Review of the Routley Fire Station
Location Analysis Report

MARCH 1, 2000

INTRODUCTION

This study was undertaken to review the findings of the fire station location analysis performed for Arlington County by J. Gordon Routley (hereafter referred to as the "Routley Report"). This review is a component of a larger, comprehensive study of the Arlington County Fire Department being performed by TriData Corporation. This study is not intended to be a "stand-alone" fire station location analysis, but rather an opportunity to comment on the findings of the Routley Report.

Rationale for Analysis

Fire station location studies are commonly performed because development in a jurisdiction creates new patterns of residence, employment, and commutation. This may result in changed patterns of demand for ambulance or fire suppression services. Since fire station locations are often a matter of historical artifact, reflecting the built environment of 20 or even 50 years ago in many communities, locations frequently are not optimal for current or expected demand.

The Routley Report was "commissioned by the Arlington County Fire Department to evaluate the locations of fire stations in the county" to ensure that both the number and location of stations made sense for present and future call demand.[1]

TriData was asked to review the Routley Report and to comment on whether we agreed with the findings, and what we would recommend differently if we disagreed with the findings.

TriData Methodology

TriData did <u>not</u> undertake a full station location analysis. To do so would have been redundant with the Routley study and beyond the scope of work of the TriData study. Instead, TriData reviewed the Routley Report's assumptions, methodology, findings, and recommendations, and compared Routley's data to information derived using the County Department of Public Works Mapping Center's Geographic Information System (GIS) – a separate, newer methodological approach.

The Routley Report is based on the popular *Flame*™ computerized station location analysis software. TriData has used this software many times in the past and has

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[1] Routley, J. Gordon, "Arlington County Fire Station Location Analysis," October 1999, p. 1.

found it to be relatively accurate and useful. It is, however, but one means of analyzing fire station locations, and it has inherent limitations (as does any software package). The program is heavily dependent on the quality of the information it is provided (which appears to be quite good in the case of the Routley Report). Ultimately, results from *Flame™* or any other similar analytical package must be viewed with an informed and critical eye. There is no one "right answer" for problems such as locating fire stations – there is a need to trade off benefits and costs, and locating fire stations becomes an exercise in making the best out of constrained resources and parochial/political interests.

Assumptions/Parameters

The Routley Report used several assumptions that bear repeating. Most of the assumptions used in the study appear valid and reasonable. The assumptions can be categorized into road travel speeds, "immovable" fire stations, turn-out time, and travel-time targets.

TriData did not validate the road travel speed assumptions empirically, but we did verify with the Arlington County Traffic Engineering Division that the assumptions were reasonable. The road travel speed assumptions include assuming that fire vehicles travel at about the posted speed limits:

- Travel speed over neighborhood (minor and principal) streets: 25 mph

- Travel speed over secondary arterial streets: 35 mph

- Travel speed over primary arterial streets: 45 mph

- Travel speed over highways: 55 mph

(We later discuss undertaking the analysis with more conservative criteria.)

The Routley Report also considered certain fire stations "immovable" in the near term for various reasons. These were:

- Station 1 (because it is relatively new and in "very good condition.")

- Station 2 (because expansion and rehabilitation are already under way)

- Station 6 (because it is owned by the City of Falls Church)

- Station 9 (because it has just undergone major renovation)

The Routley Report also listed Station 5 as immovable. The area protected by Station 5 certainly needs to be covered by a fire station; however, it is not clear from the description of the station that it must be considered immovable.

The Routley Report assumes that units in fire stations can be on the way to an emergency within one minute of notification (generally referred to as "turn-out time"). This is the assumption that TriData also uses in similar calculations.[2]

Travel-time targets for first-due and second-due units were based on performance objectives for the fire department's response time (not the system's response time, which should include the call-processing time). Travel-time targets were established by subtracting one minute of turn-out time from the Department's overall response time goals. Travel-time assumptions are consistent with those in the Routley Report, which were reasonable and correctly calculated. They are as follows:

- First-due unit: 3 minutes

- Second-due unit: 5 minutes

Analytical Process

TriData worked in conjunction with the Arlington County Department of Public Work's Mapping Center to complete the maps used in TriData's review.

The first step of the analysis was to "geocode" the 1999 incident data contained in the ACFD CAD system. Geocoding is a process by which each incident is assigned a longitude and latitude so it can be displayed graphically on a map of the county by a geographic information system (GIS). To geocode an incident, the street name and address in the CAD system are matched against a list of addresses in the GIS master database. The latitude and longitude are then transcribed into the incident database. Coordinates for virtually every structure and intersection in Arlington County are contained in the GIS master database.

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[2] A one-minute turn-out time is one of the accreditation standards of the Commission on Fire Accreditation International. Compliance with this standard can and should be verified empirically. Not all fire departments meet this standard, and it should be checked on a regular basis.

Unfortunately, some of the addresses were for calls that occurred outside the county, on federal installations (such as the Pentagon and Arlington National Cemetery), National Airport, and along some highways, and hence were not represented in the GIS master database. They therefore had not been geocoded. The Mapping Center identified several common addresses that could be used for a number of the "uncodable" locations. After remedial geocoding, some 18,341 incidents (80 percent of the incidents that ACFD handled in 1999) could be plotted on a map of the County, constituting an excellent representation of the geographical dispersion of demand for ACFD's services.

The next step was to determine "service areas" for each of the stations. The service area represents the coverage that any given station could provide. The ACFD's response time performance objectives are to place a unit on-scene from the closest fire station to the emergency within four minutes or less of dispatch. The data recorded by the ACFD reflect "road travel time" (i.e., the amount of time it takes from notification of a call to the unit's arrival to the closest point on the street). The ACFD recorded response times do not include either the dispatch time (i.e., the amount of time it takes to receive a call and alert the appropriate units) or "vertical" response time (i.e., the amount of time it takes to get from the street to the patient's side or the seat of the fire). Personnel in the Emergency Public Safety Communications Center estimate that the dispatch time averages 45 seconds. To be conservative in this analysis, TriData used a dispatch time of one minute. To meet a response time performance objective of four minutes (including both dispatch and travel time) means that travel time should not exceed three minutes. Hence, TriData's analysis is based on a three-minute travel time.

TriData and the Mapping Center used the Arlington County road network from the GIS to determine three-minute service areas for each station. This task was somewhat complicated because actual road travel speeds for road segments were not contained in the GIS master database. Instead of using actual road travel speeds, proxy travel times were calculated for every road segment in the county, as follows:

1. Each road segment had previously been assigned a road service class by the County (discussed above) – neighborhood, secondary arterial, primary arterial, and highway. The Arlington County Traffic Engineering Division sets speed limits for each road service class of 25 miles per hour (mph), 35 mph, 45 mph, and 55 mph, respectively. Although an emergency vehicle may exceed the posted speed limit when using its lights and sirens, in actuality emergency vehicles rarely sustain speeds in excess of the speed limit on any

given stretch of road. In fact, most responses occur at or below the speed limit (because of safety, road conditions, and traffic). Accordingly, TriData requested the Mapping Center to adjust road travel speeds for the service classes as follows for the purposes of this analysis:

- neighborhood – 25 mph,

- secondary arterial – 35 mph,

- primary arterial – 45 mph, and

- highway – 50 mph.

2. Based on the length of the road segments and the adjusted road travel speeds for each service class, the GIS computer calculated how long it should take to traverse each road segment in the county.

3. In order to calibrate the calculated road travel times to actuality, the ACFD was requested to have emergency vehicles use stopwatches to determine the true length of time to travel certain road segments. These times were compared to the computer's estimates of how long it should have taken to travel those segments, and a calibration factor was calculated.

4. The calibration factor was then used to compute proxy travel times for every road segment in the county.

The GIS computer was then instructed to show the endpoint of every road segment that could be reached within three minutes from each station in the county. To account for red lights and stop signs, an "impedance factor" of ten seconds was added to the response time for each intersection encountered, irrespective of whether the vehicle was going straight or turning, and irrespective of whether the vehicle had the right of way at the intersection (i.e., had a green light).[3] This practice corresponds to reality because ACFD emergency vehicle operators are instructed stop at all intersections that do not have a green light to ensure that traffic has yielded the right of way. Using an impedance factor of 10 seconds was thought to be conservative – most stops at intersections do not

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[3] By contrast, the *Flame* model used in the Routley Report assigns an impedence factor of 15 seconds <u>only</u> for turns at intersections.

take 10 seconds, and one would expect to encounter green lights at a portion of the intersections along the way to a call.

Ten maps, corresponding to the three-minute endpoints accessible from each fire station, were drawn by the computer. The maps sometimes produced odd shapes because access to a highway or arterial road would identify some areas that were accessible within three minutes but that were quite far removed from the physical location of the station. In order to be conservative about the service areas, these distantly accessible response areas were "snipped" from the generalized service area for most stations. Eliminating these "tails" from the service areas also is warranted because neither GIS nor the *Flame* model account for the fact that travel speed is not uniform (i.e., theoretically, the maps represent fire apparatus beginning and ending emergency runs at the top-rated speed of the street – not with acceleration and deceleration). The result was a polygon on a map that represented a three-minute service area.

These polygons were then combined on a map of the county to show the areas of the county that could be reached within three minutes of any fire station. The geocoded incidents were then overlaid on the three-minute service areas, and the computer was instructed not to display any incident that fell within a service area. Map #1 shows present configuration of fire stations and the three-minute coverages that result. The map also shows the 2,708 incidents out of 18,341 (14.8 percent) that fell outside of the three-minute coverage areas in 1999.

ANALYSIS

Two main areas or "pockets" of the county lack adequate three-minute coverage under the existing resource deployment scheme. The first is in the very northernmost point of the county. This area is primarily residential in nature and contains few suitable parcels of land on which to build a fire station (though conceivably a private dwelling could be purchased and converted to use as a fire station, assuming a zoning variance could be obtained). The second area is located along the southwest border of the county. It is commercial and residential in nature, but it contains a number of suitable locations for building a fire station.

Covering the northernmost coverage gap would require building a station north of either Station #3 or Station #8. The two stations lie in close proximity to one another. Station #3 is a single-bay structure leased from the Cherrydale Volunteer Fire

Department. Station #3's first-due area is largely covered by Station #8 and Station #10. The engine company located at Station #3 could be relocated without diminishing service to the residents of that area. Further, the light unit now located at Station #8 could be moved to the Cherrydale station, thus freeing up some bay space at Station #8.

As noted earlier, the territory to be covered in the northern end of the county is largely residential. Few good fire station sites exist, and condemnation procedures under the County's right of eminent domain would likely be met with stiff resistance and would come at a high cost. With the assistance of the Mapping Center, TriData identified a parcel of county-owned land at North Glebe Rd. and Williamsburg Blvd. that could be an excellent site for a new fire station. Another benefit of this site is that it provides increased three-minute coverage to the north with some overlapping coverage to the northern portion of Station #8's first-due area. The major drawback of moving a station as far north as proposed is that units located there would be more likely to be dispatched into Fairfax County under the automatic aid plan that exists with Fairfax County.

Covering the second gap, along the southwest border, could be accomplished by relocating Station #4 to a County-owned site at Columbia Pike and Arlington Mill Rd. When one examines the three-minute service area of Station #4 on Map #1, it becomes clear that there is no portion of that service area that is not covered by the three-minute service area of an adjoining station. This supports the Fire Chief's contention that Station #4 could be moved to a lesser served area of the county without significantly degrading the service in its first-due area. (It should be noted, that Station #4 does make an excellent "second-due" station to most areas of the county, but the resources housed in Station #4 could be much better utilized elsewhere in the county.) Response times in Station #4's present area might increase slightly when one of the stations that now overlaps that area is on a call (because calls near Station #4 would be farther away from the other stations), but response times would generally remain within the service goals. The result would be more equitable service for the county as a whole.

Map #2 shows the effect that moving Station #3 north and Station #4 west would have on the coverage of calls in 1999. While the proposed arrangement would not have provided three-minute coverage to 100 percent of the county, it would have made a major improvement. Had this station configuration been in effect during 1999, only 1,251 calls of the 18,341 (6.8 percent) plotted would have been outside of three-minute coverage areas. This represents a decrease of 54 percent in the number of such calls.

Management Working Documents For County Manager Deliberative Use

The Routley Report had identified Station #7 as underutilized (especially for Arlington County, as about half of its calls are into Fairfax County and Alexandria) and the area south of Crystal City as being an area of high demand for service in the near future. We concur with this assessment. The scenario portrayed in Map #2 shows

Station #7 in its present location. However, Station #7 could be moved closer to Crystal City (to assist with a projected increased call volume in and south of Crystal City) without affecting coverage in the most southerly portion of the county.

Map #3 depicts new locations for Stations #3 and #8 (as identified in Map #2) and a new location for Station #7 – a site identified at South Glebe Rd. and South Lang St. Moving Station #7 in this manner provides better coverage to the Arlington Ridge area west of Crystal City while enhancing service delivery to Crystal City and areas to the south of Crystal City. Under this configuration, only 907 of the 18,341 calls plotted (4.9 percent) would have fallen outside of the three-minute coverage areas. This represents a decrease of 67 percent in the number of such calls.

The table below summarizes the three maps and the effects of the station location schemes depicted in each.

Map Number	Scenario	Number of Calls Outside 3-minute Coverage Area	Percent of Calls Outside of 3-minute Coverage Area
1	Current Locations	2,708	14.8%
2	Move Station #3 to N. Glebe Rd. Move Station #4 to Columbia Pike	1,251	6.8%
3	Move Station #3 to N. Glebe Rd. Move Station #4 to Columbia Pike Move Station #7 to S. Glebe Rd.	907	4.9%

Summary

This report was intended to provide a calibration for the Routley Report. It was not intended to be a complete, stand-alone station location analysis. It did however, result in development of a new analytical methodology for the ACFD and some new findings and thoughts regarding potential station locations. The framework for analysis will allow the County to conduct its own analyses in the future.

Three scenarios were assessed using a GIS-based methodology that was developed and implemented through joint collaboration between TriData Corporation and the Department of Public Works' Mapping Center. Leaving station locations at the status quo means that approximately 15 percent of calls in Arlington County will occur in areas outside of a three-minute drive from the closest fire station.

Management Working Documents For County Manager Deliberative Use

The scenarios presented in Maps #2 and #3 for relocating stations result in approximately seven percent and five percent of the calls occurring outside of a three-minute drive. Either scenario would provide enhanced coverage for the present, although the third scenario (involving the relocation of Station #7) would provide better coverage for the future, when the Potomac Yards have been developed.

The coverage areas shown in the maps are conservative. In all probability, the three-minute coverage areas are larger than depicted; however, prudence dictates that conservative assumptions be used in this type of planning.

Our analysis concurs in large part with that of the Routley Report, especially with the need to reposition stations northward and southward to deal with existing and potential gaps in three-minute coverage in those areas. The Routley Report recommends:

- Moving either Station #3 or Station #8 northward,

- Adding a station in Crystal City,

- Moving Station #7 to a site on George Mason Drive, and

- Consolidating Station #4 and Station #10.

The Routley Report's methodology appears sound, and its recommendations are well-grounded in the analysis performed. TriData's findings differ slightly from Routley's, but this should not be construed to mean that the Routley Report's conclusions are incorrect. TriData has merely arrived at an alternate scenario that we feel should be considered, in part or in whole. Improved coverage of the county could be obtained by:

- Moving Station #3 northward to North Glebe Rd.,

- Moving Station #4 westward to Columbia Pike, and

- Moving Station #7 northeastward to South Glebe Rd.

Once the Rosslyn redevelopment is complete, the Rosslyn area will be three times as dense as it is now. There is a high likelihood that this will generate additional demand for service in this area. Given this pending change, the present location of Station #10 should prove advantageous for minimizing response times to Rosslyn.

Two caveats about both analyses are in order here. The first is that these analyses used historical data as the basis for comparison. It is possible to "guestimate" where calls will occur as a result of future development; however, it is not possible to pinpoint them exactly as to either volume or location. Where increased development is slated to occur, one may assume that the call volume will increase, and where no development is expected, historical call volumes should suffice as predictors of future call volume, so long as socioeconomic conditions do not change drastically in the near future.

The second is that these analyses represent coverage available when units are in stations. Performing a second-order analysis – one that simulates the availability of coverage given the actual consumption of resources – is a complex mathematical endeavor, requiring analytical and computational resources beyond the state-of-the-art models commonly available.[4] As such, one must consider that response times will be longer for second calls in areas in which response resources are already consumed. In other words, once a unit is unavailable for a response, another unit from farther away will have to handle the call, and that farther-away unit may not be from an adjoining station. One basically trades an improvement in first-due response times over a wider area for a slight increase in response times on those occasions when a second-due unit is needed.

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[4] Although it would be expensive and complicated to develop, it would be possible to create a mathematical simulation of Arlington's call volume and locations for this purpose; however, this was not contemplated during the formulation of the project.