FINAL REPORT

Four Hills Speed Hump Evaluation Study

Albuquerque, New Mexico

Michael J. Cunneen

July 2007

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Executive Summary

The City of Albuquerque installed fifteen speed humps along Stagecoach Road and Wagon Train Drive in the Four Hills neighborhood during September and October of 2004. Six additional humps were installed in May 2005 along Warm Sands Drive in response to resident concerns on that street that traffic seeking to avoid the speed humps on Stagecoach Road was diverting to Warm Sands Drive. The speed humps along Stagecoach Road and Wagon Train Drive impacted the major circulating route in the Four Hills area, the route that the great majority of vehicles must take entering or leaving the neighborhood. Concerns have been raised in the general neighborhood with regard to the impact these speed humps may have on emergency vehicle access to the area and the overall impact on public health. This study was undertaken at the request of the City Council as an independent assessment of this issue.

This report contains an analysis of the public health impact of the speed humps in the Four Hills neighborhood with a new fire station to be sited on Via Posada. This addresses both lives saved by accident reduction and lives lost by delays to emergency vehicles caused by the speed humps. It also examines the overall traffic safety impact of speed humps within Albuquerque. Specific recommendations are made for the roadway sections within Four Hills now covered by speed humps.

This study also examined geometrics, operations, and safety throughout the speed hump portions of Stagecoach Road and Wagon Train Drive, especially specific conditions and current traffic turning volumes at the following intersections:

- Four Hills Road and Stagecoach Road (North "Y" Intersection);
- Four Hills Road and Stagecoach Road (South Intersection by Country Club);
- Stagecoach Road and Warm Sands Drive;
- Stagecoach Road and Stagecoach Lane;
- Wagon Train Drive and Via Posada; and
- Wagon Train Drive and Sagebrush Trail/ Cuatro Cerros Trail.

Evidence is presented that a number of alternative strategies and devices that do not cause any delay to emergency vehicles can be implemented that can also reduce traffic accidents and/or traffic speeds and may substitute for the speed humps. These alternative strategies include roadway re-striping to create narrower travel lanes, installing bulb-outs (also known as neckdowns or chokers or curb extenders) to narrow the roads at a few points, installing raised median islands to narrow the roadway at other points, employing transverse rumble strips and optical speed bars (transverse lines across the road), and applying better delineation, using mirrors, reflectors, and signage to highlight danger areas.

It is believed that the alternative measures proposed, in combination with the downward trend in accidents in this area, will result in safe traffic conditions little different than existing conditions with the speed humps on Stagecoach Road and Wagon Train Drive. The recommendations would also result in considerably less delay to emergency vehicles, thereby improving overall public health.

The analysis developed the following findings and recommendations:

FINDINGS

Roadway Accident Analysis

- Traffic accidents in the affected roadway sections have been in decline, averaging only 1.5 traffic accidents per year since 1995 and averaging only 0.5 accidents per year since 2001. In the 1990-1994 period traffic accidents in the same sections were averaging 4.6 per year.
- Only 19% (8 of 42) of traffic accidents between 1990 and 2005 on the affected roads involved injuries, most of them minor. In fact, 80% of the injuries were recorded as Class C, meaning "*Complaint of injury but none visible*".
- Only 23.8% (10 of 42) of the traffic accidents between 1990 and 2005 involved either "*excessive speed*" or speed "*too fast for conditions*" as one of the highest contributing factors causing the accident.
- Only 20% of these 10 speed-related accidents involved injuries, none of which occurred after 2001, three years before the speed humps were installed
- While there are few accidents, 67% of those which occurred after 1995 were concentrated in two areas: 1) the horizontal and vertical curve area on Wagon Train Drive between Toro Street and Cuatro Cerros Trail; and 2) the horizontal curve area on Wagon Train Drive and Stagecoach Road between Running Water Circle and Via Posada.

Speed Humps Impacts

- Speed humps in Albuquerque were found to reduce the rate of injury accidents by about 6% and the overall accident rate by about 7%.
- Less than 1% of injury accidents in Albuquerque involve fatalities.
- Assuming 1.5 traffic accidents per year, the speed humps in Four Hills would prevent only about three or four injuries (3.4 injuries) and no deaths (0.024 deaths) over 50 years.

Fatality Increase Due to Speed Humps Involving Cardiac Arrest

- Because of its high proportion of the aged, the general Four Hills area (Census Tract 7.10) population is 40% more susceptible to cardiac arrest.
- Cardiac arrest requires rapid treatment as brain damage occurs after three minutes and the likelihood of survival diminishes rapidly after five minutes; a delay of even a fraction of a minute significantly decreases the chances of survivability.
- The American Heart Association's Survivability Curve for intervention in sudden cardiac arrest was applied to the entire area that would be served by the new fire station on Via Posada and impacted by the existing speed humps. The impact area was sub-divided into 48 zones, each coded for travel time from the fire station at 30 mph, for the number of speed humps that emergency vehicles would have to traverse en route, and for its population. The Survivability Curve model was then applied to gauge the number of fatalities induced by speed hump delay. The impact area consists of Four Hills Village, Winterwood Park, and the eastern portion of Tijeras Arroyo south of Singing Arrow Park.
- Using data developed by the Portland, Oregon Fire Department, fire trucks would be delayed an average of 4.8 seconds per speed hump while the smaller rescue squad vehicles would be

delayed an average of 2.6 seconds per speed hump. The average emergency vehicle would be delayed 4.0 seconds per speed hump.

- Under existing conditions but with a new fire station on Via Posada with 21 speed humps in the impact area, the average emergency vehicle would go over 5.3 speed humps incurring 21 seconds of delay. If the Southeast Detour via Wagon Train Drive is used, the average emergency vehicle would go over 4.0 speed humps incurring 16 seconds of delay.
- A conservative estimate of delays due to the existing speed humps would be 18.7 additional fatalities (with a standard deviation of 11.7) in the Four Hills impact area over 50 years with a new fire station to be sited on Via Posada. This is about one additional death every two and a half years or about 800 times the lives estimated saved by the speed humps.
- Delays due to speed humps under the recommended plan would reduce additional fatalities to 7.8 (with a standard deviation of 11.8) over 50 years or about 300 times the lives estimated saved by the speed humps with the new fire station. This reduction would be because most of speed humps on primary emergency routes would be eliminated. Were all speed humps removed, there would be no additional fatalities due to delay.
- Without the new fire station on Via Posada, emergency service from Fire Station #12 would take longer to reach the Four Hills and overall fatalities would be higher, with the impact of the speed humps only adding to the long trip. Therefore, there would be fewer fatalities attributable to speed hump delay.
- Switching emergency service from Fire Station #12 to a new station on Via Posada would reduce the trip to Four Hills by over a mile with the faster response estimated to save nearly 130 lives over 50 years (with a standard deviation of 10.3).

Other Emergency Medical Problems

- Delays induced by speed humps would tend to increase the spread of fires, increasing the likelihood of burns and damage to lungs.
- Because of its high proportion of the aged, the general Four Hills area (Census Tract 7.10) population is 52% more susceptible to stroke.
- Delays induced by speed humps would tend to increase the damage from stroke, drowning, hypothermia, heat stroke, heat exhaustion, seizures, septic shock, burns, drug overdose, and reactive airway disease.

More Limited Use of Speed Humps

- Speed humps have a long distance "shadow" effect in reducing speeds up to 3,500 feet away and were found to do so by 2-11% in Four Hills Village. Therefore, a wider spacing of speed humps would also be effective in restraining vehicle speeds.
- It is widely recommended that speed humps should not be employed on primary emergency response routes such as Stagecoach Road or Wagon Train Drive.
- It is recommended by many jurisdictions that speed humps should not be employed on bus routes, a point applicable to parts of Stagecoach Road and Warm Sands Drive.
- It is also recommended by many jurisdictions that speed humps should not be employed on collector or major local routes. Many jurisdictions have guidelines that they should not be

placed on routes with weekday volumes exceeding 3,000 vehicles, a level exceeded on Stagecoach Road as far east as Warm Sands Drive and on Wagon Train Drive at Via Posada.

Alternatives to Speed Humps

- Many other measures have been proven to be effective at reducing speeds or reducing accidents or both. While each is generally less drastic than speed humps are in reducing speeds, the cumulative effect of employing several of these measures should result in keeping speeds at acceptable levels and at making drivers more alert and safer.
- The re-striping already implemented in the southern sections of Stagecoach Road and Wagon Train Drive achieved a slight reduction in speed even where traffic was moving along very near the speed limit to begin with.
- The perception by motorists of a narrower roadway by re-striping generally tends to reduce speeds and make driving a bit safer.
- The use of bulb-outs (also known as chokers, neckdowns, or curb extenders) also makes the street narrower and generally results in speed reduction.
- Two studies have demonstrated that the use of bulb-outs makes streets safer, with dramatic reductions in accident rates relative to sites without these devices.
- Raised median islands also make streets narrower, generally resulting in a reduction of both accidents and speeds.
- Transverse rumble strips and optical speed bars (transverse lines across the road) have also been found to cause speed reduction and promote safety.

RECOMMENDATIONS

The following measures are recommended for the affected roadway sections in Four Hills so as to reduce delay to emergency vehicles while simultaneously retaining or adding safety features that would tend to slow general traffic and foster driver safety:

- Remove 10 of the 15 speed humps on Stagecoach Road and Wagon Train Drive and 2 of the 6 speed humps on Warm Sands Drive.
- Under the recommended plan with a new fire station on Via Posada and nine speed humps in the impact area, the average emergency vehicle would go over 2.0 speed humps incurring eight seconds of delay. If the Southeast Detour via Wagon Train Drive is used, the average emergency vehicle would go over 1.7 speed humps incurring seven seconds of delay.
- None of the speed humps recommended for removal are in the two problem sections where 75% of all vehicles involved in accidents have experienced collisions.
- To address one of the two prime problem areas, install two raised median islands in the curve on Wagon Train Drive between Toro Street and Cuatro Cerros Trail while retaining the one speed hump there.
- To address the other prime problem area, install a raised median island in the curve on Wagon Train Drive and Stagecoach Road between Running Water Circle and Via Posada

along with enhanced signage and delineation (including reflectors, mirrors, and striping) on this curve while retaining both speed humps there.

- Add measures to slow traffic on the west part of Stagecoach Road between the "Y" at Four Hills Road and the western end of Lamp Post Circle by installing two raised median islands there, with a bulb-out just west of the "Y".
- On the eastern part of Stagecoach Road between the "Y" and Four Hills Court, install another bulb-out just east of the "Y" while retaining the speed hump east of Four Hills Road.
- Extend the re-striping already in place on the southern sections of Wagon Train Drive and Stagecoach Road onto all of the affected street sections.
- Consider installing transverse rumble strips at intervals along the affected street sections, subject to an examination of noise levels.
- Install optical speed bars at approaches to the curve in the northwest section of the roadway.
- Prior to the opening of the new fire station on Via Posada, ensure that emergency vehicles can unlock the metal gate now barring through movement on Calle Verda to permit faster emergency vehicle access to the neighborhood to the north.
- At the Four Hills Road and Stagecoach Road North intersection (the "Y"), extend the sidewalk along the western side of Four Hills Road through the intersection, tapering out northeast of Lamp Post Circle.
- Also at the "Y" intersection, add arrow signs and painted arrows on the pavement to better delineate the inbound left turn movement and add "Merge" signs to warn of the merge between the two inbound turning movements.
- At the Four Hills Road and Stagecoach Road South intersection (by the Country Club), trim the bushes to ensure adequate sight distance to and from the east while also adding arrow signs and painted arrows on the pavement to better delineate the inbound left turn movement and add "No Entry" and "Merge" signs to prevent collisions.
- The City should consider re-classifying Four Hills Road north of Stagecoach Road as a Minor Arterial and re-classifying Stagecoach Road and Wagon Train Drive as Minor Collector streets.
- The ABQ Ride #1 Juan Tabo bus route should not operate on Stagecoach Road and Warm Sands Drive because of the presence of speed humps there.
- The City might consider a general policy of de-centralized emergency medical response service from more stations to reduce response times and, in areas where speed humps have been allowed to proliferate, make greater use of lighter rescue squad vehicles.
- The City might monitor before and after speeds and accident trends on Stagecoach Road and Wagon Train Drive if the recommended plan in this report is adopted.
- The City should adopt guidelines not to install speed humps where weekday volumes are less than 500 vehicles a day or greater than 3,500 vehicles a day or on collector or primary emergency response routes or where 85th percentile speeds do not exceed 30 miles per hour.

Introduction

PROJECT DESCRIPTION

The focus of this report is the impact of the speed humps that were installed in the autumn of 2004 and later in the Four Hills neighborhood of Albuquerque along Stagecoach Road, Wagon Train Drive, and Warm Sands Drive. The report examines the overall public safety impact of speed humps in the Four Hills neighborhood. This includes an examination of the accident reduction potential of the speed humps as well as fatalities that might be attributable to speed humps because of the delay they add to emergency vehicle trips. The overall effect on fatalities was quantified for a 50-year period for this impact area. The concerns about the speed humps is the extent to which they delay emergency access to the Four Hills Village neighborhood and adjoining neighborhoods south of the Tijeras Arroyo that receive emergency service along the same route.

The Four Hills neighborhood is an exclusively residential area with no retail or commercial buildings and no schools, located in the outlying, southeast corner of Albuquerque just north of Kirtland Air Force Base. It is physically separated from the rest of the city, including nearby neighborhoods, by the Tijeras Arroyo and by a lack of road connections to the east, west, or south. Four Hills Road is presently its only outlet and the route all emergency vehicles must take to reach this area .The impact area had a 2000 population of 3,280 people. The need for emergency vehicle access to the impact area is especially critical as its proportion of those aged 65 or older is about twice the national average such that the incidence for sudden cardiac arrest or stroke would be much higher.

The study area is shown in Figure 1. The roads that had speed humps installed on them are shaded on Figure 1. Both Stagecoach Road and Wagon Train Drive form what amount to collector streets in Four Hills, though they are designated only as major local streets. They collect traffic from the local streets and deliver it to Four Hills Road, a wide, designated collector route that links this neighborhood to Central Avenue (NM 333), Tramway Boulevard (NM 556), and the Coronado Freeway (Interstate 40). These three major routes are linked to Four Hills Road about 4,500 to 5,000 feet to the north of Stagecoach Road. Near the junction of these roads is the nearest shopping center. The great majority of traffic in and out of the Four Hills neighborhood must go by way of Four Hills Road and must go over the series of speed humps on Stagecoach Road and Wagon Train Drive. Little traffic goes over the speed humps on Warm Sands Drive, a side street where the humps were installed largely to thwart any traffic diverting from Stagecoach Road.

This analysis focused on the speed hump's impact to emergency vehicle service from the planned new Albuquerque Fire Department station, to be located near what is now the western end of Via Posada, just east of Juan Tabo Boulevard. Emergency vehicle trips from the new fire station to the impact area would have to travel on either Stagecoach Road or Wagon Train Drive. Both routes now have a total of 15 speed humps on them: twelve to the east and three to the south. These are the only available emergency routes from the planned new fire station on Via Posada to Four Hills Village, Winterwood Park, or the eastern portion of the Tijeras Arroyo neighborhood, located just west of Four Hills Road.

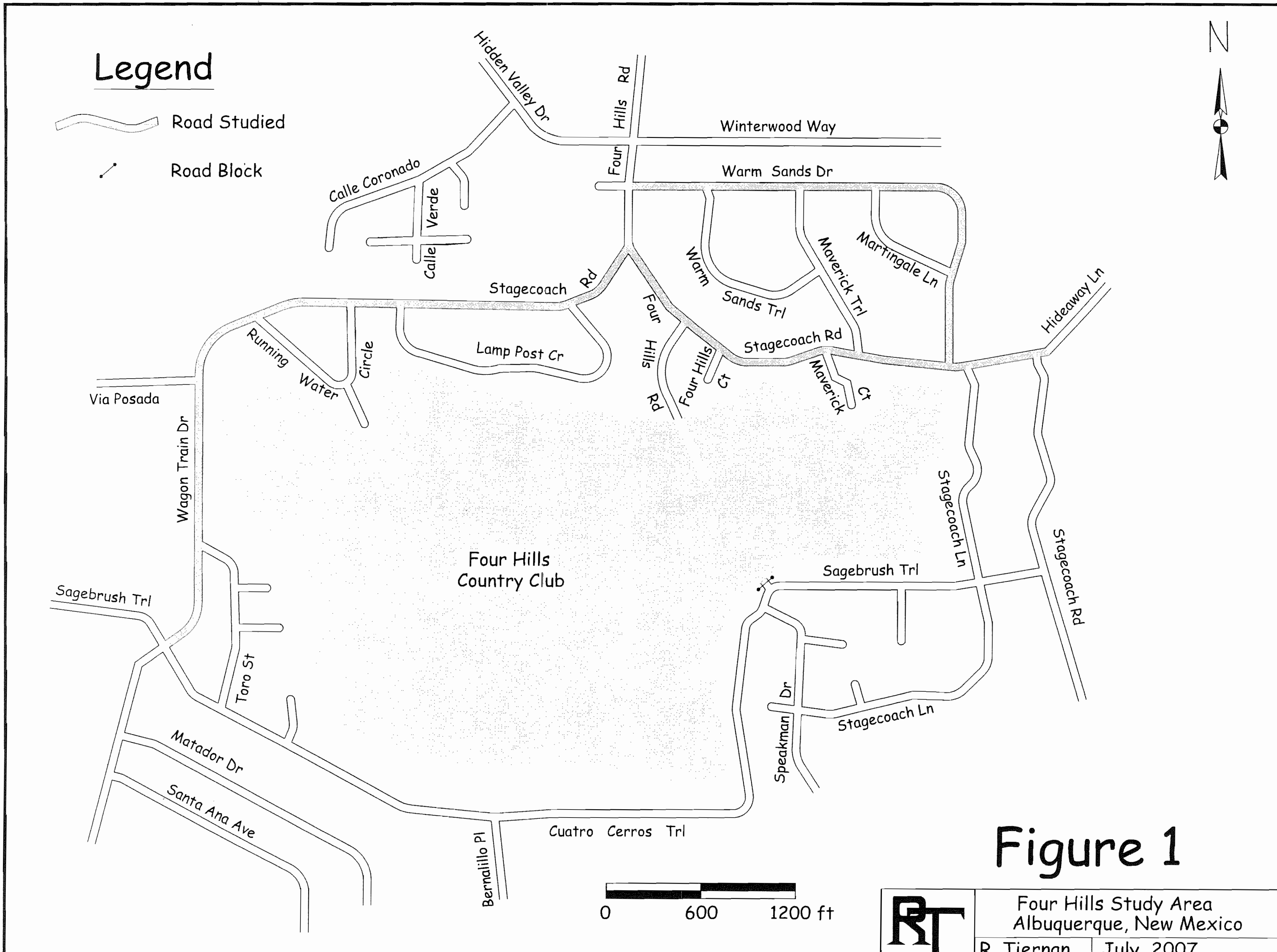

Figure 1

RT	Four Hills Study Area Albuquerque, New Mexico	
	R. Tiernan	July 2007

SCOPE OF STUDY

The study was intended to be a review of the speed humps currently employed in the Four Hills as to design, spacing between humps, spacing related to intersections and intersection controls, design speed, and impact on driving. The local street system containing the speed humps was reviewed with regard to roadway width, geometry, lateral clearance space, traffic control, access, pedestrian and bicyclist features, speeds, safety, sight distance, accident rates, and traffic volumes. Consideration was given to speed reduction, changes in accident rates, delay to emergency vehicles, alternative traffic calming devices, neighborhood traffic control, and neighborhood quality of life issues in trying to examine the overall public health and safety benefits of the speed humps.

This study also examined geometrics, operations, and safety throughout the speed hump portions of Stagecoach Road and Wagon Train Drive, especially conditions and current traffic turning volumes at the following intersections:

- Four Hills Road and Stagecoach Road (North "Y" Intersection),
- Four Hills Road and Stagecoach Road (South Intersection by Country Club),
- Stagecoach Road and Warm Sands Drive,
- Stagecoach Road and Stagecoach Lane,
- Wagon Train Drive and Via Posada, and
- Wagon Train Drive and Sagebrush Trail/Cuatro Cerros Trail.

Meetings were held with Four Hills neighborhood citizen groups favoring and opposing the speed humps and with City officials of the City Council and the Traffic Engineering Division. The report addresses the following issues:

- Traffic safety of the affected roadway sections in Four Hills;
- Traffic safety problem areas along the affected route,
- Traffic safety impact of speed humps in Albuquerque,
- Estimated prevention of injuries and deaths due to the speed humps in Four Hills,
- Peak hour turning volumes at key intersections,
- Problems experienced by emergency medical services with speed humps.
- Medical opinions on delays and emergency medical treatment
- Estimated fatalities due to speed hump delay,
- Safety measures that might be undertaken other than speed humps,
- Speed reduction and accident reduction found with such measures, and
- Conclusions and recommendations.

Existing Conditions

The existing conditions and those that have prevailed in the Four Hills study area were examined to obtain the operational, geometric, and safety characteristics of the affected roadways. The study site was visited and inventoried in April 2007. At that time, information was collected regarding site conditions, land use, existing traffic operations, accidents, prevailing speeds, neighborhood opinions, and transportation facilities in the study area.

TRANSPORTATION FACILITIES

Roadway Facilities

As indicated in Figure 1, the study area contains three local streets that now have speed humps on them. These are Stagecoach Road west of Stagecoach Lane, Wagon Train Drive from where it becomes Stagecoach Road at the northwest corner of the neighborhood to where it intersects Sagebrush Trail and Cuatro Cerros, and Warm Sands Drive between Four Hills Road and Stagecoach Road. Stop signs are used exclusively for traffic control in this area. The existing traffic control devices in the study area are shown in Figure 2.

Both Wagon Train Drive and Stagecoach Road in the study area are curbed, two-lane major residential streets, functioning as minor collectors. They each have a posted speed of 25 mph in both directions, 20 mph at the northwest curve. They are both about 40 feet wide in pavement, unstriped, without designated shoulders, bicycle lanes, and largely without sidewalks. Warm Sands Drive is similar in these characteristics. Linking the Four Hills neighborhood to the north is Four Hills Road, a two-lane collector road which transitions into four lanes just north of Warm Sands Drive. It has curbing and sidewalks north of Stagecoach Road. Table 1 summarizes the roadways included in this analysis with characteristics in or near the affected street sections.

Stagecoach Road and Wagon Train Drive funnel local traffic onto Four Hills Road, which, in turn, connects the neighborhood to the Four Hills shopping center at Wenonah Avenue and Tramway Boulevard and to Central Avenue (four to five-lane NM 333), Tramway Boulevard (four to five-lane NM 556), and the Coronado Freeway (six-lane Interstate 40). These three major routes provide access to the rest of the metropolitan area.

Table 1
Existing Transportation Facilities and Roadway Designations

Roadway	Classification	Cross Section	Speed Limit	Side-walks	Bicycle Lanes	On-Street Parking
Four Hills Road	Collector	2-lane	25 mph	No	No	No
Stagecoach Road	Major Local	2-lane	25 mph	No	No	Yes
Wagon Train Drive	Major Local	2-lane	25 mph	Partial	No	Yes
Warm Sands Drive	Local	2-lane	25 mph	No	No	Yes

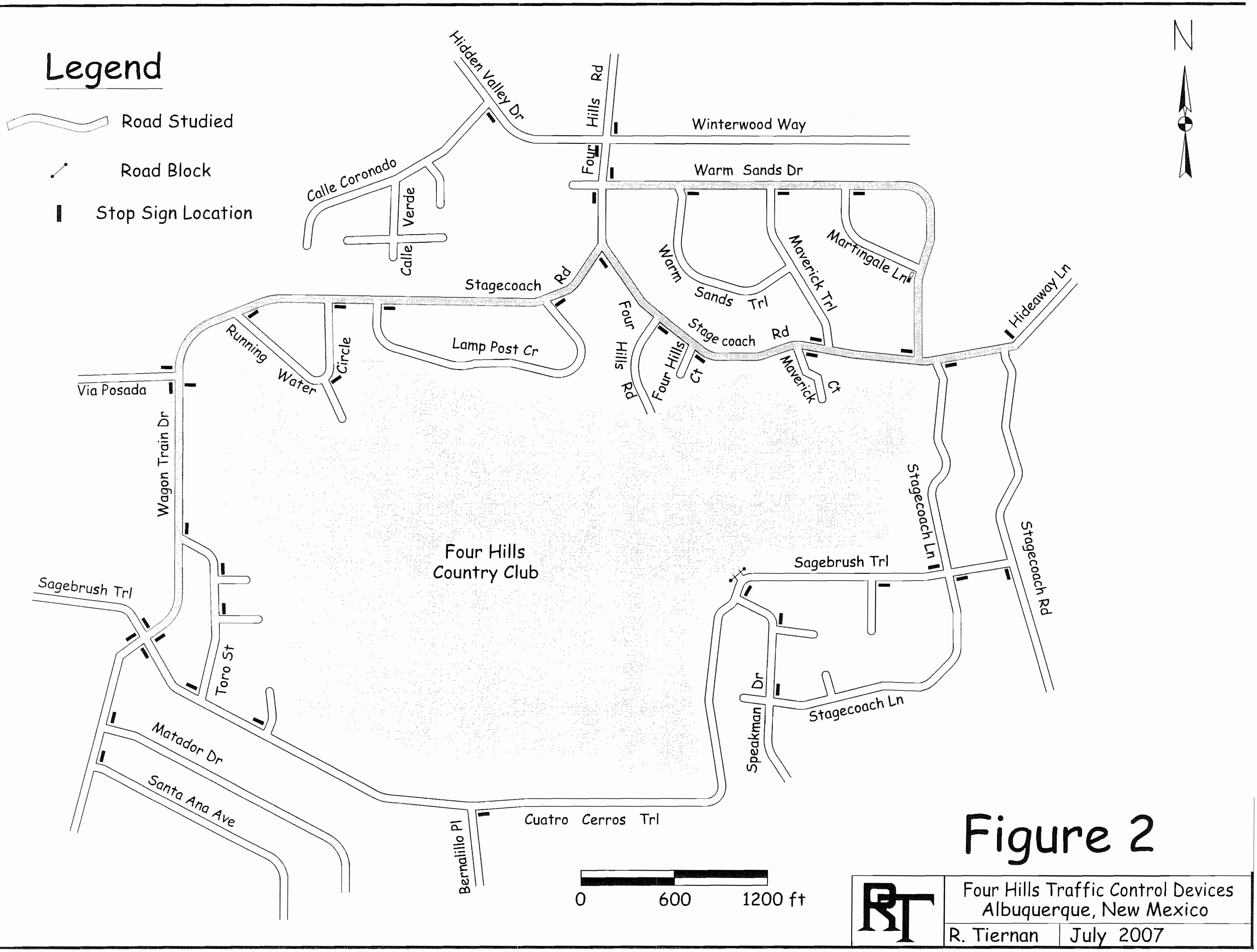

Figure 2

Four Hills Traffic Control Devices
Albuquerque, New Mexico

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Speed Humps

There are 21 speed humps within the study area, fifteen on Wagon Train Drive and Stagecoach Road, and six on Warm Sands Drive. The former were installed in the autumn of 2004 while those on Warm Sands Drive were installed in May 2005. These speed humps are the subject of this study. Not dealt with in this study are three other speed humps, considerably to the southeast, on Stagecoach Road at La Tuna, Pedregoso, and Arenas Places. Figure 3 identifies the location of speed humps in the study area. Nearly all of these are spaced between 300 and 500 feet apart. The speed humps on Wagon Train Drive and Stagecoach Road are 18 feet wide and extend across the whole road.

Pedestrian and Bicycle Facilities

Field observations within the study area revealed light pedestrian and bicycle activity along the affected streets with little pedestrian crossing activity. There are no designated bicycle lanes; narrow sidewalks exist in only a few places on the west side of the study area. There are no sidewalks near the key "Y" intersection connecting to the sidewalks on either side of Four Hills Road north of the study area. There are no schools in the neighborhood nor other land uses that would generate significant pedestrian and bicycle activity.

Transit Facilities

There is only one public bus route which operates anywhere in the affected street network. That is the #1 Juan Tabo Boulevard route, which makes a loop on Warm Sands Drive, Maverick Trail, Stagecoach Road, and Four Hills Road over seven speed humps before heading to Wenohah and Tramway. This service is provided by the City of Albuquerque Transit Department (ABQ Ride). This service is limited, however, to only four runs daily. School buses also operate on all the streets that have speed humps.

Roadway Weekday Traffic Volumes

The weekday traffic volumes used in this analysis were based on manual turning movement and classification counts taken 4:00-6:00 p.m. in April 2007 at six intersections in the study area. Profiles of traffic volumes by hour taken by Automatic Traffic Recorder (ATR) tubes over the course of an entire day were provided by MRCOG for a point on Four Hills Road north of the study area. From the above-cited data, weekday p.m. peak hour and 24-hour traffic volumes were developed. Figure 4 shows estimated weekday 24-hour volumes. These show daily volumes highest at the "Y" but receding further south and east, away from the "Y". The weekday p.m. peak hour turning movements are shown in Figure 5. These show the same pattern with the "Y" intersection having the highest volumes, especially in turns. Volumes at all intersections are low and suggest a high level of service with small delays.

The following intersections were counted in April 2007 during the weekday p.m. peak hour:

- Four Hills Road and Stagecoach Road (North "Y" Intersection),
- Four Hills Road and Stagecoach Road (South Intersection by Country Club),
- Stagecoach Road and Warm Sands Drive,
- Stagecoach Road and Stagecoach Lane,
- Wagon Train Drive and Via Posada, and
- Wagon Train Drive and Sagebrush Trail/Cuatro Cerros Trail.

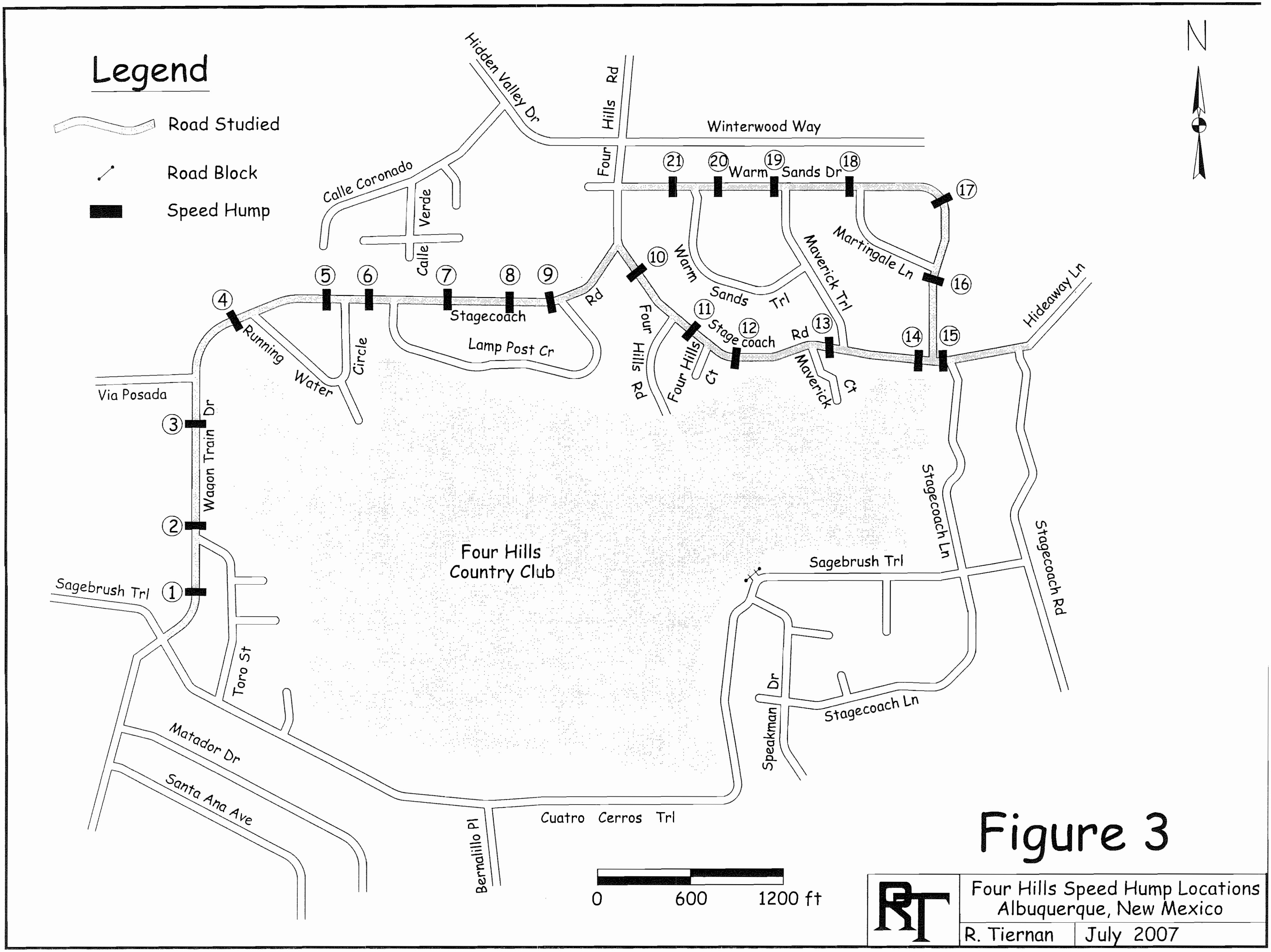

Figure 3

Four Hills Speed Hump Locations
Albuquerque, New Mexico

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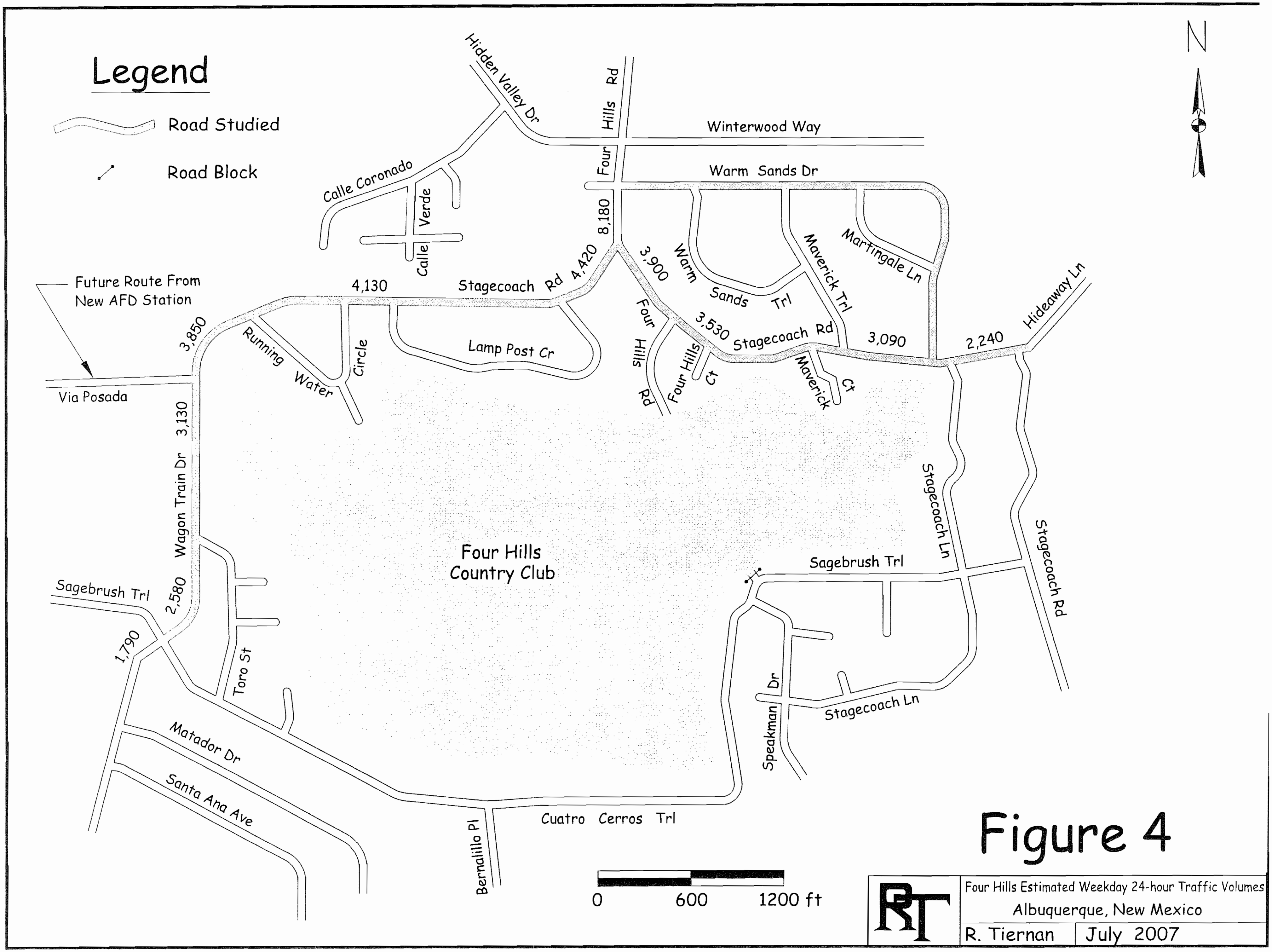

Figure 4

Four Hills Estimated Weekday 24-hour Traffic Volumes
Albuquerque, New Mexico
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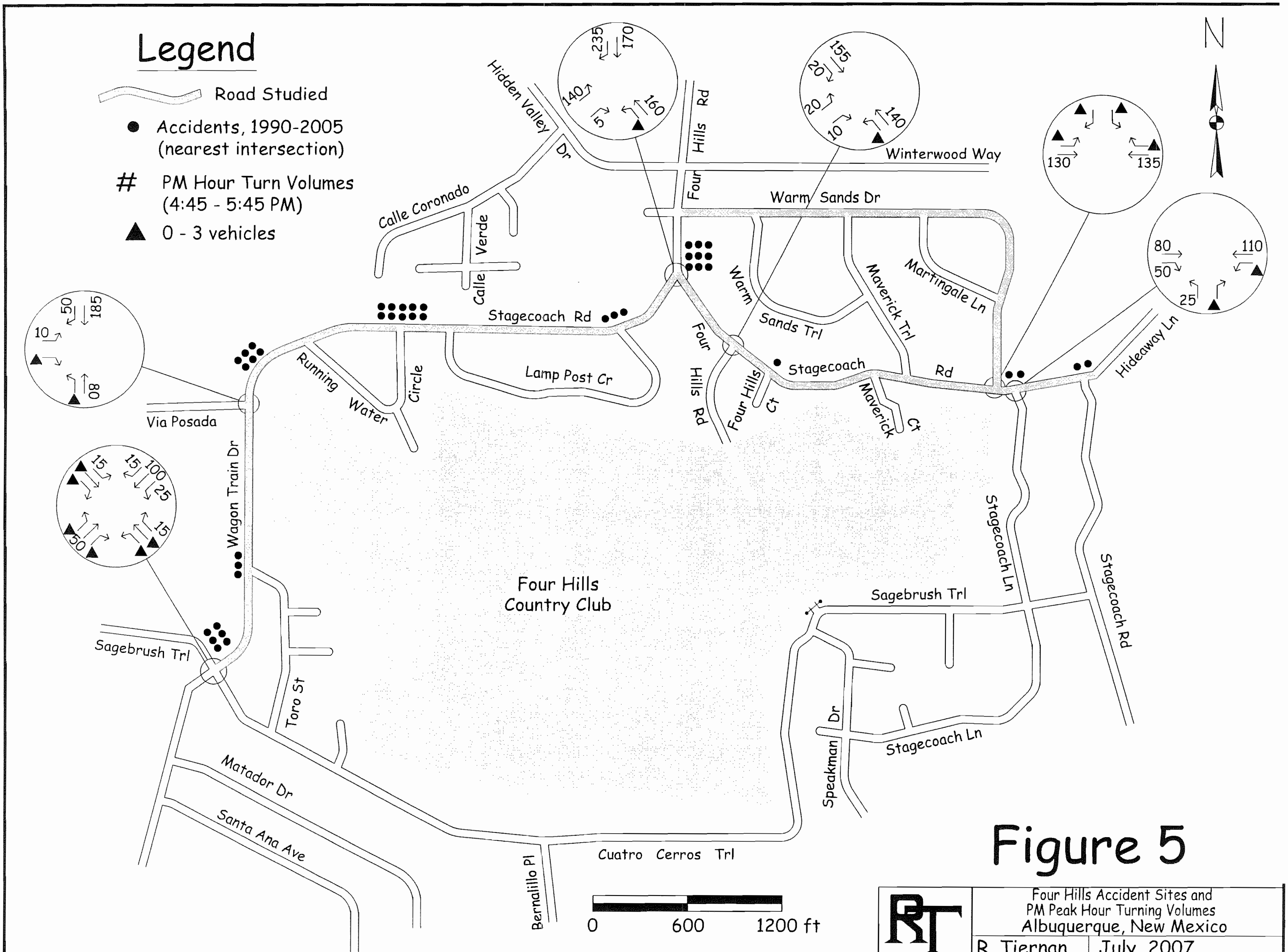


Figure 5

Four Hills Accident Sites and PM Peak Hour Turning Volumes
Albuquerque, New Mexico
R. Tiernan | July 2007

TRAFFIC SAFETY

Traffic safety problems in the study area have been heavily concentrated in just two curve sections, located in the northwest and southwest corners of the study area. Figure 5 shows the generalized location of traffic accidents during 1990-2005 on the affected streets. The two curve sections which have sustained the lion's share of local accidents are:

- Wagon Train Drive between Toro Street and Cuatro Cerros Trail, a section with both horizontal and vertical curvature; and,

- Wagon Train Drive and Stagecoach Road between Running Water Circle and Via Posada, a section with a sharp horizontal curvature,

About 67% (10 of 15) of all the1996-2005 accidents occurred in these two curve areas. The accidents in these two curve areas involved 78% of all vehicles involved in accidents during the same period. During 1990-2005, 75% of all vehicles involved in accidents on the study sections of Stagecoach Road and Wagon Train Drive were in collisions that occurred in these two curve areas. Of all eight injury accidents that occurred during 1990-2005 in the same sections, 75% were in these same two curve areas. However, both sections have experienced a considerable decline in accidents since all-way stops were created at the Via Posada and Cuatro Cerros Trail intersections with Wagon Train Drive.

Speed was a factor in only a minority of all study area accidents. Only 23.8% (10 of 42) traffic accidents occurring between 1990 and 2005 involved either "*excessive speed*" or speed "*too fast for conditions*" given as one of the contributing factors that caused the accident. Only 20% of these speed-related accidents involved injuries. None of these have occurred since 2001, over three years before the speed humps were installed

Few accidents have involved injuries. Only 19% (8 of 42) of the traffic accidents that occurred between 1990 and 2005 involved injuries. Most of these injuries were minor, 78% of them categorized as Class C, which is defined as "*Complaint of injury but none visible*". None of these injuries were classified as Class A, defined as "*Incapacitating injury*" or were fatalities.

Traffic accidents on the affected roadway sections have been in decline. Figure 6 shows the long term accident trend from 1990 to 2005 in the study area. The trend line, best represented by a five-year average, has been going down since the early 1990's. Traffic accidents on the affected roadway sections have averaged only 1.5 traffic accidents per year since 1995 and averaged only 0.5 accidents per year since 2001. In contrast, during 1990-1994, traffic accidents in the same sections averaged 4.6 per year.

The reasons for this decline in accidents on these local streets include the following.

- Nationwide trends, prevalent for decades, towards greater safety awareness and declining accident rates,
- Demographic changes in the Four Hills neighborhood, including the maturing of population and decline in the number of young drivers,
- The installation of all-way stops on Wagon Train Drive at Cuatro Cerros Trail and, more recently, at Via Posada,
- High local consciousness of traffic safety on the affected street sections.

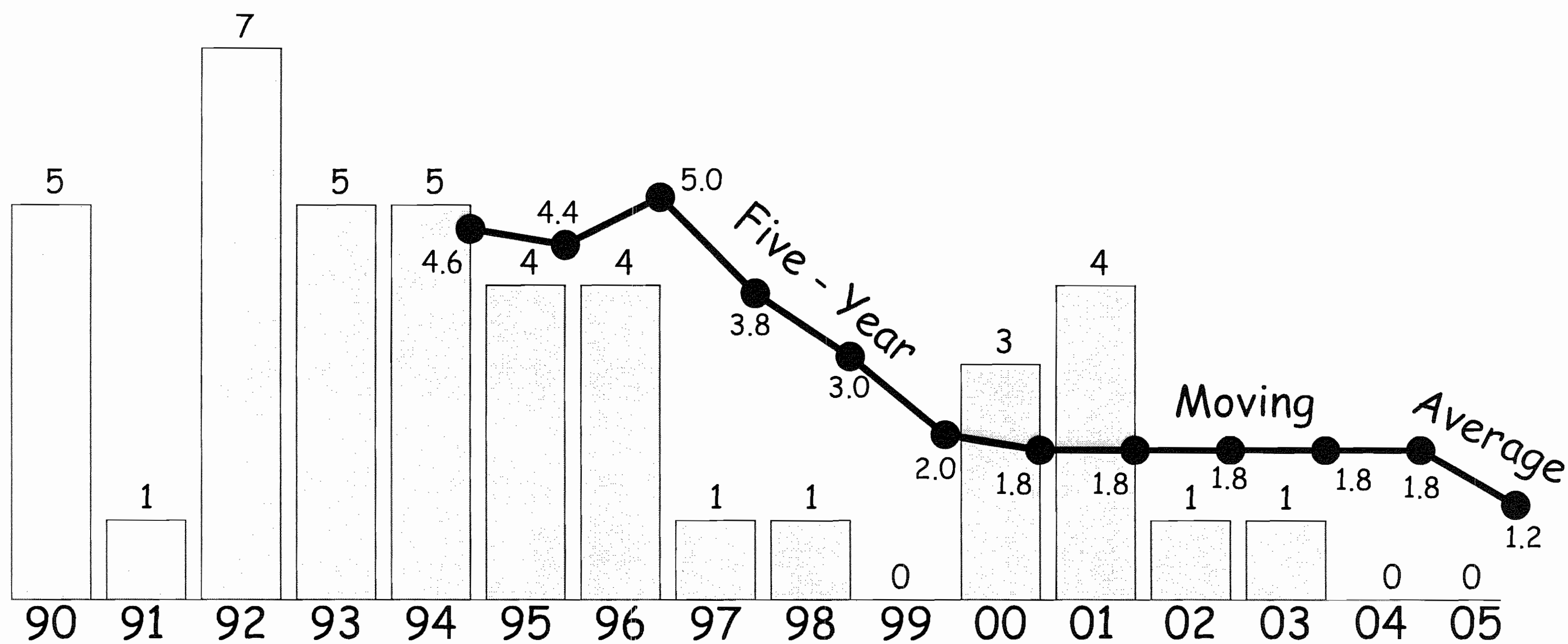


Figure 6

Four Hills Accident Trend, 1990-2005 Albuquerque, New Mexico	
R. Tiernan	July 2007

Speed Hump Impacts

Speed humps have been used widely within the City of Albuquerque and other jurisdictions to reduce the speed of traffic traveling on residential streets. They have been perceived as a measure that would enhance safety, foster compliance with speed limits, and improve the quality of life. The City Traffic Engineering Division uses a point system of criteria to assess the potential employment of speed humps on any given street (Reference 1). These criteria are shown below. None of the speed humps installed in the Four Hills area would qualify under the last three criteria. They would qualify only as to the first two criteria: volume and speed, though volumes exceed the normal range.

- Average daily traffic on street sections, especially 1,500 to 3,000 vehicles per day,
- A high proportion of vehicles traveling over the signed speed limit,
- The presence of an elementary or middle school,
- The presence of other significant generators of pedestrian traffic, including high schools, elderly housing, or parks, and
- A significant number of speed-related accidents within the past three years.

ASSESMENT OF SPEED HUMP IMPACTS

Traffic Volumes and Speeds, Citywide

The speed humps installed on the affected streets in the Four Hills study area have been in too short a time to assess their safety impact. In addition, the number of accidents on any street section can fluctuate widely (see Figure 6) such that an accurate long term trend may not be ascertained for a decade or longer. To estimate the likely safety impacts of speed humps in the Four Hills, generalized impacts derived from speed hump street sections throughout the City of Albuquerque were employed.

Several hundred speed humps have been implemented in the City of Albuquerque since at least 1999. As of April 2007, the City Traffic Engineering Division had listed 272 street sections (1999-2007) on which speed humps had been installed and for which they had developed comprehensive before and after speed and volume data. To derive estimated accident reduction likely for the Four Hills, this comprehensive citywide data was used. A large sample of street sections with speed humps was chosen. For this sample of street sections, not only was volume and speed data used, but also four full years of accident data. Street sections on which speed humps were installed prior to 2000 were excluded from consideration; those installed after February 2003 were also excluded because accident data was only available to the end of 2005, with that year subject to revision. From the list of 272 street sections, a total of 93 street sections were chosen which could be identified on which speed humps had been installed in 2000, 2001, 2002, and early 2003. These street sections selected for analysis represented a 34% sample of the speed hump street sections on the City Traffic Engineering Division list.

The results of this analysis are shown on Table 2. These show aggregate results obtained by adding together data from all 93 speed hump street sections. Results for individual street sections vary widely and are misleading because of their small sample size and the unique circumstances prevailing on many streets. As can be seen in Table 2, where speed humps were installed, there was an overall decline in traffic volumes as traffic tended to divert away to other streets without speed humps. This trend has been well established by data from many other speed hump impact studies and reflects the tendency of drivers to seek the fastest and most convenient route. The aggregate decline in weekday traffic volumes was 7.5%. Average speeds also declined 11.5%, from 25.7 to 22.7 miles per hour. Another key measurement of speed is the 85th percentile of speed. Average 85th percentile speeds declined 10.9%, from an average of 31.9 to an average 28.4 miles per hour. These speed reduction trends have also been well established in other speed hump studies. Speed humps are clearly effective at reducing speeds. Similar reductions in both traffic volumes and speeds are also reflected in City Traffic Engineering Division data on the rest of the 272 street sections on which speed humps have been installed.

Table 2
Impact of Speed Humps in Albuquerque, Summary, Before and After Data From 93 Street Sections Where Speed Humps Installed

Component of Change	Conditions		Change	
	Before	After	Number	Percent
Volume	113,865	105,293	-8,572	-7.5%
Average Speed *	25.7	22.7	-3.0	-11.5%
85th % Speed*	31.9	28.4	-3.5	-10.9%
Accidents	617	532	-85	-13.8%
Accident Rate**	5.42	5.05	-0.37	-6.8%
Injury Accidents	233	202	-31	-13.3%
Injury Accident Rate	2.05	1.92	-0.13	-6.2%
Pedestrian Accidents	6	10	+4	+67%***

** Speed in miles per hour. The 85th percentile speed is the speed that 85% of vehicles are moving slower than and 15% faster than.*
*** Accident Rate refers to the number of accidents divided by the traffic volume.*
**** The pedestrian accident data here is based on such a small sample size that these results cannot be considered reflective of general pedestrian safety tendencies.*

How much speed reduction is likely to be obtained with the installation of speed humps varies by the speed on the street prior to implementation. The City Traffic Engineering data on street sections where speed humps have been installed was analyzed according to the "before" speed of the street. Street sections were sub-divided into four categories: those with 85th percentile speeds below 27 miles per hour, those with 85th percentile speeds between 27 and 30 miles per hour, those with 85th percentile speeds between 30 and 35 miles per hour, and those with 85th percentile speeds between 35 and 45 miles per hour. Of the 272 street sections where speed humps had been installed prior to April 2007, such speed data was available for 238 of them.

The results of this analysis are shown on Table 3. These show average changes in speed for each of the four speed-related categories of street sections. As can be seen in Table 3, where 85th percentile "before" speeds were highest, so was speed reduction. Where 85th percentile "before" speeds were lowest, speed reduction was also lowest.

Where 85th percentile "before" speeds were under 27 miles per hour, the "after" speeds with speed humps actually increased. Where speeds had been between 27 and 30 miles per hour, the "after" speeds decreased on average less than one mile per hour. However, where 85th percentile speeds had been between 30 and 35 miles per hour, the "after" speeds decreased by an average of 4.4 miles per hour or 13.5%. Where 85th percentile speeds had been between 35 and 45 miles per hour, the "after" speeds decreased by an average of 7.2 miles per hour or 19.4%.

Table 3
Speed Change of 85th Percentile Speed, Summary by Speed Range Where Speed Humps Installed, 1999-2007

Speed Range	Sample	MPH Change	Percent Change
Below 27 MPH	24	+0.5	+2.0%
27 to 30 MPH	50	-0.8	-2.8%
30 to 35 MPH	107	-4.4	-13.5%
35 to 45 MPH	57	-7.2	-19.4%

Accident Impact Citywide

The safety impact of the speed humps is also shown on Table 2. The safety impact involved was determined by comparing two years of accident data prior to the implementation of the speed humps with two years of accident data subsequent to the implementation of the speed humps. This comparison produced a before and after picture of the impact of speed humps. Accident data was obtained by City Council staff from the data base compiled by the University of New Mexico's Division of Government Services for the New Mexico Department of Transportation. The number of accidents on these 93 street sections was found to have declined 13.8%, from 617 to 532 accidents. Accidents involving injuries declined by 13.3%, from 233 to 202. The tendency for accidents to decline after speed humps have been implemented has been found in many studies. The number of pedestrian accidents actually increased. However, this was from such a small sample size that these results cannot be considered indicative of a general trend. Speed humps do not seem to reduce pedestrian accidents and, as shown in this sample, pedestrian accidents can actually increase after speed hump installation.

As shown on Table 2, while accidents declined 13.8% after speed hump implementation, the aggregate accident rate declined by only 6.8%. Accident rate is a key measure of relative safety and is defined as the number of accidents per volume of traffic. Effectively, it is the probability of a driver being involved in an accident on a given street. It can be seen that roughly half of the reduction in accidents can be attributed to the reduction in traffic volumes. There are fewer accidents largely because there are fewer vehicles traveling on these streets, not because the streets are very much safer.

Results obtained in this study are similar to those obtained by a 1998 study of 33 street sections on which speed humps (referred to as "bumps") had been installed in Portland Oregon (Reference 2). That study "*found that there is a five percent reduction in crashes per ADT (Average Daily Traffic) after speed bumps were installed*" and noted that this "*change is not statistically significant*". The Portland study found *"that the reduction in crash frequency is mainly due to the reduction in traffic volumes on* *treated streets"*. Along with the 5% reduction in accident rates, the Portland study found that after speed hump installation, weekday traffic volumes had declined of 28% (7.5% for the Albuquerque sample) and average 85^{th} percentile speeds had declined 7.2% (10.9% for Albuquerque). Before and after data for nine more recent Portland speed humps (on the current City of Portland website under "Collisions on Traffic Calmed Streets") show an average accident rate reduction of only 3%.

To illustrate the difference between the sheer number of accidents and the accident rate, consider the following example. On Street X there are 10 accidents per year and a volume of 1,000 vehicles per day. Speed humps are installed on Street X. After the speed humps are installed, the number of accidents decreases to 9 per year while the traffic volume drops to 900 per day. Residents of the street may be pleased with these results because they are seeing less traffic on their street, likely moving at somewhat lower speeds, and there has been a decline in accidents. These are accurate observations. However, there has been no change whatsoever in the accident rate, which remains at 1 accident per 100 vehicles a day. For people driving on this street, including the residents, the street has become no safer. Moreover, let us assume that all streets in the area receive speed humps. The traffic that diverted away to avoid the speed humps no longer has any reason to divert. It would likely resume its original path, returning to the street. As the other streets all have speed humps, diversion would offer no advantage in time or convenience. If the speed humps have caused no change in the accident rate, then the volume would again rise to 1,000 vehicles a day while the number of accidents would likely revert back to10 accidents per year.

For the sections of Wagon Train Drive and Stagecoach Road that have speed humps, the change in the number of accidents and in accident rate would be almost equal. This is because traffic there has virtually nowhere to divert to. Whether there are speed humps or not on these streets, the same traffic has to use them as there is no other way in or out of the Four Hills neighborhood. Therefore, to predict the impact of speed humps on these streets, the likely change in accident rate can be applied. Changes in accident rates on individual street sections can be drastically different because of the small sample size involved. Within the 93 sample street sections for instance, only 41, a minority of the street sections, actually registered a decline in accident rate. In 22 street sections, the accident rate actually went up. In the remaining 30 street sections the accident rate remained unchanged, usually because no accidents had taken place in the two-year periods before or after the speed humps went in.

This analysis of the effect of speed humps on accident rates could be improved upon in the future. To do so would require a comparison of accident rate reduction on streets with humps to a large "control" sample of similar streets without humps or to the total network of local streets within Albuquerque. Within two or three years, sufficient accident data for street sections with humps installed in 2003, 2004, and 2005 would be available. This analysis could then be conducted with a much larger sample size, with three or more years worth of before and after data, and with greater accuracy.

The reason for using a "control" is that accident trends generally can be going up or down regardless of any new features on the roadway network. The accident rate changes measured on the "hump" streets may be more reflective of these general trends than of the impact of the humps themselves. Traffic accident rates have generally been declining in the United States and in New Mexico for many decades. Between 1987 and 2005, for instance, the overall traffic accident rate in New Mexico declined 31.7%, an average of 1.7% per year. During this same period in the United States, the accident rate declined 25.8%, an average of 1.4% per year. Insufficient data for this study prevented any comparison of how significant the accident reduction after speed hump implementation really was. The overall traffic accident rate within the City of Albuquerque has changed little in recent years. It was reported in NMDOT data as 41.2 accidents per capita in 2000 and as 41.3 per capita in 2005.

Traffic Speeds, Four Hills

The City Traffic Engineering Division monitored the speed humps installed on the affected streets in the Four Hills study area for speed, before and after speed hump installation. This data was summarized in a Traffic Engineering Division memorandum (Reference 3) and is shown below in Table 4.

Table 4
Impact of Speed Humps in Four Hills, Summary of Before and After Data, Stagecoach Road and Wagon Train Drive Where Speed Humps Installed

Roadway Point	Average Speed		85th Percentile Speed	
	Before	After	Before	After
Stagecoach Road near Lamp Post Cir	32.5	24.5	37.8	29.0
Stagecoach Road near Maverick Trl	32.8	26.5	38.6	31.4
Wagon Train Drive near Toro Street	29.8	24.4	34.3	29.0
Average	**31.7**	**25.9**	**35.4**	**30.7**
Percent Change	**NA**	**-20.7%**	**NA**	**-19.2%**

- *Speed in miles per hour. The 85th percentile speed is the speed that 85% of vehicles are moving slower than and 15% faster than.*

As can be seen in Table 4, both average and 85th percentile speeds declined significantly with the implementation of speed humps. Average speeds declined from about 30 miles per hour to near the speed limit of 25 miles per hour or over 20%. While the 85th percentile speeds also declined nearly as much, these tended to remain at about 30 miles per hour. Results were quite similar at all three speed survey sites on the affected portions of Stagecoach Road and Wagon Train Drive.

Speed data was also collected for Warm Sands Drive, where six speed humps were installed in May 2005. The average speeds there declined 14.3% from 25.8 miles per hour (virtually at the speed limit) to 22.1 miles per hour (below the speed limit). There was an 11.3% decline in the 85th percentile speeds there, from 31.6 to 28.0 miles per hour. The major effect of installing speed humps on Warm Sands Drive was to reduce traffic volumes there. There was no reason to use Warm Sands Drive as a bypass route after it had been altered by the installation of speed humps. The City's counts showed a decline on Warm Sands Drive west of Maverick Trail from over 800 vehicles a day to about 300 a day after speed humps went in.

ESTIMATE OF DEATH AND INJURY REDUCTION IN FOUR HILLS

The safety impact analysis of 93 speed hump street sections within Albuquerque yielded an accident reduction rate for injury accidents of about 6%. Other speed hump studies have found somewhat higher rates of injury accident reduction. To estimate the injury reduction that speed humps in the Four Hills might cause, a reasonably high estimate of a 10% reduction was used.

In the last 10 years for which accident data is available, there has been an average of 1.5 accidents per year on the affected street sections of Wagon Train Drive and Stagecoach Road in the Four Hills. Applying an estimate of injuries over a 50-year time span, this would amount to 75 accidents over half a century. In the last 10 years, 19% of accidents in the road sections under analysis have involved injuries. However, citywide this is about 38%. For the future, it is assumed that 30% of all Wagon Train Drive and Stagecoach Road accidents would involve injuries. This results in an estimated 22.5 injury accidents that could reasonably be expected in half a century. Traffic accident data shows that in Albuquerque there is an average of 1.5 injuries per injury accident. This results in an estimated 34 traffic-related injuries that could reasonably be expected over a 50-year period. Applying the 10% reduction rate for speed humps to these 34 injuries, the total estimated number of injuries prevented by speed humps in this part of the Four Hills would come to 3.4 injuries over 50 years

A similar estimate can be made for fatality prevention due to speed humps. As determined above, there would be an estimated 22.5 injury accidents that could reasonably be expected in half a century. Traffic accident data shows that in Albuquerque, fatal accidents represent slightly less than 1% of injury accidents. Therefore, 1% of 22.5 or 0.225 fatal accidents could be expected in half a century. There is an average of 1.08 fatalities per fatal accident in Albuquerque. This results in an estimated 0.24 fatalities that could reasonably be expected over 50 years. Applying the 10% reduction rate for speed humps to these 0.24 fatalities, the total estimated number of fatalities prevented by speed humps in this part of the Four Hills comes to 0.024 fatalities over 50 years. This is only 2-3% of one, or likely zero.

Thus, over a 50-year time span, the speed humps on the affected street sections of Wagon Train Drive and Stagecoach Road. can reasonably be expected to prevent three or four injuries and zero deaths.

Without the new fire station on Via Posada, emergency service from Fire Station #12 would take longer to reach the Four Hills. With this longer distance to cover, fatalities would be higher. The additional impact of the speed humps would add to the long trip, however, since the response time itself is so long, there would be fewer fatalities that could be attributable to speed hump delay. Fatalities could be reduced with the removal of speed humps even with existing Fire Station #12 service. However, given the more marginal advantage in response time that would yield, the advantage of doing this would be far less than if emergency vehicle trips originated closer at Via Posada.

Recommendations

The following measures are recommended for the affected roadway sections in Four Hills so as to reduce delay to emergency vehicles while simultaneously retaining or adding safety features that would tend to slow general traffic and foster driver safety:

- Remove 10 of the 15 speed humps on Stagecoach Road and Wagon Train Drive and 2 of the 6 speed humps on Warm Sands Drive.
- Under the recommended plan with a new fire station on Via Posada and nine speed humps in the impact area, the average emergency vehicle would go over 2.0 speed humps incurring eight seconds of delay. If the Southeast Detour via Wagon Train Drive is used, the average emergency vehicle would go over 1.7 speed humps incurring seven seconds of delay.
- None of the speed humps recommended for removal are in the two problem sections where 75% of all vehicles involved in accidents have experienced collisions.
- To address one of the two prime problem areas, install two raised median islands in the curve on Wagon Train Drive between Toro Street and Cuatro Cerros Trail while retaining the one speed hump there.
- To address the other prime problem area, install a raised median island in the curve on Wagon Train Drive and Stagecoach Road between Running Water Circle and Via Posada along with enhanced signage and delineation (including reflectors, mirrors, and striping) on this curve while retaining both speed humps there.
- Add measures to slow traffic on the west part of Stagecoach Road between the "Y" at Four Hills Road and the western end of Lamp Post Circle by installing two raised median islands there, with a bulb-out just west of the "Y".
- On the eastern part of Stagecoach Road between the "Y" and Four Hills Court, install another bulb-out just east of the "Y" while retaining the speed hump east of Four Hills Road.
- Extend the re-striping already in place on the southern sections of Wagon Train Drive and Stagecoach Road onto all of the affected street sections.
- Consider installing transverse rumble strips at intervals along the affected street sections, subject to an examination of noise levels.
- Install optical speed bars at approaches to the curve in the northwest section of the roadway.
- Prior to the opening of the new fire station on Via Posada, ensure that emergency vehicles can unlock the metal gate now barring through movement on Calle Verda to permit faster emergency vehicle access to the neighborhood to the north.
- At the Four Hills Road and Stagecoach Road North intersection (the "Y"), extend the sidewalk along the western side of Four Hills Road through the intersection, tapering out northeast of Lamp Post Circle.

- Also at the "Y" intersection, add arrow signs and painted arrows on the pavement to better delineate the inbound left turn movement and add "Merge" signs to warn of the merge between the two inbound turning movements.
- At the Four Hills Road and Stagecoach Road South intersection (by the Country Club), trim the bushes to ensure adequate sight distance to and from the east while also adding arrow signs and painted arrows on the pavement to better delineate the inbound left turn movement and add "No Entry" and "Merge" signs to prevent collisions.
- The City should consider re-classifying Four Hills Road north of Stagecoach Road as a Minor Arterial and re-classifying Stagecoach Road and Wagon Train Drive as Minor Collector streets.
- The ABQ Ride #1 Juan Tabo bus route should not operate on Stagecoach Road and Warm Sands Drive because of the presence of speed humps there.
- The City might consider a general policy of de-centralized emergency medical response service from more stations to reduce response times and, in areas where speed humps have been allowed to proliferate, make greater use of lighter rescue squad vehicles.
- The City might monitor before and after speeds and accident trends on Stagecoach Road and Wagon Train Drive if the recommended plan in this report is adopted.
- The City should adopt guidelines not to install speed humps where weekday volumes are less than 500 vehicles a day or greater than 3,500 vehicles a day or on collector or primary emergency response routes or where 85th percentile speeds do not exceed 30 miles per hour.

Figure 7 shows these recommendations over the entire Four Hills area. Figure 8 shows intersection-specific recommendations for the two intersections of Four Hills Road with Stagecoach Road.

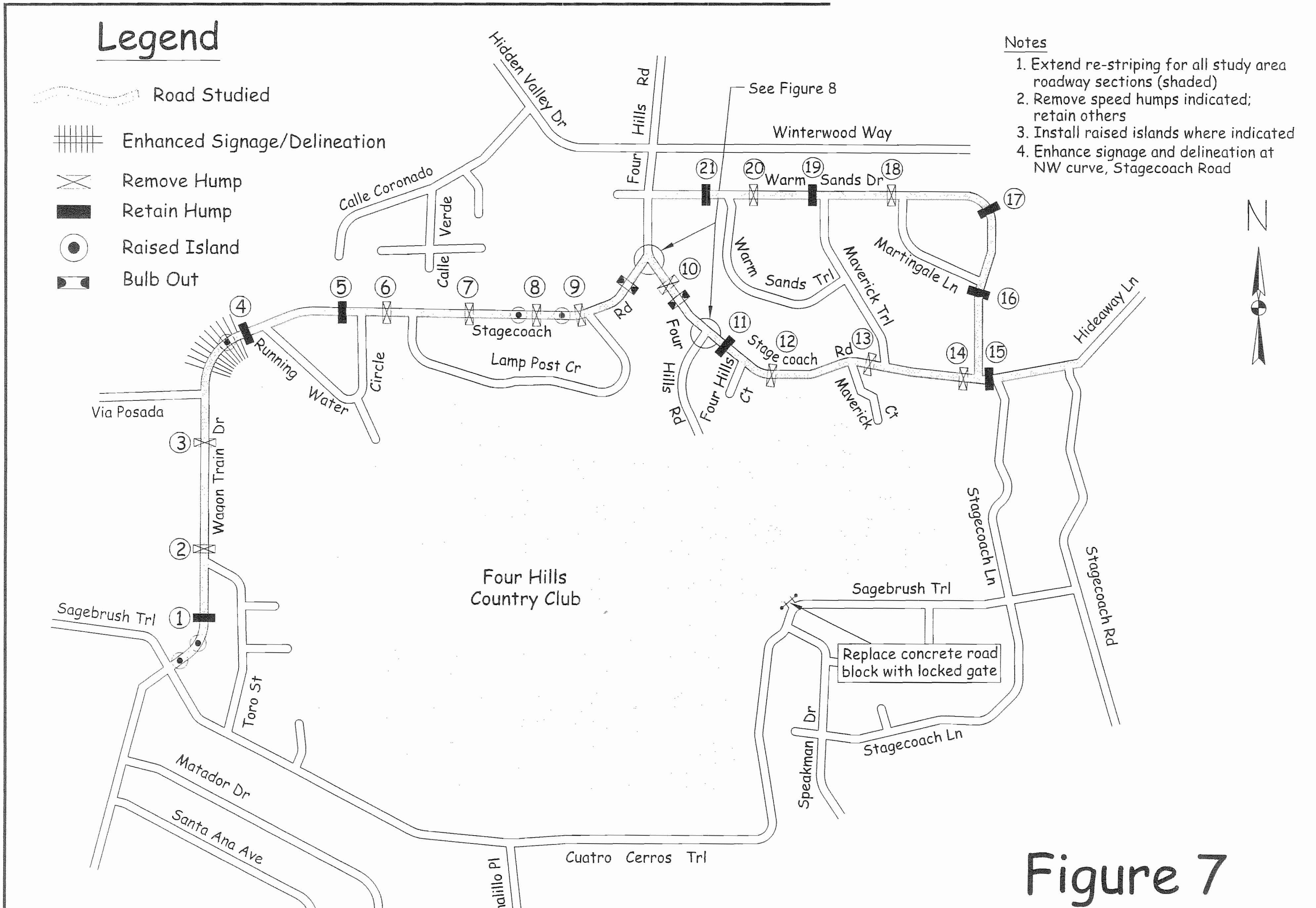


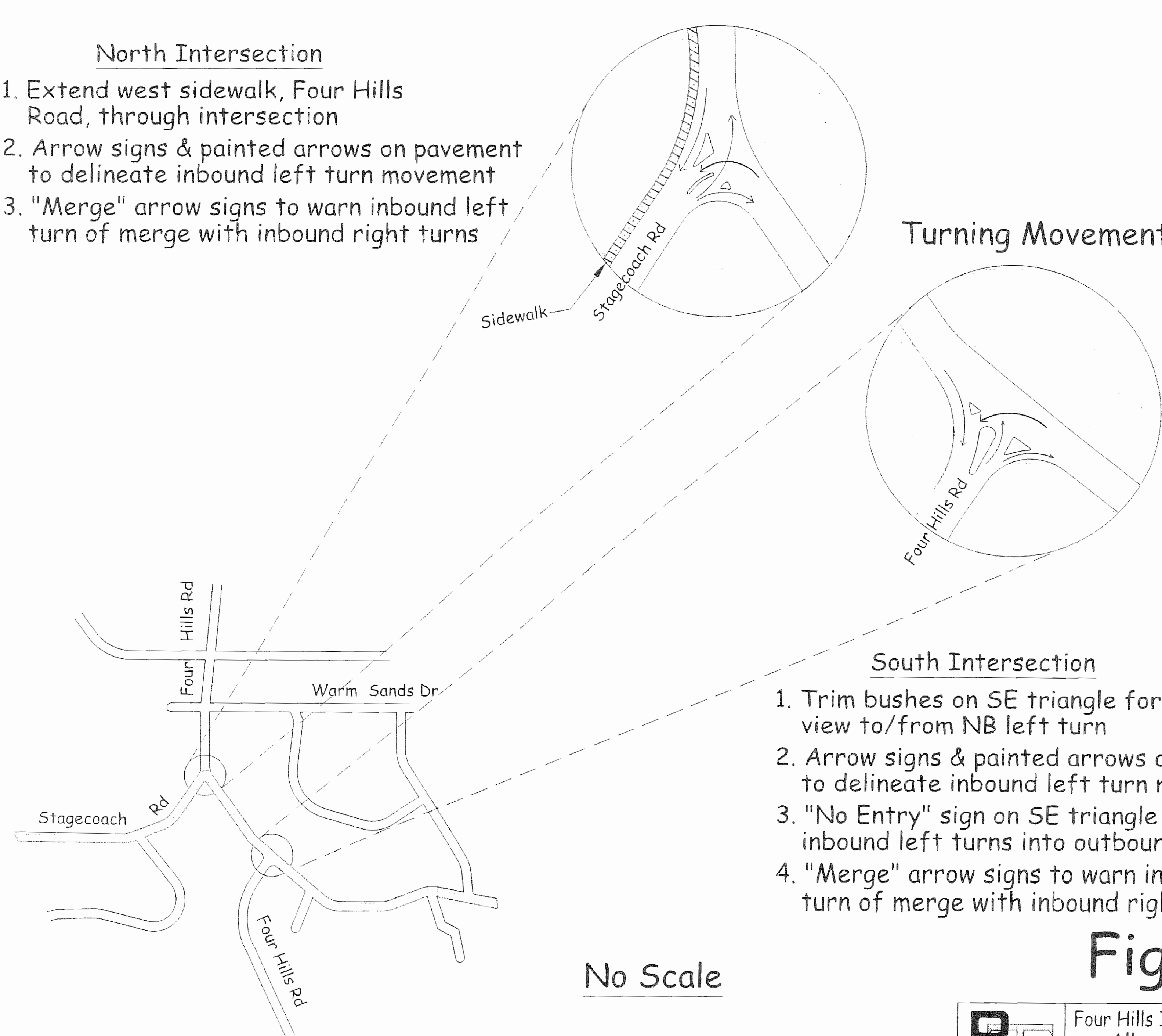
Figure 7

Four Hills Roadway Recommendations
Albuquerque, New Mexico

R. Tiernan | July 2007

North Intersection

1. Extend west sidewalk, Four Hills Road, through intersection
2. Arrow signs & painted arrows on pavement to delineate inbound left turn movement
3. "Merge" arrow signs to warn inbound left turn of merge with inbound right turns



Turning Movements Only Shown

South Intersection

1. Trim bushes on SE triangle for better view to/from NB left turn
2. Arrow signs & painted arrows on pavement to delineate inbound left turn movement
3. "No Entry" sign on SE triangle to ward off inbound left turns into outbound left turn lane
4. "Merge" arrow signs to warn inbound left turn of merge with inbound right turns

No Scale

Figure 8

Four Hills Intersection Recommendations Albuquerque, New Mexico	
R. Tiernan	July 2007

Fatalities Due to Cardiac Arrest

The positive impact of the speed humps in reducing traffic accidents was found to be in reducing speeds significantly and in reducing injury accidents more slightly. While accidents may decline on local streets in the aftermath of speed hump installation, this is usually because some traffic has diverted to other streets without speed humps that have less delay. The actual decline in accident rates is modest. As a 1998 study of speed humps in Portland Oregon noted: *"the reduction in crash frequency is mainly due to the reduction in traffic volumes on treated streets"* (Reference 2). That study found a 5% decrease in accident rate associated with speed humps; this study found a 6-7% decrease in accident rate. Even these rates, derived from a comparison of before and after data, may be misleading because speed humps tend to be installed after an accident or accidents occur and contain some bias toward making accident decreases look bigger than they may be over a longer term period.

The estimated fatalities reduced by speed humps are virtually zero, or 0.024 lives saved over 50 years. There had been a significant long term decline in accidents on the streets in the Four Hills prior to speed humps installation. Only two accidents have occurred in the past four years for which data is available. Neither involved injuries. No fatalities or serious injuries have occurred in any traffic accident on the affected streets since at least 1990. In this section, the negative impact of speed humps have in increasing fatalities by delaying emergency vehicle access is examined and resulting fatalities estimated.

ESTIMATE OF FATALITIES CAUSED BY SPEED HUMPS

To estimate fatalities in the Four Hills area it was first necessary to quantify exactly the boundaries of the impact area, the population impacted, and the parameters of the study.

The Greater Four Hills Impact Area

The impact area was defined as all households that were presumed to receive Albuquerque Fire Department emergency service in the future when the planned fire station on Via Posada comes into operation whose service would be affected by the speed humps now in place along Wagon Train Drive and Stagecoach Road. This impact area is shown on Figure 9.

Stagecoach Road and Wagon Train Drive would be the prime emergency routes from the fire station to anywhere within Four Hills Village, Winterwood Park, or the separated eastern portion of the Tijeras Arroyo neighborhood which uses Hidden Valley Drive or Executive Hills Lane to reach Four Hills Road. This neighborhood is not connected to Stagecoach Road at Calle Verde because of a metal gate blocking that access. These streets would be used by all emergency vehicles to access the area in response to emergency calls involving cardiac arrest, stroke, fires, criminal incidents, and other matters requiring a rapid response by the Fire and Rescue Department, the Police Department, and the Albuquerque Ambulance service. The impact area does not include the North Four Hills or Singing Arrow neighborhoods or the portion of the Tijeras Arroyo neighborhood to the west of Four Hills Village.

The impact area consists of all of Census Tract 7.10 south of the Tijeras Arroyo. It had a 2000 population of 3,280 (out of 3,611 in Tract 7.10). An estimated 2,600 of these live in Four Hills Village. The impact area is entirely residential, with virtually no commercial buildings or schools within it. It lies at the southeast corner of the City of Albuquerque and is physically cut off from the rest of the city by the Tijeras Arroyo.

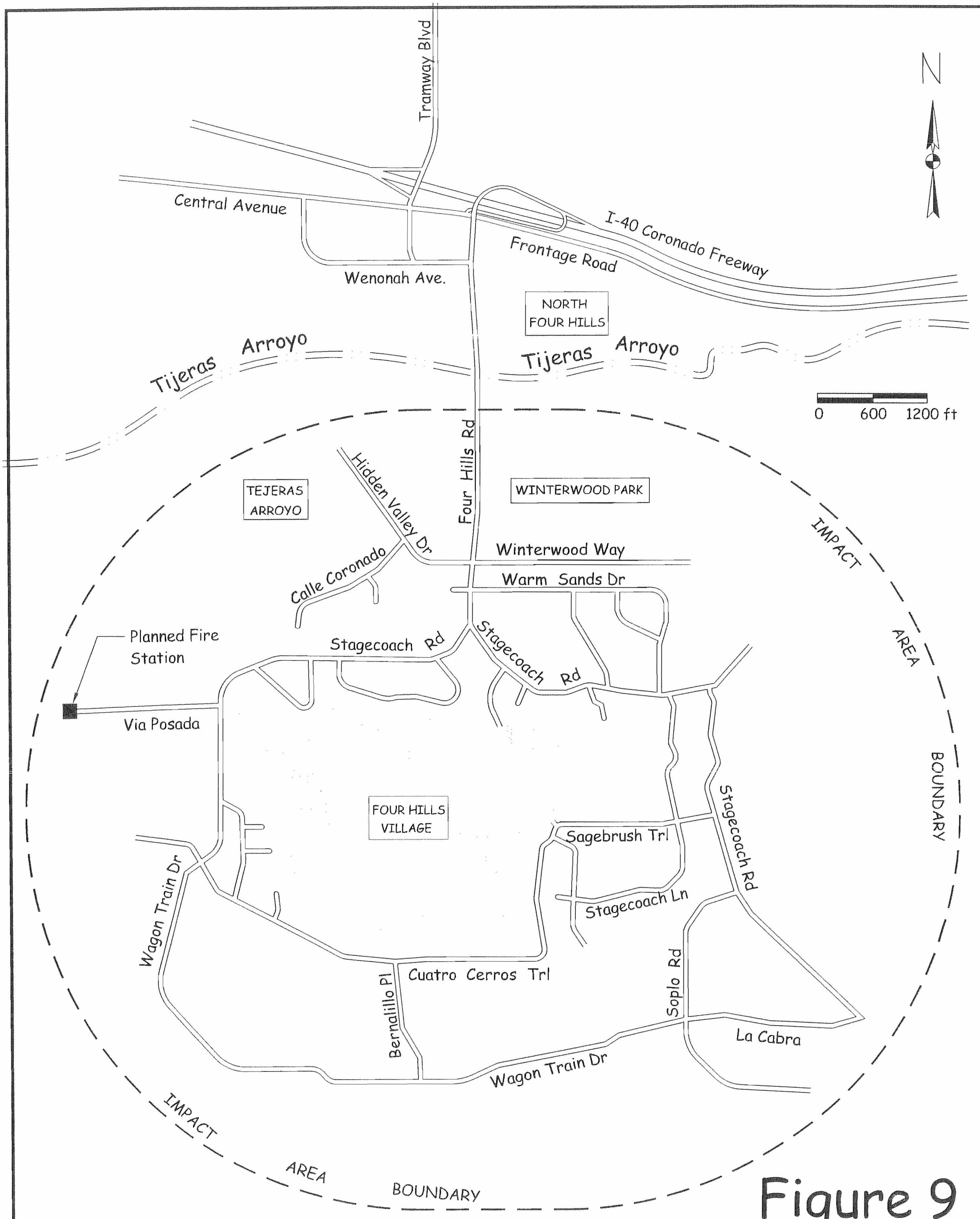


Figure 9

Speed Hump Impact Area
Albuquerque, New Mexico

R. Tiernan | July 2007

Presently, Fire Department and Albuquerque Ambulance vehicles enter this area on Four Hills Road, which is the only road now leading in. Emergency vehicles from the Albuquerque Fire Department presently come from Fire Station 12, with a few sometimes from Fire Station 8. Fire Station 12 is located northwest of Muriel Street and Linn Avenue, off Juan Tabo Boulevard near Central Avenue. This is 2.2 miles from the 'Y' intersection of Four Hills and Stagecoach Roads. Fire Station 8 is located on Indian View Place just east of Tramway Boulevard by Indian School Road. This is 3.0 miles from the 'Y' intersection of Four Hills and Stagecoach Roads. As part of the proposed fire station on Via Posada, just west of the impact area, Via Posada would be linked to an extension of Juan Tabo Boulevard. The proposed fire station on Via Posada would be about 1.0 miles from the 'Y' intersection of Four Hills and Stagecoach Roads and therefore able to provide much faster response times. This Via Posada route, however, would not be open to general traffic, only to emergency vehicles via a locked gate, shutting off Four Hills Village from traffic to the west.

The major demographic characteristic of the impact area that makes emergency medical service so critical is the high proportion of residents aged 65 or older. For all of Census Tract 7.10 (in which 3,280 out of 3,611 live in the impact area) the Census found 24.6% of the population to be 65 or older. In the entire United States that age group comprised only 12.4% of the population in 2000. This high proportion of elderly residents means that the incidence of cardiac arrest, stroke, and other emergency medical problems is much greater than the norm. Table 5 shows this age population profile, comparing the greater Four Hills impact area to the United States, and further shows the incidence for all heart diseases, coronary heart disease, and stroke in the United States (Reference 4). From this data, the higher incidence of these problems estimated for the impact area is also shown. The impact area is likely to have about 40% more cases of cardiac arrest (coronary heart disease) and over 50% more cases of stroke than a typical American neighborhood of this size.

Table 5
Estimated Higher Incidence of Heart Disease and Stroke in Impact Area

Age Group	Entire U.S.A.	Impact Area	Heart Disease	Coron-ary H.D.	Stroke
Ages 0-65	87.6%	75.4%	36.6%	51.9%	41.3%
Ages 65+	12.4&	24.6%	63.4%	48.1%	58.7%
Higher Incidence Estimated for Impact Area			+57%	+40%	+52%

Source: Centers for Disease Control and Prevention, Summary Health Statistics for U.S. Adults: National Health Interview Survey, 2005, Washington, DC, Table 2.
Impact Area Population Characteristics: 2000 Census for Albuquerque Census Tract 7.01

Cardiac Arrest Survivability Curve

There is a mathematical relationship between the likelihood of a cardiac arrest victim surviving the heart attack and the time that goes by until he or she receives resuscitation. Rapid treatment is essential because the chances of surviving decrease with every minute. If medical aid is received within three minutes, the chance of survival is over 70%. However, after three minutes, brain damage can occur. After four minutes, the chance of survival falls to about 50%, while after 5.8 minutes the chance of survival falls to under 10%. Figure 10 shows the survivability curve for intervention in cardiac arrest, developed by the American Heart Association (Reference 5).

Survival Rates for Cardiac Arrest by Intervention Time

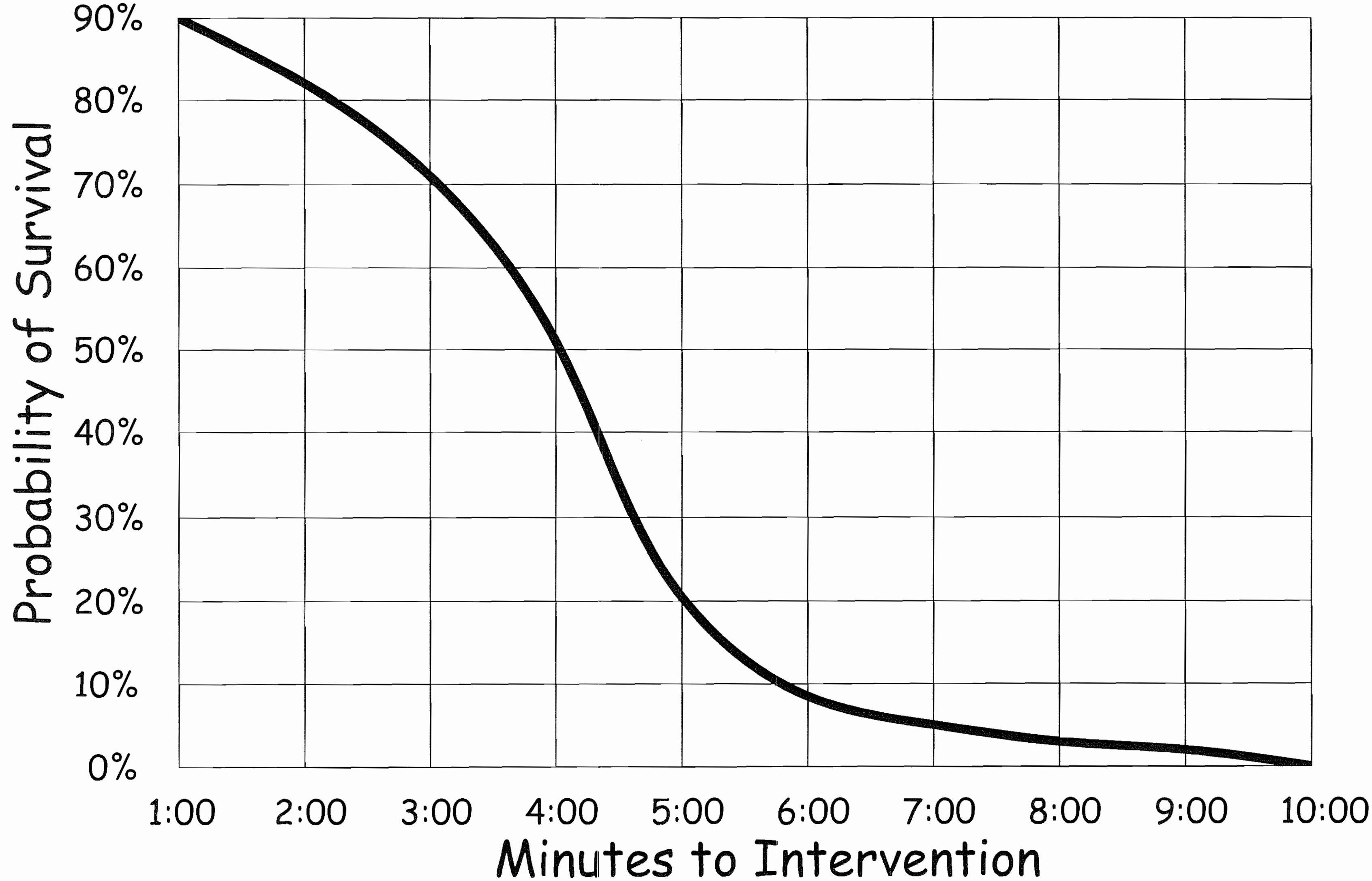


Figure 10

Source: Boulder Colorado Fire Department Master Plan, 1996

Survival Curve for Cardiac Arrest Albuquerque, New Mexico	
R. Tiernan	July 2007

Application of Survivability Model

The survivability curve was applied to the standard incidence of cardiac arrest in the American population multiplied by 1.5. The reason for this 1.5 factor was to account for the 40% higher incidence of cardiac arrest likely in the impact area due to its much higher proportion of elderly residents and to account for survivability for other emergency medical problems such as stroke. Therefore, were cardiac arrest alone considered, the results of this analysis can be multiplied by 93% (140/150) to derive results just for that. The additional 7% is a conservative estimate of other emergency health problems for which survivability may also be dependent on rapid emergency medical access.

The survivability curve model was applied to the impact area in a detailed fashion. The impact area was subdivided into 48 zones. The travel time from the proposed Via Posada fire station to each zone was calculated at 30 miles per hour to the approximate population center of each zone. The travel times includes 90 seconds of "turnout time". This is the time between the fire station's receipt of the emergency call and when the emergency vehicle actually leaves the fire station. In that time the crew is informed as to where to go and the nature of the emergency, then turns out with full equipment and gets the vehicle into motion. Turnout time standards typically vary between 60 and 120 seconds with 90 seconds being a medium value (References 6, 7, and 8).

In addition, the approximate population of each zone was calculated from Census Block data and from counting the number of homes in each zone and assuming the same number of people per house for all the zones. The number of people affected and emergency service travel time could therefore be measured for all zones within of the impact area.

Two changes were made in the application of the survivability curve model since Draft Technical Memorandum #2 was issued. First, the travel times to the neighborhood north of Four Hills on the west side of Four Hills Road were originally predicated on emergency vehicles leaving the proposed fire station on Via Posada, traveling east along Stagecoach Road, and then north on Four Hills Road to reach Hidden Valley Drive. In the revised forecast contained in this report, it is instead assumed they would have a shortcut: the locked gate on Calle Verde was assumed open to emergency vehicles. Second, an alternative scenario was considered under which emergency vehicles leaving the proposed fire station and traveling to seven zones in southeast Four Hills would take the longer route on Wagon Train Drive to avoid the greater number of speed humps to be found on Stagecoach Road. This Southeast Detour was applied to Zones 32, 33, 34, 35, 37, 38, and 39, an area roughly bordered by Sagebrush Trail and Catron Court on the west and Soplo Road to the east. The remaining three southeast zones, which form a sliver of southeast Four Hills further east along Stagecoach Road, can be reached so much faster via Stagecoach Road that this Southeast Detour was not applied to them. Both of these changes tended to reduce the estimate of fatalities caused by speed humps.

Delay Per Speed Hump

The survivability model used had fixed values for population and travel time. The variable that could change for each zone was the number of speed humps that emergency vehicles would have to traverse in order to reach the zone. This variable was tested for five scenarios: 1) existing conditions with 15 speed humps on Wagon Train Drive and Stagecoach Road, 2) existing conditions with the Southeast Detour, 3), recommended conditions with five speed humps on Wagon Train Drive and Stagecoach Road, 4) recommended conditions with the Southeast Detour, and 5) conditions under which all speed humps would be eliminated.

The delay imposed by the speed humps was calculated in a conservative fashion. It was based on data developed by the Portland, Oregon Fire Department, (Reference 9) The Portland data on the delay of emergency vehicles was created in 1995 using six different types of emergency vehicles and two types of speed humps, those 14-feet wide and those 22-feet wide. Tests were run on six streets, and a total of 24 runs were made on each street. In general, the streets were straight, level, and the speed humps were spaced far enough apart to allow determination of impact distance, which is the length of street that cannot be driven at a given desirable speed because of the speed hump's influence. The Portland Fire Department was then able to calculate average delays to two types of individual speed humps at 25, 30, 35, and 40 miles per hour in desired speed for the six vehicle types.

The Portland delays per hump assume that vehicles can return to their desired cruising speed of up to 40 miles per hour after passing over a speed hump. The Portland runs were conducted where there were long distances between speed humps, allowing vehicles to recover speed between humps. In the Four Hills, speed humps are spaced about 300-500 feet apart, such that fire trucks in Four Hills have difficulty getting back to 30 miles per hour before encountering another hump. Therefore, the Portland data does not take into account delay caused by a generally reduced cruising speed between humps and tends to understate overall delay. The Portland data was used because of its precision as to delay per hump by vehicle type, its conservative nature, and because better data for delays by vehicle type applicable to the Four Hills was not readily available. Use of the Portland data may tend to underestimate the delays, and hence the estimated number of deaths due to delay.

The calculation of delay per speed hump is shown in Table 6. The Portland data was based on 14-foot and 22-foot speed humps. The Four Hills speed humps are 18 feet wide. Therefore, the values used are an average of the values developed by Portland for the 14-foot and 22-foot speed humps. A match was made, based on weight and length, between the most common vehicles used in Albuquerque with similar vehicles tested in Portland. The Albuquerque Fire Department dispatches two types of vehicles to the Four Hills area: about 65% of the time a large pumper truck is sent (as opposed to a larger ladder truck) while about 35% of the time a smaller rescue squad truck is sent. Assuming a normal cruising speed of 30 miles per hour, the pumper truck would be delayed an average of 4.8 seconds per speed hump while the rescue squad truck would be delayed an average of 2.6 seconds per speed hump. The weighted average of all emergency vehicles would be 4.0 seconds per speed hump. Under existing speed hump conditions, the average emergency vehicle from Via Posada would go over 5.3 speed humps, incurring 21 seconds of delay. Assuming the Southeast Detour is used, the average emergency vehicle trip from Via Posada would go over only 4.0 speed humps, incurring 16 seconds of delay.

Table 6
Estimated Delay Per Speed Hump

Vehicle Type	Width of Speed Humps			% Dispatched	Average Delay
	14'	22'	18'		
Pumper Truck	4.7	4.8	4.8	65%	4.0
Rescue Squad	4.1	1.0	2.6	35%	

Source for Delay Per Speed Hump: Portland (Oregon) Fire Department, Impact of Traffic Calming Devices on Emergency Vehicles Report, January 1996, Tables 1, 2, and 3.
Source for Proportion by Vehicle Type: Albuquerque Fire Department log of emergency calls dispatched to impact area, November 2006 to April 2007.

The Portland data on the delay of emergency vehicles is in line with studies done elsewhere to gauge the impact on travel time for emergency vehicles. A similar travel time examination done in 1997 in Montgomery County, Maryland (Reference 10) found that, at a desired speed of 25 miles per hour, their emergency vehicles would be delayed an average of 2.8 to 7.3 seconds per speed hump, varying by vehicle type. Studies done in Austin, Texas found delays per hump ranging from 2 to 10 seconds in 1996 (Reference 11). The 4.0 seconds per hump used here is in line with those results.

Estimated Fatalities Due to Speed Humps

Based on all the assumptions and data previously described, delays due to the existing speed humps would result in an estimated 18.7 (with a standard deviation of 11.7) to 21.0 (with a standard deviation of 11.6) additional fatalities in the Four Hills impact area over 50 years were first responder emergency service based at the proposed Via Posada fire station. The difference between these two estimates depends on whether or not the Southeast Detour via Wagon Train Drive would be taken by emergency vehicles to avoid the greater number of speed humps found on Stagecoach Road. If so, fatalities would be 18.7. Under the original assumptions for emergency vehicle routes from Via Posada, based on shortest distance, there would be a weighted average of 5.3 speed humps between the fire station and the average home in Four Hill under existing conditions. Under the recommended plan, there would be a weighted average of 2.0 speed humps between the fire station and the average home. If the Southeast Detour onto Wagon Train Drive is assumed, emergency vehicles from Via Posada would encounter a weighted average of only 4.0 speed humps between the fire station and the average home in Four Hills. This would be only 1.7 speed humps between the fire station and the average home under the recommended plan. This analysis does not include the impact of three speed humps installed on Stagecoach Road near its southern terminus in 2003.

These results are shown in Table 7. Fatalities caused by speed hump delays would outweigh lives saved by accident reduction associated with speed humps by a ratio of about 800:1.

Table 7
Estimated Fatalities Due to Speed Hump Delays in Four Hills Impact Area Over 50 Years

Condition	Added Fatalities	Reduced Fatalities	Approximate Ratio
Existing	21.0	0.02	870:1
Existing, SE Detour	18.7	0.02	780:1
Recommended	8.6	0.02	360:1
Rec, SE Detour	7.8	0.02	300:1
No Humps	0.0	0.02	0:0

Existing, SE Detour: Existing number of speed humps with emergency service vehicles detouring to Wagon Train Drive to reach southeastern zones within Four Hills to avoid more speed humps.

Rec, SE Detour: Recommended number of speed humps with emergency service vehicles detouring to Wagon Train Drive to reach southeastern zones within Four Hills to avoid more speed humps.

Fatalities would be equal to about one death every two and a half years. Assuming there would be 21.0 fatalities, 19.5 would be cardiac arrest victims and 1.5 victims of other maladies. Draft Technical Memorandum #2 contained a higher fatality estimate of 25.7. This was revised based on the assumption that emergency vehicles from the proposed fire station on Via Posada would have a shortcut via the locked gate on Calle Verde to reach streets near Hidden Valley Drive.

Delays due to speed humps under the recommended plan would reduce additional fatalities due to speed humps to about 8.6 (with a standard deviation of 11.8) over 50 years or 7.8 (with a standard deviation of 11.8) if the Southeast Detour is assumed. This is about 40% of those under the existing conditions. Of the estimated 8.6 victims, 8.0 would involve cardiac arrest. The reduction in casualties would be entirely due to the reduction in the number of speed humps on key emergency routes. Fatalities caused by speed hump delays under the recommended plan would outweigh lives saved by accident reduction associated with speed humps by a ratio of over 300:1. On the other hand, were all speed humps removed, there would be no additional fatalities due to delay.

The tendency for fatalities to be reduced by reducing the number of speed humps is further demonstrated on Table 8. Table 8 shows the reduction in fatalities as estimated by the same survivability model applied to a varying average number of speed humps that residents of the impact area might experience. The fewer the speed humps, the lower the number of fatalities.

Table 8
Fatality Results Over 50 Years for Impact Area Varying By Number of Humps Encountered By Average Emergency Vehicle Trip

Number of Speed Humps Per Trip	25 MPH		30 MPH	
	Deaths	Increase	Deaths	Increase
1	4.8	NA	3.2	NA
2	11.0	+129%	7.4	+131%
3	17.2	+56%	11.5	+55%
4	23.3	+35%	15.6	+36%
5	28.4	+25%	19.8	+27%
6	33.3	+22%	23.9	+21%
7	35.7	+7%	28.0	+17%
8	38.1	+7%	32.2	+15%

Calculations were also done with emergency service from Fire Station #12. That fire station is over twice as far away as the Via Posada site. This means that trips take a longer time to reach the Four Hills so fatalities are higher than they would be with a Via Posada station. The speed humps only add to what is already a long trip. There would be an estimated 2.0 fatalities (with a standard deviation of 9.2) attributable to speed hump delay over 50 years. Fatalities caused by the speed humps would likely outnumber lives saved by them by a considerable margin. Generally, shifting the emergency response station from #12 to Via Posada would likely reduce fatalities from about 330 to 200 over 50 years.

Other Emergency Medical Problems

The fatality estimates developed in the preceding section considered only preventable deaths to cardiac arrest, with only another 7% added on to account for all other fatalities that delayed emergency services would otherwise prevent. This 7% may be conservative; a Boulder, Colorado study of the health impacts of speed humps used a figure of 30% (Reference 12). Lacking firm time-impact data on other conditions, this 7% figure was used. Readily available data could not be found on the delay impacts in treating maladies such as stroke, drowning, choking, ruptured appendices, electric shock, snake bite, hypothermia, heat stroke, heat exhaustion, seizures, septic shock, burns, drug overdose, reactive airway disease, as well potential deaths from delayed response to fires. Lacking firm data on these things does not mean that they do not matter nor that death or serious injury cannot occur if emergency medical treatment is delayed in dealing with them.

MEDICAL CONDITIONS REQUIRING RAPID TREATMENT

Besides cardiac arrest, there are many other medical emergencies that require the rapid delivery of medical service and often rapid delivery to a hospital emergency room as well. In many cases, medical treatment must be rendered inside the emergency vehicle, even while it is moving. The swaying motion caused by vehicles going over speed humps complicates some procedures. A good guide to the importance of speed and smooth trips to the hospital may be gained from the current *Albuquerque Bernalillo County Emergency Medical Services System Protocols and Guidelines* manual (Reference 13). This manual has this to say about treating the following conditions:

- M-2 Reactive Airway Disease: "*Transport ASAP; Enroute: monitor vital signs, IV NS, nitrate fluid to patients condition*";
- M-4 Heat Exhaustion and Heat Stroke: "*Expeditious Transport*";
- M-6 Hypothermia: "*Expeditious Transport*";
- M-9 Stroke: "*Transport without delay*";
- M-10 Seizures, Status, Epilepticus: "*Transport ASAP";*
- M-14 Septic Shock: "*Rapid Transport*";
- M-15 Drowning/Near Drowning: "*Transport without delay to appropriate facility*";
- T-7 Burns: "*Enroute, establish one large bore peripheral IV with Lacerated Ringers Solution. Avoid burned area if possible when establishing IV access. Do not delay transport to establish IVs on scene in critical patients*";
- I-12 EMT-1 Drug Overdose: "*Transport without delay*"
- B-6 EMT-6 Reactive Airway Disease: "*Transport ASAP if possible*".

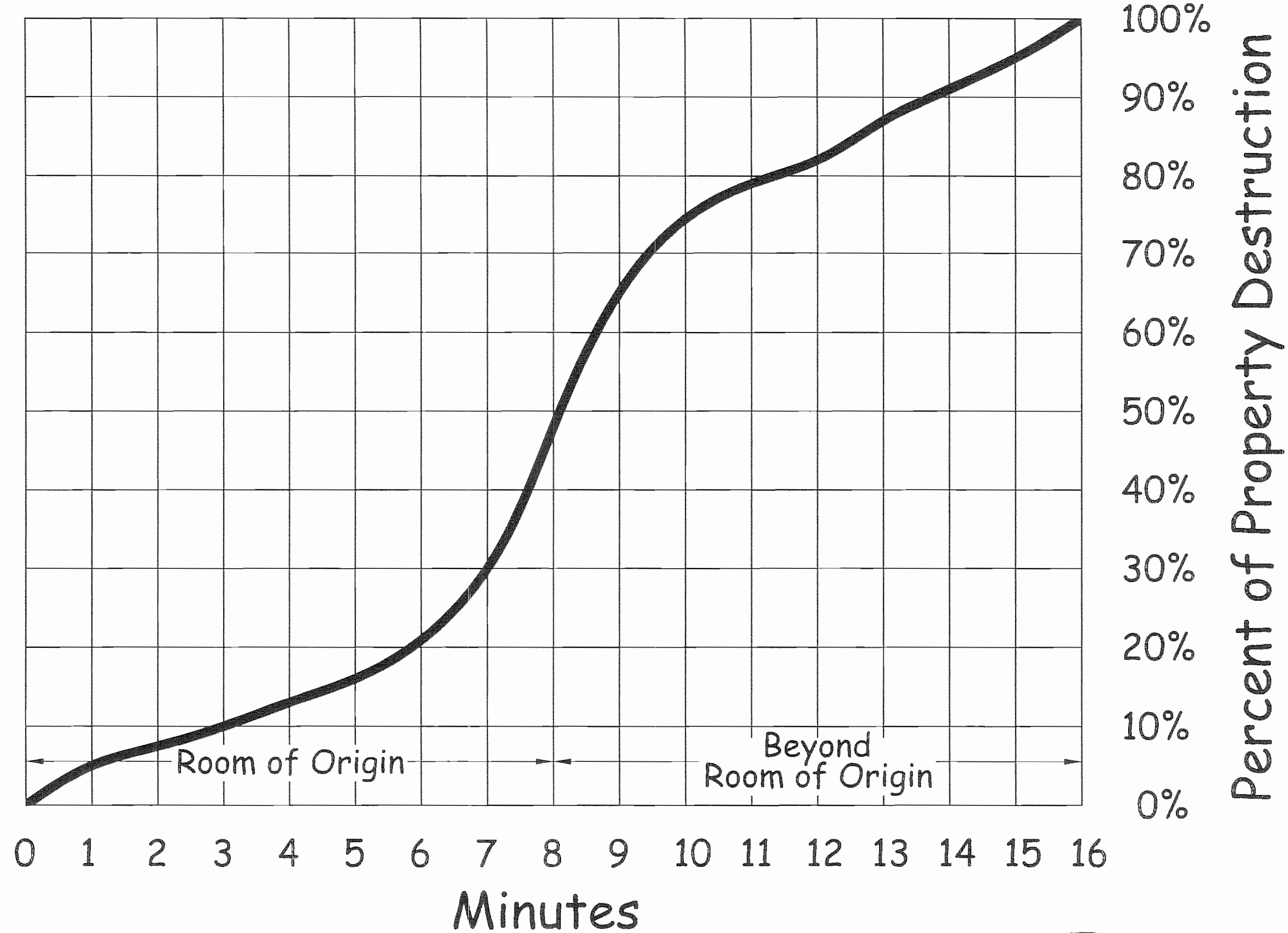


Figure 11

Source: Portland, Oregon Fire Department
Service Delivery System Study, 2006

RT	Fire Propagation Curve Albuquerque, New Mexico	
	R. Tiernan	July 2007

FIRE PROPAGATION

The major traditional concerns of fire departments have been the evacuation of people and extinguishment of fires, preferably as soon as possible. It is widely known that fires can spread very quickly, hence the importance of rapid arrival at the scene. The National Fire Protection Association has compiled results from many studies of fire damage in homes to produce a fairly reliable estimate of the extent of fire damage in the first sixteen minutes of a typical fire. This is shown in Figure 11.

Figure 11 shows the standard fire propagation curve, indicating the percent of home damage incurred with every minute that the fire spreads. A fire that spreads for three minutes might be expected to destroy only 3% of a home. If allowed to spread just two minutes more, over 15% of a home is destroyed. If the fire continues for eight minutes, half the home is destroyed (Reference 14).

The importance of fire fighters getting into action as quickly as possible must be understood in the context of the stages of progression which occurs in home fires. A fire usually starts in one small area and may spread slowly at first, depending on what is immediately around it. During this Incipient Stage, the fire is fueling itself by contact with flammable material and increasing in temperature. With cooler air drawn into the base of the fire, the flames rise along with the temperature of the fire into a Free Burning Stage in which the fire generates much more smoke and gas. It then can go on to a Smoldering Stage in which the fire temperature can reach 1,300 degrees Fahrenheit but, lacking a fresh supply of oxygen, the fire may just smolder in its origin area. The danger is that the fire will go on to the Flashover Stage by entering new rooms or otherwise finding more oxygen to fuel itself. As shown in Figure 11, when flashover occurs, the destruction can become rampant (Reference 15).

COMMENTS FROM EMERGENCY MEDICAL PROFESSIONALS

As part of this study, interviews were held with top professionals in the field of emergency medical service and reports by several medical professionals examined to learn more about the medical problems posed by speed humps and the importance of the rapid delivery of emergency medical service.

A textbook on treating cardiac arrest by a national expert noted: "*The speed with which defibrillation is performed is the major determinant of the success of resuscitative attempts … A major determinant in these studies was time. It is clear that the earlier defibrillation occurs, the better the prognosis*" (Reference 16). Another textbook on cardiac arrest by the same expert noted: "*The major determinant of survival … was time*" and that "*the sooner someone starts CPR the sooner the defibrillator arrives, the better the outcome*". He noted that: *Emergency personnel have only a few minutes after the collapse of the victim to reestablish a sustained perfusing rhythm….*" (Reference 17).

One recent study noted that by reducing response time to cardiac arrest, the survival rate was more than tripled. This is consistent with findings from other studies that showed survival declining for each minute of delay. The authors wrote: "*The significant shorter arrival times of the first responders for the saved patients … further supports the impact of the intervention time on the favorable outcomes, as recommended by international guidelines*" (Reference 18).

These points about the necessity of rapid emergency medical access to patients were emphasized by those familiar with or engaged in emergency medicine or patient movement in Albuquerque.

In interviewing Dr. James Tryon, a physician trained in emergency medicine and president of the New Mexico Medical Society, Tryon emphasized that even three minutes of oxygen deprivation to the brain can cause severe damage and that many conditions require rapid treatment and could potentially be life threatening. These included stroke, drowning, snake bites, and acute asthmatic attacks. Dr. Tryon pointedly referred to speed humps throughout the talk as "*traffic impediment devices*". He confirmed that IVs are sometimes performed in the ambulances, as is incubation with oxygen masks, and other treatments. He pointed to the obvious problems in administering these treatments within an ambulance when going over or even around speed humps due to the bouncing or swaying motion (Reference 19).

In interviewing Bett Clark of the Bernalillo County Fire Department, she said that speed humps not only interfere with medical procedures but can be jarring and exacerbate pain suffered by patients. Speed humps seriously delay emergency service, slowing vehicles down to about five miles per hour unless a risk is taken to damage apparatus by moving faster. As a major provider of emergency service to a substantial population outside of Albuquerque, her service's assessment of speed humps was quite clear: "*We hate them*" (Reference 20).

Also interviewed was Drue Bralove, who manages Albuquerque Ambulance's emergency medical service. Albuquerque Ambulance generally transports patients to the hospital but sometimes acts as the first responder rather than the Albuquerque Fire Department. Bralove said that speed humps made ambulance trips "*terribly difficult*" and "*uncomfortable for patients*", complicating any procedures that must be performed within the ambulance as it is moving. She said "*They slow us down*", sometimes to a speed between 15 and 20 miles per hour in street sections covered by speed humps. Among the problems inside the moving ambulance are IV hookup, making incisions, giving shots, electro cardiogram tracings (thrown off by the motion experienced in going over speed humps), and any procedure involving a sharp instrument or needle (Reference 21). Speed humps, according to Bralove, "*compromise emergency response*".

To provide a sense of how many and what type of emergency trips are involved, in 2006 the Albuquerque Fire Department Station #12 made 165 trips into the Four Hills impact area. In addition, a few more trips were made by Station #8. Albuquerque Ambulance made additional trips, taking people to hospitals as the second responder to most Fire Department trips. Of the 165 trips made into the Four Hills impact area by vehicles from Station #12, two were classified by the dispatcher as cardiac arrest cases, five involved other heart problems, 19 involved chest pain, 11 involved breathing problems, three were convulsions or seizures, five hemorrhage or laceration, 14 were stroke cases, three were traumatic injuries, three were overdose cases, 10 involved fainting or falling unconscious, 22 were logged simply as involving a "*Sick Person*", while eight were "*Unknown Problem*". These classifications represent only the dispatcher's record as to the reason for the call with the information known at the time. They were not medical diagnoses. The actual number of cardiac arrest cases could have been higher but these cases might have been logged as belonging to several other categories at the time of the call.

More Limited Use of Speed Hump

SPACING OF SPEED HUMPS AND "SHADOW" EFFECT

The positioning of speed humps at intervals of 300-400 feet or less is predicated on the belief that, left unchecked, motorists will simply accelerate after going over a speed hump to a speed higher than is warranted. The spacing of speed humps on Stagecoach Road and Wagon Train Drive is based on this. However, even where drivers are not physically forced to drive slower, they typically do moderate their speed if they encounter anything that suggests going faster may be unsafe. Therefore, encountering even a single speed hump changes the motorist's perception of the street and may tend to moderate speed even 1,000 feet away. A recent study of residential streets in Florida concluded "*that more than one speed hump on short roadway sections, usually less than 1,000 feet, does not necessarily yield any more benefits than only one installation*" (Reference 22).The driver moving at a speed much higher than is appropriate for the street is caused to undergo a transition by a single speed hump (or other device). While the driver accelerates back to a cruising speed after passing the speed hump, that speed is generally lower than the original speed.

Evidence that speed humps influence speeds several blocks away has already been demonstrated in the Four Hills. In conducting before and after surveys for the speed hump project, the City Traffic Engineering Division monitored not only sites in between humps shown in Table 4, but remote sites. These remote sites were over 1,500 feet away from the nearest speed hump on Stagecoach Road and Wagon Train Drive. Results from these remote sites are shown below in Table 9.

Table 9
Impact of Speed Humps at Sites Over 1,500 Feet Away on Stagecoach Road and Wagon Train Drive, Before and After Data

Roadway Point	Average Speed		85th Percentile Speed	
	Before	After	Before	After
Stagecoach Rd, near Sagebrush Trl	27.5	27.0	32.4	30.9
Wagon Train Dr south of Raton	26.6	25.9	31.7	30.6
Wagon Train Dr, Riva Ridge-Bravos	28.9	25.8	35.4	31.0
Wagon Train Dr, east of Santa Ana	25.4	23.4	30.7	28.9
Average	**27.1**	**25.5**	**32.6**	**30.3**
Percent Change	**NA**	**-5.9%**	**NA**	**-7.1%**

- *Speed in miles per hour. The 85^{th} percentile speed is the speed that 85% of vehicles are moving slower than and 15% faster than.*
- *The distances from the nearest speed hump for these sites is as follows: Sagebrush Trail- over 1,500 feet; south of Raton – over 1,500 feet; Riva Ridge to Bravos – over 2,000 feet; east of Santa Ana – over 3,300 feet.*

The four remote sites identified on Table 9 are between 1,500 and 3,500 feet away from the nearest speed hump. The "before" speeds at these sites were near the speed limit and significantly lower than speeds on the sections of Stagecoach Road and Wagon Train Drive that speed humps were installed on. Yet after the distant speed humps were installed, speeds at all four remote sites dropped by an average of nearly 6%. These declines in average speed varied between 2-11% .The average "after" speed at these sites (25.5) was slightly lower than the average "after" speed at the speed hump sites (25.9) shown in Table 4. This suggests that the speed humps may have had a considerable "shadow effect" that was felt up to 3,300 feet away, with speed reduction occurring even where traffic was already moving near the posted speed limit before implementation.

The effect was quite similar on 85^{th} percentile speeds. The 85^{th} percentile speeds at the four remote sites were about 8% less than on the speed hump sections of Stagecoach Road or Wagon Train Drive in the "before" condition. Yet after the speed humps were installed, 85^{th} percentile speeds at the four remote sites dropped an average of 7%, ending up being slightly lower (30.3) than the "after" speeds where speed humps had been installed (30.7).

These speed reductions over 1,500 feet away from the nearest speed hump suggests that if the recommended plan is adopted and most humps removed, those remaining speed humps will still have a significant effect on keeping average speeds close to the speed limit.

SPEED HUMPS ON EMERGENCY SERVICE AND BUS ROUTES

Guidelines issued by professional organizations in the field of traffic safety and control are unequivocal that speed humps should not be placed on emergency service routes or bus routes. The Institute of Transportation Engineers guidelines (Reference 23) state:

> *Speed humps should not be installed on streets that are defined or used as primary or routine emergency vehicle access routes.*

The City of Sacramento (California) guidelines (Reference 24) on speed humps are: "*Not installed on emergency response or bus routes.*" The City of Los Angeles (California) guidelines (Reference 25) on speed humps are: "*Speed humps and tables shall not be installed on designated truck or transit routes or on any street identified as a primary emergency route by any emergency response agency.*" The City of Modesto (California) guidelines (Reference 26) on speed humps are: *The street should not be an important emergency vehicle access route.* The Pennsylvania Department of Transportation handbook on traffic calming (Reference 27) advised: "*Only permit traffic calming measures with minimal or no impacts on emergency response times on major emergency response routes*". The Vermont Department of Transportation guidelines (Reference 28) on speed humps are that they: "*Should not be used on critical emergency response routes or bus routes. May affect emergency service response times.*"

The Vermont Department of Transportation guidelines also note that speed humps are appropriate for "*Local, residential streets only*" and "*for low-traffic local, streets*". Similar statements can be found at state, county, and municipal level in speed hump guidelines elsewhere. The sections of Stagecoach Road and Wagon Train Drive where the speed humps were installed are, along with Four Hills Road, the most important emergency vehicle access routes in the Four Hills area. Additionally, both Stagecoach Road between Four Hills Road and Maverick Trail (where four speed humps are installed), and Warm Sands

Drive between Four Hills Road and Maverick Trail (where three speed humps are installed) are on the ABQ Ride bus transit #1 route.

SPEED HUMPS ON COLLECTOR OR MAJOR LOCAL ROUTES

Guidelines issued by professional organizations in the field of traffic safety and control also tend to suggest limiting use of speed humps to local residential streets, especially side streets, with limited or no use on higher volume major local or collector streets. The Institute of Transportation Engineers guidelines (Reference 23) on this are:

> *Speed humps should only be installed on local two-lane residential streets with less than 3,000 vehicles per day ....*

Many state, county, and city guidelines also repeat this guideline of not installing speed humps on routes with volumes over 2,500 or 3,000 or 4,000 vehicles daily or on collector routes. The Virginia Department of Transportation guidance (Reference 29) for streets with volumes of over 4,000 vehicles daily is "*no traffic calming measures*". A maximum standard of 3,000 vehicles a day would have ruled out speed humps on all the sections of Stagecoach Road where they were installed and on Wagon Train Drive near Via Posada. A statement commonly found in many local guidelines is that speed humps should only be installed on local residential streets "*where the primary function is to provide access to abutting residences*" (Reference 26). This would rule out the northern segments of Stagecoach Road and Wagon Train Drive as they are predominantly through traffic routes. Many city guidelines also rule out emplacing speed humps where the total weekday volume is less than 500 vehicles a day, a position embraced by Los Angeles, Sacramento, Kansas City, and Mesa in Arizona.

Besides Stagecoach Road, the City of Albuquerque has installed speed humps on only four other street sections (out of 272) prior to April of 2007 where total weekday volumes exceeded 3,000 vehicles a day. Only one of these had a volume exceeding that of Stagecoach Road, though not by much. No where in Albuquerque have speed humps been installed where total weekday volumes exceeded 4,000 vehicles a day according to city traffic counts. Besides Stagecoach Road, they were installed in only one other street section where total volumes exceeded 3,500 vehicles a day.

Many adopted guidelines also rule out streets where speeds are simply not high enough to warrant concern. The City of Orlando (Florida) guidelines (Reference 30) on speed humps state: "*The 85^{th} percentile speed of the vehicles traveling on the proposed street must be 33 mph or greater." This would have ruled out any* speed humps being installed on Warm Sands Drive, where humps were installed in May 2005. The 85^{th} percentile speed there was only 31.6 miles per hour.

In terms of street width, volume carried, and actual function, Four Hills Road might better be classified as a Minor Arterial rather than as a Collector, as four-lane roads with 40 mph speed limits are in most places. Both Stagecoach Road and Wagon Train Drive might better be classified as a Minor Collector streets, not Major Local Streets, given their width, volumes, and function in collecting traffic from local streets and providing through movement for local traffic to reach Four Hills Road. This would especially apply to Wagon Train north of Cuatro Cerros Trail and to all of Stagecoach Road north of Soplo Road.

Alternatives to Speed Humps

The disadvantages that speed humps pose for emergency vehicle service, for certain disabled people, for vehicle maintenance, and their unpopularity with many residents, has led to an examination of alternative strategies that promote neighborhood traffic safety. The world's leading traffic calming author, Australian activist David Engwicht gave some of his reasons as to why he does not recommend speed humps (or bumps as he calls them) as a solution at a recent talk: (Reference 31)

> *Speed bumps aren't the panacea that a lot of people think they are because ...somebody has to put up with the noise of people going over them outside their house and, interesting enough, the people between the speed bumps have to put up with faster traffic ....you've got traffic braking to go bump, bump – over the speed bumps and then speeding up in between ....*

Evidence exists that a number of alternative strategies and devices that do not cause much delay to emergency vehicles can be implemented that can also reduce traffic accidents and/or traffic speeds and may substitute for the speed humps. These alternative strategies include roadway re-striping to create narrower travel lanes, installing bulb-outs (also known as neckdowns or chokers or curb extenders) to narrow the road at a few points, installing raised islands to narrow the roadway at other points, the use of transverse rumble strips, the use of optical speed bars, and applying better delineation, using mirrors, reflectors, and signage to highlight danger areas.

RE-STRIPING FOR TRAVEL LANE DELINEATION

Until recently, the wide main roads within Four Hills Village were mostly unstriped except for a median yellow line. The lack of striping results in the motorist receiving imprecise visual guidance as to where the travel lanes are that he or she is supposed to stay in. Hence vehicles can stray too near the curb, where vehicles park and pedestrians walk, if no line is clearly visible. A number of studies suggest that where motorists see only a wide open road, with no striping, they tend to drive faster and to incur somewhat higher accidents. As the City Traffic Engineering Division (Reference 3) noted for the southern section of Stagecoach Road:

> *As parking on this section of roadway is infrequent, this lane configuration gave the appearance of two wide driving lanes. These wide driving lanes may have been contributing to the motorist's impression that the allowable speed was higher than the posted 25 MPH.*

The comment could also apply to most sections of Stagecoach Road and Wagon Train Drive, including the sections where speed humps were implemented.

Early in 2006, after speed humps were installed on Stagecoach Road, Wagon Train Drive, and Warm Sands Drive, the City Traffic Engineering Division began a project to restripe the outer sections of Stagecoach Road and Wagon Train Drive in Four Hills. In April 2006 the re-striping went into effect on Stagecoach Road between Quimera Trail and Stagecoach Lane and on Wagon Train Drive between Cuatro Cerros Trail and Bernalillo Place. The re-striping consisted of a two-foot wide painted yellow median strip, two 11-foot wide travel lanes, and two 8-foot wide parking lanes, separated by solid white lines from the travel lanes. The major impact of the re-striping was to alter the perception of the roadway to approaching motorists such that two narrow travel lanes now appeared rather than a wide open road. The parking lanes, still only lightly used for parking, act more like bicycle lanes.

As part of that effort, speed studies were conducted at several points along Stagecoach Road and Wagon Train Drive where re-striping was implemented. Speed data on these sections of Stagecoach Road was summarized in a Traffic Engineering Division memorandum (Reference 3) and is shown below in Table 10. The Traffic Engineering Division also monitored before and after speeds on a nearby part of Stagecoach Road where speed humps had been installed in 2003 near La Tuna, Pedregoso, and Arenas Places. The combined results are also shown in Table 10.

Table 10
Impact of 2006 Re-Striping on Stagecoach Road, Before and After Data, Compared to Speed Humps

Roadway Point	Average Speed		85th Percentile Speed	
	Before	After	Before	After
Re-Striping Speed Survey Sites				
Stagecoach Road near Sagebrush Trl	27.1	26.7	31.4	30.7
Stagecoach Road near Soplo Road	24.7	24.7	31.1	31.0
Speed Hump Speed Survey Site				
Stagecoach Road near Arenas Place	23.9	22.4	29.7	28.7

- *Speed in miles per hour. The 85th percentile speed is the speed that 85% of vehicles are moving slower than and 15% faster than.*
- *The speed hump survey site near Arenas Place measured the speed impact of three speed humps on Stagecoach Road in that area.*

As can be seen in Table 10, both average and 85th percentile speeds declined slightly both with the implementation of speed humps and of re-striping on this southern section of Stagecoach Road. Average speeds (which were under the speed limit even before implementation) declined 6.3% with the speed humps. Average speeds declined 1.5% with re-striping near Sagebrush Place (where traffic was only slightly above the speed limit) but stayed the same (under the speed limit) at Soplo Road. The 85th percentile speeds declined 3.4% with the speed humps. The 85th percentile speeds declined 2.2% with re-striping near Sagebrush Place but declined only 0.3% at Soplo Road.

What this data suggests is that while re-striping by itself will not reduce speeds as much as speed humps do, it is effective at generally reducing speeds. The combination of re-striping with other measures recommended in this section may result in speed reduction approaching the level achieved by the existing speed humps.

The tendency for re-striping to lower speeds is also apparent in Traffic Engineering Division before and after speed data at four sites on Wagon Train Drive, which was also re-striped in April 2006. This data is shown in Table 11. As can be seen in Table 11, both average and 85th percentile speeds declined slightly with the re-striping on Wagon Train Drive. Average speeds (which were at the speed limit even before re-striping) declined 1% as did 85th percentile speeds. As traffic was moving slower in this section of Wagon Train Drive than where speed humps were implemented, this is not a good indication of the full potential re-striping has for speed reduction; the average vehicle was moving at the speed limit even prior to implementation so had little reason to slow down more. Both average and 85th percentile "after" speeds in this re-striped section were slightly lower (24.7 and 30.0, respectively) than the average and 85th percentile "after" speeds in the average speed hump section on Stagecoach Road and Wagon Train Drive (25.9 and 30.7, respectively) shown in Table 4.Therefore, the end result was about the same with re-striping as it was with speed humps.

Table 11
Impact of 2006 Re-Striping on Wagon Train Drive, Before and After Data

Roadway Point	Average Speed		85th Percentile Speed	
	Before	After	Before	After
Wagon Train Dr south of Matador	24.6	24.6	30.9	30.6
Wagon Train Dr south of Raton	25.9	25.0	30.6	29.8
Wagon Train Dr, Riva Ridge-Bravos	25.8	26.0	31.0	30.8
Wagon Train Dr, east of Santa Ana	23.4	23.2	28.9	28.7
Average	**24.9**	**24.7**	**30.3**	**30.0**
Percent Change	**NA**	**-0.9%**	**NA**	**-1.1%**

- *Speed in miles per hour. The 85th percentile speed is the speed that 85% of vehicles are moving slower than and 15% faster than.*

The tendency for re-striping to create narrower travel lanes and lower speeds has been found in other studies. The Pennsylvania Department of Transportation handbook on traffic calming (Reference 27) noted that a "*low-cost way of reducing speeds is to narrow the roadway lane through the use of edge lines and centerlines .... These applications have generally reduced speeds by one to two mph with reported reductions as high as five mph in some locations*". As shown in Tables 10 and 11, this description of the speed reduction potential of re-striping reflects the actual experience in Four Hills.

BULB-OUTS (NECKDOWNS, CHOKERS, CURB EXTENDERS, ROAD NARROWING)

This particular device, while known by several different names, is simply an extention of the edge of the roadway into the road so as to narrow it. These can be installed either at intersections or at points in between intersections (the latter are known as neckdowns or chokers). The intention is to slow traffic by causing concern within the motorist's mind as the road's narrowing forces more careful driving. They also convey to the motorist a transition in the type of road being traveled on. The bulb-out suggests they are no longer on a fast through route but on a local, residential street on which they do not want to be near the edge and on which they must slow down.

Field surveys indicate that bulb-outs tend to reduce speed, but less so than speed humps do. A summary of data at several sites by the Delaware Department of Transportation showed that neckdowns, like speed humps, also tend to reduce traffic speed. In the examples cited, speeds were reduced by an average of 7.7 miles per hour by speed hump treatment. Speeds were reduced by an average of 2.6 miles per hour by neckdown treatment (Reference 32).

A Washington Department of Transportation handbook on traffic calming assessed the speed reduction potential of mid-block slow points or bulb-outs as "*Yes*" but noted they pose only a "*Minor constraint*" to emergency services and had positive safety benefits (Reference 33). A City of Phoenix pamphlet on traffic calming assessed the speed reduction potential of mid-block chokers or bulb-outs as "*Minor*" but noted that, unlike speed humps, they pose "*No problems*" to emergency services and had positive safety benefits (Reference 34).

The Pennsylvania Department of Transportation handbook on traffic calming (Reference 27) noted that: "*Mid-block curb extensions may also be used to address speeding on streets where speed humps are not permitted*". The Pennsylvania handbook goes on to that they can be used to: "*Slow traffic by funneling it through a narrower street opening ...Most curb extensions result in speed reductions of 1-2 mph*". The Virginia Department of Transportation traffic calming guide (Reference 29) notes that the benefits include "*reduces speeds*".

The safety impact of bulb-outs has been under-examined by researchers into traffic calming because it has tended to be perceived as a pedestrian safety device or because these were usually installed on low volume residential streets with little accident data to go on. To make up for this deficiency, the author examined these in detail where considerable data was available: at a series of intersections on a two-lane highway that goes through a small town in Oregon. At two intersections bulb-outs were installed, but at four others nearby on the same road they were not. Weekday volumes at this Oregon site are three to four times higher than on Stagecoach Road near Four Hills Road. Over four years of accident data was examined both before and after the bulb-outs were installed. The results were that at the two intersections with bulb-outs, the accident rate declined 39%. At the four "control" intersections without bulb-outs, the accident rate increased over 49%. This suggests that the bulb-outs caused motorists to drive more carefully, likely slowing down as they saw the highway narrowing (Reference 35).

A larger scale study done at several different locations within all five counties within New York City also examined the safety impact of bulb-outs. It examined accidents at intersections where bulb-outs had been installed and also at nearby "control" intersections without bulb-outs. Several years of accident data were examined both before and after the bulb-outs were implemented. The results of this study were rather similar. At the "control" intersections without bulb-outs, the accident rate increased substantially. At the intersections with bulb-outs, the accident rate increased far less such that accident rates at bulb-out sites in all five boroughs of the city examined improved relative to the "control" sites. These results also suggest that the bulb-outs caused motorists to drive more carefully, likely slowing down as they saw the street narrowing (Reference 36).

RAISED MEDIAN ISLANDS

This particular device, also known under a few different names, is similar to the bulb-out in that it narrows the roadway. The difference lies in the fact that it is sited in the middle of the road. It is usually implemented to make pedestrian crossings safer but is also used to slow traffic and to convey a more park-like atmosphere to a street, with foliage and flowers usually planted on the island. This conveys to motorists that this is a residential street and not a fast through road. Median islands can be installed either at intersections or at points in between intersections. Their intention is to slow traffic by causing concern within the motorist's mind. These devices, or ones similar, already exist within Four Hills Village at Speakman Drive at Sagebrush Trail and the Stagecoach Road intersections with Four Hills Road. They are also present in other forms near the north end of Four Hills Road and at many other sites throughout Albuquerque.

A Washington Department of Transportation handbook on traffic calming assessed the speed reduction potential of "*median mid-block islands*" (exactly what is being recommended) as "*Slight*" but noted they pose only a "*Minor constraint*" to emergency services and had positive safety benefits (Reference 32). The Virginia Department of Transportation traffic calming guide (Reference 29) notes that the benefits include "*reduces speeds*". The City of Palo Alto (California) in its traffic calming guide refers to these devices as "*median island slow points*" intended for "*slowing traffic*" (Reference 37). They further explain that:

> *The resulting narrowing and horizontal deflection can lower speeds in the vicinity of the median…Speeds may be reduced by about five percent…. Median island slow points may be used on emergency response routes.*

The Pennsylvania Department of Transportation handbook on traffic calming (Reference 27) noted that raised median islands may have these impacts:

> *Vehicle speeds may decrease, particularly if the median islands result in roadway narrowing. Reductions in speed may range from one to five mph, with reductions of two to three mph most prevalent.*

The safety impact of raised median islands, like bulb-outs, has been under-examined by researchers of traffic calming. To compensate for this, the author examined the safety of these devices in detail at sites in Portland, Oregon. Nine intersections were found in Portland where small raised median islands had been installed between 1994 and 2005 on both sides of the intersection to create pedestrian refuges. These islands were similar to the ones recommended for Stagecoach Road. Three years of accident data was examined both before and after these islands were installed. The results showed an overall 33% decline in traffic accidents. This also suggests more careful and likely slower driving, similar to the effect of bulb-outs (Reference 38).

Another study was done on a suburban New Jersey roadway where a continuous raised median strip was installed, somewhat narrowing and dividing the road down its center (Reference 39). Both average and 85^{th} percentile speeds in both directions declined 2-3 miles per hour or about 5%. The report adds that:

> *Directly at the median, the 85^{th} percentile speed went down 3 mph. Away from the median the speed dropped an average of 1.5 mph.*

Significant reductions in accident rates and speed reduction caused by raised median islands have also been found in European studies. One major Scandinavian handbook estimated a 9% decline in traffic accidents as a likely result of median island installation even where primarily intended as a refuge island on a pedestrian crossing. Again, the effect seems to be to make drivers more careful and drive somewhat slower (Reference 40).

TRANSVERSE RUMBLE STRIPS AND LINES

Transverse rumble strips are lines of carefully grooved pavement laid across a road, intended to cause vibration and a warning noise to motorists as they drive across them. Rumble strips are usually longitudinal, installed in the centerline of a road or along its shoulders. They are intended to alert motorists that they are straying out of their travel path. The transverse rumble strips are also warning devices but their purpose is to cause concern to the motorist both in a tactile and audible fashion, causing speed reduction and more alert driving.

Optical speed bars are thick, painted lines across the road tend to alert motorists, cause them to pay closer attention, and to reduce speeds. They do not cause vibration or noise but only have a visual effect to warn motorists. The Pennsylvania Department of Transportation, describing white lines drawn across the road in its handbook on traffic calming (Reference 27) noted that:

> *Double thick thermoplastic transverse pavement markings have been successful in slowing traffic in diverse areas such as school zones, hospitals, approaches to severe curves, and stop signs ...It is estimated that each cluster reduces approach speeds by one to three mph.*

A recent Massachusetts study (Reference 41) found that: "*Transverse road markings ... can also be used to alter speeds by modifying drivers' perception ... These marking patterns may be an effective measure for reducing speeds...*". A recent federal Department of Transportation study (Reference 42) found that: "*Studies by New York, Mississippi, and Texas show transverse pavement markings can effectively reduce mean speeds, 85th percentile speeds, and speed variance*".

The safety impact of both these pavement treatments, like median islands and bulb-outs, has been under-examined by traffic calming researchers. However, their contribution to speed reduction and traffic safety is widely noted. A Washington Department of Transportation handbook on traffic calming assessed the speed reduction potential of pavement treatments involving "*Marking and Striping and Color*" as "*Possible*" with "*Possible Improvement*" in safety and further noted they had "*No effect*" on emergency services (Reference 33).

A recent University of Kentucky study examined both these pavement treatments and signing at three highway locations near curves to see what effect they had on speed reduction. The results of this study were that both transverse rumble strips and optical speed bars reduced speeds by about 2% while the combined use of both devices plus better signage and delineation resulted in a 3% speed reduction in average speed (Reference 43). A 1999 Kansas study found that: "*The results of this study affirm that optical speed bars have potential for reducing speeds and speed variations ...*" (Reference 44). A 2007 Virginia study found that optical speed bars reduced speeds by 2-17% at four sites surveyed: "*Optical speed bars are effective in reducing the speeds of vehicles approaching a hazardous roadway section, a reduced speed zone, or other roadway/travel change area*" (Reference 45).

The use of transverse rumble strips in residential neighborhoods is controversial because of the concern over noise. More investigation is needed on this issue to determine if these devices could be used within acceptable noise levels. There is, however, no drawback to the use of optical speed bars.

Conclusions

The analysis developed the following findings and recommendations:

FINDINGS

Roadway Accident Analysis

- Traffic accidents in the affected roadway sections have been in decline, averaging only 1.5 traffic accidents per year since 1995 and averaging only 0.5 accidents per year since 2001. In the 1990-1994 period traffic accidents in the same sections were averaging 4.6 per year.
- Only 19% (8 of 42) of traffic accidents between 1990 and 2005 on the affected roads involved injuries, most of them minor. In fact, 80% of the injuries were recorded as Class C, meaning "*Complaint of injury but none visible*".
- Only 23.8% (10 of 42) of the traffic accidents between 1990 and 2005 involved either "*excessive speed*" or speed "*too fast for conditions*" as one of the highest contributing factors causing the accident.
- Only 20% of these 10 speed-related accidents involved injuries, none of which occurred after 2001, three years before the speed humps were installed
- While there are few accidents, 67% of those which occurred after 1995 were concentrated in two areas: 1) the horizontal and vertical curve area on Wagon Train Drive between Toro Street and Cuatro Cerros Trail; and 2) the horizontal curve area on Wagon Train Drive and Stagecoach Road between Running Water Circle and Via Posada.

Speed Humps Impacts

- Speed humps in Albuquerque were found to reduce the rate of injury accidents by about 6% and the overall accident rate by about 7%.
- Less than 1% of injury accidents in Albuquerque involve fatalities.
- Assuming 1.5 traffic accidents per year, the speed humps in Four Hills would prevent only about three or four injuries (3.4 injuries) and no deaths (0.024 deaths) over 50 years.

Fatality Increase Due to Speed Humps Involving Cardiac Arrest

- Because of its high proportion of the aged, the general Four Hills area (Census Tract 7.10) population is 40% more susceptible to cardiac arrest.
- Cardiac arrest requires rapid treatment as brain damage occurs after three minutes and the likelihood of survival diminishes rapidly after five minutes; a delay of even a fraction of a minute significantly decreases the chances of survivability.
- The American Heart Association's Survivability Curve for intervention in sudden cardiac arrest was applied to the entire area that would be served by the new fire station on Via Posada and impacted by the existing speed humps. The impact area was sub-divided into 48 zones, each coded for travel time from the fire station at 30 mph, for the number of speed humps that emergency vehicles would have to traverse en route, and for its population. The Survivability Curve model was then applied to gauge the number of fatalities induced by

speed hump delay. The impact area consists of Four Hills Village, Winterwood Park, and the eastern portion of Tijeras Arroyo south of Singing Arrow Park.

- Using data developed by the Portland, Oregon Fire Department, fire trucks would be delayed an average of 4.8 seconds per speed hump while the smaller rescue squad vehicles would be delayed an average of 2.6 seconds per speed hump. The average emergency vehicle would be delayed 4.0 seconds per speed hump.
- Under existing conditions but with a new fire station on Via Posada with 21 speed humps in the impact area, the average emergency vehicle would go over 5.3 speed humps incurring 21 seconds of delay. If the Southeast Detour via Wagon Train Drive is used, the average emergency vehicle would go over 4.0 speed humps incurring 16 seconds of delay.
- A conservative estimate of delays due to the existing speed humps would be 18.7 additional fatalities (with a standard deviation of 11.7) in the Four Hills impact area over 50 years with a new fire station to be sited on Via Posada. This is about one additional death every two and a half years or about 800 times the lives estimated saved by the speed humps.
- Delays due to speed humps under the recommended plan would reduce additional fatalities to 7.8 (with a standard deviation of 11.8) over 50 years or about 300 times the lives estimated saved by the speed humps with the new fire station. This reduction would be because most of speed humps on primary emergency routes would be eliminated. Were all speed humps removed, there would be no additional fatalities due to delay.
- Without the new fire station on Via Posada, emergency service from Fire Station #12 would take longer to reach the Four Hills and overall fatalities would be higher, with the impact of the speed humps only adding to the long trip. Therefore, there would be fewer fatalities attributable to speed hump delay.
- Switching emergency service from Fire Station #12 to a new station on Via Posada would reduce the trip to Four Hills by over a mile with the faster response estimated to save nearly 130 lives over 50 years (with a standard deviation 10.3).

Other Emergency Medical Problems

- Delays induced by speed humps would tend to increase the spread of fires, increasing the likelihood of burns and damage to lungs.
- Because of its high proportion of the aged, the general Four Hills area (Census Tract 7.10) population is 52% more susceptible to stroke.
- Delays induced by speed humps would tend to increase the damage from stroke, drowning, hypothermia, heat stroke, heat exhaustion, seizures, septic shock, burns, drug overdose, and reactive airway disease.

More Limited Use of Speed Humps

- Speed humps have a long distance “shadow” effect in reducing speeds up to 3,500 feet away and were found to do so by 2-11% in Four Hills Village. Therefore, a wider spacing of speed humps would also be effective in restraining vehicle speeds.
- It is widely recommended that speed humps should not be employed on primary emergency response routes such as Stagecoach Road or Wagon Train Drive.

- It is recommended by many jurisdictions that speed humps should not be employed on bus routes, a point applicable to parts of Stagecoach Road and Warm Sands Drive.
- It is also recommended by many jurisdictions that speed humps should not be employed on collector or major local routes. Many jurisdictions have guidelines that they should not be placed on routes with weekday volumes exceeding 3,000 vehicles, a level exceeded on Stagecoach Road as far east as Warm Sands Drive and on Wagon Train Drive at Via Posada.

Alternatives to Speed Humps

- Many other measures have been proven to be effective at reducing speeds or reducing accidents or both. While each is generally less drastic than speed humps are in reducing speeds, the cumulative effect of employing several of these measures should result in keeping speeds at acceptable levels and at making drivers more alert and safer.
- The re-striping already implemented in the southern sections of Stagecoach Road and Wagon Train Drive achieved a slight reduction in speed even where traffic was moving along very near the speed limit to begin with.
- The perception by motorists of a narrower roadway by re-striping generally tends to reduce speeds and make driving a bit safer.
- The use of bulb-outs (also known as chokers, neckdowns, or curb extenders) also makes the street narrower and generally results in speed reduction.
- Two studies have demonstrated that the use of bulb-outs makes streets safer, with dramatic reductions in accident rates relative to sites without these devices.
- Raised median islands also make streets narrower, generally resulting in a reduction of both accidents and speeds.
- Transverse rumble strips and optical speed bars (transverse lines across the road) have also been found to cause speed reduction and promote safety.

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