Broken Arrow Fire Department (Oklahoma)
Deployment Analysis Study

Prepared by:

The Ludwig Group
9525 E. Vista Drive, Suite 200
Hillsboro, MO 63050
(636) 789-5660

August 2015

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While there are too many to mention individually, we wish to especially thank the following individuals for helping to launch, coordinate, and advise the project.

Jeremy Moore	Fire Chief
James Annas	Assistant Fire Chief

The Ludwig Group Staff and Consultants

Gary Ludwig, Project Manager
JoEllen Walker, GIS Specialist

Broken Arrow Fire Department

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Executive Summary

This report examines the current deployment of fire department resources in the City of Brown Arrow, Oklahoma. In addition, in consultation with fire department staff and software analysis, we were able to generate options for the redeployment and addition of resources to better serve the city with response performance objectives.

While Broken Arrow Fire Department is currently providing good service, fire stations and response resources are not well positioned to serve many newly developing and future development areas. As the maps in this report will indicate, there is very little overlap of existing fire stations.

The desires of this analysis will accomplish several important objectives:

- A more efficient delivery system will be provided to the community.
- The department is better deployed to serve future development and growth within the city.
- Better compliance with the response performance recommendations of National Fire Protection Association Standard 1710 for career fire departments.

A review of the GIS information and formulation of existing and hypothetical fire stations in Broken Arrow has indicated some areas are underserved when compared against call volume and location. As such, there is a need for additional fire stations and equipment to achieve better coverage.

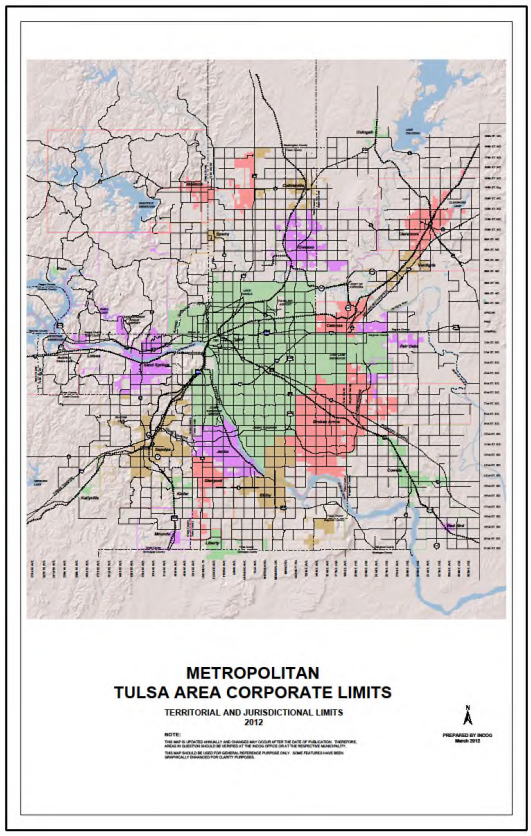
Implementation of any redeployment or addition of resources is dependent upon the decision-makers in the City of Broken Arrow. Adjustments may be needed to accommodate changes in expected growth patterns or other factors not currently known. Continued departmental review of response performance, demographic changes, and new development, should be accomplished to ensure the long-term viability of this study.

The recommendation is to relocate two fire stations and build a seventh fire station.

The City of Broken Arrow, Oklahoma

The City of Broken Arrow, Oklahoma is a part of the Tulsa metropolitan area and resides mostly in Tulsa County, with a smaller section located in Wagoner County. Broken Arrow borders the City of Tulsa to the southeast and is the largest suburb of Tulsa. The land mass of the community is 45.6 square miles.

As a suburb of Tulsa, Broken Arrow continues to see rapid growth over the last ten years. With an increase in population of 32 percent since 2000, the City of Broken Arrow is now the fourth largest city in the State of Oklahoma.



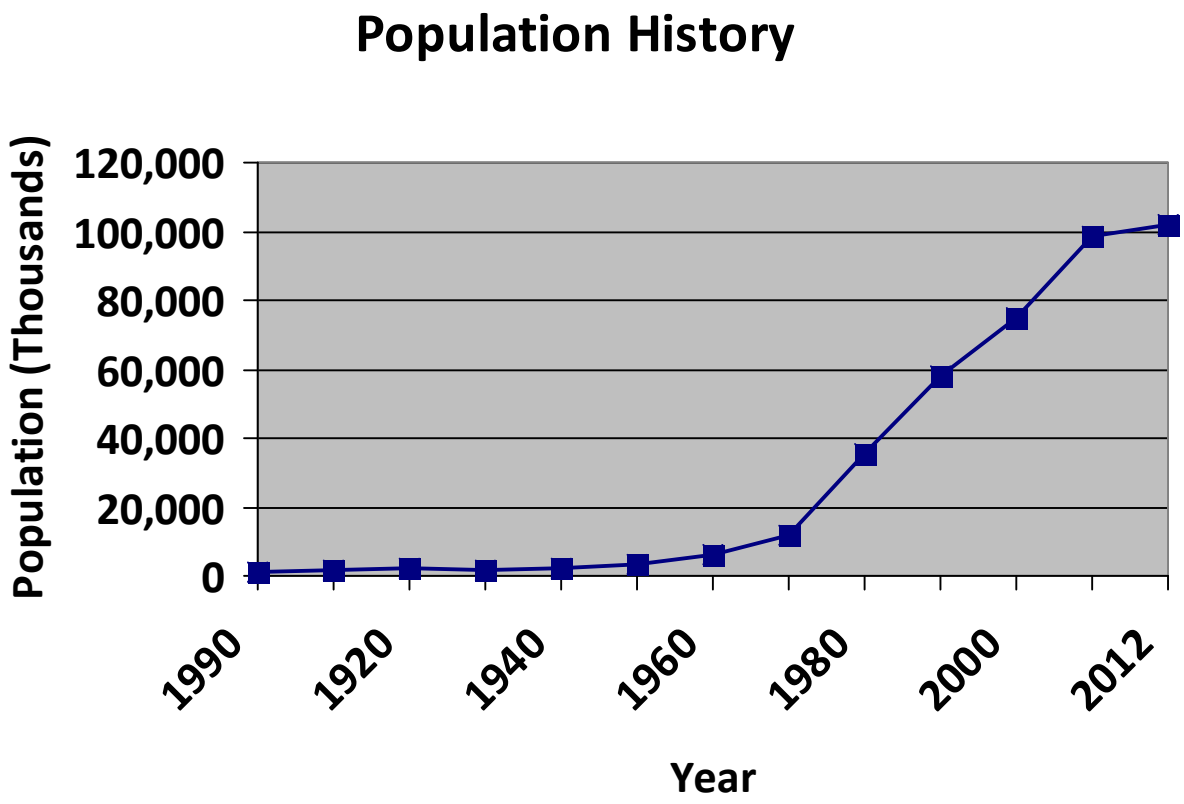
The business community is diverse and consists of a large manufacturing base. As the community as grown, there has been a growth in the commercial/business community over the last several years including a Bass Pro Shop and other traditional name-brand stores and franchises. In 2005, the City adopted a revitalization plan for the downtown's historic district with a variety of planned developments.

Population

According to the 2010 census, there were 98,850 people, 36,141 households, and 27,614 families residing in the city. The population density was 2,200 people per square mile. There were 38,013 housing units at an average density of 602.0 per square mile. The racial makeup of the city was 79.3% White, 4.3% African American, 5.2% Native American, 3.6% Asian and the balance was made up of other races.

The median income for a household in the city was $65,385 and the median income for a family was $74,355. The per capita income for the city was $29,141. About 7.2% of the population was below the poverty line. Figure 1 reflects the growth history of the community with rapid growth escalating between 1970 through the present.

Figure 1



Broken Arrow Fire Department

The Broken Arrow Fire Department was established on June 15, 1906 and has grown steadily as the community and the risk has continued to grow. In 1973, the Broken Arrow Fire Department also began providing ambulance service to the citizens and visitors to the community and now operates six ambulances that are all advanced life support capable.

The Broken Arrow Fire Department consists of more than 142 paid personnel, 11 Fire Corps volunteers, 3 full-time and 1 part-time civilians and 6 fire stations. The response coverage is over 105 square miles and protects over 100,000 residents at an ISO level rating of 2. On any given day, there is a minimum of 33 firefighters, one fire investigator, a battalion chief, 6 fire engines, 6 squads (EMS units), 6 brush trucks, one 105-ft aerial ladder and one rescue unit available for response. The department also houses a Technical Rescue Trailer equipped to deploy for large scale incidents and it is complemented with a specially trained staff.

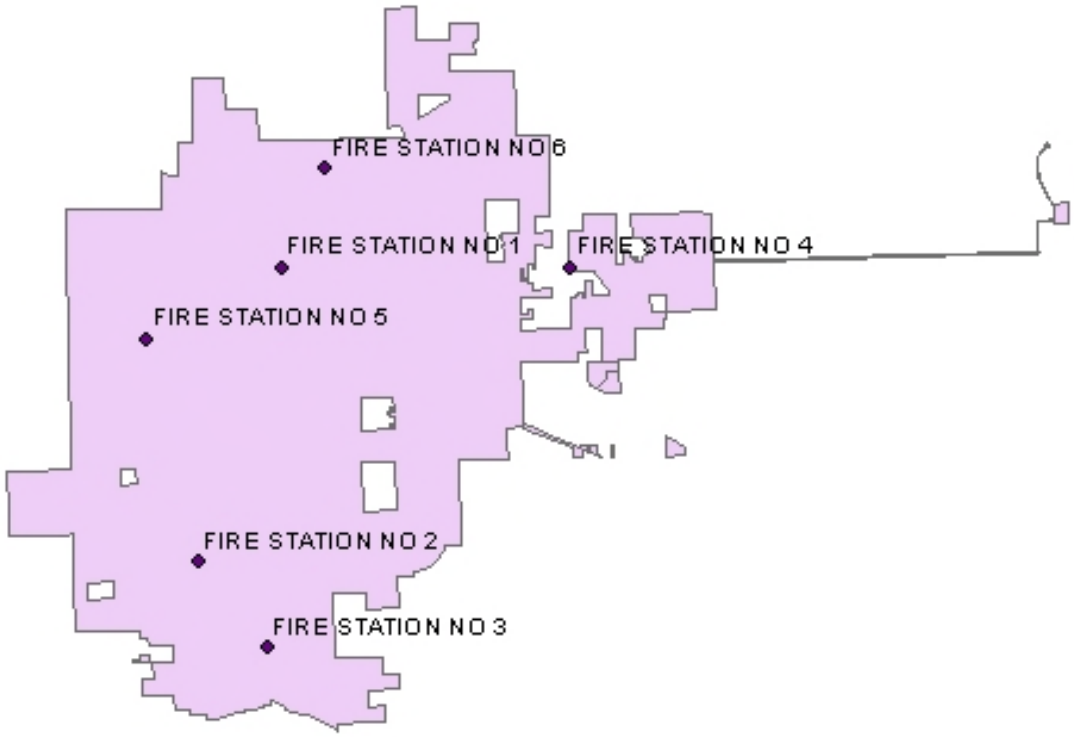
Table 1 reflects fire station locations and equipment housed at each station.

Table 1

Station	Address	Companies
1	120 W. Kenosha	Engine, Ambulance
2	2300 W. Norfolk Drive	Engine (Quint), Ambulance
3	8000 S. Elm Place	Engine, Ambulance
4	6201 E. Kenosha	Engine, Ambulance
5	3301 W. Houston	Engine (Quint), Ambulance
6	3151 N. 9th	Engine, Ladder, Medium Duty Rescue, Ambulance

Map 1 shows the location of all fire stations in the City of Broken Arrow.

Map 1

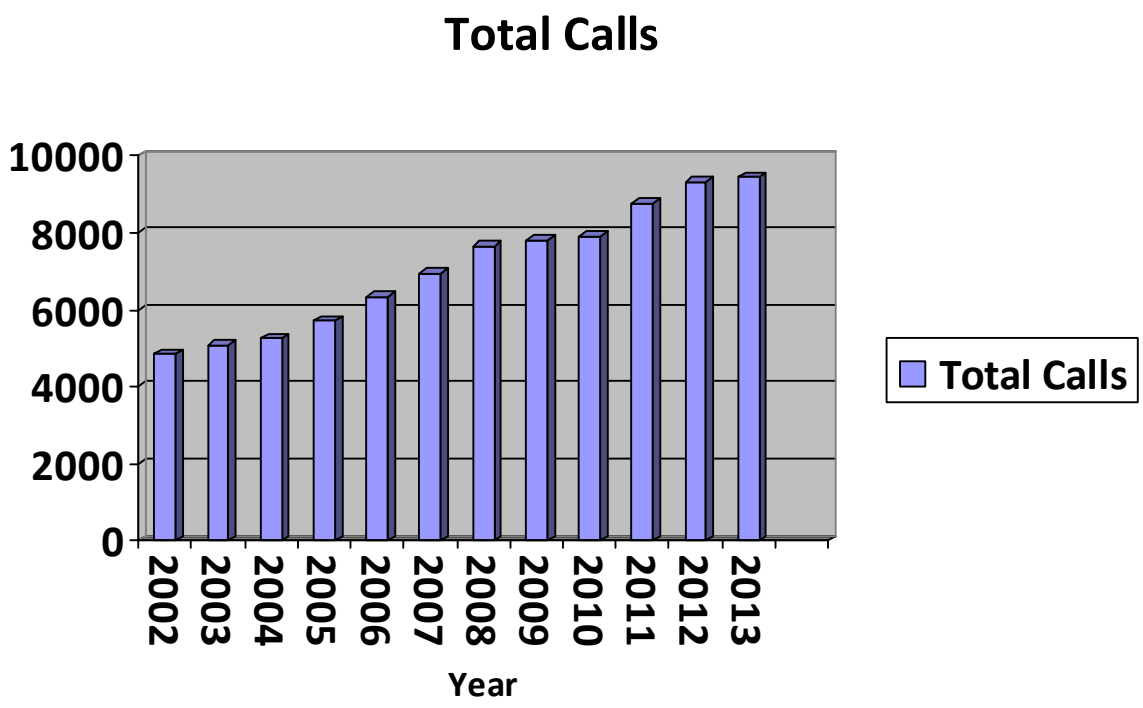


Workload Performance

The Broken Arrow Fire Department is an all hazards fire department responding to a variety of incidents including fires, emergency medicals services, hazards material mitigation, and other types of specialized rescue. The population will always have an impact on the volume of calls and the type of calls a fire department responds to. Although a fire can break out anywhere at any time, EMS calls are somewhat predictable based upon the size of the population, the socio-economic status of the population, and how active that population is. Thus, factors such as the age of the population, population density, and other demographics drive a fire department's workload.

Figure 2 reflects the total number of fire, EMS, exposure, and unknown calls during the period of 2002 through 2013.

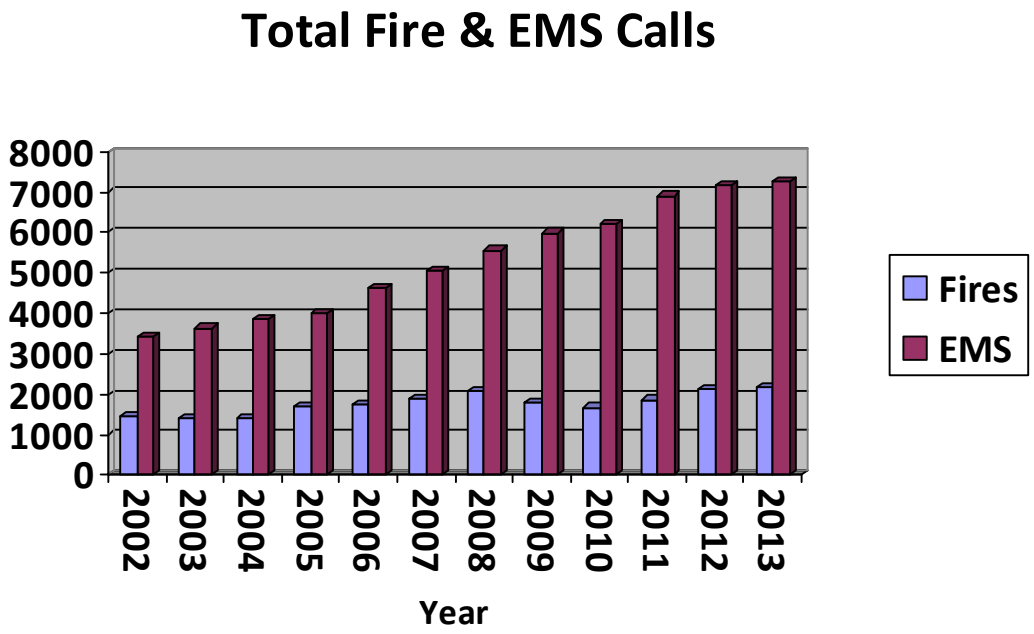
Figure 2



During the 12-year period displayed in Figure 2, there has been a 94.7 percent increase in call volume for all types of calls.

Figure 3 provides a representation of fire calls contrasted against the number of EMS calls for the period of 2002 through 2013.

Figure 3



As displayed in Figure 3, the increase in call volume is mainly attributable to the increase of EMS calls. As the population of the community increases, it is anticipated that the EMS call volume will grow exponentially.

While fire calls have increased 52 percent over the 12-year period, there has been a 112 percent increase in EMS calls over the same period.

Figure 4 reflects the number of fire calls during the period of 2002 through 2013.

Figure 4

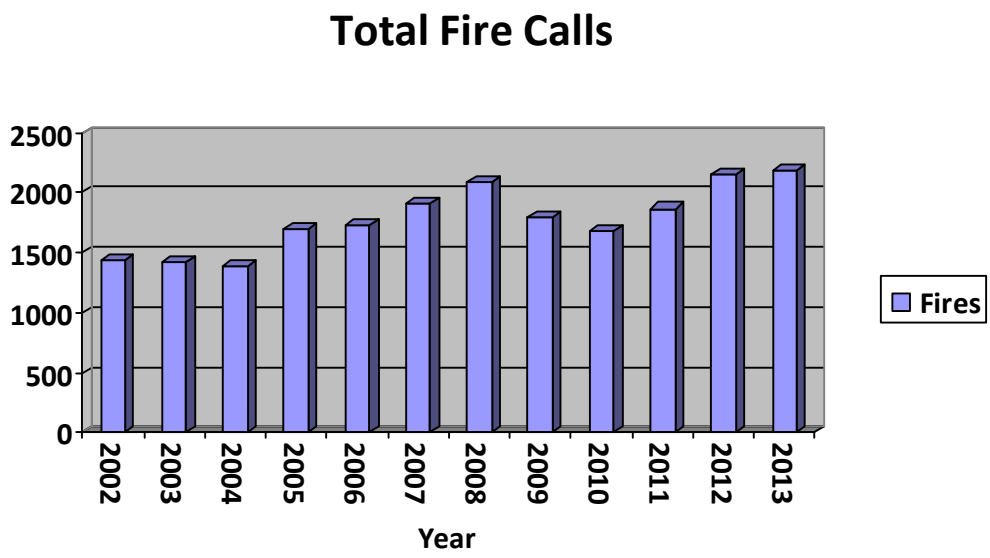


Figure 4 reflects that there has been a 52 percent increase in fire calls during the last 12-year period.

Figure 5 reflects the total number of EMS calls from 2002 through 2013.

Figure 5

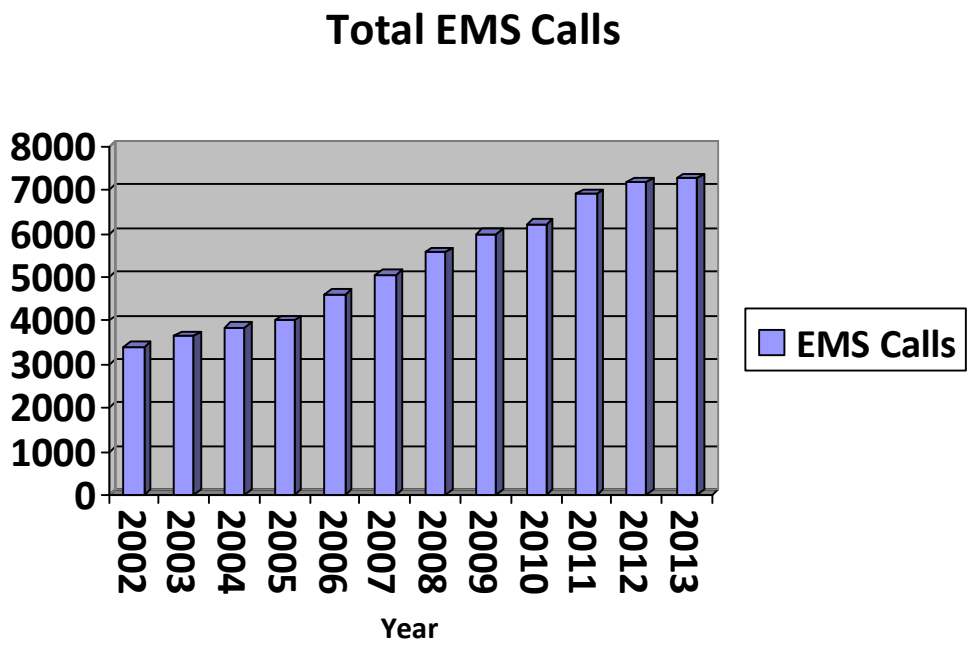
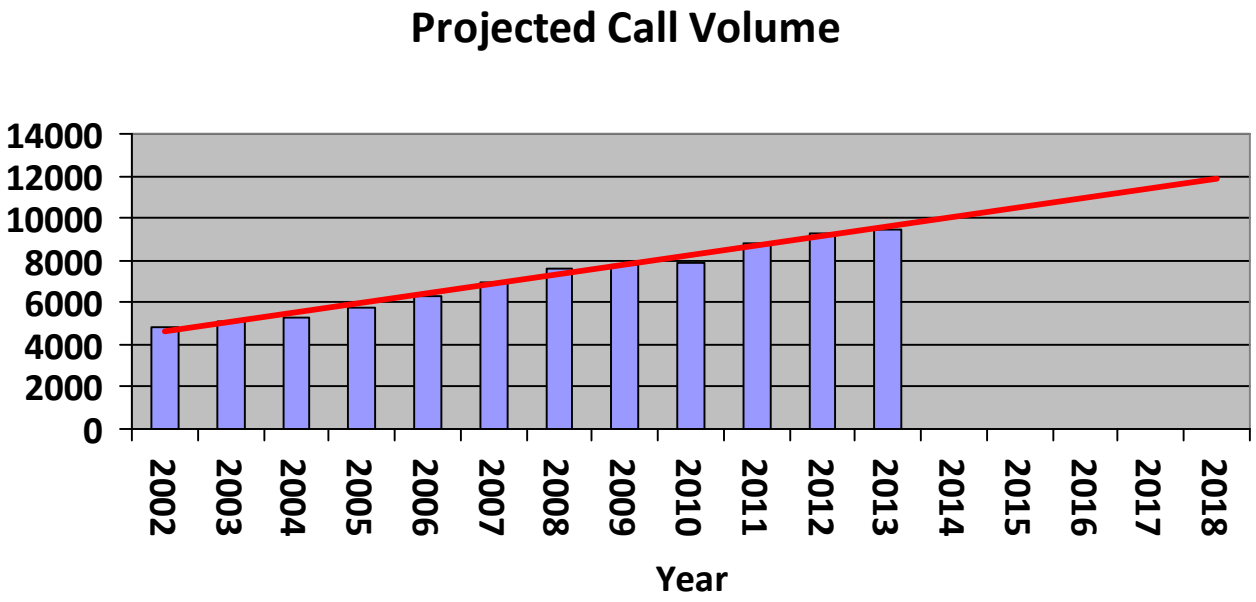


Figure 5 indicates there has been a 112% increase in EMS run volume over the last 12-year period.

Using linear regression modeling and past call volume history, it is possible to project future call volume based upon past historical run data. Figure 6 is computer modeling reflecting the anticipated run volume by the year 2018 if present community and population growth occurs. Anticipated run volume by the year 2018 is anticipated to be approximately 12,000 calls per year. This results in a 22 percent increase over the current run volume. Most of these calls are anticipated to be EMS calls because of population growth.



Response Times

This section of the report will deal with each fire engine and ladder truck response times and discuss well-accepted industry standards.

Response Time Standards

Response time should be defined as the total elapsed time between obtaining a verifiable address in the communications center and the arrival of sufficient trained personnel at the scene of the emergency. In some systems, fire responses are defined as the total time elapsed from the receipt of a verifiable address until the situation has been successfully mitigated.

Response times may be examined individually, as an average, or as fractals.
Individual response time is measured on a single call basis. Some systems review this single measure on every call to ensure that response times stay within set guidelines.

Average response time is the mathematical mean (average) time. All response times are added up and the total response is divided by the total number of calls.

Fractal response time is the reporting method preferred to response time averaging. This method is essentially a frequency distribution of response times. Response times are listed by length of time in order from the shortest to longest time. Then, a cut-off is drawn to include a percentage (i.e. 90 percent) of the response times. The response time below that line is the 90 percent fractal response time (i.e. response time within 6 minutes, 90 percent of the time). All calls that fall within this 90 percent range are then averaged to determine a fractal response time. The median response time is the response at the 50 percent line. This method provides easy data analysis to facilitate further research and system effectiveness reports.

NFPA 1710 Standard

The National Fire Protection Association (NFPA) has issued a response time standard for fire departments. This standard, among other things, identifies a target response time performance objective for career fire departments and a target staffing standard for structure fires. Though not a legal mandate, NFPA 1710 does provide a useful benchmark against which to measure fire department performance.

NFPA 1710 contains time performance standards for structure fire response as well as emergency medical response. Each will be discussed individually.

Structure Fire Response

NFPA 1710 recommends that the first company arrive at the scene of a structure fire within 240 seconds or less, 90% of the time after leaving the fire station. The standard establishes that a response company consists of four personnel. The standard does not require that all four be on the same vehicle, but does expect that the four will operate as a single functioning unit once on scene.

Emergency Medical Response

There are provisions in the NFPA 1710 for emergency medical response. The NFPA recommends that the arrival of a unit with first responder or higher level of capability (basic life support) be with 240 seconds, within four minutes, 90% of the time and the arrival of an advanced life support unit, where this service is provided by the fire department, within 480 seconds or less, 90% of the time

Factors Affecting Response Times

A. Elapsed Time between Inception of a Problem and Detection

The period from start of ignition or detection of a medical problem is a most critical stage in fire and life safety. Very often, major fires have been a result of a long burning time before detection. The same can be said for medical emergencies. The term “Golden Hour” is used to describe the time period from which the medical emergency is detected and definitive care can be delivered. Unfortunately, whether it is a fire or medical emergency, this period is the most difficult for a fire department to control and reduce.

B. Report of Emergency

The major area of concern to be considered in minimizing the time required to report an emergency is to educate the residents of the City of Broken Arrow with the proper procedures to follow after detecting an emergency. 911 have reduced confusion about whom to contact during an emergency.

C. Receipt of Alarm and Dispatch of Apparatus

Presently, the Broken Arrow Fire Department is dispatched by the Broken Arrow Police Department from the Public Safety Complex with dedicated fire dispatchers. The alarm center is capable of receiving an alarm, determining appropriate response assignments, and dispatching equipment. These alarms should be dispatched within 60 seconds. The utilization of computer-aided dispatching systems improves efficiency.

Turnout Time

Turnout time varies depending on the time of the day and location. Career members may be able to clear the station in 30 seconds or less during the day if the location is known. Nighttime responses require a longer man-up time, as can incidents involving unfamiliar locations. The time target is to clear the station in one minute despite the time of day or location in first-due areas.

E. Response Time to the Scene of the Alarm

Influencing the response time to the scene is station location, street patterns, conditions of the streets, traffic congestion, location of fire companies at time of alarm, and activities of the fire companies. The standard for response is dictated by the National Fire Protection Association 1710 standard of the first engine company arriving within 240 seconds, 90 percent of the time and the first full alarm assignment arriving on the scene within 480 seconds, 90 percent of the time.

F. Station Location

When considering that the fire companies are based statically at stations. Station location must become the point of focus in calculating the anticipated lapse time between the fire companies' receipt of alarm and their arrival at the fire or emergency medical scene.

G. Other Factors Affecting Response Time

The fire station location considers street patterns, conditions of streets, and traffic congestion. The remaining two factors that influence the response time to the scene of an emergency are location of fire companies at time of alarm and activities of the companies. These are an administrative consideration and with proper management have little effect upon the response time.

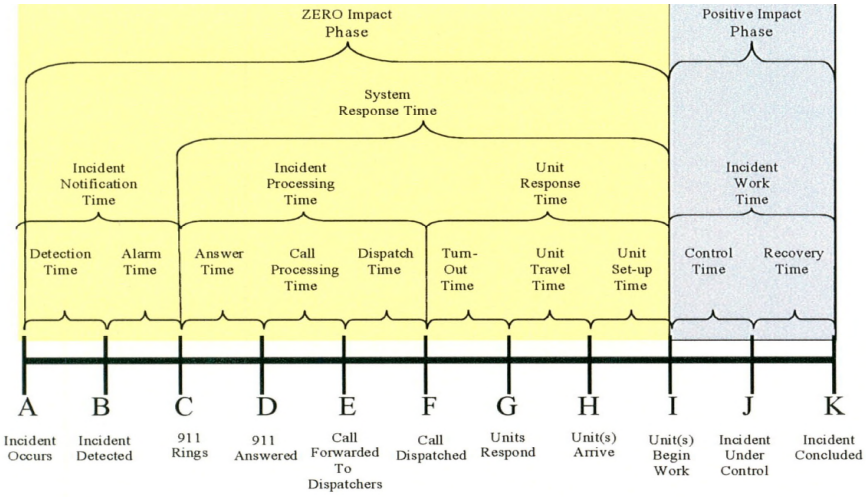
H. Set-up Time At the Scene of the Emergency

Set-up time is that time required for the fire companies to obtain a supply source of water, lay hose lines in place, locate apparatus, select proper equipment and devices, place ladders, gain entry, and prepare for the application of an extinguishing agent or care for a victim.

The time required for fire companies to accomplish the set-up on the emergency scene and apply an extinguishing agent to the fire is directly related to the staffing levels. Also impacting this is the type of apparatus, access to the structure, type of alarm, water supply and hydrant distribution, built-in fire protection, the magnitude of involvement, number of companies required, and training of personnel. Operational procedures and standards are established that will limit set-up time for the first due companies to two minutes or less. All aspects of the response time assessment and operation of the fire department relating to set-up time will be directed toward this objective.

Figure 7 reflects the various segments along a response time continuum and what impact a fire system can have at various points.

Figure 7: Incident Response Timeline

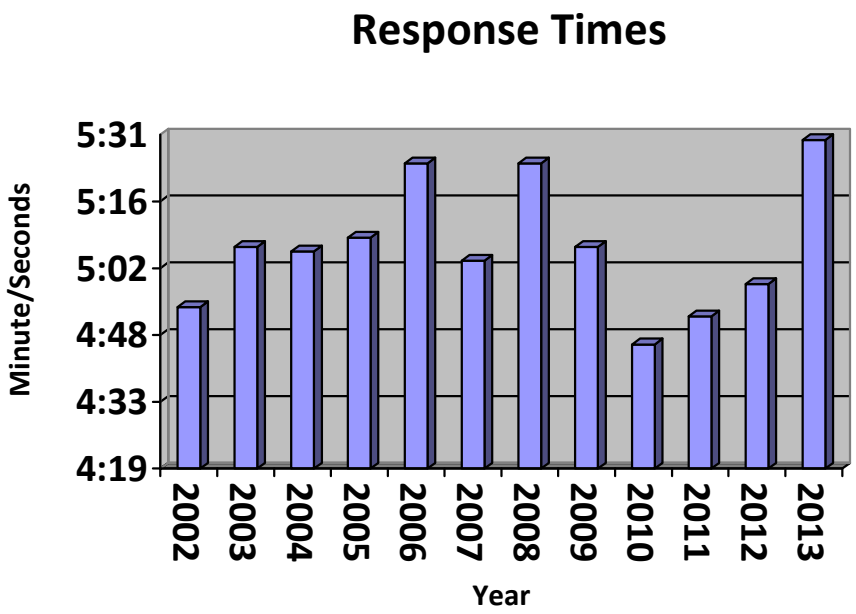


To determine the most appropriate response time, several factors must be considered. These factors include:

1. The level of demand for fire protection throughout Broken Arrow, Oklahoma.
2. Actual running time required to reach the various parts of the city from existing and potential fire station locations.
3. Existing and possible automatic aid agreements with adjoining fire agencies.
4. Acceptable standards of lapse time for arrival of the first engine company.

Figure 8 reflects the response times in the City of Broken Arrow from 2002 – 2012.

Figure 8



Fire Station Placement

The section details call volume and analysis based upon current fire station placement in the City of Broken Arrow. Any recommendations in this report will take into consideration any and all impact that would be placed on other fire stations if one or more fire stations were to be closed or moved.

In 2013, there were 9,444 calls in the City of Broken Arrow. This does not reflect the number of runs. As an example, one call can result in four runs if three fire engines and a chief officer are dispatched on a call.

Of the 9,444 calls, 7,254 were EMS calls. This equates to approximately 73.77 percent of the call volume being EMS related. Typically, these are single company responses unless a first responder is also sent. Of the remaining 2,194 calls (26.23 percent) there is a mixture of single company and multi-company responses.

In order to efficiently create a more even coverage distribution in the City of Broken Arrow, a careful analysis of the existing call volume with respect to engine and truck company static deployment was examined

Facilities

The fire station is the single, most vital unifying force within a fire department. It not only provides housing for the department's apparatus and equipment, but also houses the department's members. The fire station, as the center of a community's fire fighting operations, is a vital symbol of the protection of lives and property.

The number and location of fire stations must be reevaluated continually because the buildings and the population of a community constantly change. The number of fire stations a department will require to accomplish its functions is, like everything else, a balance between the costs of the buildings and their maintenance on the one hand, and

the need for more fire stations on the other. If a fire station is located near the high-response section of a community – such as a heavily populated area of multi-occupancy or wood frame structures – then fire station relocation would be inappropriate. Fire station relocation would be more feasible if a fire station is located in a rural area that is a considerable distance from the normal population flow and from urban housing and development.

The location of a fire station in a community directly affects the total response time needed to combat fire effectively. For example, although a fire station is centrally located in a community, the majority of the fires might occur at substantial distances from the station. Therefore, an evaluation of time from receipt of an alarm to the arrival at a fire plays an important part in deciding the need for relocating a fire station.

Fire Station Planning

Fire station planning is critical to managing local fire protection and emergency medical services. Sound planning of fire station locations can be done in various ways. With the help of historical response data, deployment can be based upon call demand or future expected demand call.

Another method for determining optimal locations for fire stations involves determining response times from various points within the protected area. The more realistic the average response speeds, the better the projected coverage can be defined.

Another factor that determines optimal fire station locations involves communities where the risks are accentuated by high population densities and heavy traffic. Fire departments usually have more fire stations, fire fighters, and fire companies per thousand population than do fire departments in communities without such features.

Estimated response time, for the purposes of this analysis, is defined as the time beginning when apparatus leaves the station enroute to the scene, and ending when apparatus arrives at the scene. Additionally, response times are based upon 240 second and 480 second travel times for EMS calls and full alarm assignments.

However, it should be noted that the total response from when the first 911 call is processed will differ because of factors affecting the time needed to process the call, dispatch the apparatus, and staff the apparatus. Traditionally, these segments should add an additional two minutes to any response time.

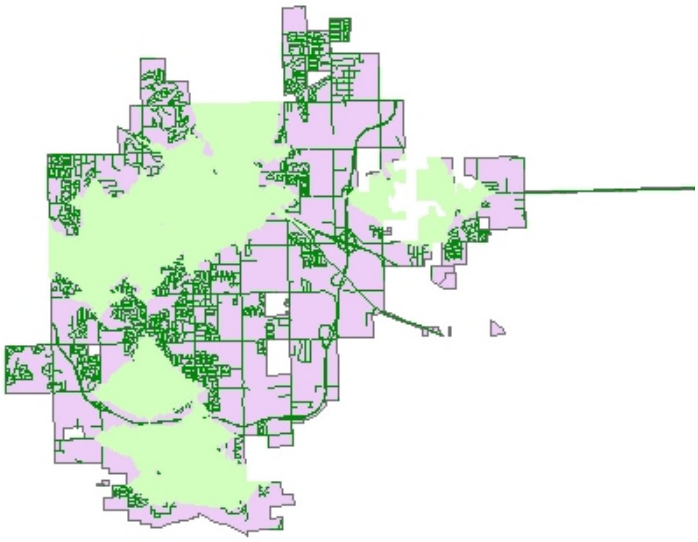
Call Volume Analysis

In the following analysis ESRI's ArcGis 10.2.2 mapping software was used which analyzes a computer model of the street network. Several plots were generated predicting which roads could be covered by the Broken Arrow Fire Department within specific time frames consistent with national accepted benchmarks for response times. The areas reached are based upon posted speed limits and there is no allowance for traffic. All data on the maps to follow is based upon 2013 data.

The deployment analysis in the following sections reflects some four minute response area and some five minute response areas. Later in this document, an analysis is conducted for a response area of five minutes with hypothetical fire station placement. The five minute deployment maps are more reflective of a truer response time since Broken Arrow fire personnel are allowed to exceed 10 miles over the speed limit.

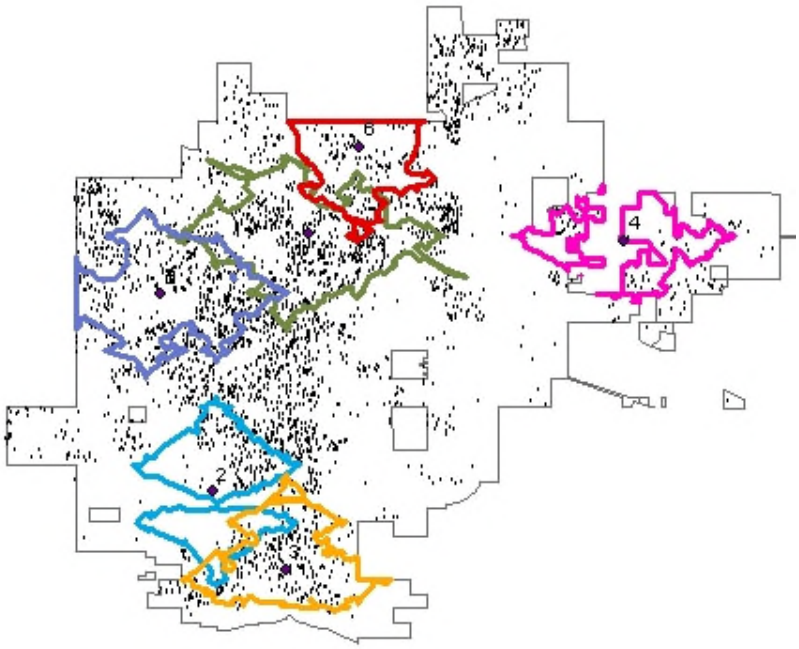
Map 2 reflects all areas of the City of Broken Arrow that can be reached within four minutes of all six fire stations. The more populated areas are reflected by the streets shown in the darker green colors.

Map 2



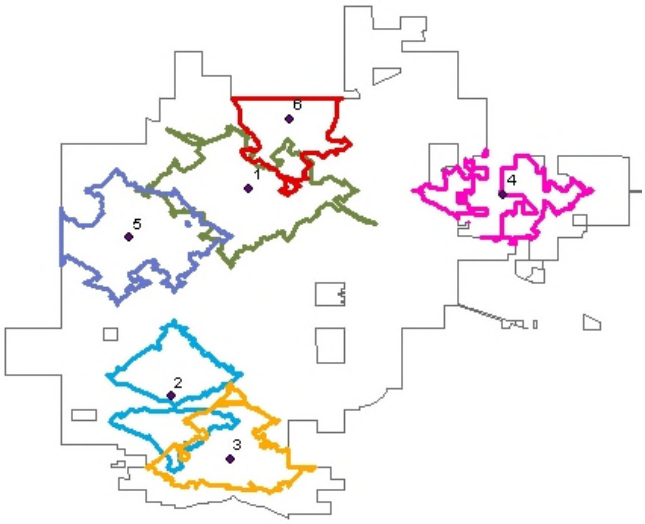
Map 3 reflects all incidents inside the City of Broken Arrow for 2013 and the existing 240 second response territories of all six fire stations.

Map 3

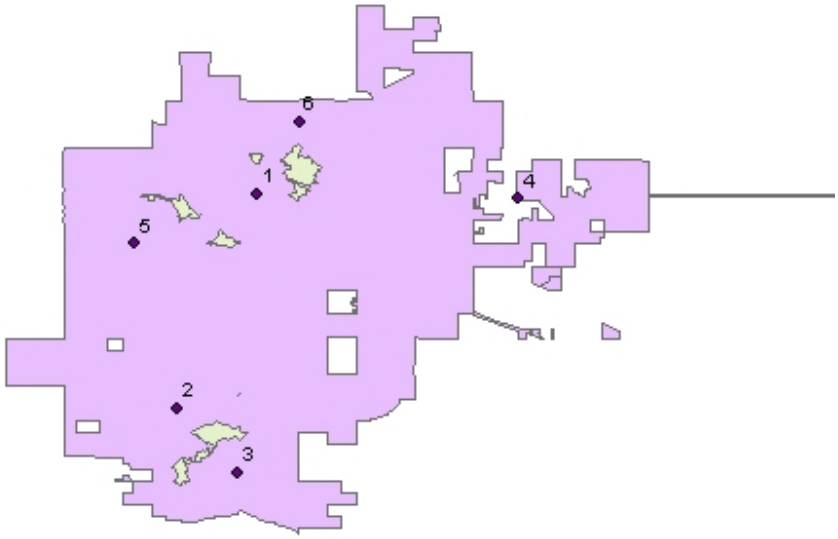


Maps 3 and 4 reflect areas that overlap among all six fire stations. As evidenced by the two maps, there is not much extension into each other's response territories.

Map 3

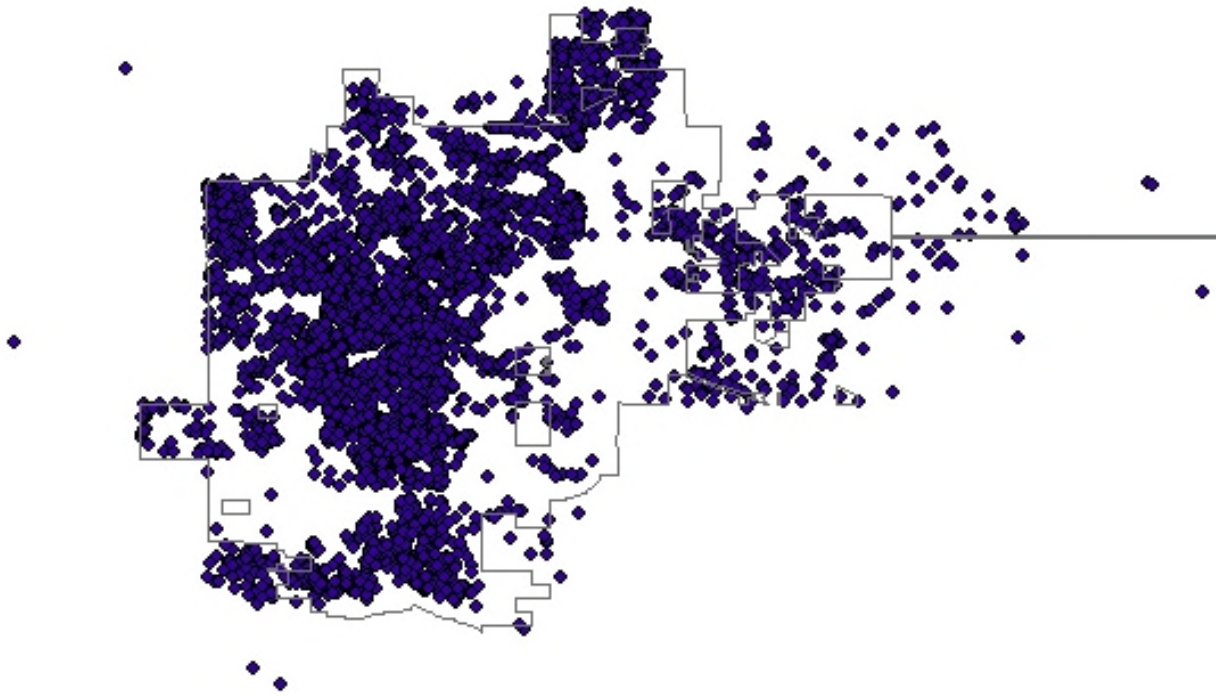


Map 4



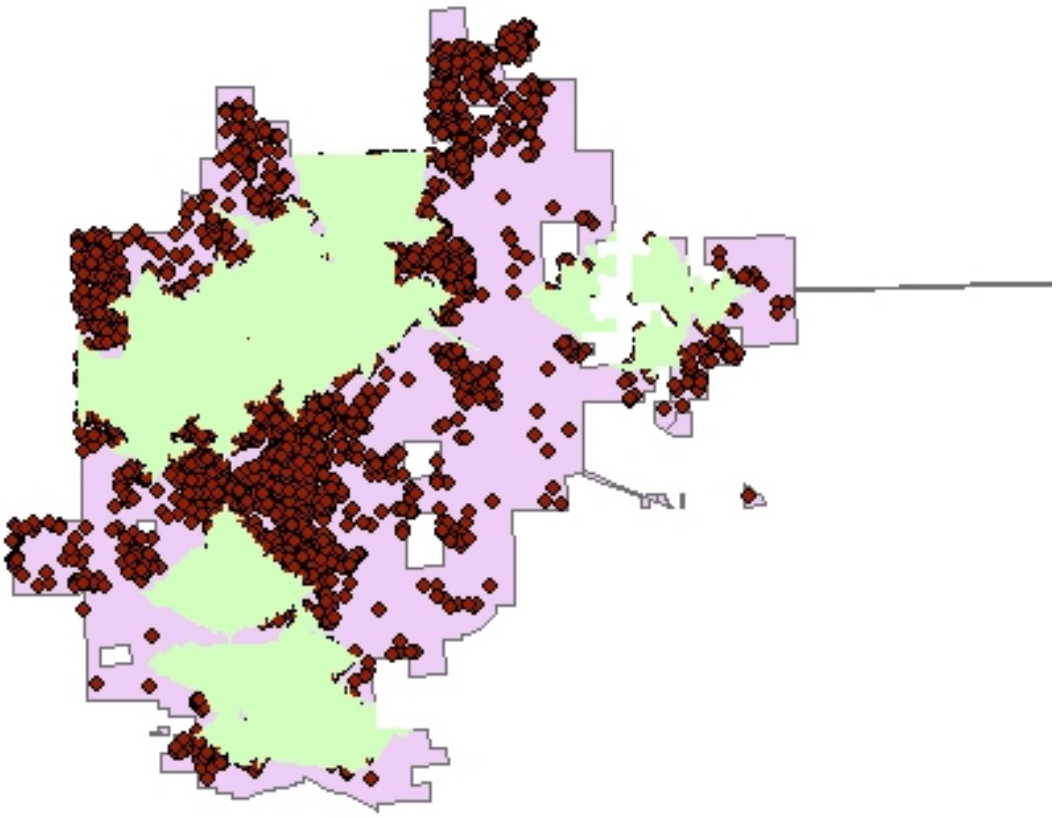
Using 2013, Map 5 reflects all incidents within the City of Broken Arrow and mutual aid runs outside the City.

Map 5



Map 6 reflects all calls within the City of Broken Arrow and those calls that could not be reached within the four minute or 240 second time standard.

Map 6

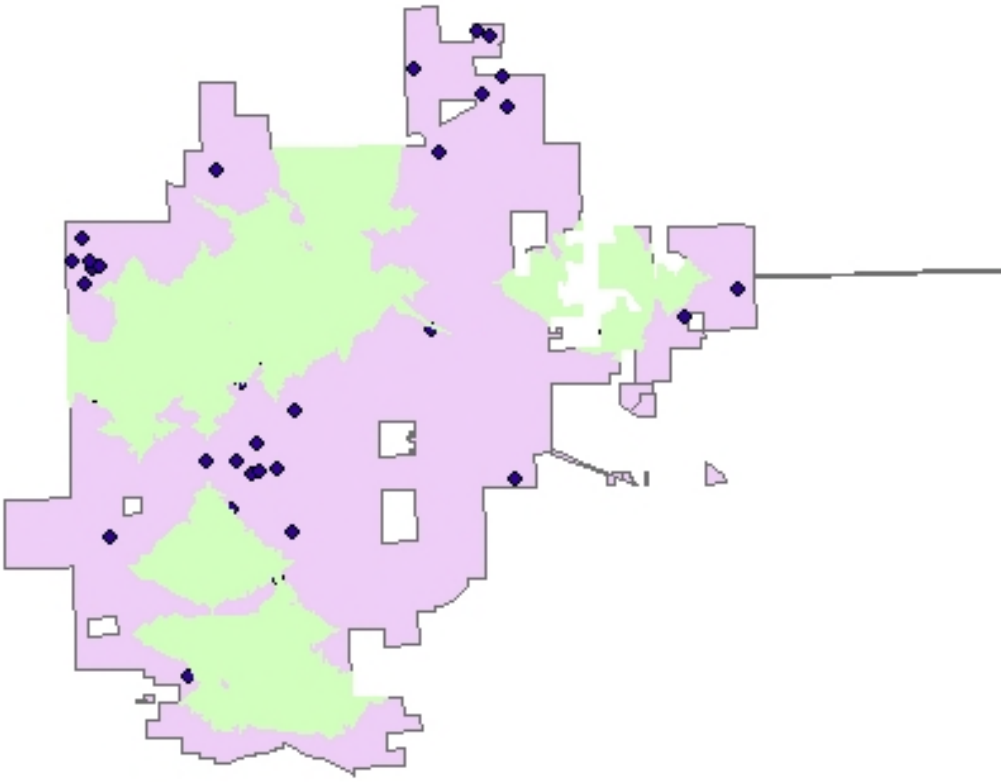


Only 54 percent of the incidents within the city limits can be reached in four minutes.

Note: The response time (turn out and travel) to approximately 46% of the incidents was five minutes or less. The response time (call processing, dispatch, turn out and travel) to approximately 66% of the incidents was six minutes or less.

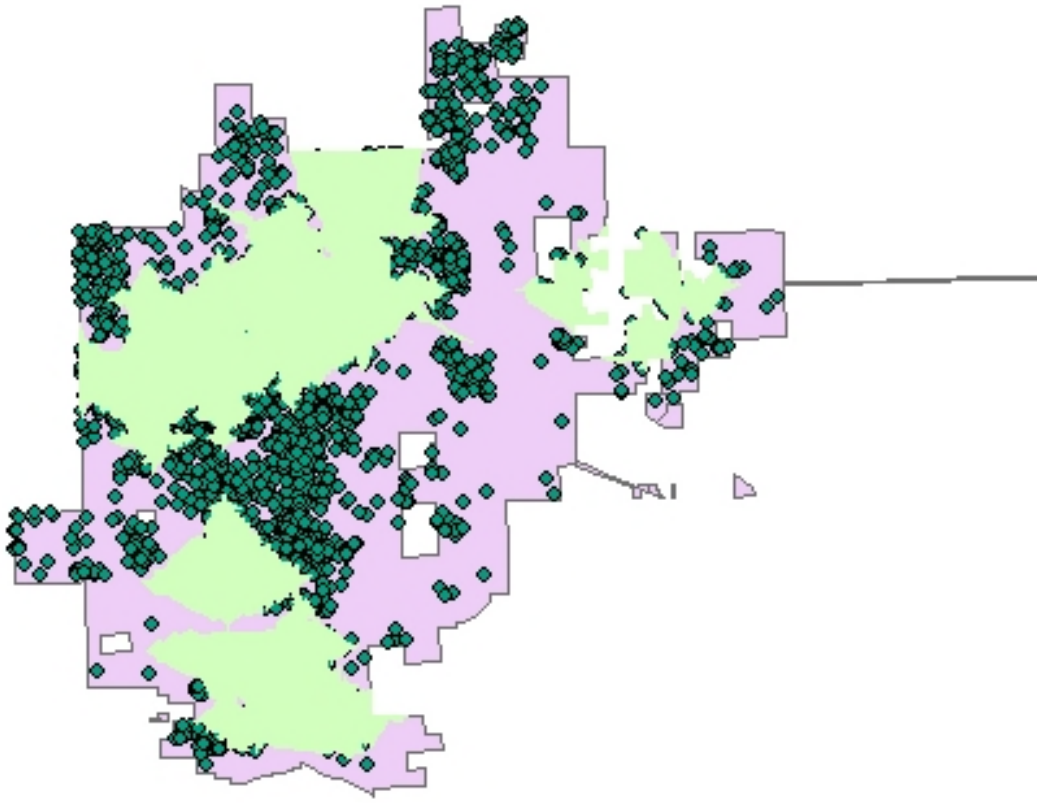
Map 7 reflects that 47% (25 or 53) of the building fires (code 111) during 2013 in the city were reached within four minutes or 240 seconds, or less.

Map 7



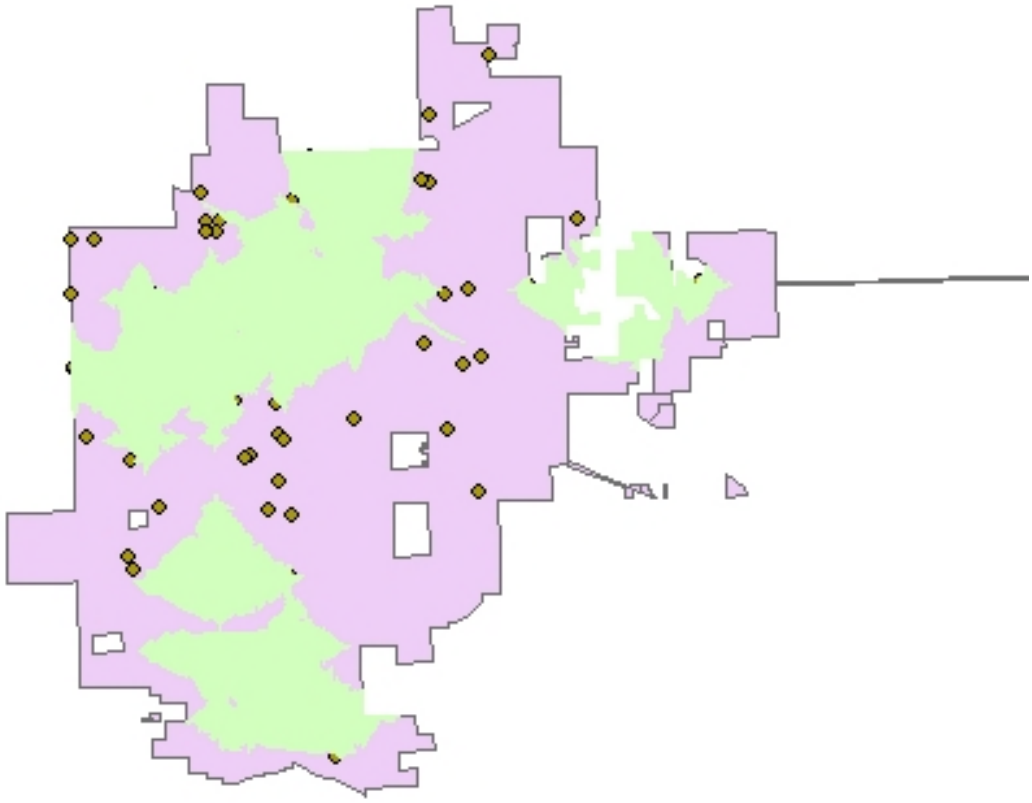
Map 8 reflects that 54 percent of all EMS calls, excluding vehicle accidents (Code 321) can be reached in 240 seconds or less.

Map 8



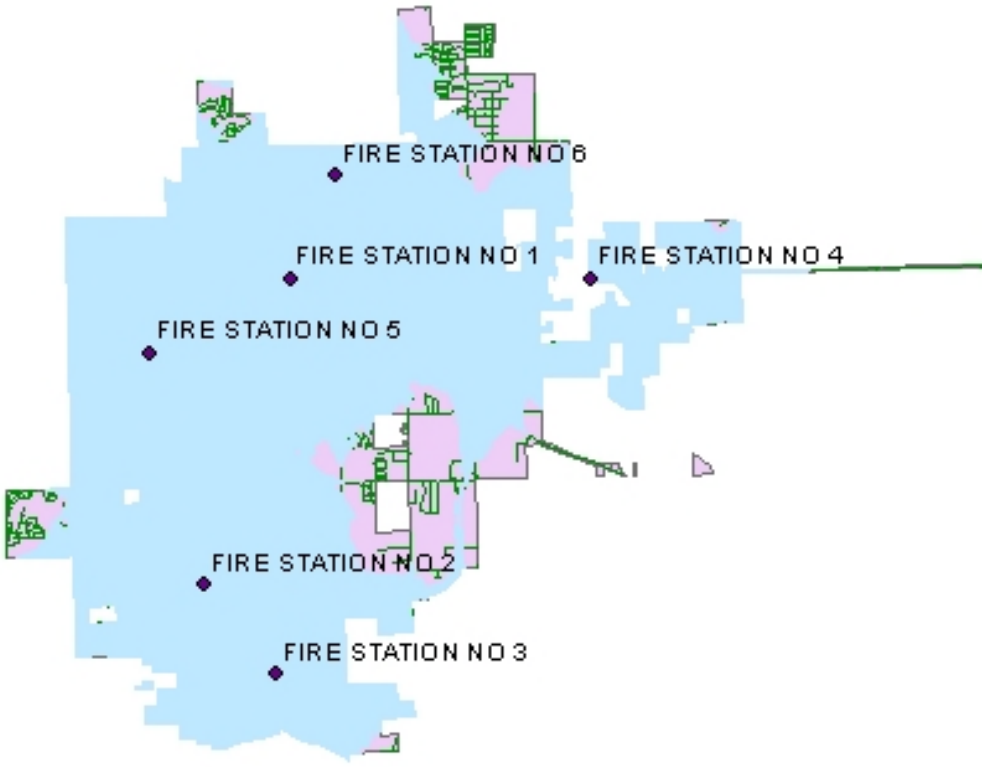
Map 9 indicates that 64 percent of the vehicle accidents with injuries (code 322) can be reached in 240 seconds or less.

Map 9



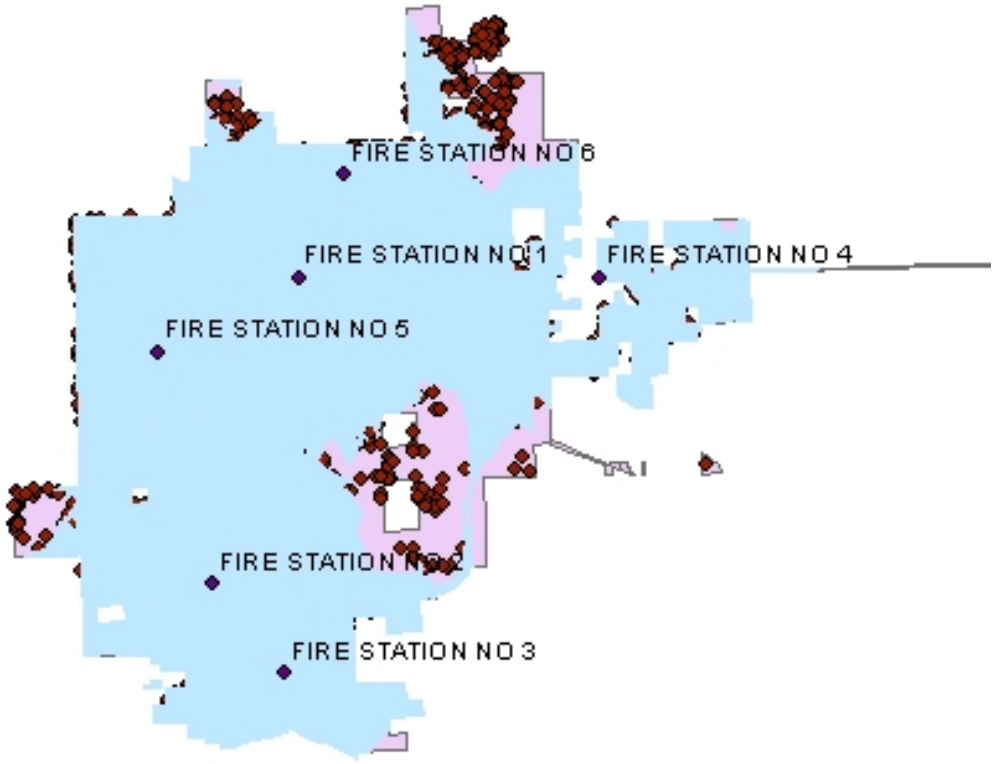
When examining EMS responses with an ambulance, Map 10 indicates that most of the city is covered within the 480 second response time for arrival of an ambulance on the scene.

Map 10



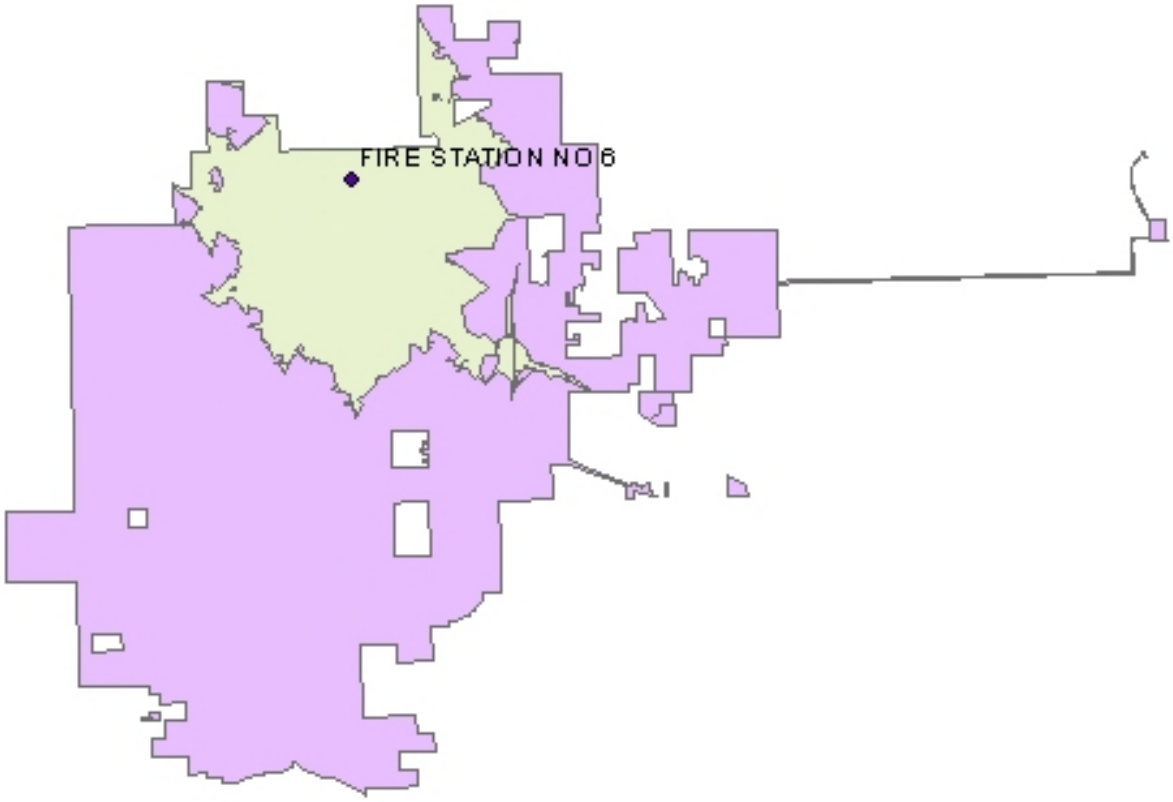
Map 11

As a continuation of Map 10, Map 11 reflects all EMS incidents in 2013 and the 480 second coverage map. As shown, most EMS incidents were covered within the response time standards for an ambulance.

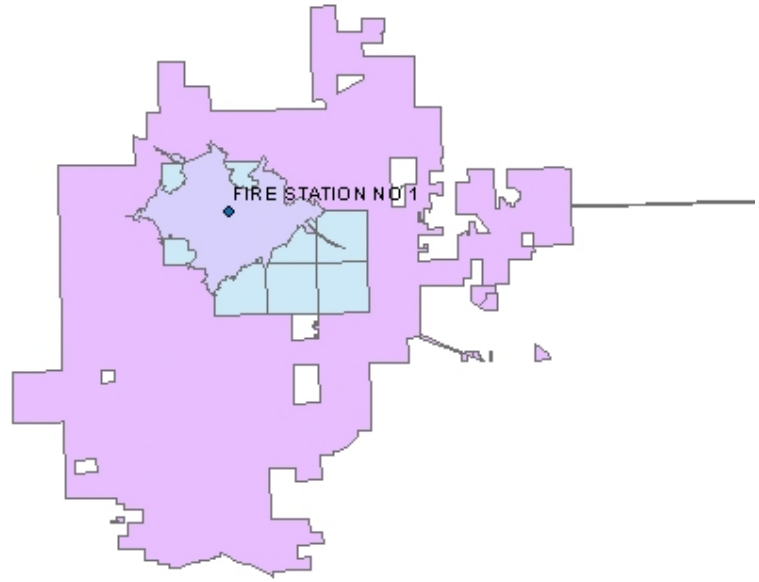


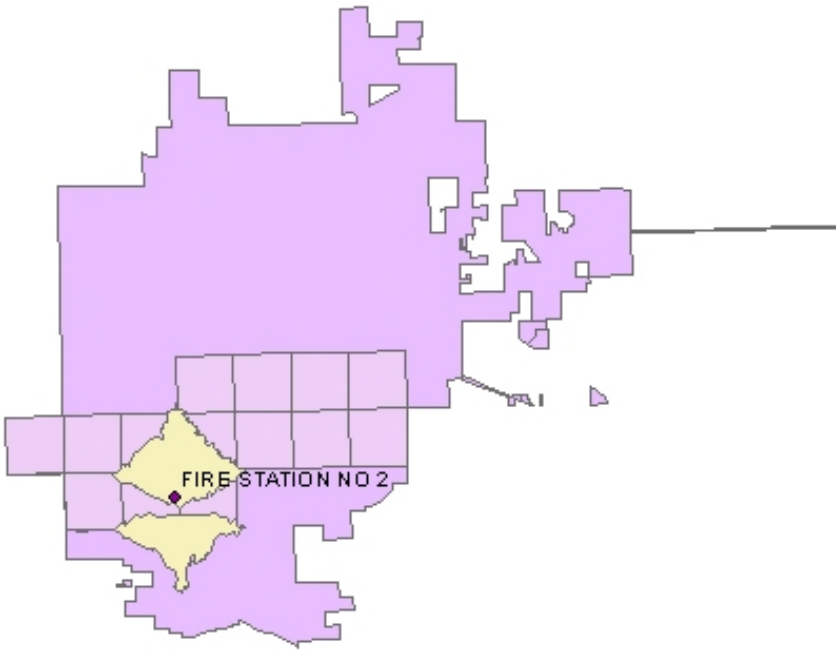
Map 12 reflects the ladder company coverage which under NFPA standards would be 480 seconds for a full alarm assignment. However, the Broken Arrow Fire Department does have two 75' foot Quints, one at Fire Station 2 and one at Fire Station 5 that could be utilized as ladder companies if necessary.

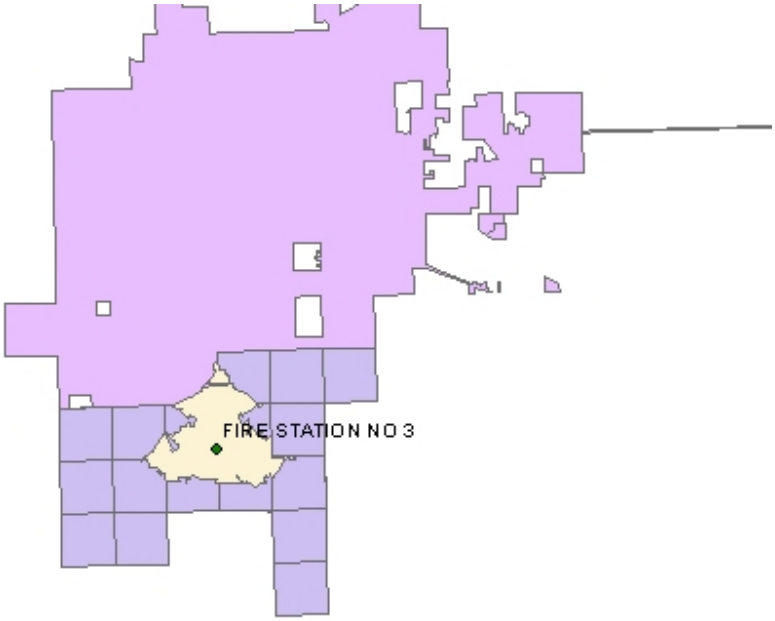
Map 12

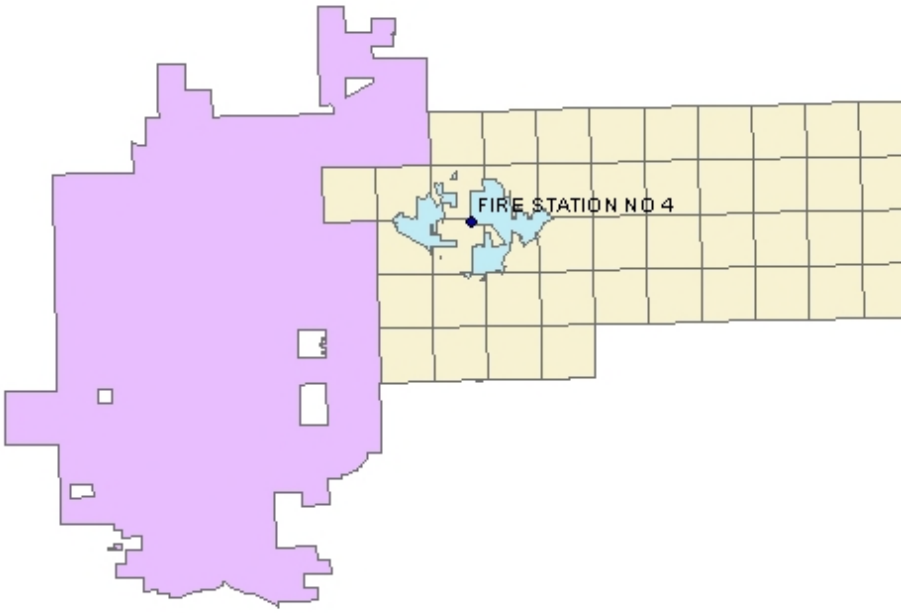


Maps 13 through 18 reflect the 240 second response coverage for each fire station. The maps also reflect what the traditional response territories are for each fire station.






FIRE STATION NO 3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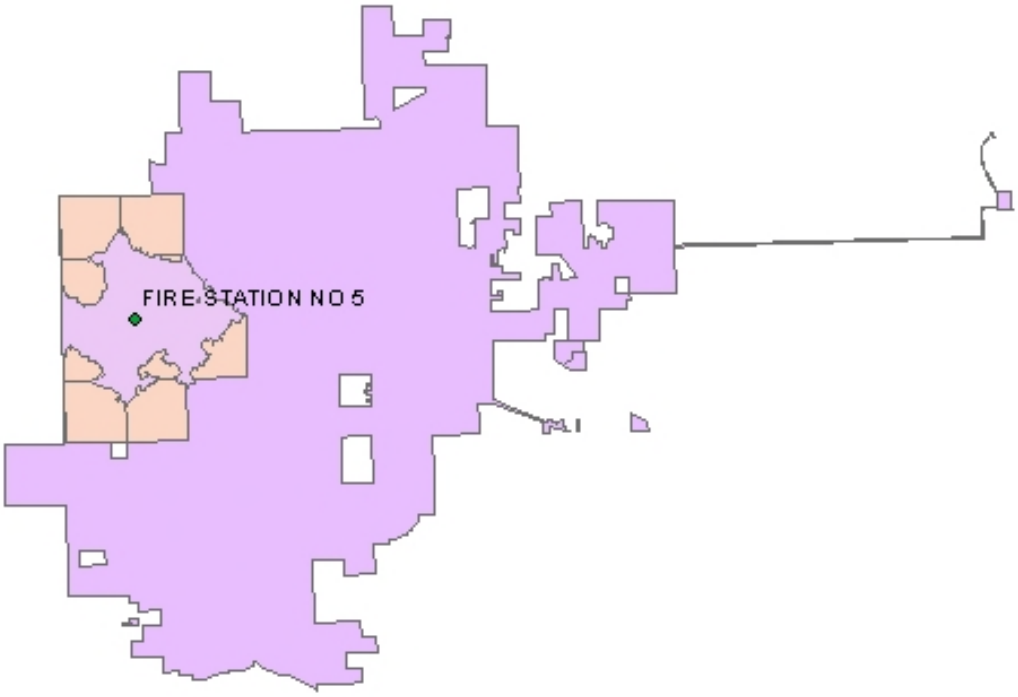
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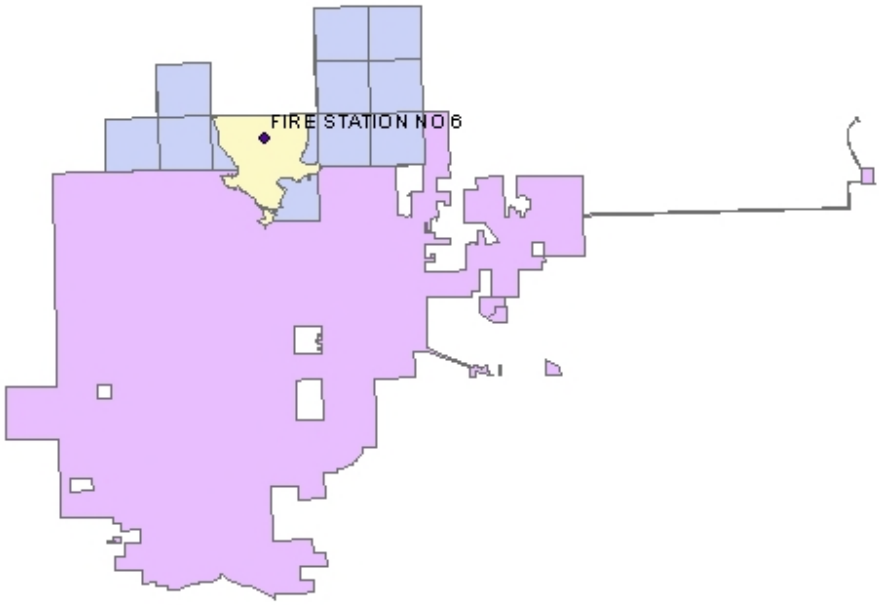

FIRE STATION NO 6

Hypothetical Fire Stations

In our analysis, there was examination of existing fire stations and coverage when compared against the NFPA 1710 consensus standards. In order to achieve the performance objectives and standards of coverage, the Broken Arrow City Fire Department will need to add additional fire stations. Any reconfiguration must not only serve current response demand but future growth and development.

The Ludwig Group worked closely with the Broken Arrow Fire Department staff to identify gaps in coverage. Additionally, the software was also allowed to identify gaps in coverage where call demand is currently realized and recommend placement of fire stations. Based on the feedback from staff and the recommends from the software, new fire station locations were identified to serve future development and population growth.

What follows on subsequent pages are those recommendations and the response coverage they would provide.

These hypothetical fire stations reflect five minute responses areas. These are a true reflection than the four minute response zones since Broken Arrow fire personnel are allowed by policy to drive 10 miles over the speed when responding to an alarm.

The GIS software was queried to determine the most optimal placement if the following scenarios were created:

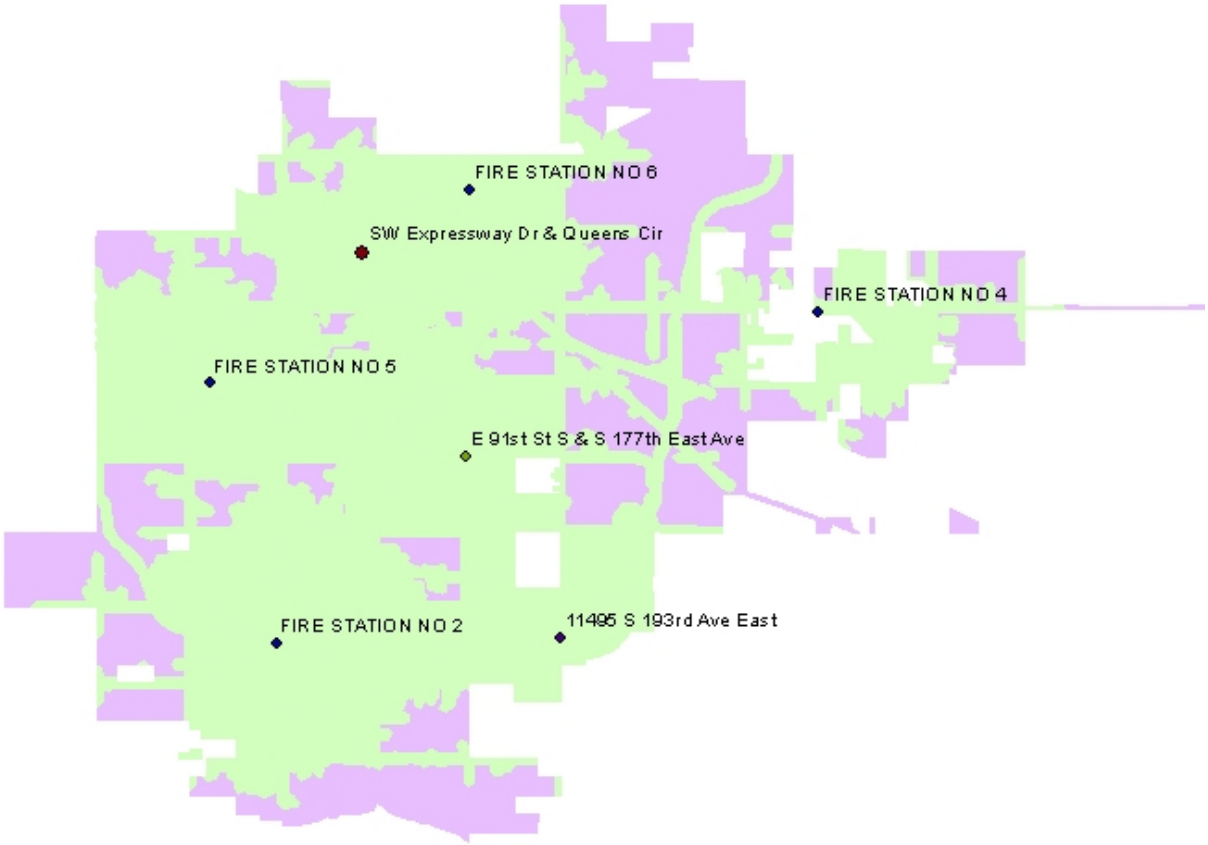
(1) Move Station #1 to optimal location
(2) Move Station #3 to optimal location
(3) Create a 7th fire station

The GIS software recommended the following while keep Station #2, 4, 5, and 6 in place.

(1) Moving and building Station #1 at SW Expressway and Queens Circle
(2) Moving and/or building Station at E.91st & S 177th East Avenue
(3) Moving and/or building Station at 11495 S 193rd Ave East

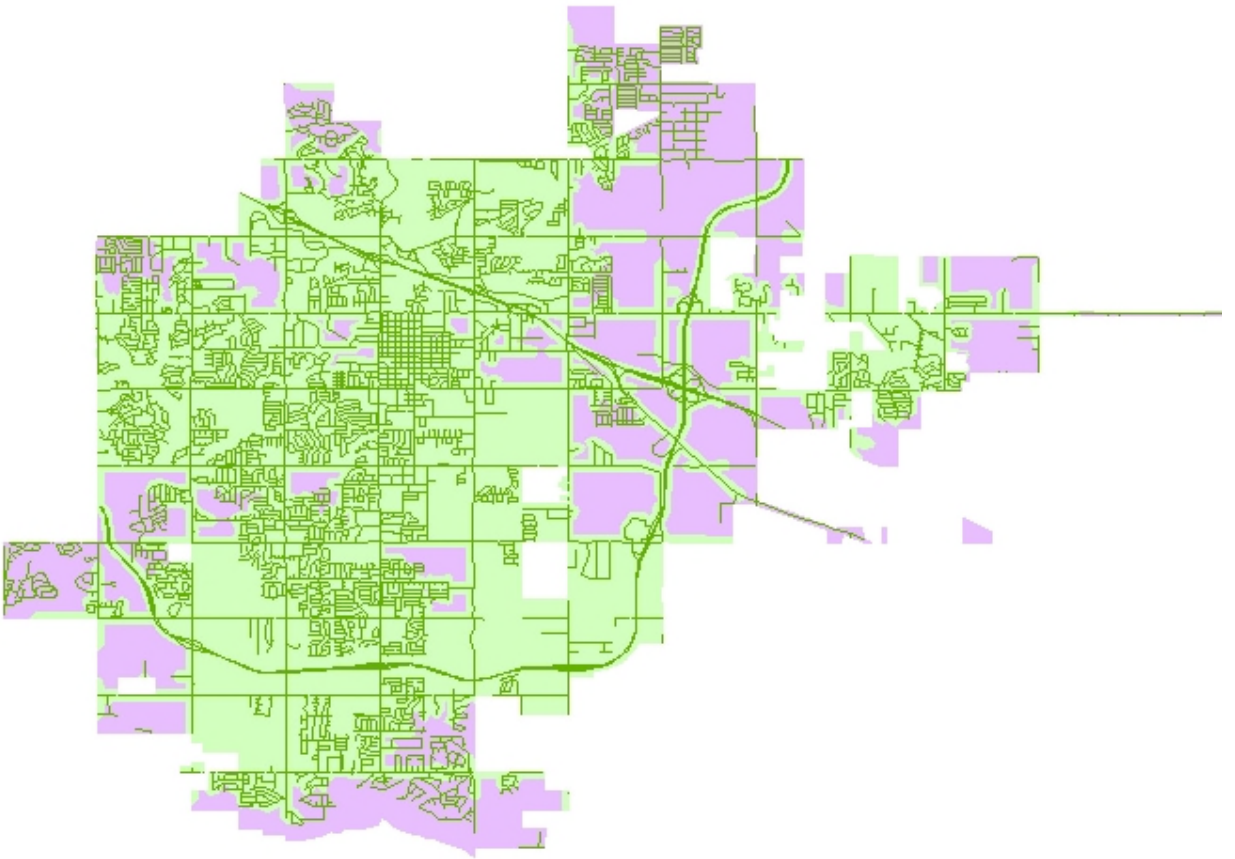
Map 19 reflects the five minute response zones for the new recommended fire stations with the existing fire stations.

Map 19



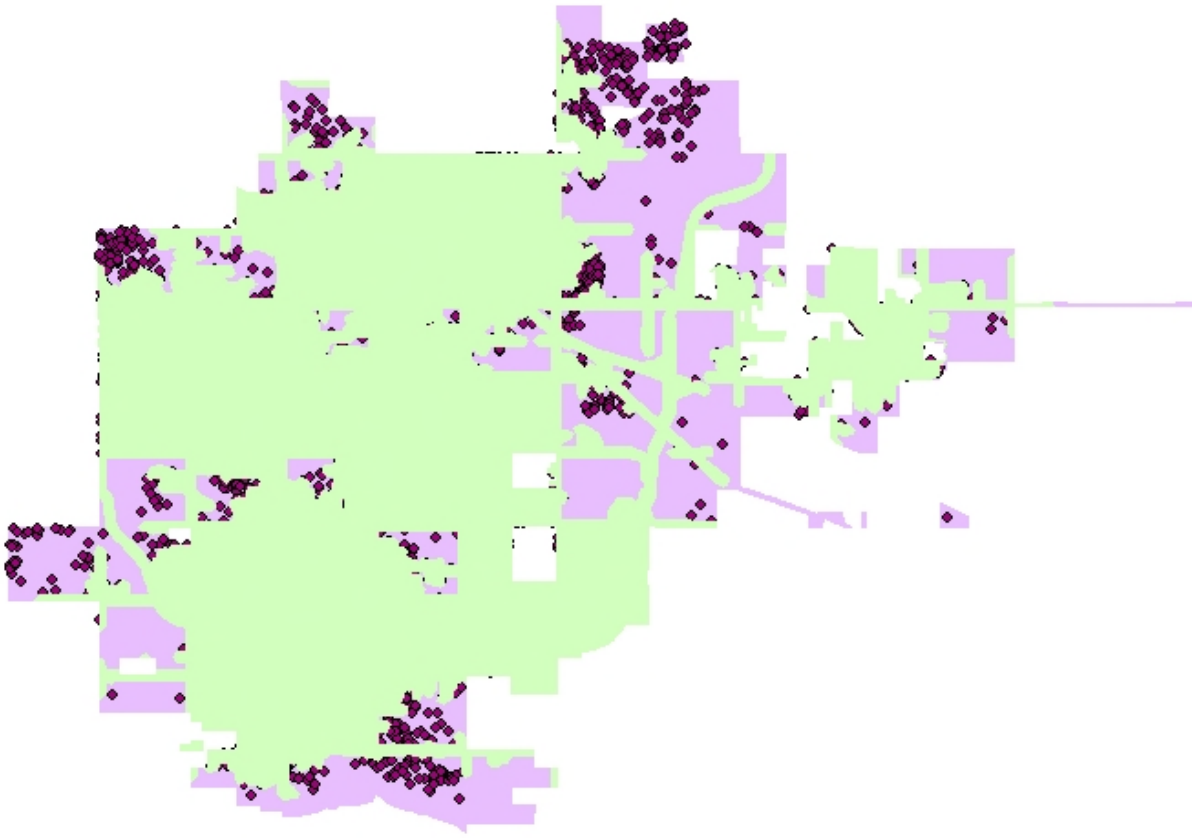
Map 20 reflects the five minute response zones for the new recommended fire stations with the existing fire stations, with the impact on the street network.

Map 20



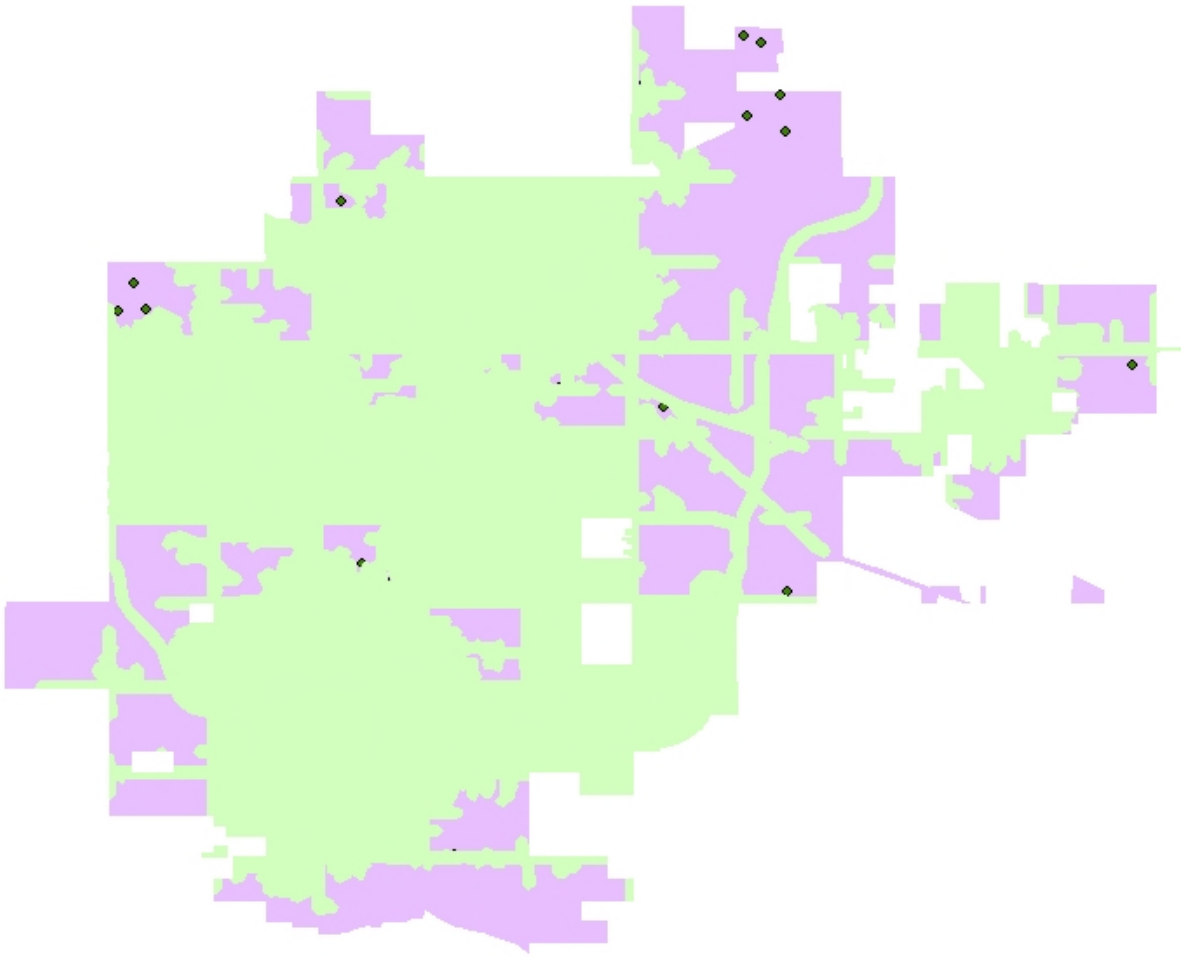
Map 21 reflects the five minute response zones for the new recommended fire stations with the existing fire stations, with the impact coverage possible on historical calls in 2013. Based upon the recommended coverage, 86 percent of all calls can be reached in five minutes or less.

Map 21



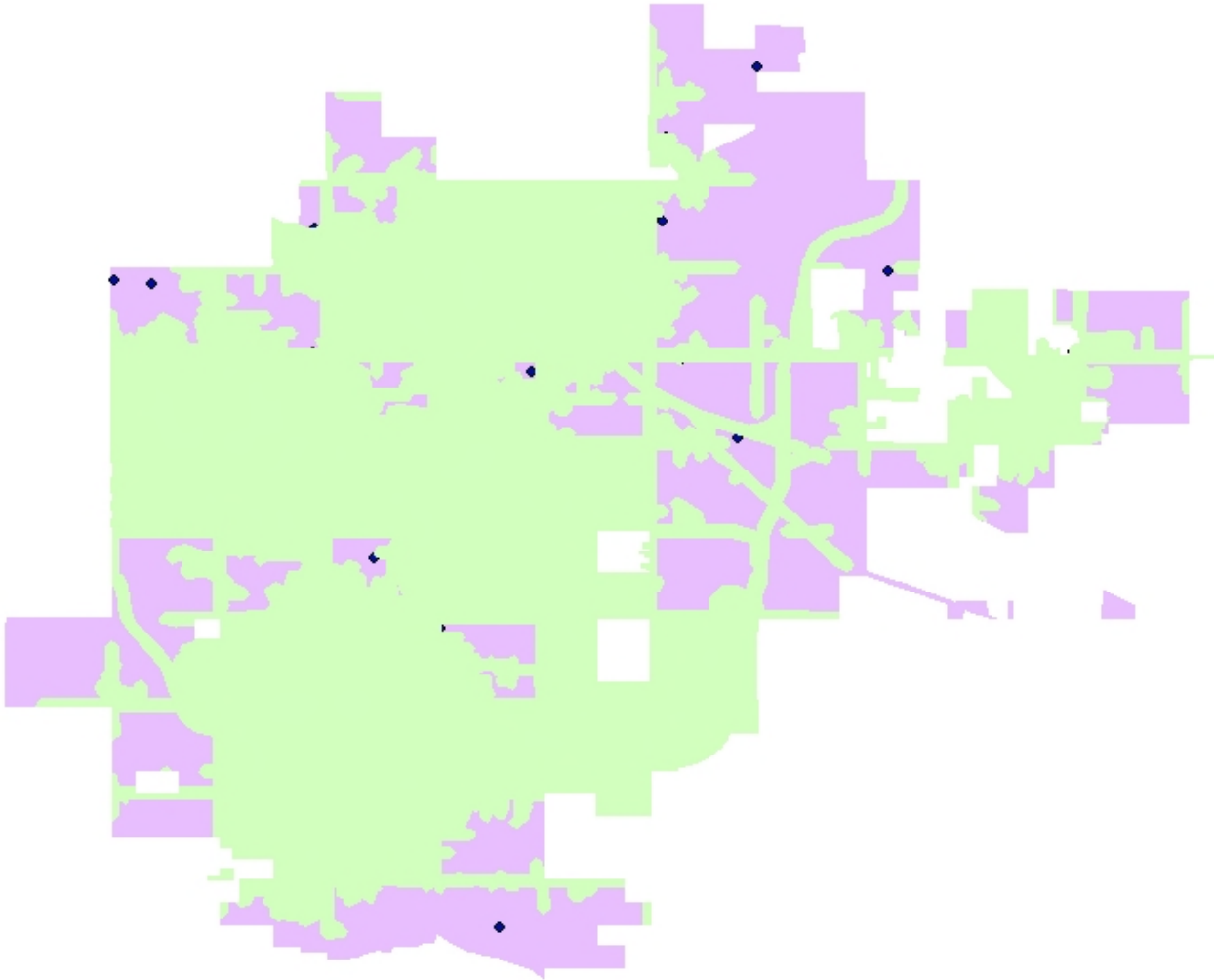
Map 22 reflects the five minute response zones for the new recommended fire stations with the existing fire stations, with the impact coverage possible on historical calls in 2013. Based upon the recommended coverage, 75 percent of all building fires can be reached in five minutes or less.

Map 22



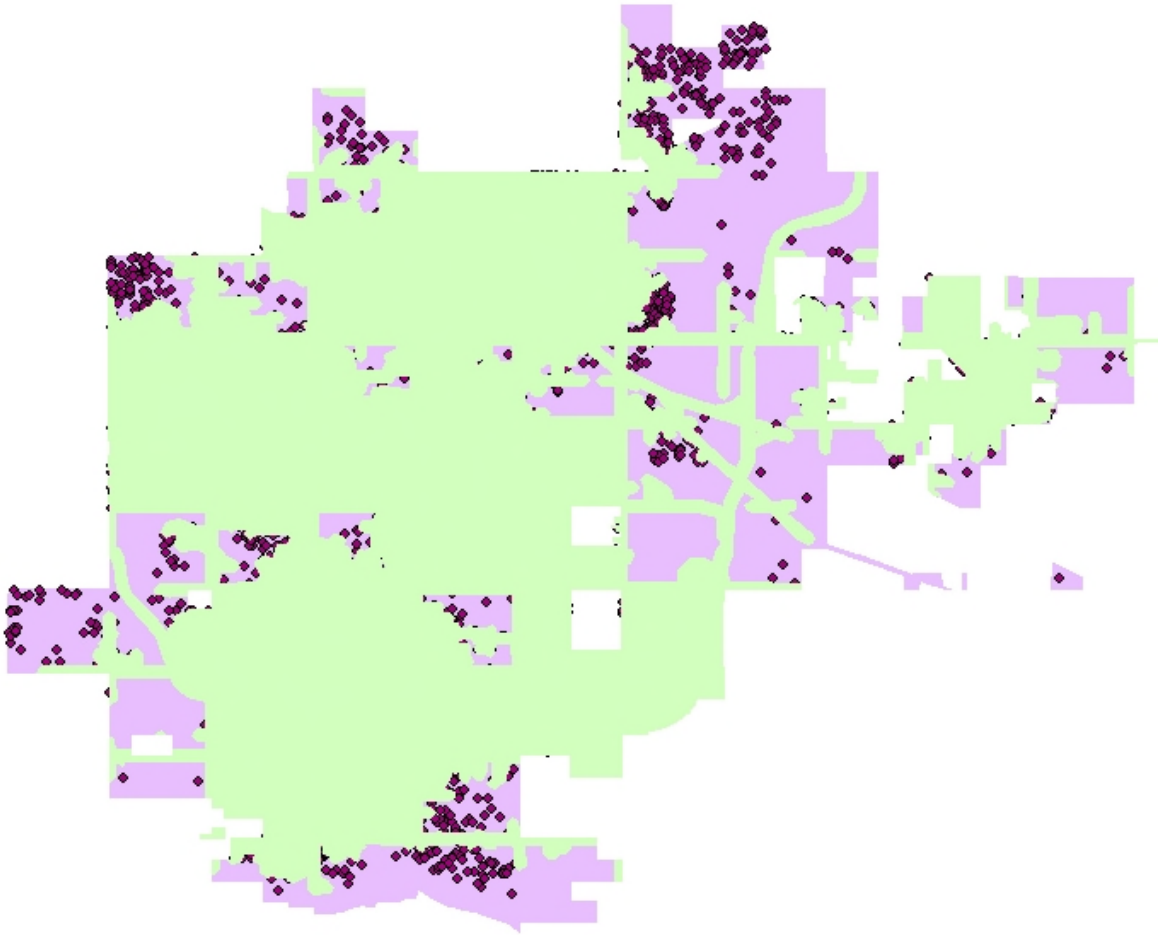
Map 23 reflects the five minute response zones for the new recommended fire stations with the existing fire stations, with the impact coverage possible on historical calls in 2013. Based upon the recommended coverage, 87 percent of all vehicle accidents can be reached in five minutes or less.

Map 23



Future Considerations

If all the recommended fire stations are rebuilt, built and/or relocated, consideration in 10 years or more should be given to building an eighth fire station in the northern section of the City to accommodate the rapid growth and call volume that will be ultimately experienced. This fire station would complement the other fire stations, while providing a timely response to a heavily populated and substantial call volume that is anticipated to be experienced.



Conclusion

This GIS fire department deployment analysis for the City of Broken Arrow has examined the historical call volume based upon current fire stations. It has also examined the relocation of two fire stations and the addition of a third fire station to better serve the community.

Having worked with officials from the City of Broken Arrow, as well as others, the principal consultant is confident that the desire to take the tough steps needed to relocate fire resources is present. The challenge will be with the decision-makers on which path they wish to follow.

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