Locating Unsafe Areas for Cyclists and Pedestrians in Monona, Wisconsin

Emily Guenther 9042798059
Zach Olson 9067679762
Laura Scott 9076104794
Cameron Wein 9067693458

University of Wisconsin-Madison
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Professor A-Xing Zhu
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Objective

The city of Monona, in partnership with the UniverCity Alliance, hopes to identify unsafe areas within its city boundaries. The UniverCity Alliance is an initiative established by Monona to work in partnership with University of Wisconsin-Madison students to explore sustainable developments issues across four topics: Housing & Development, Community Media, Parks & Recreation, and Transportation. The objective of this project is to evaluate and identify unsafe areas within existing bike, pedestrian, and transit infrastructure. Unsafe areas shall be defined as those that pose risks to pedestrians and cyclists as determined by analyzing five variables: traffic speed, traffic volume, slope of the terrain, incidence of previously reported bicycle versus motor vehicle or pedestrian versus motor vehicle accidents, and absence of bike lanes or sidewalks.

Introduction

Background

The term "livable cities" is a relatively new concept in the arena of regional and urban planning referring to the general quality of life of a community's residents.Several factors influence a community's livability score including quality schools and healthcare facilities, safety and security, reliable and affordable public transportation, access to shopping, culture and recreation, and a physical environment conducive to walking and biking (AARP 2015). Walkable neighborhoods are highly desirable because of the benefits they offer. These benefits include reduced noise and traffic, increased physical health and wellbeing of residents, increased economic activity, higher home values, and increased community pride.

Study Area

The city of Monona, located in Dane County, Wisconsin, is a community of approximately 7900 residents. The community boasts over 330 acres of green space, including parks, woodlands, and wetlands. Uniquely located entirely within the city of Madison, Monona possesses a small-town charm combined with the luxury of urban services and amenities. Because of its unique geography, Monona faces challenges that other cities and towns of similar size likely do not have to consider. Because the City of Madison surrounds Monona, several of its main corridors serve to connect East Madison with the Isthmus. Thus, traffic volume on its main corridors is significantly increased. Recent redevelopment of one of the city's major traffic corridors, Monona Drive, has brought economic revitalization to the area. In its mission to provide and maintain a high standard of living to its residents, city planners hope to pinpoint unsafe areas in order to implement strategies for improved safety for future projects.

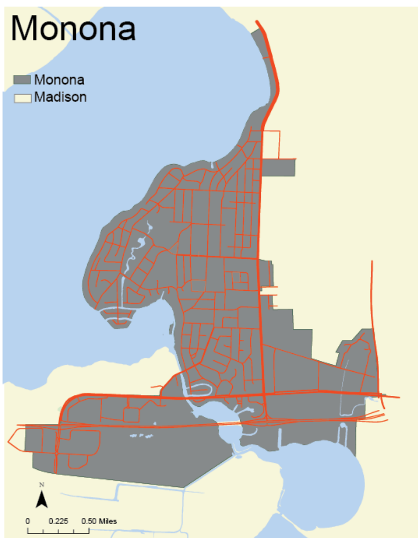


Figure 1: Study Area

Methodology

In order to identify and locate unsafe areas for pedestrians and bicyclists, first the definition of "unsafe" must be clearly defined. There are hundreds of factors that could amount to an unsafe environment for pedestrians and bicyclists, however for the scope of this project factors were filtered until five variables were selected. These variables include traffic speed, traffic volume, slope of the terrain, incidence of a previously recorded motor vehicle vs. pedestrian or motor vehicle vs. bicyclist accident, and absence of dedicated bike lanes or sidewalks. By combining these variables, an overall risk assessment can be used to locate areas which are unsafe for either pedestrians or bicyclists.

The factors that were chosen to be utilized in the analysis were among the most perceivably influential. Traffic speed was the first variable used. While some may argue that the roadway infrastructure is designed to accommodate the risk of speed, it can also be argued that if an accident is to occur, a higher speed would cause more harm and therefore be a higher risk to pedestrians and bicyclists. Traffic volume was the second factor used in the analysis. A higher level of traffic can increase the number of potential accidents given that with a higher level of traffic it can be more difficult to fully perceive one's surroundings. In other words, busy streets tend to lead to more difficult driving situations. The third variable that was analyzed was slope. This variable has two potential impacts on the risk for pedestrians and bicyclists. A high slope gradient at an intersection or crossroad could potentially lead to a visual obstruction increasing the risk for an accident. In addition, in a situation where road conditions are poor, a steep gradient could impede stopping distance. The fourth variable taken into consideration was the presence of a previous accident. This information was used to verify and further explore the areas which could have a high level of risk. The last variable to be integrated into the study was the presence of bike lanes for bicyclists or sidewalks for pedestrians. Without the appropriate infrastructure, there is a clear elevated risk for the pedestrians and bicyclists given they are forced to inhabit the same space as automobiles without any type of safety buffer separating them from traffic. This variable is also where the question of locating unsafe areas is divided into two sub questions; where unsafe areas exist for pedestrians and where unsafe areas exist for bicyclists. While some of these areas may overlap, many will be unique to the respective mode of transportation. Throughout the analysis, the first three variables will be the same for both sub questions; however, the presence of infrastructure and the presence of accidents will be specific to pedestrians or bicyclists.

In order to create a final product that would incorporate all of the factors into the final analysis, a scoring system was used to rank each variable. Each factor was treated as its own data layer that would then be combined with the other layers in the final analysis. For each factor a unique threshold was determined and the areas that did not meet or exceed that threshold were given a score of “0” (no risk) and the areas that did exceed it were given a score of “1” (potential risk). Once all the layers were classified with zeros and ones, they were overlaid and the values were added to calculate total risk given all the factors. The higher the total value of an area, the higher the risk for a pedestrian or bicyclist. These areas of high risk were further inspected and compared with the previous accidents layer. The following sections will detail the processes involved for creating the factor risk layers.

Traffic speed:

A roadway layer created by the City of Monona was the foundation for most of the layers that were generated in this project. This layer contained all of Monona's thoroughfares split into smaller segments, typically at every intersection. First, the layer was projected using a NAD83 UTM zone 16 projection, which also would be the projection used through the rest of the project. Because it is difficult to overlay lines when performing the final analysis, a 4.57-meter buffer, the approximate width of lane within a residential road, was then applied to all the line segments. This created polygons that could then be assigned a zero or one value and overlaid in the final steps of the project. Once the buffered roadway layer, which served as the base layer for most of the factors, was created, the traffic speed layer could then be generated. An exact copy of the roadway buffer layer was created to serve as the traffic speed layer.

Monona has a rather narrow range of speed limits for its roadways. The range extends between 25 mph for most of the residential areas to 30 - 40 mph on the more major thoroughfares. Because of this, there was a natural break in roadway classification between residential and major roads with regard to their speed limits and therefore the threshold for higher risk was set to 30 mph. Any roadway segment that had a speed limit greater than or equal to 30 mph was given a value of one and anything less a value of zero. The speed limits of each roadway segment were already accounted for in the data layer's attribute table and therefore identifying the segments that meet or exceed the threshold was an easy as a simple attribute query. Once the segments were identified, a new column was created in the attribute table labeled "Points" and the selected segments were given a value of 1. The selection was then inverted and the remaining segments were given a value of zero.

Figure 2: Speed Map

Traffic Volume:

Unlike traffic speed, traffic volume data was not included in the provided roadway data layer. Therefore, this information was obtained via the Wisconsin Department of Transportation's Interactive Highway Map. Approximately 30 data points measuring the estimate of typical daily traffic on a road segment for all days of the week, Sunday through Saturday, over the period of one year, were provided by the DOT's map and added to the buffered roadway attribute table under a new column labeled "Volume." A volume of 4000 was decided as the threshold based on a 2002 study by the State of Virginia Department of Transportation study defining this number as potentially problematic for residential neighborhoods and unsuitable for traffic calming measures. Any road segment greater than 4000 cars per day would be given a value of one and any segment under, a value of zero.

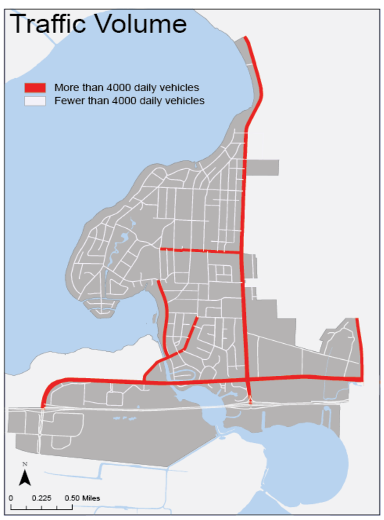


Figure 3: Volume Map

Coverage of traffic volume data is somewhat sparse for Monona so approximations were used on some segments that existed between data points but on the same street. Many streets lacked any traffic information, however they typically were residential areas which given the known data, all had a daily total under 2000 with most being around 1000 cars per day. With this evidence, it was assumed that the unknown values were most likely under the 4000 cars per day threshold. As for the major thoroughfares, one if not more data points were known and therefore were not subject to this assumption.

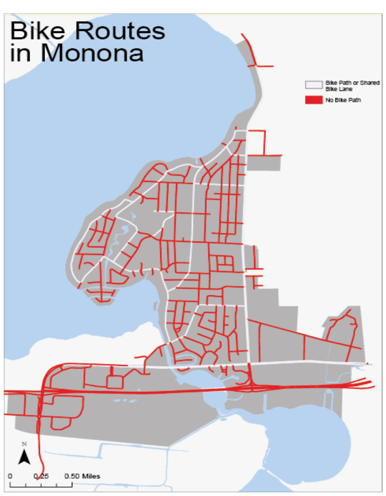


Figure 4: Established Bike Routes

Generating the traffic volume risk layer had similar steps to traffic speed layer. It started with creating a duplicate of the buffered roadway layer. Then the known and estimated data points were added to the attribute table for each of the roadway segments. Another column for points was created, all values exceeding the threshold were given a value of 1, and all unknown values and values under the threshold were given a value 0.

Presence of bike paths/sidewalks:

The next variable that was looked at was bike infrastructure. For this project, bike lanes, bike routes, and shared lanes were combined into one group. The presence of bike infrastructure was the only concern regarding the analysis. Once again, an exact copy of the roadway buffer layer was created and roadway segments that overlapped with the bike layer were selected. For this variable, the roadway segments that were selected were assigned a zero in the new points column in the attribute table instead of a one. This is because segments that had bike infrastructure present were considered safe. The selection was then inverted and the remaining segments were given a value of one.

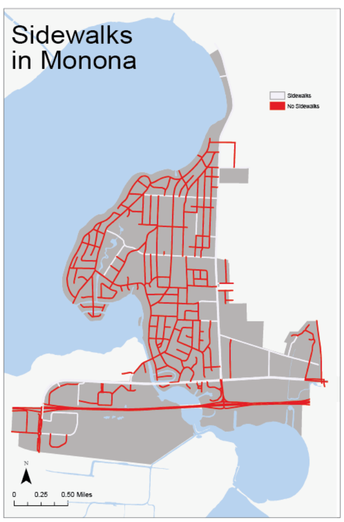


Figure 5: Sidewalks

Sidewalks were analyzed in the exact same fashion as the bike path variable. A copy of the roadway buffer layer was created and the roadway segments with at least one sidewalk adjacent to them were selected and given a value of 0 in the added points column in the attribute table. Unlike the bike path layer, there was no digitized sidewalk layer available, only a pdf of the existing sidewalks. In order to create the sidewalks layer, the pdf was georeferenced with the original Monona roadway layer using 10 control points. Once the pdf was properly aligned with roadway layer a new lines feature class was created and one by one the sidewalks segments were digitized and added to the layer.

Slope:

Although fairly flat, Monona still has some of topographic relief to contend with. Slopes can influence roadway safety in a few ways (as described earlier), so it is appropriate to analyze. The end goal was to find the steep slopes in Monona by using an existing topographic data layer. A threshold of 7%, or approximately 4 degrees, was established. Any value over the 7% threshold was assigned a value of 1 for high risk and below 7% a 0 for low risk. The threshold was decided after examining DOT standards (State of Florida Department of Transportation, 2013), where they recommend residential roads in flatter areas to be around a 7% grade.

A two-foot contour topographic data layer of Monona was used as the starting point of this analysis. A topo to raster tool then converted the contour map to a DEM. An output resolution of one meter was chosen as it seemed be a good balance of being high enough resolution yet not so high that it would take too long to calculate. The DEM was compared to the topographic map to make sure that it was accurate enough for the analysis. Once the DEM was created, a gradient tool was used to convert the elevation pixels to slope values. Again, the slopes were checked back to the Monona topographic map to verify the results. Once the slopes were verified, they were clipped to the boundaries of the roadway buffers. The clipped layer was then reclassified, where any slopes greater than 4 degrees or 7% (ArcMap indicates slopes in degrees, not percent grades) were given a value of one and under 7% a value of zero. The resulting data layer showed roadways that had a potentially dangerous slope.

Figure 6: Slope

Accidents:

The accidents layer had a different function than the rest of the variables. This layer did not contribute to the total risk score, rather it was used to validate areas that were rated as high risk in the final assessment as well as a tool to bring attention to areas that may not have been flagged as dangerous by the analysis that needed further inspection. The accident layers were divided up accordingly to their type; either they were in a list of vehicle-bicycle accidents or vehicle-pedestrian accidents. The accidents were provided from the City of Monona and given in the form of street addresses. To accommodate for this in ArcMap, they first needed to be geocoded into geographic coordinates. This was done using an online geocoding tool. The tool created points with latitude and longitudinal in a WGS84 GCS which then were geocoded as x and y data in a NAD83 UTM zone 16N projection and overlaid with their respective total risk maps as described in the next section.

Final steps:

The last step before the final analysis required all the risk factor layers to be converted to raster using the polygon to raster tool. Once the layers were converted to raster, pixel addition could be applied using the addition tool. For the pixel addition to function properly the pixels for every layer had to be the same size and align perfectly. When creating each raster layer the pixel size was set equal to the pixels generated in the slope layer (i.e. 1 x 1 meter). In addition, the snap to raster option was activated in the environment settings to ensure the pixels aligned properly. This resulted in the final two unsafe area maps, one for pedestrians and one for bicyclists, with the highest pixel values indicating areas of high risk. Finally, the geocoded previous accidents layers were overlaid the two final risk raster maps.

Figure 7: Pedestrian Safety Analysis Map

Results and Discussion

Figure 8: Pedestrian Safety Analysis: Low Risk Area

The final total risk maps had scores between zero and four for both pedestrians and bicyclists. However, there were so few pixels with a score of four, for simplicity they were merged with the group of pixels that had a score of three. It should also be noted that no pedestrian or bicycle traffic is allowed on the Beltline and therefore is excluded from the analysis.

For the Pedestrian Safety Analysis Map, shown in figure 7, the roads with the highest risk were Monona Drive, Bridge Road, and Broadway. While these roads had sidewalks, they also had high traffic volume, high speed, and areas with a slope greater than 7%. All pedestrian accidents from 2010-2016 with the exception one occurred on one of these roads. Two thirds of the pedestrian accidents occurred Monona Drive, which has the highest volume of traffic ranging from about 18,000-20,000 cars per day within the city of Monona. Bridge Road and Broadway are the only ways to cross the Yahara River to access the southwestern portion of Monona as well as south Madison besides the Beltline.

Roads with the lowest risk include the western portion of Nichols Road, Healy Lane, Dean Avenue, and Femrite Drive. These roads have sidewalks on residential roads where speed, traffic volume, and slope aren't factors. Figure 8 highlights the portion of Nichols Road and Healy Lane which surround Winnequah Park and Nuestros Mundo Community School. Dean Avenue is one of the few residential roads in Monona that has sidewalks, making it safer for pedestrians as it also has low traffic volume, low speed, and no slope. This can be verified by the absence of any accidents along this roadway. One section of Schofield Street is an area that was ranked with as 0, yet an accident occurred in the area. While this seems contradictory, the accident was between a bicyclist and pedestrian as opposed to a pedestrian and a motor vehicle and therefore most of the risk factors do not apply in this situation. This accident is the only accident that occurred in an area with a risk of 0.

Figure 9: Bicycle Safety Map

Like the Pedestrian Safety Analysis Map, The Bicycle Safety Analysis Map, figure 9**,** also highlights Monona Drive, Broadway, and Bridge Road to the east of the Yahara River as roads with the most risk to bicyclists due to having high speed, high traffic volume, and areas with greater than 7% slope. Of the twenty-two bicycle accidents from 2010-2016, thirteen of which occurred on these roads.

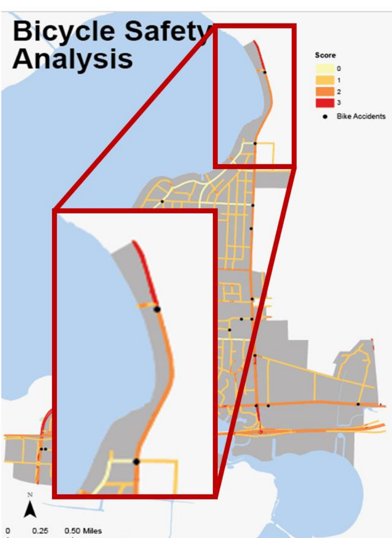


Figure 10: Bicycle Safely Map (detail)

Eight out of the twenty-two bicycle accidents occurred on Monona Drive, making it the road with highest accident rate of all the roads in our study area. In figure 10, the northernmost section of the road within Monona, is considered a risk of 3 because there are no bike lanes, and the area has high traffic volume and high

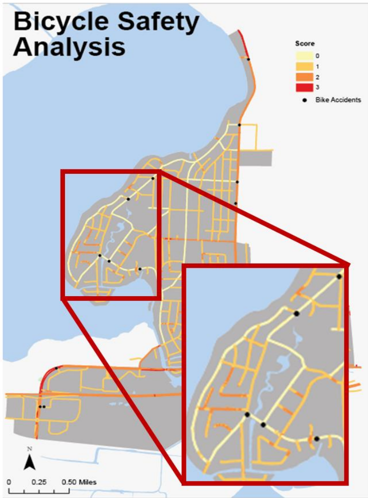


Figure 11: Bike Safety Map (detail)

speed. One of the accidents on Monona Drive occurred on the intersection where the bike lanes end.

The safest roads for bicyclists were Winnequah Road, Tonyawatha Trail, Winnequah Trail, Healy Road, Midmoor Road, and the eastern portions of Dean Avenue and Frost Woods Road because they have bike lanes, low traffic volume, and low speed with a slope less than 7%. However as shown in figure 11, five bicycle accidents have occurred along Winnequah Road. While Winnequah Road is designated as a bike route, no painted bike lanes exist and the bike route is only indicated by signage. Because of this there is an increased risk for bicyclists who use this thoroughfare for bike travel.

Conclusion

Speed and volume seem to have a greater impact on pedestrian and bicycle accidents on roadways than the other factors assessed. Even with the presence of sidewalks and bike lanes, most pedestrian and bicycle accidents happened on Monona Drive. There were fewer accidents for both pedestrians and bicyclists in residential areas that lacked sidewalks or any type of bike lanes compared to roads with high traffic volume and high speed. Winnequah Road and other roads considered to have bike paths but lacking painted bike lanes and clear signage could be improved upon. The presence of painted lanes markers in addition to signage would make motorists more aware of bicycles on the roadway.

Future considerations for safety analysis include considering obstructions including trees, shrubs, and center dividers on the roadways. Motorists, along with pedestrians and cyclists, could be safer if everyone has better visibility. Crosswalks could also be considered since they directly crosscut lanes of traffic and can put pedestrians at an even greater risk than walking along with or against the flow of traffic on the side of a road. The current signage on roadways is also an important factor to be considered for future study. Lastly, a more nuanced scoring system could be utilized to greater emphasize areas of risk. This more intricate scoring system could include intervals for point values as opposed to a binary zero and one scoring system, that way different traffic speeds and volumes could be more thoroughly analyzed. In addition, different types of bike lanes could have different scoring values to prevent overlooking dangerous areas such as Winnequah Road for bicyclists.

References:

AARP Public Policy Institute. *Livable Communities: An Evaluation Guide*. 2005. Accessed online 4/26/2017. https://assets.aarp.org/rgcenter/il/d18311_communities.pdf

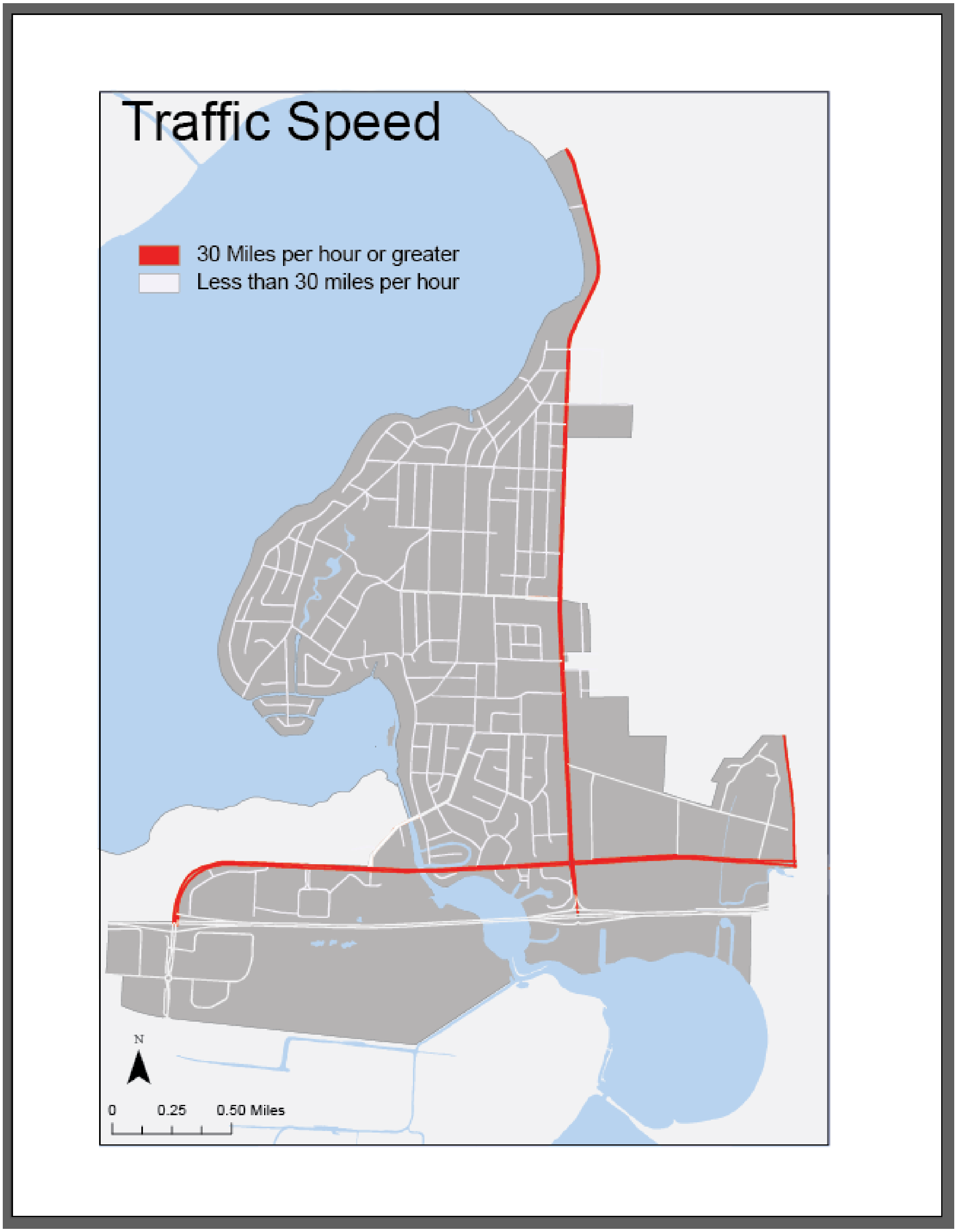
City of Monona: Official Website. Accessed online 4/6/2017. http://www.mymonona.com/

State of Florida Department of Transportation. *Manual of Uniform Minimum Standards for Design Construction and Maintenance for Streets and Highways*. May 2013. Accessed online 4/6/2017. http://www.fdot.gov/roadway/FloridaGreenbook/FloridaGreenbook.pdf

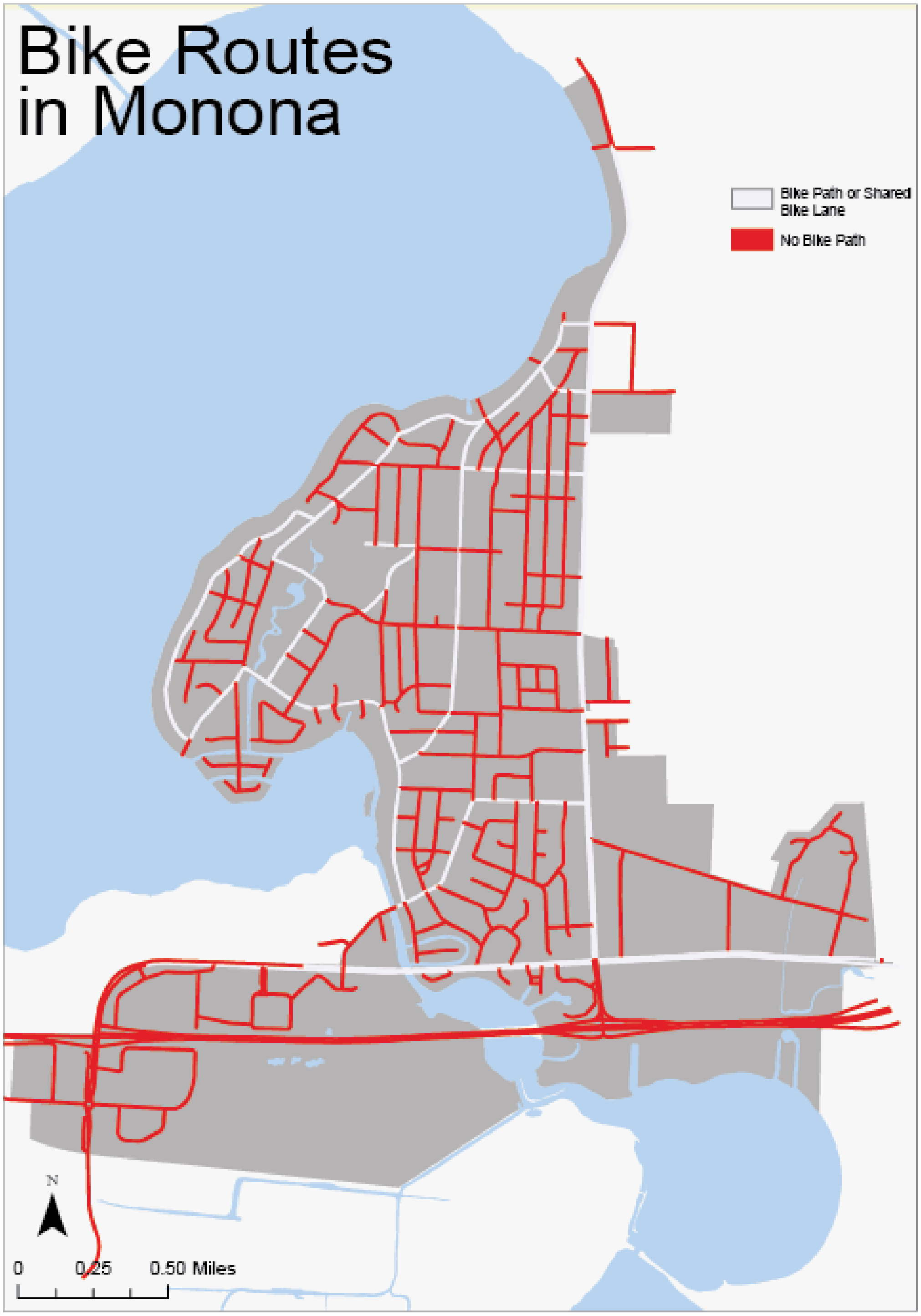
State of Virginia Department of Transportation. *Traffic Calming Guide for Local Residential Streets*. October 2002. Accessed online 3/30/2017. http://www.virginiadot.org/business/resources/TrafficCalmingGuideOct2002.pdf

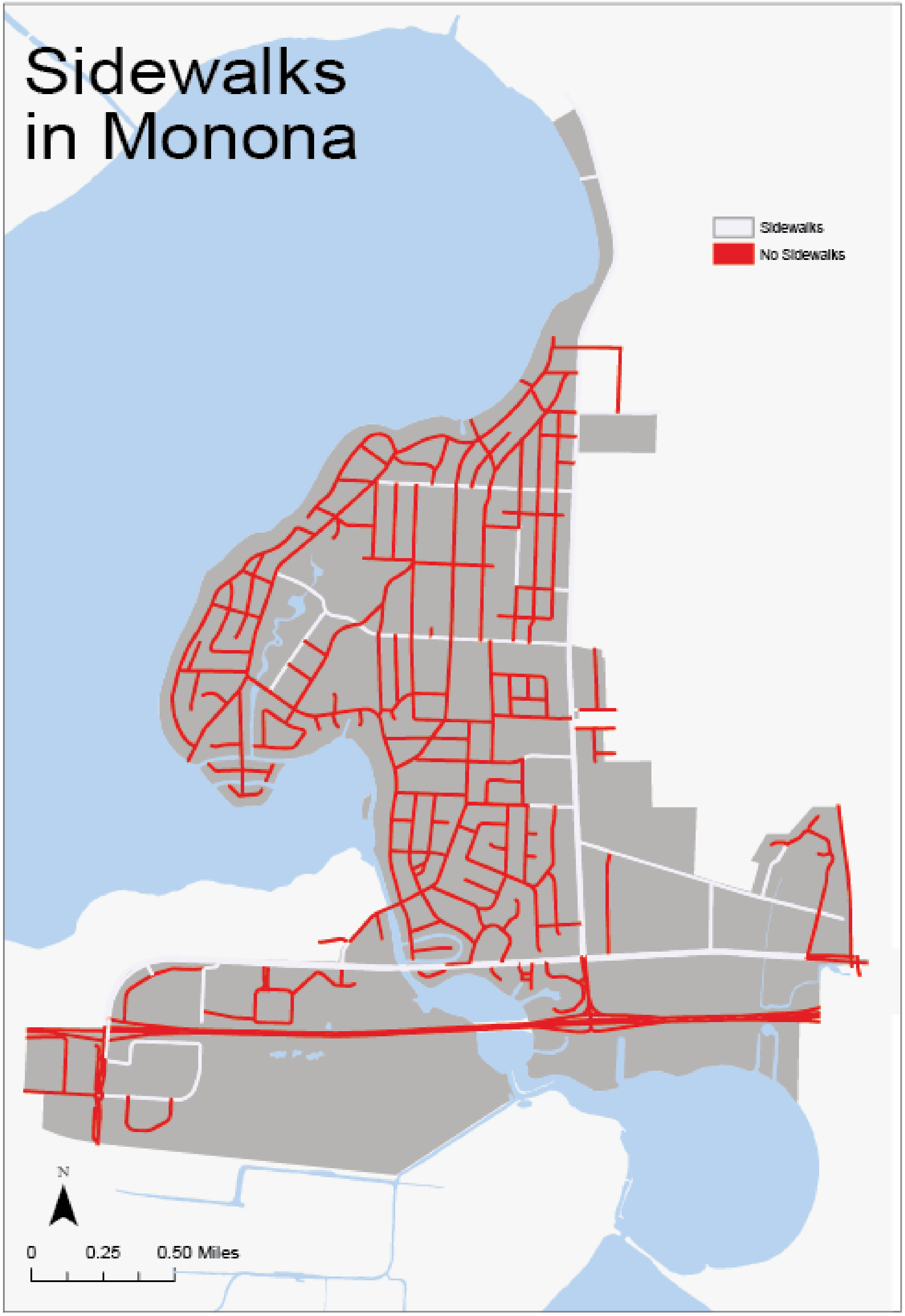
State of Wisconsin Department of Transportation: Interactive Traffic Map. Accessed online 4/4/2017. https://trust.dot.state.wi.us/roadrunner/

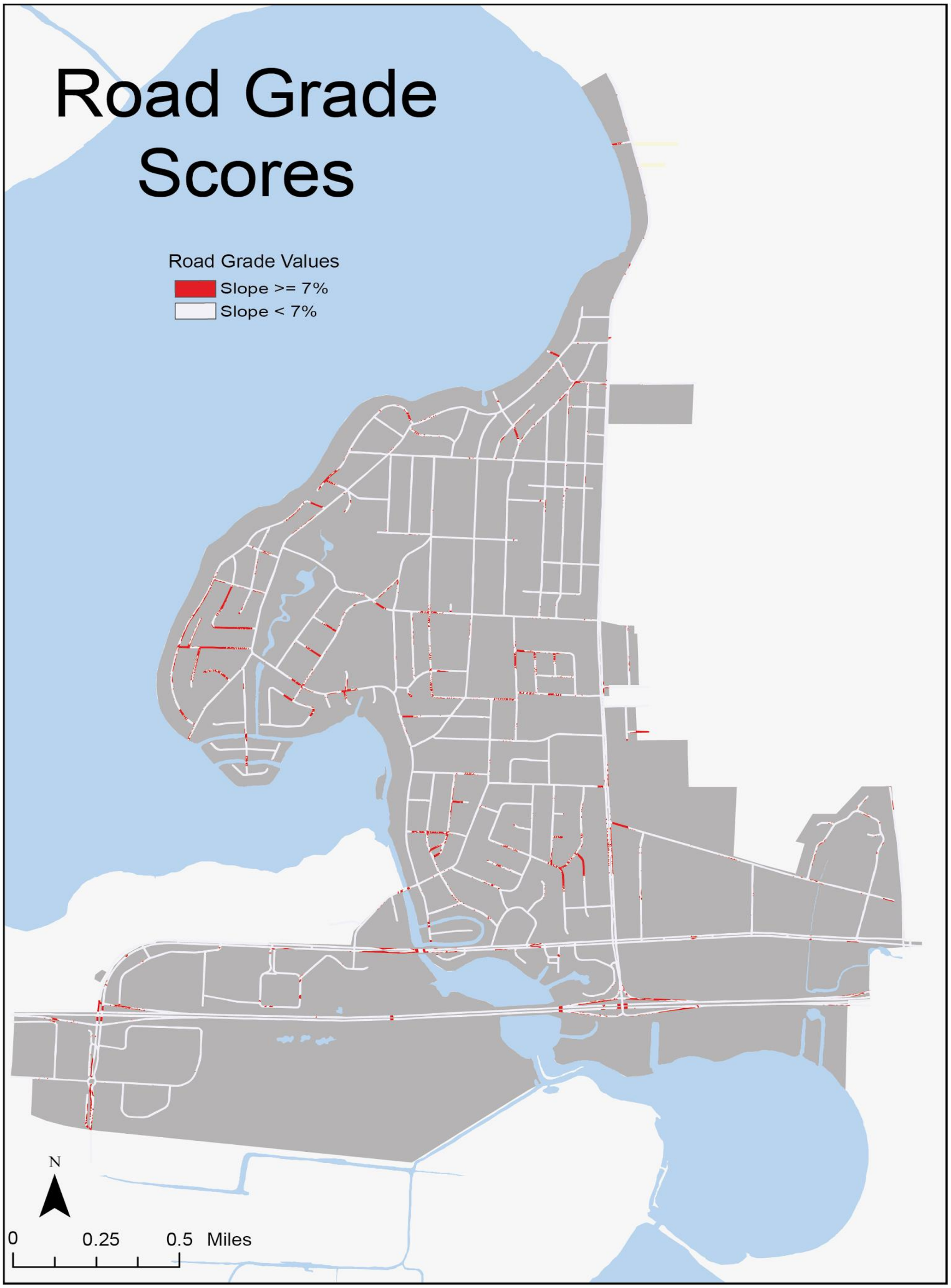
Appendix:

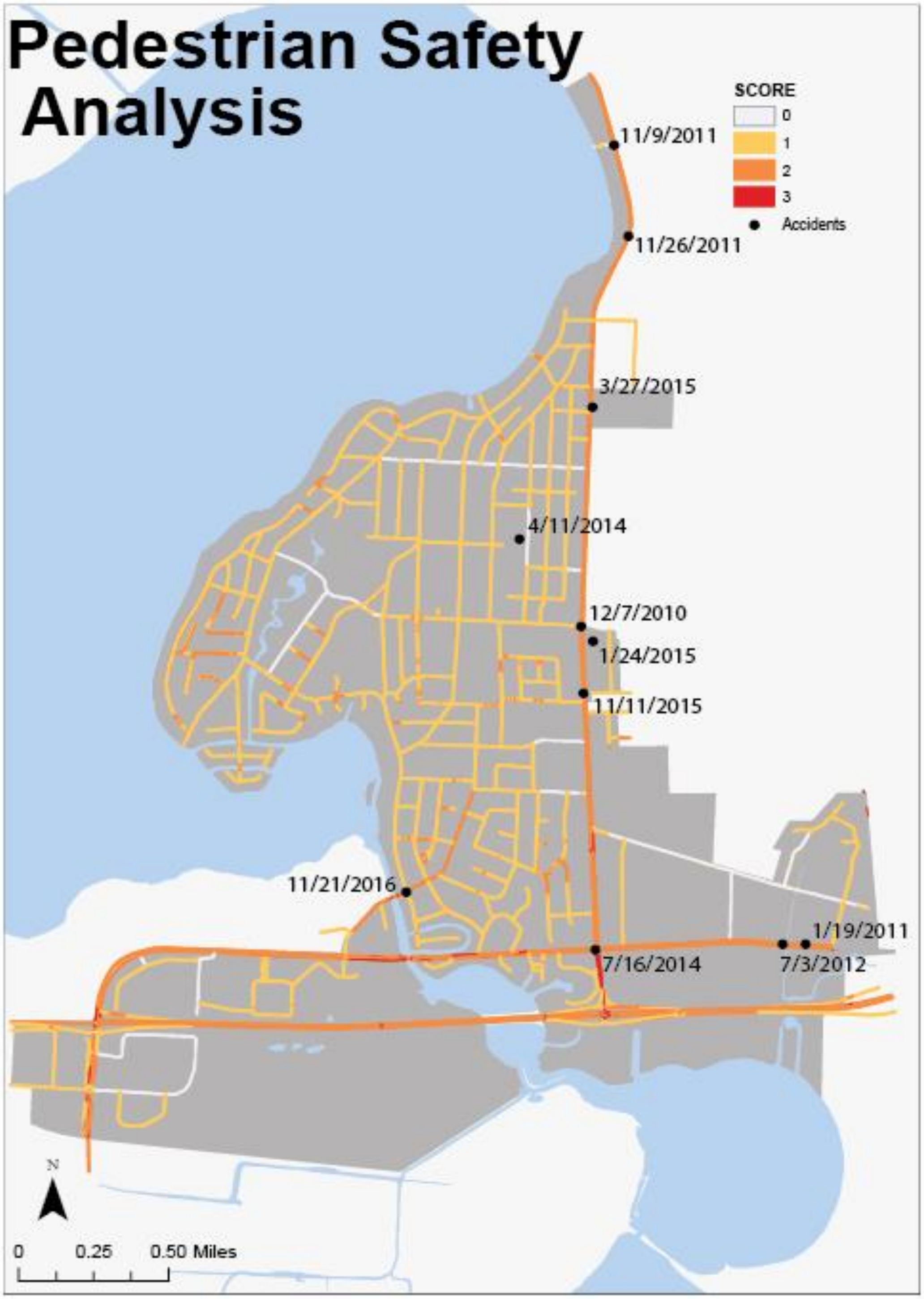

Traffic Speed
30 Miles per hour or greater
Less than 30 miles per hour
N
0
0.25
0.50 Miles


Traffic Volume
More than 4000 daily vehicles
Fewer than 4000 daily vehicles
N
0
0.25
0.50 Miles


Bike Routes in Monona
Bike Path or Shared Bike Lane
No Bike Path
N
0
0.25
0.50 Miles


Sidewalks in Monona
Sidewalks
No Sidewalks
N
0
0.25
0.50 Miles


Road Grade Scores
Road Grade Values
Slope >= 7%
Slope < 7%
N
0
0.25
0.5 Miles

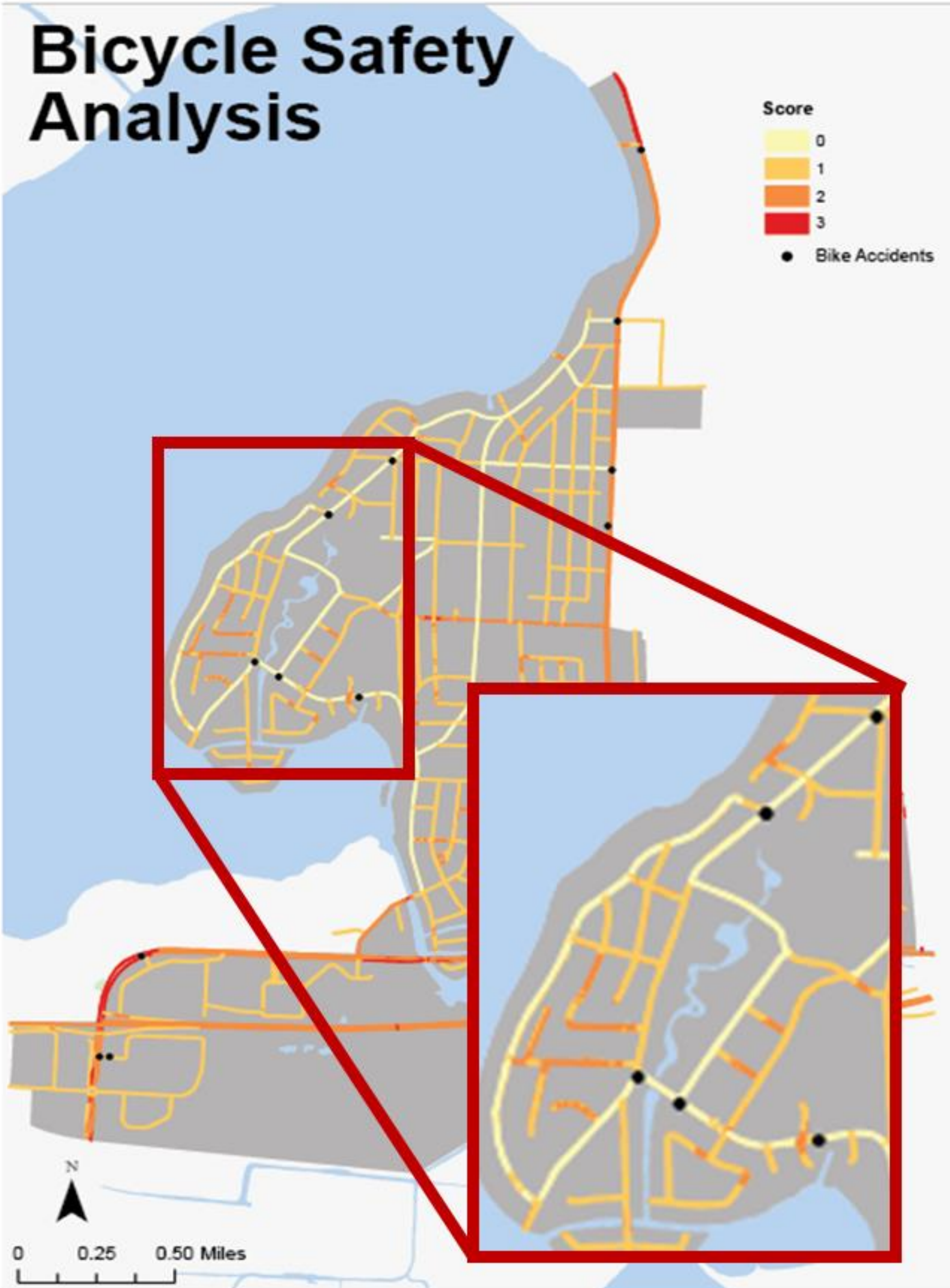


Pedestrian Safety Analysis
SCORE
0
1
2
3
Accidents
11/9/2011
11/26/2011
3/27/2015
4/11/2014
12/7/2010
1/24/2015
11/11/2015
11/21/2016
1/19/2011
7/16/2014
7/3/2012
N
0
0.25
0.50 Miles

Pedestrian Safety Analysis
SCORE
0
1
2
3
Accidents
N
0
0.25
0.50 Miles

Bicycle Safety Analysis
Score
0
1
2
3
Bike Accidents
6/9/2015
9/9/2013
7/26/2015
10/20/2011
6/9/2014
12/16/2011
5/20/2013
3/28/2015
11/21/2011
7/5/2015
7/15/2015
5/10/2011
6/22/2010
9/11/2015
7/23/2014
9/9/2012
7/13/2012
11/14/20
8/14/2011
7/7/2010
N
0
0.25
0.50 Miles


Bicycle Safety Analysis
Score
0
1
2
3
Bike Accidents
N
0
0.25
0.50 Miles


Bicycle Safety Analysis
Score
0
1
2
3
Bike Accidents
N
0
0.25
0.50 Miles