Enhancing Dublin’s Emergency Road Network for Hazard Preparedness in the Event of Natural Disaster

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Approval Page

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Executive Summary

The purpose of this study is to assess and analyze the City of Dublin’s current emergency road network and provide recommendations to improve emergency evacuation in the event of natural disasters in the City of Dublin, California.

Planning for emergency preparedness, especially in the aftermath of the wildfires in Paradise and Montecito, California, is more relevant than ever. Learning from these disasters highlight the importance of preparedness, as well as the consideration of roadway capacity and conditions to evacuate during emergencies. This study analyzes the volume, capacity, density, and travel time to determine the capability of a mass evacuation in the City of Dublin in the event of a natural disaster. The results of this study are to enable citizens and decision-makers to visually identify the problem locations and determine which routes best serve for an emergency evacuation. This can help in alignment planning for alternate evacuation routes, in improving upon the current evacuation routes, and in stimulating emergency preparedness education for citizens.
I. Introduction

Natural Disasters and the Law

The United States experiences several natural disasters in a given year. The State of California is prone to natural disasters, such as wildfires, earthquakes, floods, mudslides, heatwaves, and heavy storms. These events led to the California Emergency Services Act, administered by the California Governor’s Office of Emergency Services (CAL OES), which handles the Standardized Emergency Management Service System (SEMS). SEMS is responsible for incident command systems, multi-agency and interagency coordination, mutual aid, and operational area concept (CAL OES, 2019). The CAL OES document, “Legal Guidelines for Controlling Movement of People and Property during an Emergency,” lists the guidelines on properly conducting an emergency evacuation. Most jurisdictions do not forcibly remove people from an area ordered evacuated, but rather warn citizens about the emergency and recommend evacuation (Cal OES, 1999). In an ideal scenario, an authority will proclaim a local emergency under the Emergency Services Act and issue an evacuation. In order to ensure success in an emergency evacuation, emergency managers and decision makers must prepare their jurisdictions (Lewin, 2016). Creating an Emergency Evacuation Route Plan in preparation for a natural disaster is vital to inform the community of the safest routes for evacuation. The goal is to ensure that emergency vehicles have entry into the city, while the community can evacuate out of city limits. This project assessed the emergency evacuation network established for the City of Dublin.
Study Purpose

The purpose of this study is to assess the current emergency road network and provide recommendations to improve emergency evacuation in the event of natural disasters in Dublin, California. The aim is to improve upon Dublin’s Emergency Routes Map by calculating and analyzing the data from the entire street network of the City of Dublin, visually identifying problem locations, and determining which travel paths best serve as emergency routes.

By evaluating overall roadway segments and the collection of trips onto fewer and fewer arterials, the study provides an overall visualization of the density and the amount of time it would take to evacuate Dublin. The results of this study are to enable citizens and decision-makers to visually identify the problem locations and determine which routes best serve for an emergency evacuation.
II. Background & Literature

Background

Dublin Census Information

The City of Dublin is located in Alameda County and is in the East San Francisco Bay Area of California. Dublin is the second fastest-growing city in the state of California, and the 11th in the United States (United States Census Bureau, 2019). The total resident population of Dublin is 64,577, with a labor force of over 32,690 people (California Department of Finance, 2019). The City of Dublin is projected to increase population to approximately 75,000 at maximum build out (City of Dublin, 2019).

Figure 2.1 is the City of Dublin’s General Plan Land Use Map (City of Dublin, 2016). This map highlights that a majority of the City of Dublin’s residential zones are located in the northern part of the City. Commercial and industrial districts are located in the southern part of the city, with Dublin Boulevard, a major arterial running through it from east to west. Dublin is located at the crossroads of two major freeways. Interstate 580, or I-580, runs from east to west along the southern border of Dublin. Interstate 680, or I-680, runs north to south on the western side of Dublin. For the purpose of this study, I-580 and I-680 act as the exit points from the City in the event of an evacuation. Parks Reserve Force Training Area, commonly known as Camp Parks, is a United States Army facility, which is located within the city limits of Dublin, towards the northern center of Dublin. Camp Parks is not included in this study, as the land is federal property (Vincent, Argueta, & Hanson, 2017).
Figure 2.1: Dublin general plan land use map (City of Dublin, 2016)
Tri-Valley Local Hazard Mitigation Plan

The Tri-Valley Local Hazard Mitigation Plan (TVLHMP) includes Dublin along with the City of Livermore and the City of Pleasanton. The TVLHMP highlights past natural hazard events that have occurred in the City of Dublin (Tetra Tech, 2018). These are listed in Table 2.1.

Table 2.1: Past Natural Hazard Events in the Tri-Valley Local Hazard Mitigation Area

<table>
<thead>
<tr>
<th>Type of Event</th>
<th>FEMA Disaster #</th>
<th>Date</th>
<th>Damage Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wildfire</td>
<td>N/A</td>
<td>10/17/2017</td>
<td>50-acre wildfire requiring automated alert system notification to 150 residents to evacuate to City sponsored Shelter. No Damage $0</td>
</tr>
<tr>
<td>Wildfire</td>
<td>N/A</td>
<td>8/22/2017</td>
<td>74-acre wildfire on Camp PARKS requiring road closures and automated alert system notification residents directed to City sponsored reunification center. No Damage $0.</td>
</tr>
<tr>
<td>Drought</td>
<td>N/A</td>
<td>2014-2015</td>
<td>CA Governor declared a state of emergency based on drought conditions in California; City proclaimed Local Emergency and mandatory conservation efforts to show support to water purveyors.</td>
</tr>
<tr>
<td>Gas Line Leak</td>
<td>N/A</td>
<td>6/2016</td>
<td>Private undergrounded jet fuel gas line traversing City of Dublin sustained a leak.</td>
</tr>
<tr>
<td>Gasoline Spill</td>
<td>N/A</td>
<td>5/2009</td>
<td>Privately operated gasoline tanker spill in neighboring jurisdiction leaked into City of Dublin storm-drain system. City had partial emergency operation center activation, provided temporary lodging vouchers and animal sheltering services to impacted neighborhoods.</td>
</tr>
<tr>
<td>Flash Flood</td>
<td>N/A</td>
<td>2/1999</td>
<td>Weeks of severe winter weather and horizontal rain caused significant damage to public facilities.</td>
</tr>
</tbody>
</table>

The City has also rated and categorized the likelihood of the occurrence of each hazard, as seen in Figure 2.2 (Tetra Tech, 2018). The Risk Rating Score is based on
multiplying the probability factor by the sum of the weighted impact factors for people, property and operations. The hazards are also organized by categories of high, medium, and low, based on the risk rating score.

Table 2.2: Hazard Risk Rating

<table>
<thead>
<tr>
<th>Rank</th>
<th>Hazard Type</th>
<th>Risk Rating Score (Probability x Impact)</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Landslide</td>
<td>54</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>Earthquake</td>
<td>36</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Severe weather</td>
<td>33</td>
<td>Medium</td>
</tr>
<tr>
<td>4</td>
<td>Wildfire</td>
<td>18</td>
<td>Medium</td>
</tr>
<tr>
<td>5</td>
<td>Flood</td>
<td>12</td>
<td>Low</td>
</tr>
<tr>
<td>6</td>
<td>Drought</td>
<td>9</td>
<td>Low</td>
</tr>
<tr>
<td>7</td>
<td>Dam failure</td>
<td>6</td>
<td>Low</td>
</tr>
</tbody>
</table>

Problem

The State of California spends enormous amounts of money on natural disasters in a given year. The most recent case studies, including the catastrophic wildfire in Paradise and tragic wildfire, mudslides, and flooding in Montecito, illustrate the enormity of the problem. Both cities had established emergency strategies in place, but the abrupt and dangerous occurrences overtook residents and emergency personnel.
Paradise

The 2018 Camp Fire in Paradise, California is known as the deadliest and most destructive wildfire in California (Baldassari, 2018). The majority of the loss was due to issues with the evacuation routes. A decade earlier, a Butte County Grand Jury report on fires that occurred in 2008, stated that the majority of the roads in Paradise had serious capacity limitations, and there were no ideal evacuation routes due to lack of compliance with fire regulations and significant constraints due to road conditions and structure (Butte County, 2009). The emergency alerts system also had major issues, as emergency officers and city officials did not notify four areas that were at risk and residents did not have sufficient time to evacuate. The evacuation routes were extremely congested and led to cars being abandoned as people evacuated on foot. This led to people being trapped inside their vehicles, which caused at least four deaths (CBS SF, 2018). The Camp Fire led to a total loss of 84 lives and many injuries (Lewin, 2019).

Montecito

In the Montecito natural disaster events, including the Thomas Fire in December 2017 and the following mudslides and Pineapple Express flooding in January 2018, the evacuation methods were ill-prepared and caused many issues throughout the period of natural hazard events (Serna, Branson-Potts, Vives, & Nelson, 2018). Approximately 104,607 residents evacuated Santa Barbara and Ventura County during the Thomas Fire (Cal Fire, 2017). During the mudslide events, only 21,000 residents evacuated from the areas of high-elevation. However, residents in the low-elevation zones were outside
the mandatory evacuation area and ignored the warnings and stayed in their homes (Raphelson, 2018). The National Weather Service and the County government sent warning messages, but they were not received in time. As a result, the mudslides in the Montecito area caused 21 deaths and 150 injuries (Dobuzinskis, 2018).

**Issues with the Dublin Emergency Routes Map**

The existing Emergency Routes map for the City of Dublin, seen in Figure 2.2, exhibits the emergency routes in the City (City of Dublin, 2018). This study paid particular attention to the potential performance of these emergency routes during an evacuation. The blue lines represent primary routes, or the major arterial segments to use in the event of evacuation. The green lines signify secondary routes, or the local street roadway segments leading to emergency services providers, such as fire stations and the Alameda County Office of Emergency Services. However, the map does not take into consideration the population of Dublin, the capacity of road segments, and the exit strategy to evacuate the city. Without these factors, this map would not be helpful in aiding decision-makers and citizens to determine an exit strategy in the event of a natural disaster.
Figure 2.2: Dublin emergency routes map (City of Dublin, 2018)
III. Analysis

Study Methodology

Data Preparation

In order to evaluate the existing emergency road network, this study took an analytical approach by calculating the density and evacuation travel time of each roadway segment. The City of Dublin provided the necessary geospatial datasets or layers. The data include roadway network and assessor’s parcel information that are consolidated into Geographic Information Systems (GIS) files. The roadway network data include the street identification number, street name, length (in feet), the speed limit, the number of lanes on each roadway segment, and the total number of buildings on each roadway segment. The assessor’s parcel data were used to create a separate layer, entitled “Emergency Zones”, which divided Dublin into 25 evacuation zones as seen in Figure 3.1. Each emergency evacuation zone had one arterial street as the zone’s initial exit point. The roadway network data were also used to create a separate layer of only arterial street segments, entitled “Emergency Routes.” The widest and safest roads are designated as arterial street segments and are best suited to be emergency routes so that emergency vehicles can come into the site, while the community can evacuate using the nearest freeways or highways (Los Angeles County Public Works, n.d.). The Appendix includes a summary of the data used for this study.
Figure 3.1: Dublin divided into emergency evacuation zones
Estimation of Capacities and Volume

The capacity is the maximum traffic flow obtainable on a given roadway using all available lanes, where the average vehicle in the traffic stream is assumed to occupy 25 feet. The capacity of each roadway segment was found using the equation:

**Roadway Segment Capacity = (Roadway Segment Length \* Number of Lanes) / 25**

*Where:*

- Segment Length: the length of the road segment (feet).
- Number of Lanes: number of directional lanes on each roadway segment.
- 25: equivalent to the default average vehicle length (feet) in an urban environment, which includes the average length of one vehicle and the gap between adjacent vehicles.

The default average vehicle length in an urban environment was found using the sum of the average length of an automobile and the average gap between two vehicles in bumper-to-bumper traffic.

The volume of each roadway segment is defined as the number of automobiles on the roadway segment. The volume was calculated for each roadway segment in residential areas using the equation:

**Roadway Segment Volume = Number of Housing Units \* 2**

*Where:*

- Number of Housing Units: The number of housing units on each roadway segment.
- 2: Equivalent to the average number of vehicles per household in the City of Dublin (United States Census Bureau, 2019).
OR

Roadway Segment Volume = other estimates of vehicles in non-residential land use.

The volume of automobiles on roadway segments in residential areas was found using the assumption that each household would evacuate using two automobiles, the average number of vehicles per household in the City of Dublin. In order to find the volume, or the number of vehicles, evacuating commercial, industrial, public, semi-public, open space, and specific plan district areas, the number of vehicles parked in parking lots were estimated from counts of parked vehicles in aerial images from Google Earth.

Calculation of Densities

The density of each roadway segment is defined as the occupancy of the roadway lanes, where the average vehicle in the traffic stream is assumed to occupy 25 feet. First, the initial density reflects when residents spill onto all street segments at the beginning of an evacuation. This is calculated using the equation:

Local Street Segment Density = Local Street Segment Volume / Local Street Segment Capacity

Where:

- Local Street Segment Volume: (Number of housing units x 2) OR other estimates of vehicles in non-residential land use.
Local Street Segment Capacity: \( \frac{(\text{Local Street Segment Length} \times \text{Number of Lanes})}{25} \)

Arterial density assumed a subsequent stage of evacuation when vehicles would have consolidated onto major arterials. Arterial density is calculated using the equation:

**Arterial Street Segment Density = Cumulative Arterial Street Segment Volume / Arterial Street Segment Capacity**

*Where:*

- Cumulative Arterial Street Segment Volume: Sum of volumes for every local street segment in that respective zone which must traverse that arterial.
- Arterial Street Segment Capacity: \( \frac{(\text{Arterial Street Segment Length} \times \text{Number of Lanes})}{25} \)

The arterial street segment density calculation is the cumulative density of each arterial roadway segment. This was done by adding the volume of every road segment in each zone, and then adding the cumulative volume of each arterial roadway segment heading towards the closest exit. Density was calculated for each arterial street using the cumulative volume and the segment capacity. The assumption was that every zone would evacuate using the main arterial nearest to the zone and then would exit to the zone’s designated freeway entrance, onto either I-580 or I-680.

**Calculation of Travel Times**

The travel time of each roadway segment is the number of hours it would take to drive through the roadway segment and evacuate. The arterial segment travel time is calculated using the equation:
Arterial Segment Trip Time = Cumulative Arterial Street Volume/ (Number of Lanes * 1900)

Where:

- Cumulative Volume: the cumulative volume from each zone into an arterial roadway segment.
- Number of Lanes: number of lanes on each road segment.
- 1900: estimation of the number of automobiles that one lane in an urban street can handle in 1 hour (Spack, 2011).

Similarly, the local street segment travel time is calculated using the equation:

Local Street Segment Trip Time = Local Street Segment Volume/ (Number of Lanes * 1900)

Where:

- Local Street Segment Volume: the individual volume calculated for each local street.
- Number of Lanes: number of lanes on each road segment.
- 1900: estimation of the number of automobiles that one lane in an urban street can handle in 1 hour (Spack, 2011).

Mapping of Results

GIS aided in organizing the large data set and visualizing the layers of information using special location mapping. There is a total of 5 maps, 3 representing variations in street segment density, and 2 representing the variations in travel time. Each map is
categorized within 6 natural breaks, ranging from clear pathways and low travel times to heavily congested and long travel times. The maps clearly highlight the areas in which it would be difficult to exit the city, such as congested bottleneck areas.

Results

Density

Figure 3.2, 3.3, and 3.4 demonstrate the progression of density during an evacuation. The density is categorized into 6 natural breaks, as green refers to low levels of density, and darker shades of red and purple refer to high levels of density and potential bottlenecks. To showcase the progression of increased density, the color classifications in the three figures correspond to the same range.

The initial levels of impact on local street segments can be seen in Figure 3.2. The major arterials are unaffected during the beginning phase of evacuation, but the local street segments face issues with ranges of medium to high levels of density. The southern portion of Dublin, which holds the majority of the commercial and industrial land uses, would face the severity of blockage during the initial phase of evacuation. Newer residential zones and commercial districts, located on the southeast side of Dublin, also tend to have higher amounts of density, as the buildings are more densely packed.
Figure 3.2: Beginning phase of evacuation: initial levels of impact on local street segments
The secondary levels of impact on both arterial and local street segments during the middle phase of evacuation can be seen in Figure 3.3. This map demonstrates the transition of vehicles loading onto arterial street segments from local street segments. As more and more vehicles from each of the designated zones load onto the assigned arterial street segments to that zone, the density of the arterial street segments increases. The purple arterial street segments show that density reaches 4 or more times over its capacity in the middle phase of evacuation. Nearly every single zone will have to evacuate to a freeway using a major arterial that has an extremely high level of density. This will lead to heavy levels of congestion as people attempt to evacuate away from Dublin. This map showcases the major issue of density increasing as the population transitions in evacuating from local to arterial street segments.
Figure 3.3: Middle phase of evacuation: secondary levels of impact on both arterial and local street segments
Figure 3.4 demonstrates the final levels of impact on arterial street segments, as majority of vehicles are loaded onto the arterial street segments from the local street segments. A majority of the arterial street segments are in purple, revealing that the street segments are 4 or more times over its capacity. The arterial street segments with the highest densities are located at the intersection of the arterial street and the freeway entrances to either I-580 or I-680. The arterial street segments that are under capacity, visualized in light green, can be due to either an increased number of lanes in the arterial, or a lower volume of vehicles evacuating from the assigned zone. The high levels of density on arterial street segments proves that the emergency road network is over maximum capacity and will need to be improved greatly in order to successfully work in the event of an emergency evacuation.
Figure 3.4: Final phase of impact on arterial street segments
Travel Times

Figure 3.5 and 3.6 demonstrate the progression of travel time in hours during an evacuation. The travel time calculated is the time that it would take to evacuate that particular street segment. This map can be used to estimate how much time it would take to evacuate from a particular location to the exit point, by adding up each street segments time in each particular route. This map can be useful for citizens to understand how much time is needed for the to evacuate from their residence. Figure 3.5 showcases the ranges of evacuation travel times for each local and arterial street segment. Figure 3.6 highlights the amount of time it will take to evacuate the arterial street segments during the final phase of evacuation. Figure 3.7 is a similar map, but with the actual amount of time in hours, so citizens can best estimate the amount of time it will take to evacuate from their location. The travel time is categorized into 6 natural breaks, with green and blue reflecting low levels of density, and darker shades of red and purple indicating high levels of density and potential bottlenecks.

Figure 3.5 represents that every local street segment, shown in light green, can be evacuated in under half an hour. However, the major issue begins when people start loading onto arterial street segments from the local street segments. A majority of the arterial street segments, as seen in shades of blue, can be evacuated from half an hour to one hour. The darker shades of red and purple indicate that it will take anywhere from 2 to 5 hours to exit that particular street segment. A major bottleneck is shown in the south-east portion of Dublin, where new residential and commercial areas have recently been developed due to the higher concentration of buildings.
Figure 3.5: Ranges of evacuation travel times for each local and arterial street segment
Figure 3.6: Ranges of evacuation travel times for arterial street segments
Figure 3.7: Ranges of evacuation travel times for arterial street segments with hours listed.
IV. Recommendations and Conclusion

Recommendations

The results of the study and the analysis of the evacuation routes confirmed that organizing by zones led to optimal use of the multiple freeway exit points from the city. However, it also highlighted that the arterial street segments leading to the freeway entrances still resulted in significant congestion. In order to improve Dublin’s emergency evacuation routes and improve evacuation times, I would recommend the following:

- Increasing the number of lanes on impacted arterial street segments to allow traffic to flow easily to an exit point.
- Increasing the number of lanes in arterial road segments with high density and high travel times, especially in the southern portions of the city, where the majority of the exits to I-580 are located.
- Identifying alternate routes to evacuate from the eastern and southern portions of the city, to reduce bottleneck scenarios.
- Preparing Dublin residents with emergency routes information prior to a natural disaster through community outreach.
- Informing Dublin residents to use the shortest path using arterial roadway segments through the city to an emergency exit.
- Advising Dublin residents to evacuate the city using 1 vehicle per household, rather than the estimated 2 vehicles per household in this study.
Conclusion

As the State of California experiences an increased amount of natural disasters with each passing year, it is vital to ensure that every jurisdiction is prepared to support its citizens during an emergency. In order to ensure success in an emergency evacuation situation, emergency managers and decision makers must prepare their jurisdictions. Assessing and analyzing the major emergency evacuation routes in the event of a natural disaster is necessary to inform the community of the safest route to evacuate and to ensure that emergency vehicles have entry into the city.

This project creates an assessment of emergency evacuation network established for the City of Dublin. This study proves that creating an Emergency Evacuation Route in preparation for a natural disaster is vital to inform the community of the safest route to evacuate. The results from this study demonstrate that evacuating a city using arterial street segments to a major freeway is the ideal scenario but can still lead to major traffic congestion issues. As an increased number of vehicles load onto arterial street segments, the density and travel time per street segment increases for every evacuation zone. In Dublin, the density and travel time are determined to be the highest on the arterial roads, especially in the southern portion of the city where the majority of the freeway exit points are located. This assessment helps visualize the spatial variation of density and travel time, guide future decisions in event of evacuation, and support emergency response planning in the City of Dublin. The most fundamental lesson from this study is the importance of being prepared with
an evacuation route, as natural disasters are becoming more frequent and detrimental.

This study is replicable to determine ideal evacuation routes in any jurisdiction.
References


Appendix

Average Vehicle Ownership Calculations

Table A.1: Average Vehicles per Household

<table>
<thead>
<tr>
<th>TENURE BY VEHICLES AVAILABLE</th>
<th>Dublin city, California</th>
<th>Vehicles per household</th>
<th>Number of Households</th>
<th>Total Vehicles</th>
<th>Average Vehicles per Household</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total:</td>
<td>19,023</td>
<td>+/−364</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owner occupied:</td>
<td>12,513</td>
<td>+/−463</td>
<td>12513</td>
<td>27223</td>
<td>2.18</td>
</tr>
<tr>
<td>No vehicle available</td>
<td>214</td>
<td>+/−83</td>
<td>0</td>
<td>214</td>
<td>0</td>
</tr>
<tr>
<td>1 vehicle available</td>
<td>2,098</td>
<td>+/−300</td>
<td>1</td>
<td>2098</td>
<td>2098</td>
</tr>
<tr>
<td>2 vehicles available</td>
<td>6,830</td>
<td>+/−415</td>
<td>2</td>
<td>13660</td>
<td>6972</td>
</tr>
<tr>
<td>3 vehicles available</td>
<td>2,324</td>
<td>+/−257</td>
<td>3</td>
<td>2324</td>
<td>742</td>
</tr>
<tr>
<td>4 vehicles available</td>
<td>742</td>
<td>+/−167</td>
<td>4</td>
<td>742</td>
<td>2968</td>
</tr>
<tr>
<td>5 or more vehicles available</td>
<td>305</td>
<td>+/−101</td>
<td>5</td>
<td>305</td>
<td>1525</td>
</tr>
<tr>
<td>Renter occupied:</td>
<td>6,510</td>
<td>+/−355</td>
<td>6510</td>
<td>10609</td>
<td>1.63</td>
</tr>
<tr>
<td>No vehicle available</td>
<td>353</td>
<td>+/−112</td>
<td>0</td>
<td>353</td>
<td>0</td>
</tr>
<tr>
<td>1 vehicle available</td>
<td>2,723</td>
<td>+/−322</td>
<td>1</td>
<td>2723</td>
<td>2723</td>
</tr>
<tr>
<td>2 vehicles available</td>
<td>2,682</td>
<td>+/−281</td>
<td>2</td>
<td>2682</td>
<td>5364</td>
</tr>
<tr>
<td>3 vehicles available</td>
<td>548</td>
<td>+/−153</td>
<td>3</td>
<td>548</td>
<td>1644</td>
</tr>
<tr>
<td>4 vehicles available</td>
<td>142</td>
<td>+/−75</td>
<td>4</td>
<td>142</td>
<td>568</td>
</tr>
<tr>
<td>5 or more vehicles available</td>
<td>62</td>
<td>+/−60</td>
<td>5</td>
<td>62</td>
<td>310</td>
</tr>
</tbody>
</table>

Source: U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates; Table B25044
Network Summary for 25 Evacuation Zones with Corresponding Arterial Street Segment

Table A.2: Evacuation Zones and Arterial Segments

<table>
<thead>
<tr>
<th>Zone</th>
<th>Number of Segments</th>
<th>Sum of Segment Volumes</th>
<th>Arterial Link</th>
<th>Total of Segment Capacities</th>
<th>Arterial Density</th>
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<tr>
<td>0</td>
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<td>296</td>
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<td>136</td>
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