



WHAT ARE KIDS' COMFORTABLE OPTIONS WHEN BICYCLING TO SCHOOL?

A look at comfortable bicycle infrastructure connectivity for 5 schools in Springfield, Oregon



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WHAT ARE KIDS' COMFORTABLE OPTIONS WHEN BICYCLING TO SCHOOL?
(A look at comfortable bicycle infrastructure connectivity for 5 schools in Springfield, Oregon)

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Abstract

For children to use bicycles as their mode of transportation to school, they and their parents must feel a certain degree of comfort. Many things can affect that comfort, reducing the probability of children using this mode of transportation. The City of Springfield, Oregon has been making great strides to improve their bicycle transportation infrastructure. This study looks at 5 of the public schools in Springfield to see if the current or recently updated bicycle infrastructure is enough to encourage bicycling by children. A comfortability measure based on the Champine metric (2014) was created to help grade road segments. The resulting grades were then analyzed to determine network connectivity of comfortable bicycle infrastructure. Case studies will be shared of areas across the country that have had similar results and what they did to remedy the issues.

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Chapter 1: Introduction

What is the problem?

Research has shown that there are many different factors that affect the mode of transportation by children to school. One such study by Stewart, Moudon, & Claybrooke (2012) narrowed the deciding factors down to eight criteria:

1. Distance to school
2. Parental fear of traffic and crime
3. Schedule constraints
4. Values
5. Weather
6. School characteristics
7. Resources
8. Culture

Other studies show that with an increase in traffic volumes and speeds, there is a reduction in numbers of people walking and biking (Jacobsen, Racioppi, & Rutter, 2009). A child's comfort level when riding a bicycle to school is one factor not mentioned in the Stewart, Moudon, & Claybrooke (2012) study.

Mekuria, Furth, and Nixon, (2012) created a metric to grade road segments based on the stress level of people riding bicycles. The stress levels of bicycle riders can be described in one of 4 categories: "Most Children", Mainstream Adult Population ("*Most Adults*"), "*Enthused and Confident*", and "*Strong and Fearless.*" The *Most Children* category applies to a level of stress tolerable to most children from traffic. The *Most Adults* category applies to the stress level of most adult cyclists that also have very little traffic stress, but require more attention than is expected from children. The *Enthused and Confident* category applies to those that are comfortable with a more stress than *Most Adults*, but prefer to ride bicycles in a specific zone set aside for bicycles. The *Strong and Fearless* category applies to those bicyclists that are comfortable riding on any street, with or without a bicycle lane.

A student at the University of Oregon did performed research on grading street segments according to comfort level on a bicycle (Champine 2014). It measured 6 criteria (Prohibited Segments, Bicycle Facility, Estimated Traffic Volume, Speed Limit, and Slope Proxy) and gave a resulting grade of either "Kids with

Training”, “Confident and Enthused”, “Most Adults”, or “Strong and Fearless”.

As of 2014, there was not a methodology that was widely accepted by planners, engineers, or bicycle coordinators that was able to determine the compatibility of a roadway for both bicycling and motor vehicle travel (Harkey, Reinfurt, & Knuiman (2014).

Why you should care?

Bicycling provides many benefits, not only to those who ride, but to the community overall. Some benefits are: reduction in obesity numbers, increased physical activity throughout the day, cardiovascular benefits, and mental health benefits.

Obesity numbers have been on the rise (U.S. Department of Health and Human Services, 2001) and children are missing out on an activity that prevents and treats childhood obesity. A study done by Tudor-Locke, Ainsworth, & Popkin, (2001) shows that children that ride bicycles to school are fighting the obesity epidemic.

Children that ride bicycles to school are physically more active than those that walk or ride in a car to school (Cooper, Andersen,

Wedderkopp, Page, & Froberg, 2005). Parents have been driving their children to school more, taking away that chance to ride a bicycle to school and get physical activity daily (McDonald & Aalborg, 2009). The higher the amount of physical activity exerted, the more health benefits one receives (Janssen & LeBlanc, 2010).

There are some mental health benefits from bicycling as well.

Multiple studies have shown that people that view or are exposed to nature and natural landscapes have an increased sense of well-being. It also shows that reduced exposure to green nature also reduces the feeling of well-being (Network (2017); Velarde, M. D., Fry, G., & Tveit, M. (2007)).

What is missing from previous research?

There were studies that create metrics that focused on the comfort or stress levels of all bicycle riders, but not as many that focused directly on school-aged children. This study focused directly on the comfort level of children bicycling to school. To do this, a metric that graded street segments for the comfort of children

riding bicycles to school was created. Many things affect the comfort level of children bicycling to school. Some of the criteria focused on in this study were: vehicle speed on a road (Jacobsen, Racioppi, & Rutter, 2009), the risk of death on a road (De Hartog, Boogaard, Nijland, & Hoek, 2010), the volume of traffic on a road (Jacobsen, Racioppi, & Rutter, 2009), lanes of car travel (Stinson & Bhat, 2014), if the road is flat or has a grade (Fraser & Lock, 2011), and the type of bicycle infrastructure improvement added to the normal street surface (Reynolds, Hariss, Teschke, Cription, & Winters, 2009).

Why is this research important?

This research is important because children need to receive the many physical and mental health benefits available for bicycle riders. This research helps to point out street segments that may be uncomfortable to children while bicycling. The Comfortability Metric was created as a grading system that can be applied to any

street segment or can be averaged to show the total bicycle comfortability of an area.

How is this information going to be used?

This study partnered with the Safe Routes to School (SRTS) program for the Eugene/ Springfield Schools. Laughton Elliot-DeAngelis pointed out 5 schools that the SRTS program is currently working with. They are Douglas Gardens Elementary, Guy Lee Elementary, Hamlin Middle, Mt. Vernon Elementary, and Thurston Elementary.

This information will be used to identify street segments that are graded less/not comfortable for children to bicycle to school on, can be used to prioritize improvements, and to show what criteria are causing a grade to fall. This data can be used for any purpose that the SRTS program sees fit. This study does not go into providing recommendations for improvements to street segments. It is used to grade street segments and leave decisions about improvements to the experts at the City of Springfield.

Background on Springfield, Oregon

Springfield, Oregon is a city located right between two beautiful rivers in the Willamette Valley, the Willamette River on the south and the McKenzie River on the north. The US Census Bureau (2016) estimates that the population was 61,893, the Median Household Income was \$39,729, the Median Housing Value was \$164,600, and the number of Persons in Poverty, by Percent was 21.5%. The main industries in Springfield are health, education, and software-based (City of Springfield, 2011). Springfield is just east of Eugene, the home of the University of Oregon and other colleges and universities. Interstate 5 is the western border of Springfield. Springfield is located almost center of the state (from north to south), on Interstate 5. It is located about an hour and a half east of the Pacific Ocean, 2-hours south on I-5 from Portland to the north, and 2 ½-hours from Medford to the south. Highway 126 is the main east-west corridor in and out of Springfield and I-5 is the main north-south corridor. There are 19 public schools in Springfield, Oregon (Springfield Public Schools, 2017).

2016 Population Estimates¹	61,893
Median Household Income²	\$39,729
Median Housing Value²	\$164,600
Total Housing Units²	25,407
Male Median Income²	\$26,096
Female Median Income²	\$18,163
Veterans³	4,422
Persons in poverty, percent³	21.50%
Educational Attainment: Percent high school graduate or higher³	86.20%
Persons without health insurance, percent³	15.20%
Number of Companies⁴	3,644
<small>¹Source: Vintage 2016 Population Estimates: Population Estimates</small>	
<small>²Source: 2011-2015 American Community Survey 5-Year Estimates</small>	
<small>³Source: 2011-2015 American Community Survey 5-Year Profiles</small>	
<small>⁴Source: 2012 Survey of Business Owners: Company Summary</small>	

Chapter 2: Literature on Comfortable Bicycling for Children to School

Literature Review

Over time, ideas change and new trends immerge. This research focuses on trends (positive and negative) in bicycle infrastructure, the benefits and barriers to children by bicycling to school, and creating a metric to be able to grade the comfort of school-aged children when bicycling.

The McDonald (2007) study shows that the numbers of children that walked or bicycled to school dropped drastically from 1969 to 2001. According to the National Personal Transportation Survey, data showed that 40.7% of children walked or bicycled to school in 1969. The proportion had dropped to 12.9% by 2001. This is a disturbing trend.

Bicycle transportation is linked to many positive health benefits for children. A couple of important health benefits gained by riding a bicycle to school are increased activity at school and throughout the day (Janssen & LeBlanc, 2010) and reduction in obesity numbers due to getting exercise (Fox, 2004; U.S. Department of Health and Human Services, 2001).

Garrard, Rissel, & Bauman (2012) studied cycling and its mental health benefits. The mental health benefits found in this study through bicycling were treating anxiety and depression, improving cognitive ability and function, and increasing the feeling of well-being. Bicycling helps with anxiety and depression by reducing depressive symptoms in those suffering with depression. The feeling of well-being is contingent on multiple factors like: Relaxation, Stress reduction, enjoyment, and social interaction. In another study, those surveyed said that their reasons for “commencing and continuing cycling included fun and enjoyment, getting outside in the fresh air, relaxation and stress reduction, and time out for ‘myself’” (Garrard, Crawford, and Hakman (2006).

This feeling of well-being or comfort is what this study was focused on. To achieve that feeling of comfort, there are factors that add or detract from that feeling.

According to the Li, Wang, Liu, & Ragland (2012) study, some things that add to the feeling of comfort are:

- separated bicycle facilities (facilities that are separated from automobile traffic)
- surrounding conditions (the overall environment that creates the bicycling condition such as physical environment, road geometry, traffic congestion, etc.)
- traffic situations for on-street bicycle infrastructure (buffer for lane to keep from vehicles, sharrows, etc.)

Some of the many barriers that can affect the mode of travel for children to school:

- Parents' fears
- Bicycle rider's perceptions
- Physical location of a school
- Land use patterns
- Street design and bicycle infrastructure type
- Comfort level on bicycles over time
- Mortality rate

Parents' fears

McDonald & Aalborg (2009) researched the decline in bicycling numbers to school and how that relates to parents. The research looked at what influenced their decision in letting their child walk or bicycle to school. The result was that 75% of parents that drive their children to school (less than 2 miles) did this because of convenience and to save time. Almost half of parents did not allow their children to walk or bike to school without the supervision of an adult. Their conclusion was that programs trying to help increase active transportation in children to school, that programs needed to focus on parental convenience and constraints on time, and to provide other options of supervised walking to school by someone besides the parent. One option suggested made was using a walking school bus. A walking school bus is one or more adults guiding a group of children on a walk (www.walkingschoolbus.org).

Bicycle riders' perceptions

Bicycle riders' perception on cycling safely is only one of the deciding factors for one to ride a bicycle or not. A metric was created and used to score 6 European cities' (Edinburgh, Cambridge, Den Haag, Rotterdam, Utrecht, and Amsterdam) bicycle riding experience. The criteria that was used in the study (Hull and O'Holleran, 2014) were: directness, attractiveness, road safety, comfort, spatial integration, experience, and socio-economic value. Directness is speaking of how direct a route is and how many obstacles, junctions, or traffic signals slow down the bicycle trip. Attractiveness speaks of how attracted one is to use the bicycle infrastructure. This can include things like having a lit bike path so it can be used at night, the quality of the bicycle infrastructure (skinny bike lanes and streets compared to separated bike paths), if a lane is next to heavy traffic, etc. In this study, road safety observes things like road maintenance (potholes, etc.), parked cars with doors opening into bike lanes, bicycle lane segregation and its promotion of feeling safe, etc. Comfort correlates with safety. The type of material used to make bicycle

lanes can add a sense of grip without increasing rolling resistance and increase the comfort. Other infrastructure improvements to increase comfort are navigable intersections for bicycles, traffic calming measure, bicycle infrastructure for roundabouts, etc. How bicycle infrastructure is spatial integrated into the urban form of the city is important. Some cities do not have a lot of space to add bicycle infrastructure due to narrower streets or other infrastructure problems. The experience the rider has bicycling depends on how quick and convenient it is, the number of other riders using the infrastructure regularly, and if it is a normal mode of travel and automobiles are used to interacting with bicycles. The socio-economic value describes how beneficial it is to ride a bicycle. In this study, there were a few things that measured out to be beneficial. They were: a variety of destinations and end trip facilities available, electric cycling charging points, and bicycle training facilities for children. A great point represented in this

paper is that it requires strong government support to provide a safe, comfortable, bicycle network creating priority for cyclists.

Fitch, Thigpen, & Handy (2016) examined the stress caused by being near automobiles while bicycling for elementary and junior high school students. They concluded that by changing the environment of the street to reduce stress from traffic on routes close to schools, that these actions will increase the numbers of children bicycling to school.

Physical location of a school and its effect on mode of travel to school

Schlossberg, Greene, Phillips, Johnson, & Parker (2006) studied the effects that urban form has on distance and travel mode to school. Their research showed that schools are being built on the fringes of the urban core due to lack of low-cost land availability and demand for larger sports fields (Schlossberg, Greene, Phillips, Johnson, & Parker, 2006). They also found that intersection density, dead-end density, and distance to school “*are significant predictors of walking rates to and from school*”, but not of bicycling to school. This promotes the need to study the street

segments rather than the intersections, to measure effects on bicycling.

Land use patterns

Neighborhoods that are set up to serve bicycle/pedestrian (bike/ped) trips have a higher number of those modes of travel in them. Likewise, auto-centric neighborhoods or areas have less bike/ped activity and more automobile users (Cervero & Radisch, 1996).

Street design and bicycle infrastructure type

Cervero and Duncan (2003) studied the effects that street design and infrastructure type had on bicycling and concluded that built-environment factors were strong predictors of using bicycling as a mode of travel rather than walking, driving, or using some other form of transit.

By rethinking about the way streets are designed, improvements can affect the way people travel and increase the use of multiple

modes of travel, often without damaging throughput for automobiles (Schlossberg, Rowell, Amos, & Sanford, 2013)

Adding street trees is a way to provide a more pleasant environment for bike/ped users by providing shade, helping to reduce harmful tailpipe emissions, increase safety to automobile and bike/ped traffic, reduce traffic speeds, lower the urban air temperature, improve psychological health, and provide a connection to nature and the human sense (Burden, 2006).

Comfort level on bicycles over time

As with most activities in life, the more one bicycles, the more comfortable they will feel with the process and the more able they are to absorb stressors while biking (Bella, 2013)

Chapter 3: Research Questions and Methodology

Research Questions

1. Is there enough interconnected, bicycle infrastructure in the City of Springfield, Oregon available to allow for school-aged children to ride bikes comfortably to school?
2. What is comfortable bicycling to school?
3. What improvements can be made to improve the connectedness of the bicycle infrastructure?
4. What are the barriers associated with increasing bicycle infrastructure?

Methodology

Creating a Comfortability Metric that can assess children's bicycle comfort was the method used in this research. The Comfortability Metric used for this study was based off the Champine (2014) study metric. The criteria in the Champine (2014) metric were prohibited segments, bicycle facility, estimated traffic volume, speed limit, and slope proxy.

Prohibited segments are segments where bicycling is not permitted by law, such as highways, freeways, and bark trails. Since

bicycles are not permitted on them, they were removed from this study's comfortability metric. They were not segments that would be frequently used by school-aged cyclists. Bicycle facilities measured the bike facility improvements that were added to the street segment. Certain types of bike facility scored higher than others. For instance, a separated bike path from traffic is more comfortable for a child to ride a bike on than a bike lane next to heavy traffic, so it is scored higher. Estimated volume of traffic was a measure of average daily vehicles per street segment that is based on observations and statistical assumptions. The speed limit is the posted, vehicle speed limit for a street segment. The slope proxy is measured from the sum of elevation gain and elevation loss then divided by the street segment length. All street segments in this study and for the study schools are on relatively flat land so for ease of calculations, all street segments were given the highest score for slope, which is 10.

There were a few steps used to make the Comfortability Metric more applicable to children. First, the two additional criteria were added to the metric that were used in this study and were not in the Champine (2014) study were mortality rate and lanes of car travel. Second, prohibited segments that were originally in the Champine (2014) study were removed as they are not routes that children would normally use. Lastly, each of the 6 criteria (except the Percent grade or slope) is weighted in a way to be more focused on children. The methods for weighting are explained under the criteria description.

What is the Comfortability Metric?

The Comfortability Metric was the instrument used to grade the street segments in the study school service boundaries. There were 6 infrastructure criteria that were used to determine the comfort grade of each street segment. They were *road or path speed*, *mortality rate* (in relation to the speed limit), *Estimated Daily Volume of Traffic (EDVT)*, *percent grade of street segment*, *lanes of travel*, and *bicycle infrastructure type*. These were weighted to show the comfort or stress level of school-aged children only. This

was done in a few different ways. First, since road and path speed and mortality rate have such a high correlation, speeds more than 35 mph are given lower grades. The mortality rate favors roads with slower speeds. For instance, a road with a 20-mph speed limit has a grade of 9, whereas the score for a 35-mph road is 3 and drops to a 0 when moving up to a 40-mph speed limit. The reason is at 40-mph, the possibility of severe injury or death moves up to 100% (AASHTO, 2011). This is unacceptable when thinking of a comfortable road for children. If a road has a 40-mph speed limit, it is still possible to have a passing grade. Bicycle infrastructure that keeps the child away from cars will increase the total average. A road that has low traffic volume each day can also increase that average, even with the 40-mph speed limit. Another way that the metric was weighted to measure children's comfort is by making the segment get a 7 or higher out of 10 to get a passing grade. The metric was applied to all street segment in all study school service boundaries. Maps showing these grades were created to show the

connectivity of the bicycle network, according to the comfort rating received using the Comfortability Metric.

Road or Path Speed: The posted vehicle speed limit on a street segment or path

Mortality Rate: Percent chance of death due to collision with vehicle

Estimated Daily Volume of Traffic: Estimated number of vehicles that travel on street segment in one day's time

Lanes of Travel: Then number of travel lanes on a street segment (one equals a one-way road, two equals a two-way road with one lane of traffic in either direction or in the same direction, three equals a road with three lanes that all travel in the same direction or a turn lane with a lane of travel going in either direction, etc.)

Percent grade of street segment: The percent incline/decline of a street segment

Bike Infrastructure Type: Includes infrastructure used for automobiles in addition to improvements specifically made for bicycle use, such as bike paths, bike lanes, etc.

Road or Path Speed

Speed is an important factor when determining comfortability for a few reasons. Some of the reasons are: higher speeds provide less time to process information before the driver must react, making avoiding a collision less likely, and the braking distance is increased with speed (SWOV, 2012). The posted road or path

speed is a loose metric because it does not guarantee that vehicles are traveling at that speed. The actual rate of speed of a vehicle fluctuates with road width, sight distance, presence of curves in the road, etc. (Goldenbeld & Schagen, 2007). These criteria are also considered when thinking about design speed (Fitzpatrick, Carlson, Brewer, & Woolridge, 2003). Using variable speed limits in areas with risky traffic conditions has been shown to reduce vehicle crash potential (Lee, Hellinga, & Saccomanno, 2006).

Mortality Rate

Mortality Rate has a direct correlation with the road or path speed. Depending on the speed of the vehicle on the road or path, the percent chance of serious injury or death fluctuates. According to the U.S. Department of Transportation (2000), a person's likelihood of fatality or severe injury increases exponentially with vehicle speed at time of collision with a pedestrian. Many pedestrian fatalities happen above 40-mph (Tefft, 2011). There are many opinions on what vehicle speed needs to be to cause mortality in a pedestrian. For example, one says that at 20 mph there is a 10% likelihood of severe injury or death, at 30 mph there

is a 40% chance of severe injury or death, and at 40 mph that number jumps up to an 80% chance of injury or death (U.S. Department of Transportation, 2000). Another study shows that risk of mortality for children at 50-mph is 100% (Richards, 2010). While bicycle riding is linked to many health benefits, they also have a rate of death twice as high as vehicle occupants (Vargo, Gerhardstein, Whitfield, & Wendel, 2015). “The risk (of fatality) increases slowly until impact speeds of around 30 mph. Above this speed, risk increases rapidly—the increase is between 3.5 and 5.5 times from 30 mph to 40 mph.” (Richards, 2010). These numbers are unacceptable. It is necessary to safeguard children and reduce the chance of severe injury or death while riding to school. The percent mortality rate in relation to speed in the Comfortability Metric is a little more conservative. This was to provide a little safety buffer in the mortality rate numbers and keep away from getting close to severe injury or death for the children.

Estimated Daily Volume of Traffic (EDVT)

A study by Landis, Vattikuti, Ottenberg, Petritsch, Guttenplan, & Crider (2001) reveals that roadway traffic volume is one of the

primary factors in grading level of service for bicycle transportation. The strongest association to real and perceived danger to a bicyclist is traffic volume (Jacobsen, Racioppi, & Rutter, 2009).

Lanes of Travel

Wider roads can accommodate more traffic lanes which can in return accommodate more traffic volume. Bicycle lanes were chosen, in a Portland study, but were not any more attractive than streets with low traffic volume (Broach, Dill, & Gliebe, 2012). The presence of a cycle lane and roads with higher speeds (40mph and 50 mph) require a wider passing distance around cyclists for automobiles (Parkin & Meyers, 2009).

Percent grade of street segment

An incline or grade is shown as a negative correlation with bicycling rates (Fraser & Lock, 2010).

Bicycle infrastructure type

The type of bicycle infrastructure that is added to the original city street in busier areas have huge implications on reducing

crashes and injuries while bicycling (Reynolds, Harris, Teschke, Cripton, & Winters, 2009).

The safer the bicycle infrastructure and the better the network connectivity of bicycle infrastructure, the more encouraging it is for people to bicycle on (Dill, 2009).

How is the Comfortability Metric applied?

Bicycle Riding Comfortability Metric						
Score	Road or Path Speed (MPH)	Mortality Rate	Estimated Daily Volume Traffic	Lanes of Car Travel	% Grade Change of Road or Path	Bicycle Infrastructure Type
10	0 to 15	0	0	0	0	Separated Multi-Use or Bicycle Path (No motorized vehicular traffic)
9	20	5%	1 to 1499	1	1	Cycle Track
8		-	1500 to 2999	2	2	Buffered Bike Lane
7	25	-	-	-	3	Bike Box; Bike Lane
6	-	-	-	3	4	Bike Boulevard with traffic diversion
5	30	40%	3000 to 4999	-	5	Shared Lane, Bike Route, Share the Road Sign, or Street only
4	-	-	-	4	6	-
3	35	80%	5000 to 9999	-	7	-
2	-	-	-	-	8	Dirt Path with rocks making bicycling difficult
1	-	-	10000 to 19999	5	9	-
0	40+	100% (0 Score)	20000+	6+	10+	Un-rideable Surface

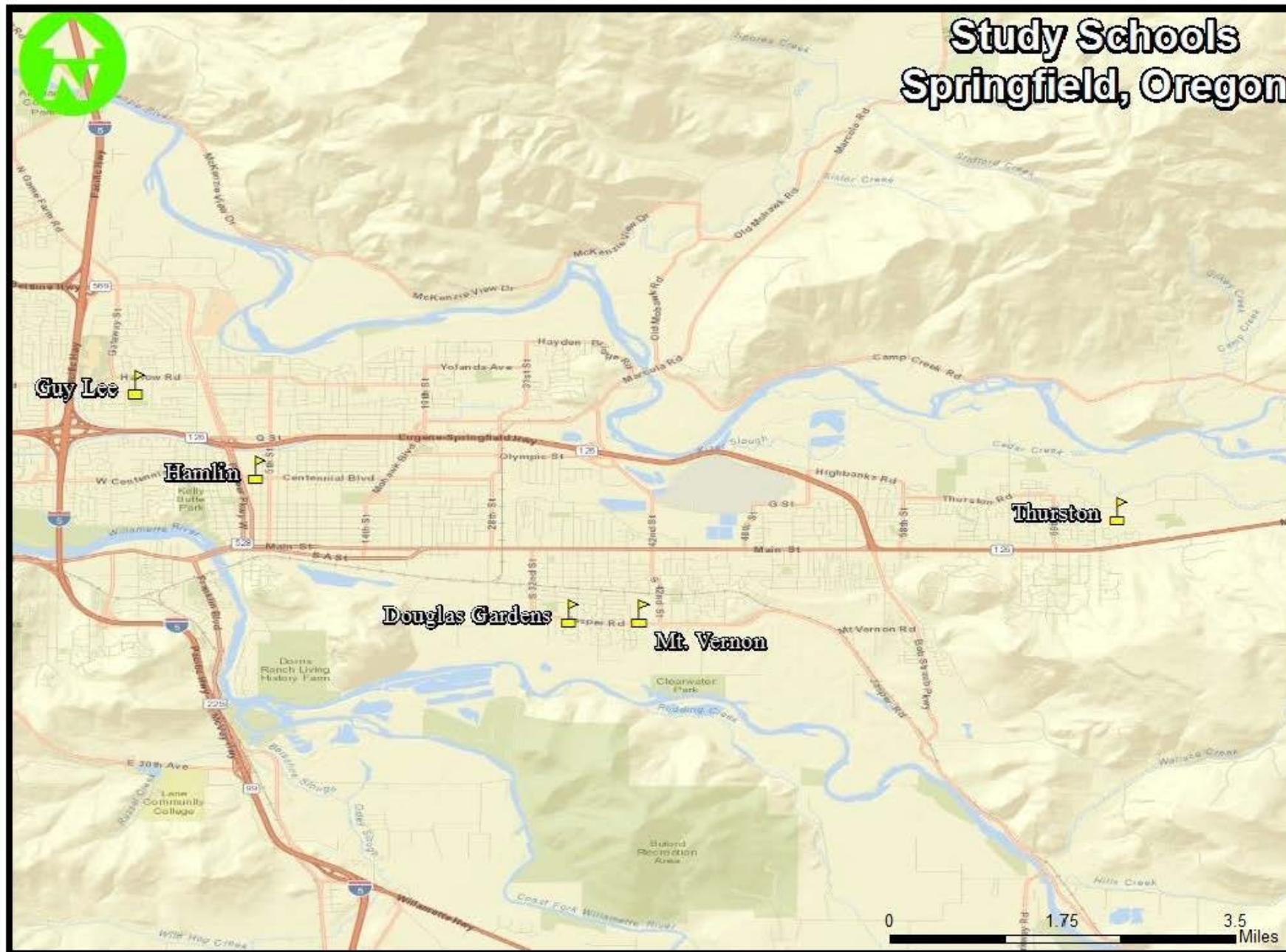
Grading was accomplished through using the attribute table of the bicycle infrastructure layer. Fields were added for the grade of each of the criteria and one for the total average grade. ‘Select by Attribute’ was used to sort large quantities of attributes. The grade field for each of the metric criteria were changed by using the ‘Field Calculator.’ This made it easy to format and change the large number of attributes quickly.

Criterion fields coincided with the Comfortability Metric Table (shown on previous page) and equated to a score. Below is an example:

Comfortability Metric Example														
Street Name	Speed Limit	Speed Limit Grade	Mortality Rate	Mortality Rate Grade	EDVT	EDVT Grade	Lanes of Car Travel	Lanes of Car Travel Grade	Bike Infrastructure Available	Bike Infra. Grade	Slope	Slope Grade		Total Grade for Segment
Columbus Drive	35	3	80%	3	19674	1	5	1	Bike Lane	7	0%	10		4.17
		3	+	3	+	1	+	1	+	7	+	10	=25 / 6=	4.17

The ‘Total Grade’ was calculated by averaging all 6 criterion grades together (adding up all 6 grades and then dividing the total number by 6). This formula was used for every street segment in all the study school service boundary buffers. After grading each street segment, a site visit was made to each of the study areas to get a general feeling and provide ground truthing of the results provided by the comfortability metric. Each of the site visits looked at getting the overall feeling of the surroundings, the initial feelings of comfort and safety, a look at the existing infrastructure that was present in the school zones, whether the infrastructure seemed to reduce traffic speeds, and the overall opinion on network connectivity.

Chapter 4: Study Schools



Map 1: All 5 of the schools observed and analyzed in this study

Douglas Gardens Elementary

Douglas Gardens is in the southern portion of Springfield, right off Jasper Road. Jasper Road is a 35 MPH (Miles Per Hour), 3-lane (one travel lane in both directions plus turn lane) road. There are bike lanes on Jasper Road. The residential areas are 25 MPH and 2-lane roads (one travel lane in each direction). The main roads used to reach Douglas Gardens Elementary are 32nd Street to the west and Jasper Road to the south. The school has a zebra-style crosswalk in front crossing Jasper Road. Traffic calming measures used are signs informing drivers of school zone and a school zone flashing light coming from both directions on Jasper Road. No other visible efforts to slow traffic were used other than standard school zone signs. The residential streets seemed like they would be comfortable to ride a bicycle on. Train tracks are located crossing 32nd Street and some children must cross them to get to school.



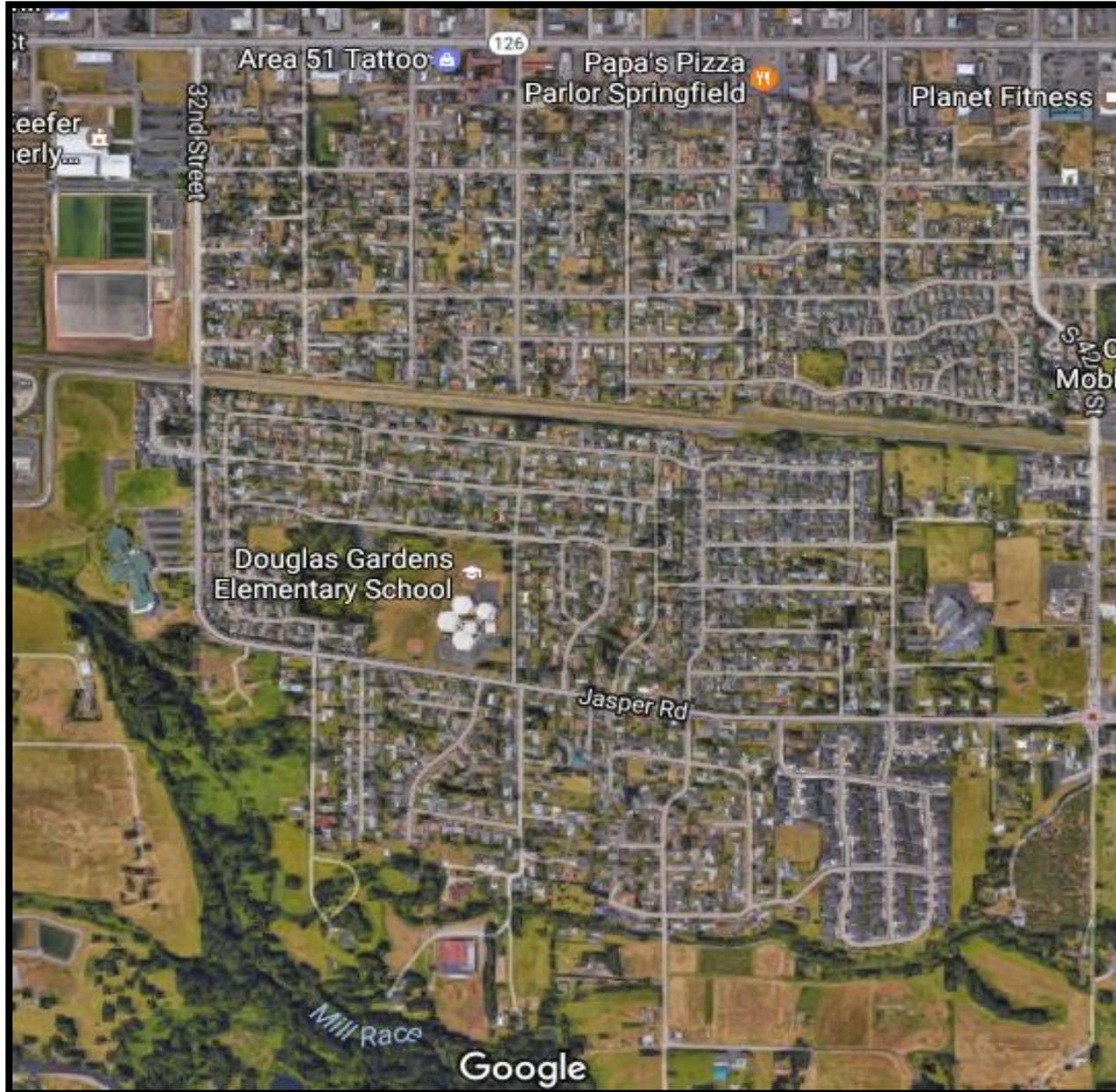
Douglas Gardens Elementary sign in front of school



Jasper Road heading west, prior to Douglas Gardens Elementary



Looking south out from the school entrance to the zebra-style crosswalk at Jasper Road and Laurel Avenue



Map 2: Aerial view of the Douglas Gardens school service area.
Source: Google Maps

Guy Lee Elementary

Guy Lee is in the northwestern portion of Springfield, right off Harlow Road. Harlow Road is a 35-mph road that has 5 lanes for most of the length in the Guy Lee Elementary School service boundary. There is an LTD bus stop directly in front of the elementary school. There is a zebra-style crosswalk at the corner of Harlow Road and Hartman Lane (runs perpendicular with Harlow Road on the west side of the elementary school). Normal school zone signs are visible and flashing lights coming from either direction on Harlow Road that let drivers know of the upcoming school zone. No other traffic calming efforts are apparent near the school. There is a signalized intersection at the corner of the school (Harlow Road and Hartman Lane). The traffic is busy and congested on Harlow Road as it is a main east-west corridor and crosses I-5 so it is a funnel of traffic. This fronts the school. This provides an unsafe feeling for pedestrians so supplemental busing occurs for students that live just north of the school and Harlow Road. There are bike lanes in this school service area but they are all located on busy streets. The residential areas have seemed comfortable enough to ride bicycles on though.



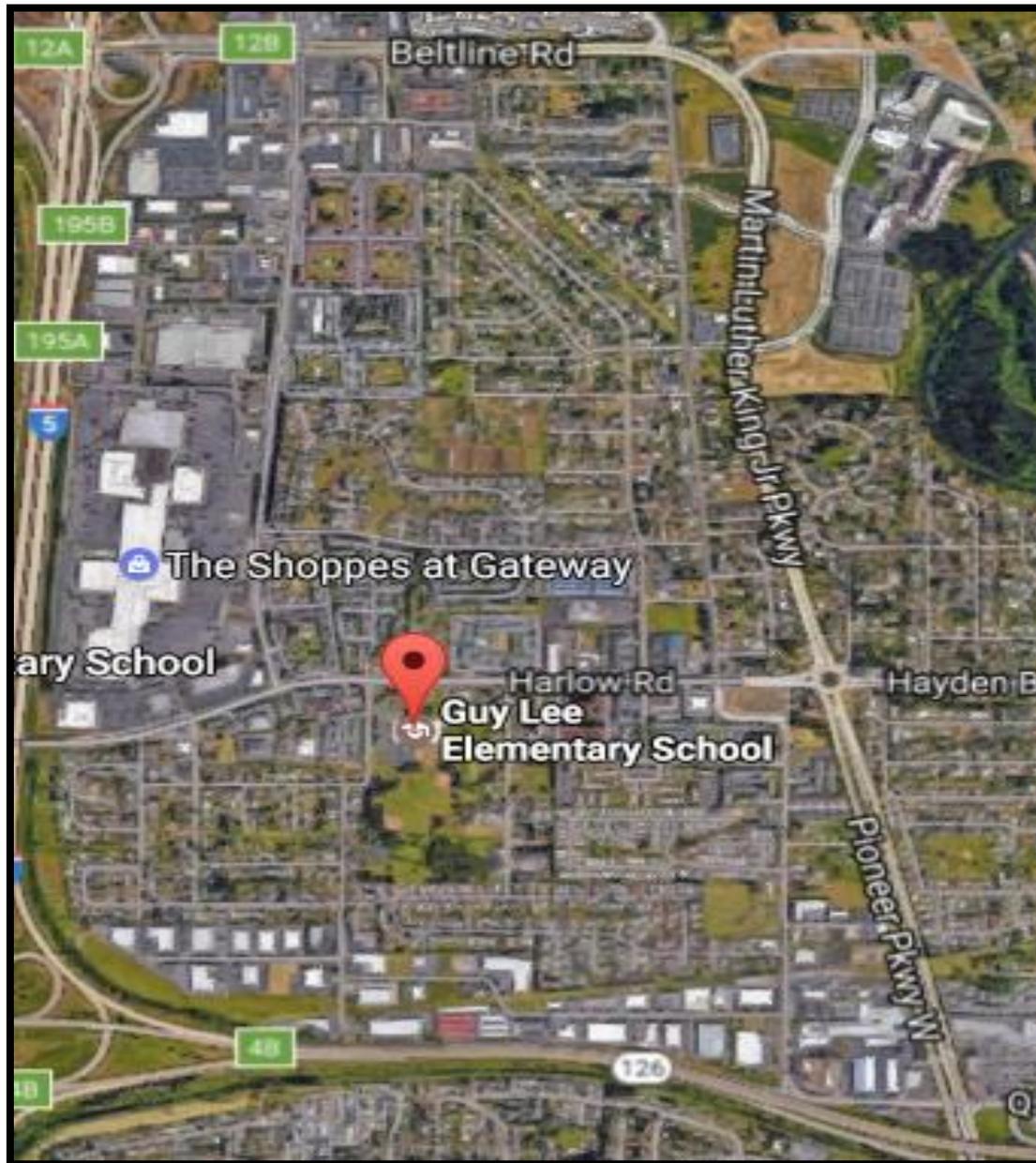
The curve on Harlow Road right at Gateway Street in Springfield, Oregon, heading east



Right after the curve on Harlow Road, heading east



The LTD bus stop directly in front of Guy Lee Elementary school on Harlow Road



Map 3: Aerial view of the Guy Lee school service area

Hamlin Middle School

Hamlin Middle is in the middle portion of Springfield, on the corner of 5th Street (running north and south) and Centennial Boulevard (running east and west). Centennial Boulevard's form changes in different areas from a 5-lane road to a 3-lane road. Likewise, 5th Street changes form from a 3-lane road to a 2-lane road in certain areas. Centennial Boulevard and 5th Street's speed limits vary in different places. Centennial varies from 30-mph to 45-mph, depending on location. 5th street varies from 25-mph to 30-mph. There is a zebra-style crosswalk that crosses Centennial Boulevard on the southern side of the school and one on 5th street (to the east of the school). Normal school zone signs are visible and flashing lights coming from either direction on both Centennial Boulevard and 5th Street to let drivers know of the upcoming school zone. No other traffic calming efforts are apparent near the school. There is a signalized intersection at the southeast corner of the school (Centennial Boulevard and 5th Street). The traffic is busy as Centennial is a main east-west corridor. There are bike lanes and bike paths in the school service area but they are all located on busy streets. The residential areas seemed comfortable enough to ride bicycles on though.



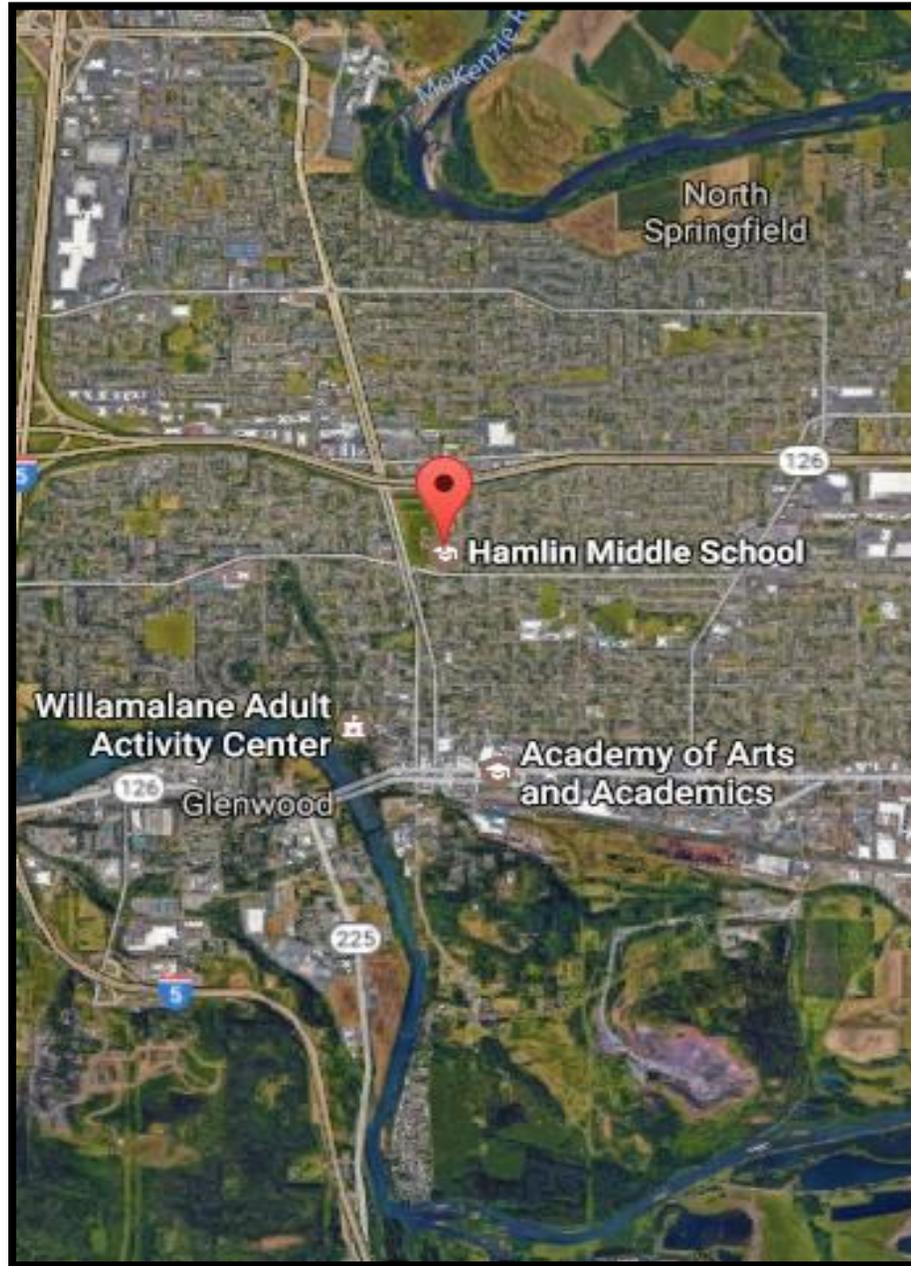
5th Street driving north near Hamlin Middle School



Heading east on Centennial Boulevard directly south of Hamlin Middle School



5th Street heading north at the intersection of Centennial Boulevard (southeast of school)



Map 4: Aerial view of the Hamlin Middle school service area

Mt. Vernon Elementary

Mt. Vernon Elementary School is in the southern portion of Springfield, right down the street from Douglas Gardens Elementary School. Mt. Vernon is located on Filbert Lane, which is right off Jasper Road. Jasper Road is a 35 MPH (Miles Per Hour), 3-lane (one travel lane in both directions plus turn lane) road. Filbert Lane is a two-lane, 25-mph road. There are bike lanes on Jasper Road and 42nd Street to the east. There is also a dedicated bike/ped path that goes from the back of the school to 42nd street through a field. The residential areas are 25 MPH and 2-lane roads (one travel lane in each direction). The main roads used to reach Mt. Vernon Elementary are 42nd Street to the east and Jasper Road to the south. The school has a zebra-style crosswalk on Jasper Road, two on 42nd Street, one on Holly Street runs perpendicular to 42nd Street to the east of the school), several at the roundabout at 42nd Street and Jasper Road. and one in front of the school on Filbert Lane. Traffic calming measures used are signs informing drivers of school zone and a school zone flashing light coming from both directions on Jasper Road. No other visible efforts to slow traffic were used other than standard school zone signs. The residential streets seemed that they would be comfortable to ride a bicycle on. Train tracks are located crossing 42nd Street and some children must cross them to get to school.



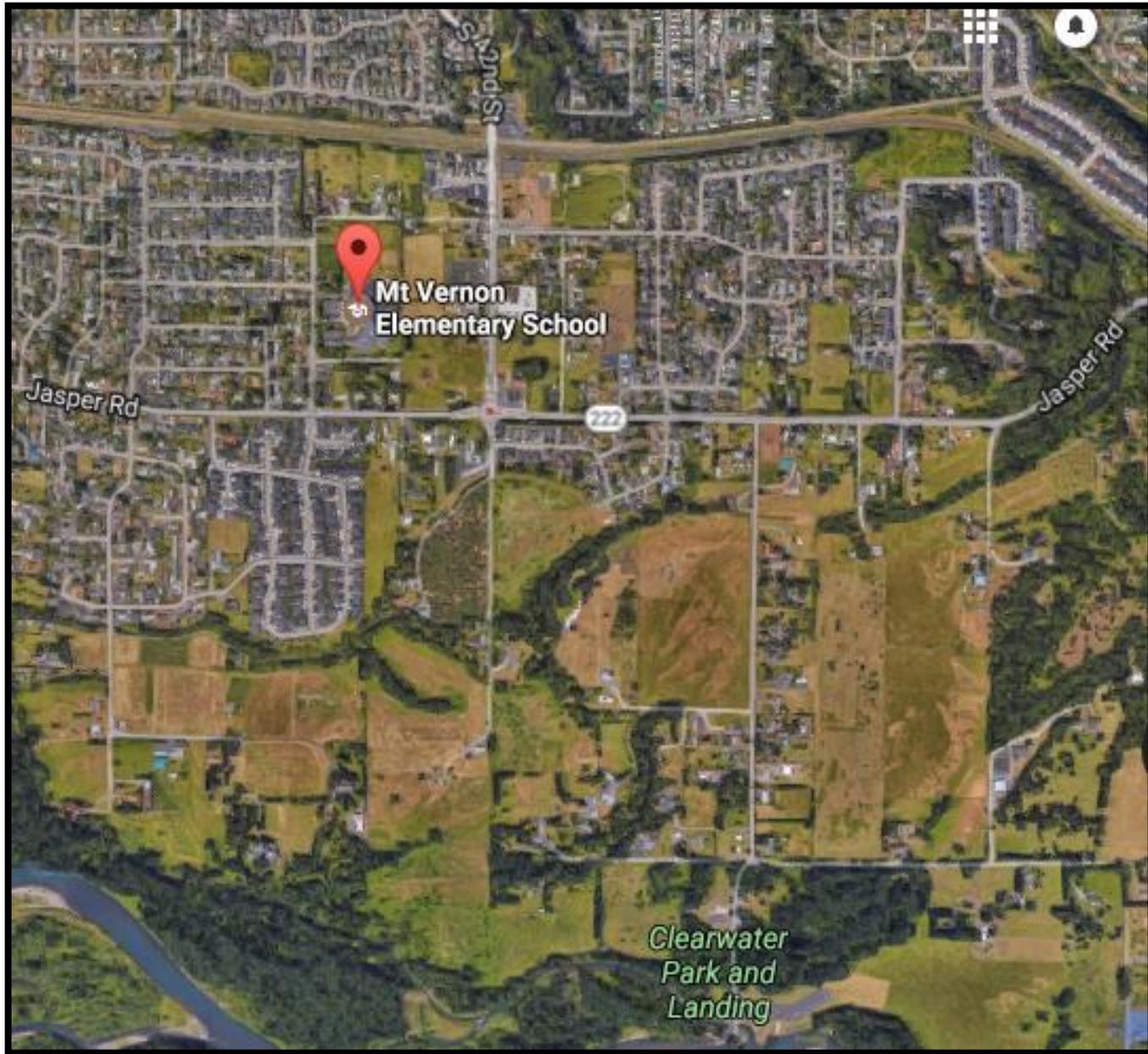
Heading west on Jasper Road, south of Mt. Vernon Elementary School



Heading north on Filbert Lane, just south of Mt. Vernon Elementary School



Heading south on 42nd Street, east of Mt. Vernon Elementary School (by Holly Street crosswalk)



Map 5: Aerial view of the Mt. Vernon Elementary school service area

Thurston Elementary

Thurston Elementary School is in the northeastern portion of Springfield. Thurston Elementary is located on Thurston Road, which runs east and west. It is right off 69th Street and runs somewhat-parallel to Main Street (Highway 126) to the south. Thurston Road is a 40-mph, 2-lane (one travel lane in both directions) road. There is a curve to Thurston Road as it approaches the elementary school. Main Street (Highway 126) is 45-mph and 5-lanes in the Thurston Elementary School service boundary. 69th Street is a 2-lane road with a 30-mph speed limit. There are bike lanes on Thurston Road, 69th Street, and Main Street (Highway 126). There is also a dedicated bike/ped path that goes from the back of the school south to B Street through a field. The residential areas are 25 MPH and 2-lane roads (one travel lane in each direction). The main roads used to reach Thurston Elementary are 69th Street to the west and Thurston Road to the north. There are no crosswalks going to Thurston elementary as an empty field lies north of the school. Traffic calming measures used are signs informing drivers of school zone and a school zone flashing light coming from both directions on Thurston Road. No other visible efforts to slow traffic were used other than standard school zone signs. The residential streets seemed that they would be comfortable to ride a bicycle on.



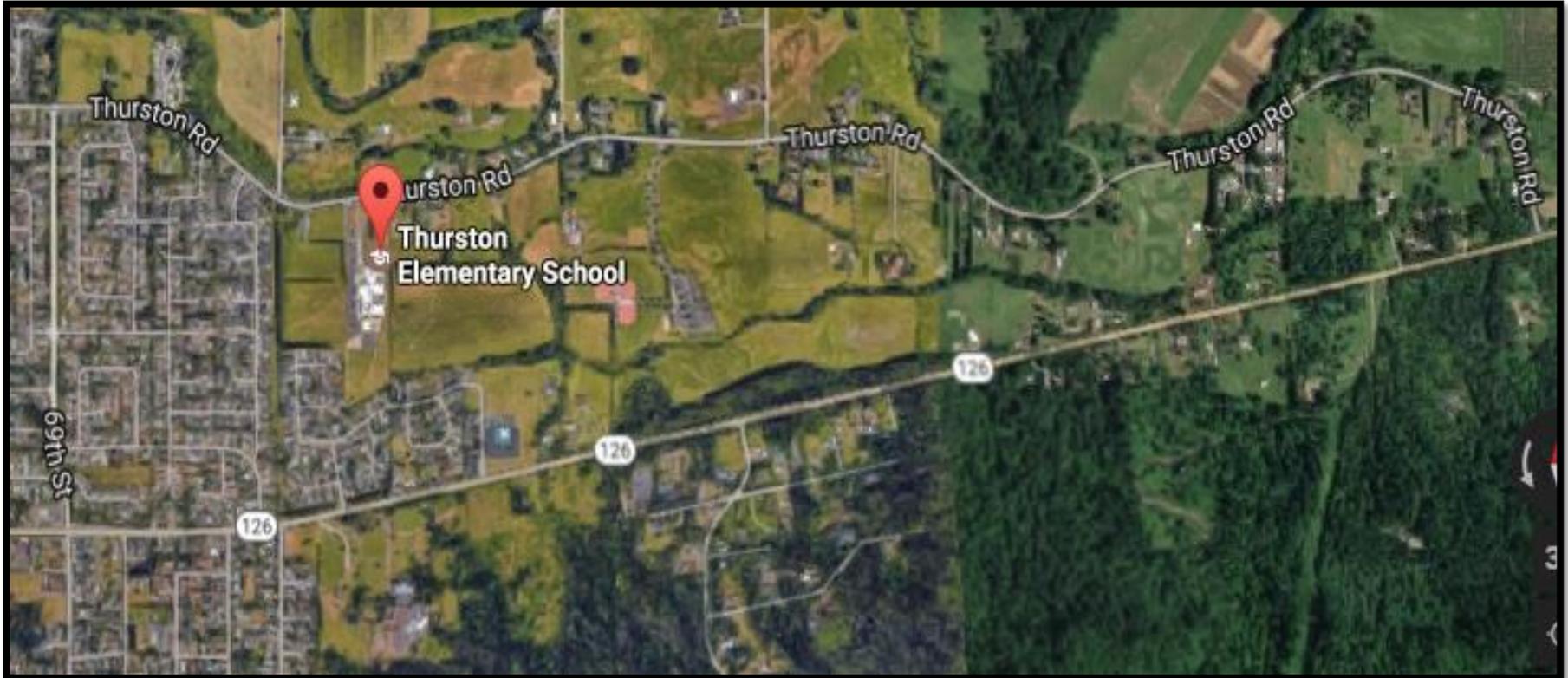
The curve on Thurston Road on approach to the elementary school, heading east



Thurston Road heading east towards Thurston Elementary School



Thurston Elementary School sign



Map 6: Aerial view of the Thurston Elementary school service area

Chapter 5: Findings

Key Findings

The comfortability metric used to grade the street segments in the 5 study schools showed interesting result. Most of the street segments in the school service area boundaries in Springfield showed that there were some uncomfortable streets in all study areas, but there were an even greater number of comfortable street segments in each study area. The result is great network connectivity in the residential areas but segmented connectivity when having to ride on the main streets, due to lowered comfort levels for children on these streets.

Overall Findings

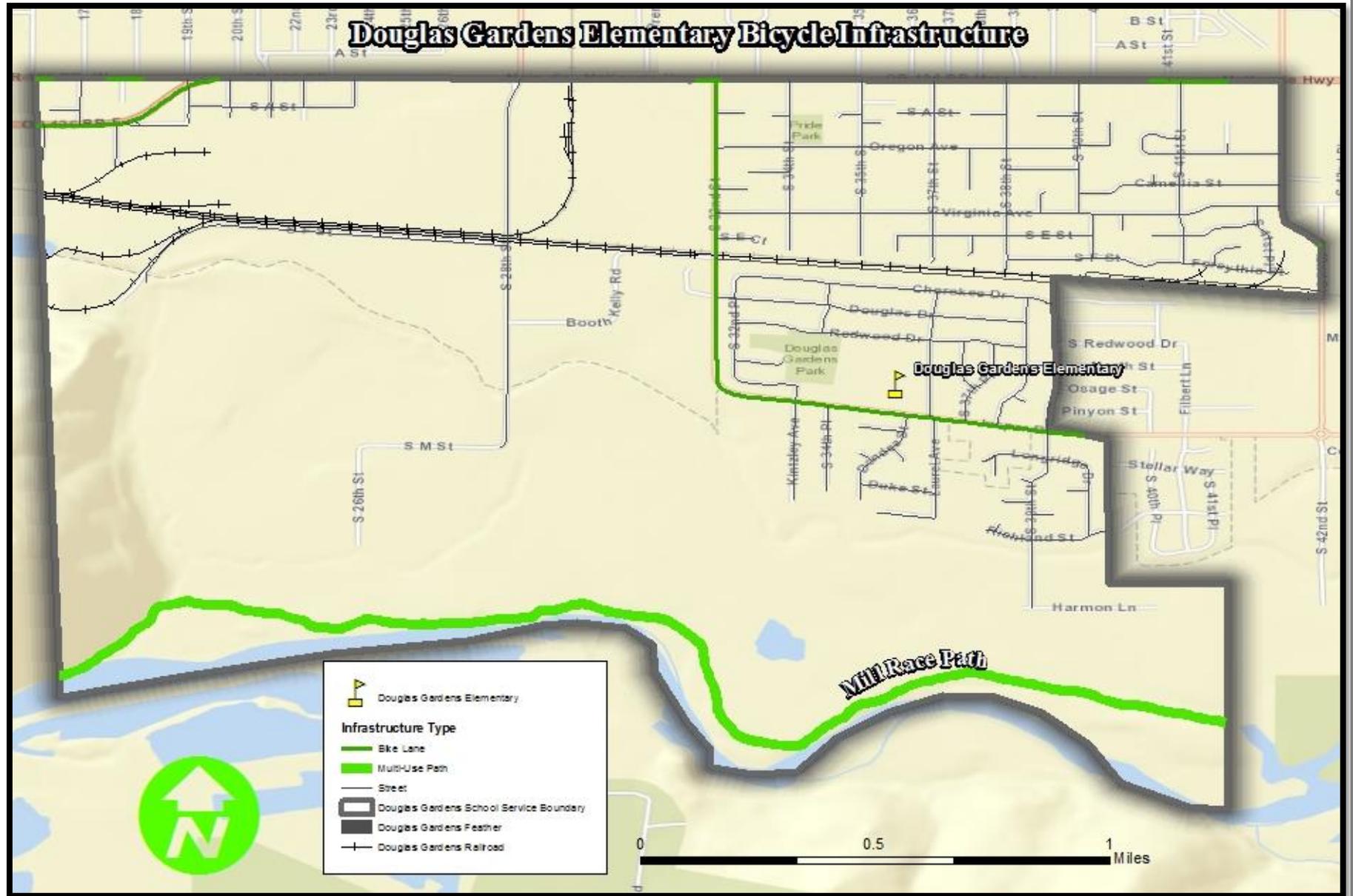
- **Douglas Gardens Elementary:** 205 street segments out of 251 received a passing grade of 7 or higher, out of 10 (**82% of street segments**)

- **Guy Lee Elementary:** 199 street segments out of 286 received a passing grade of 7 or higher, out of 10 (**70% of street segments**)
- **Hamlin Middle:** 1105 street segments out of 1307 received a passing grade of 7 or higher, out of 10 (**85% of street segments**)
- **Mt. Vernon Elementary:** 292 out of the 352 street segments received a grade of 7 or higher, out of 10 (**83% of street segments**)
- **Thurston Elementary:** 258 out of the 291 street segments received a grade of 7 or higher, out of 10 (**89% of street segments**)

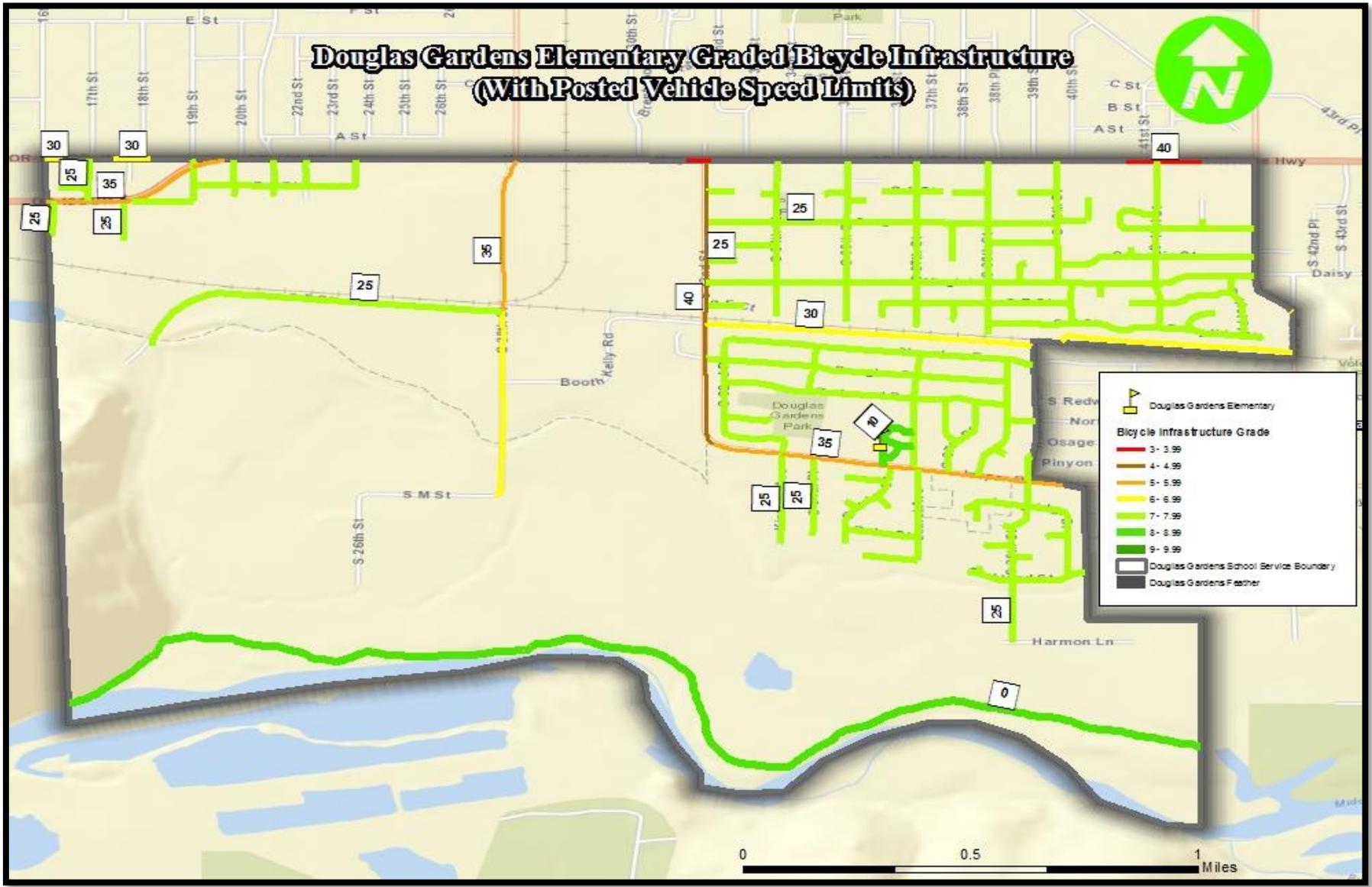
What do the grades of road segments mean?

The grades on the road segments show the average of the scores on the Comfortability Metric for each segment.

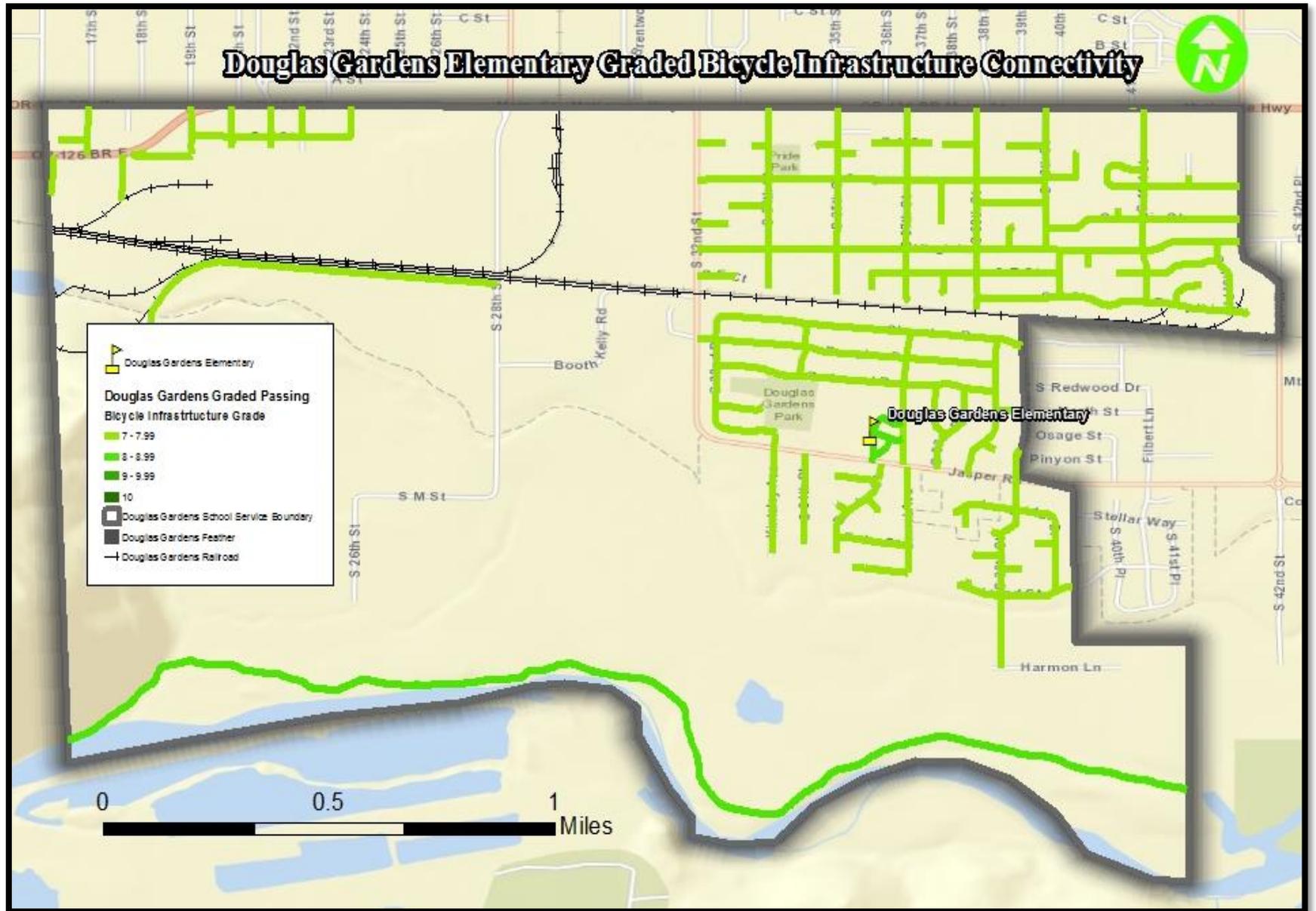
Douglas Gardens Elementary School



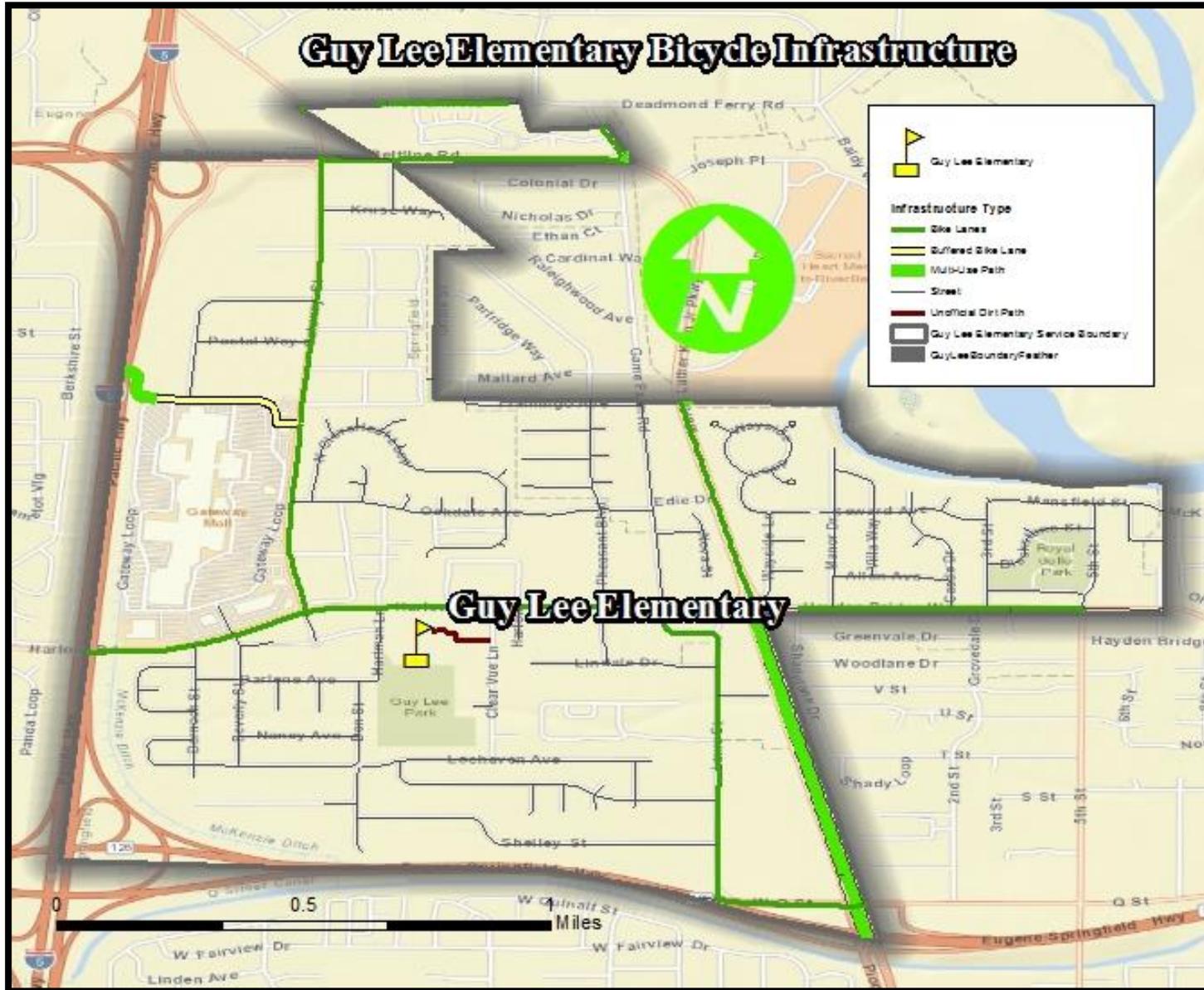
Map 7: Bicycle Infrastructure in Douglas Gardens Elementary School Service Boundary



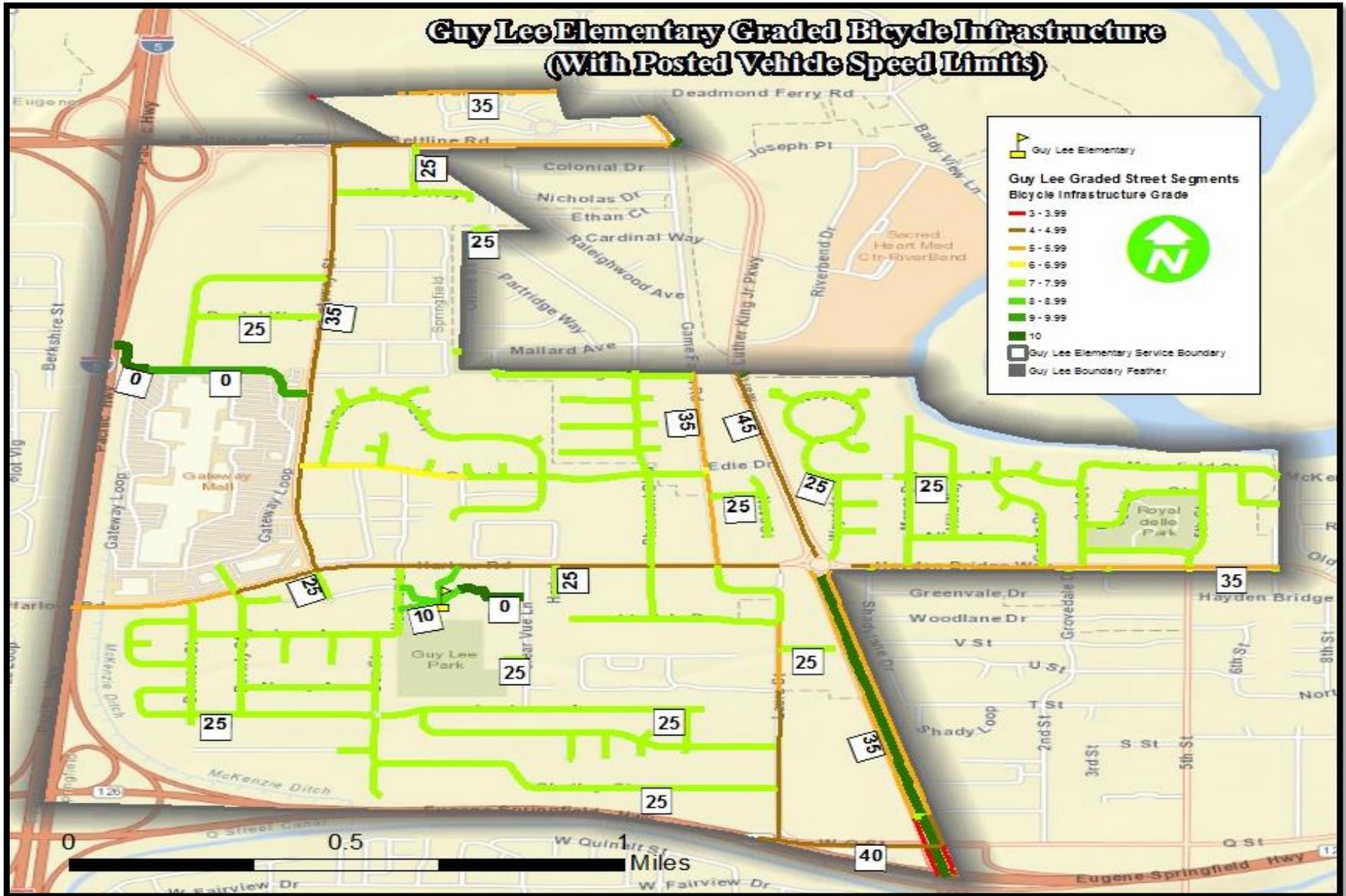
Map 8: Graded Bicycle Infrastructure in Douglas Gardens Elementary School Service Boundary with Posted Speed Limits



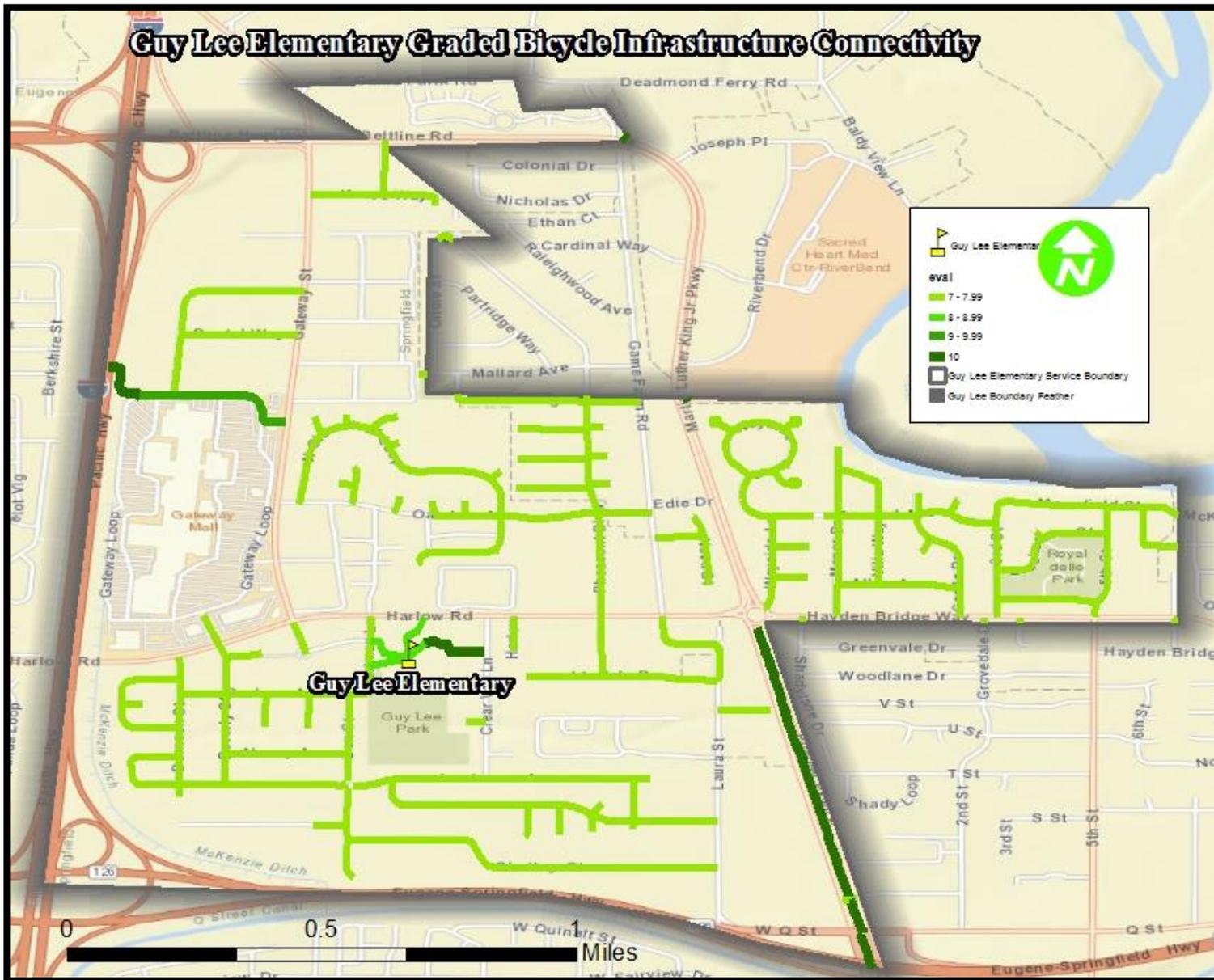
Map 9: This map shows the remaining connectivity in the Douglas Gardens Elementary School Service Boundary if the street segments that did not receive a passing grade were removed from the network



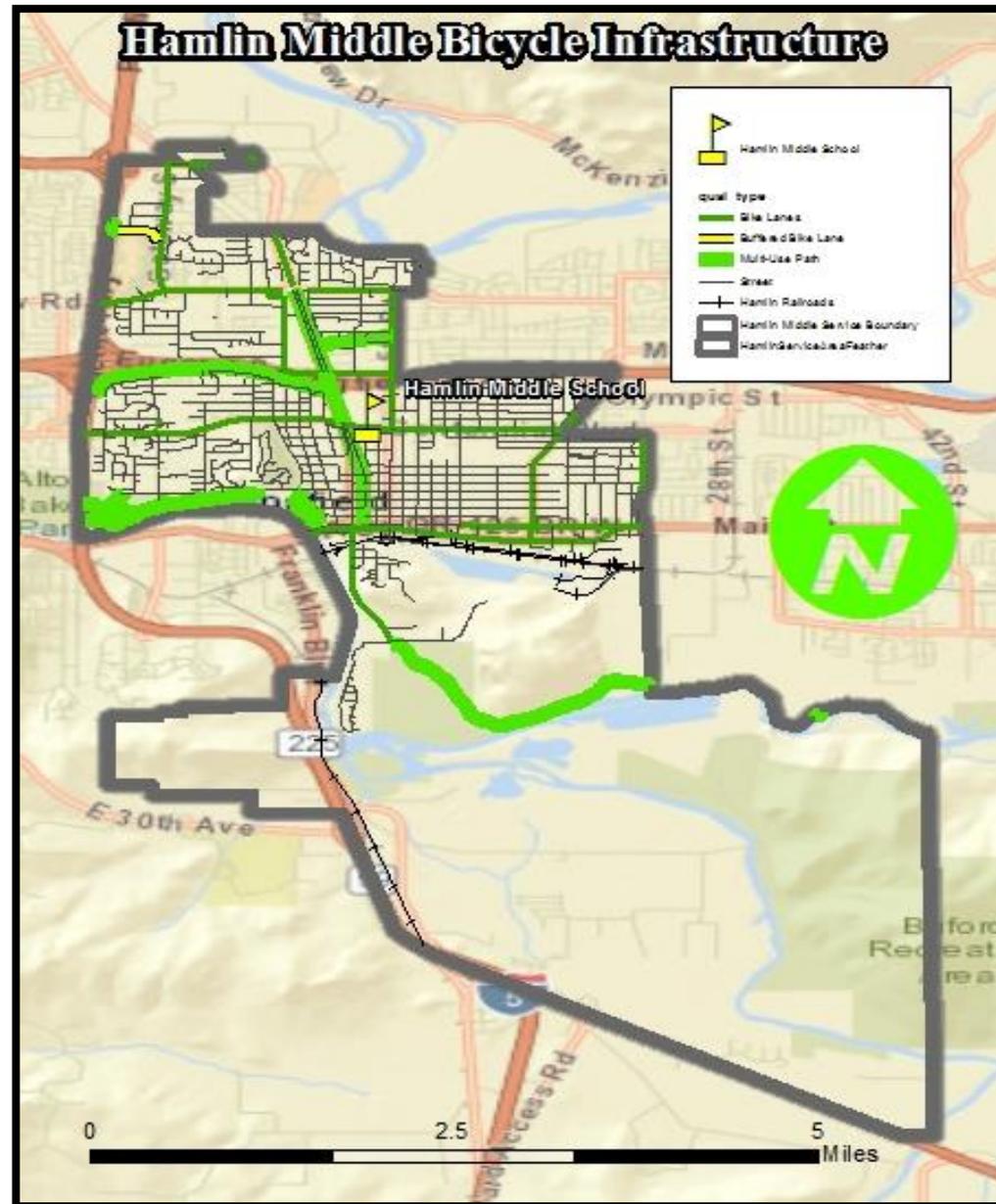
Map 10: Bicycle Infrastructure in Guy Lee Elementary School Service Boundary



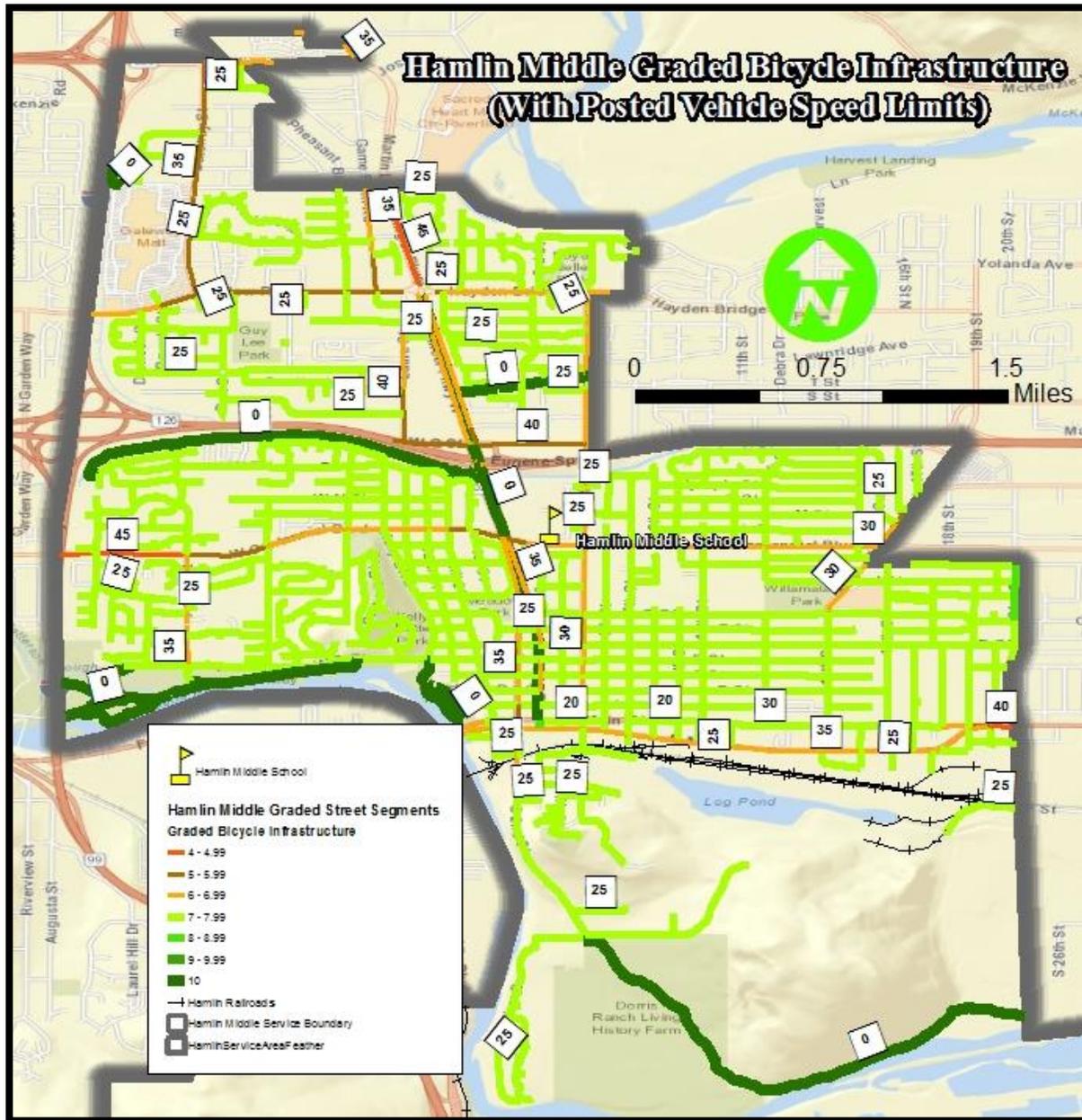
Map 11: Graded Bicycle Infrastructure in Guy Lee Elementary School Service Boundary with Posted Speed Limits



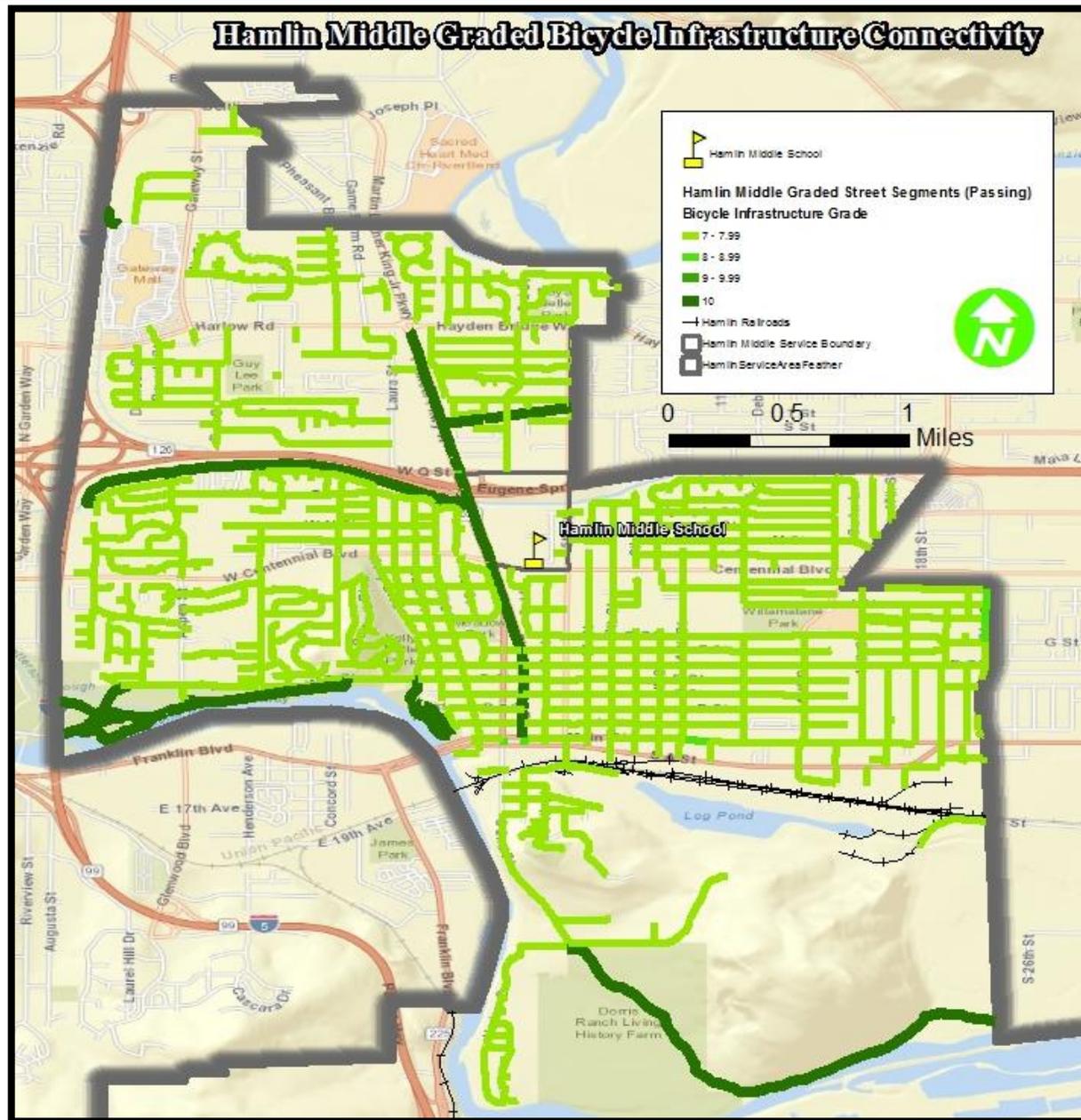
Map 12: This map shows the remaining connectivity in the Guy Lee Elementary School Service Boundary if the street segments that did not receive a passing grade were removed from the network.



Map 13: Bicycle Infrastructure in Hamlin Middle School Service Boundary

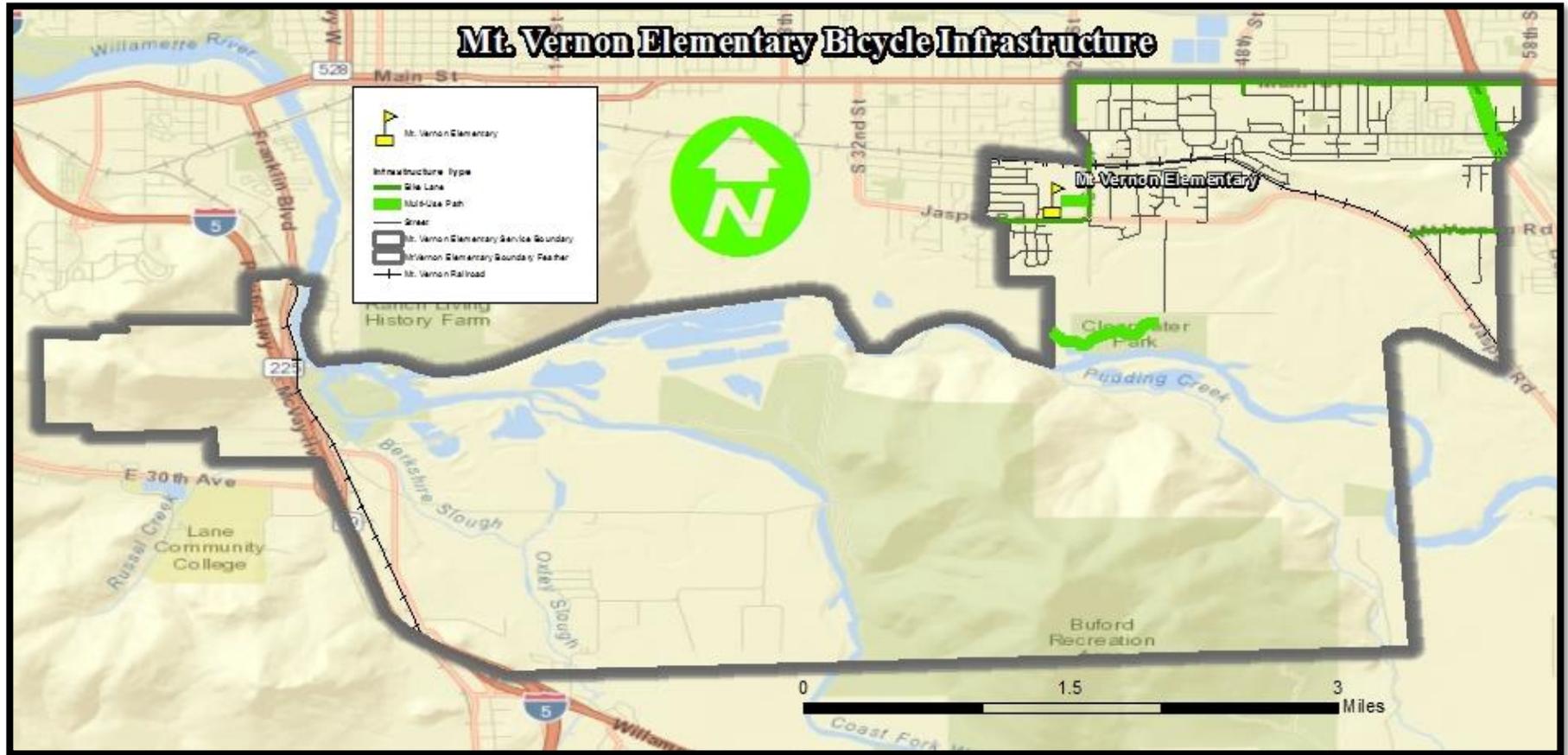


Map 14: Graded Bicycle Infrastructure in Hamlin Middle School Service Boundary with Posted Speed Limits

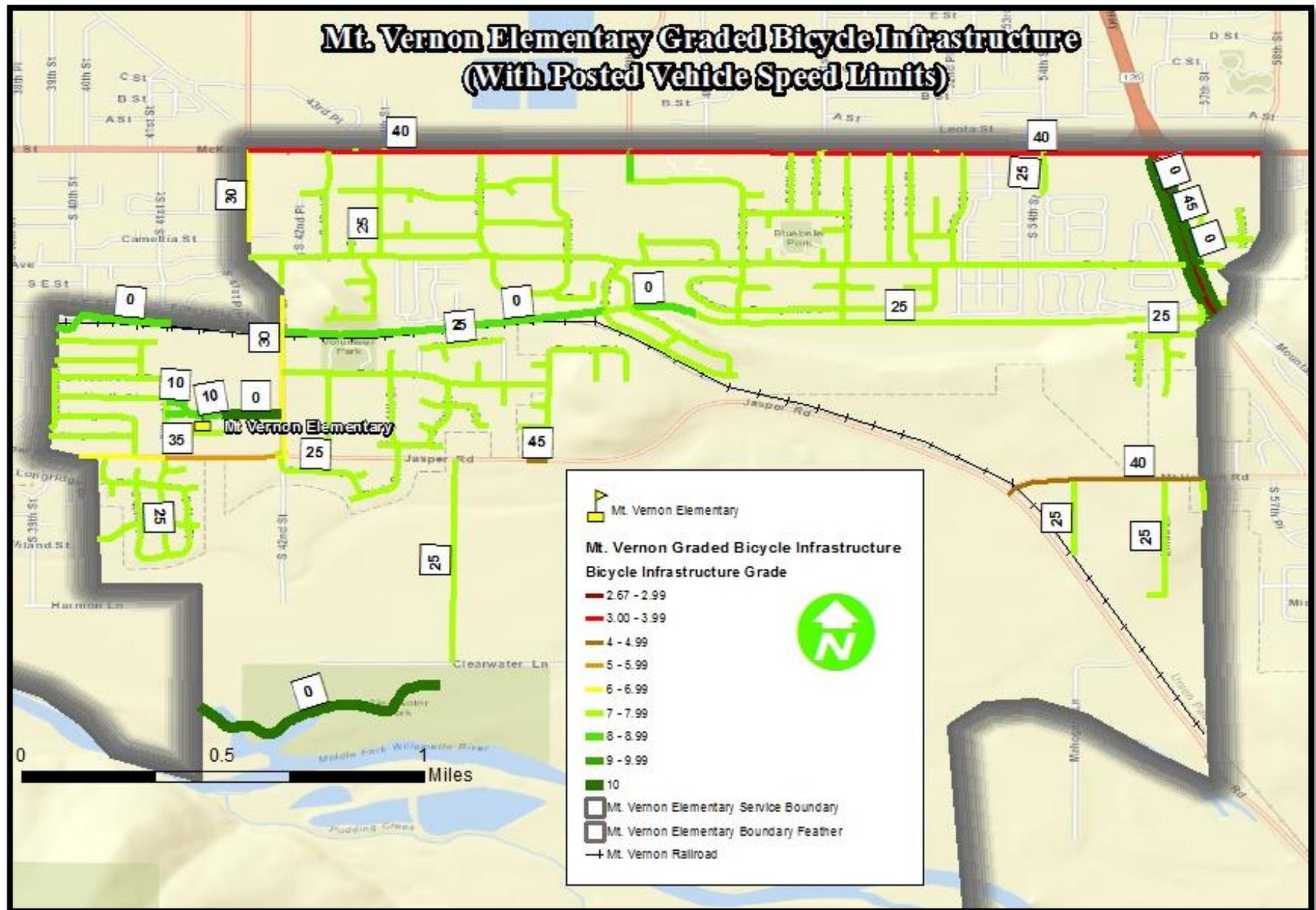


Map 15: This map shows the remaining connectivity in the Hamlin Middle School Service Boundary if the street segments that did not receive a passing grade were removed from the network

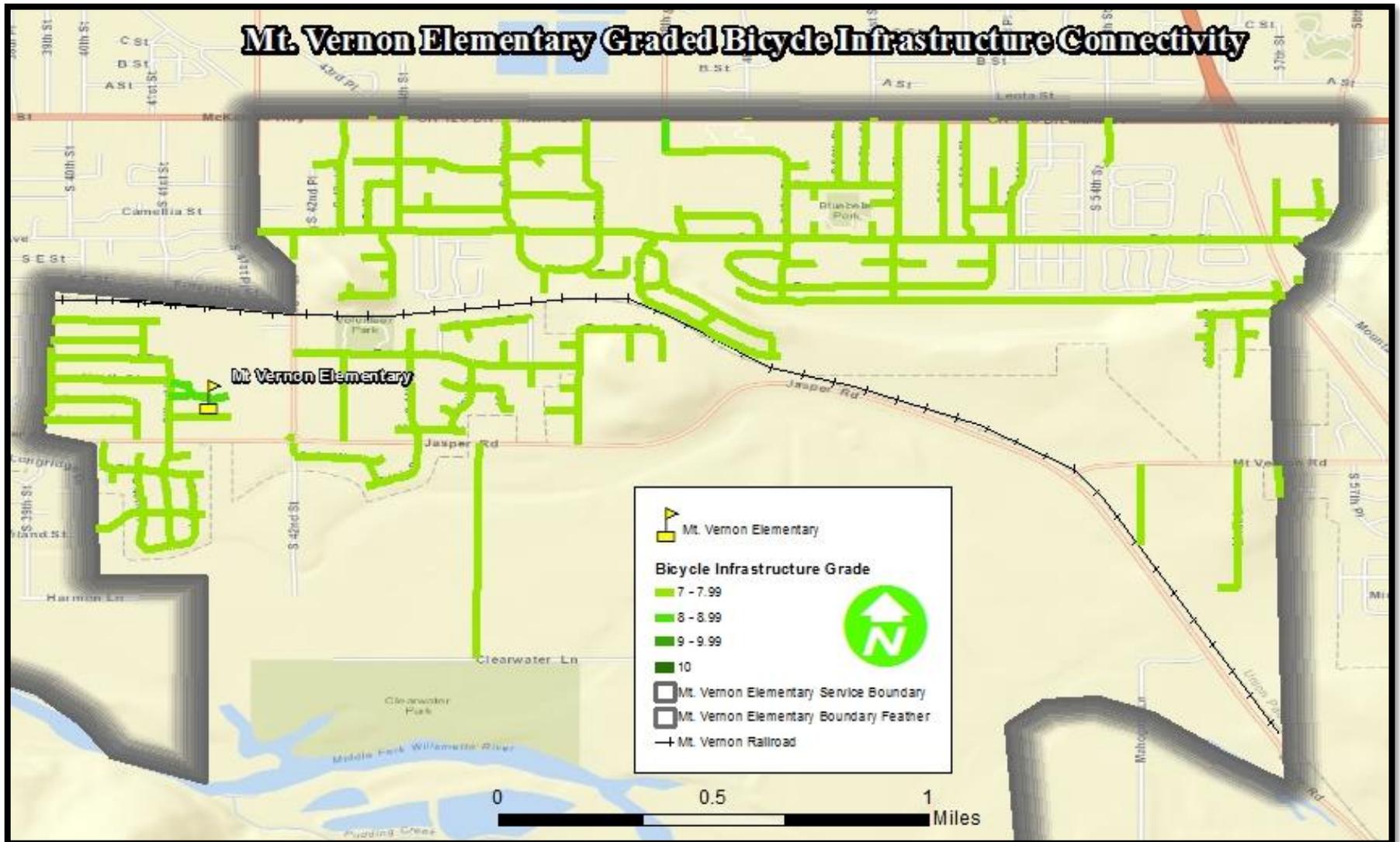
Mt. Vernon Elementary



Map 16: Bicycle Infrastructure in Mt. Vernon Elementary School Service Boundary

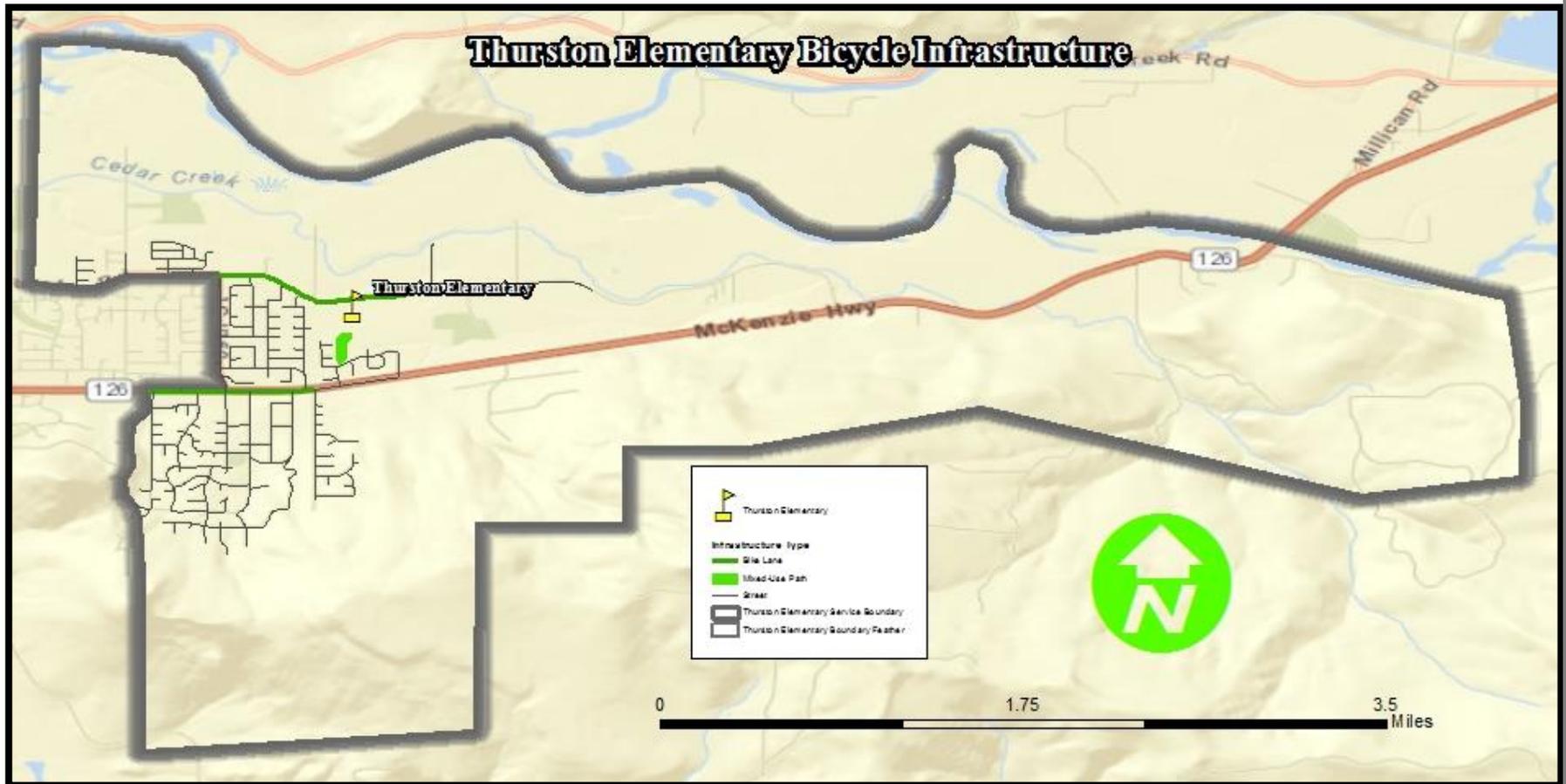


Map 1: Graded Bicycle Infrastructure in Mt. Vernon Elementary School Service Boundary with Posted Speed Limits

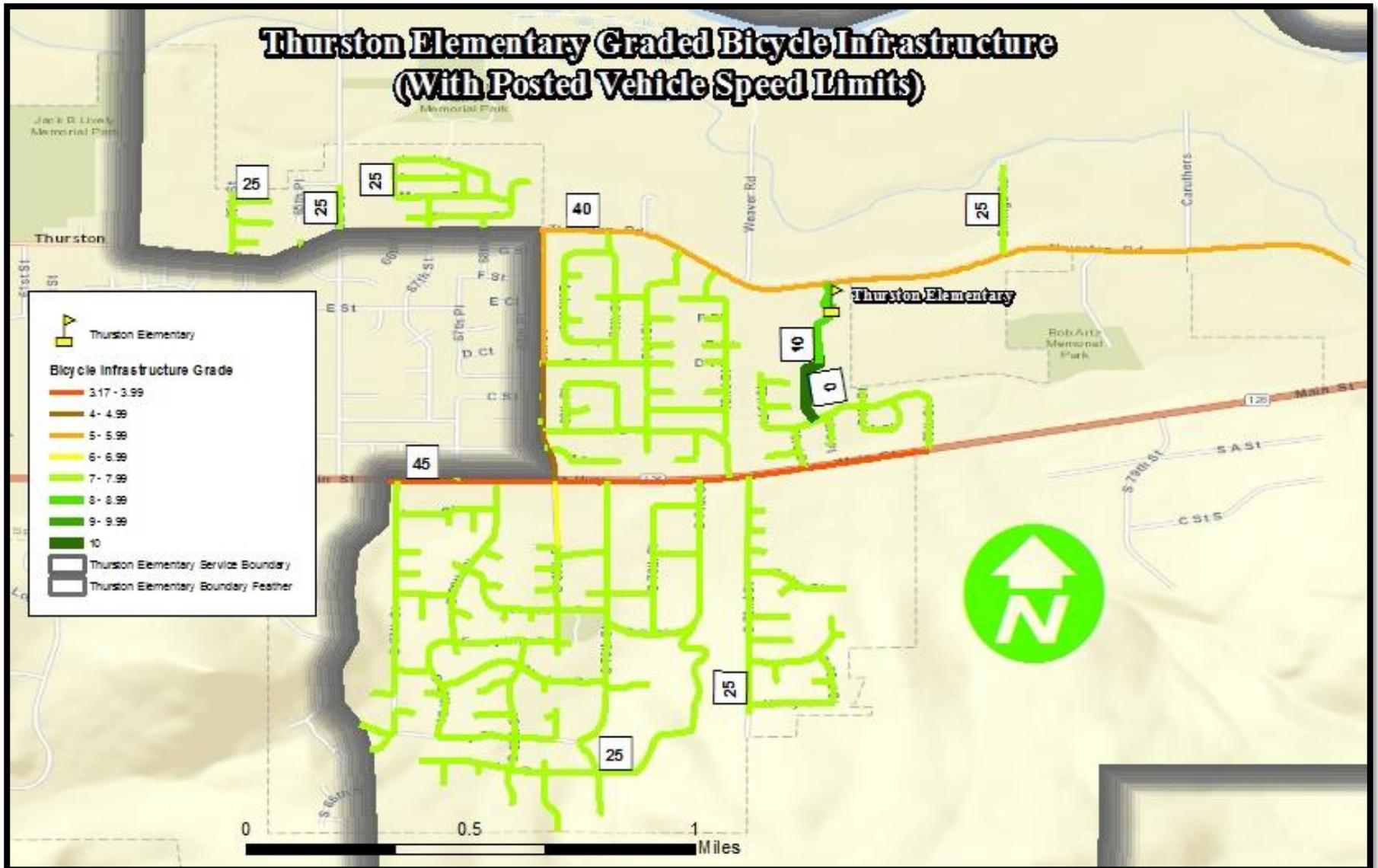


Map 2: This map shows the remaining connectivity in the Mt. Vernon Elementary School Service Boundary if the street segments that did not receive a passing grade were removed from the network

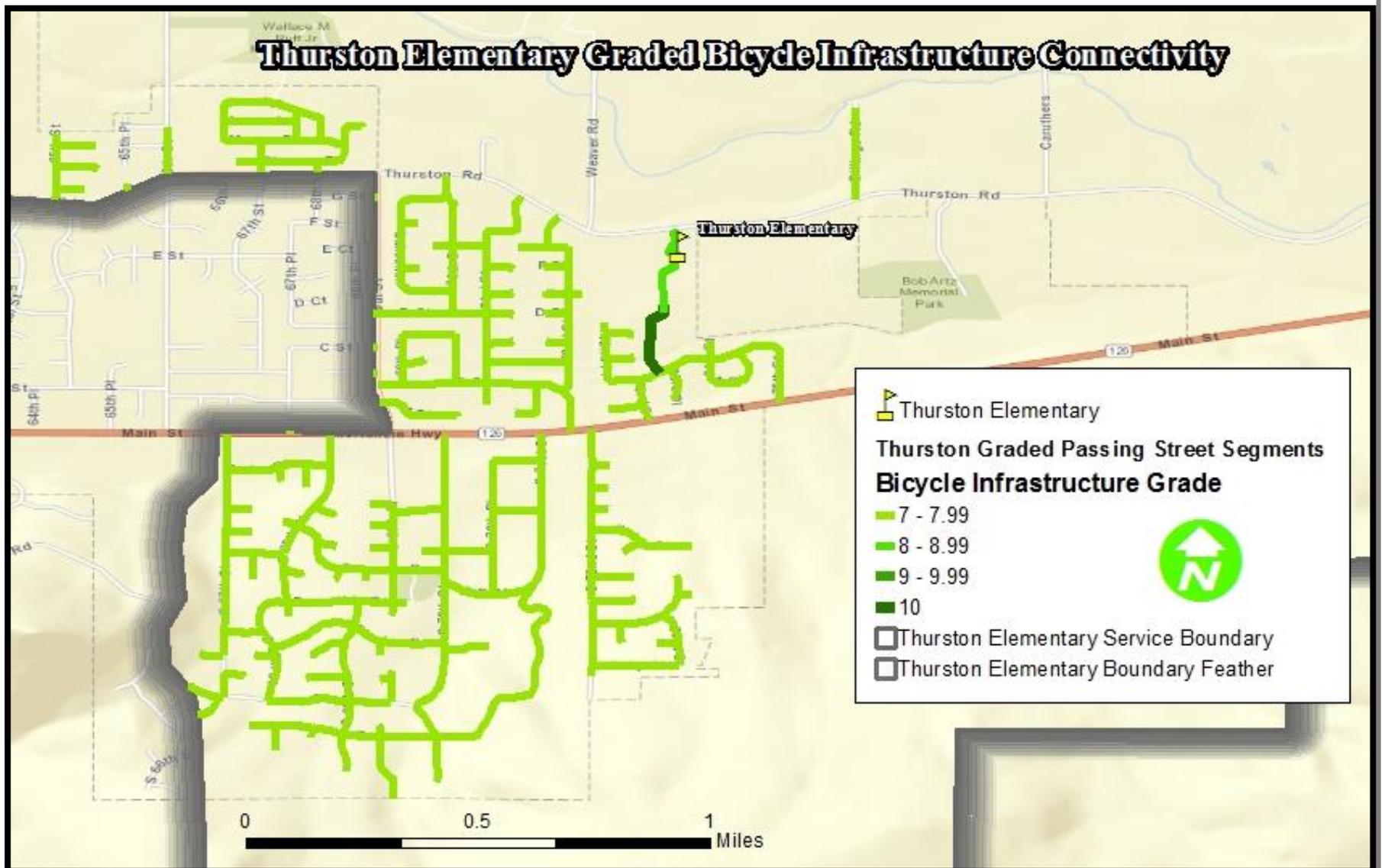
Thurston Elementary



Map 19: Bicycle Infrastructure in Thurston Elementary School Service Boundary



Map 20: Graded Bicycle Infrastructure in Thurston Elementary School Service Boundary with Posted Speed Limits



Map 21: This map shows the remaining connectivity in the Thurston Elementary School Service Boundary if the street segments that did not receive a passing grade were removed from the network

Implications

As shown on the third map of each school service area, without being able to comfortably ride a bicycle on the main streets, network connectivity was reduced and segmented islands came to exist. Some segmentation was more severe than others. All school service areas had somewhere between 2 to 5+ sections that became isolated without a comfortable road segment to ride that would connect to other comfortable street segments. If children feel uncomfortable with travelling on certain street segments, they will be more likely to not use a bicycle to travel to school. This can lead to increased obesity rates in children, a missed opportunity in an increased feeling of well-being and other mental and physical health benefits and the opportunity to be in a natural environment on the trip to school.

Chapter 6: Traffic Calming Measures

Traffic Calming

There are many options to help improve the bicycling comfort of children to increase bicycle ridership so children can receive the many benefits from bicycling described previously in this study. One option will be looked at and it is school zone traffic calming. The National Center for SRTS and the Institute of Transportation Engineers (ITE) created 9 briefing sheets for program planning and implementation of the SRTS program (SRTS & ITE, 2013). One of the sheets covers traffic calming measures that can be used near schools. Google defines traffic calming as, “the deliberate slowing of traffic in residential areas by building speed bumps or other obstructions.” There are many other types of traffic calming measures available for transportation practitioners to choose from. The traffic calming measures that are mentioned in the SRTS & ITE (2013) study are: curb extensions, chicanes, lateral shifts, and chokers, speed humps, speed tables and raised crosswalks, raised intersections, neighborhood traffic circles/mini traffic circles, modern roundabouts, half-street closures, median islands, and forced-turn islands. Deciding which, if any, should be implemented near the study schools in Springfield is the job of the extremely qualified transportation practitioners, so there will not be any recommendations made in this study.

Traffic Calming Best Practices

Radarsign (2013) claims that there are “three E’s of school zone traffic calming” that help to create a safer school zone. The “three E’s” are Engineering (deals with the built environment, signage, traffic safety, street markings, etc.), Enforcement (crossing guards and law enforcement), and Education (training students, parents, teachers, and community members about the challenges and responsibilities of school zone safety).

The *Neighborhood Traffic Calming Guidelines* for the City of Arroyo Grande, California (Arroyo Grande Community Development Department Engineering Division, 2016) states three types of measures that are used to calm traffic, passive measures, active measures, and volume reduction measures. Passive traffic calming measures are things like police enforcement, high-visibility crosswalks, use of a radar trailer or speed feedback trailer, speed feedback signs, pavement striping, signed turn restrictions, and truck restrictions. Active traffic calming measures are things like speed humps, speed tables or raised crosswalks, raised intersections, speed cushions, neighborhood traffic circles, mid-block chokers, medians, bulb-outs, and chicanes. Volume reduction measures are a partial closure of a street, full street closure, or a diversion to another street.

Chapter 7: Case Studies

Case Studies

It is possible to learn lessons from others' successes and failures. Case studies are used to rely on previously established work and research in a way that can encourage people to apply their principles (Rowley, 2002). Looking at comparable case studies shows what others did to frame the problem, what options they had to remedy the problem, and then the steps used and the option chosen to remedy the problem.

Springfield, Oregon is not the only municipality that may be having issues with uncomfortable street segments. A couple of case studies will follow that show examples of what other cities have done to improve their streets. The cities and streets are:

1. Second Street, Long Beach, California
2. Vanderbilt Avenue, Brooklyn, New York

Second Street—Long Beach, California

Before

- Two lanes of traffic in each direction
- Turn lane/island in the center

After

- One travel lane on both sides continued as a travel lane
- One travel lane on both sides changed to shared auto/bike lane with green stripes that mark usage for bicycles to share with automobiles
- Maintained parking on each side and the turn lane island

Results

- Increase in bicyclists from 1320 over a 3-day period to 2,428 a year later
- Traffic accidents declined by roughly 25% nearly four years after the paint was added
- Cyclists have adjusted to automobile traffic and learned to coexist with automobiles

(Pictures and data from Schlossberg et al.(2013))



Before picture of Second Street in Long Beach, CA



After picture of Second Street in Long Beach, CA after making streetscape enhancements

Vanderbilt Avenue—Brooklyn, New York

Before

- Two lanes of travel in each direction

After

- one moving lane in either direction
- a flush center median
- parking lane in each direction
- left turn lanes at intersections

Results

- Reduced number of speeding vehicles
- Increased turning vehicle and pedestrian safety, and increased the number of new cyclists using the corridor

(Pictures and data from New York City D.O.T.(2008))



Before picture of Vanderbilt Avenue in Brooklyn, New York



After picture of Vanderbilt Avenue in Brooklyn New York after traffic calming strategies were implemented.

Chapter 8: Conclusion

The goal of this research was to grade the street segments in the school service boundaries for a child's comfort level. Applying the Comfortability Metric to each street segment accomplished this goal. The results showed that much of each school service area had a comfortable bicycle network. There were only a small number of street segments that were graded as uncomfortable.

Study Limitations

There are substantial financial and political costs in trying to implement changes in street systems and to improve connectivity of bicycle infrastructure. None of these costs were talked about or weighed out in this study. These are left to the experts to manage and weigh.

This study was an analysis of street segments, not crosswalks or intersections. Street segments are only a portion of the bicycle infrastructure that a child uses to ride on to school. Crosswalks and intersections are a big part of that as well. The Comfortability Metric showed many street segments that were not passing as comfortable for children, but a greater number of residential areas that were passing. A crossing or intersection improvement could possibly link two passing areas that are separated by a failing segment and create a connected bicycle network.

The Comfortability Metric in this study was not tested for statistical significance. The study that the metric is based off (Champine, 2014) was however. With all the changes made with weighting criteria different, adding new criteria, and removing criteria that was in the original study, testing the new Comfortability Metric for statistical significance is necessary.

Areas for Future Research

Crosswalks, intersections, and other types of crossings need to be researched further to improve network connectivity. Grading street segments provides one picture but leaves a portion out. If both portions (street segments and intersections or crossings) were graded, there would be a more complete picture of the connectivity of a comfortable bicycle network. A crossing or intersection can provide a way to cross over a failing street segment and connect two comfortably connected areas.

The rest of the street segments in the school service boundaries in Springfield can be graded in the same manner as the 5-study school in this paper. This will benefit the City of Springfield Transportation Planners and Engineers by providing a list of street segments that may not be comfortable for bicycling children. This list may allow them to prioritize improvements that may be needed to increase comfortability.

A combination of this research (street segments) and an additional metric that grades crosswalks and intersections for comfortability can be combined to provide the whole picture in question.

Appendices

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Appendix B: Maps and Images

All maps were created by Kendal Black.

(Sources: Google Maps, ESRI ArcGIS online, City of Springfield GIS Department, RLID)

All photos for each school area were taken by Kendal Black.