond from their different locations to the station, staff an apparatus, and respond that unit to a given location. The GIS software is also unable to accurately display the predicted response capabilities of apparatus deploying from a fire station when staffed with "callback" personnel. As such, the unpredictable response capabilities of units staffed by off-duty personnel responding as "callback" fire fighters are omitted from this analysis.

Map 2



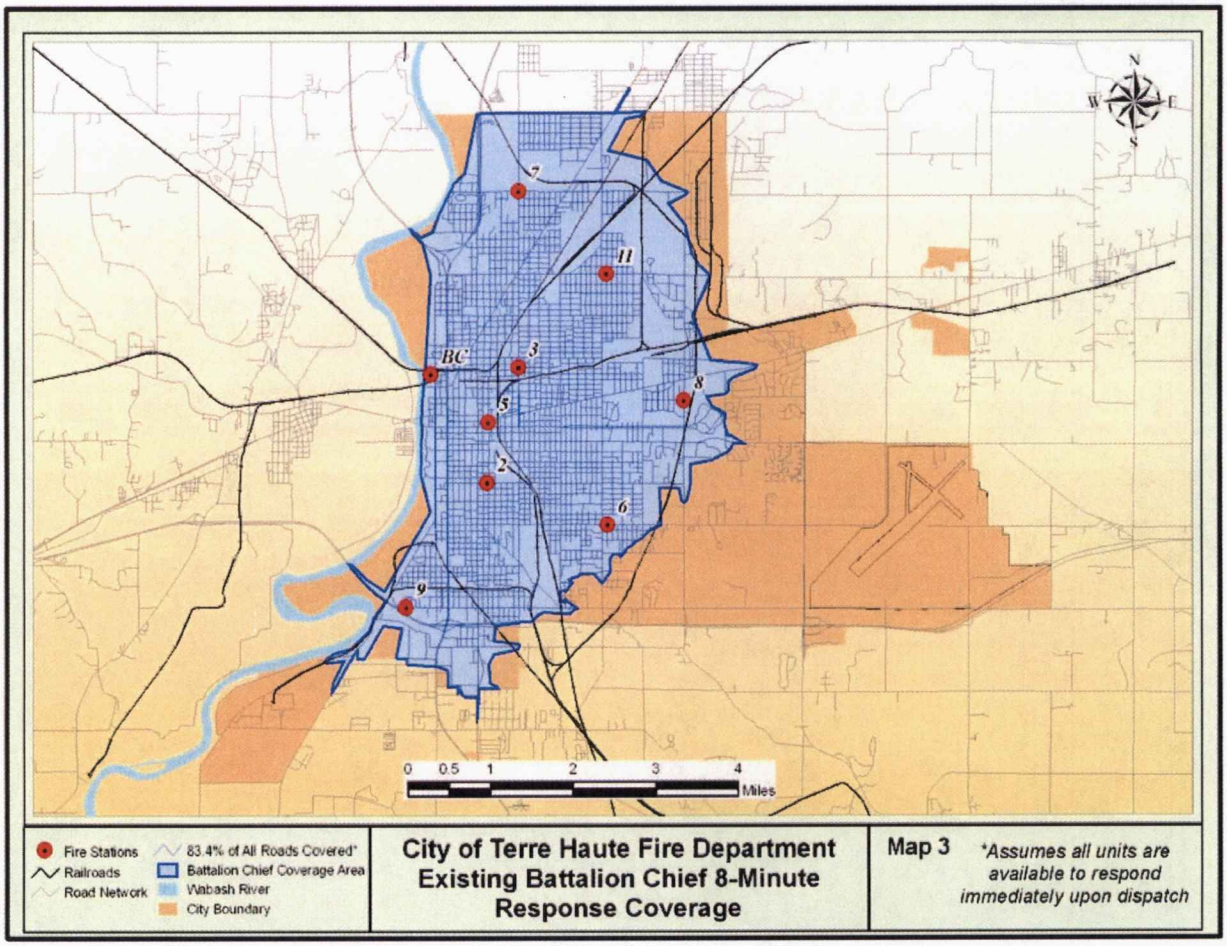
Map 2 indicates the existing 4-minute response capabilities for the Battalion Chief. Currently, the Battalion Chief that deploys from the designated location is capable of responding to **25.9% of all roads located within the response jurisdiction in 4 minutes or less,** *assuming the unit is available to respond immediately upon dispatch.*

Map 2A



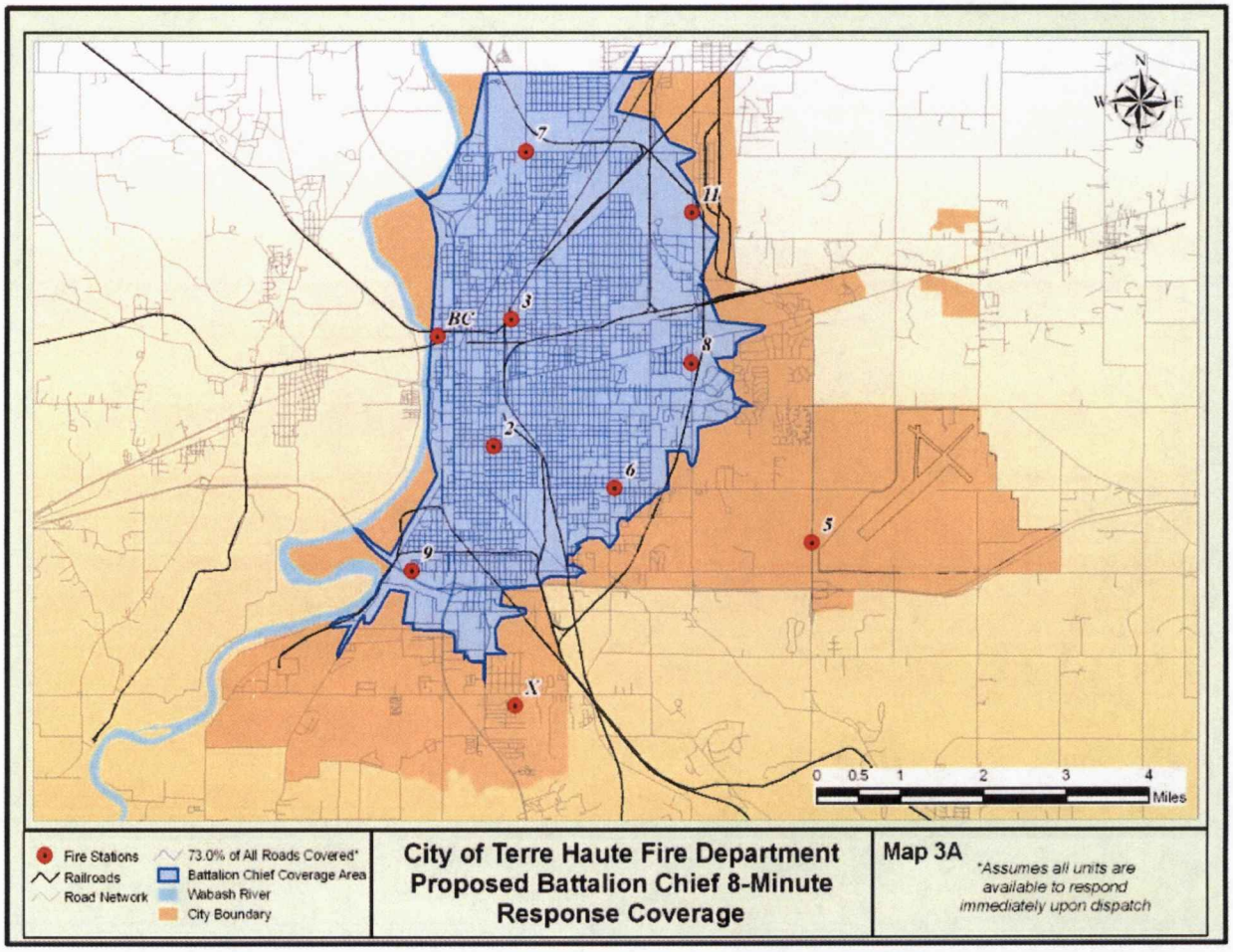
Map 2A indicates the proposed 4-minute response capabilities for the Battalion Chief. The Battalion Chief that deploys from the designated location is capable of responding to **21.1% of all roads located within the future response jurisdiction in 4 minutes or less,** *assuming the unit is available to respond immediately upon dispatch.*

Map 3



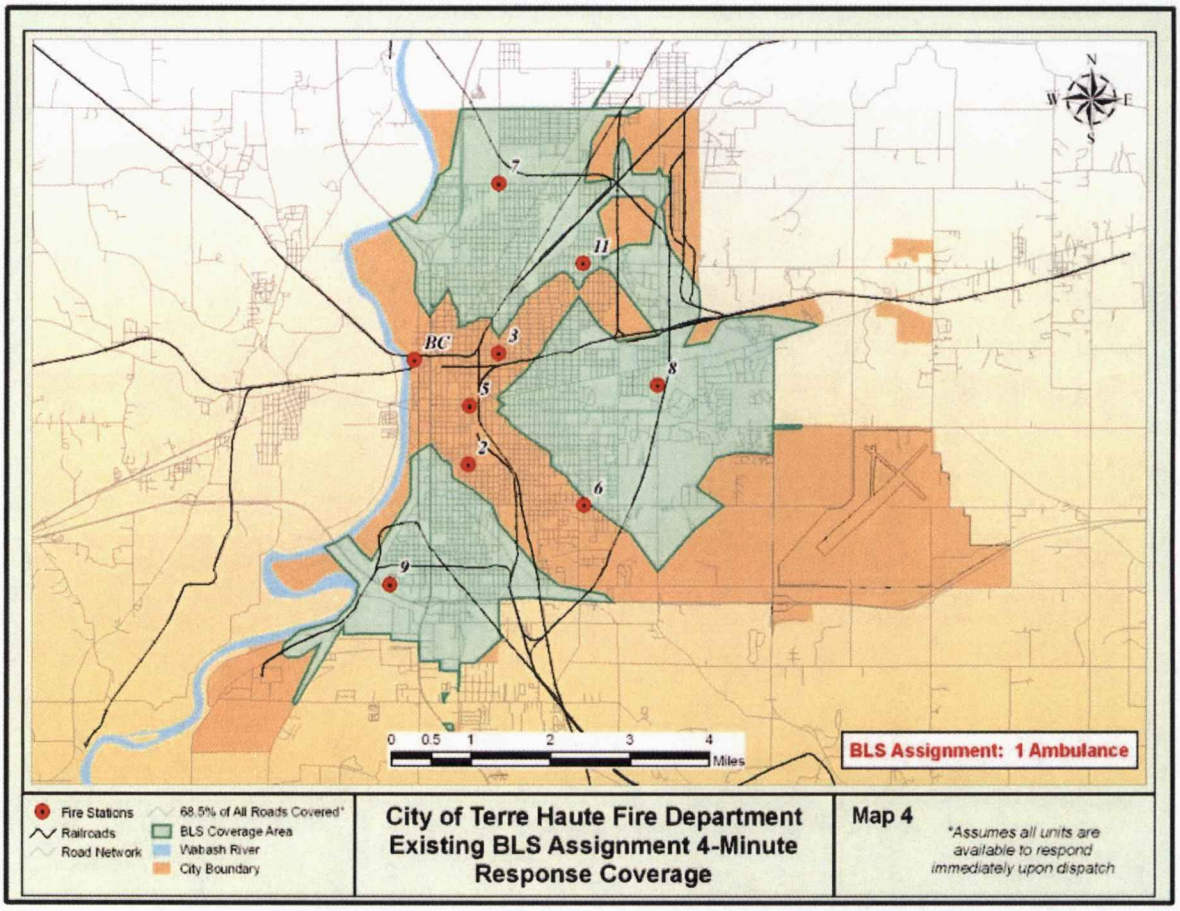
Map 3 indicates the existing 8-minute response capabilities for the Battalion Chief. Currently, the Battalion Chief that deploys from the designated location is capable of responding to **83.4% of all roads located within the response jurisdiction in 8 minutes or less,** *assuming the unit is available to respond immediately upon dispatch.*

Map 3A



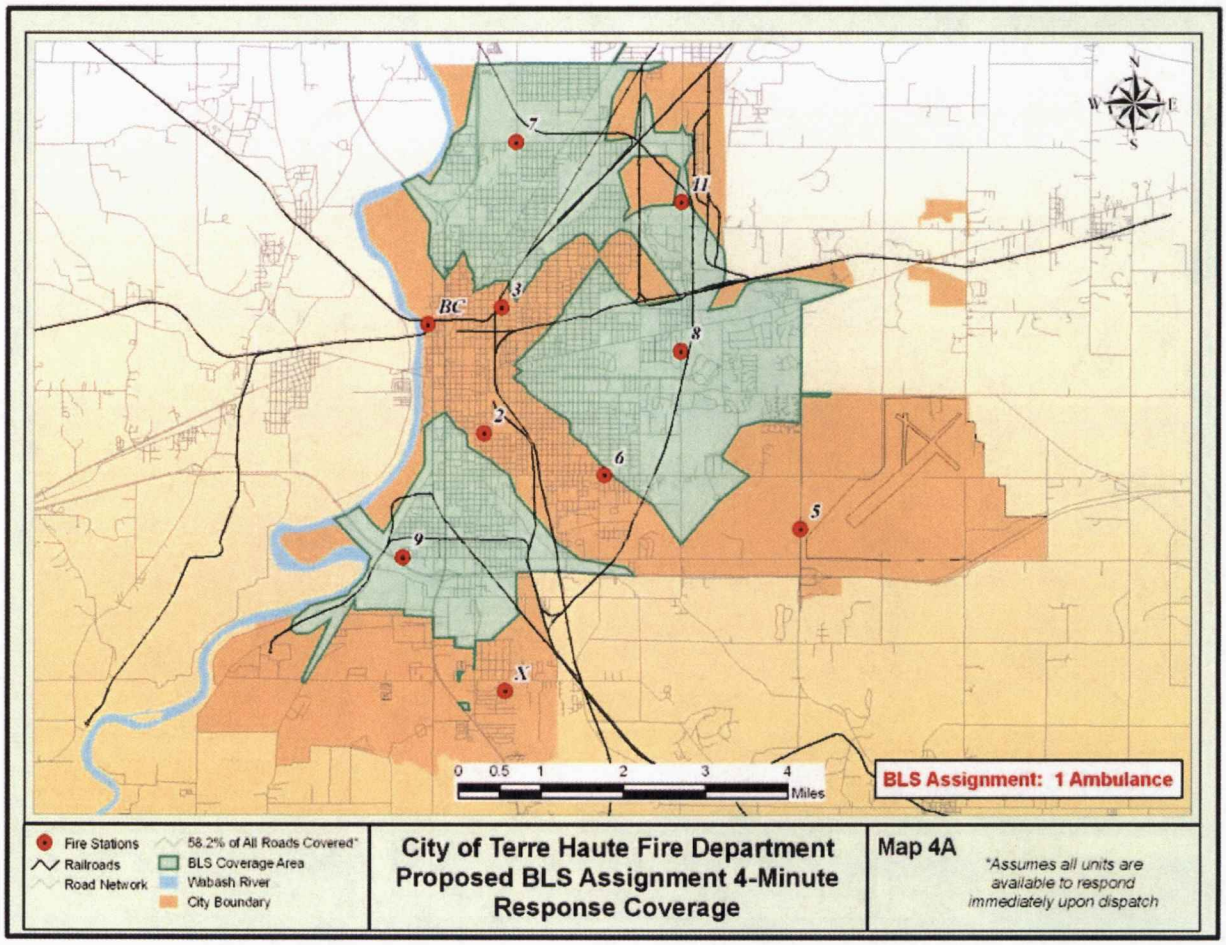
Map 3A indicates the proposed 8-minute response capabilities for the Battalion Chief. The Battalion Chief that deploys from the designated location is capable of responding to **73.0% of all roads located within the future response jurisdiction in 8 minutes or less,** *assuming the unit is available to respond immediately upon dispatch.*

Map 4



Map 4 indicates the 4-minute response areas for the Basic Life Support (BLS) units that deploy from Stations 7, 8, and 9. Currently, the BLS Ambulance units that deploy from these locations are capable of responding to **68.5% of all roads within the city in 4 minutes or less**. *Assuming all units are available to respond immediately upon dispatch.* However, significant areas of the city remain beyond the existing 4-minute response capabilities of the Fire Department's BLS companies. Under these conditions, **31.5%** of the city roads are not in the 4-minute response areas.

Map 4A



Map 4 indicates the proposed 4-minute response areas for the Basic Life Support (BLS) units that will deploy from Stations 7, 8, and 9. The BLS Ambulance units that will deploy from these locations are capable of responding to **58.2% of all roads within the city in 4 minutes or less**. *Assuming all units are available to respond immediately upon dispatch.* However, significant areas of the city will remain beyond the existing 4-minute response capabilities of the Fire Department's BLS companies. Under these conditions**, 41.8%** of the city roads are not in the 4-minute response areas.

The Importance of the 4-minute Response
In the Provision of Emergency Medical Services:

The City of Terre Haute Fire Department responds to all emergencies in the city necessitating the skills, capabilities, and resources of the fire service. The prehospital care rendered by fiorefighters in such instances encompasses the "A.B.C.s" of basic emergency medical care – maintenance of the **A**irway, ensuring the patient can continue **B**reathing, and maintaining **C**irculation. The bandaging of wounds, the realignment of broken limbs, when necessary, and protection of the spine are also priorities for the Fire Department in the prehospital setting.

Of the many types of medical emergencies firefighters respond to, the City of Terre Haute Fire Department's response to cardiovascular accidents (stroke) and myocardial infarctions (heart attacks) are the most time critical. A stroke is a sudden loss of brain function. It is caused by the interruption of the flow of blood to the brain or the rupture of blood vessels in the brain. The interruption of the blood flow or the rupture of blood vessels causes brain cells in the affected area to die. A heart attack occurs when the blood supply to part of the heart muscle itself is severely reduced or stopped. This happens when one of the arteries supplying blood to the heart muscle is blocked. If the blood supply to the heart muscle is cut off for longer than several minutes, muscle cells in the affected area suffer irreversible injury and die.

The American Heart Association notes that, "Nearly 2,600 Americans die of cardiovascular disease each day, an average of 1 death every 34 seconds. Cardiovascular disease claims more lives each year than the next 5 leading causes of death combined, which are cancer, chronic lower respiratory diseases, accidents, diabetes mellitus, and influenza and pneumonia."[40] According to the Occupational Safety & Health Administration, there are 300,000 – 400,000 deaths *per year* in the United States from cardiac arrest,[41] making it one of the leading causes of death in the nation. Most cardiac arrest deaths occur outside the hospital, resulting in survival rates ranging between 1% and 5%.

In spite of these statistics, cardiac arrest remains one of the most time-critical medical emergencies that can be treated in the field. The four-part "chain of survival" concept, as illustrated in Figure 10, is essential to ensuring positive patient outcomes. The "Chain of Survival" consists of:

1. **EARLY ACCESS:**
   - *Quickly calling the Emergency Medical Services (9-1-1) system*
2. **EARLY CPR:**
   - *Promptly giving cardiopulmonary resuscitation when needed*
3. **EARLY DEFIBRILLATION:**
   - *Having proper equipment and being trained to use it when indicated*
4. **EARLY ADVANCED CARDIOVASCULAR CARE**:
   - *Initiating advanced airway management and I.V. and drug therapy provided by firefighter-paramedics*

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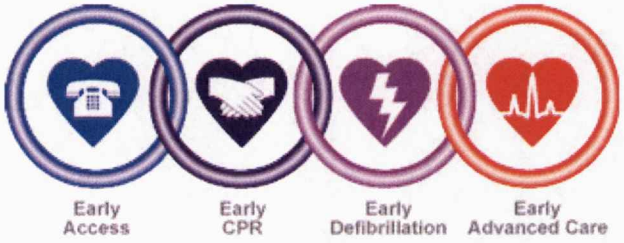
[40] American Heart Association, "Heart Disease and Stroke Statistics – 2004 Update;" AHA website visited September 21, 2004
< http://www.americanheart.org/downloadable/heart/1079736729696HDSStats2004UpdateREV3-19-04.pdf >

[41] U.S. Occupational Safety and Health Administration, Technical Information Bulletin: Cardiac Arrest and Automated External Defibrillators (AEDs), < http://www.osha.gov/dts/tib/tib_data/tib20011217.html >

FIGURE 10:[42]
"THE CHAIN OF SURVIVAL"



• If fire fighters responding within 4 minutes of receiving an alarm initiate CPR, the probability of *patient survival quadruples*, from 4.6% to 18.2%.

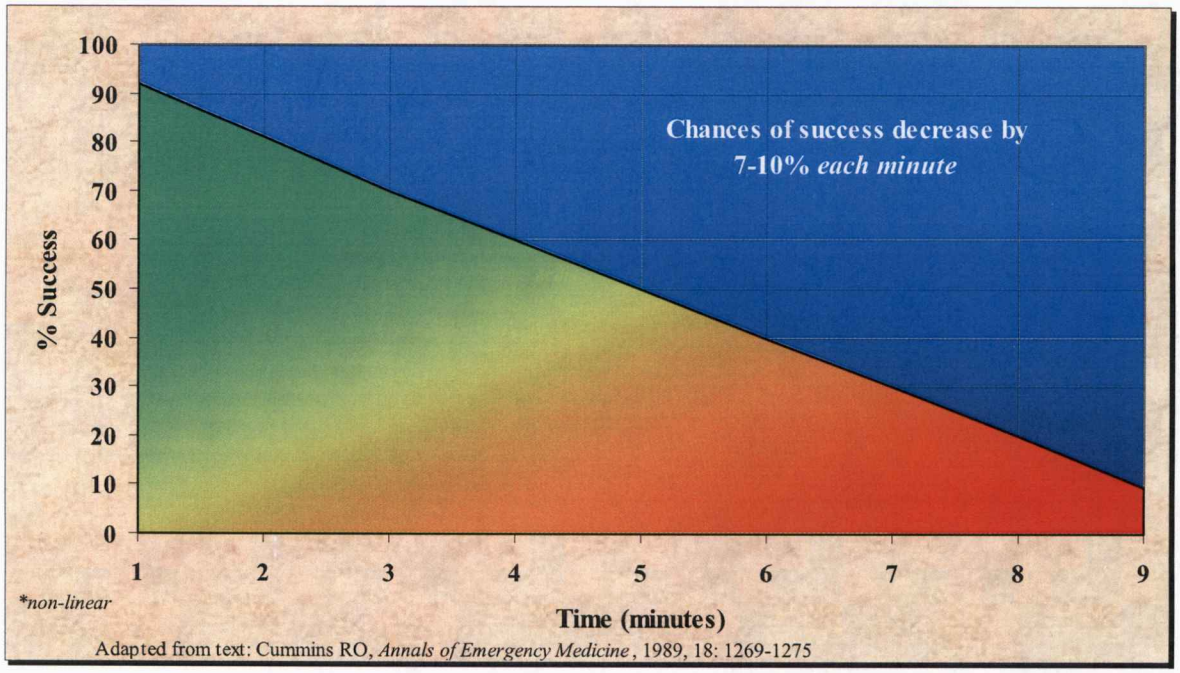
• If those same fire fighters are equipped and trained to provide defibrillation, the expected survival rate is *five times greater* at 25.8%.

• Finally, if those fire fighters are trained and equipped as paramedics, the survival rate is increased to 34.3% - nearly *a sevenfold increase.*[43]

The use of an automated external defibrillator (AED) by trained personnel is integral to the treatment and survival of cardiac arrest. Abnormal heart rhythms, with ventricular fibrillation (VF) being the most common, cause cardiac arrest. Defibrillation within 2 minutes can produce cardiac arrest survival rates as high as 90%. However, **"if defibrillation is delayed more than 10 minutes, survival rates drop to less than 5%."**[44]

[42] "Chain of Survival" diagram courtesy of "ChainofSurvival.com"
< http://www.chainofsurvival.com/cos/COSOverview_detail.asp >
[43] "Predicting Survival From Out-of-Hospital Cardiac Arrest: A Graphic Model," Annals of Emergency Medicine (November 1993)
[44] American Heart Association, Sudden Deaths from Cardiac Arrest Statistical Fact Sheet (2003)

FIGURE 11:
"CARDIAC ARREST SURVIVAL RATE"



While patient survivability from cardiac arrest depends upon a series of critical interventions, such as are provided by firefighters cross-trained as EMTs and Paramedics, "rapid defibrillation is the most important single factor in determining survival."[45] The highest hospital discharge rates have been achieved in cardiac arrest patients in whom CPR was initiated **within 4 minutes of arrest** and ACLS within 8 minutes. A rapid emergency medical response is therefore essential in improving survival rates.[46]

So effective is the use of an AED in increasing survivability of cardiac arrest patients, the International Association of Fire Chiefs has endorsed equipping every fire suppression unit in the United States with an automated external defibrillator.[47] Mirroring this recommendation, NFPA 1710 states, "the fire department… shall ensure [that] emergency medical response capability includes personnel, equipment, and resources to deploy at the first responder level with automatic external defibrillator (AED) or higher treatment level."[48] In accordance with NFPA Standard 1710, Section 4.3.2, the City of Terre Haute Fire Department equips all of its apparatus with AEDs and ensures all fire fighters are trained in their proper and effective operation.[49]

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[45] Emergency Cardiac Care Committee and Subcommittees of the American Heart Association, "Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiac Care," Journal of the American Medical Association (October 28, 1992): 2289

[46] Ibid, 2184.

[47] American Heart Association, Sudden Deaths from Cardiac Arrest Statistical Fact Sheet (2003).

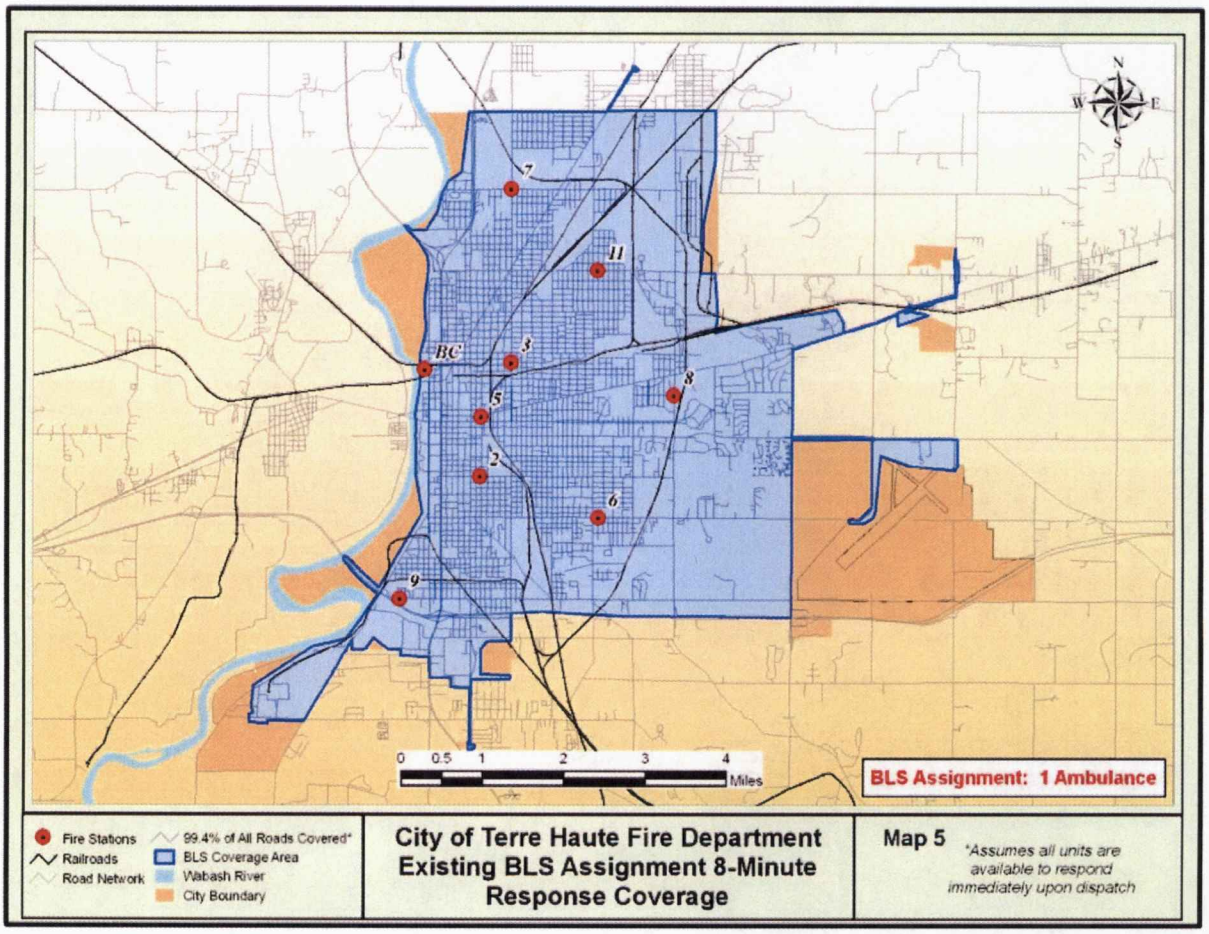
[48] NFPA 1710, § 4.3.2 - "The fire department… shall ensure [that] emergency medical response capability includes personnel, equipment, and resources to deploy at the first responder level with automatic external defibrillator (AED) or higher treatment level."

[49] NFPA 1710, § 4.1.3.1.1(2)

Moreover, the 1710 Standard requires that a "fire department shall establish the response time objectives of **4 minutes or less for the arrival of a unit with first responder or higher capability at an emergency medical incident.**"[50] As previously indicated, however, assuming all engine companies are available to respond immediately upon dispatch, 100% of all roads can expect to receive a fire department first response within 4 minutes. Approximately 94% of Terre Haute's roads can receive initial response resources within 4 minutes, when considering railroad crossing delays.

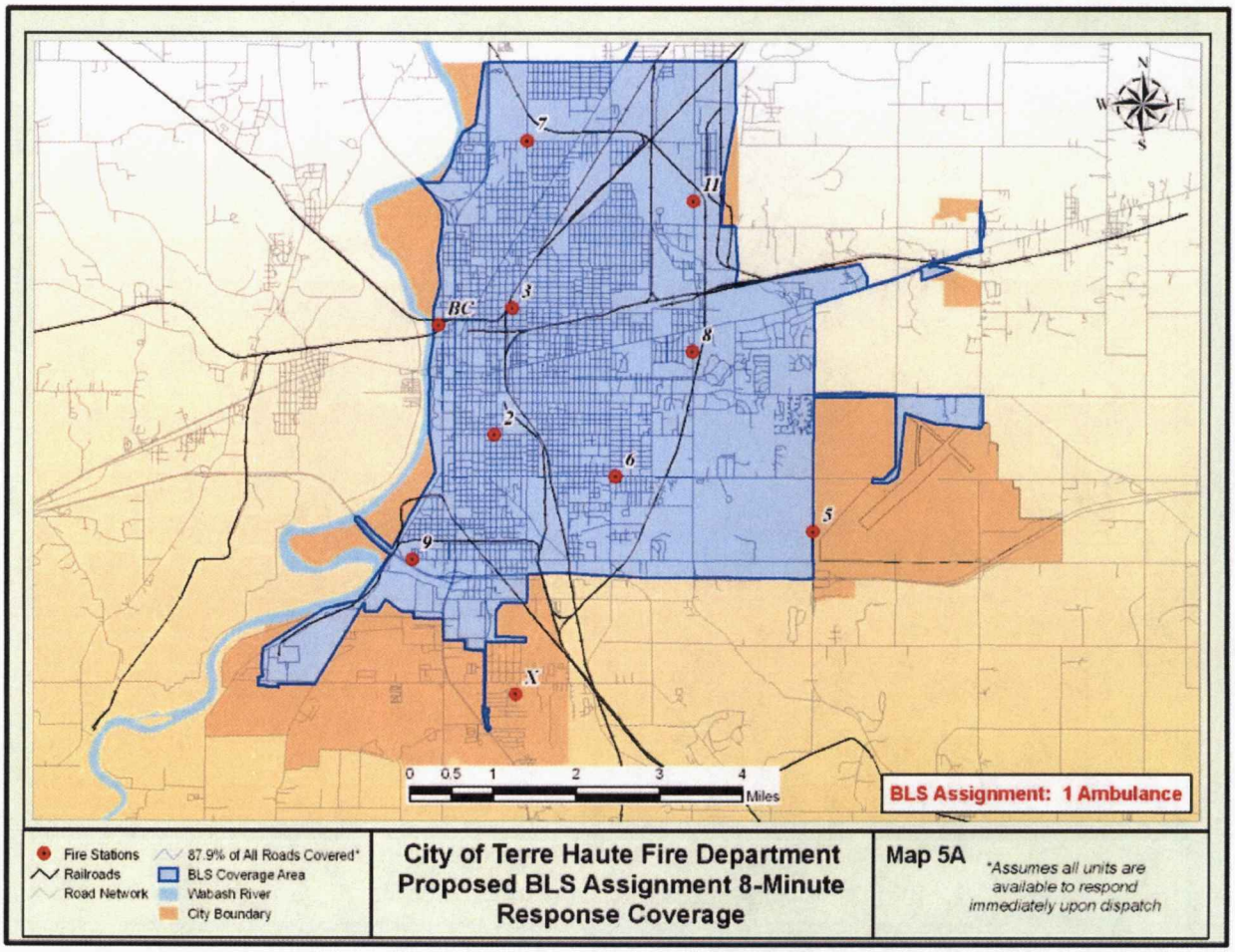
[50] NFPA 1710, § 4.1.3.1.1(2)

Map 5



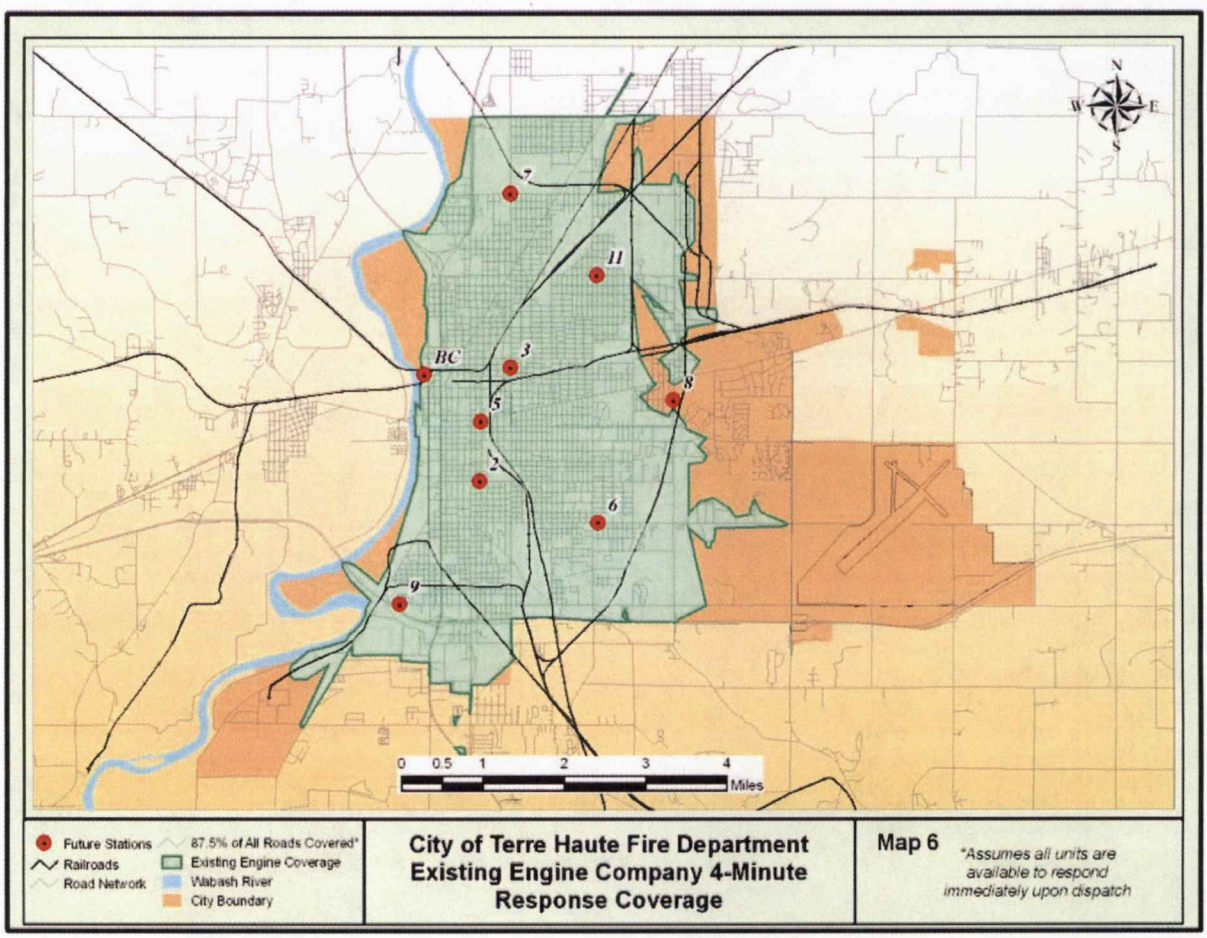
Map 5 indicates the 8-minute response areas for the Basic Life Support (BLS) units that deploy from Stations 7, 8, and 9. Currently, the BLS Ambulance units that deploy from these locations are capable of responding to **99.4% of all roads within the city in 8 minutes or less**. *Assuming all units are available to respond immediately upon dispatch.*

Map 5A



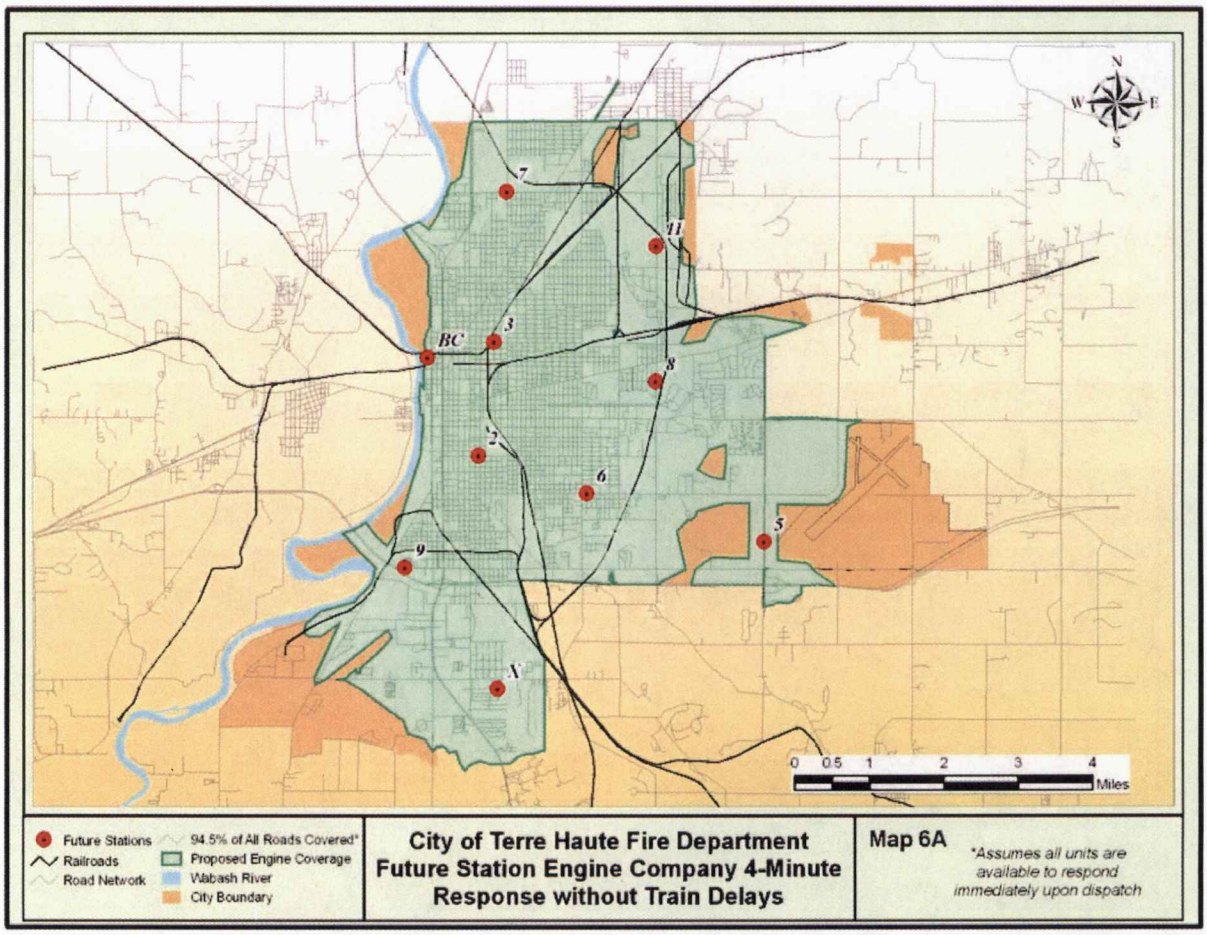
Map 5 indicates the proposed 8-minute response areas for the Basic Life Support (BLS) units that will deploy from Stations 7, 8, and 9. The BLS Ambulance units that deploy from these locations are capable of responding to **87.9% of all roads within the city in 8 minutes or less**. *Assuming all units are available to respond immediately upon dispatch.*

Map 6



Map 6 indicates the existing 4-minute response capabilities for engine companies responding from existing Fire Stations 2, 3, 6, 7, 9, and 11. Currently, engines that deploy from these stations are capable of responding to **87.5% of all roads located within the response jurisdiction in 4 minutes or less** *assuming all units are available to respond immediately upon dispatch.* The *unavailability* of an engine to respond to emergencies within its primary response district creates a gap in services to that area of the community, and a delay in fire department response. Any delay in response translates directly into a proportional *increase* in the expected loss of life and property.

Map 6A



Map 6A indicates the proposed 4-minute response capability for Engines responding from Stations 2, 3, 5, 6, 7, 8, 9, 11, and "X". Engines that could deploy from these stations are capable of responding to **94.5% of all roads located within the city jurisdiction in 4 minutes or less,** *assuming the unit is available to respond immediately upon dispatch.* The *unavailability* of staff to respond to emergencies within its primary response district creates a gap in services to that area of the community, and a delay in fire department response. Any delay in response translates directly into a proportional *increase* in the expected loss of life and property.

The Importance of the 4-minute Engine Company Response In Structural Fire Fighting Operations:

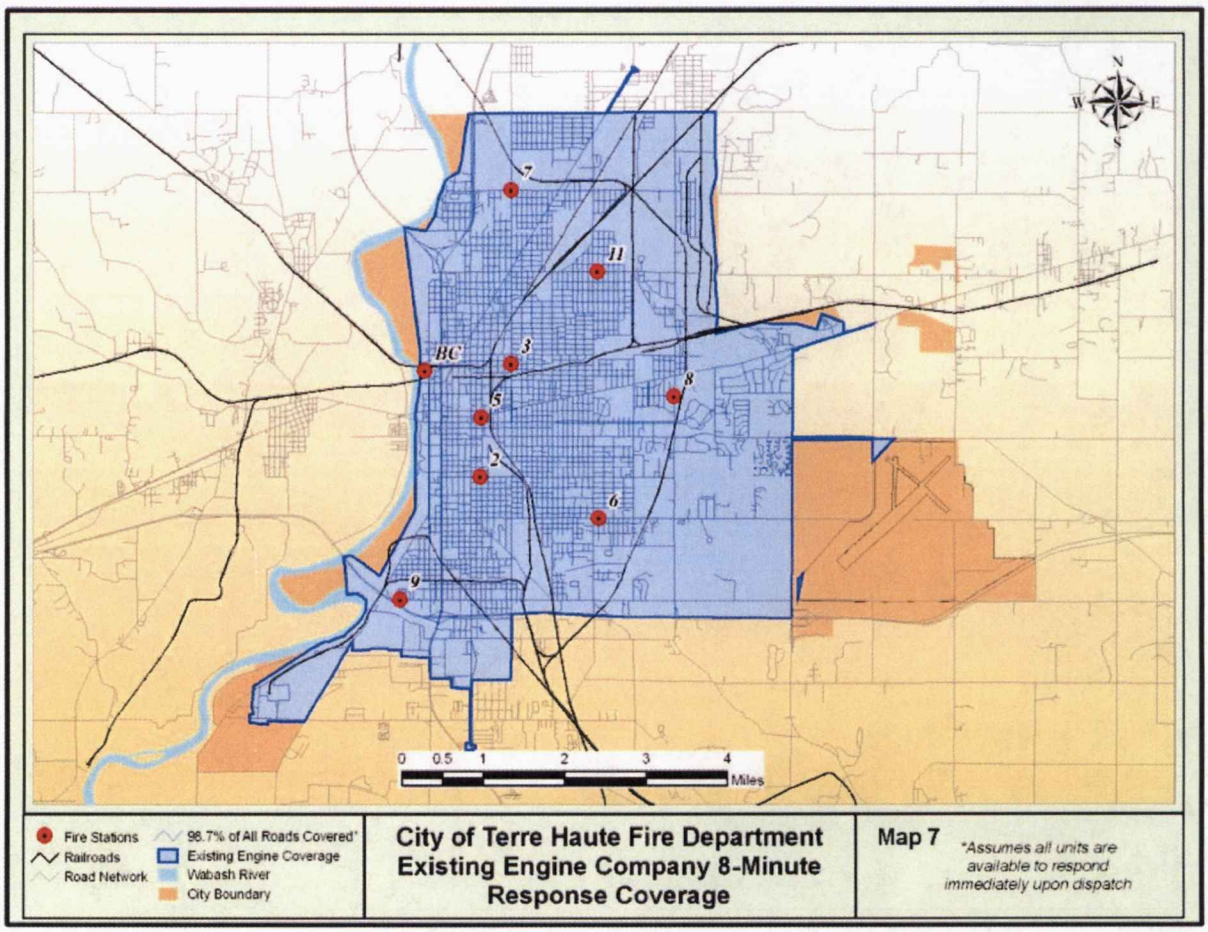
Fire growth- the rate of spread and the intensity of the fire- is directly linked to the time it takes to initiate fire suppression operations. As a rule, a fire doubles in size for every minute that passes without the application of aggressive fire suppression measures. In less than 30 seconds a small flame can rage completely out of control and turn into a major fire. During fire growth, the temperature of a fire rises to 1,000° to 1,200° F. Flashover (the very rapid spreading of the fire due to super heating of room contents and other combustibles) at 1,100° to 1,200° F. may occur in a burning room in as little as 4 minutes, depending upon its contents.[51]

At flashover, the odds of survival for individuals inside the structure- both victim and rescuer- are virtually non-existent. The 4-minute goal for arriving fire suppression companies is therefore critical. Recognizing the criticality of a rapid fire department response, NFPA Standard 1710 states that a fire department shall establish the response time objective of "**4 minutes or less for the arrival of the first arriving engine company at a fire suppression incident.**"[52]

[51] In general, however, flashover is most likely to occur within 10 minutes of fire ignition within a confined space, and with typical contents.

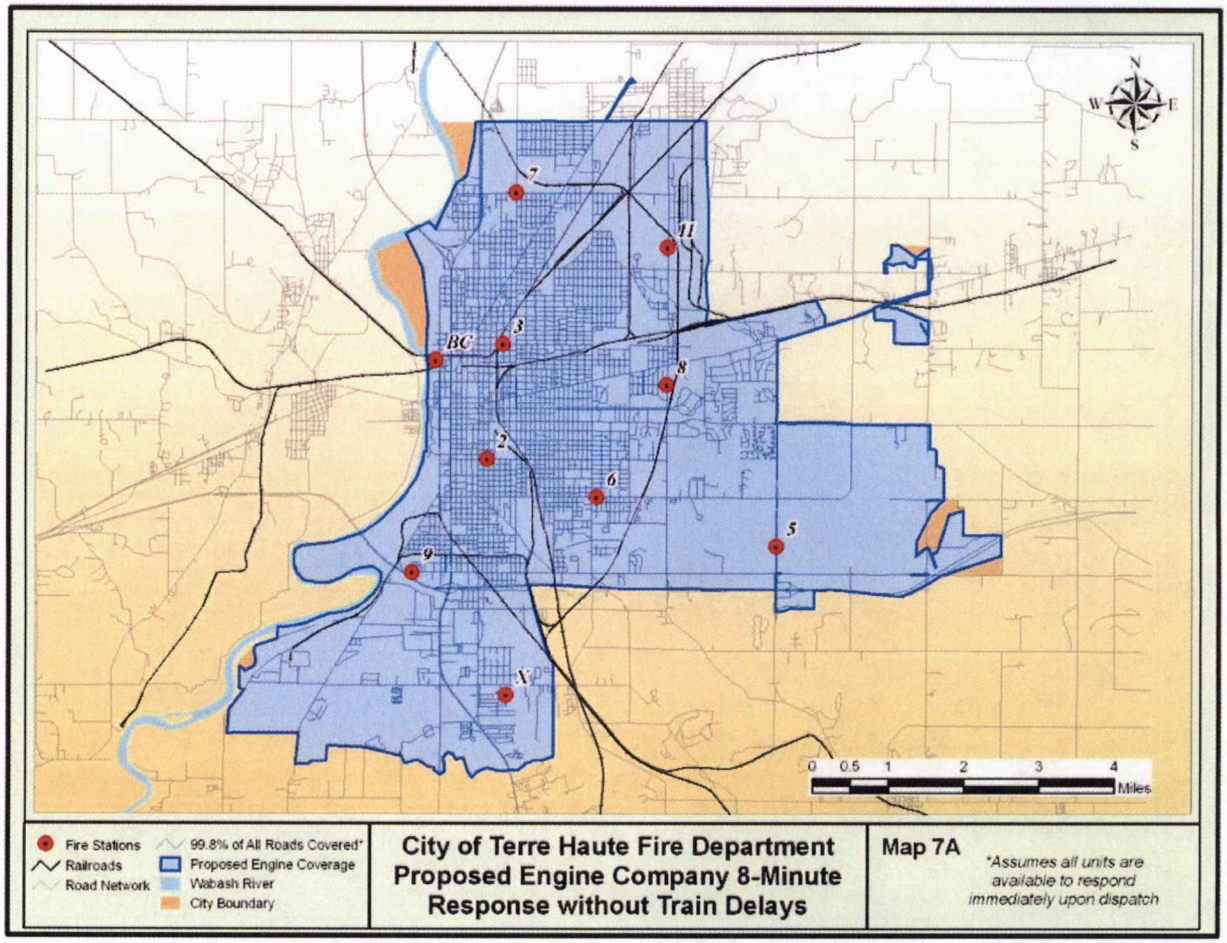
[52] NFPA 1710, § 4.1.3.1.1 (1)

MAP 7



Map 7 indicates the existing 8-minute response capabilities for engine companies responding from existing Fire Stations 2, 3, 6, 7, 9, and 11. Currently, engines that deploy from these stations are capable of responding to **98.7% of all roads located within the response jurisdiction in 8 minutes or less** *assuming all units are available to respond immediately upon dispatch.* The *unavailability* of an engine to respond to emergencies within its primary response district creates a gap in services to that area of the community, and a delay in fire department response. Any delay in response translates directly into a proportional *increase* in the expected loss of life and property.

MAP 7A

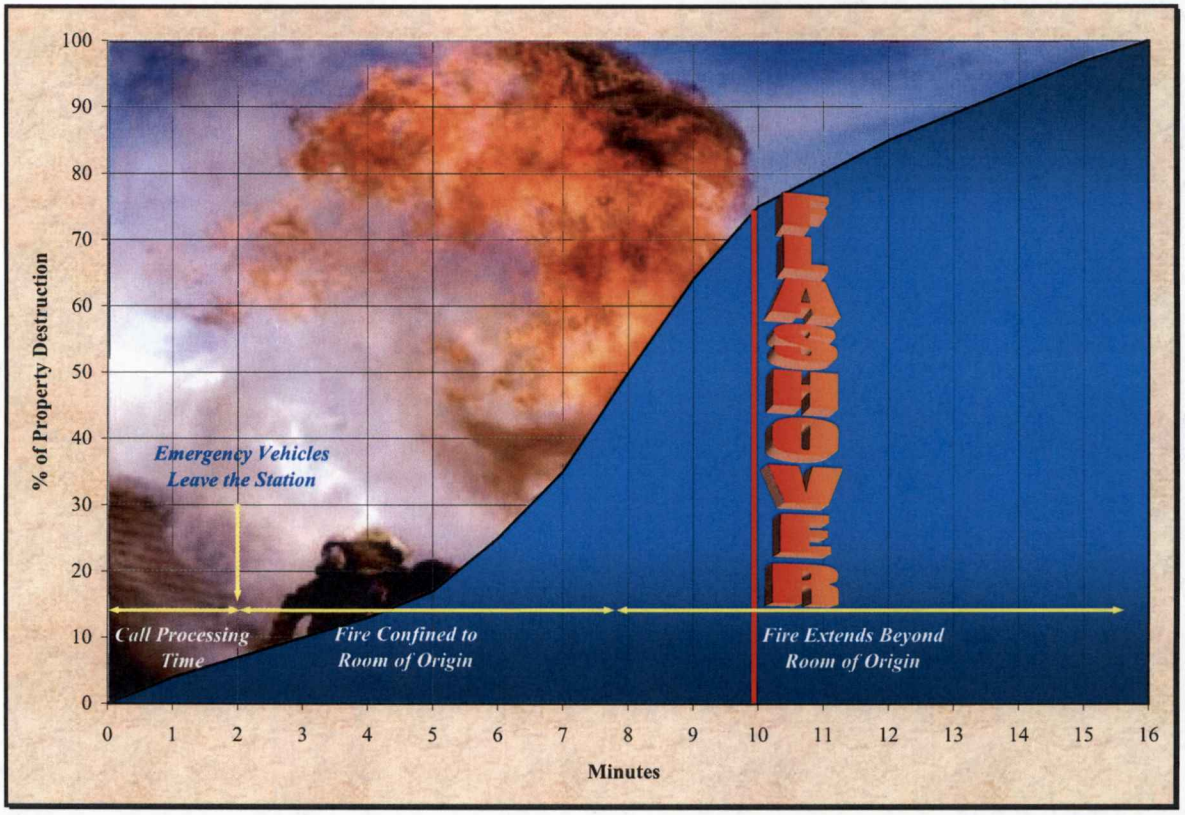


Map 7A indicates the proposed 8-minute response capability for Engines responding from Stations 2, 3, 5, 6, 7, 8, 9, 11, and "X". Engines that would deploy from these stations are capable of responding to **99.8% of all roads located within the city jurisdiction in 8 minutes or less,** *assuming the unit is available to respond immediately upon dispatch.* The *unavailability* of staff to respond to emergencies within its primary response district creates a gap in services to that area of the community, and a delay in fire department response. Any delay in response translates directly into a proportional *increase* in the expected loss of life and property.

The Importance of the 8-minute Engine Company Response In Structural Fire Fighting Operations:

The 8-minute goal for arriving companies is critical because the progression of a structural fire to the point of "flashover" (the very rapid spreading of the fire due to super heating of room contents and other combustibles) generally occurs in less than 10 minutes. As there is a potential delay between fire ignition, discovery, and the transmission of an alarm it may be said that flashover is likely to occur within 8 minutes of firefighters receiving the alarm.

FIGURE 12:
"THE FIRE PROPAGATION CURVE"



Minimally, a crew of four is required to make a safe initial attack on a fire, with a crew of two working inside the burning structure and a backup crew of two standing by to assist as necessary. This is known as the "2 In/2 Out" regulation, and is codified as OSHA CFR 1910.134. Currently, the City of Terre Haute Fire Department *does not* staff all engine companies with four fire fighters, in compliance with NFPA recommendations.

The Importance of the 8-minute Engine Company Response In the Provision of Emergency Medical Services:

Sudden cardiac arrest- one of the leading causes of death in America- is also one of the most time-critical medical emergencies that can be treated in the field. The eight-minute benchmark is crucial because a rapid fire department response expedites the delivery of more advanced lifesaving interventions, such as defibrillation, advanced airway management, and drug therapy.

Two-tiered EMS systems such as these, where the more widely-distributed fire department Basic Life Support (BLS) providers arrive in advance of Advanced Life Support (ALS) providers, have improved survival rates over one-tiered systems, particularly when the first responder provides automated external defibrillation.[53]

According to the Journal of the American Medical Association, "two-tier systems in which the first responders are trained in early defibrillation are most effective in providing rapid Advanced Cardiac Life Support (ACLS)."[54] **Cardiac arrest victims have a 33% higher survival rate when Paramedics arrive within eight minutes**, according to the American Heart Association. After eight minutes, the prospects of recovery decreases rapidly.[55] Hence, by gaining access to the scene and ensuring patient stabilization by initiating CPR, and providing defibrillation and airway management, North Tahoe firefighters set the stage for the arrival of ALS units, the provision of ACLS, and the opportunity for increased patient survivability. A timeline of a typical emergency response to an incident of sudden cardiac arrest is provided in "Appendix A," *Timeline of a Typical Emergency Response to an Incident of Cardiac Arrest.*

The Eisenberg Model

A 1993 University of Washington study of 1,667 cardiac arrests linked survival of cardiac arrest to the time that elapsed before the initiation of three critical interventions: CPR, defibrillation and advanced cardiac life support. From this landmark study, researchers produced a model for predicting cardiac arrest survival rates, known as the *Eisenberg Model.*[56] Because it clearly links response time to the probability of survival, the *Eisenberg Model* has become a standard method for measuring effectiveness in the delivery of pre-hospital emergency medical services. The Eisenberg model is summarized in Figure 13.

FIGURE 13:
"THE EISENBERG FORMULA"

Survival Rate = 67% (*maximum percentage survival rate of out-of-hospital cardiac arrest patients if all three interventions were to occur upon collapse. This figure represents the assumption that only 2/3 of the population can be expected to survive an of out-of-hospital cardiac arrest.* ***One minute is added to the observed response times to allow for dispatch and turnout. An additional minute is added for gaining access to the patient.***)

- Less 2.3% per minute until CPR is started
- Less 1.1% per minute until defibrillation is provided
- Less 2.1% per minute until ACLS is initiated

[53] Analysis of some systems with high survival rates for out-of-hospital cardiac arrest reveals common practices of (1) multi-tiered systems deployed by a 911 priority dispatch system, (2) aggressive use of fire department apparatus for first response and automated defibrillation, (3) intensive medical supervision, and (4) widespread citizen awareness and CPR training.

[54] The Journal of the American Medical Association (October 28, 1992): 2290.

[55] Matthew Cella, "Response Rate of EMS Declines," The Washington Times, 1 April 2003

[56] M.P. Larsen, M.S. Eisenberg, et al., "Predicting Survival from Out-of-Hospital Cardiac Arrest: A Graphic Model," Annals of Emergency Medicine 22, no. 11 (November 1993): 1652 – 8.

Table 5 indicates predicted survivability rates for cardiac arrest patients, based upon the Eisenberg formula for predicting cardiac arrest survival rates, following the initiation of CPR, defibrillation, and advanced cardiac life support (ACLS) in 5, 6, and 7 minutes, respectively.

TABLE 5:
"EFFECT OF EMERGENCY CARE RESPONSE TIMES ON CARDIAC PATIENT SURVIVAL RATES"[57]

Fire Dep't. Response Time	Initiation of CPR ♥	Time to Defibrillation ↯	Time to Advanced Cardiac Life Support (ACLS) 🚑	Predicted Survival Rate/ All Cardiac Arrest *(percentages)*
9 minutes	10 minutes	11 minutes	13 minutes	4.6%
4 minutes	F.D. EMT: 5 minutes	11 minutes	12 minutes	18.2%
4 minutes	F.D. EMT: 5 minutes	F.D. EMT-D: 6 minutes	11 minutes	25.8%
4 minutes	**F.D. EMT: 5 minutes**	**F.D. EMT-D: 6 minutes**	**F.D. Paramedic: 7 minutes**	**34.3%**

This scenario requires two fire fighters to provide CPR, one to prepare the AED and analyze the results of an electrocardiogram (ECG) report, and one to prepare for and initiate advanced cardiac life support measures, such as advanced airway management, I.V. therapy, and pharmacological interventions. This breakdown of the expected capabilities of a medical alarm assignment requires a minimum contingent of four EMS personnel to arrive at the scene of a cardiac arrest within 5 minutes of receiving an alarm. Most experts agree that four responders (at least two trained in ACLS and two trained in BLS) are the minimum required to provide ACLS to cardiac arrest victims[58] (see also "Appendix A," *Timeline of a Typical Emergency Response to an Incident of Cardiac Arrest*).

As the table indicates, a 9-minute response time means that CPR is not initiated until at least 10 minutes have elapsed from the time of cardiac arrest; 11 minutes have elapsed before defibrillation; and 13 minutes have elapsed before ACLS care is initiated, resulting in an expected patient survival rate of only 4.6 percent. Conversely, a 4-minute fire department response – with CPR initiated in 5 minutes, defibrillation in 6 minutes, and ACLS in 7 minutes – results in patient survivability rates of over 34%.

Put another way, based upon Eisenberg's maximum percentage survival rate of 67%, the following conclusions can reached:

[57] M.P. Larsen, M.S. Eisenberg, et al., "Predicting Survival from Out-of-Hospital Cardiac Arrest: A Graphic Model," Annals of Emergency Medicine 22, no. 11 (November 1993): 1652 – 8.
[58] The Journal of the American Medical Association (October 28, 1992): 2291.

- **A 9-minute initial arrival time prior to pre-hospital emergency medical intervention gives the patient only a 1 in 15 chance of survival.**

- **A 4-minute arrival by fire fighters, with the initiation of CPR in 5 minutes, increases the probability of patient survivability to 1 in 4.**

- **Fire fighters delivering defibrillation within 6 minutes increases the probability of patient survivability to 1 in 3.**

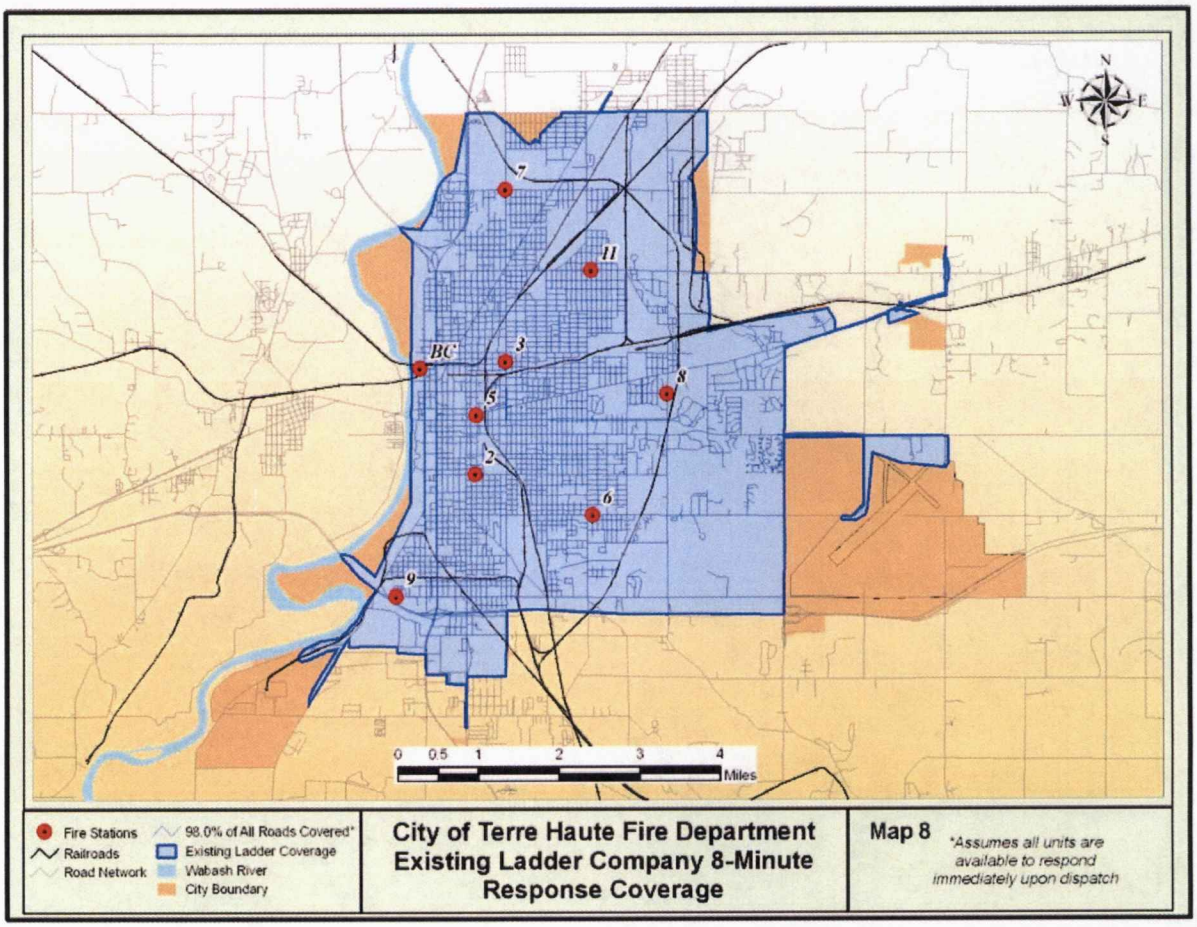
- **Fire fighters trained as paramedics, and delivering cardiac medication within 7 minutes, increases the probability of patient survivability to 1 in 2.**

The simple reduction of 4 to 5 minutes in the response time through the use of cross-trained fire fighters has a substantial impact of increased patient survival, with improved patient outcomes for each increase in level of pre-hospital training that fire fighters receive. The Eisenberg Model supports the findings published in the *Journal of the American Medical Association*, which concluded that "two-tier systems in which the first responders are trained in early defibrillation are most effective in providing rapid Advanced Cardiac Life Support."[59]

It is clear that the quick arrival of an appropriate number of adequately trained personnel deploying with lifesaving medical resources is critical to increasing survivability from cardiac arrest and traumatic injury. For these reasons, **this analysis recommends every engine company continue to be staffed with four full-time fire fighters, all of which are trained, at a minimum, to the level of EMT-B. Inasmuch as an increase in survivability correlates with the degree to which fire fighters are trained in emergency medicine, the fire department should pursue efforts to ensure that, of the four firefighters assigned to all engine companies, two fire fighters should be certified as EMT-Paramedics** (EMT-Ps).

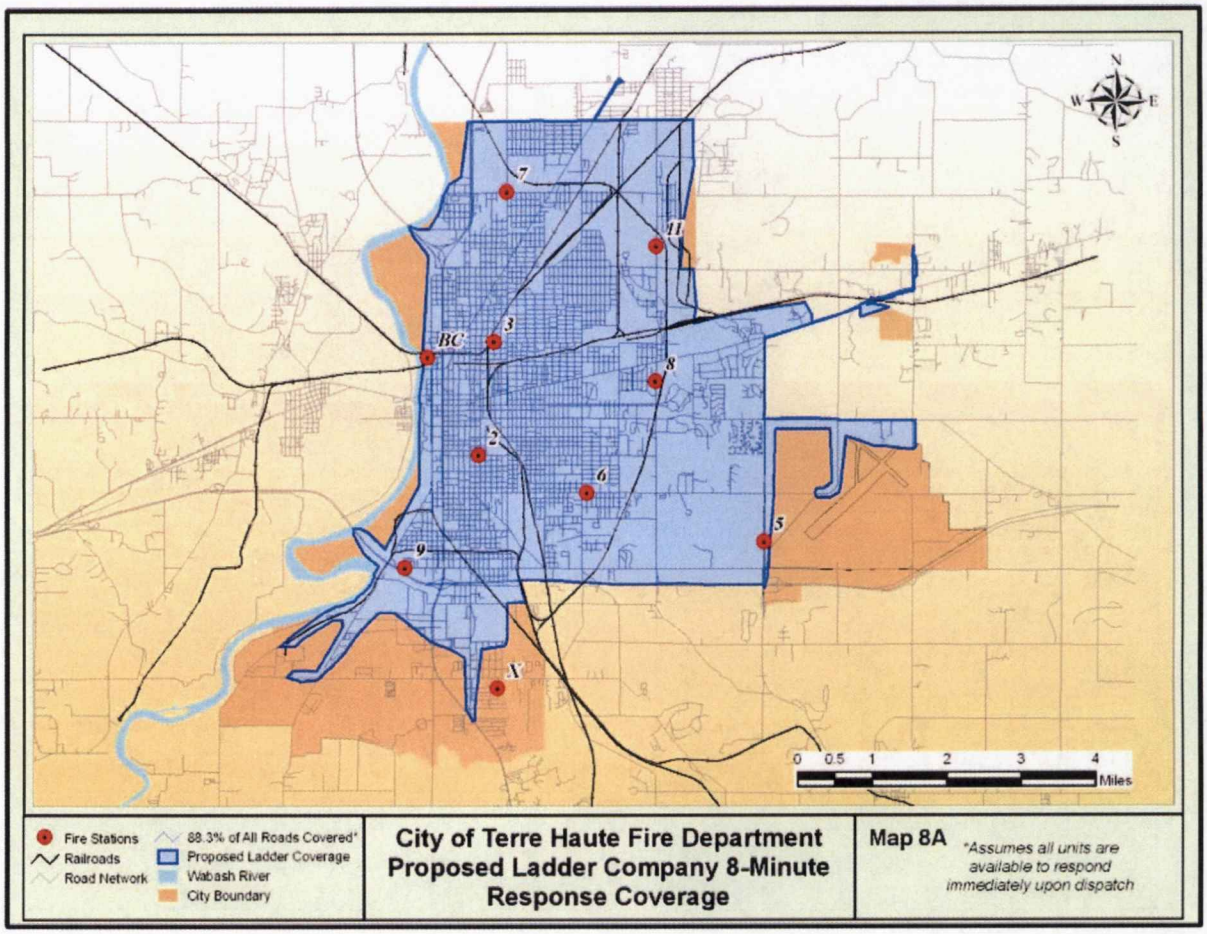
[59] The Journal of the American Medical Association (October 28, 1992): 2290.

MAP 8



Map 8 indicates existing Ladder company 8-minute response capabilities deploying from Stations 5 and 8 without train delays. Currently, in the absence of any ladder apparatus, the Ladder companies respond to **98.0% of all roads located within the city in 8 minutes or less,** *assuming all units are available to respond immediately upon dispatch.* The unavailability of a ladder to respond to emergencies within its primary response district creates a gap in services to that area of the community, and a delay in fire department response. Secondary units responding from neighboring response districts will experience increased response times due to increased travel distances, which may be exacerbated by any number of impedances. Any delay in response translates directly into a proportional increase in the expected loss of life and property.

MAP 8A



Map 8A indicates the proposed 8-minute response capability for Ladder Companies responding from Stations 2, 7, and 8. Currently, Ladders that would deploy from these stations are capable of responding to **88.3% of all roads located within the city jurisdiction in 8 minutes or less,** *assuming the unit is available to respond immediately upon dispatch.* The *unavailability* of staff to respond to emergencies within its primary response district creates a gap in services to that area of the community, and a delay in fire department response. Any delay in response translates directly into a proportional *increase* in the expected loss of life and property.

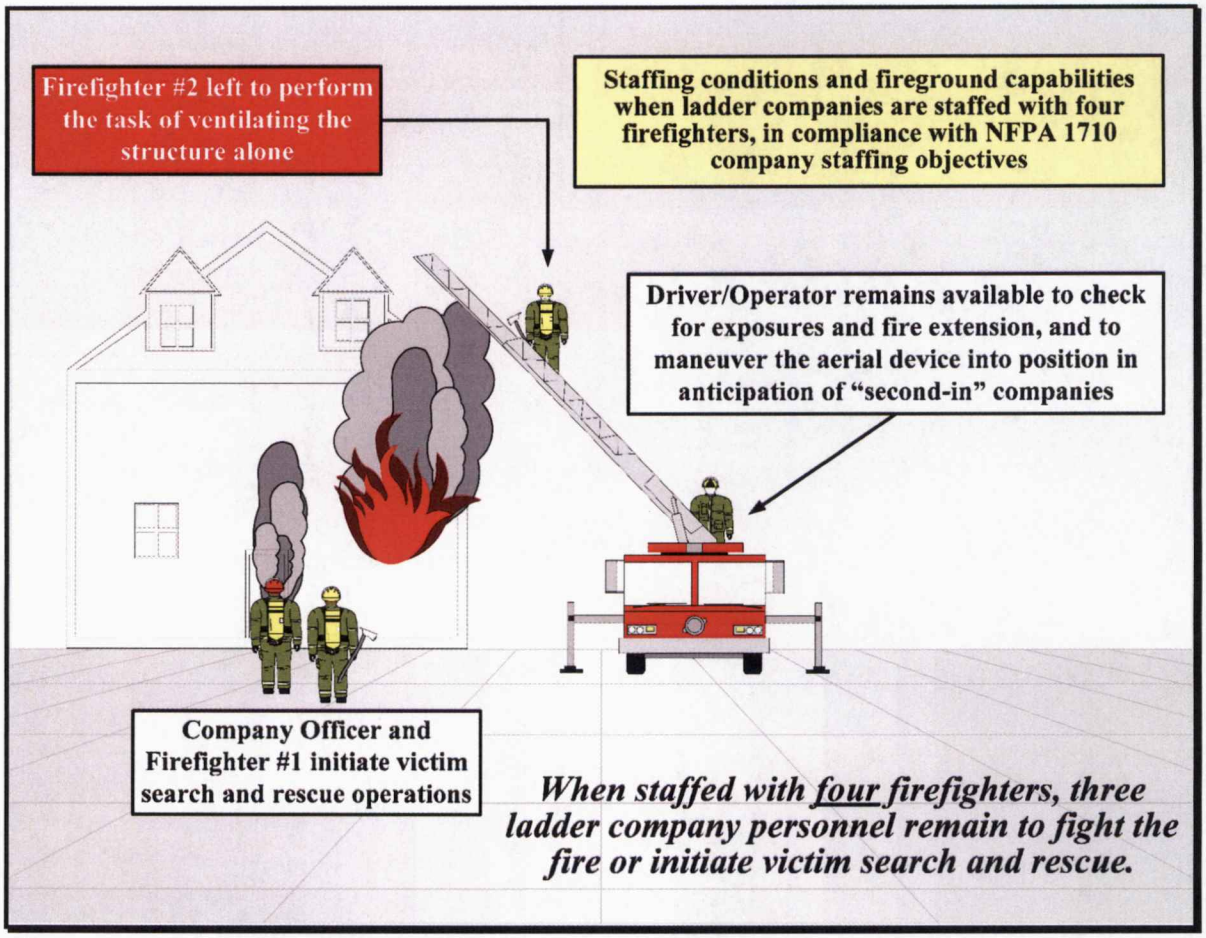
The Importance of the 8-minute Ladder Company Response In Structural Fire Fighting Operations:

Ladder companies play a vital role on the scene of a structure fire securing building access and overseeing the ventilation of dangerous, superheated products of combustion from the building. The importance of being able to ventilate a building efficiently, effectively, and *in coordination* with interior attack operations is key to supporting search and rescue operations. Once the superheated gases and smoke from the building have been ventilated, fire fighters conducting interior fire suppression and rescue operations are able to more clearly locate the seat of the fire and more effectively perform victim search and rescue. The rapid extrication of victims from inside a burning structure is critical to saving lives: the quicker fire victims are removed from the structure, the quicker they can be treated by fire department and medical personnel for smoke inhalation, burns, and other injuries related to fire. Thus, the response of the truck *in concert with* other fire suppression companies assigned to respond to a structure fire is critical to initiating *safe* and *effective* fire suppression and rescue operations. Any delay in response translates directly into a proportional *increase* in the expected loss of life and property.

To ensure the rapid extrication of fire victims, NFPA 1710 states that "Fire companies whose primary functions are to perform the variety of services associated with truck work, such as forcible entry, ventilation, search and rescue, aerial operations for water delivery and rescue, utility control, illumination, overhaul and salvage work… shall [also] be staffed with a **minimum of four on-duty personnel.**"[60] A crew of four is required to make a safe initial attack on a fire, with a crew of two working inside the burning structure and a backup crew of two standing by to assist as necessary. This is known as the "2 In/2 Out" regulation.

[60] NFPA 1710, Section 5.2.2.2 and 5.2.2.2.1

FIGURE 14:
"LADDER COMPANY FIREGROUND OPERATIONS WHEN STAFFED WITH FOUR FIREFIGHTERS"



When staffed with four firefighters, in compliance with industry standards, firefighters are 79% effective in ventilating the structure, 90.3% effective in accomplishing victim search and rescue, and 80.2% effective in checking for exposures and fire extension.

TABLE 6:
"LADDER COMPANY EFFICIENCY: 3 FIREFIGHTERS VS. 4 FIREFIGHTERS" [61]

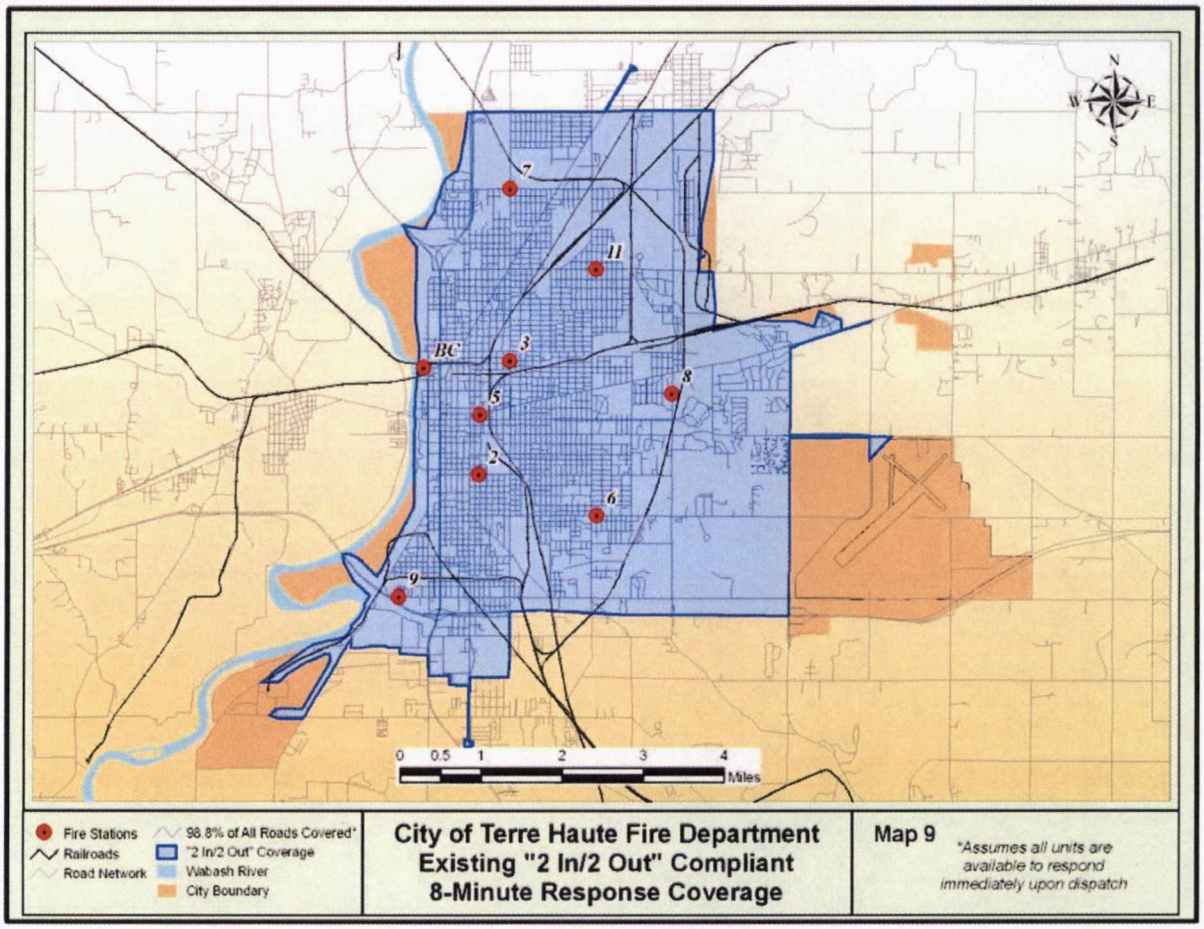
NUMBER OF FIREFIGHTERS	ROOF VENTILATION	SEARCH & RESCUE	CHECK EXPOSURES FOR FIRE EXTENSION
5 Firefighters	100.0%	100.0%	100.0%
4 Firefighters	79.0%	90.3%	80.2%
3 Firefighters	0.0%	79.6%	0.0%

[61] McManis Associates and John T. O'Hagan & Associates, Dallas Fire Department Staffing Level Study, (June 1984); pp. 1-2 and II-1 through II-7.

For these reasons, **it is the recommendation of this study that the City of Terre Haute Fire Department ensure the safe and effective delivery of emergency services by staffing all fire suppression apparatus with *at least* four multi-role fire fighters cross-trained to the level of EMT-B.**[62]

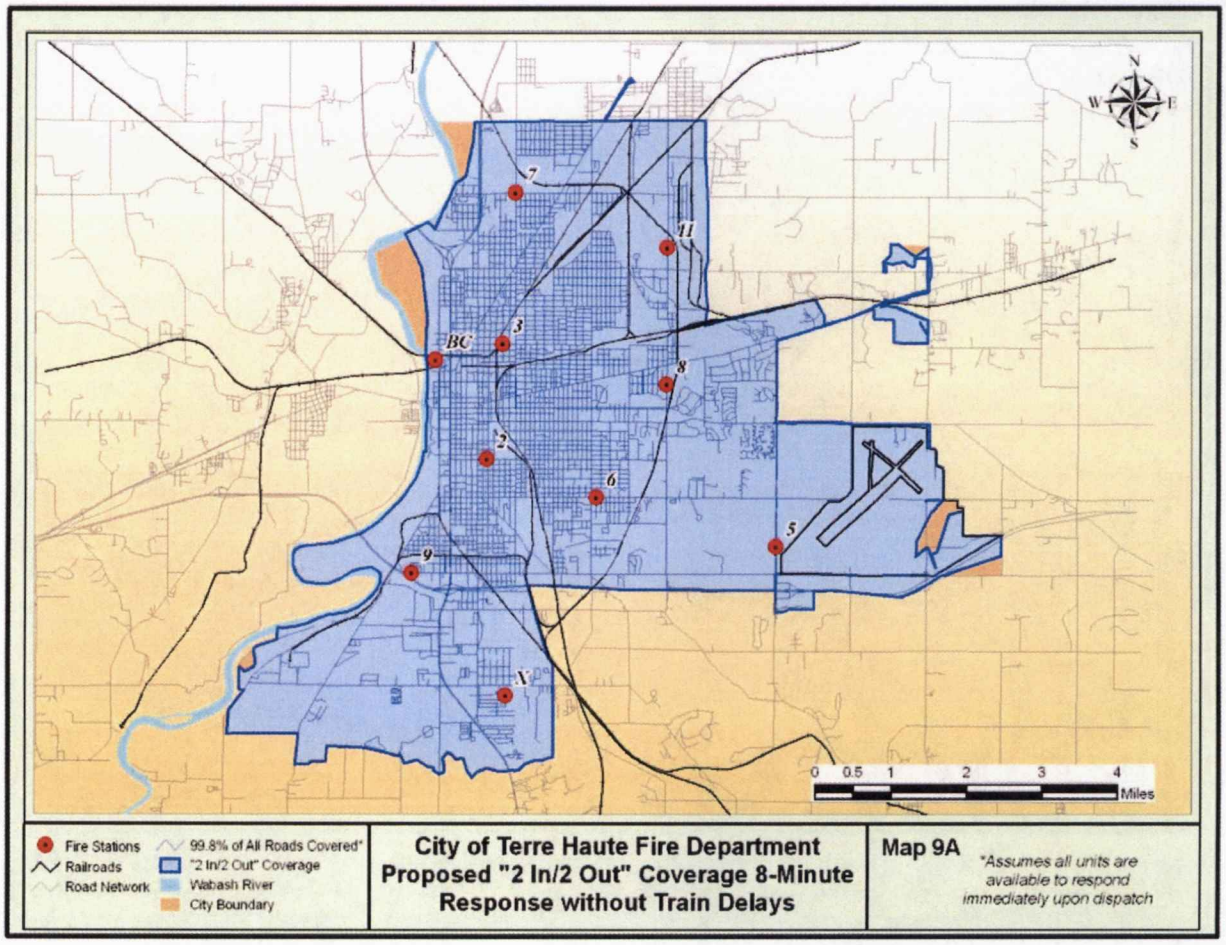
[62] NFPA 1710, §5.2.2.1.2 and §5.2.2.2.2 - "In jurisdictions with tactical hazards, high hazard occupancies, high incident frequencies, geographical restrictions, or other pertinent factors as identified by the authority having jurisdiction, these companies shall be staffed with a minimum of five or six on-duty members."

MAP 9



Map 9 indicates those areas where the City of Terre Haute Fire Department is currently capable of initiating *safe* and *effective* fire suppression and rescue operations, within 8 minutes, in accordance with the "2 In/2 Out" regulation. Under these conditions, it is predicted that **the Fire Department is capable of initiating fire suppression and rescue operations in accordance with the "2 In/2 Out" regulation on 98.8% of all roads within 8 minutes,** *assuming all units are staffed at existing staffing levels and available to respond immediately upon dispatch.*

MAP 9A

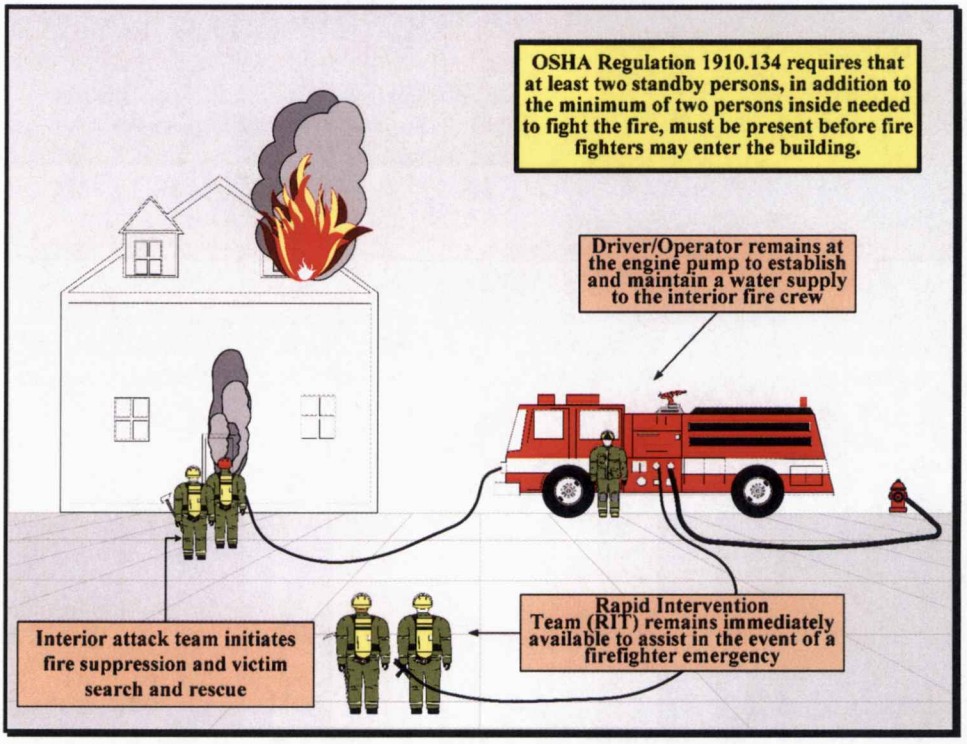


Map 9A indicates those areas where the City of Terre Haute Fire Department would be capable of initiating *safe* and *effective* fire suppression and rescue operations, within 8 minutes, in accordance with the "2 In/2 Out" regulation. Under these conditions, it is predicted that **the Fire Department is capable of initiating fire suppression and rescue operations in accordance with the "2 In/2 Out" regulation on 98.8% of all roads within 8 minutes,** *assuming all units are staffed at existing staffing levels and available to respond immediately upon dispatch.*

OSHA's "2 In/2 Out" Regulation

The "2 In/2 Out" policy is part of paragraph (g)(4) of OSHA's revised respiratory protection standard, 29 CFR 1910.134. The safety of fire fighters engaged in interior structural firefighting is the major focus of paragraph (g)(4) of the OSHA Respiratory Protection standard. OSHA's interpretation on requirements for the number of workers required being present when conducting operations in atmospheres that are immediately dangerous to life and health (IDLH) covers the number of persons who must be on the scene before firefighting personnel may initiate an interior attack on a structural fire. An interior structural fire (*an advanced fire that has spread inside of the building where high temperatures, "heat" and dense smoke are normally occurring*) would present an IDLH atmosphere and, therefore, require the use of respirators. In those cases, at least two standby persons, in addition to the minimum of two persons inside needed to fight the fire, must be present before fire fighters may enter the building.[63, 64] This requirement is mirrored in NFPA 1500, which states that "a rapid intervention team shall consist of at least two members and shall be available for rescue of a member or a team if the need arises. Once a second team is assigned or operating in the hazardous area, the incident shall no longer be considered in the 'initial stage,' and at least one rapid intervention crew shall be required."

FIGURE 15:
"OSHA '2 IN/2 OUT' ILLUSTRATED"



Two of the most important elements in limiting fire spread are the quick arrival of sufficient numbers of personnel and equipment to attack and extinguish the fire as close to the point of

[63] Under the NFPA standards relating to fire fighter safety and health, the incident commander may make exceptions to these rules if necessary to save lives. The Standard does not prohibit fire fighters from entering a burning structure to perform rescue operations when there is a "reasonable" belief that victims may be inside.
[64] Paula O. White, letter to Thomas N. Cooper, 1 November 1995 (OSHA)

origin as possible, as well as rescue any trapped occupants and care for the injured. Several existing National Fire Protection Association standards address this time-critical issue. NFPA 1500 states, "while members can be assigned and arrive at the scene of an incident in many different ways, it is strongly recommended that interior fire fighting operations not be conducted without an adequate number of qualified firefighters operating in companies under the supervision of company officers. **It is recommended that a minimum acceptable fire company staffing level should be four members responding on or arriving with each engine and each ladder company responding to any type of fire.**" NFPA Standard 1710 further recommends that "fire companies whose primary functions are to pump and deliver water and perform basic fire fighting at fires, including search and rescue… shall be staffed with **a minimum of four on-duty personnel**,"[65] while "fire companies whose primary functions are to perform the variety of services associated with truck work, such as forcible entry, ventilation, search and rescue, aerial operations for water delivery and rescue, utility control, illumination, overhaul and salvage work… shall [also] be staffed with **a minimum of four on-duty personnel**."[66] For either fire suppression company, NFPA 1710 states that "in jurisdictions with tactical hazards, high hazard occupancies, high incident frequencies, geographical restrictions, or other pertinent factors as identified by the authority having jurisdiction, these companies shall be staffed with a minimum of five or six on-duty members."[67]

There exist a number of incidents in which the failure to follow "2 In/2 Out" procedures have contributed to fire fighter casualties. For example, in Lexington, Kentucky, one fire fighter died and a second was severely injured following a fire where Kentucky OSHA later cited the fire fighters' employer for failing to utilize "2 In/2 Out" procedures. In a second case, two fire fighters died from smoke inhalation after being overcome by toxic fumes while fighting an accidental fire in Philadelphia, PA. Although two additional fire fighters were outside the home, both were engaged in support activities (hydrant hook-up and pump operation), and neither was fully accountable for monitoring the interior personnel.

There also exist a number of success stories following the adoption of "2 In/2 Out" procedures. In Pittsburgh, PA, the Fire Department implemented an accountability and rescue system following a fatal fire. In one instance, four fire fighters who were performing an interior attack on an apartment building fire became disoriented and were trapped in the building. The standby personnel were able to initiate rescue operations promptly and, although the four interior fire fighters and two of the rescuers were injured, all survived.[68]

"2 In/2 Out," Flashover, & Fire Department Operations:

Only those structure fires located within a limited area, as depicted in Map 6, where a sufficient number of personnel arriving on appropriate apparatus can arrive at a common destination within 8 minutes, will receive the equipment and personnel required to initiate *safe* and *effective* fire suppression and rescue operations in accordance with the OSHA and NFPA guidelines outlined in this report. As the progression of a structural fire to the point of flashover generally occurs within 10 minutes, it is predicted that those structure fires at the furthest reaches and beyond the extent of the 8-minute polygons indicated in Map 6 are *more likely* to continue to burn up to and beyond the point of flashover.

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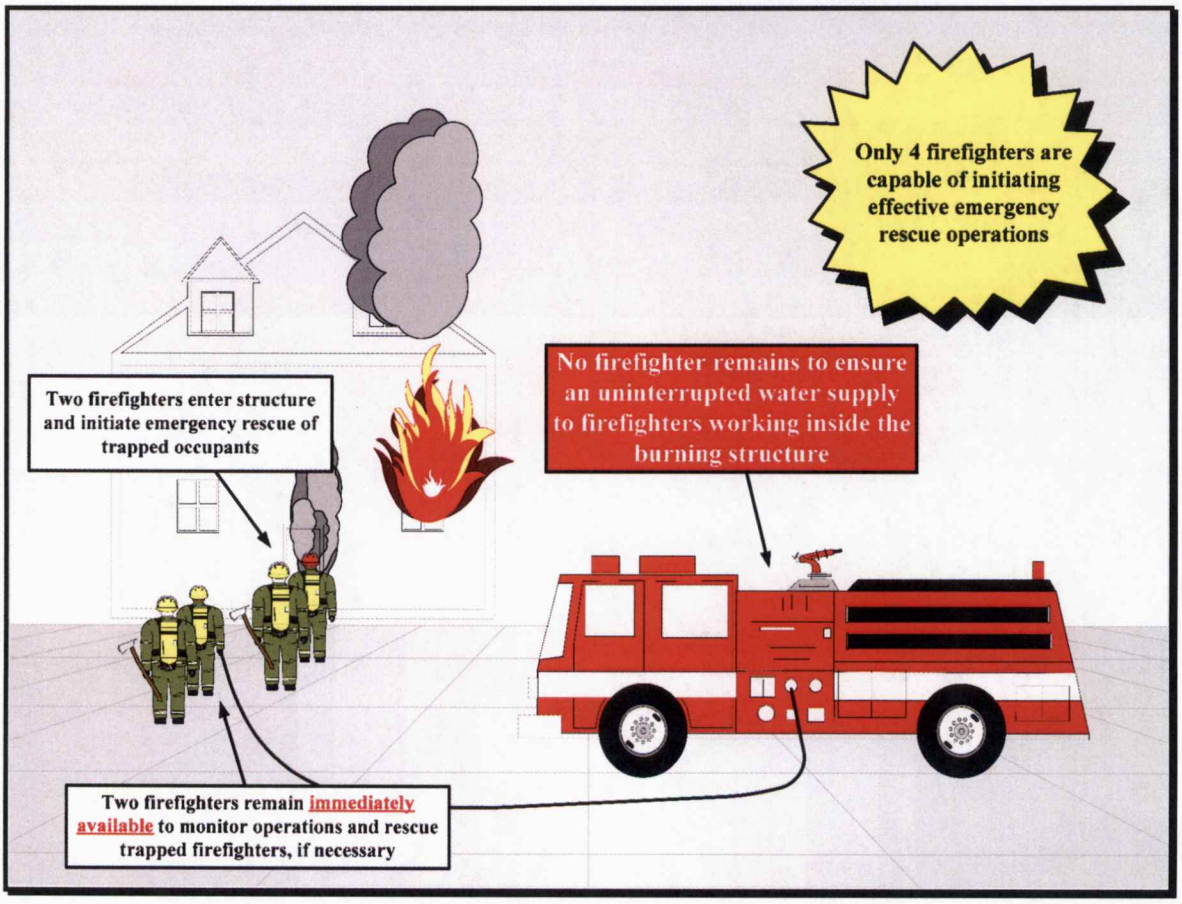
[65] NFPA 1710, § 5.2.2.1 and § 5.2.2.1.1
[66] NFPA 1710, § 5.2.2.2 and § 5.2.2.2.1
[67] NFPA 1710, § 5.2.2.1.2 and § 5.2.2.2.2
[68] John B. Miles, Jr., letter to J. Curtis Varone, Esq., 29 April 1998 (OSHA)

Flashover is a critical stage of fire growth for two reasons. First, no unprotected living thing in a room where flashover occurs will survive and the chance of saving lives drops dramatically. Second, flashover creates a huge jump in the rate of combustion, and a significantly greater amount of water is needed to reduce the burning material below its ignition temperature. A post-flashover fire burns hotter and moves faster, requires more resources for fire attack, and compounds the problems of search and rescue, exposure protection, and containment.[69]

It warrants emphasizing that the ability of the Fire Department to assemble a sufficient number of firefighters to initiate "2 In/2 Out" fire suppression and rescue activities occurs *within* 8 minutes. It is very likely that the first-in company may arrive in significantly *less than* 8 minutes, and the second-in company may arrive closer to the 8-minute mark. This lag time between the arrival of units is significant in that if staffed with less than four fire fighters, fire companies are *completely* unable to perform fire and rescue operations in accordance with the "2 In/2 Out" regulation.

FIGURE 16:
"EMERGENCY '2 IN/2 OUT' OPERATIONS
WHEN FIRE COMPANIES ARE STAFFED WITH 4 FIREFIGHTERS"

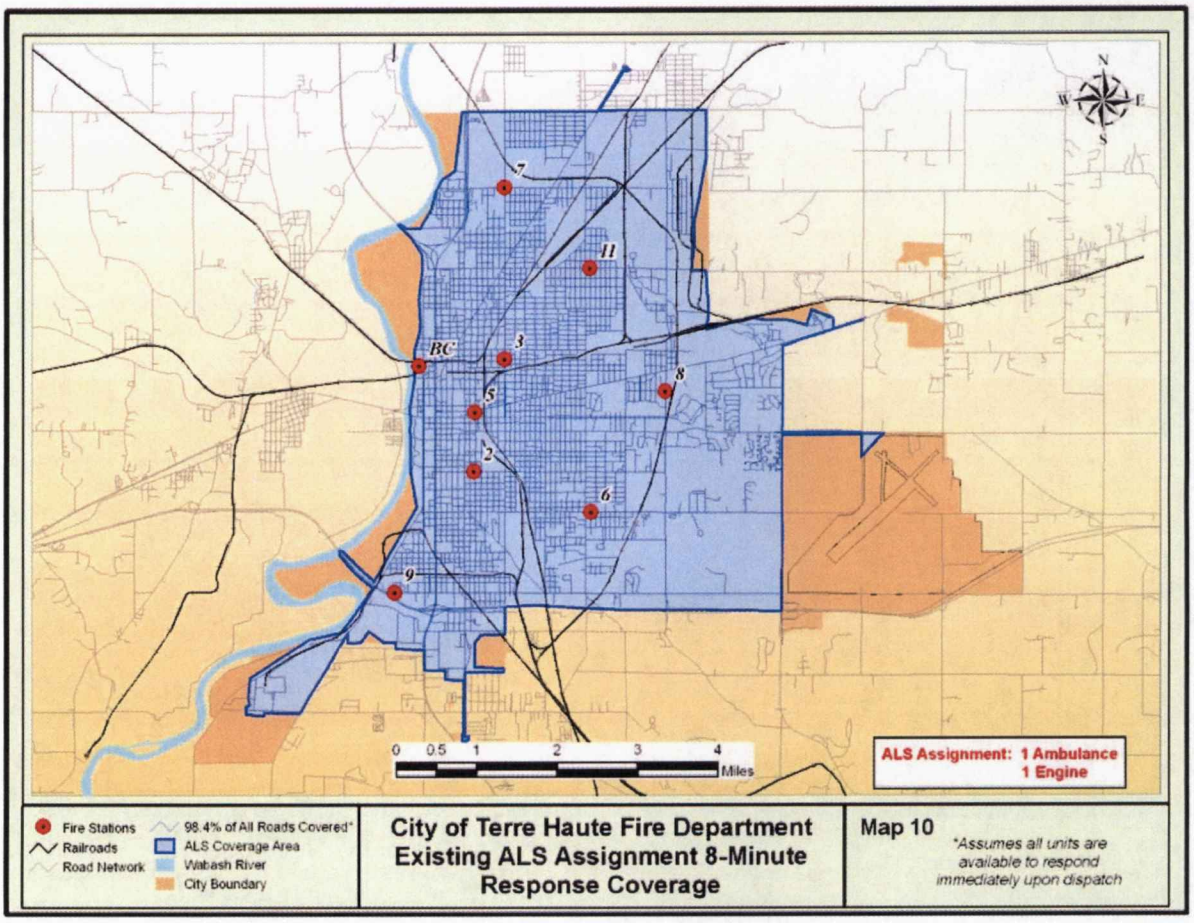


[69] The University of California at Davis Fire Department website; site visited April 2, 2004.
< http://fire.ucdavis.edu/ucdfire/UCDFDfiresuppression.htm >

When confronted with occupants trapped in a burning structure and a single fire company is on scene, only a company staffed with four firefighters is able to initiate emergency search and rescue operations in compliance with "2 In/2 Out" operations. As indicated in the previous graphic, this requires the complete engagement of every fire fighter from the first-in fire company, staffed with four, to participate in the effort, and means that the driver-operator of the apparatus will not be able to tend to the pump to ensure the delivery of water to the fire fighters performing the initial attack and search and rescue operations.

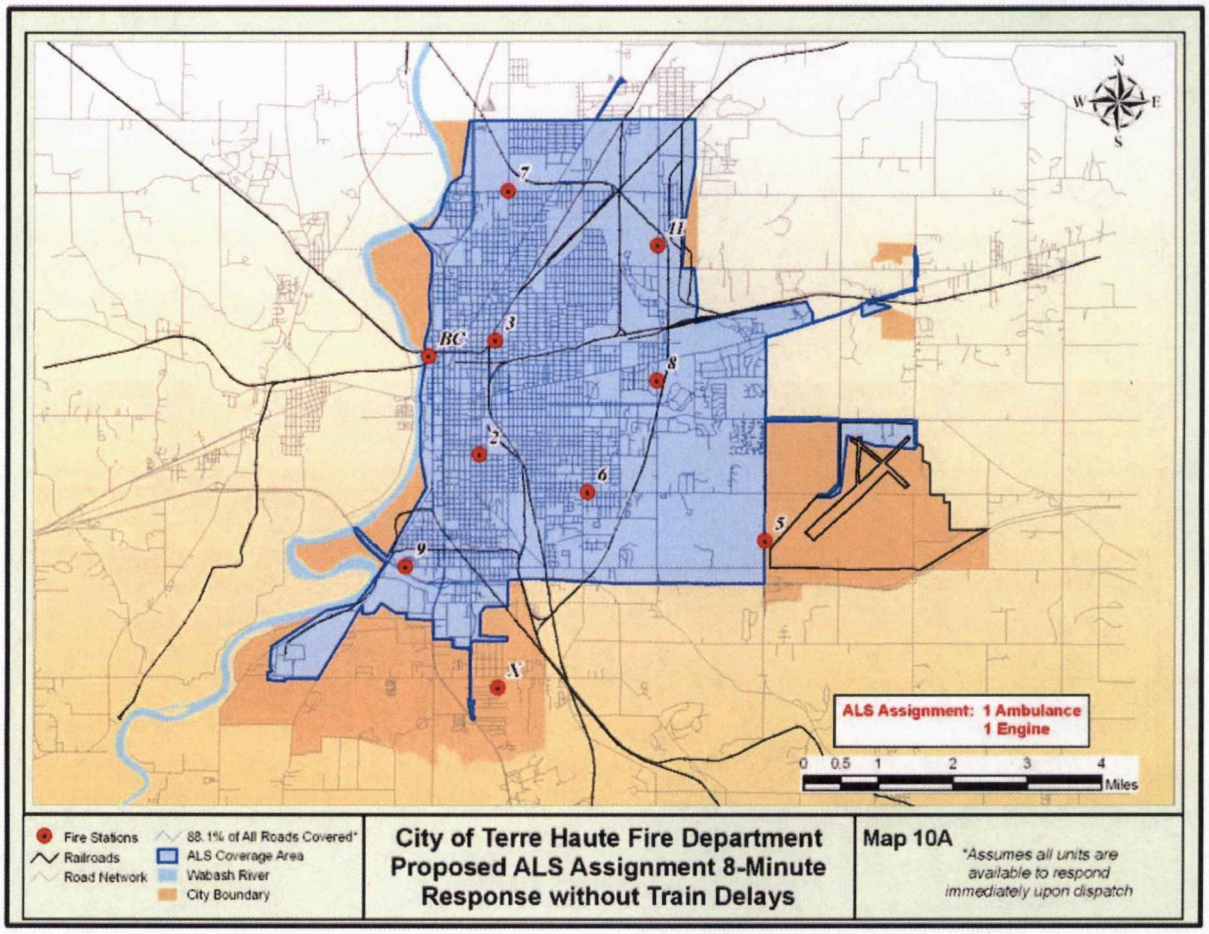
Regardless, when there exists an immediate threat to life, only a company of four fire fighters can initiate fire suppression and rescue operations in compliance with the "2 In/2 Out" regulation, and in a manner that minimizes the threat of personal injury. In all other instances with a four-person fire company (i.e., when there is not an immediate threat to life), the first-in company must wait until the arrival of the second-in unit to initiate safe and effective fire suppression and rescue operations. This condition underlines the importance and desirability of fire companies to be staffed with four firefighters, and stresses the benefit of four-person companies and their ability to save lives without having to wait for the second-in company to arrive.

Map 10



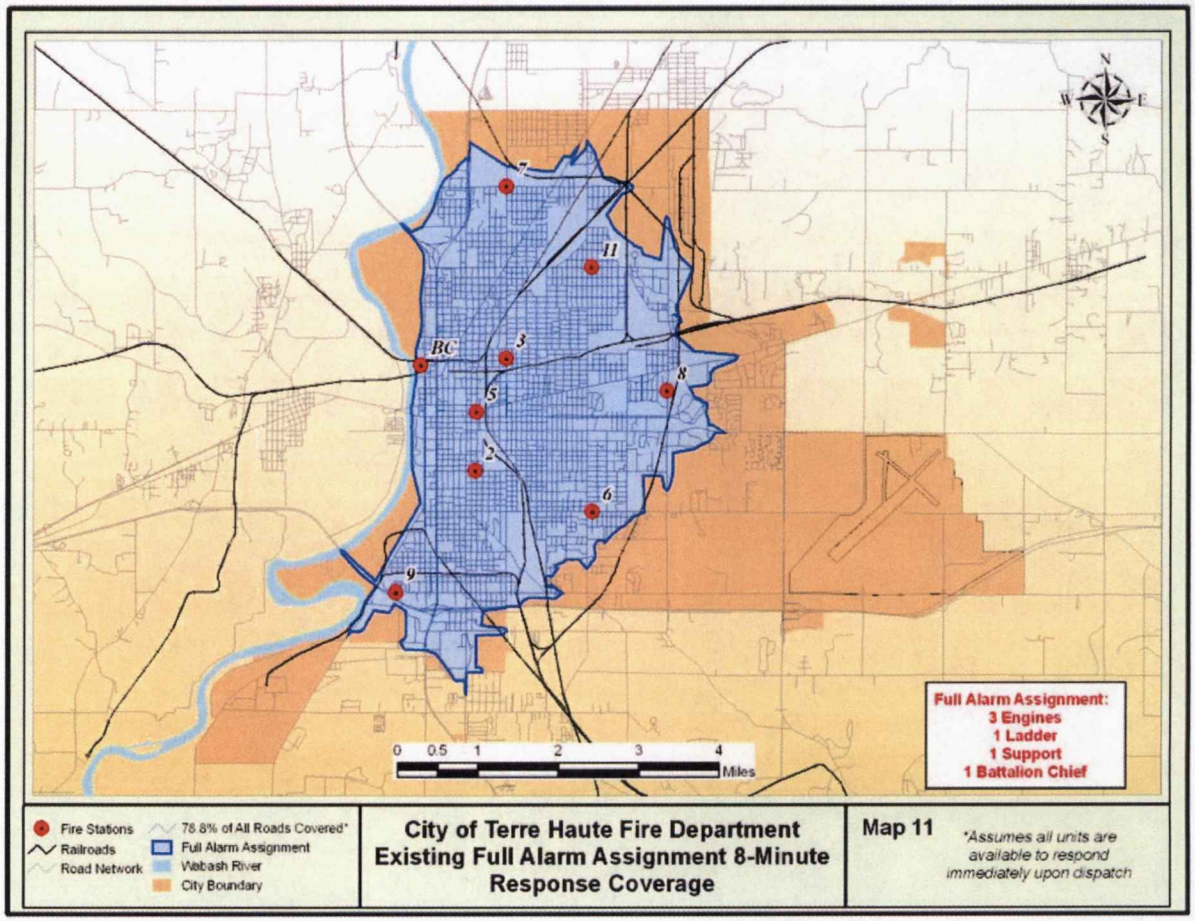
Map 10 indicates the 8-minute response areas for the Advanced Life Support (ALS) assignment. An ALS assignment consists of 1 Engine and 1 Ambulance. Currently, the ALS assignment units that deploy are capable of responding to **98.4% of all roads within the city in 8 minutes or less**. *Assuming all units are available to respond immediately upon dispatch.*

Map 10A



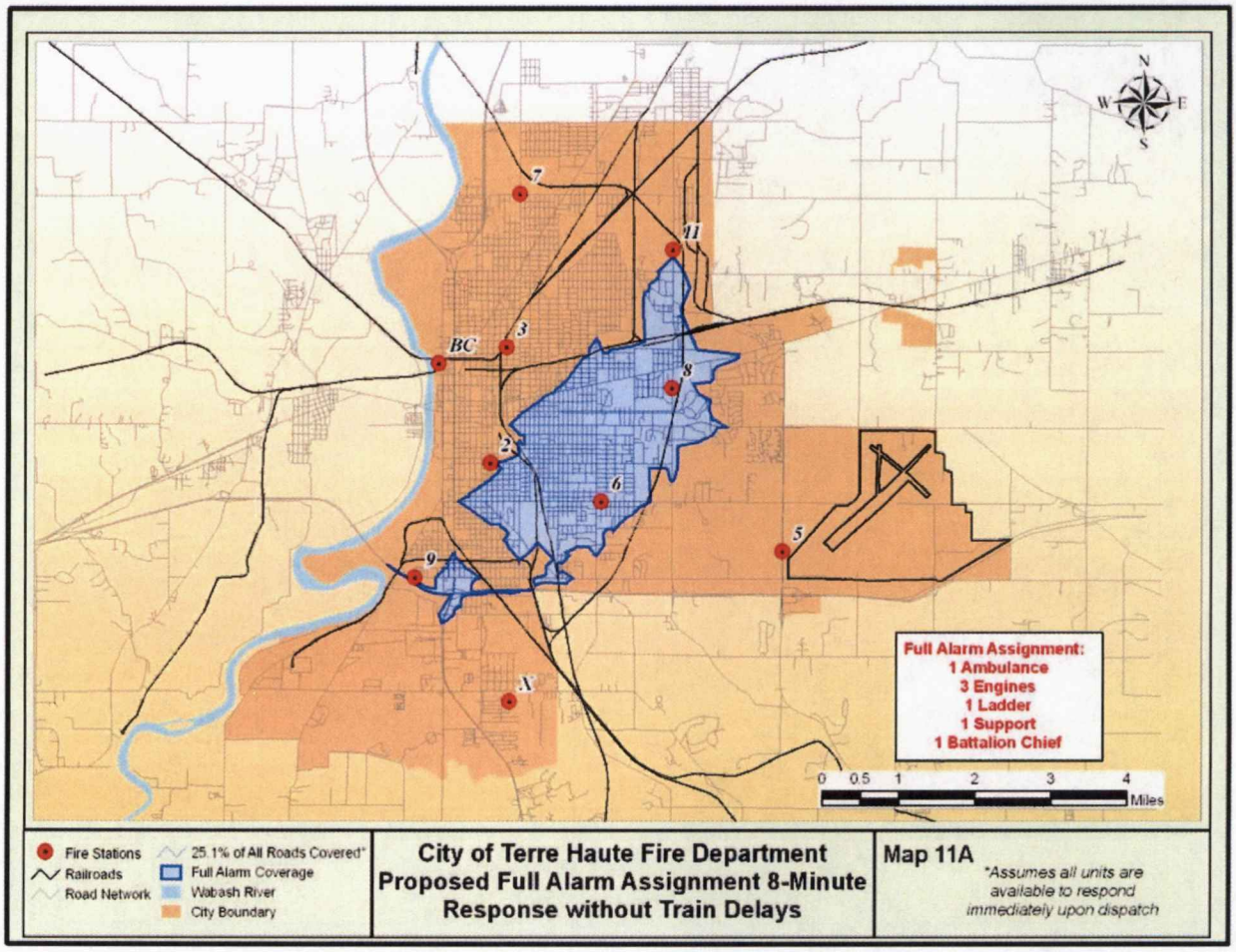
Map 10A indicates the 8-minute response areas for the Advanced Life Support (ALS) assignment. An ALS assignment consists of 1 Engine and 1 Ambulance. The proposed ALS assignment units could deploy would be capable of responding to **88.1% of all roads within the city in 8 minutes or less**. *Assuming all units are available to respond immediately upon dispatch.*

Map 11



Map 11 indicates the 8-minute response areas for the existing station Full Alarm Assignment without train delays. The full alarm assignment consists of 3 Engines, 1 Ladder, 1 Support Unit, 1 Ambulance, and the Battalion Chief. Currently, the full alarm assignment units that deploy are capable of responding to **78.8% of all roads within the city in 8 minutes or less**. *Assuming all units are available to respond immediately upon dispatch.*

Map 11A



Map 11 indicates the 8-minute response areas for the existing station Full Alarm Assignment without train delays. The full alarm assignment consists of 3 Engines, 1 Ladder, 1 Support Unit, 1 Ambulance, and the Battalion Chief. The proposed full alarm assignment units that deploy are capable of responding to **25.1% of all roads within the city in 8 minutes or less**. *Assuming all units are available to respond immediately upon dispatch.* The coverage area for the Full Alarm Assignment in Map 11A is contingent that the Support Unit will relocate to the new Station 5. If the Support Unit relocates to the new Station 5, the amount of roads covered by the Full Alarm Assignment **reduces by 53.7% from the original coverage area**. *Please note the city limit boundaries and amount of roads are less on the existing coverage area.* Coverage areas for each apparatus deployed from specific Stations have less overlap since the Stations will be placed further apart. If the Support Unit remains at a fire station on the western side of Terre Haute, the Full Alarm Assignment road coverage will increase, primarily because the coverage areas from the Support Unit and the Battalion Chief will have greater overlap. Based on the assumption that Support 5 moves to the eastern side of Terre Haute, the Support Unit will be on the opposite side of town and experience greater travel distances than the other apparatus and the Battalion Chief that can assemble for a Full Alarm Assignment within 8 minutes. The coverage overlap decreases between the Support Unit and the other Full Alarm Assignment apparatus in the present scenario.

Fire Growth, Flashover, and the Importance of a Rapid Response to a Fire in a Residential Structure:

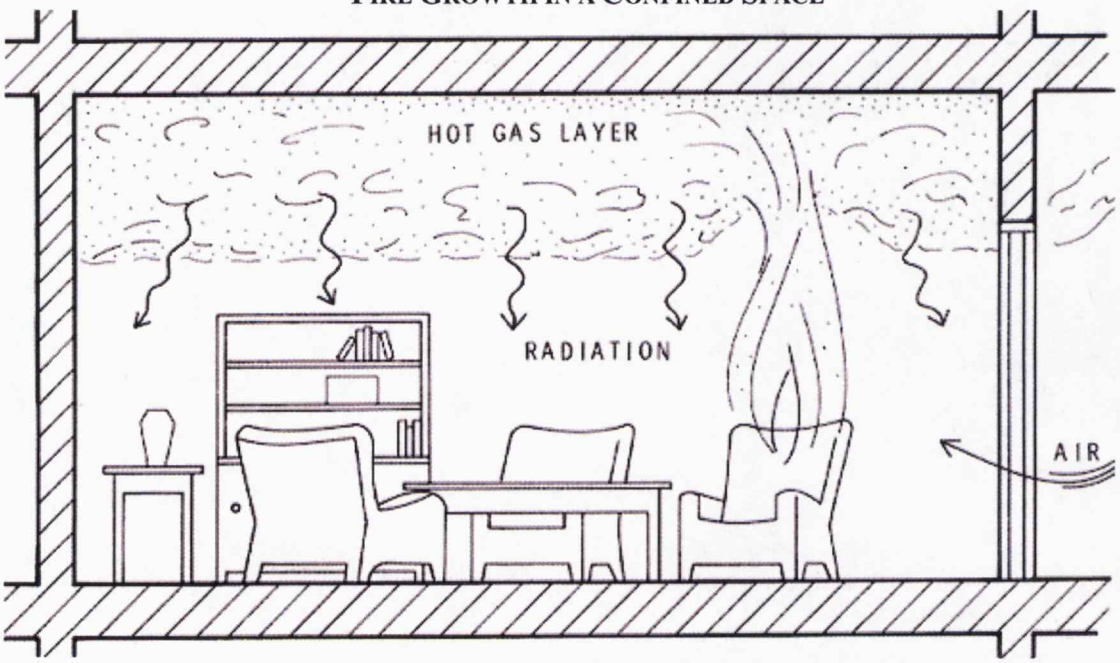
The Smoldering Phase

The first stage of any fire is the smoldering stage. When heat is applied to a combustible material, the heat oxidizes the material's surface into combustible gases. The oxidation process is exothermic, meaning that the oxidation process itself produces heat. The heat from oxidation raises the temperature of surrounding materials, which increases the rate of oxidation and begins a chemical chain reaction of heat release and burning. A fire can progress from the smoldering phase immediately or slowly, depending upon the fuel, nearby combustibles, and the availability of oxygen in the surrounding air.

The Free Burning Phase

The second stage of fire growth is the "free" or "open burning" stage. When the temperature of a fire gets high enough, visible flames can be seen. The visible burning at this stage is still limited to the immediate area of origin. The combustible process continues to release more heat, which heats nearby objects to their ignition temperature, and they begin burning. In a wildland fire the surrounding growth will ignite and the flames will spread, quickly if wind and dry growth are present. A structure fire is different, because the gaseous products of combustion, most of which are flammable and lighter than air, rise and are contained in the upper levels of the structure. When this occurs, the structure fire is at a critical point: either the fire has insufficient oxygen available to burn and it progresses back to the smoldering stage, or it has sufficient oxygen available to move on to the next stage.

FIGURE 17:
"FIRE GROWTH IN A CONFINED SPACE"[70]



When an object in a room starts to burn (such as the armchair in Figure 17), for some time after ignition, it burns in much the same way as it would in the open. After a short period of time, however, confinement begins to influence fire development. The smoke produced by the

[70] Image courtesy of University of California at Davis Fire Department

burning object rises to form a hot gas layer below the ceiling; this layer heats the ceiling and upper walls of the room. Thermal radiation from the hot layer, ceiling, and upper walls begins to heat all objects in the lower part of the room and may augment both the rate of burning of the original object and the rate of flame spread over its surface.

At this point, the fire may go out if, for example, the first object burns completely before others start, or if sufficient oxygen cannot get into the room to keep the object burning. Sometimes, however, the heating of the other combustibles in the room continues to the point where they reach their ignition temperatures more or less simultaneously. If this occurs, flames suddenly sweep across the room, involving most combustibles in the fire. This transition from the burning of one or two objects to full room involvement is referred to as "flashover."[71]

Flashover

The third stage of fire growth is called *flashover*. It is the most significant moment of any structure fire. As combustible gases are produced by the two previous stages they are not wholly consumed. They rise and form a superheated gas layer at the ceiling. As the volume of this gas layer increases, it begins to bank down to the floor, heating all combustible objects regardless of their proximity to the burning object. In a typical structure fire, the gas layer at the ceiling can quickly reach temperatures of 1,500 degrees Fahrenheit. If there is enough existing oxygen, usually near floor level, flashover occurs and everything in the room breaks out into open flame at once. The instantaneous eruption into flame generates a tremendous amount of heat, smoke, and pressure with enough force to push beyond the room of origin through doors and windows. Usually at the time of flashover, windows in the room will break, allowing for the entry of fresh air. The introduction of fresh air serves to further fuel the growth of the fire, increase the temperature of the fire, and aid in the spread of the fire beyond the room of origin. The combustion process then speeds up because it has an even greater amount of heat to move to unburned objects.

The ability of adequate fire suppression forces to greatly influence the outcome of a structural fire is undeniable and predictable. Data generated by the National Fire Protection Association provides empirical proof that rapid and aggressive interior attack can substantially reduce the human and property loss associated with structural fires. At each stage of a fire's extension beyond the room of origin, the rate of civilian deaths, injuries, and property damage grows).

TABLE 7:[72]
"THE RELATIONSHIP BETWEEN FIRE EXTENSION AND FIRE LOSS"

Rate Per 1,000 Fires			
Fire Extension in Residential Structures:	Civilian Deaths	Civilian Injuries	Average Property Damage
Confined to Room of Origin	2.07	24.30	$1,505.00
Confined to Floor of Origin	18.60	80.44	$12,134.00
Beyond Floor of Origin	27.23	55.37	$21,343.00

[71] J.R. Mehaffey, Ph.D., Flammability of Building Materials and Fire Growth, Institute for Research in Construction (1987)

[72] Source: National Fire Protection Association

The Importance of Adequate Staffing to Conduct Safe and Effective Fire Suppression and Rescue Operations:

A prime objective of fire service agencies is to maintain enough strategically located personnel and equipment so that the minimum acceptable response force can reach a reasonable number of fire scenes before flashover is likely.[73] Two of the most important elements in limiting fire spread are the quick arrival of sufficient numbers of personnel and equipment to attack and extinguish the fire as close to the point of origin as possible, as well as rescue any trapped occupants and care for the injured. Rapid and aggressive interior attack of structure fires, as close as possible to the point of origin, can reduce human and property losses. Sub-optimal staffing of arriving units may delay such an attack, thus allowing the fire to progress to more dangerous conditions for fire fighters and civilians. "If the arriving units have adequate resources to handle the situation, then they will fight the fire aggressively and offensively. They will attack the problem head-on and, following department standards, will accomplish their objectives efficiently, effectively, and safely. If they do not have adequate resources to aggressively handle the situation, then they will have to fight the fire in a defensive mode of attack. This mode will continue until enough resources can be massed to then change to an aggressive, offensive attack."[74]

NFPA 1500 and 1710 both recommend that a minimum acceptable fire company staffing level should be **four members responding on or arriving with each engine and each ladder company responding to any type of fire.** The City of Terre Haute Fire Departments staffs all engine companies with three fighters, *not* in compliance with professional standards for the provision of safe and effective fire suppression and rescue operations. Recall, however, that at the scene of an emergency, the driver/operator of the engine must remain with the apparatus to operate the pump. Likewise, the driver/operator of the ladder truck must remain with the apparatus to safely operate the aerial device. Such activities, which help to ensure the safe and effective delivery of fire suppression and rescue services, leave a crew of only two firefighters from an engine company and two firefighters from a ladder company to support the attack or complete search and rescue activities. Due to the demands of fireground activities which reduce the effective firefighting force deploying from each company from two to one, a fire attack initiated by a single fire company is not capable of effecting a safe and effective fire suppression and/or rescue operation in compliance with the "2 In/2 Out" regulation until a second company arrives with sufficient personnel to support the fire attack and/or rescue operation, and to assist the first company in the event of an unexpected emergency.[75] Industry studies have confirmed that **four fire fighters are capable of performing the rescue of potential victims 80% faster than a crew of three fire fighters.**[76]

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

[74] National Institute for Occupational Safety and Health, High-Rise Apartment Fire Claims the Life of One Career Fire Fighter (Captain) and Injures Another Career Fire Fighter (Captain) – Texas, 13 October 2001

[75] Recall that a four-person fire company may initiate emergency search and rescue operations at the order of the incident commander if there is a "reasonable" and immediate threat to life.

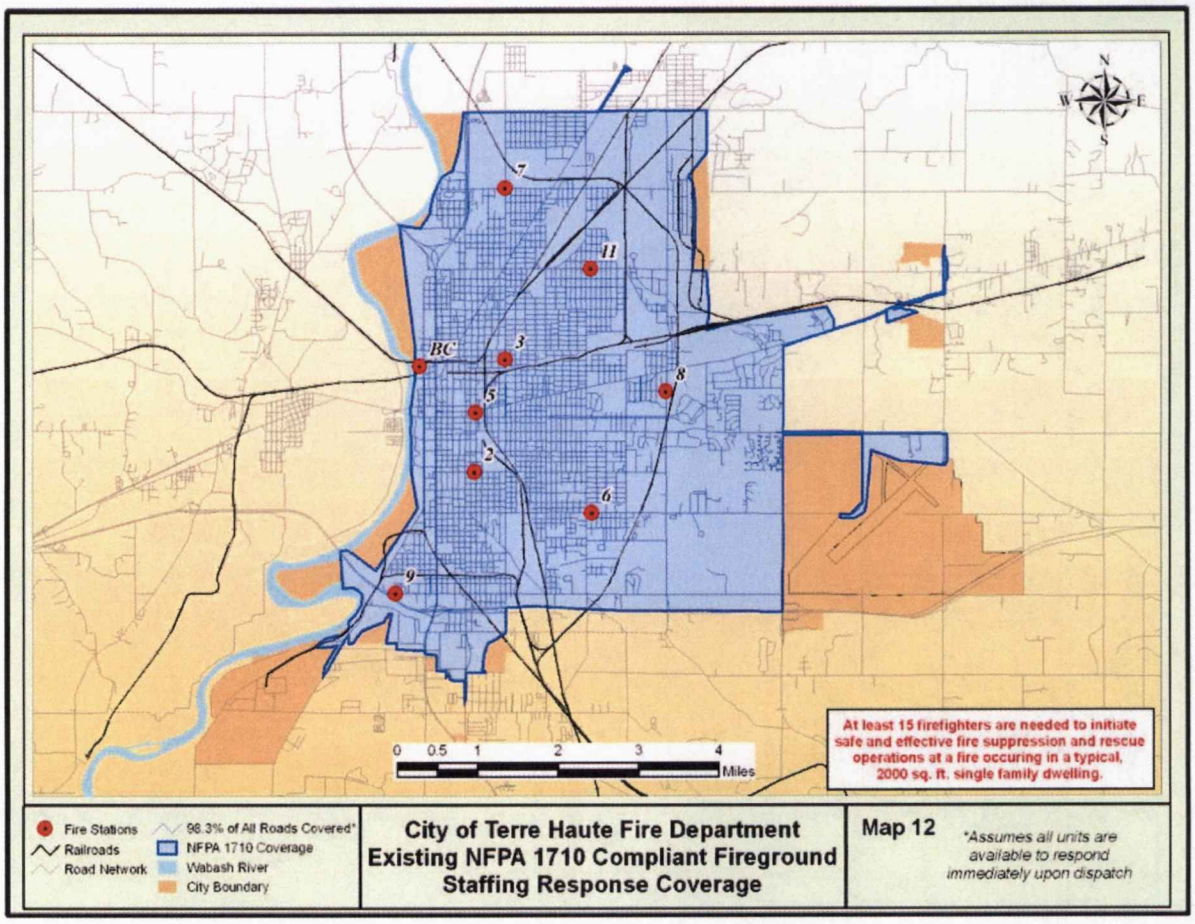
[76] McManis Associates and John T. O'Hagan & Associates, Dallas Fire Department Staffing Level Study, (June 1984); pp. 1-2 and II-1 through II-7; Richard C. Morrison, Manning Levels for Engine and Ladder Companies in Small Fire Departments, (1990)

The Importance of a Rapid Response in Initiating Safe and Effective Fire Suppression and Rescue Operations:

Any delay in the initiation of fire suppression and rescue operations translates directly into a proportional *increase* in expected property, life, and economic losses (reference "The Relationship between Fire Extension and Fire Loss," Table 7, p. 77). It warrants emphasizing that if a structure has no automatic suppression or detection system, a more advanced fire may exist by the time the fire department is notified of the emergency and is able to respond. Fires of an extended duration weaken structural members, compromising the structural integrity of a building and forcing operations to shift from an offensive to defensive mode.[77] This mode will continue until enough resources can be amassed to then change to an aggressive, offensive attack.

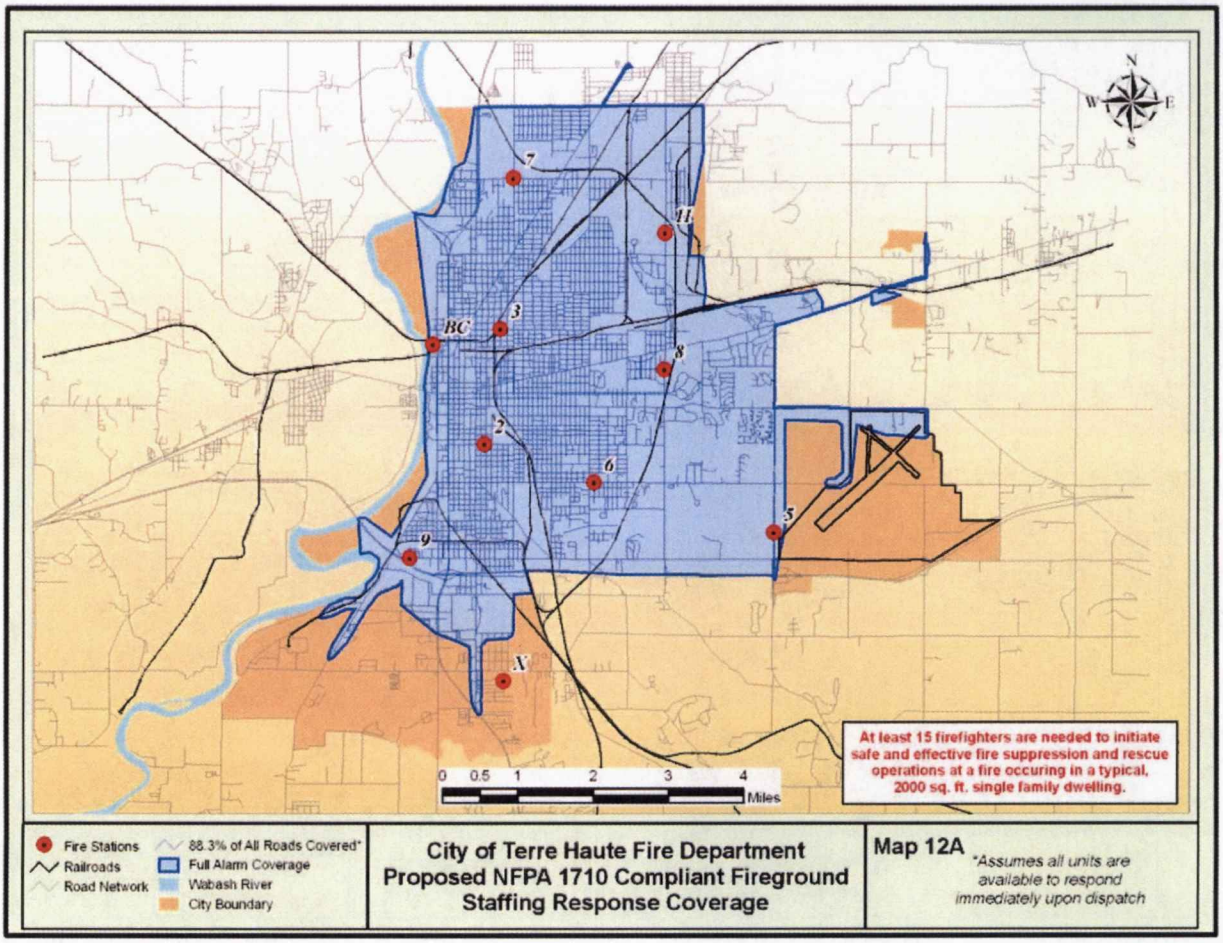
[77] According to the NFPA, "it's important to realize that every 250 GPM stream applied to the building can add up to one ton per minute to the load the weakened structure is carrying."

MAP 12



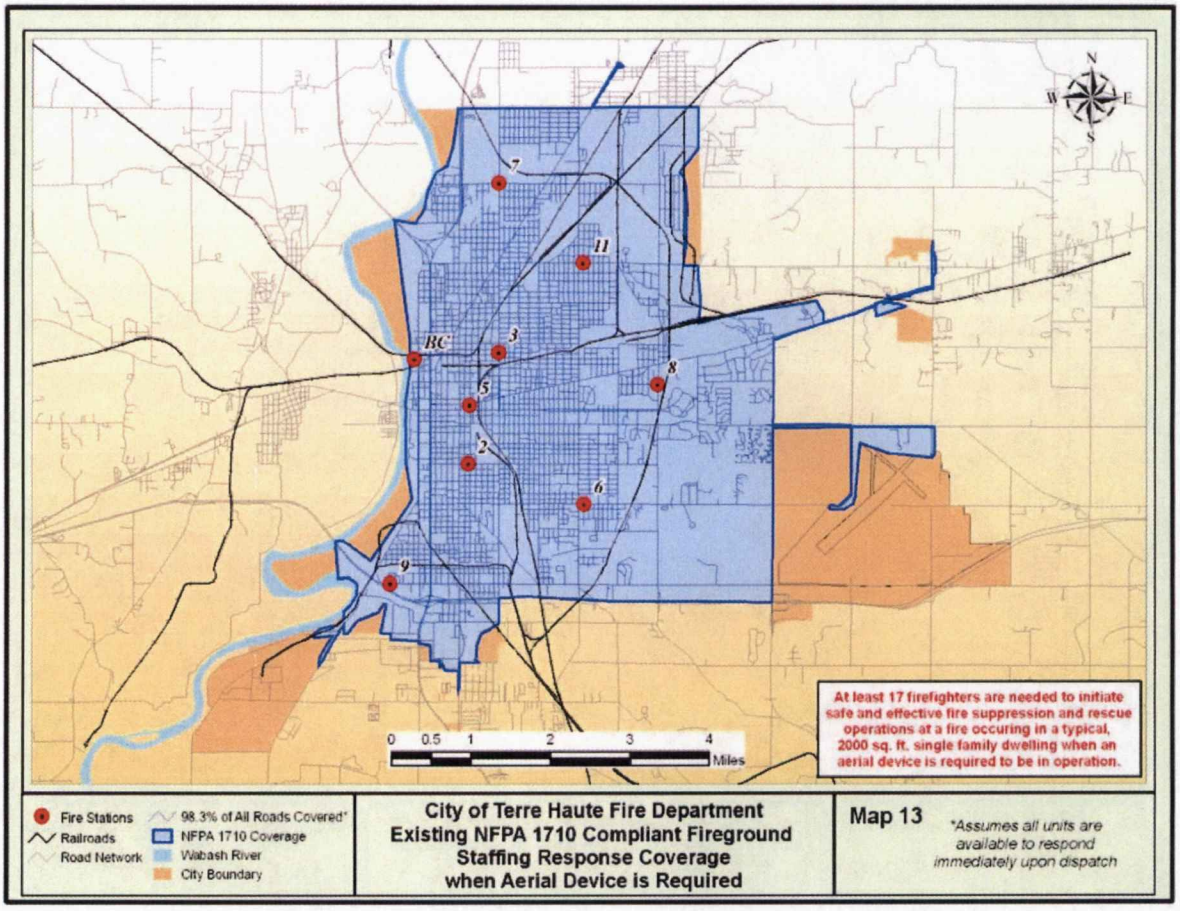
Map 12 examines the ability of the City of Terre Haute Fire Department to respond to incidents with at least fifteen personnel within an 8-minute time frame. Utilizing all apparatus and personnel in all stations, it is predicted that **98.3% of all roads currently receive a sufficient number of fire suppression personnel within 8 minutes of receiving an alarm to comply with NFPA Standard 1710**, *assuming all units are fully staffed at existing staffing levels and available to respond immediately upon dispatch.*

MAP 12A



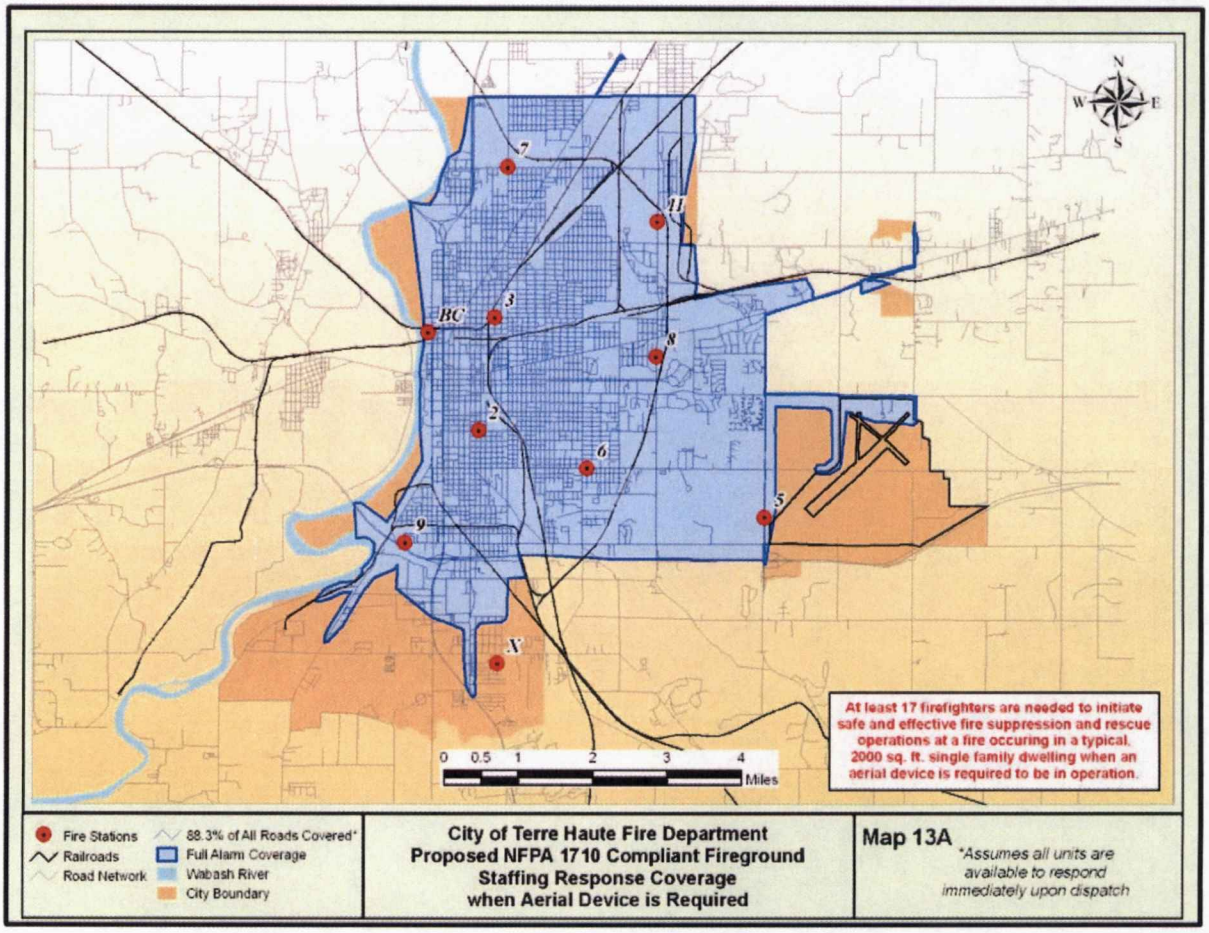
Map 12A examines the ability of the City of Terre Haute Fire Department to respond to incidents in the proposed city boundary from future station locations with at least fifteen personnel within an 8-minute time frame. Utilizing all apparatus and personnel in all stations, it is predicted that **88.3% of all roads currently receive a sufficient number of fire suppression personnel within 8 minutes of receiving an alarm to comply with NFPA Standard 1710,** *assuming all units are fully staffed at existing staffing levels and available to respond immediately upon dispatch.*

MAP 13



Map 13 examines the ability of the City of Terre Haute Fire Department to respond to incidents with at least seventeen personnel within an 8-minute time frame with the addition of an aerial apparatus. Utilizing all apparatus and personnel in all stations, it is predicted that **98.3% of all roads currently receive a sufficient number of fire suppression personnel within 8 minutes of receiving an alarm to comply with NFPA Standard 1710**, *assuming all units are fully staffed at existing staffing levels and available to respond immediately upon dispatch.*

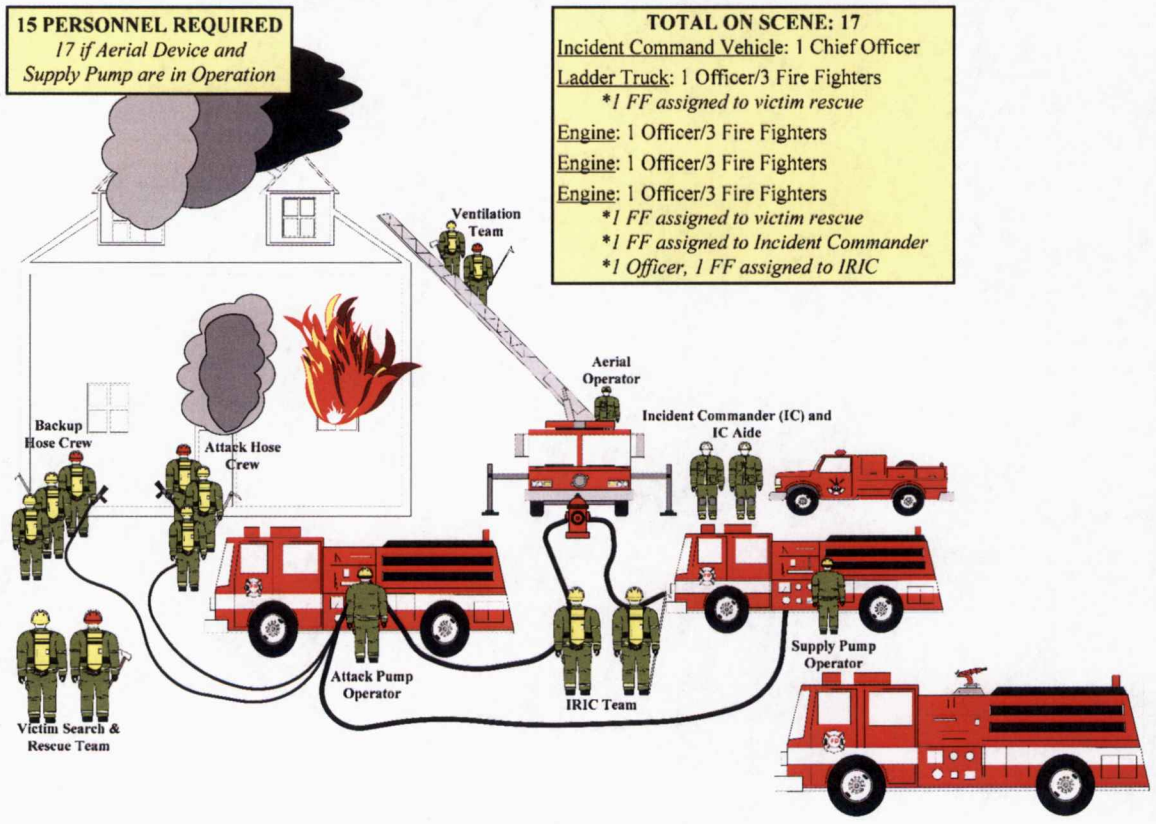
MAP 13A



Map 13A examines the ability of the City of Terre Haute Fire Department to respond to incidents with at least seventeen personnel within an 8-minute time frame from future station locations with the addition of an aerial device. Utilizing all apparatus and personnel in all stations, it is predicted that **88.3% of all roads currently would receive a sufficient number of fire suppression personnel within 8 minutes of receiving an alarm to comply with NFPA Standard 1710**, *assuming all units are fully staffed at existing staffing levels and available to respond immediately upon dispatch.*

Initial Full Alarm Assignment Capability, as outlined in NFPA Standard 1710, recommends that the "fire department shall have the capability to deploy an initial full alarm assignment within an 8-minute response time to 90 percent of the incidents… [and that the] initial full alarm shall provide for the following: a minimum of one individual dedicated to establishing incident command outside of the hazard area, assisted by an aide; establishment of an uninterrupted water supply, which shall be maintained by an operator who shall ensure uninterrupted water flow application; establishment of attack and backup lines, operated by a minimum of two personnel each to effectively and safely maintain the line; provision of one support person for each attack and backup line to provide hydrant hookup, assist in line lays, utility control, and forcible entry; a minimum of one search and rescue team, consisting of two personnel; a minimum of one ventilation team, consisting of two personnel; and establishment of an Initial Rapid Intervention Crew (IRIC), consisting of a minimum of two properly equipped and trained personnel."[78] This breakdown of the expected capabilities of a full alarm assignment, in compliance with NFPA Standard 1710, requires a minimum contingent of fifteen fire suppression personnel, including the Incident Commander (IC) and the IC's aide[79], to arrive at the scene of a structure fire within 8 minutes of receiving the alarm.[80]

FIGURE 18:
NFPA 1710 INITIAL FULL ALARM ASSIGNMENT DEPLOYED WITHIN 8 MINUTES



[78] NFPA 1710, § 5.2.3.2.1 and § 5.2.3.2.2, (a) – (h)
[79] NFPA 1710, § 5.2.1.2.5
[80] It should be noted that a minimum on-scene contingent of seventeen fire suppression personnel are required by NFPA Standard 1710 when a second pump and an aerial device are in operation at the incident scene.

Assessing Fire Department Performance Based Upon NFPA 1710 Response Criteria:

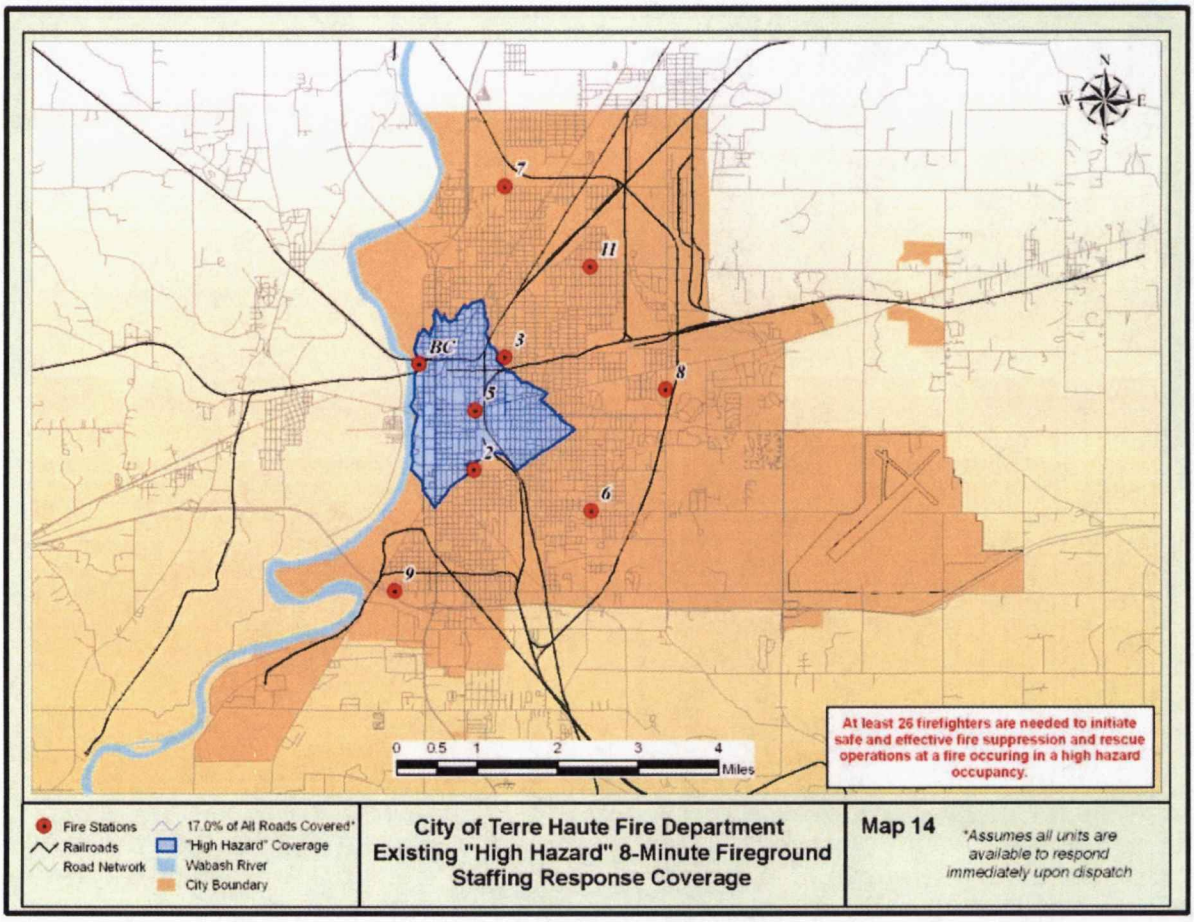
NFPA 1710 states that **"the fire department's fire suppression resources shall be deployed to provide for the arrival of an engine company within a 4-minute response time and/or the Initial Full Alarm assignment within an 8-minute response time to 90% of the incidents."**[81] Under the existing staffing and deployment configuration, and as indicated in Map 6, **the City of Terre Haute Fire Department is capable of deploying engine companies on 87.5% of all roads in the response jurisdiction within 4 minutes**. Assessing fire department compliance with NFPA 1710 based upon the Standard's 4-minute engine company response criteria, it is evident that the Fire Department does not currently meet NFPA 1710 compliance. **The Fire Department is capable of deploying an Initial Full Alarm on 98.3% of all roads in the response jurisdiction within 8 minutes.** The Fire Department is currently in compliance with NFPA 1710 when assessing fire department compliance based upon the Standard's 8-minute Initial Alarm response criteria. **Under the proposed conditions the Fire Department will be capable of deploying engine companies on 94.5% of all roads in the future response jurisdiction.** The Fire Department will be in compliance with NFPA 1710 when assessing fire department compliance based up the Standard's 4-minute engine response criteria. **The Fire Department's NFPA 1710 Full Alarm response capabilities fall to 88.3% of all roads covered under the proposed conditions and future response jurisdiction.** Hence, the Fire Department will fail to meet compliance with NFPA 1710 when assessing the Standard's 8-minute Initial Alarm response criteria.

TABLE 8:
"ASSESSMENT OF FIRE DEPARTMENT COMPLIANCE WITH NFPA 1710"

SCENARIO	RESPONSE CAPABILITIES
NFPA 1710 Initial Full Alarm 8-minute Response Requirement	The arrival of an engine company within 4-minutes *and/or* the Initial Full Alarm assignment within an 8-minute response time to 90% of the incidents
Existing Stations Engine Company 4-minute Response Capabilities	**87.5% of all roads covered within 4 minutes.**
Existing Stations NFPA 1710 Fireground Staffing 8-minute Response Capabilities *(15+ personnel)*	**98.3% of all roads covered within 8 minutes.**
Proposed Stations Engine Company 4-minute Response Capabilities	**94.5% of all roads covered within 4 minutes.**
Proposed Stations NFPA 1710 Fireground Staffing 8-minute Response Capabilities (15+personnel)	**88.3% of all roads covered within 8 minutes.**

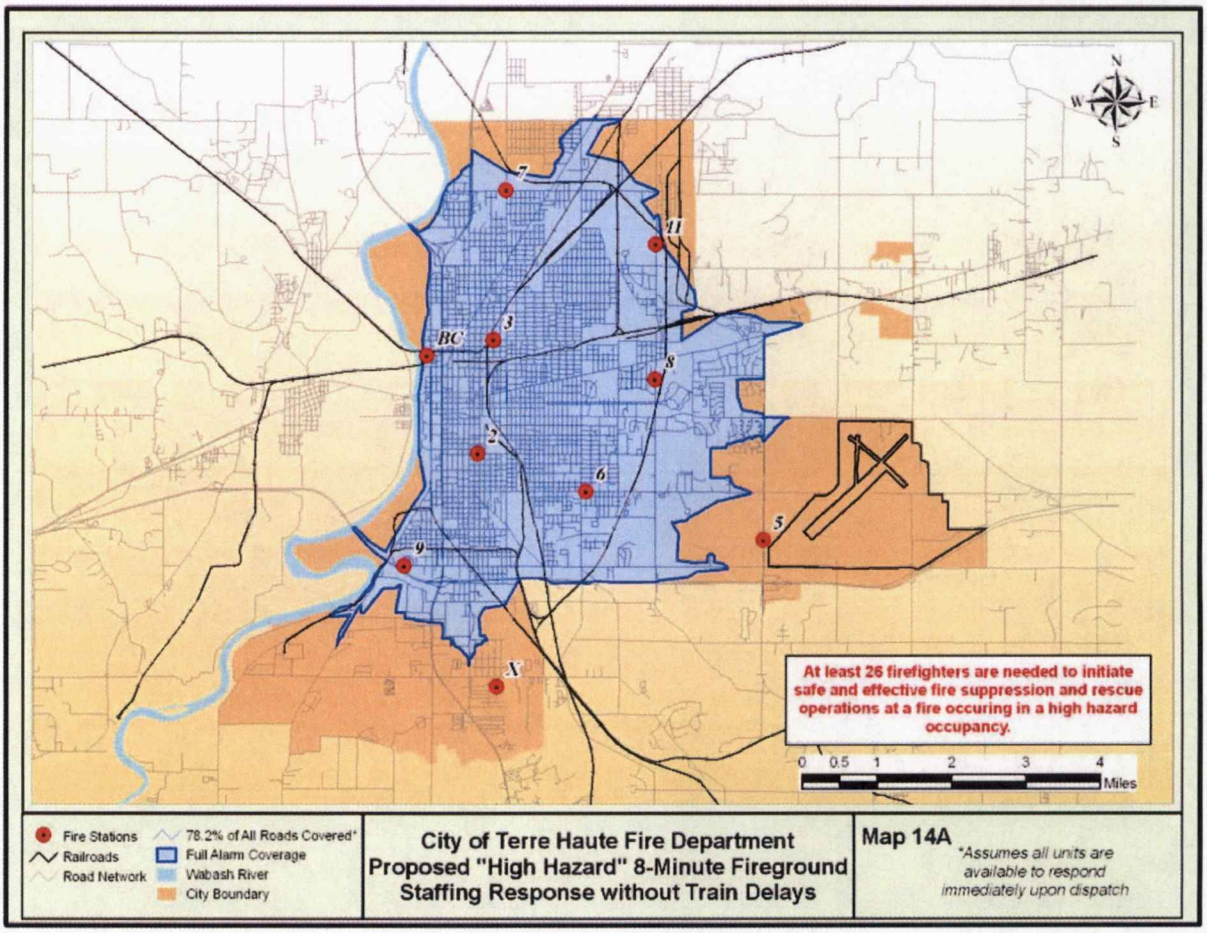
[81] NFPA 1710, Section 5.2.3.1.1

MAP 14



Map 14 indicates those areas where the City of Terre Haute Fire Department is currently capable of assembling the units assigned to respond to a fire in a high rise or high hazard structure within 8 minutes. Under existing conditions, it is predicted that **the Fire Department is capable of responding to 17% of all roads within 8 minutes,** *assuming all units are staffed and available to respond immediately upon dispatch.*

MAP 14A



Map 14A indicates those areas where the City of Terre Haute Fire Department would be capable of assembling the units assigned to respond to a fire in a high rise or high hazard structure with at least 26 personnel within 8 minutes. Under proposed conditions that staff 55 firefighters per shift, it is predicted that **the Fire Department is capable of responding to 78.2% of all roads within 8 minutes,** *assuming all units are staffed and available to respond immediately upon dispatch.*

Fire Growth and the Importance of a Rapid Response To a Fire in a High-Rise Structure:

A comprehensive study of adequate staffing and resources conducted by the Dallas Fire Department, one of the primary differences between a high-rise fire and those in other structures is the scale of the operation.[82] Whereas a residential structure could be two stories and thirty feet in height and occupy 2,000 square feet, a high-rise building can be multiple stories, hundreds of feet high, and cover several thousand square feet. Significantly affecting fire potential is the fire load, including office furniture, files and papers. Many, if not most, floors can be expected to have a significant load of computer and electronic equipment, adding to the fire load.

Several additional factors complicate fire suppression and rescue operations at the scene of a high-rise fire. Firefighters can be faced with an increased danger if the windows at the fire floor have vented, resulting in a "blow-torch" effect, and multiple victims of fire can be expected to become trapped or unaccounted for. Effective fire suppression and rescue operations under such conditions hinge upon the availability and reliability of building elevators. The Dallas Study illuminates the major issues associated with elevators in a high-rise fire as follows:

> There are a limited number of elevator cars and the cars have limited capacity. Therefore, multiple trips must be made. To control elevator car movement, a firefighter must be assigned to operate the car manually. Elevator systems were never designed to operate in fire environments. The products of combustion, heat, and water can disrupt the elevator programming and cause the cars to move erratically. Inevitably, delays occur while waiting for, traveling in, loading, and unloading cars.[83]

Due to elevator unreliability, firefighters are often required to use the stairs. As previously mentioned, it is difficult to deliver fire fighters and equipment to the upper floors due to falling glass and debris, a lack of water, difficulty in ventilating the structure, and heavy smoke in the stairwells in which fire fighters are attempting to ascend while panicked occupants are attempting to descend.

A high-rise fire also presents logistical difficulties similar to those experienced in commercial structures. For example, when a firefighter depletes an air cylinder at the scene of a residential structure fire, it can be easily replaced at the incident scene, requiring little more than a return to the incident staging area where the cylinder can be easily and rapidly replaced. Conversely, in a high-rise structure it is impractical to return to the street level from an upper floor of the building to obtain tools and equipment, such as air cylinders for self-contained breathing apparatus (SCBA) and fire hose. Provision of sufficient personnel must be made to deliver these and other items to the locations in the building where they are needed.

A final distinction between a residential fire and that in a high-rise building is the time frame of the operation. As compared to a residential structure, "the relative inaccessibility of the high-rise building, the elevated location of the fire, the dependency on elevators, the larger size and number of potential fire areas, the greater exposure of occupants, the larger quantities of water required for control of the fire, and the more hostile fire environment all contribute to a more

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[82] McManis Associates and John T. O'Hagan & Associates, Dallas Fire Department Staffing Level Study, (June 1984), V-1.

[83] McManis Associates et al., V-1.

prolonged operation which cannot be attacked with the same speed."[84] Factors such as these require a greater number of firefighters to initiate safe and effective fire suppression and rescue operations.

Fire Growth and the Importance of a Rapid Response To a Fire in a Commercial (High Hazard) Structure:

Fires in industrial and commercial areas pose unique and significant risks to fire fighters operating on the fire ground, and are some of the most difficult fires to control. Modern warehouses and storage occupancies are especially subject to rapidly developing fires of great intensity because complex configurations of storage are conducive to rapid fire spread, presenting numerous obstacles to fire suppression efforts. Additionally, windows with iron shutters- or buildings with no windows at all- hamper a fire department's efforts to gain access to the building. If passageways are impassable, the fire can be reached only by streams operating through windows, and the opening of shutters may be a time-consuming operation.[85, 86]

The logistics of a commercial fire-fighting operation must not be underestimated. Even under ideal conditions, successfully fighting a fire requires large numbers of personnel and supplies. Physical demands on fire fighters due the building's sheer size requires regular rotation of personnel out of the fire area for rest and rehabilitation.[87]

Other required supplies include air cylinders. Most self-contained breathing apparatus (SCBA) have only a 30-minute rating and probably last only half that long during strenuous fire-fighting operations. Fire fighters who must walk 300 feet into the building to the actual fire area may only be able to spend 5 to 7 minutes fighting the fire before they must replenish their air supply. Hence, pre-incident plans should contain provisions for assembling a large pool of trained personnel to assist in fire-fighting operations.[88]

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[84] McManis Associates et al., V-2.
[85] Fire Chief's Handbook, 4th ed., "Advanced Fire Fighting," (Saddle Brook, N.J., 1987) 498.
[86] National Fire Protection Association, Warehouse Operations, Fire Protection Handbook, 18th ed. (Quincy, MA: NFPA, 1997) § 9-110
[87] National Fire Protection Association, Warehouse Operations, Fire Protection Handbook, 18th ed. (Quincy, MA: NFPA, 1997) § 9-114
[88] Ibid.

CONCLUSIONS

CONCLUSIONS

This analysis reveals the extent of 4- and 8-minute coverage provided within the City of Terre Haute by the City of Terre Haute's Fire Department under existing and proposed staffing and deployment arrangements. Based on the output of the ArcView apparatus response model, the following conclusions can be reached *(note that the statements below pertain to a single incident only, and do not assume like performance in simultaneously occurring incidents)*:

BATTALION CHIEF

Existing Conditions

The City of Terre Haute Fire Department Battalion Chief is currently able to provide service on **25.9% of all roads within 4 minutes** and **83.4% of all roads within 8 minutes,** *assuming the unit is available to respond immediately upon dispatch.*

Proposed Conditions

The City of Terre Haute Fire Department Battalion Chief would be able to provide service on **21.1% of all roads within 4 minutes** and **73.0% of all roads within 8 minutes,** *assuming the unit is available to respond immediately upon dispatch.*

BASIC LIFE SUPPORT (BLS) ASSIGNMENT

Existing Conditions

The City of Terre Haute Fire Department medic companies are able to provide essential emergency medical services, in addition to fire rescue and disaster incident support to **68.5% of all roads within 4 minutes** and **99.4% of all roads within 8 minutes,** *assuming all units are available to respond immediately upon dispatch.*

Proposed Conditions

The City of Terre Haute Fire Department medic companies will be able to provide essential emergency medical services, in addition to fire rescue and disaster incident support to **58.2% of all roads within 4 minutes** and **87.9% of all roads within 8 minutes,** *assuming all units are available to respond immediately upon dispatch.*

ENGINE COMPANIES

Existing Conditions

The City of Terre Haute Fire Department engine companies are currently able to provide fire suppression, disaster incident mitigation, and essential emergency medical services on **87.5% of all roads within 4 minutes** and **98.7% of all roads within 8 minutes,** *assuming all units are available to respond immediately upon dispatch.*

Proposed Conditions

The City of Terre Haute Fire Department medic companies will be able to provide essential emergency medical services, in addition to fire rescue and disaster incident support to **94.5% of all roads within 4 minutes** and **99.8% of all roads within 8 minutes,** *assuming all units are available to respond immediately upon dispatch.*

LADDER COMPANIES

Existing Conditions

The City of Terre Haute Fire Department's Ladder Companies are currently able to provide ladder duties on **98.0% of all roads within 8 minutes**, *assuming all units are available to respond immediately upon dispatch.*

Proposed Conditions

With the addition of potential railroad delays, the City of Terre Haute Fire Department Ladder companies will be able to provide service to **88.3% of all roads within 8 minutes,** *assuming all units are available to respond immediately upon dispatch.*

"2 IN/2 OUT" OPERATIONS

Existing Conditions

The City of Terre Haute Fire Department fire suppression companies are currently able to initiate *safe* and *effective* fire suppression and rescue operations in accordance with the "2 In/2 Out" regulation on **98.8% of all roads within 8 minutes,** *assuming all units are staffed and available to respond immediately upon dispatch.*

Proposed Conditions

The City of Terre Haute Fire Department fire suppression companies will be able to initiate *safe* and *effective* fire suppression and rescue operations in accordance with the "2 In/2 Out" regulation on **98.8% of all roads within 8 minutes,** *assuming all units are staffed and available to respond immediately upon dispatch.*

ADVANCED LIFE SUPPORT (ALS) ASSIGNMENT

Existing Conditions

The City of Terre Haute Fire Department ALS assignment companies are able to provide essential emergency medical services, in addition to fire rescue and disaster incident support to **98.4% of all roads within 8 minutes,** *assuming all units are available to respond immediately upon dispatch.*

Proposed Conditions

The City of Terre Haute Fire Department ALS assignment companies will be able to provide essential emergency medical services, in addition to fire rescue and disaster incident support to **88.1% of all roads within 8 minutes,** *assuming all units are available to respond immediately upon dispatch.*

FULL ALARM ASSIGNMENT

Existing Conditions

The City of Terre Haute Fire Department Full Alarm assignment companies are able to provide essential emergency medical services, in addition to fire rescue and disaster incident support to **78.8% of all roads within 8 minutes,** *assuming all units are available to respond immediately upon dispatch.*

Proposed Conditions

The City of Terre Haute Fire Department Full Alarm assignment companies will be able to provide essential emergency medical services, in addition to fire rescue and disaster incident support to **25.1% of all roads within 8 minutes,** *assuming all units are available to respond immediately upon dispatch.* The proposed condition and road coverage assumes the Support Unit moves to the new Station 5 location on the east side of Terre Haute.

NFPA 1710 Initial Full Alarm Personnel Count

Existing Conditions

The City of Terre Haute Fire Department fire suppression and command units are currently able to assemble an "Initial Full Alarm" response with *fifteen* firefighters, in compliance with NFPA 1710 performance objectives, on **98.3% of all roads within 8 minutes, and 98.3%** with *seventeen* firefighters. *assuming all units are available to respond immediately upon dispatch.*

Proposed Conditions

The City of Terre Haute Fire Department fire suppression and command units will be able to assemble an "Initial Full Alarm" response with *fifteen* firefighters, in compliance with NFPA 1710 performance objectives, on **88.3% of all roads within 8 minutes, and 88.3%** with *seventeen* firefighters. *assuming all units are available to respond immediately upon dispatch.*

NFPA "High Hazard Alarm"

Existing Conditions

The City of Terre Haute Fire Department fire suppression and command units are currently able to assemble a "High Hazard Alarm" response, *consisting of at least 26 fire department personnel*, on **17.0% of all roads within 8 minutes,** *assuming all units are available to respond immediately upon dispatch.*

Proposed Conditions

The City of Terre Haute Fire Department fire suppression and command units will be able to assemble a "High Hazard Alarm" response, *consisting of at least 26 fire department personnel*, on **78.2% of all roads within 8 minutes,** *assuming all units are available to respond immediately upon dispatch.*

FINAL SUMMARY

FINAL SUMMARY

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

While it is impossible to predict where most of a jurisdiction's fire and medical emergencies will occur, the City of Terre Haute Fire Department should examine where emergencies have typically occurred in the past and make efforts to ensure these areas continue to enjoy the same level of coverage, while adjusting resources and deployment in an effort to achieve complete compliance with NFPA Standard 1710. Areas with accelerated development and growth will require additional coverage in the future. Any projected increase in emergency response demands should also be considered before changes are implemented, focusing on associated hazard types and planned response assignments.

In addition, a fire department should be designed to adequately respond to a number of emergencies occurring at once in a fashion that aims to minimize the loss of life and the loss of property that the fire department is charged with protecting. Any proposed changes in staffing, deployment and station location should be made only after considering the historical location of calls, response times to specific target hazards, compliance with departmental Standard Operating Procedures, existing national standards, including NFPA 1500 and NFPA Standard 1710, and the citizens' expectation of receiving an adequate number of qualified personnel on appropriate apparatus within acceptable time frames.

GIS MAP DETAIL