Andrea Nieto, Project Manager/GIS Analyst

Bryan Heisinger, Assistant Manager/GIS Analyst

Matthew Mitchell, GIS Analyst

Nadine Oliver, GIS Analyst

Spatial Analysis for Construction of a San Marcos Fire Station

Prepared for:

Prepared by: CenTex 360°

February 12, 2013

TABLE OF CONTENTS

INTRODUCTION

Summary

According to the United States Census Bureau, between 2010 and 2011, San Marcos experienced a 4% increase in population, reaching more than 45,000 people. To meet the demand of this growth trend, the City of San Marcos is proactively developing a plan to construct a new fire station. The City of San Marcos has approached CenTex 360° to analyze factors based on a previous study published in 1994, *An Equation for Station Location*. A GIS implementation would enable the San Marcos Fire Department to provide faster response times and emergency services in areas that are in need of a fire station.

Purpose

The purpose of this study is to determine potential locations in San Marcos, Texas where the economic and demographic conditions of the area justify the construction of a fire station. To do this, we will consider the following factors: parcel area, parcel value, day/night time population, square footage of buildings, value of improvements, conflagration potential and wildlife urban interfaces. We will use this data to analytically determine the areas of the city that demonstrate a need for future firefighting services.

Scope

San Marcos, Texas is approximately 30 square miles and contains about 1500 people per square mile (United States Census Bureau). We will calculate and analyze data based on parcels found in grid cells that have been pre-determined by the City of San Marcos. The shape of these cells is similar to the diamond shaped cells used in the study, *An Equation for Station Location*. There are 16 grid cells total and 11 of these do not contain a fire station. Our focus will be on the 11 grid cells without a fire station. Limiting our analysis to these cells will allow us to conduct a precise analysis, leading to results that will enable the San Marcos Fire Department to better serve San Marcos.

LITERATURE REVIEW

Assessing the distribution and allocation of firefighting resources in an urban area would help ensure that policy makers are providing their citizens with the best emergency services possible. Accordingly, we found several similar studies and reports that aided us in the development of our analysis.

For our methodology we primarily relied on one study done by the Austin Fire Department that was published in *Fire Chief* Magazine in 1995. Because of city ordinances that require the Austin Fire Department to provide complete services to all Austin city residents, it was important to assess the areas where the developing city had outgrown current fire response services. In order to do this, Fire Chief Bill Roberts developed a diamond-shaped grid system to delineate emergency service areas. This system was more conducive for quick emergency service on grid-based road networks and optimized response time. These grid cells also served as the spatial unit of comparison for the study. A similar grid pattern has been adopted and applied to San Marcos for the purposes of this study. Taking into account factors such as development patterns, population distribution by time, taxable improvement values, and square footage of structures, they empirically compared areas by need of firefighting services. Because of similarities in scope and objective, we have modeled our study from this article.

In order to most accurately determine which areas might be in need of improved firefighting services, we were asked to create an index to empirically measure the conflagration potential of a given area. While the National Fire Protection Agency Handbook, 12th edition, states, "there is no universally accepted exact definition of conflagration", we have described it as the ability of a fire to spread from one structure to another (Sybesma, 1995). Another article, published by the NFPA, *Urban Conflagrations* (2010), describes in detail the factors associated with urban conflagration and provides case-study examples of past urban area fires. Designed to educate the reader on how to develop a strategy for combating urban fires, it explains methods of heat transfer and the importance of adequate firefighting resources. This article greatly contributed to our understanding of the contagious nature of fires and directly influenced the development of our conflagration index.

One study I would like to include in this report that might be useful for future use is an analysis done by the Belgium Ministry of the Interior. This study used a risk-modeling and location-allocation model approach to determine the lowest-cost option for ensuring that 90% of fires can be reached within a designated time frame. Using these GIS tools, not only were they able to determine optimal locations for fire stations, but also assess intervention time and assign staff and equipment to individual fire stations. I believe that this study would be applicable not only on a nation-wide scale, but, given the resources, could be used to assess the need for improving and optimizing fire station locations on a municipal scale.

PROPOSAL

Data

The data needed to complete this comprehensive fire station analysis is as follows:

- A city grid composed of grid cells each indicating the service area of a future fire station.
- A parcels layer of the City of San Marcos to calculate the area, value, and day/night population of each grid cell.
- A buildings layer that includes information on the total square footage of each establishment.
- A tax roll spreadsheet of the city that will be used to determine the value of improvements in each parcel.
- A city parks layer which will assist in determining whether or not there is a wildlife urban interface in each grid cell.

We will be using ArcGIS to help us interpret this data and conduct our analysis. All of the data was provided to us by the GIS administrators in the Development Services department of the City of San Marcos.

Methodology

To complete this analysis, we have complied a series of computational steps that will be applied to each of the 11 grid cells that do not contain a fire station. We will examine the grid cells and record the corresponding data one at a time to maintain efficiency and minimize data processing. The data will be recorded on a spreadsheet we have developed and will be given to the City of San Marcos upon completion. Below is the process that we intend to follow when conducting this study.

Finding Developed, Vacant and Total Parcel area of each Grid Cell

To find the total acreage of developed land, we will use the *Identify* tool to select each parcel that has been developed found inside the given grid cell boundary. The parcel acreage will be determined using the *acreage* field of the attribute table for the selected parcel. If a parcel happens to cross a grid cell boundary, we will select and create a new layer out of that particular parcel and clip it to the grid cell. At this time we will apply *calculate geometry* to the clipped portion of the parcel in order determine the new acreage amount. These values will be recorded onto the spreadsheet under two columns titled, *Developed/Undeveloped* and *Acreage.* A 'yes' or

'no' indicator will be recorded describing whether the parcel is *Developed/Undeveloped*. The amount of acreage found in each parcel will be recorded in the *Acreage* column. The acerage for all the developed parcels will be added together to determine the total number of developed acreage within the grid cell and placed in the *Acreage* column. We will use *Calculate geometry* on the *shape_area* field of the grid cell's attribute table to find the total acreage of the cell.

Total Parcel Value

To find the total value of the vacant, developed, and multi-family parcels, we will turn to the grid cell's spreadsheet. On the spreadsheet we will add a new column titled *Total Parcel Value*. We will find the parcel value by looking at the TOTALASSES field of the Hays County tax roll data. The information for each parcel category (vacant, developed, and multi-family) will be recorded under their individual column. The parcel values of column will then be added together to find the total parcel value.

Day and Night time Population

Two additional columns will be added to each parcel documented on the spreadsheet. One titled *Commercial/Residential,* will indicate whether the parcel is residential or commercial. The other titled *Population,* will have the population for that parcel. We will add the commercial population values in the population column of the spreadsheet to determine the day time population for the grid cell. We will apply the same process using the residential population values to determine the night time population in each grid cell. We will find all of this information using the attribute table for each parcel.

Square footage of buildings

To determine the square footage of buildings, we will add a buildings layer to each grid cell in ArcMap. Using the *Select by Location* tool, we will identify every building located within a grid cell boundary. Once we have identified the buildings, using the attribute table of the selected buildings, we will apply the statistics tool to the *shape_area* field to calculate the total square footage of all buildings within the grid cell. If a building is two or more stories tall, we will multiply its *shape_area* by the number of stories and apply its value to the total square footage. We will record this data in the column labeled *Building Sq. Footage* of our spreadsheet.

Value of improvements

To find the value of improvements, we will join tax roll data from the City of San Marcos to the parcels ID field in the attribute table. We will look at county prefixes — labeled by a single letter — to differentiate between counties. The field TOTALIMPMK will tell us the value of improvements in each parcel. This information will be recorded in a column labeled *VOI* in the spreadsheet. To find the total value of improvements of the grid cell, we will add together all the *VOI* parcel values on the spread sheet.

Wildlife and Urban Interface

We will create a column titled Wildlife/Urban Interface in the grid cell spreadsheet. A city parks layer will be added to the grid cells. If any wildlife or urban areas exist within a grid cell, a 'Yes' will be recorded. Otherwise, an indicator of 'No' will be recorded.

Conflagration Index

Another way to assess the necessity for a fire station is to determine the likelihood that a fire will spread from one structure to another. We propose to create a conflagration index, for which we referenced the National Fire Protection Agency Journal. They have identified several common factors that increase conflagration potential in urban areas:

- closely built structures;
- the use of untreated wood shingles as exterior covering for roofs or walls;
- poor water supplies, weaknesses in automatic or manual fire suppression systems;
- dilapidated structures, especially abandoned buildings in large numbers;
- large-scale combustible construction or demolition projects;
- wildland/urban interfaces; and
- built-up areas near high-hazard locations, where a transportation or industrial fire or explosion could quickly involve large numbers of buildings (Klaene 2008, 28).

The optimal index would have weighed all of the factors and ranked them on a scale of 1-10, where the higher ranking would indicate more factors present and therefore higher conflagration potential. However, due to the intense data collection required to be able to account for all of the factors, we propose to focus on the following with respective weights: proximity of buildings to each other (7), wildland/urban interface (2), and frequency of buildings three stories in height or greater (1). These three factors have been identified in our literature to contribute significantly to conflagration potential and we have weighed them accordingly.

Firstly, in order to properly measure the proximity of buildings, we will create a concentric layer buffer around each of the building polygons to determine distance between buildings. The buffers are tiered in order to account for different intensities of fires with buffers of 2.5', 5', and 10'. These buffers will then be analyzed to determine percentage of buildings within a 10', 20' and 40' radius (distance doubled to account for both building's buffers joining). This percentage will allow us to compare relative proximity between grids, thereby identifying areas where buildings are located closer and therefore more likely to allow fire to spread.

Secondly, according to *Fire Chief* magazine, "having a developed area with homes adjacent to an undeveloped wildland area is a significant problem whenever wildland fire develops" (Sybesma 1995, 63). We will account for this factor by total length of developed bordering wildland or park area per unit.

Lastly, we will assign a small weight for the frequency of buildings three or more stories in height. Chief Roberts of Austin has "identified buildings that are three stories or more in height…as potential conflagrations" and we want to include this factor in our analysis to account for the contributions vertical structures, such as large apartment buildings, have in conflagration potential (Sybesma 1995, 63).

The combination and weights of these factors we believe will reasonably gauge the potential an area has for conflagration. It will also be able to be used as a basis of comparison between areas as a factor for our broader analysis.

Implications

This analysis will be able to assist policy makers with decisions regarding the expansion of the San Marcos Fire Department. Preemptively determining the siting of future fire stations will allow the city services to accommodate predicted population growth trends and provide the best possible service to its citizens. Additionally, the information generated during our analysis will also aid the Fire Department by providing them with a detailed report regarding the characteristics of the area they service.

Budget

Data Acquisition and Analysis

Analysts	
3 Analysts *(10 hours/wk over 2 weeks)*	60
1 Analysts *(5 hr/wk over 2 weeks)*	10
Hourly Rate	$30.00
Subtotal	**$2,100**

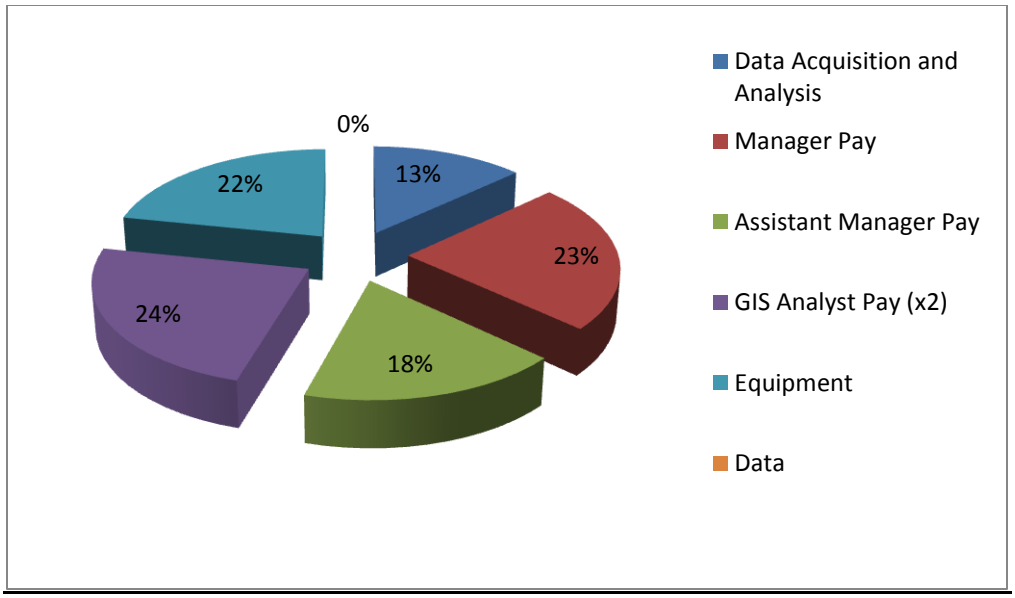
System Management

Project Manager	
Hours *(5hrs/wk over 10 weeks)*	50
Hourly Rate	$75.00
Pay	$3,750.00
Assistant Project Manager	
Hours *(5hrs/wk over 10 weeks)*	50
Hourly Rate	$56.25
Pay	$2,812.50
GIS Analyst *(x2)*	
Hours (*7hrs/wk over 10 weeks*)	70
Hourly Rate	$27.00
Pay	$1,890.00
Total Pay	**$10,342.50**

Equipment Cost (for 10 weeks)

Supplies *($250/workstation*4 workstations)*	$1,000.00
Technical Support & Maintenance *(4*$100/unit)*	$400.00
Poster printing (36”X48”, gloss)	$65.00
Depreciation *($20,000 [$5000*4]/30*3)*	$2,000.00
Subtotal	**$3,465.00**
Data	**$0.00**
Total Cost	**$15,907.50**

Allocation of Resources



Data Acquisition and Analysis	$2,100
Manager Pay	$3,750.00
Assistant Manager Pay	2,812.50
GIS Analyst Pay *(x2)*	3780
Equipment	3465
Data	0

Timetable

- **Weeks 1 - 2** of this project will be spent meeting with the City of San Marcos to complete a needs assessment. The City of San Marcos will provide the data that they would like for us to use to conduct our analysis.
- **Weeks 3 - 4** will be spent preparing the proposal and developing our methodology. We will present our proposal to the City of San Marcos on Wednesday February 20th.
- **Weeks 5 - 7** we will start the data processing portion of this process, calculating grid cell values for the analysis. During this time we will also prepare documentation for a progress report. Our progress report will be presented to The City of San Marcos on Monday, March 25th.
- **Weeks 8 - 9** we will review our feedback from the progress report and tweak our methodology to fine tune the analysis.
- **Weeks 10 - 12** we will work on preparing our final deliverables.
- **Week 13** our final analysis will be presented to The City of San Marcos on Monday, April 29th.
- **Week 14** our final deliverables will be turned in on Friday, May 3rd.

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
	28-Jan	4-Feb	11-Feb	18-Feb	25-Feb	4-Mar	11-Mar	25-Mar	1-Apr	8-Apr	15-Apr	22-Apr	29-Apr	3-May
Client Presentations														
Data Collection														
Preparation of Proposal														
Proposal Presentation														
Data Processing														
Data Analysis														
Progress Report Preparation														
Progress Report Presentation														
Data Interpretation														
Preparation of Deliverables														
Final Presentation														
Final Deliverables														

Final Deliverables

Upon completion of this project, we will present The City of San Marcos and the Texas State Geography Department with a poster that will display the results of our analysis. We will create a website that will include all of the documentation presented. We will also provide a CD that will include the data and information of the project including the following:

- All data used
- Metadata
- PowerPoint highlighting our final analysis
- Final Report (2 copies)
    - Map (or map book) of each grid cell
    - Spreadsheet containing all statistics that were calculated during the analysis
    - Summary of project explaining methodology

- Electronic Data Copy (CD Format/ 2 copies)
    - Shapefiles
    - Metadata
    - Final Report
    - Power Point Presentation
    - Manuals
    - Instructions for CD- Readme file

CONCLUSION

As first responders, the San Marcos Fire Department provides a service to protect the lives and property of San Marcos residents and visitors. The result of the project will be to identify potential areas in San Marcos that justify the construction of a fire station. To do this, we will consider the following factors: parcel area, parcel value, day/night time population, square footage of buildings, value of improvements, conflagration potential and wildlife urban interfaces. This data will highlight areas of the city that demonstrate a need for the construction of a fire station. Out of the 16 grid cells the City of San Marcos is broken down into we will create a maps/map book of each remaining grid without a current fire station (11 total). We will also provide a spreadsheet for each grid outlining all statistics that were calculated during our analysis. We will use ArcGIS to help us interpret this data as previously mentioned was provided to us by the GIS administrators in the Development Services department of the City of San Marcos. This can be used by the City of San Marcos to identify future fire station issues, as well as giving the city an efficient way to keep records, and plan for future fire stations accordingly. The city will also have the opportunity to expand and continue development on our map/model to meet their evolving needs as the city grows.

PARTICIPATION

Andrea Nieto Project Manager GIS Analyst	• Authored *Introduction (Summary, Purpose, Scope)* and *Timetable* • Organized documents final draft of the Proposal • Prepared final draft of PowerPoint presentation
Bryan Heisinger Project Assistant Manager GIS Analyst	• Authored *Data & Methodology* sections of Proposal • Prepared final draft of PowerPoint presentation
Matthew Mitchell GIS Analyst	• Authored *Project Budget*, *Final Deliverables*, *Conclusion*, and *Participation* • Prepared final draft of PowerPoint presentation
Nadine Oliver GIS Analyst	• Authored *Literature Review* and *Implications* • Prepared final draft of PowerPoint presentation

REFERENCES

Chavalier, Phillippe, and Isabelle Thomas. "Locating Fire Stations: An Integrated Approach for Belgium." *Socio-Economic Planning Sciences* 46 (2012): 173-82. Retrieved from http://www.sciencedirect.com/science/article/pii/S0038012112000080

Klaene, B., & Sanders, R. (2008). Urban conflagrations. *NFPA Journal, 102*(6), 28-28,86. Retrieved from http://search.proquest.com/docview/216397377?accountid=5683

Sybesma, Pieter. (1995). An Equation for Station Location. *Fire Chief* Oct. 1995: 55-65. Print.

United States Census Bureau. "San Marcos (city) QuickFacts from the US Census Bureau." *San Marcos (city) QuickFacts from the US Census Bureau*. N.p., 10 Jan. 2013. Web. 12 Feb. 2013.