Using Pedestrian Accessibility Indicators to Locate Schools: A Site Suitability Analysis in Greenville County, South Carolina

by

Nathan Stewart

A Thesis Presented to the
Faculty of the USC Graduate School
University of Southern California
In Partial Fulfillment of the
Requirements for the Degree
Master of Science
(Geographic Information Science and Technology)

May 2016

To my wife Amanda, without her love and support this thesis would have been impossible.

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Acknowledgements

I am grateful to my thesis advisor, Professor Warshawsky, for his patience with me. In addition, his ability to give me the direction I needed was invaluable to the thesis process. I would also like to thank the other faculty members who gave me assistance when I required it. Also, I am grateful for the data provided to me by Greenville County’s Geographic Information Science Department and the assistance in editing and proofing by my wife Amanda Stewart.

List of Abbreviations

GIS	Geographic information system
GIST	Geographic information science and technology
USC	University of Southern California
GCGISD	Greenville County Geographic Information Science Department
DEM	Digital elevation model
SSA	Site suitability analysis

Abstract

Walking and biking have always been important ways for children to get to school, but these modes of transportation have declined significantly in recent years as the majority of children now arrive to school via bus or automobile. Importantly, walking or riding a bike to school can help students; not only does it promote better health, but it also improves student concentration and academic success. Studies have shown that students who walk or ride their bike to school perform better due to the exercise they receive prior to beginning their learning for the day. For this reason, this thesis focuses on finding suitable locations for schools that promote pedestrian accessibility and student walking. Greenville County, in South Carolina, is used as the study area for this thesis. The question that this site suitability analysis (SSA) examines is the following: where are the best possible locations for new schools that meets the district's needs and maximizes the student's pedestrian accessibility? This study uses seven different criteria to determine the most suitable location for an elementary, middle, and high school to answer that question. The data are analyzed and a few suitable locations are identified. Then, the data are scored using population density and pedestrian accessibility. Lastly, the results are tabulated to reveal the best possible location for this SSA. This study could serve as a guide for future planning committees, school boards, districts, or city developers to help determine how and where schools should be placed throughout the country.

Chapter 1 Introduction

1.1 Background

As of 2015, society has become very dependent on forms of transportation other than walking or biking. That dependency has spread to the children of today as well. A study from 2012 shows that students who walk or ride their bikes to school in the morning are in better health, concentrate better in school, and have greater academic success (Vinther 2012). For this reason, this study is designed to find a suitable location for new schools in Greenville, South Carolina that not only meets district needs, but also promotes pedestrian accessibility.

In 1969, roughly 48 percent of the students between kindergarten and eighth grade walked to school on a daily basis in the United States (National Center for Safe Routes to School 2011). By 2009, in the same age ranges the percentage of students walking was down to just 13 percent. To add to that, in 1969, roughly 41 percent of children lived within one mile of the school they attended. Of those 41 percent, 89 percent of them usually walked or rode bikes to school. By contrast, in 2009 the percentage of students living within one mile of the school they attended was down to 31 and of those students the walking percentage was only 35 percent (USDOT 1972).

Through the years there has been a dramatic increase in vehicle traffic on the roads. Moreover, the population of the United States has increased from 202.7 million in 1969 to roughly 322.5 million in 2014 (US Census Bureau 2014). That means in the last 46 years the population of this country has grown by almost 120 million people. That alone is astounding, but it fails in comparison to the fact that if those 120 million people were to make up their own country, that country would be the 12th most populous country in the world, just 3 million people behind Mexico (Worldometers 2014). To expand upon this, due to the increased population more people own cars and communities have grown larger, both of which contribute further to the increase of vehicle traffic.

The question is how do these facts relate to selecting a new school location? Studies have shown that walking or riding a bike to school can help students (Vinther 2012). However, with the increase in population and traffic, more parents are convinced that it is not safe for their children to walk or bike to school (Pedestrian and Bicycle Information Center 2015). In 2011, roughly 11,000 pedestrians 14 and under, were injured while walking or biking, and in 2013 that number climbed to nearly 15,000 (NHTSA 2015). It can be understandable why parents may feel that it would be safer to drive rather than walk or ride a bike.

This notion of increased traffic however, is really what brings the focus back to this study. One reason traffic has increased through the years is due to the location of where a school is built in a city. Distance to school is a critical factor in the safety of the students walking or riding bikes to school. In the 1960's when more students were walking it was not just because there were less people and traffic, but schools were located in community centers. Starting in the 1970's, districts began to build schools on the edges of communities. The reasoning behind this change is reasonable, as the district wanted to save money and put more into the schools. The properties on the edge of communities are generally lower cost than the ones in the community centers (Pedestrian and Bicycle Information Center 2015). As a community grew, the service area for a school did as well which again contributes to students traveling farther. This in turn, makes it more difficult for students to walk or bike to school and increases the amount of traffic.

The average distance a student would have to travel from home to school in 1981 was 2.4 miles for elementary and 4.3 miles for secondary. In 2002, that distance increased to 3.6 and 6.0 miles respectively (USDOT 2008). This means that not only has the amount of traffic increased through the years, but the distance that students must travel has also increased, placing the students at higher safety risks.

In May of 2015, the district of Greenville had 406 buses and transported approximately 25,000 students per day (Greenville County Schools 2015). As of that same date, the current minimum distance a student must live away from a school is 1.5 miles in order to use the bus system (Greenville County Schools 2015). Bike Walk Greenville conducted a recent study on the elementary schools in the district to test their walkability. The study concluded that only 10 of the 50 schools were actually safe to walk to (Bike Walk Greenville 2013). Moreover, the information discusses that the district has been built to rely on vehicle transportation, whether it is by bus or car, and how that negatively affects the children’s health.

For these reasons when districts decide to build a new school, pedestrian accessibility should be one of the, if not the top, priorities considered. This study focuses on finding a suitable location for a new school that not only meets the needs of the district, but also uses pedestrian accessibility to make the location of the new school more manageable for walking, and reduce the safety risks presented above. As of 2015, the idea of choosing a school location based on pedestrian accessibility has been under-utilized and it is important to reform school site suitability models so that pedestrian accessibility plays a prominent role in decision making.

1.2 Thesis Goals

There are many criteria that already go into school site selection, but the idea of pedestrian accessibility for students should not be overlooked. Many children that live within a 2-mile radius of their school are still being driven to school by their parents due to unsafe routes or bad sidewalk planning by the city or district (National Center for Safe Routes to School 2011).

The overarching goal for this study is to determine the optimal locations for different school levels within the county of Greenville, South Carolina. This goal focuses on determining where the district should place new schools to optimize not only cost, but also the pedestrian accessibility of the location. Furthermore, this goal focuses on returning school locations to safer areas for students who walk and bike to school.

This study also has three secondary goals. The first of these is to determine which of these locations under selection would be the best for each school level in terms of just pedestrian accessibility, regardless of cost to the district. This goal is important to look at because it takes the bias of cost out of the equation. This focuses on what is best for the students in terms of safety and being able to walk or bike to school.

The next goal goes further to identify the five best sites for population density, pedestrian accessibility, and cost, as it relates to parcel and utility needs, for each school level. For this to work the sites must all be looked at for viability at the elementary, middle, and high school layers. In summation of this goal there are a list of 15 site locations in total, which identify which sites are best suited for each type of school. Furthermore, this list is for the districts to identify and use cost benefit analysis to determine which of the sites chosen for their pedestrian accessibility and population density also match the districts cost needs.

The last goal is to look at the present schools in the district to determine which of the existing schools are currently the most accessible to pedestrians. This helps the district explore options when it is time to rebuild schools, or when funding comes in to help make the area more pedestrian accessible. This may also be a helpful tool for the district to see where the biggest problems are when they choose sites in the future, based on current methods. More importantly, it could be eye opening information that makes the district rethink its policies and procedures for placing new schools.

The motivation for this study is positioned on the idea of building an analysis method to help districts and school planners understand the importance of pedestrian accessibility and build accordingly. Planning for a perfect school site often overlooks these key ideas for the students' needs and focuses more on the districts needs in terms of cost and expansion ability. By outlining this approach, it allows for districts and school planners to investigate further into where to place new schools and gives more criteria to consider when choosing the optimal location for a new school.

This study uses seven separate criteria to both screen and score locations for new schools. The locations were put through the criteria and dwindled down until a group of suitable locations remain for each school level. Once the criteria have been screened and the number of locations diminished, the remaining sites will be scored based on their population density and pedestrian accessibility. The top five sites for each school level location are presented in the results with the cost involved for each site location. One site is then chosen as the optimal site location based solely on pedestrian accessibility. Lastly, the currently existing schools are scored based on population density and pedestrian accessibility to determine a ranking order of how they measure up to optimal locations.

1.3 Study Area

The chosen study area for this thesis is the county of Greenville, South Carolina. Located in the foothills of the Smoky Mountains and the upstate region of South Carolina, Greenville is the largest county in the state (Greenville Area Development Corporation 2015). Figures 1 and 2 display the location of Greenville County relative to the rest of the state and the proposed study area respectively. Greenville County is rapidly growing and consists of a single school district. As of 2010, the population in the county was 451,225 with an expected growth increase of roughly 92,000 people in the next 20 years (Greenville County Schools 2015). As of 2015, the county currently has plans to build new schools in the near future to accommodate the growth occurring. Planning has already begun for a new high school, middle school, and elementary school (Greenville County Schools 2015).

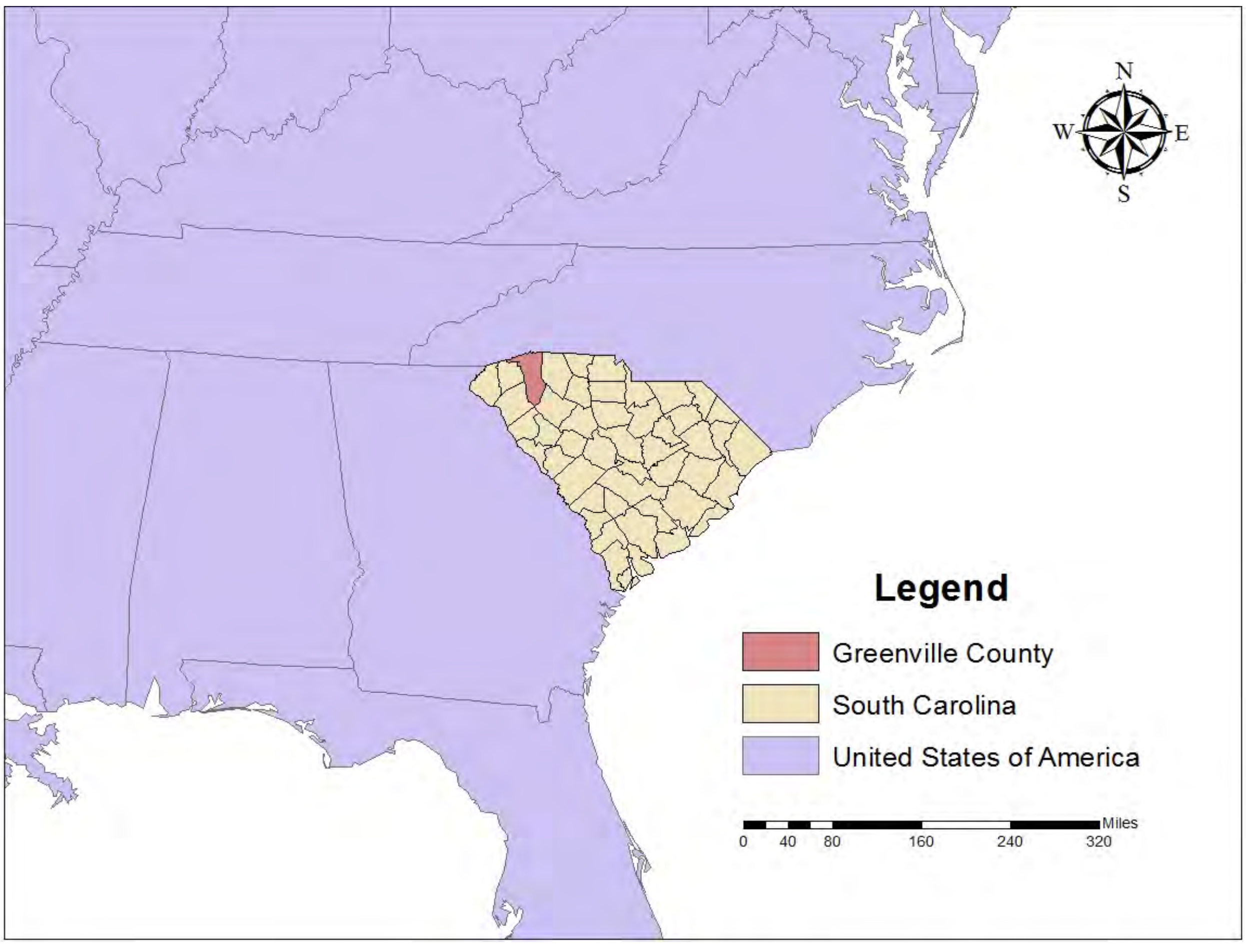

Figure 1 Greenville County, South Carolina

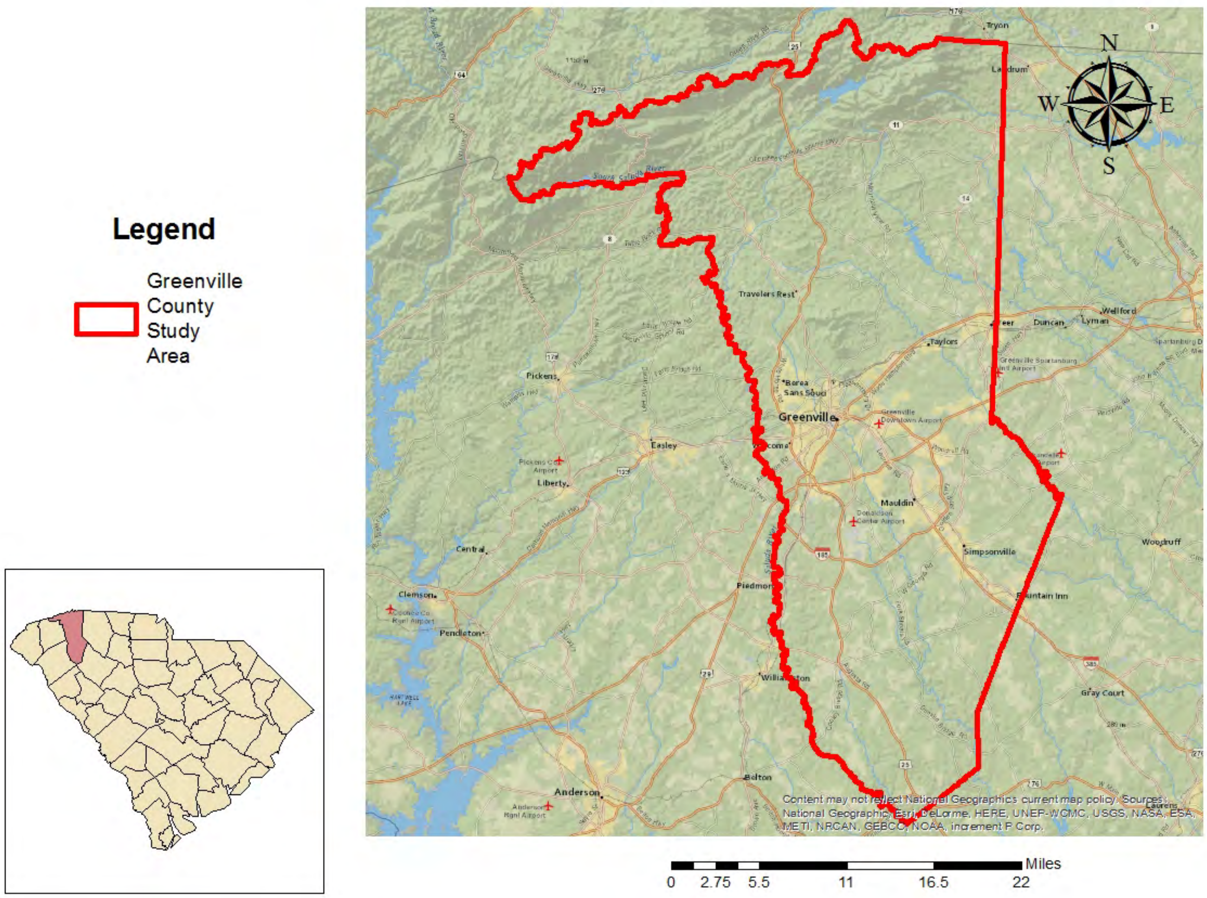

Figure 2 Proposed Study Area of Greenville County

Greenville County is comprised of 101 schools in the district; made up of 50 elementary schools, 19 middle schools, 14 high schools, and 18 schools designed for career centers, special education centers, and child development centers (Greenville County Schools 2015). As of 2014, the district has 72, 712 students in attendance making it the 46th largest school system in the nation. The school district of Greenville County also employs just over 5,000 teachers’ and 9,506 total employees (Greenville County Schools 2015).

This district is a great location for this study because it not only has room to expand in building area, but the population is currently expanding as well. This means that the district will need to create new schools in the future to accommodate the growth into the area. By using the methods set forth in this thesis, district planners will be able to approach the site location for schools from a new perspective to accommodate not only the influx of people, but also the use of pedestrian accessibility in determining safety and school improvement.

The rest of this thesis is comprised of four chapters. Chapter Two focuses on related works about school locations using site suitability analysis and the criteria and processes selected to achieve them. Chapter Three examines the methodological processes chosen and the criteria selected for this study. Furthermore, it goes on to discuss the data acquisition and the techniques chosen to both screen and score the criteria. Chapter Four discusses the results of the study and shows the visual representation of the findings. Lastly, Chapter Five provides a summation to the thesis and discusses future research and scope of the thesis.

Chapter 2 Background and Literature Review

In the past hundred years several different approaches have been used to plan school locations; in 2015, there are still many differing views on how to approach choosing these locations. Each state has its own rules as to what the district or city must do, and what they may do. Each district and city in turn, has their own method of determining where and how they will choose the needed location. In short, there is not a customary method that everyone uses to determine a standard way to choose a suitable school location. Moreover, there likely will never be one method only, due to the differences in the land and cultural values. The notion of walking to school is something that different communities may value.

The idea of pedestrian accessibility is not a novel idea by any means. In the 1950's, when suburban areas were becoming popular, school districts were beginning to build new schools in areas around the subdivisions for students to be able to walk with ease (Schrader 1963). With the growth of the subdivision and more people leaving the city centers, it became harder for a school that serviced many subdivisions to be placed within walking distance for all of them. In the early 1970's, districts were forced to begin bussing more and more students to school and it became essential to more rural areas. More than that, districts did not have the money to build new buildings to keep up with the rising growth of the subdivisions that were being built (Schrader 1963). Site suitability location for schools has a history based on this need to be able to plan for the current level of population and the future level. By no means is this an easy task or exact science, but today Geographic Information Systems (GIS) help to sort through the data and make the best educated guesses available.

GIS has been a useful tool for school districts and planners when selecting suitable sites for new schools. Although the needs of the districts may vary, the goals are generally similar.

School districts and planners attempt to find the perfect site for a new school that will both fit the needs of the school and the budget of the district. GIS is a tool that allows the districts and planners to utilize data to help optimize this idea.

Previous studies provide a base knowledge of what goes into choosing a suitable location for a new school. This chapter will explore three different avenues to dealing with what goes into choosing a location for a new school. The three avenues to be explored are criteria selected, methodology used, and goals and outcomes of past school site suitability analyses. The information provided helps to create understanding for why pedestrian accessibility is an important need in school site selection.

2.1 Previous Criteria Selected for School Locations

As of 2015, there have been many school site suitability analyses completed (Henninger 2004; Kerkow 2014; Svatos n.d.). The criteria used when choosing a location varies based on where you are and who is in charge. For the purpose of this study, “criteria selected” will refer to the scope of what categories will be chosen or have been chosen to determine the suitability of a school site.

The importance of choosing criteria cannot be understated. The choices made in this process likely, affect the entire project for a district. Each of the works discussed in this section focus on different areas of what a district was looking for when determining what criteria to select. This demonstrates that there is a multitude of ways for planners and districts to come to conclusions of what site to choose simply by varying the way in which they begin with their choices.

In South Carolina, the criteria for a school site selection are based on five key criterions. The first of these criterions is land use (Office of School Facilities 2013). Land use is classified in five main categories and then broken into sub-categories (State of North Carolina Center for Geographic Information and Analysis 1994). It describes the human activity on the surface of the earth at that location or how a community uses the land within their boundaries.

The second criterion chosen by the state is zoning. This criterion is chosen by the state so that new development does not interfere with, nor is placed near incompatible existing zones. Zoning can be a major factor in determining what areas will be usable for a school. By determining how an area is zoned one is able to see how close the school will be to residential areas and other undesirable areas like industrial zoning. This gives planners an opportunity to know what types of commercial, residential, or industrial growth might occur in the area in the future. By understanding the zoning of an area planners and districts can consider better options when choosing a site.

Slope is the third criterion. The state uses this to make sure that the slope in which the school will be placed is not too far off level. They have a maximum slope acceptability of ten degrees where the school will be placed (Office of School Facilities 2013). However, a parcel may exceed the slope limit if more than half of the parcel is less than ten degrees and there is an abrupt drop of no more than 30 meters that returns to a plane that is less than ten degrees for the remaining land in the parcel.

The fourth criterion is traffic. The state uses the level of traffic as a guide of where not to put a school. The goal of the state is to avoid unnecessary safety hazards, and putting a school near a major road or intersection is often avoided if possible. The environment surrounding the school or the route to the school should not only be safe, but also conducive to learning

(Schrader 1963). Therefore, high-level traffic areas are a less attractive route than crossing a park, neighborhood, or library.

The last criterion used by the state of South Carolina is that of pedestrian accessibility. The idea of pedestrian accessibility as defined by the state is, “A designated safe path between the adjacent roads, school drives, parking areas and the school building” (Office of School Facilities 2013, 3-2). For the purposes of this study, however, pedestrian accessibility will not only include the immediate environment of the school building itself, but the 1.5 mile distance that has been determined by the district as the maximum feasible walking distance to and from a school (Greenville County Schools 2015).

These five criteria make up the state’s base school planning for a suitable site. An example of different criteria selected comes from a suitability analysis of Brisbane, Australia (Kerkow 2014). For this study, three main criteria were selected from Kerkow (2014), including population density of the area, distance from existing schools, and distance from main roads. This study focused on putting schools into neighborhoods with more population density and off the main road to reduce noise pollution and make sure there was easy access to the schools. Kerkow’s study wanted to find a way to get students into new schools, but he wanted to make sure that the schools were located centrally to population density. Therefore, the main criterion in this study was that of population density and he sacrificed possible useful site locations that were not within the framework of his population density needs. This study placed more emphasis on being in the centroid of a densely populated area rather than allotting for some sites that fit the other needs, but were slightly out of the population dense area.

Another example of a variation of criteria comes from a study done in Delaware (Svatos n.d.). In this study Svatos uses current school sites, property parcels, land use, sewer sheds, digital orthophotos, surrogate student locations, and environmental constraints such as; floodplains, water resource protection areas, and steep slopes. He then went further and limited his sites by using network analysis to determine if GIS could be implemented to help select suitable sites for schools in his state. With his initial ideas, Svatos broke down the criteria he selected and made each of them a type of screening criteria. His overarching goal was to find the best locations for schools in the three districts that make up Delaware. Due to the limit of network analysis he describes in his study, he was unable to fully complete the study when he published. He did however, rank the sites based on his screening criteria, but exclaimed that the limited networking analysis tools he had at his disposal did not allow him to determine if network analysis was a viable option for school site selection. Svatos's report lends itself to the base for which this study begins.

Both of these examples have their merits and there is reason behind what criteria were selected. The question is, what are the best criteria to choose? This is hard to answer, because so many different opinions exist. Deciding which criteria to choose is just as important as deciding which site to choose. If an important criterion is left out of the planning phase it may be impossible for the school district to reverse any problems that arrive from that missing criterion. For instance, if a river ran through the property and the district did not account for that river other than for its aesthetics and built the school, then it would be due to not accounting for that criterion in the beginning. Ten years later when the school needs to expand, they would not be able to expand, due to the river; something that could have been avoided had the criterion been analyzed in greater detail.

In Greenville, SC, pedestrian accessibility is arguably a missing criterion. As stated previously, only 20% of the elementary schools in the district are safe to walk to (Bike Walk

Greenville 2013). The other 80% are lacking sidewalks or are located too far from the students that attend them (Bike Walk Greenville 2013). This is why this study focuses around pedestrian accessibility when determining a suitable site location.

2.1.1. GIS Methods Used and School Locations

In many of the studies reviewed (Henninger 2004; Kerkow 2014; Schrader 1963), the approach is very similar. Most studies started with the parcel data and open available lots. Then, they selected the criteria that would be used to conduct their site suitability analysis. Running each criterion through and determining what locations were suitable followed the criteria selection. Lastly, the results were tallied and the best sites were chosen for the site selection of the schools.

Many of the studies and resources looked at approached the method of site selection in this way (California Department of Education 2014; Georgia Department of Education 2012; Henninger 2004; Kerkow 2014; Schrader 1963). However, the study completed in Delaware took a slightly different approach (Svatos n.d.). Svatos's study started fairly similar to the others, but took the site selection one step further. Instead of concerning itself with the cost of the building, it went on to do a network analysis to determine the best location from the sites that would place the school in an area with the most school-aged children.

This SSA will build upon the studies mentioned herein and work with network analysis to determine the pedestrian accessibility of the sites that are being considered for a suitable location. Svatos's methods will be utilized and built upon to help identify suitable locations. The goal is to use this idea to make pedestrian accessibility a useful criterion and help children get to school safer and ready to learn.

One of the most critical aspects lacking in the referenced material above is that of the student's safety and the route's pedestrian accessibility. Although, each of the studies attempts to determine the best location for a new school, they all seem to leave out the importance of walking distance and route safety. For these reasons, this thesis focuses on pedestrian accessibility as a main criterion when determining what site selection would be best.

2.1.2. School Locations and Outcomes for Students

Previous studies and district or state agencies have focused on varying goals or outcomes for how to successfully choose a suitable school site. In many cases districts are concerned with the cost of the land, building materials, infrastructure, the slope grade, and upkeep above all else. The studies that were looked at focused more on what was in the surrounding areas such as, other schools, recreational areas, elevation, roads, population, and environmental constraints (Henninger 2001; Kerkow 2014; Svatos n.d.). None of these approaches took into account the health or educational benefits of pedestrian accessibility.

This study focuses on the outcome of choosing a site that meets both district and student needs. One of the major problems with Greenville schools is that they are not always located where they will serve the most people. In many instances, the final location of schools in the district were determined by cost analysis; however, by doing this they have made many schools unable to be walked to and from (Bike Walk Greenville 2013). As a result, they have effectively lowered the initial cost of the school, but have increased the overhead costs of transportation for the foreseeable future.

According to a study done in 2012, one of the goals of having students walk to school is not just to be more healthy or safe. The study showed that students that walked or rode a bike to school were able to concentrate better in school, which translated into higher test scores (Vinther

2012). The goals of a district, state, or society at large, should not be to just keep the cost down, but rather to make the environment in which our children learn the best that it can be. This ideology includes how the students get to the school as well. If pedestrian accessibility can have an impact on their education, concentration, and health, then it should be considered a major goal of where to plan a school location.

Chapter 3 Methodology

This study was conducted to discuss an overarching main question: Where are the most suitable locations to place elementary, middle, or high schools in Greenville, South Carolina based on pedestrian accessibility? This chapter explores this question in detail and explains the methods and data used to determine the optimal locations for placing these new schools. This chapter also examines secondary questions that arise as well. For instance, based on pedestrian accessibility, which of the school sites selected for optimal location are best for students to walk to on a daily basis? Once the sites selected for their location and pedestrian accessibility are determined the next question arises; what are the top five locations based on cost for the district? The last of the three secondary questions is, what schools currently have the best and worst site suitability for pedestrian accessibility? Together these three secondary questions and the main goal of this study illuminate the research questions and design for this project. A synopsis of how this chapter reads begins with the research design. Moving on, the next section of the chapter accounts for the data sources. Then, the procedures and analyses done on the study are detailed to illuminate the route to completion.

3.1 Research Design

This study is based on the state of South Carolina and the county of Greenville's policies for finding suitable sites for school locations. Beyond that, multiple case studies have contributed to the design of this project. Among those studies are the site suitability studies of (Henninger 2004) (Kerkow 2014) and (Svatos n.d.). These three analyses each contributed to the ideas and structure of this report. Each one added a measure of criterion from which the final criteria were chosen. By using each of these as base models and contributing the South Carolina and

Greenville County policies, the final criteria could be selected to determine the optimal site suitability for the schools. Figure 3 depicts the methods and workflow of this study, which is detailed in 3.3 Procedures and Analysis section.

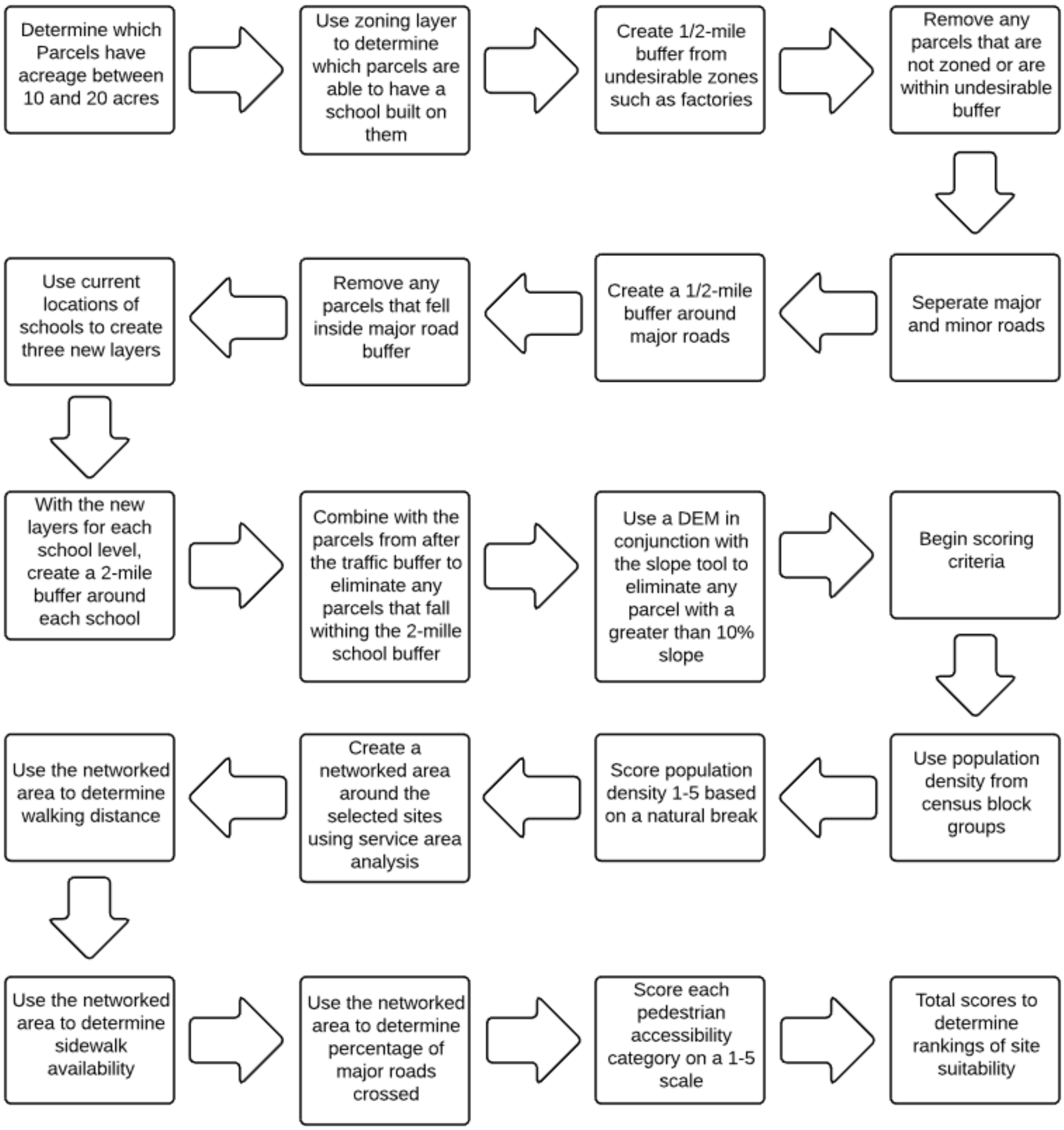

Figure 3 Flow Chart of Methods and Procedures Used for Study

3.1.1. Equipment Used in Study

The entirety of this study was conducted using ArcGIS software via ArcMap. More specifically the toolsets used for this project consisted of buffer, intersect, erase, selection by location, selection by attributes, union, merge, slope tools, and network analysis. These techniques were chosen to provide the most optimal outcome for this site suitability analysis. The county of Greenville offers their data in an online GIS format for people who are not accustomed to using ArcGIS. They may then find and use the data more easily. For this study, ArcGIS was chosen for the ability to do more and to avoid constrictions of what is allowed in the online version. More importantly, being able to manipulate the data was useful and allowed for more understanding of the information.

3.1.2. Major Variables of Research Design

This study is broken down into seven criteria that utilize the case studies, along with South Carolina and Greenville County policies. These criteria are then broken down into subsections, the first being screening criteria and the second being scoring criteria. The screening criteria are used to reduce the initial number of sites for school locations, to be further analyzed for site suitability using the scoring criteria.

3.1.2.1. Screening Criteria

Screening criteria consists of five major variables. These variables are parcel size, zoning, slope, traffic, and current school locations. The purpose of the screening criteria is to determine the physical, zoning, and traffic needs of suitable locations. Each of these criteria will contribute to reducing the number of possible site locations prior to the final scoring phase.

As the first criterion, parcel data was used to determine which parcels fit the acreage needs of the school. The ideal acreage for a South Carolina school falls between 10 and 20 acres. This screening data was used to eliminate parcels that did not fall within the desired range. Parcels that were under the allotted acreage were not considered in this study, even if they could be combined with another parcel to create an appropriate parcel size.

Zoning data was the second criterion chosen to help limit the number of parcels used in site selection. In this study the zoning criterion will handle both the zoning and land use mandates by the state. Ideal zones were those that could be used for school locations and were not near industrial sites. Zones chosen for inclusion in the study were neighborhood commercial zones, flexible review zones, planned development zones, residential zones, and un-zoned parcels. These zones were selected because each of them is capable of having a school placed within the area.

Slope was then used to determine what parcels fit the slope needs mandated by the state of South Carolina. The state requires that for a parcel to be used as the site of a school, the given parcel must not exceed a 10% grade throughout the extent of the area. The exception to this rule is that a parcel may exceed the slope limit if more than half of the parcel is less than ten degrees and there is an abrupt drop of no more than 30 meters that returns to a plane that is less than ten degrees for the remaining land in the parcel. Slope is a required criterion of the state for not only building purposes, but also future expansion plans.

The next criterion used was traffic. Traffic consists of major and minor roads throughout the county. This criterion is used to satisfy the mandate of the state. Major roads are made up of interstates, major arterial freeways/expressways, major arterial roads, and major collector roads. The minor roads are made up of minor arterial roads, minor collector roads, and local roads.

Private roads were not considered for the purpose of this study. The purpose of using traffic as a criterion was to eliminate parcels that were within half a mile of a major road.

The fifth criterion used was current school locations. The purpose of this criterion was to eliminate parcels within a two-mile buffer zone of the current school locations. The elimination of these parcels ensures that schools will not overlap the population of students that they serve.

3.1.2.2. Scoring Criteria

Scoring criteria consisted of two major variables, population and pedestrian accessibility. The purpose of the criteria is to determine which sites, among those selected from the screening criteria, would be the ideal location for a school. These two criteria were used to score the available parcels in descending order based on the sites optimal location and cost efficiency.

Population was the first scoring criterion used to determine suitable site locations. The purpose of using population was to find the areas that have the largest population density of people under the age of 18. This in turn helped to determine which areas were the most in need of a new school. It also established what areas would be best suited for a school within walking distance.

Most importantly, pedestrian accessibility was used. The aim of the pedestrian accessibility criterion was to determine which sites are the safest and most walk-able for students. The goal of this site suitability analysis was to determine the best site location that would allow for students to walk or bike to school. In South Carolina, walking and biking both take place on sidewalks. Therefore, it was of the utmost importance that sites were scored and ranked based on how safe paths leading to possible school locations are. This scoring criterion is also the last mandated criterion of the state.

3.2 Data Requirements and Data Sources

Without strong data, any site suitability analysis is bound to fail. Therefore, when beginning this venture the data needed was going to have to be strong and accurate. Originally it was very difficult to get the proper data, as there is generally a fee for the data this project called for. However, the Greenville County GIS Department was very helpful and distributed the data needed for the study at no cost.

3.2.1. Data Quality Requirements

The key to this project is to maintain as much accuracy as possible given the data at hand. That being said, one of the hardest challenges for quality came in the form of the digital elevation model (DEM) for the county. The best DEM that was available was a 30m DEM and that came in separate chunks of the county, which needed to be inserted together. A 30m DEM is great for a general idea of the land and the ebbs and flows of the crests and valleys. This was perfect for use with the Slope tool in ArcMap to show the slope of the county. To allow for greater detail and precision of size of a slopes fall a data layer from the Greenville County GIS Department was used which showed 4' topographic contour lines. These two tools together allowed for greater precision when determining slope of the parcels.

Another issue with data quality arose in the original data finding portion of the project when the only parcel layers available for no cost were incomplete and did not cover the majority of the county. Importantly, the vector data received from the Greenville County GIS Department contained a complete and up to date parcel layer with all of the data needed to complete the project.

The biggest part of this project was based around pedestrian accessibility. In the end, the most significant hurdle to overcome was the lack of sidewalk data for the road systems. To help determine which roads had sidewalks and which did not, aerial imagery was used to look at the most up to date photos of the roads. In conjunction with the imagery, the road classifications were used to help determine how safe a road may be.

For the overall quality requirements of the project, the data used in this study either met or exceeded the minimum quality needed to complete the project. The data gives enough information that demonstrates the site locations chosen in the project are placed appropriately.

3.2.2. Data Sources

The majority of the source data for this project came from the Greenville County GIS Department. The vector data obtained from them helped to fill in gaps in the data quality and allowed for a more cohesive data set. The data acquired for this project was built around the need for accuracy and to fulfill the goals of the research design. To fill in the blanks of what was not located in the data from the county, data available online were used. Data in the form of shapefiles, tables, and aerial imagery were used. US Census, Geo Community, and Google Earth were among the data sources used for this project.

3.2.2.1. Parcel Data

For the parcel layer, vector data was obtained from the Greenville County GIS Department. This data is rich with information about parcel size, cost, land use, city, zoning, and other important material. Each parcel has a unique FID and in total, there are 206,326 parcels in Greenville County. This data was easily useable to match the needs of the research design of the study. By being able to identify the different parcels it allowed for a starting point in the screening process. The only limitation found for this data is the ability to be able to combine parcels to meet the ten-acre minimum for a school zone.

3.2.2.2. Zoning Data

An important criterion in this project was zoning data. This data was obtained from the Greenville County GIS Department as well. This data holds the information about what parcels are able to hold a school on them when it comes to zoning. Furthermore, it illuminates which areas are zoned where schools should not be placed close by. For instance, a school should not be placed within a half-mile of a sewage treatment plant or a factory. This data shows which parcels are zoned for industrial, commercial, residential, and governmental use. It further breaks the information into zoning classifications. These data are very useful for this study because it singles out the zones that are allowed to have schools built on them currently while showing what parcels need to be avoided. The biggest limitation for zoning data is the government's ability to change what an area is zoned for in the future. This could have an impact later on for a school, even if everything was planned properly.

3.2.2.3. Slope Data

For use in this study, the slope data was obtained using a raster data DEM, which was downloaded from Geo Community. The DEM was broken into 24 different sections, that when put together, covered the entire county. The data is made up of a 30m DEM, which is useful for determining slopes. In addition to the DEM, vector topographic contour lines were used at 4-foot intervals. These contour lines were obtained from the Greenville County GIS Department. These two data sets are perfect for the data needed for the research design. They allow for slope determination on the parcels, to establish whether or not they meet the state criteria of a ten-degree slope.

3.2.2.4. Traffic Data

Once again, the data used for the traffic criterion was also gathered from the Greenville County GIS Department. This data was made up of vector lines, which lay out the centerlines of each road in the county. The roads were broken into major and minor road segments. The major road segments consisted of highways, interstates, major arterial roads, and major collector roads. The minor roads consisted of minor arterial roads, minor collector roads, and local roads. These data were imperative to the project, as they allowed for an understanding of where the safer roads are located in the scope of pedestrian accessibility. In terms of the research design, these data were instrumental in determining where to place new schools. The biggest limitation with traffic data is that they do not depict if there are sidewalks on the road or not. To counteract this limitation, the study used aerial imagery from the ESRI ArcMap base maps to look at the actual road and determine if there are actual sidewalks in the vicinity.

3.2.2.5. Current School Locations

The current school location data layer was gathered from the Greenville County GIS Department. This layer consisted of vector polygons of the school locations. Although there are only 100 schools in the district of varying levels, there are just over 500 polygons associated with this layer. They depict each building on the school grounds. Many schools in this area are made up of more than one building. The location of the schools was important to the research design because it allowed for proper spacing between school sites.

3.2.2.6. Census Block Data

The final data set was the census block data files. The census block data came from the US Census in the form of shapefiles. Among the information that comes from the census data is population density and population of children under the age of 18. Both of these sets of data were used to help in the scoring criteria of the research design. By determining how many people under the age of 18 are in an area, the study was more accurately able to choose a suitable location that would contribute to pedestrian accessibility. The only limitation for the census data is that it is from 2010 and not completely up to date. As of 2015, there is an estimated increase in population of roughly 42,000 people since 2010.

3.3 Procedures and Analysis

3.3.1. Criteria Based Procedures

The study focused on seven key criteria to determine a suitable site location for a new school in the Greenville County School District. The criteria included parcel size, zoning, traffic, current school locations, slope, population, and pedestrian accessibility. The process began by dividing the analysis into two parts. The first part determined the areas that fit the physical, zoning, and traffic needs, known as the screening criteria. The second focused on the population and pedestrian accessibility needs, which are the scoring criteria.

Building on the ideas laid out in the case study designs, the study began by analyzing all of the sites that meet the criteria for a suitable location based on the criterion selected. Figure 3 illustrates the flow of work and is detailed below. The first step was to determine which parcels met the required acreage for a school in South Carolina. The appropriate size for the parcel must be at least 10 acres, but not more than 20 (Schrader 1963). Furthermore, the parcel should not have any rivers or environmental obstructions.

Using the parcel vector data, a selection by attributes was used to select only those parcels that fall within the acreage goals. A new layer was then created which only contained those chosen parcels. In this one single step, the number of parcels was reduced from 206,326 to 3,766.

The next step in the process was to use the zoning layer to determine which parcels, from the newly selected parcels, allowed for a school to be built in them. By using the intersect tool the study was able to determine that the majority of the parcels remained usable for site selection. The number of parcels that met the zoning requirements reduced the total slightly. However, this was not the only part of the zoning criteria looked at in the study. In addition to being able to just place a school in the zone, part of the criteria was to make sure the zone chosen was not near a factory or other undesirable zone. Therefore, a buffer was used to create a half-mile radius from any undesirable zone.

Following the zoning data was the traffic data. This purpose of the traffic data was to eliminate parcels that were too close to a major road. The first step with the traffic data was to separate the major and minor road segments. Using a selection by attribute to select the major roads and then creating a new layer to work with them sets the stage for the next step. With the major roads now identified, a half-mile buffer was placed around them. Next, the parcel data that was intersected with the zoning data was used to intersect with the buffered main roads. By using the erase tool, all of the parcels that fell within the buffered zone were removed. This output was renamed parcel traffic buffer.

Using a buffer on the traffic data main roads allowed the project to uncover what parcels would be within a half-mile radius of high traffic roads. This served three purposes; the first purpose was to make the only selectable parcels those that were outside of the half-mile buffer zone, to increase walking safety. Secondly, by making a half-mile buffer the district keeps from congesting major roads twice a day during pick-up and drop-off times. Lastly, by reducing the traffic level near the schools, the noise level will also greatly diminish providing a better learning area for the students.

To begin the next step, the locations of the current schools were used from the school location data. In this process, in order to make everything work the way it was designed, the different school levels were divided into three categories. The three categories were Elementary School, Middle School, and High School. Once each new layer was created, a two-mile buffer was placed around each school within its respective layers. This ensured that a site would not be chosen that is too close to another school of the same type. From here the project split into three separate avenues. The study was concerned with finding the best sites for all schools and used the top five sites selected from the screening criteria for each school type to then move to the scoring criteria. Therefore, a total of 15 sites will be presented and scored based on their optimal criteria.

Once the buffers were set around the schools, each layer was then combined with the Parcel Traffic Buffer layer separately to create three new layers. This was done by once again using the erase tool to remove any parcels that fell into the two-mile buffer zones.

The last of the screening criterion used was that of slope. The study used the 30m raster DEM of the county and the 4' topographic contour lines. Then with the help of the slope tool, the areas that had a greater than 10% slope were identified. The topographic contour lines were used to test precision in the event there is a quick drop, but the slope then returns to normal. The slopes identified as less than 10% were used with the school layers to determine which parcels are no longer considered. This was done with the intersect tool.

Once the final screening selections were made, the scoring criteria took over. The first of the scoring criterion was based on population. This uses the data from the US Census block groups to identify the population density of people under the age of 18. In determining where the highest density areas are, the study uses this information to score parcels based on those densities. The scoring system was broken into 5 levels. The highest level being 5 was given to the highest areas of density. Using a natural break to determine where the levels are divided, the other 4 levels were then scored. By using a natural break it allowed for even distribution of the results, giving a score relative to where the other parcels scored. If equal interval was used here it would have skewed the results only slightly as the parcels were already divided fairly evenly. Parcels that found themselves inside of the highest population density areas were given a score of 5; those in the lowest density areas were given a score of 1. This scoring index is illustrated in Table 1 below. These scores were then used in conjunction with the next step of pedestrian accessibility to determine where the most suitable locations were.

Table 1 Population Density Scoring Index

Scoring Rank Given 5=Highest Score	Population Density of Persons Under 18 years Old/Mile^2
5	>100/mile^2
4	76-100/mile^2
3	51-75/mile^2
2	31-50/mile^2
1	<30/mile^2

In the final step of the process, pedestrian accessibility was used to determine the final scores of the suitable sites. The purpose of pedestrian accessibility is to make the walk or bike ride safe and enjoyable for students as well as to maximize the number of students who participate in the walking or biking. By using all of the data compiled to this point, pedestrian accessibility was then used to find the best sites possible. Pedestrian accessibility was scored using network analysis with three separate sections. The first section was based on the accessibility to pedestrians in terms of walking distance in the networked 1.5-mile area from a possible location. The second section was a score based on the percentage of sidewalk availability in the networked area. The last section was based on the percentage of major roads that students would have to cross in the networked area to get to the location.

Using the network analysis of a 1.5-mile area around potential site locations the study was able to determine the average walking distance from the five closest subdivisions where the students would be coming from to attend the new school. The distance was measured using the centroid of the selected site as the origin and the centroid of the subdivisions as destinations using a service area analysis. A subdivision is considered for this study to be a set of homes in close proximity to each other, which share the same road access. This allowed for scoring the average walking distance of pedestrians to a site and scoring that site on a 1-5 scale. The breakdown of this scoring can been seen in Table 2.

Table 2 Accessibility to Pedestrians Scoring Index

Scoring Rank Given 5=Highest Score	Accessibility to Pedestrians in Walking Distance from the 5 Nearest Neighborhoods
5	<0.8 mile average walking distance
4	0.8-1 mile average walking distance
3	1.1-1.3 mile average walking distance
2	1.31-1.5 mile average walking distance
1	>1.5 mile average walking distance

The next section designed to determine a score for sidewalks and safety is based on a percentage of sidewalk coverage in the networked area. Equal interval was used to delineate between the scores in this section because it is based on a percentage of 100% and lends itself to breaking easily into five categories. Using the same-networked area as the section above the use of aerial photography was employed to determine the number of routes along the networked paths that had sidewalks. This information was then assessed against the number of paths that did not contain a sidewalk and a percentage was determined for the number of paths with sidewalks from the total amount of sidewalks. Table 3 displays the scoring index for this section based on a 1-5 point scale.

Table 3 Sidewalk Scoring Index

Scoring Rank Given 5=Highest Score	Percentage of Sidewalk Coverage along the Networked Area Paths
5	>80% of Sidewalk Coverage along the Networked Area Paths
4	61-80% of Sidewalk Coverage along the Networked Area Paths
3	41-60% of Sidewalk Coverage along the Networked Area Paths
2	21-40% of Sidewalk Coverage along the Networked Area Paths
1	<20% of Sidewalk Coverage along the Networked Area Paths

The third section is based on a 1.5-mile route from the proposed site location. For this study a route is considered a path a student may take from a subdivision to the site selection areas along a road. In order to determine if the route passes any major roads, the road layer and remaining parcels were combined into a network. Then the network analysis tool was used to identify if the possible routes pass through or along a major roads. A percentage is used to score the section based on how many major roads are crossed in the area using the possible networked paths. Table 4 displays the scoring index for this section.

Table 4 Major Road Crossing Scoring Index

Scoring Rank Given 5=Highest Score	Percentage of Major Roads Crossed in Networked Area Paths
5	0% of Major Roads Crossed in Networked Area Paths
4	1-10% of Major Roads Crossed in Networked Area Paths
3	11-20% of Major Roads Crossed in Networked Area Paths
2	21-30% of Major Roads Crossed in Networked Area Paths
1	>30% of Major Roads Crossed in Networked Area Paths

3.3.2. Expected Outcomes

The expected outcomes of this study will depend greatly on how many sites remain after the screening process is complete. After the final process of pedestrian accessibility was completed for the sites, the final scores were tallied and are ranked in order based on total score. They are also shown in terms of cost of the parcel to give options to the district. For the purpose of determining the total scores and rankings, cost will be used as a tiebreaker. The cost in this study will be based on the tax market value of the property and by no means is equivalent to exactly what a property may sell for, but represents a cost number for the property based on the current owners tax payment. Once the new site selections have been narrowed down, the pedestrian accessibility can be scored of the current schools of the district to determine the scores of those schools and compare them to the sites that have been proposed.

With these scores, this study is designed to not only have a low number of suitable sites after the screening process, but to be tough on the scoring of each site. Likely, there will be only a handful of sites that meet the needs of both the screening and scoring criteria. However, within this study is the optimistic ideal that there will be at least five strong candidates for each level of school system.

Chapter 4 Results

The process of reducing the number of usable school location sites to find the optimal locations was dependent on the initial screening criteria and the scoring criteria. The initial inspection of the number of parcels available in Greenville County, South Carolina revealed that there were a total of 206,326 parcels. After beginning the initial screening criteria the number dropped to 3,766 when the parcels were selected to range from ten to twenty acres. The number again dropped further as the screening criteria went forward. After finishing the zoning and major roads screening the usable number of sites was down to 1,689. Finally, the last two screening methods, current school locations and slope of the land, were used to dwindle the number of usable locations to 10 elementary school locations, 15 middle school locations, and 21 high school locations.

4.1 Overall Ranking Results

As the overall results of the ranking system were tabulated, the results were similar to the assumptions made when doing on-site investigations of the areas themselves, discussed later in this chapter. The biggest surprise of the final results is the location of the majority of the sites. Based on the analysis, the locations fit mainly into four main city areas, Mauldin, Taylors, Travelers Rest, and Woodruff. From the outset of this study the goal was to determine not only the best location to build schools, but to find the locations that would need them the most. These areas are currently growing rapidly in South Carolina and will be among the first to need the new schools. It would appear that the locations determined suitable would benefit the rising needs of these areas. Table 5 shows the final results of the site rankings for the elementary schools, Table

6 shows the final results of the site rankings for the middle schools, and Table 7 shows the final results of the rankings for the high schools. Each table is ranked in order from highest to lowest score according to the methodology employed in this study. Figure 4 displays the overall ranking scores for elementary schools, Figure 5 displays the overall scores for middle schools, and Figure 6 displays the overall scores for high schools. Each of these figures displays the final results of the total scores for each level of school. In addition, they show where the sites are located within the county and are displayed as graduated symbol maps to depict higher total scores as bigger symbols and by contrast, lower total scores with smaller symbols.

The highest possible total score was 20 and each of the variables was scaled 1-5. The average score for elementary school, middle school, and high school locations were 14.9, 12.26, and 12.85 respectively. The highest score of any of the school locations was 19 while the lowest was 9 and the median of all of the school locations was 13. Figure 7 illustrates a frequency graph of the total rankings for each level combined together. This graph displays the number of times a total score occurred from the sites selected.

Table 5 Final Elementary School Site Suitability Location Scores

Location	Population Density Score	Accessible to Pedestrians	Sidewalk Score	Major Road Crossing	Score Total	Acreage	Cost of Parcel	Overall Parcel Rank
PO Box 17859	5	5	4	4	18	14.54	155,515	1
287 Lakewood Dr	5	4	4	5	18	15	525,220	2
19 Robinson Rd	4	5	2	5	16	16.92	146,190	3
PO Box 17467	4	5	3	3	15	13.37	80,520	4
2510 Locust Hill Rd	5	3	2	5	15	16.98	117,660	5
200 Confederate Cir	4	5	1	5	15	19.87	330,605	6
1909 E Main St	3	5	1	5	14	11.08	128,931	7
421 Dallas Rd	2	3	3	5	13	10.6	94,284	8
427 Wood Rd	3	3	2	5	13	10.54	310,287	9
585 Tanyard Rd	3	3	1	5	12	17.43	475,734	10

Table 6 Final Middle School Site Suitability Location Scores

Location	Population Density Score	Accessible to Pedestrians	Sidewalk Score	Major Road Crossing	Score Total	Acreage	Cost of Parcel	Overall Parcel Rank
4806 Old Spartanburg Rd	5	5	3	4	17	10.39	56,557	1
1201 Parkins Mill Rd	4	5	4	4	17	10.22	104,180	2
400 Roper Mountain Rd	5	5	3	4	17	11.2	204,720	3
PO Box 17467	4	5	3	3	15	13.37	80,520	4
511 meece Bridge Rd	2	5	3	5	15	10.99	232,720	5
5415 Gilboa Rd	3	4	2	5	14	16.61	177,360	6
208 Patrol Club Dr	3	3	2	5	13	15.47	191,485	7
PO Box 25791	4	2	1	4	11	18.81	188,592	8
129 Evelyn Dr	2	2	1	5	10	17.25	160,510	9
130 Jervey Rd	1	3	1	5	10	10	995,830	10
470 Patrol Club Rd	2	1	1	5	9	11.94	152,302	11
147 Jervey Rd	1	2	1	5	9	16.44	259,187	12
123 Jervey Rd	1	2	1	5	9	14.58	603,570	13
PO Box 9147	1	2	1	5	9	16.96	1,072,110	14
145 Jervey Rd	1	2	1	5	9	16.82	1,104,740	15

Table 7 Final High School Site Suitability Location Scores

Location	Population Density Score	Accessible to Pedestrians	Sidewalk Score	Major Road Crossing	Score Total	Acreage	Cost of Parcel	Overall Parcel Rank
PO Box 170248	5	5	5	4	19	13.35	59,030	1
4806 Old Spartanburg Rd	5	5	3	4	17	10.39	56,557	2
PO Box 443	5	4	3	5	17	13.46	57,857	3
400 Roper Mountain Rd	5	5	3	4	17	11.2	204,720	4
388 Old Farrs Bridge Rd	4	4	3	5	16	10	13,884	5
PO Box 5835	4	4	3	5	16	12.75	61,770	6
511 meece Bridge Rd	2	5	3	5	15	10.99	232,720	7
10 Kathryan Cir	3	4	1	5	13	10.81	135,116	8
208 Patrol Club Dr	3	3	2	5	13	15.47	191,485	9
PO Box 16449	3	5	1	4	13	13.7	268,400	10
40 W Broad St STE 500	3	5	1	4	13	10.8	746,060	11
615 Roper Mountain Rd	3	5	1	4	13	10.15	849,920	12
100 Tower Dr Unit 12	2	3	1	5	11	11.88	166,758	13
PO Box 25791	4	2	1	4	11	18.81	188,592	14
1202 Old Grove Rd	2	4	1	4	11	14.01	264,060	15
130 Jervey Rd	1	3	1	5	10	10	995,830	16
470 Patrol Club Rd	2	1	1	5	9	11.94	152,302	17
147 Jervey Rd	1	2	1	5	9	16.44	259,187	18
123 Jervey Rd	1	2	1	5	9	14.58	603,570	19
PO Box 9147	1	2	1	5	9	16.96	1,072,110	20
145 Jervey Rd	1	2	1	5	9	16.82	1,104,740	21

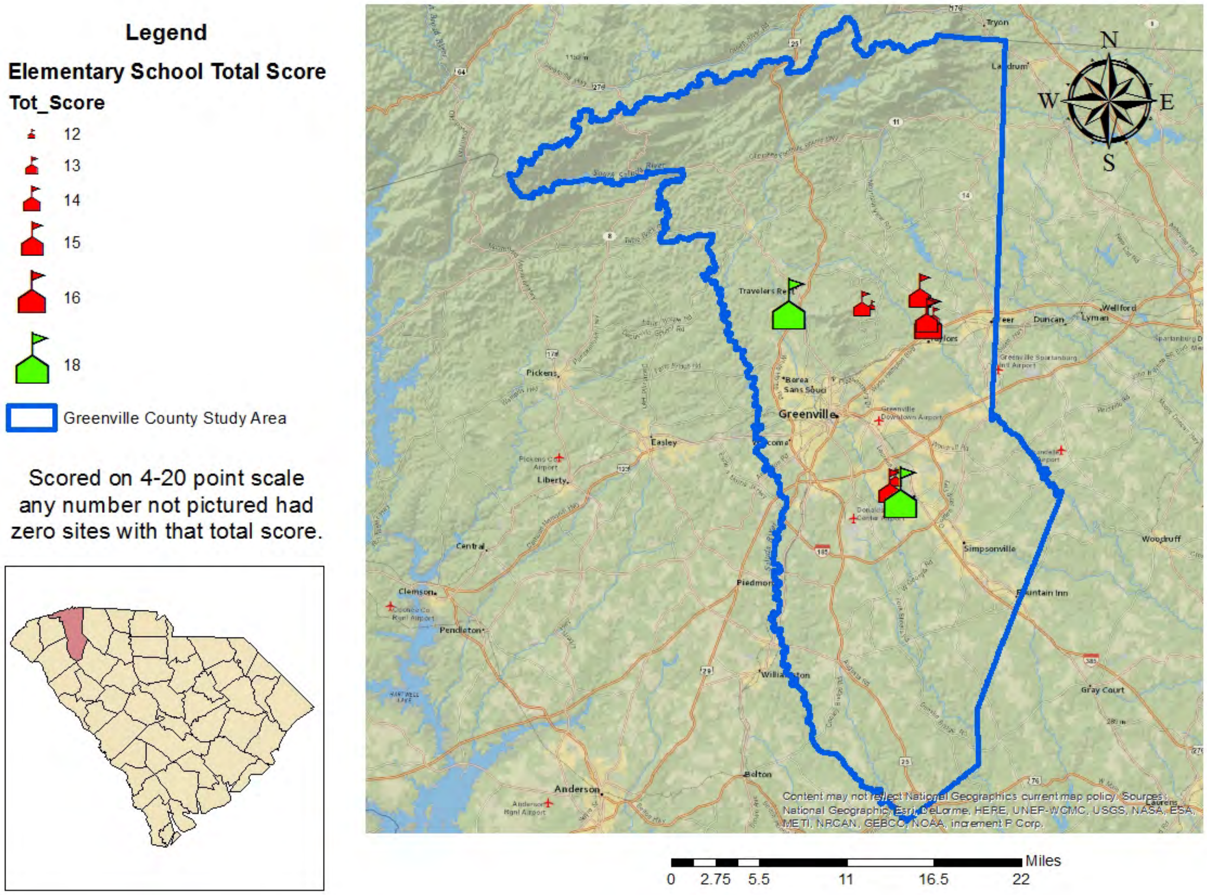

Figure 4 Elementary School Site Suitability Location Total Scores

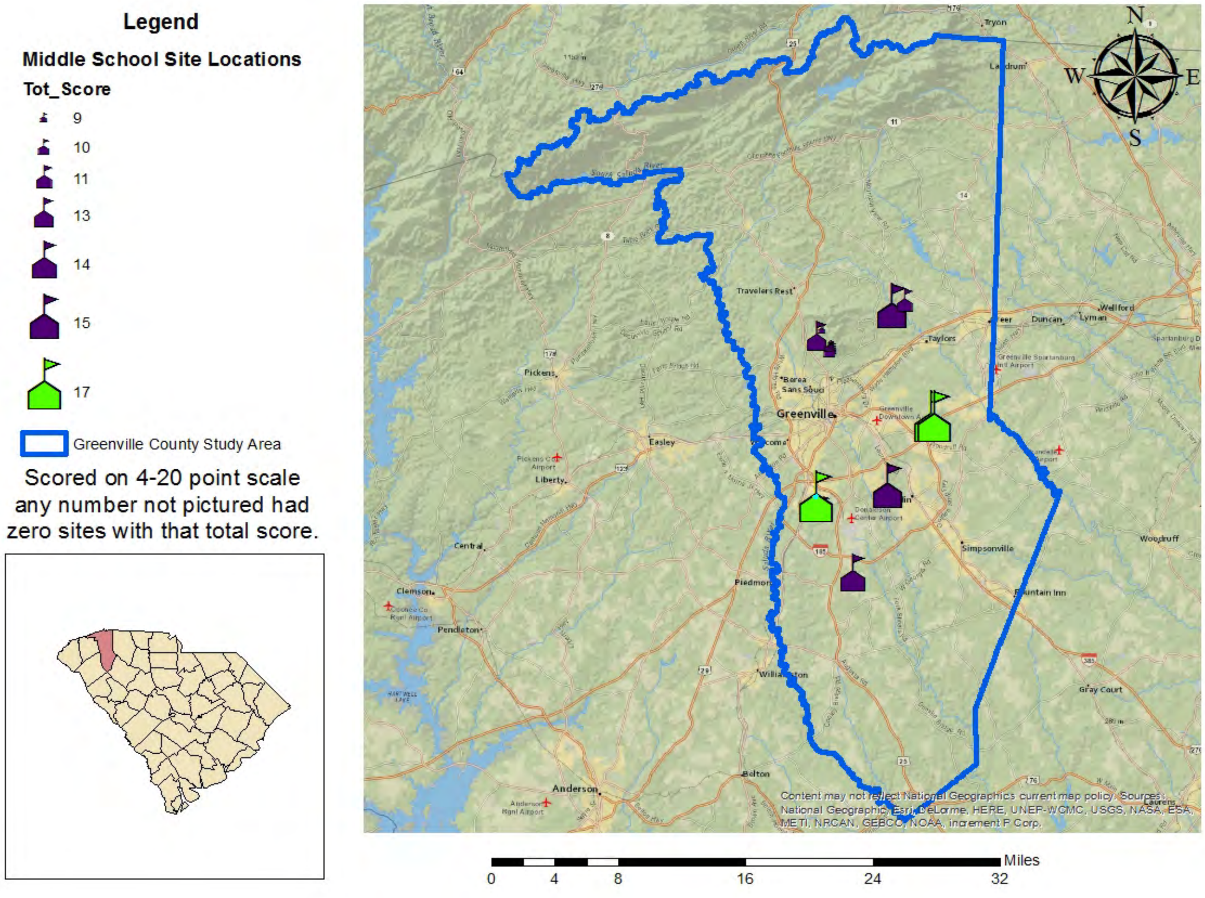

Figure 5 Middle School Site Suitability Location Total Scores

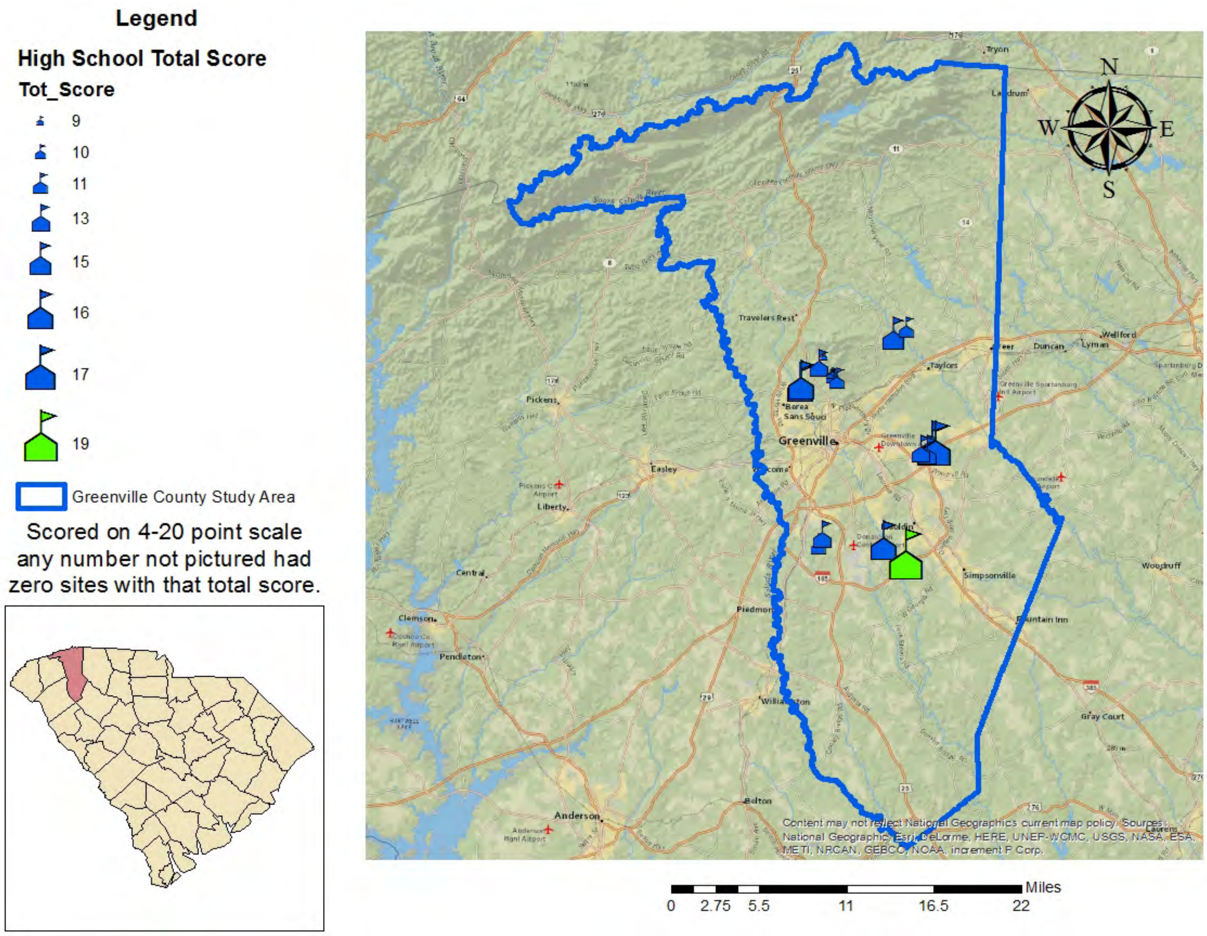

Figure 6 High School Site Suitability Location Total Scores

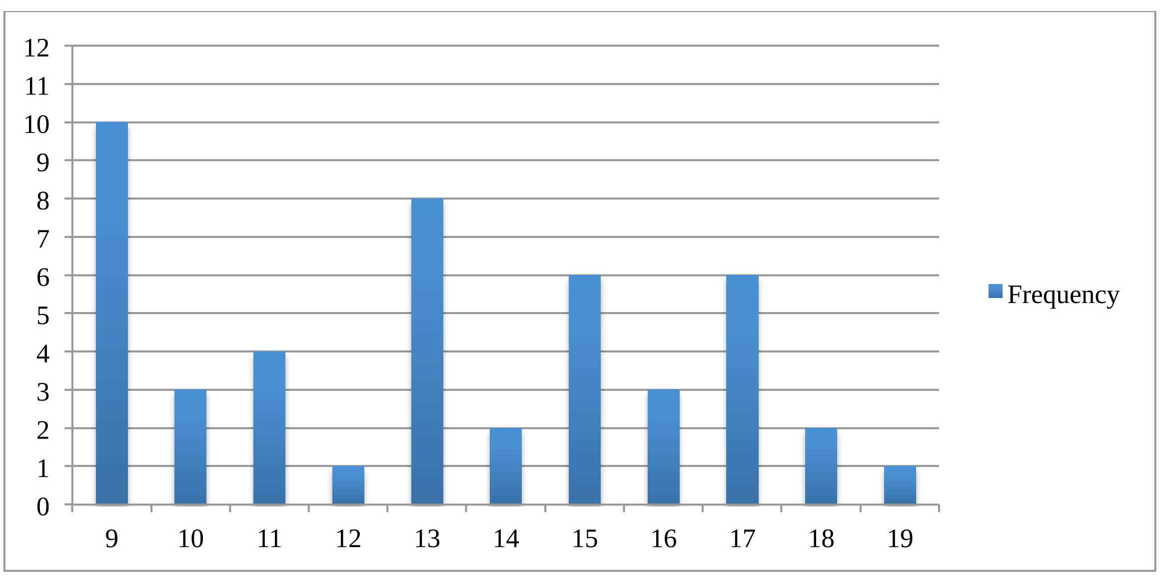

Figure 7 Total Score Ranking Frequency for All Site Suitability Locations

4.2 Variable Ranking Results

This section builds on the previous section to individually break down the results of all of the variables used to determine the final scores in the scoring criteria. Furthermore, it analyzes any commonalities and differences between the locations chosen for each level of school development.

4.2.1. Population Density

As Figure 9 demonstrates, the population density scores for the elementary school locations were pretty evenly distributed between ranks 3,4, and 5 for frequency. The average score for elementary schools was 3.8. What this means is that the sites under selection mainly fall in the higher population dense areas. Figure 8 demonstrates that the clusters of higher (4-5 scores) are located in Mauldin and Taylors, two rapidly growing areas in the County. The three sites that scored a 5 were PO Box 17859, 287 Lakewood Drive, and 2510 Locust Hill Road.

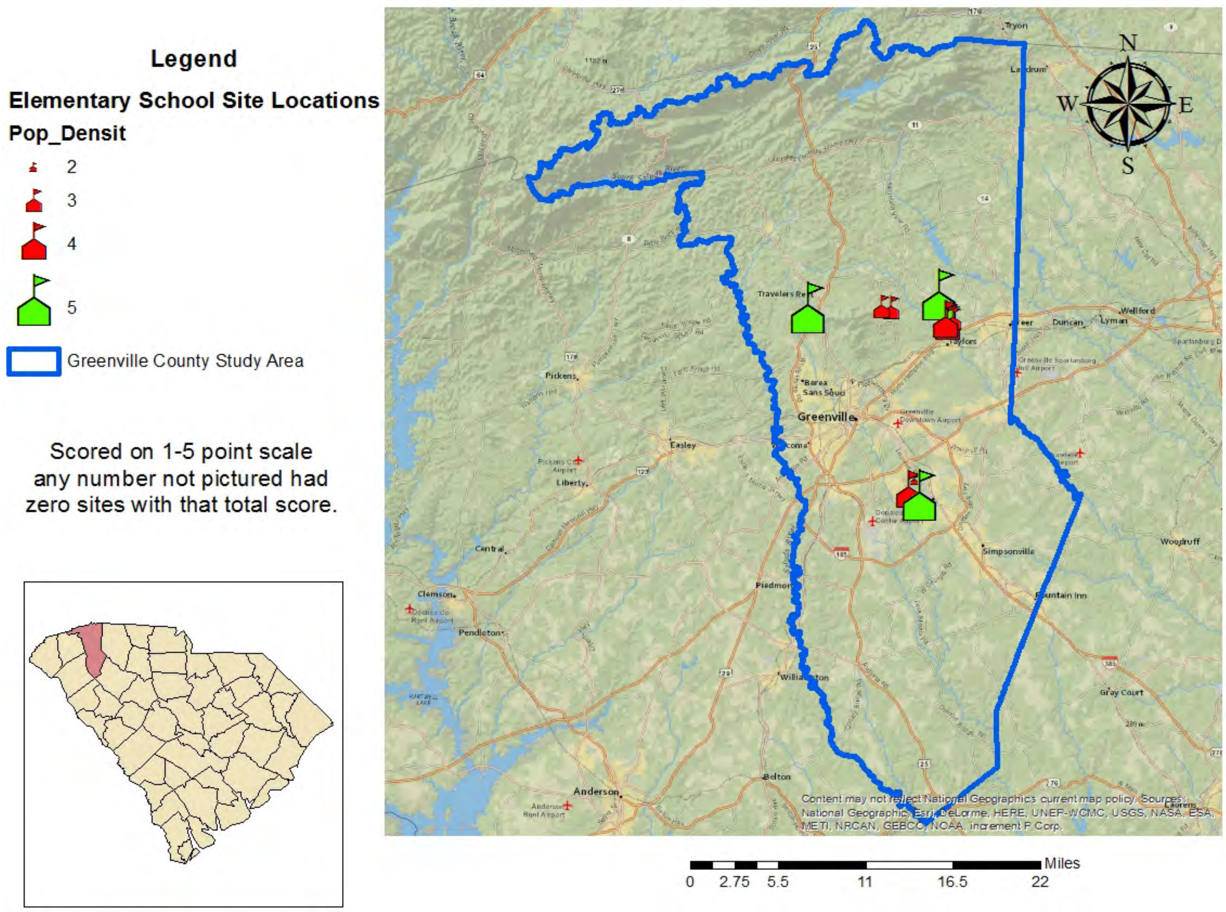

Figure 8 Proportional Map of Population Density Variable Ranking for Elementary Schools

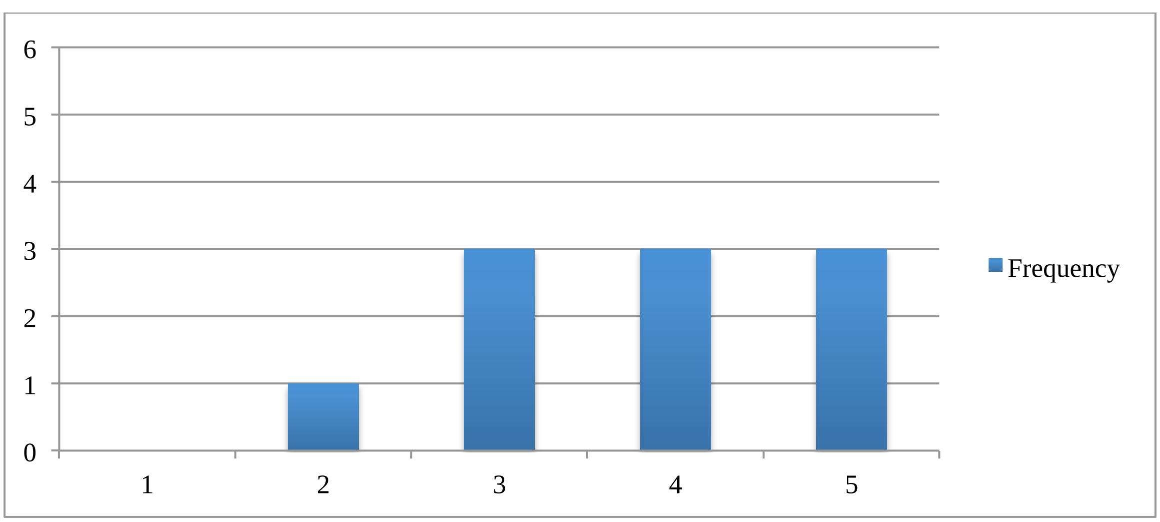

Figure 9 Frequency of Population Density Variable Ranking for Elementary Schools

Figure 10 shows the population density for the middle school locations somewhat more spread out than the elementary locations. As seen in Figure 10, the proportional relationships between the locations and the results illustrate that Mauldin and Taylors score high, but those cities are also joined by the city of Gantt. Figure 11 displays the frequency of the middle school population density variable. The graph shows a spread in the rankings from 1-5 with the average score of 2.6. The only two sites to score a 5 were 4806 Old Spartanburg Road and 400 Roper Mountain Road.

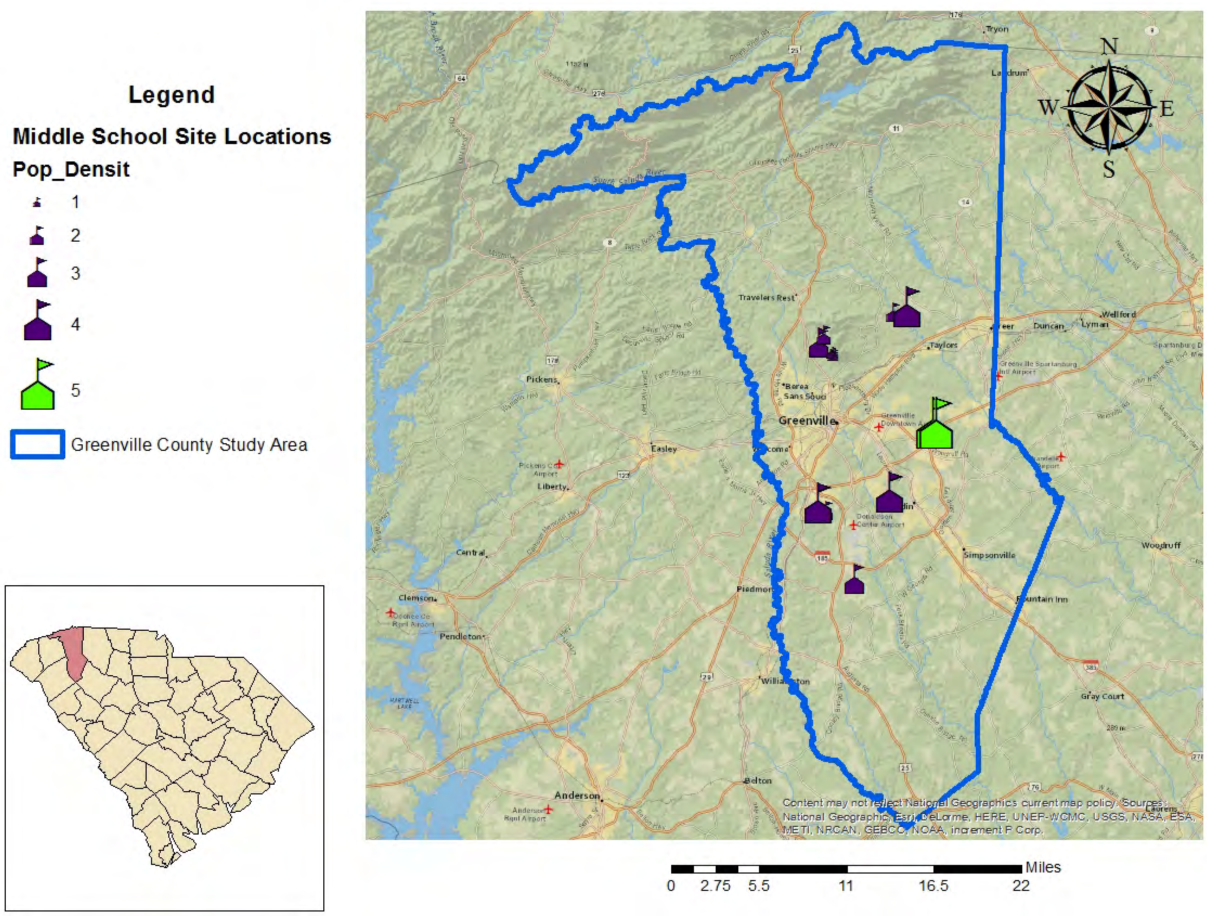

Figure 10 Proportional Map of Population Density Variable Ranking for Middle Schools

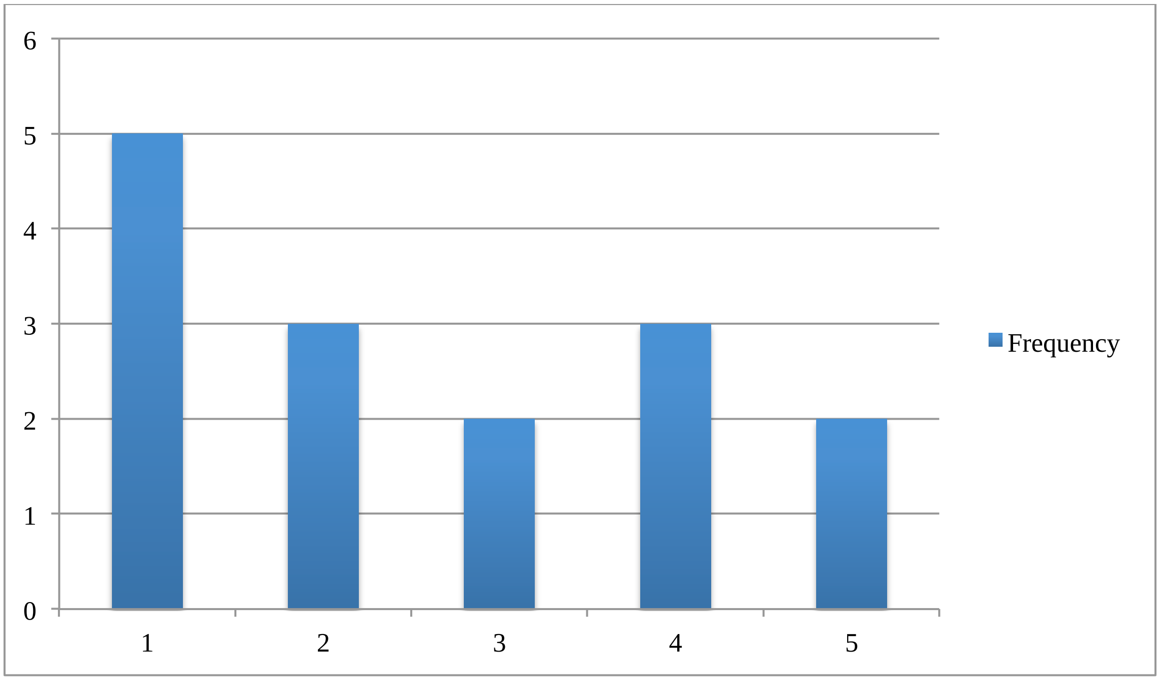

Figure 11 Frequency of Population Density Variable Ranking for Middle Schools

Looking at the results for the high school population density variable, Figure 13 shows that there is a very even distribution in all of the scoring columns and the average score came it at 2.8. Figure 12 demonstrates that both the Mauldin and Taylors' areas are highly represented supporting previous findings of both the elementary and middle school sites. One difference is that with the high school sites the area of Travelers Rest is also high on the scoring ranking. There were four different sites that scored a 5 for the high school selections, PO Box 170248, 4806 Old Spartanburg Road, PO Box 443, and 400 Roper Mountain Road.

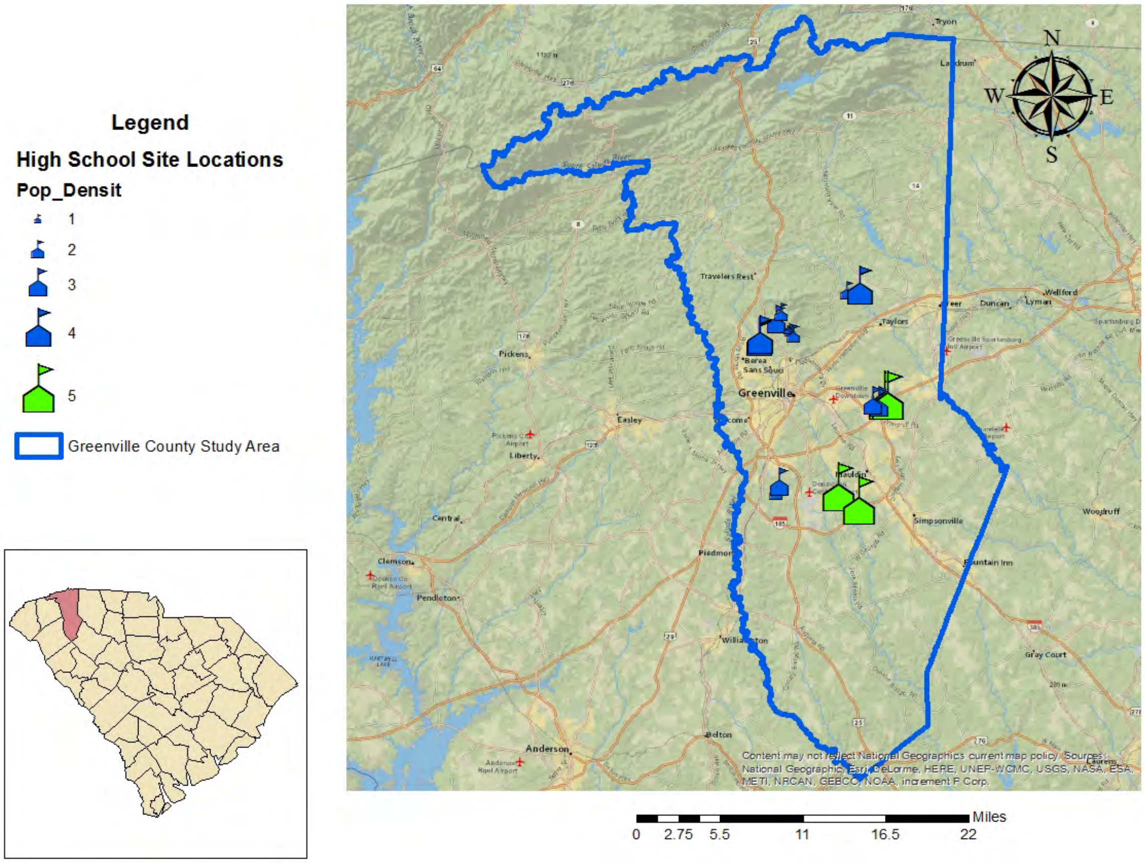

Figure 12 Proportional Map of Population Density Variable Ranking for High Schools

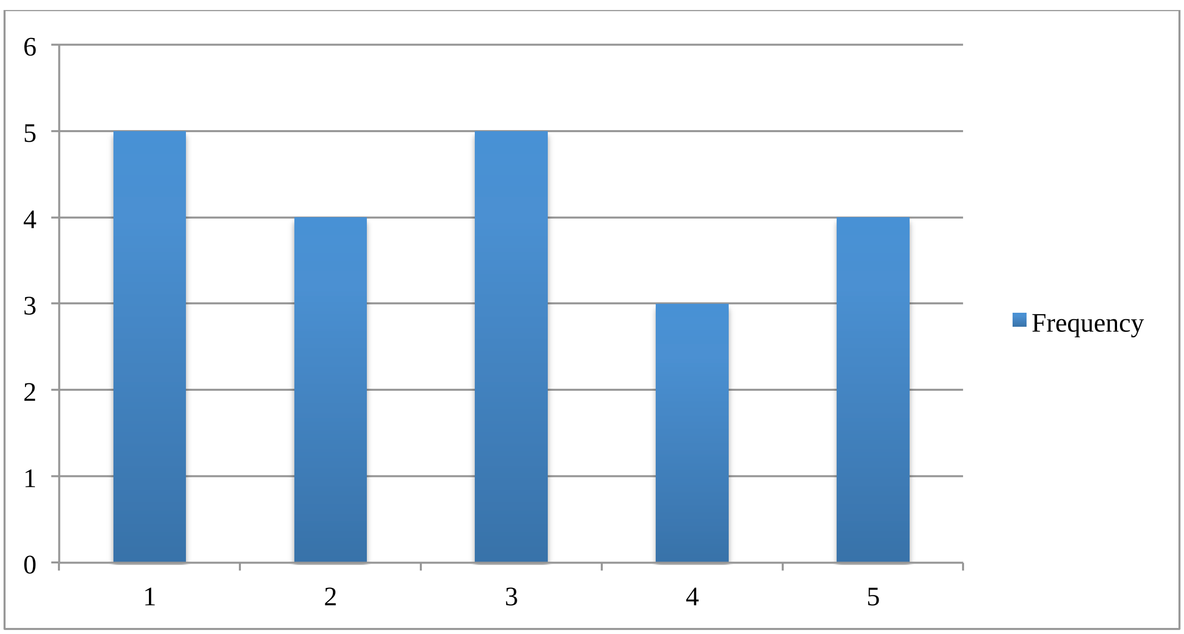

Figure 13 Frequency of Population Density Variable Ranking for High Schools

4.2.2. Accessibility to Pedestrians

Figure 14 shows the accessibility to pedestrian scores for the elementary school sites. Half of the sites received a score of 5; they were PO Box 17859, 19 Robinson Road, PO Box 17467, 200 Confederate Circle, and 1909 E Main Street. This score means that each of these sites network path average walking distance fell below 0.8-miles to the site location. The average score for this variable was 4.1 and the elementary sites did not score any 1's or 2's, which means they all averaged under at least 1.3-miles. Figure 15 depicts the breakdown in the frequency of each score for the variable.

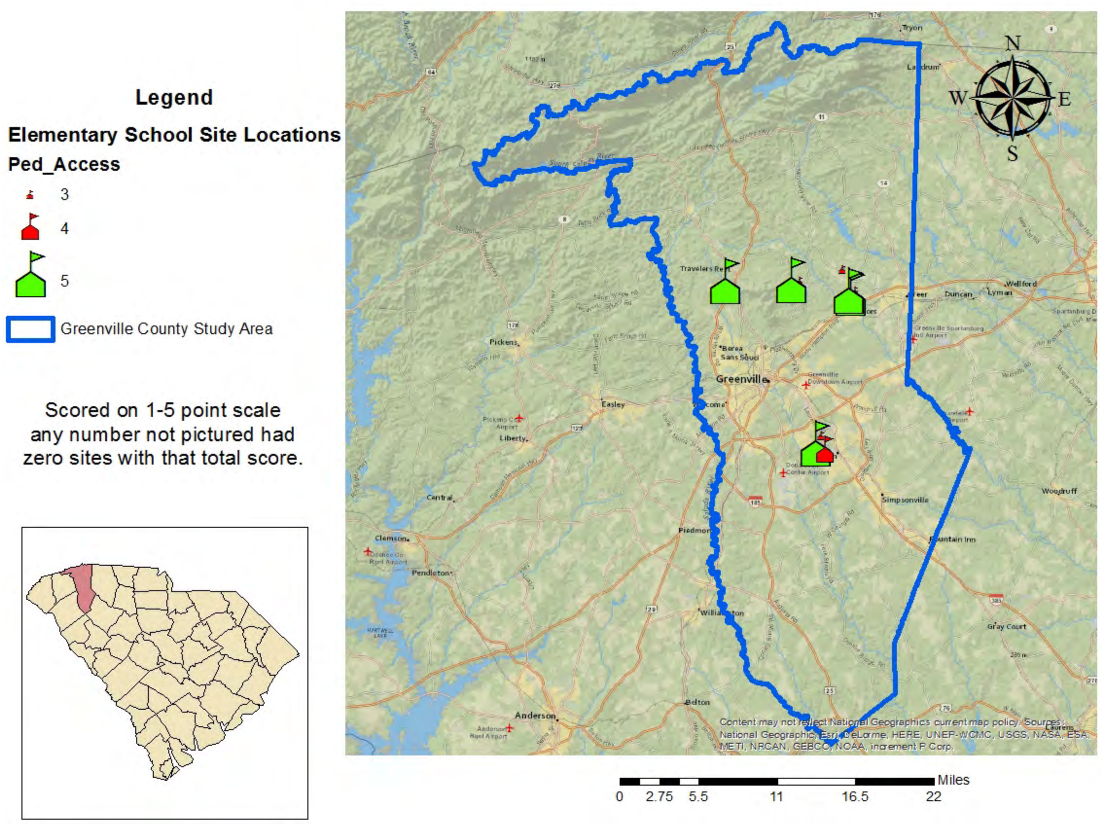

Figure 14 Proportional Map of Accessibility of Pedestrians Variable Ranking for Elementary Schools

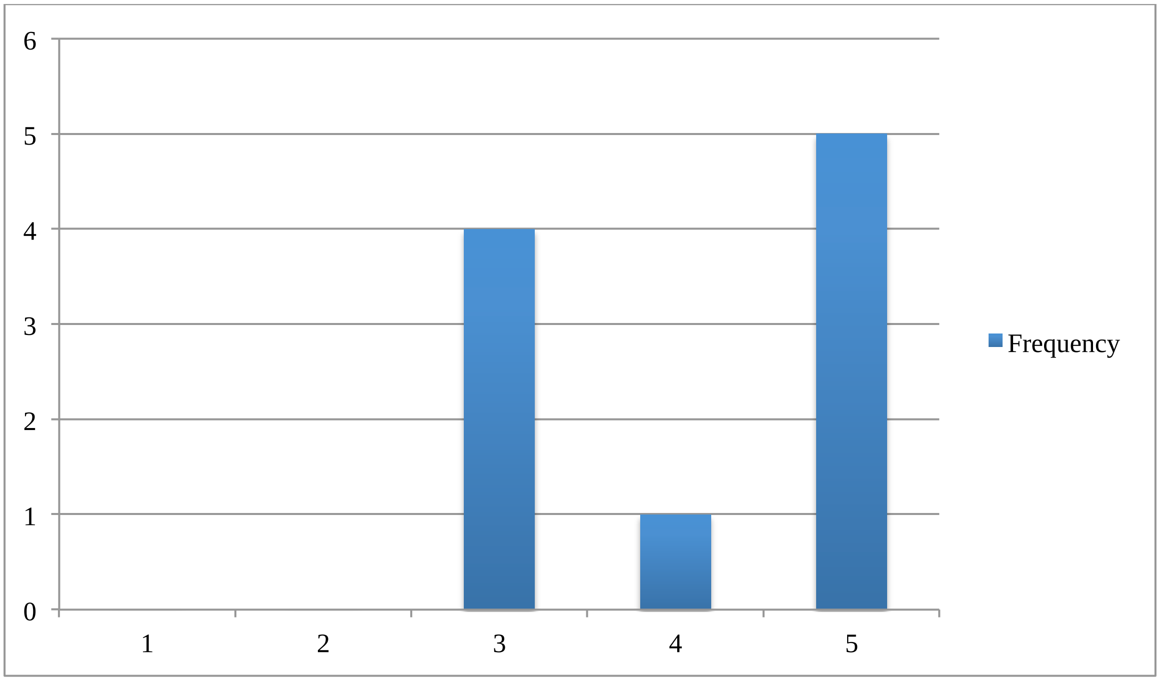

Figure 15 Frequency of Accessibility to Pedestrians Variable Ranking for Elementary Schools

The rankings for the middle school sites were a little lower on the average than that of the elementary sites. The average came in at 3.2 and the scores ran the gambit from 1-5. Figure 17 depicts the frequency of the middle school accessibility scores. Figure 16 shows the proportional map for the scores. The major city areas are all represented well with the exception of the Travelers Rest area. Similar to the elementary results there were five sites that scored a 5; they were 4806 Old Spartanburg Road, 1201 Parkins Mill Road, 400 roper Mountain Road, PO Box 17467, and 511 Meece Bridge Road.

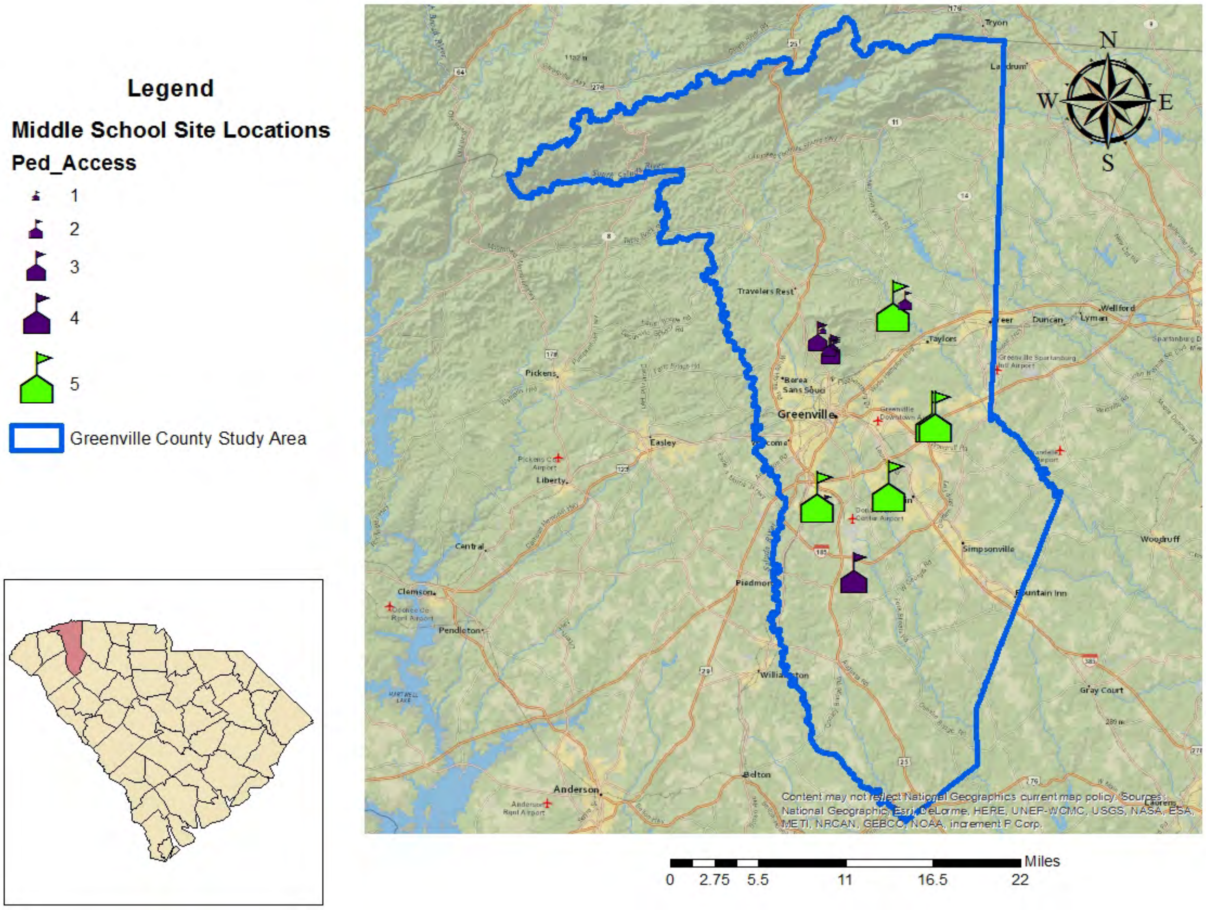

Figure 16 Proportional Map of Accessibility of Pedestrians Variable Ranking for Middle Schools

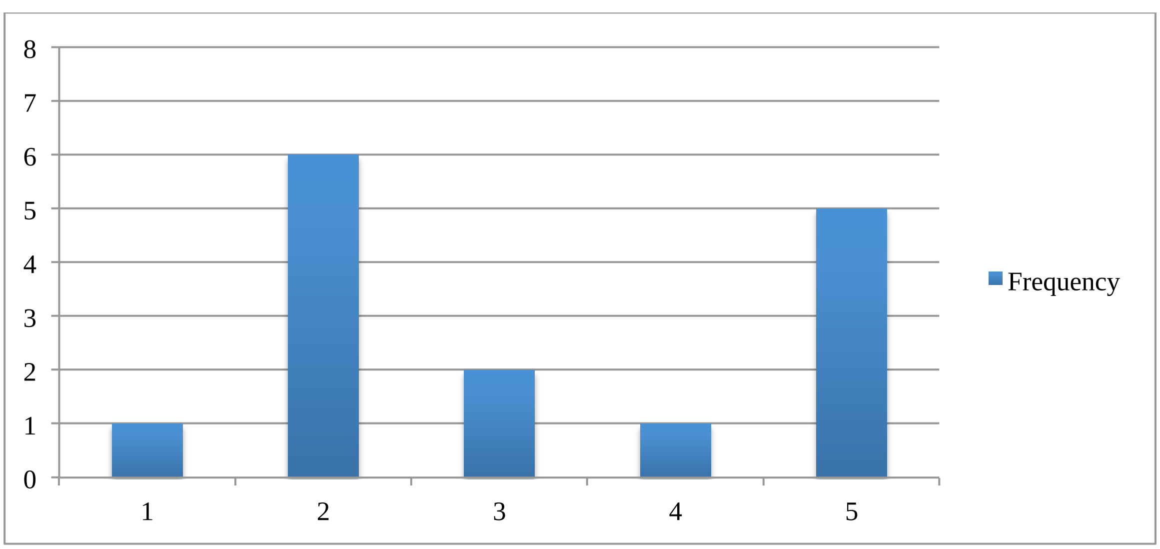

Figure 17 Frequency of Accessibility to Pedestrians Variable Ranking for Middle Schools

The final rankings for accessibility to pedestrians were completed with the high school sites. Figure 19 shows the frequency of the scores and demonstrates that while not as high as the elementary sites the average of 3.6 is greater than the middle school sites in this category. All totaled, seven different sites received a score of 5 on this variable for the high school rankings. Figure 18 shows the total scores for the sites proportionally.

The results for each of the different school levels and their selection sites were expected as the higher populated areas tend to have better accessibility for pedestrians; however, the lower scores of the Travelers Rest area for the most part were somewhat surprising given the growing population in that area. It is unclear why the scores came out this way, but this result could be attributed to the amount of forestation more plentiful in that area.

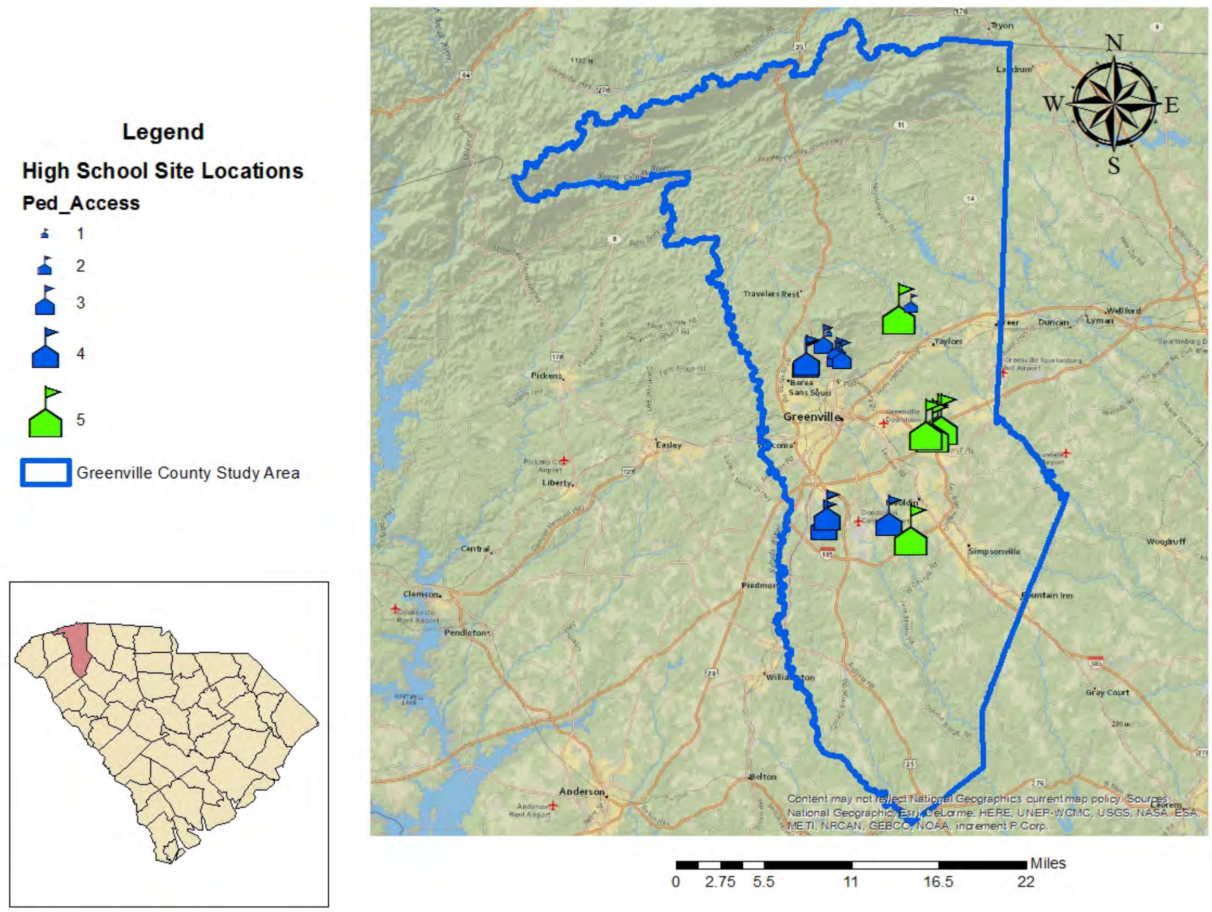

Figure 18 Proportional Map of Accessibility of Pedestrians Variable Ranking for High Schools

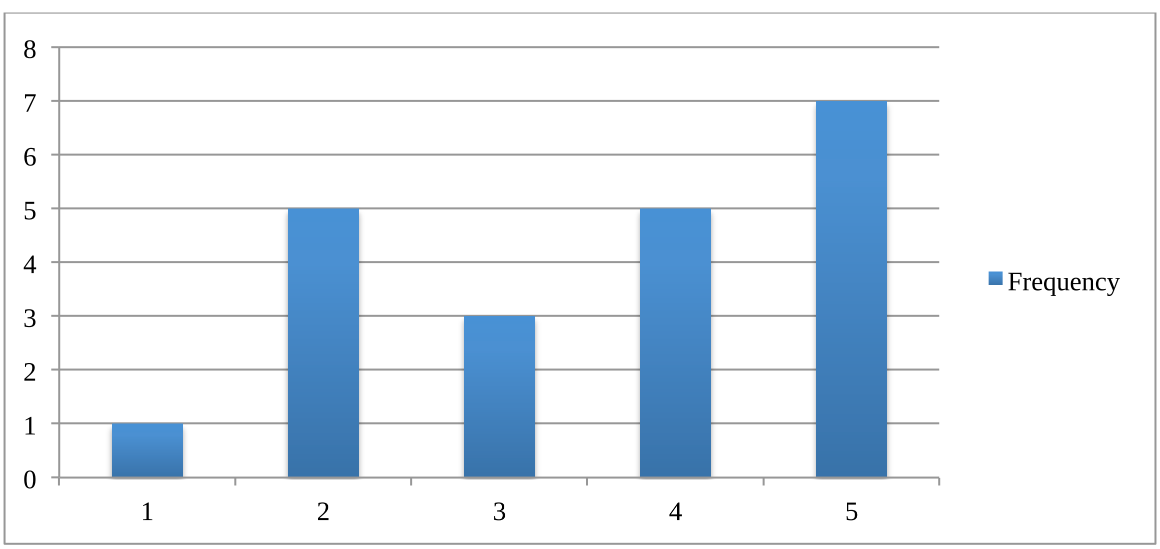

Figure 19 Frequency of Accessibility to Pedestrians Variable Ranking for High Schools

4.2.3. Sidewalk Score

Figure 21 shows the breakdown of rankings based on frequency for the sidewalk score for elementary school sites. No site received a score of 5 in this category and only 2 sites received a 4, PO Box 17859 and 287 Lakewood Drive. The average score for this category was 2.3, which compared to the other categories is the lowest for the elementary school sites. Figure 20 shows the total scores of each of the sites with the two highest coming out of the Mauldin area.

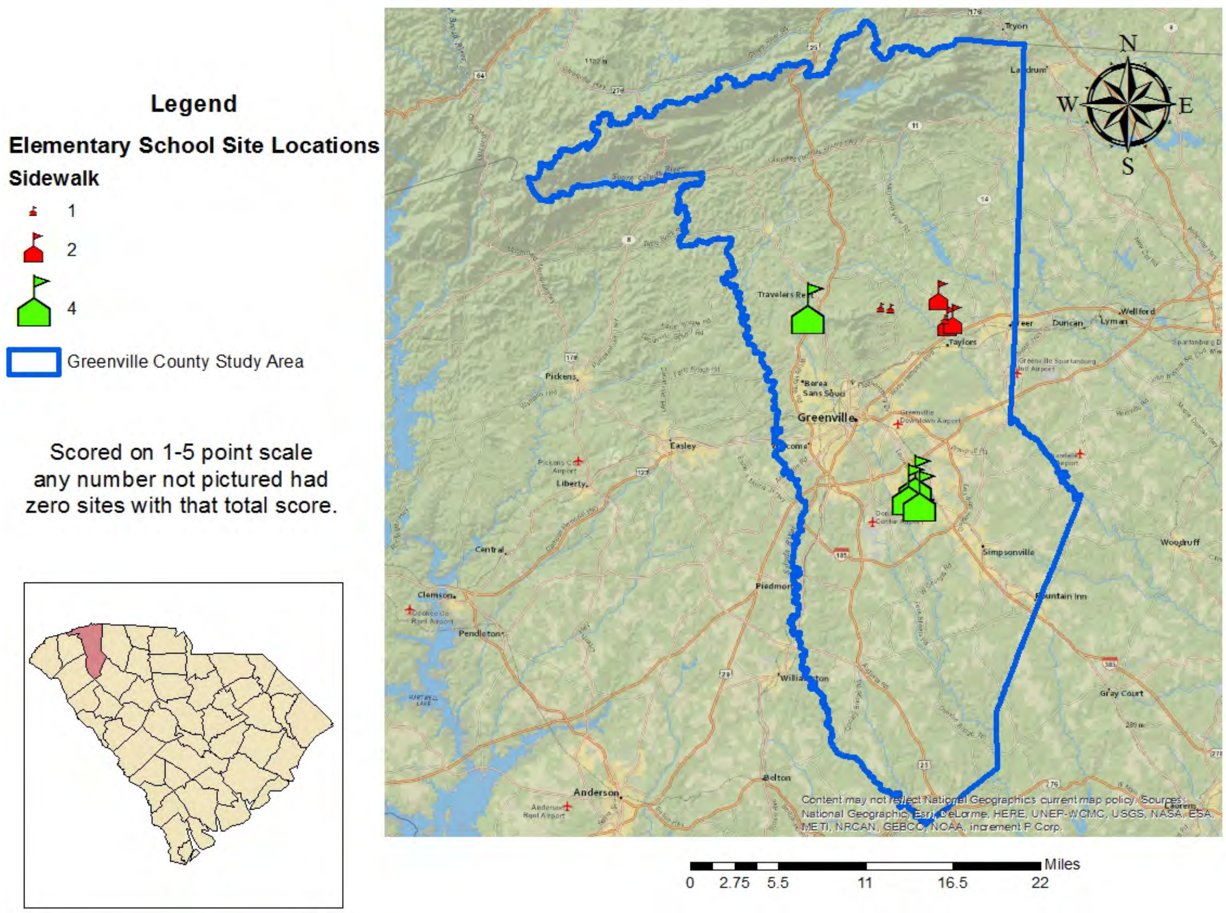

Figure 20 Proportional Map of Sidewalk Score Variable Ranking for Elementary Schools

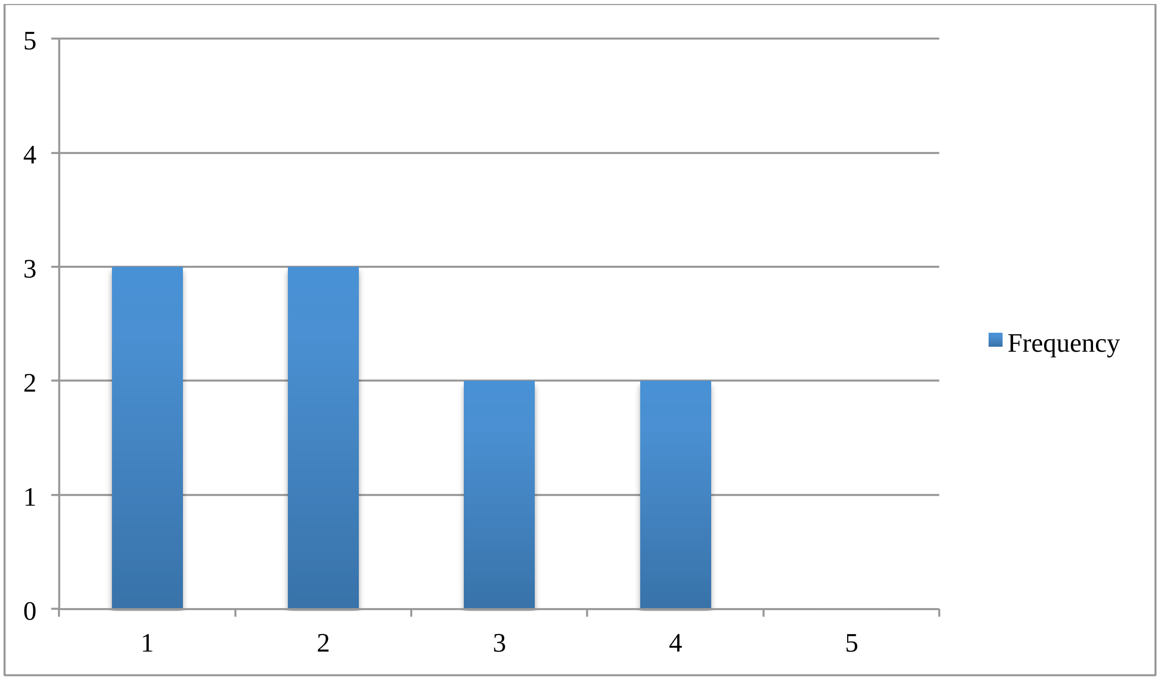

Figure 21 Frequency of Sidewalk Score Variable Ranking for Elementary Schools

For the middle school sidewalk score rankings Figure 23 shows that the overwhelming majority of the sites end up scoring on the low end of the ranking system. The average score for the middle school sites was 1.86, which just like the elementary school sites, is the lowest for the middle school site variables. Not one site received a 5 in this category and only one, 1201 Parkins Mill Road received a score of 4. Eight of the sites received a score of 1 and two more received a 2 making up 75% of the scores given. Figure 22 shows the total scores proportionately with the largest score coming out of the Gantt area.

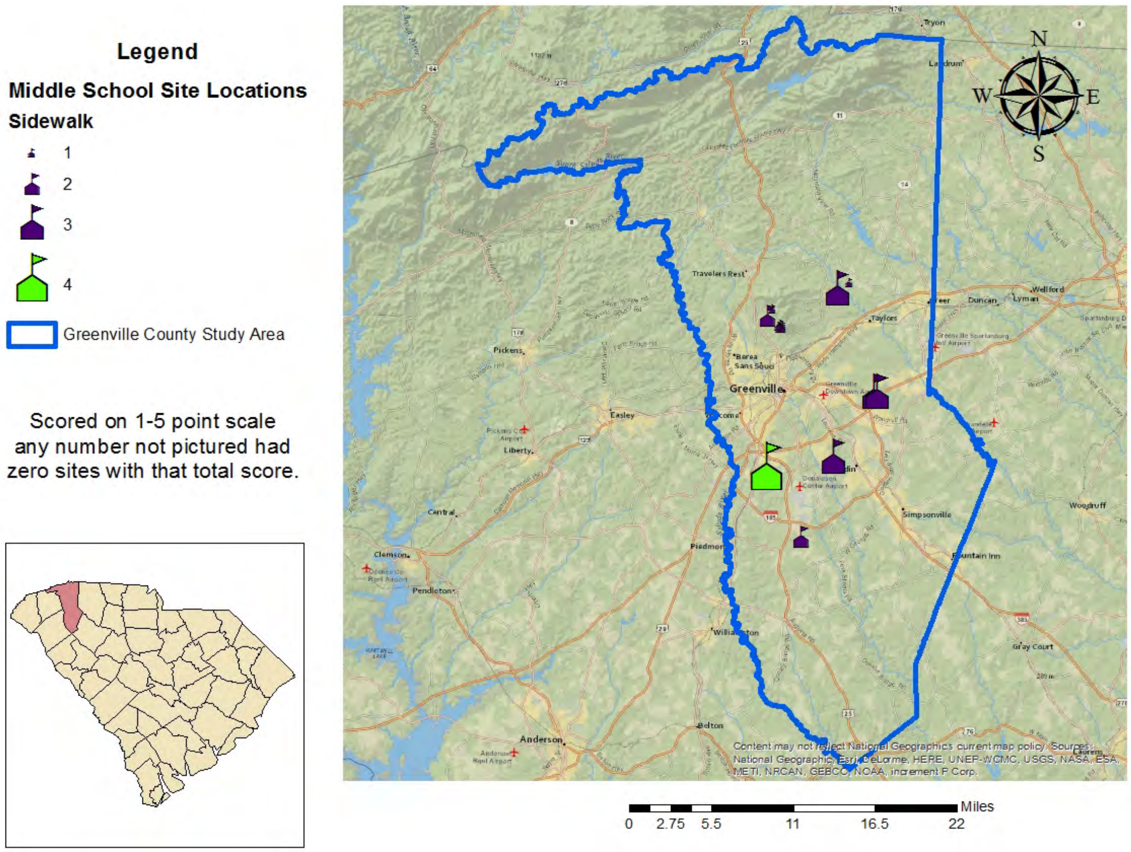

Figure 22 Proportional Map of Sidewalk Score Variable Ranking for Middle Schools

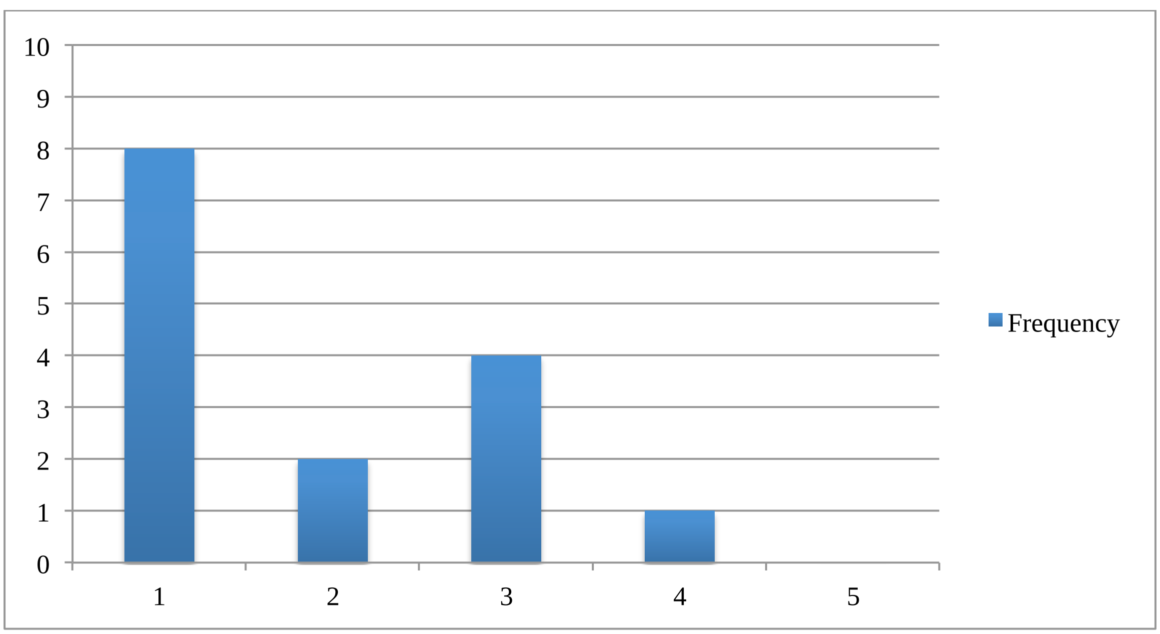

Figure 23 Frequency of Sidewalk Score Variable Ranking for Middle Schools

Turning now to the high school selection sites for sidewalk scores, Figure 25 depicts an alarming majority of the sites scoring a 1 much like the middle school sites. 13 of the 21 sites scored a 1 in this variable of the high school selection sites to help create an average of 1.80; however, unlike the elementary and middle school results the high school sites were the only ones to produce a site with a score of 5, PO Box 170248. That high score as shown in Figure 24 came from the Mauldin area.

The results of the sidewalk score variable, although low, are not unexpected. As stated earlier Greenville County does not have a strong system of sidewalks in place and most areas are either without sidewalks or have very little in the way of sidewalks. The more surprising result was finding a site that scored a 5 in this variable. As stated earlier in this study, Greenville's sidewalk system only covers roughly 20% of the county; therefore, to find a site that falls almost completely within that 20% is not easy. Most sites have some sidewalk coverage, but PO Box 170248 is the only site looked at that had 87% sidewalk coverage.

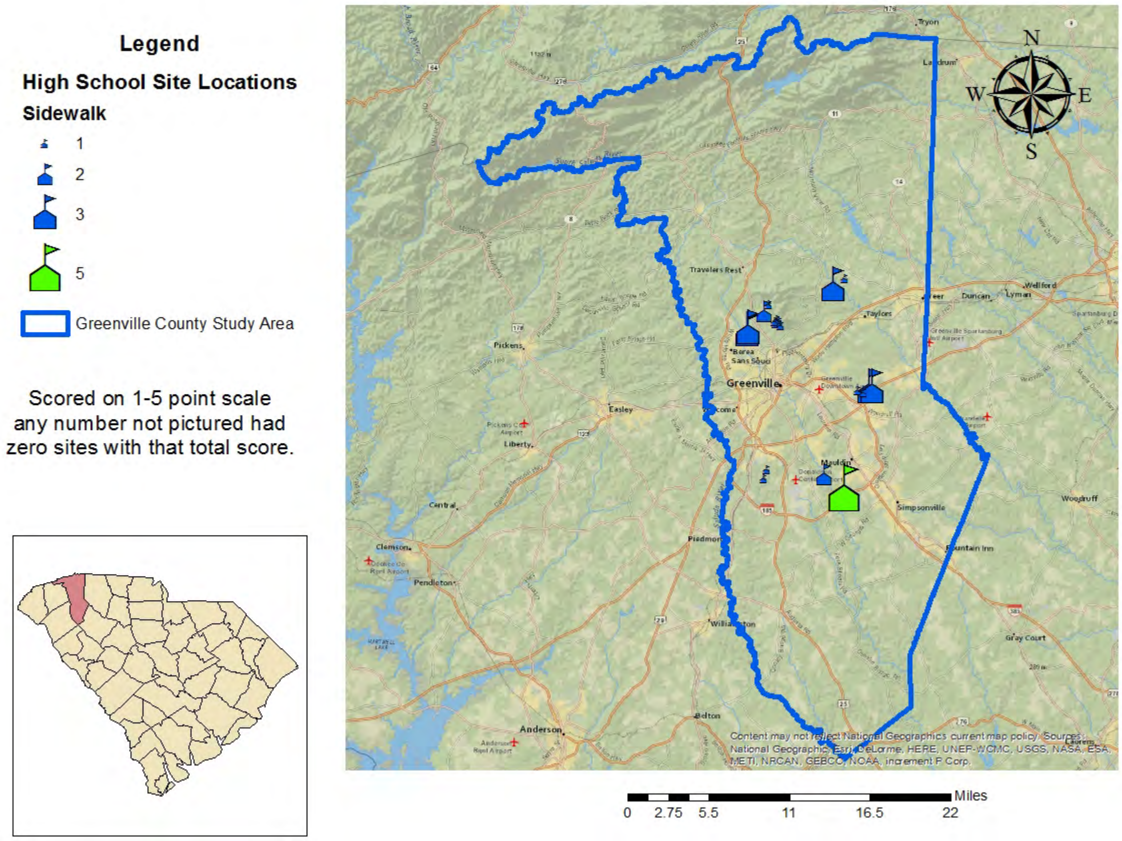

Figure 24 Proportional Map of Sidewalk Score Variable Ranking for High Schools

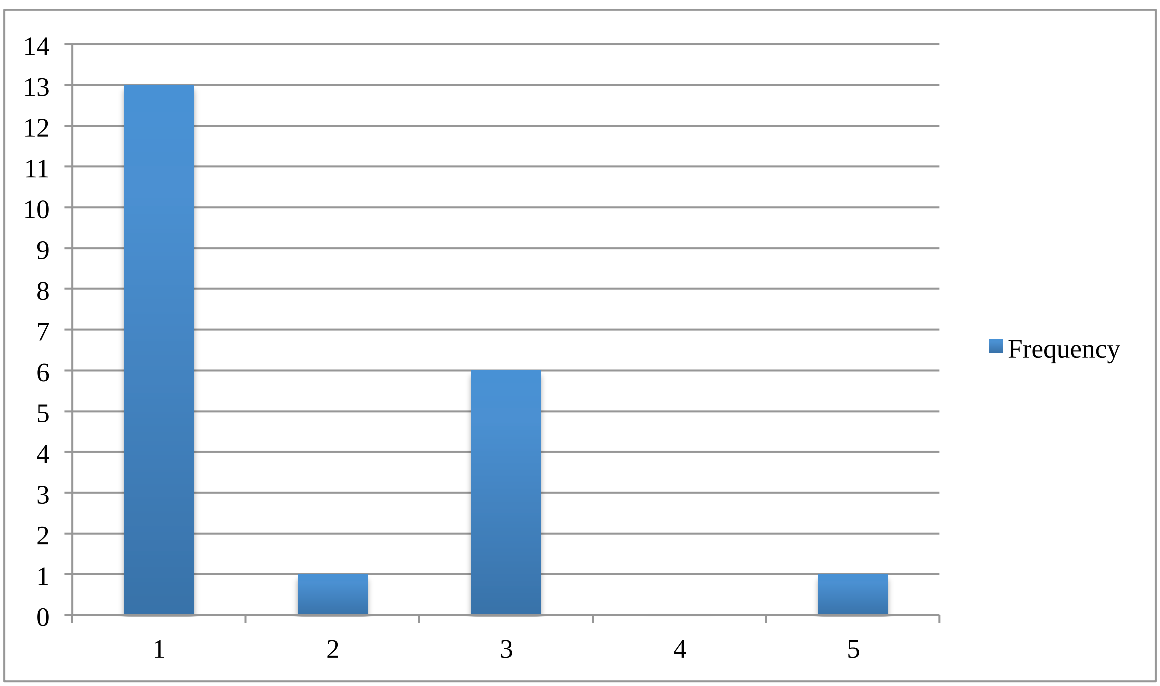

Figure 25 Frequency of Sidewalk Score Variable Ranking for High Schools

4.2.4. Major Road Crossing

In terms of the major road-crossing variable, Figure 27 illustrates the frequency of the rankings scores and illustrates the incredibly high skewing towards the score of 5. In fact, the average score for the elementary results is 4.7 with only two locations, PO Box 17859 and PO Box 17467, not scoring a 5. Figure 26 shows the breakdown of the total scores proportionately.

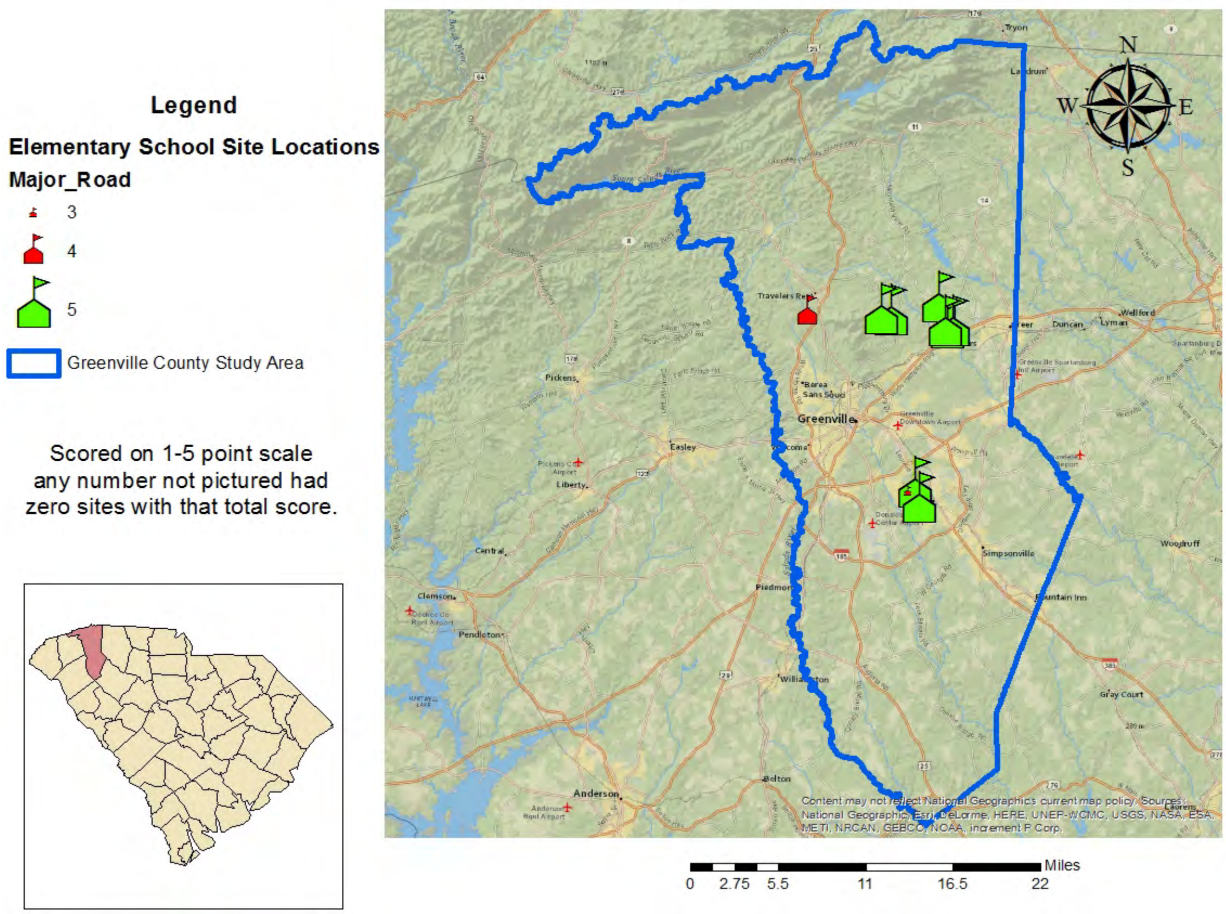

Figure 26 Proportional Map of Major Road Crossing Variable Ranking for Elementary Schools

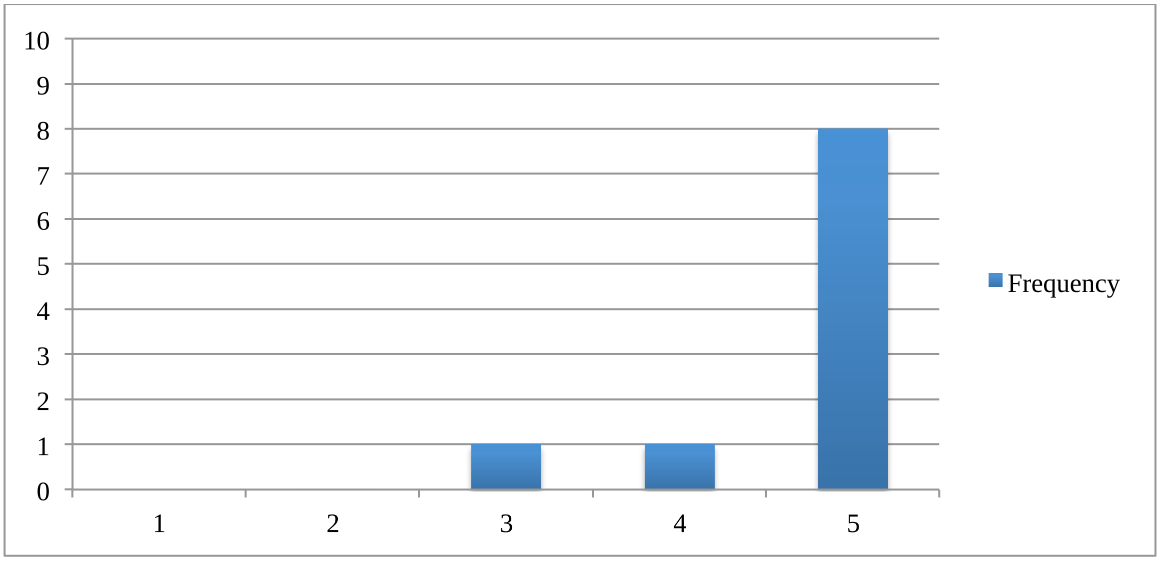

Figure 27 Frequency of Major Road Crossing Variable Ranking for Elementary Schools

Figure 28 displays the results of the middle school frequency scores for major road crossing. In those results, similar to the elementary results the scores are higher with an average of 4.6 and 75% of the sites receiving a score of 5. Figure 27 displays the total scores for the middle school sites and it seems that all of the sites in the Travelers Rest area scored a 5 in this variable.

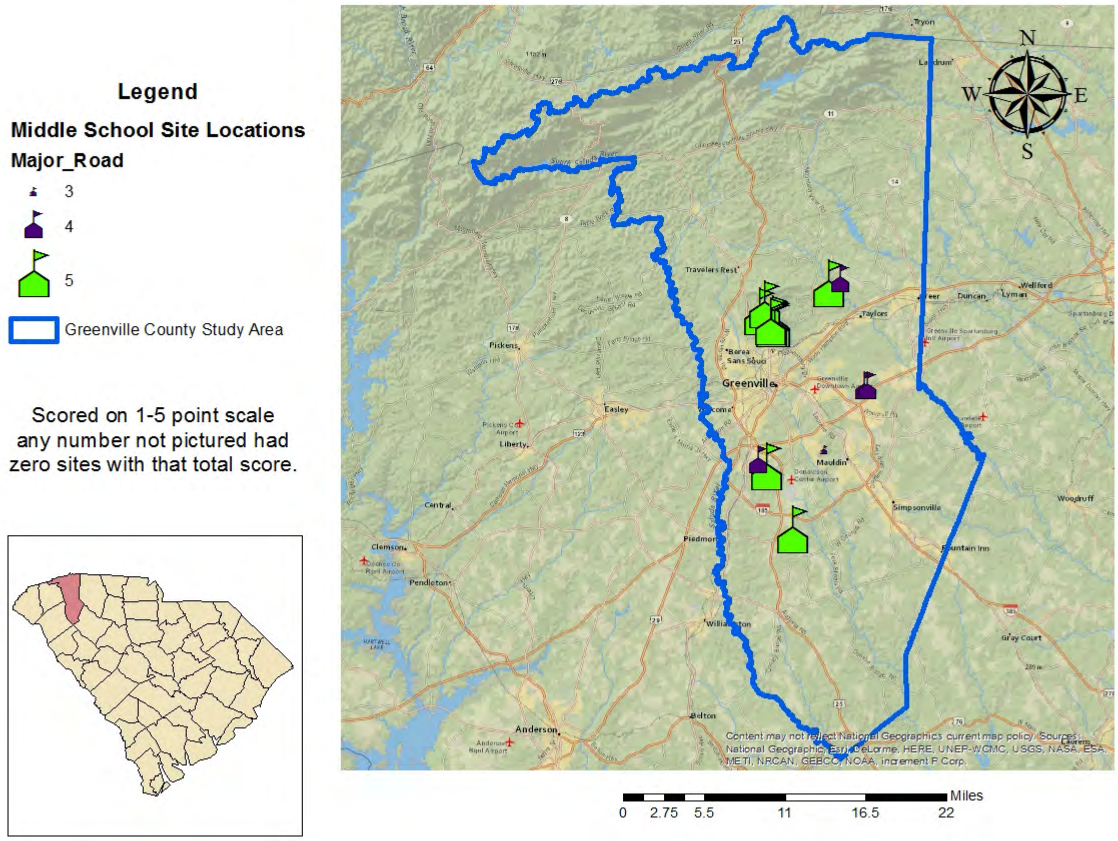

Figure 28 Proportional Map of Major Road Crossing Variable Ranking for Middle Schools

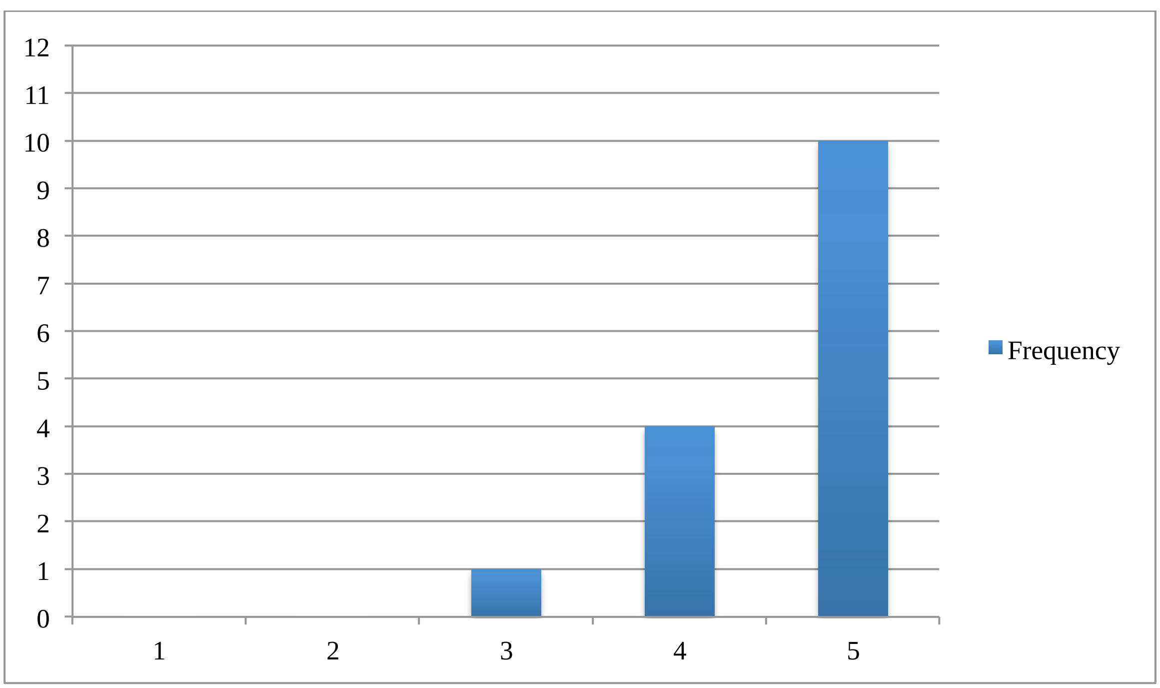

Figure 29 Frequency of Major Road Crossing Variable Ranking for Middle Schools

The last section of the major road-crossing variable is the high school selection site results. Figure 31 depicts the final frequency results and similarly to the elementary and middle school sites the scores are high. In fact, no site scored below a 4 in this variable. The average score was 4.62 with 13 of the 21 sites scoring a 5. Figure 30 shows the total scores mapped by proportion. Another similarity arises as the Travelers Rest region once again receives scores of all 5’s in this category.

These results were not entirely unexpected. During the initial screening process of this study a buffer was placed at half a mile from any major roads for site location purposes; therefore, the chances of having a score of 1 or 2 were pretty low. At the same time, after doing the network analysis the most surprising aspect of this variable was how many routes still crossed major roads within the 1.5-mile walking distance set up. Eight high school, five middle school, and 2 elementary school sites all had network routes leading to them that crossed major roads causing their scores to come down. The only expected part of the results came from the high scores in the Travelers Rest area due to the lack of major roads in that area and the abundance of forestry.

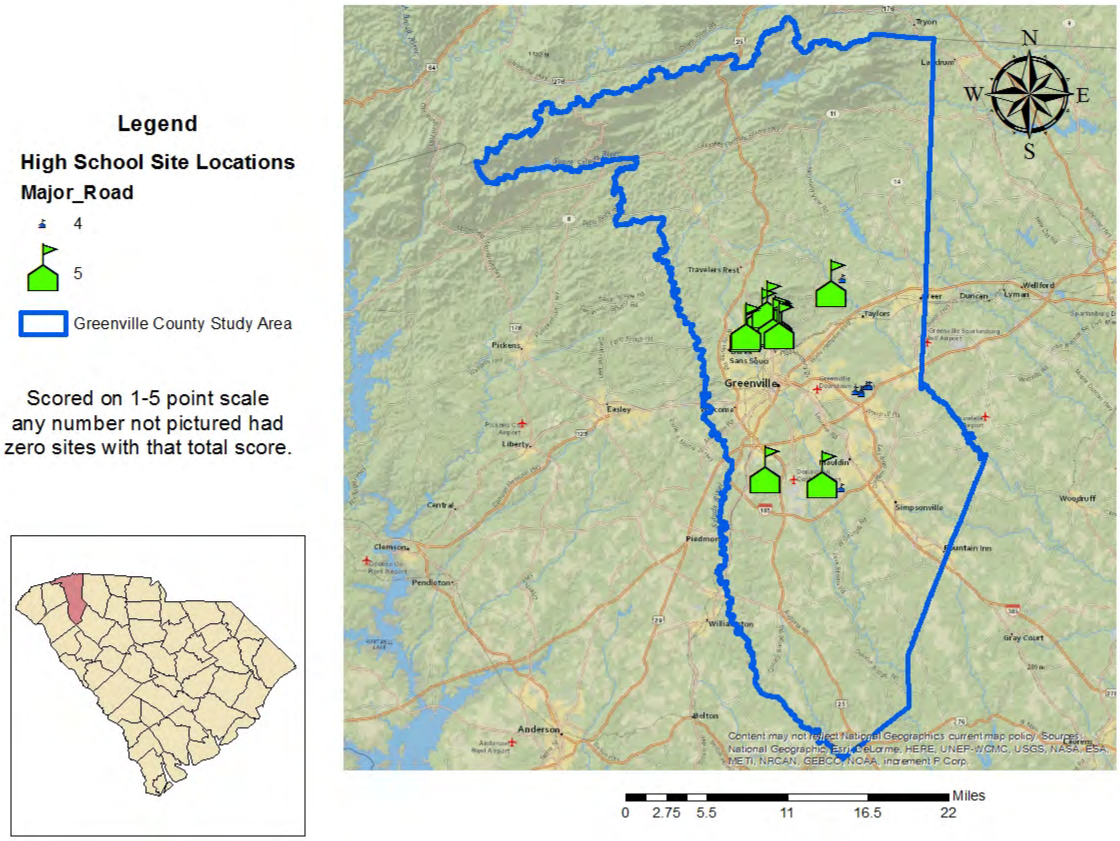

Figure 30 Proportional Map of Major Road Crossing Variable Ranking for High Schools

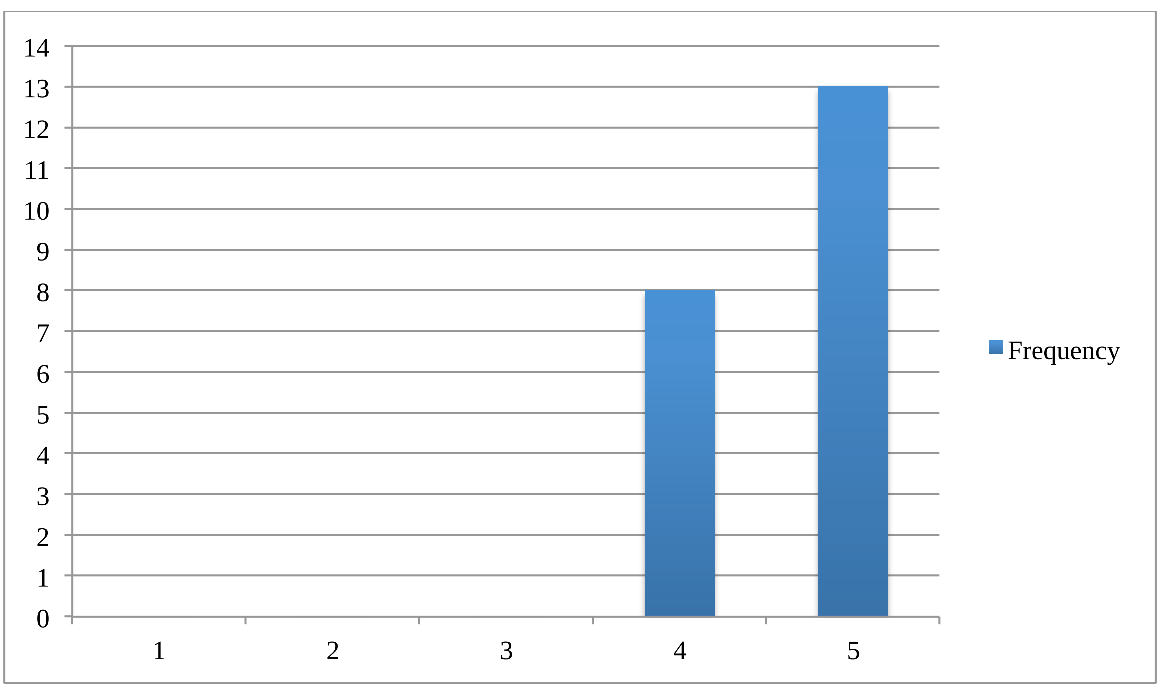

Figure 31 Frequency of Major Road Crossing Variable Ranking for High Schools

4.3 On-Site Analysis

The top five locations from each education level were selected for on-site analysis. This section will go through each location, the pros and cons of the location, and ultimately its suitability as a selection site. Overall the results of the on-site analysis were very similar to the aerial imagery with very little change. Aerial imagery was used from the ESRI ArcMap base maps, this was a way of finding out what type of terrain the site had prior to on-site analysis but was not used to eliminate any site from contention. The results on-site supported the results from the model and in most cases confirmed what was seen in the aerial imagery in selecting suitable site locations to build a new school.

4.3.1. Elementary School Site Suitability Locations

This section will look at the top five site locations for elementary schools as determined by the study in ranked order from first to fifth.

4.3.1.1. PO Box 17859

The overall highest scoring parcel for the elementary level was PO Box 17859, receiving a total score of 18 out of 20. The location scored a 5 in the population density and accessibility to pedestrians' variables, while scoring 4's in the sidewalk score and major road crossing variables. The location is easily accessible by foot, bike, and car for all attending students and parents. Moreover, the location is nestled nicely on the backside of a subdivision, which makes access and walkability even better (see Figure 32). The surrounding area bodes six other subdivisions with the mile and a half walking radius with all but one walking path not crossing a major road.

The lot itself is unrefined and currently has no structures built on it. The area is moderately covered with vegetation and trees. Further on-site analysis showed that the aerial photos were unable to see past the tree canopy revealing less vegetation that originally thought. The tax market value of the property is $155,515, which is much less than the next highest ranked property as well. The acreage of the property is 14.54 acres. After analysis this property would make a good choice as a school location.

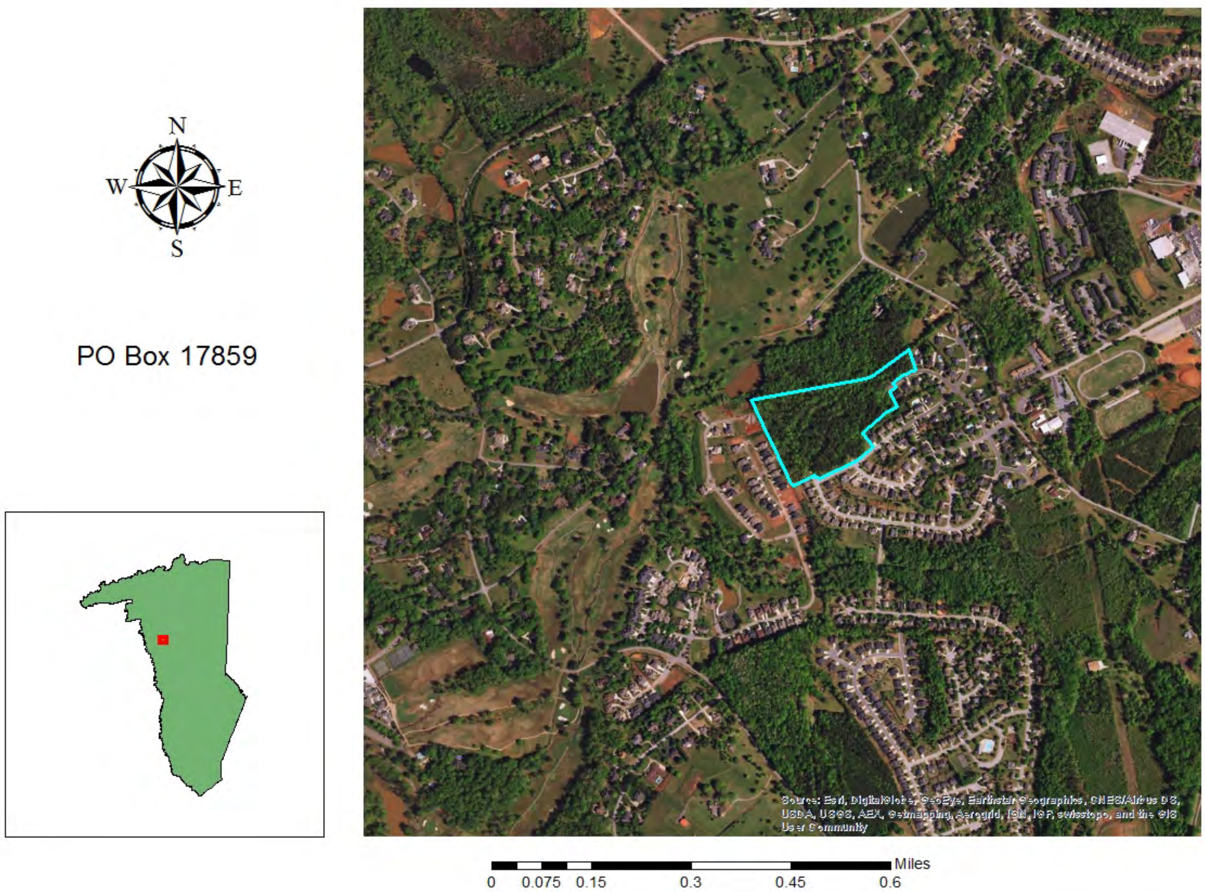

Figure 32 Aerial View of PO Box 17859

4.3.1.2. 287 Lakewood Drive

The second property in the elementary rankings is 287 Lakewood Drive. Receiving a score of 18 out of 20 as well. The site received a score of 5 in population density and major road crossings and a 4 in accessibility to pedestrians and sidewalk score. Currently the area does have a single dwelling on the property (see Figure 33). The lot is 15 acres and is next to a subdivision. There are five subdivisions located within the mile and a half walking area and no major roads are crossed in the network analysis. The site also has smaller amounts of vegetation than the first site, but the tax market value on this property is nearly four times the amount of the first property at $525,220. There are sidewalks present both in the community near the site and leading to the site. The total accessibility for students is however a longer average walk than the first site. The average walk comes in at 0.98 miles. After visually inspecting this site, it appears to be a good location for a school as long as the school is able to keep the elementary students away from the lake that the site is adjacent to for safety measures.

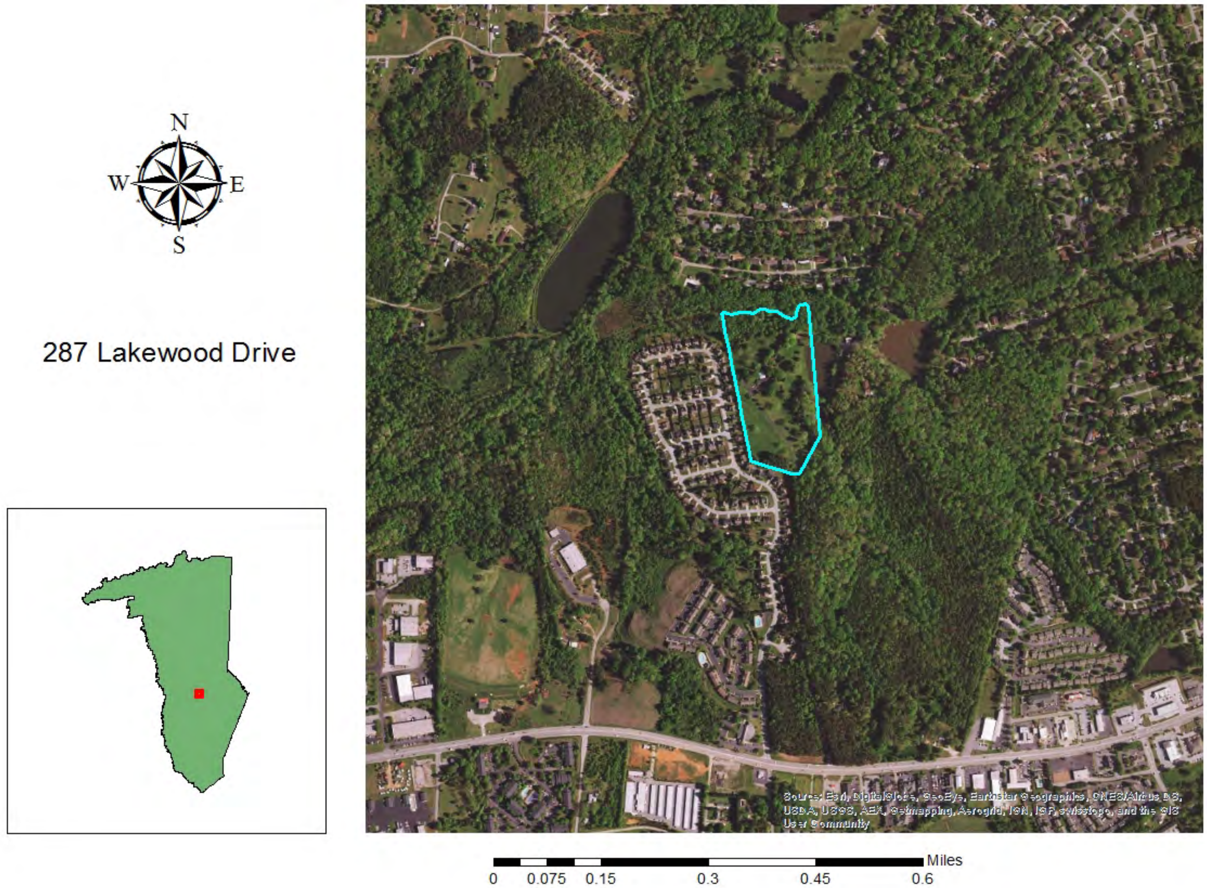

Figure 33 Aerial View of 287 Lakewood Drive

4.3.1.3. 19 Robinson Road

The third selection site is 19 Robinson Road. At 16.92 acres the site is large and most definitely could house a school. The site received a total score of 16 out of 20 with scores of 5 in accessibility to pedestrians and major road crossing, while receiving a 4 in population density and a 2 in sidewalk score. The lot is set near four neighboring subdivisions with a population density of 79-people/square mile. The network analysis showed that there were no major roads crossed for students walking to get to the site in the mile and a half area. The most significant drawback of this site is the lack of sidewalks. Within the networked area, only 32% of the roads had sidewalks, which means most of the paths students would take to walk or ride to school would be on the road and increasing safety hazards. After viewing the lot on-site I have also found that the original two buildings revealed in Figure 34 from the aerial view on the lot, has now become thirteen and it seems as if the area is under development. For these reasons, this lot should not be used as an elementary school location.

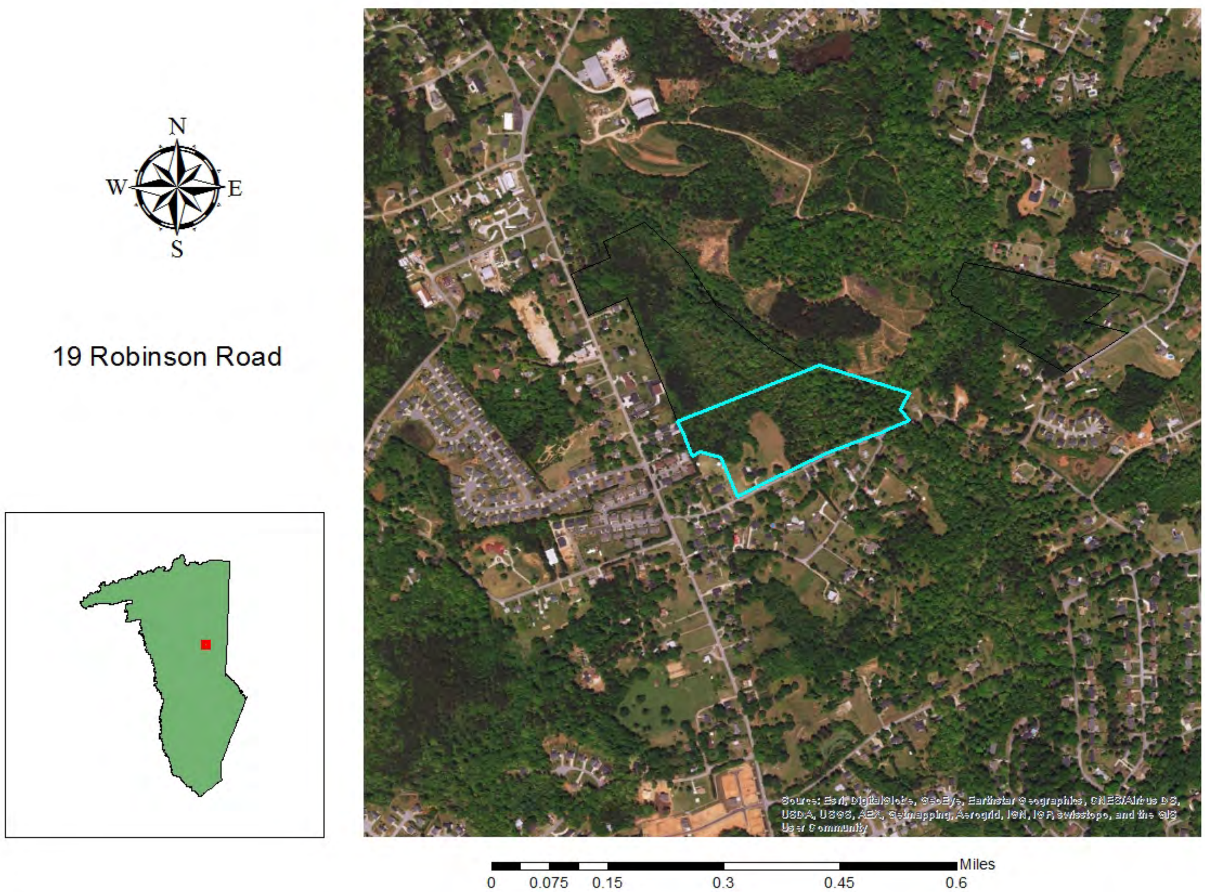

Figure 34 Aerial View of 19 Robinson Road

4.3.1.4. PO Box 17467

PO Box 17467 was ranked as the fourth best site location for an elementary school. Receiving a total score of 15 out of 20, the location scored a 5 in accessibility to pedestrians, a 4 in population density, and a 3 in sidewalk score and major road crossing. Figure 35 depicts the aerial view of the site and reveals a structure already on the site. This site is located near 4 small subdivisions and some outlying houses; as well, accessibility from those neighborhoods averages at 0.76 miles walking distance. However, the sidewalks in the area are only on 44% of the roads in the networked area. The other draw back is that of the possible routes to the location 16% of them cross a major road. The tax market value for this property is $80,520 and the property boasts 13.37 acres. After on-site analysis the area matches the aerial imagery. This site could be used as a school site location.

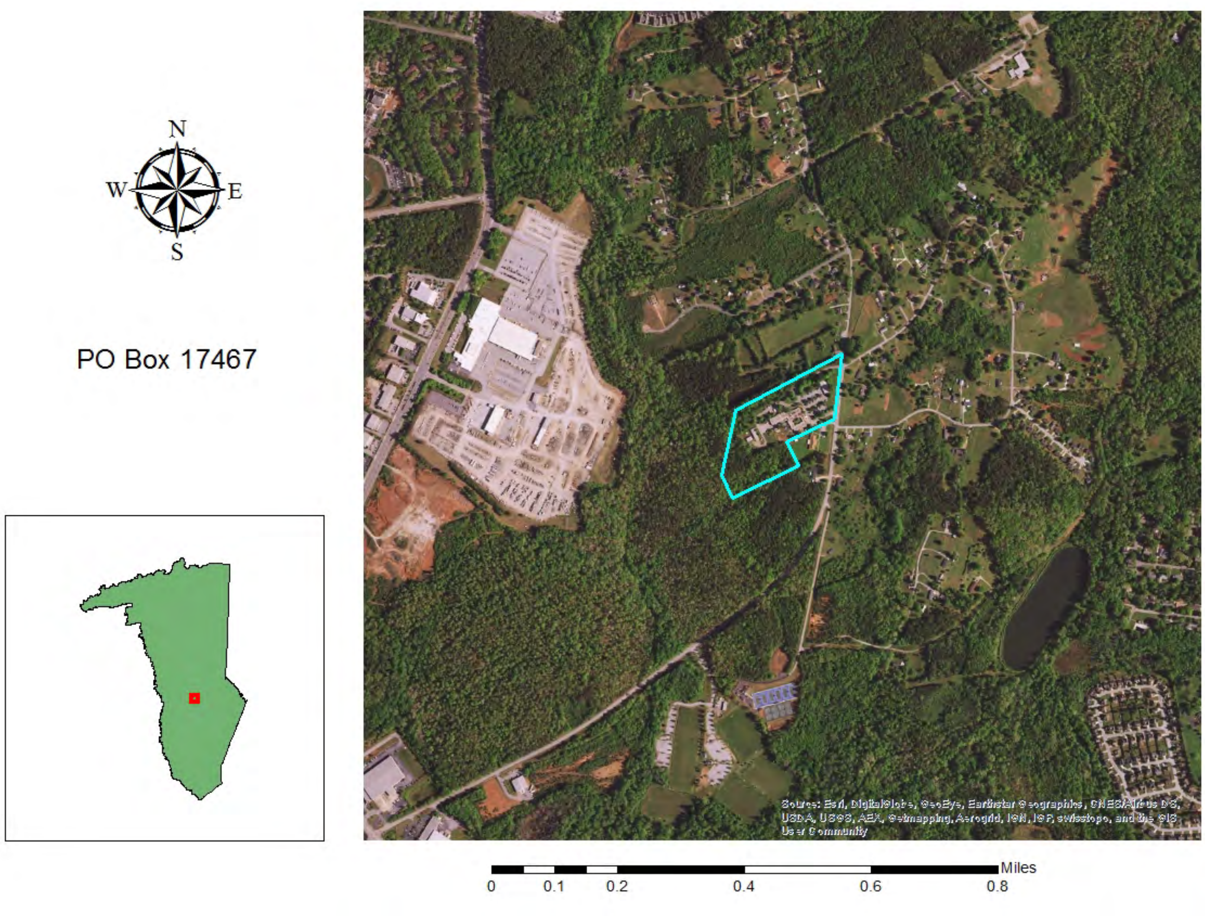

Figure 35 Aerial View of PO Box 17467

4.3.1.5. 2510 Locust Hill Road

2510 Locust Hill Road is the fifth ranked site location for the elementary sites. Receiving a total score of 15 our of 20, the site scored a 5 in population density and major road crossing, while earning a 3 in accessibility to pedestrians and a 2 in sidewalk score. The site is surrounded by seven subdivisions and some outlying houses and boasts the highest population density score of the five sites selected; however, it is almost entirely surrounded by vegetation with few ways in reducing the accessibility and making the walk farther for students (see Figure 36). The average path to the site came in at 1.21 miles. Although, this seems like a down side, the area could be easily renovated to connect with the neighboring subdivisions to considerably reduce the walk time and increase the accessibility. The other negative to this site is the 38% of roads in the area that do not have sidewalks. Of the seven subdivisions near this only two of them have sidewalks in the system. The final pro to this site is that there were no paths that crossed major roads to get to the site in the mile and a half area. An on-site analysis did show that this area is dense vegetation, but the tax market value is only $117,660 for 16.98 acres. Therefore, if the district were willing to clear the land of the vegetation, this location would be a good spot for a new school.

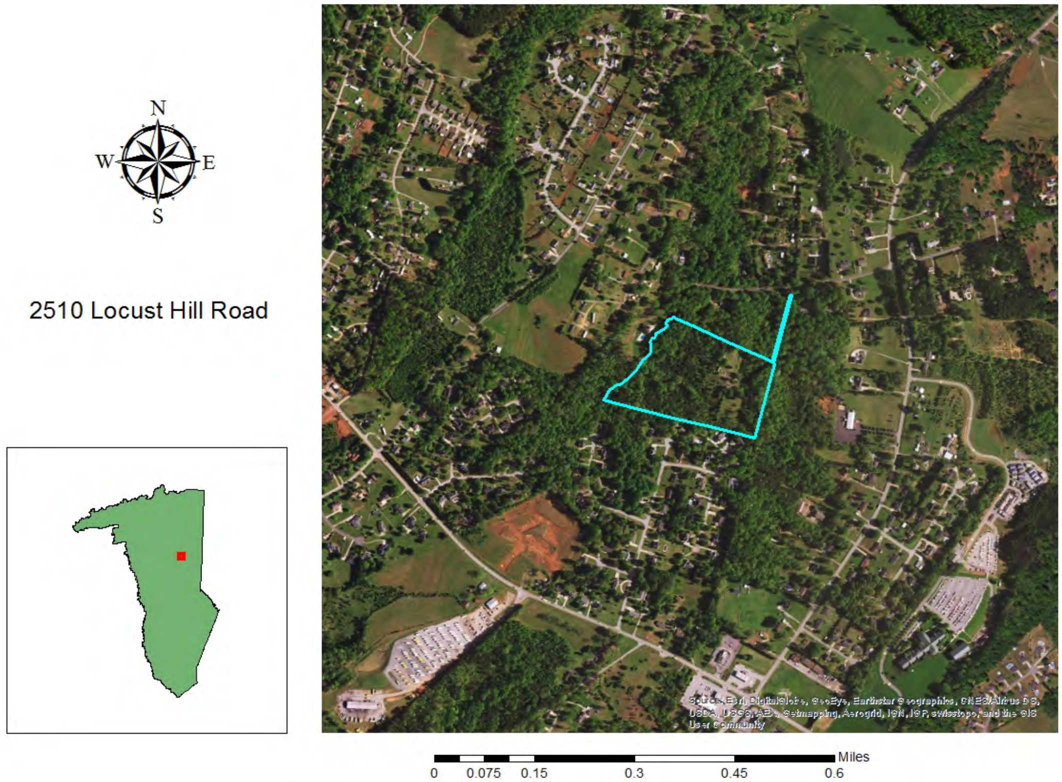

Figure 36 Aerial View of 2510 Locust Hill Road

4.3.2. Middle School Site Suitability Locations

This section will look at the top five site locations for middle schools as determined by the study in ranked order from first to fifth.

4.3.2.1. 4806 Old Spartanburg Road

The first location in the middle school rankings went to 4806 Old Spartanburg Road. It received a total score of 17 out of 20 with a score of 5 in both population density and accessibility to pedestrians. The site also received a score of 4 for major road crossing and a 3 for sidewalk score. This site is surrounded by six separate subdivisions in the mile and a half area and has the highest population density of the top five locations. In addition, the accessibility to pedestrians is also high, with an average walk distance of only 0.26 miles. There are two downsides to this lot as it does have about 7% of the paths crossing a major road and the sidewalk is only available on 57% of the roads in the area. The tax market value of this lot is $56,557 and it incorporates a total of 11.2 acres. As illustrated from the aerial view in Figure 37 the majority of the area is open and clear. After an on-site visit, it is evident that the land parcel is mainly farmland with a parking lot running through part of the lot. This parcel would be a good candidate for placing a school on it.

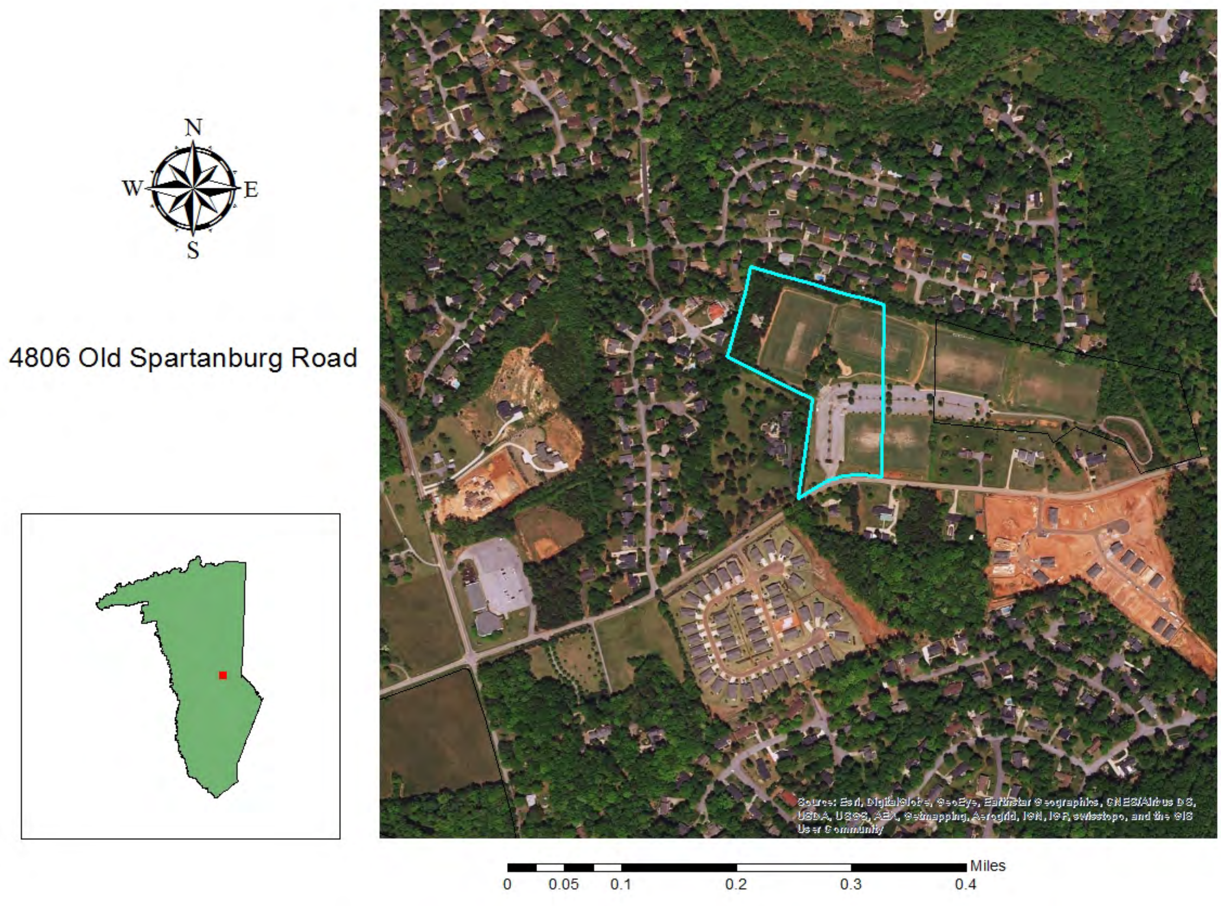

Figure 37 Aerial View of 4806 Old Spartanburg Road

4.3.2.2. 1201 Parkins Mill Road

The second site selected for a middle school is 1201 Parkins Mill Road. This site scored a 17 out of 20 in total score similar to the site on Old Spartanburg Drive, but there are a few differences. This site scored only one 5 in accessibility to pedestrians the other three categories were scored as 4's. The population density for this site came in at 82-people/ square mile. The average walking distance for accessibility was .56 miles. Close to five different subdivisions this site also had 76% of the streets with sidewalks and only 3% of the routes crossed major roads. Figure 38 shows the area is dense vegetation and after an on-site examination, that continues to be true. The area is very thickly grown and hard to navigate to see the majority of the lot. However, from the on-site examination the slope of the land and the lack of structures already in place could be identified. This site would be a good candidate for a school.

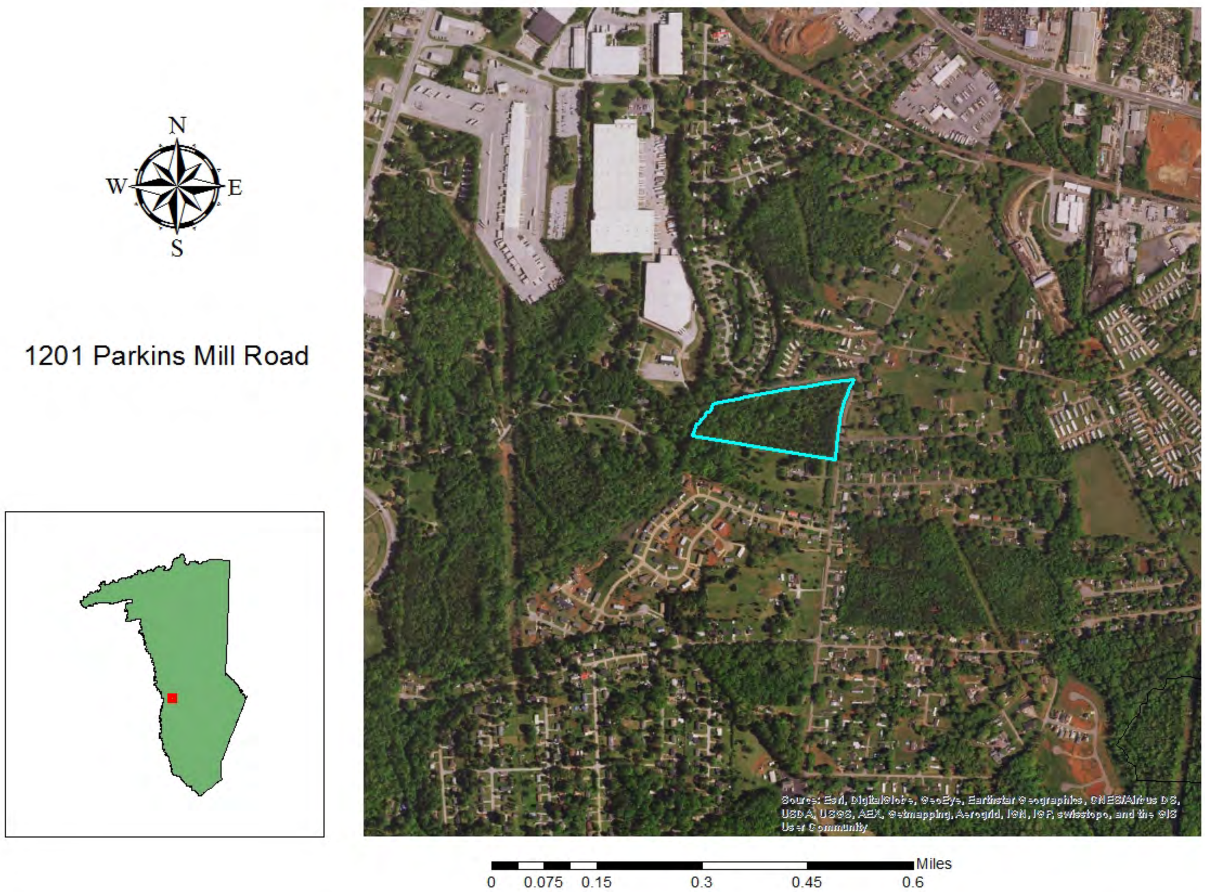

Figure 38 Aerial View of 1201 Parkins Mill Road

4.3.2.3. 400 Roper Mountain Road

Located just next to 4806 Old Spartanburg Road, the 400 Roper Mountain Road site came in at number three on the ranking list. The total score for this site was 17 out of 20 and the break down was identical to the Old Spartanburg Road location, mainly because they are right next to each other. Just like the other location, Figure 39 shows the aerial view of the site and most of the area is cleared. This lot is slightly bigger than the Old Spartanburg Road location coming in at 11.2 acres as opposed to 10.39 acres. This lot also comes with a loftier price tag of

$204,720 as compared to the $56,557 of the Old Spartanburg Road location. After the on-site analysis, this site as with its neighbor would be a good spot to build a school.

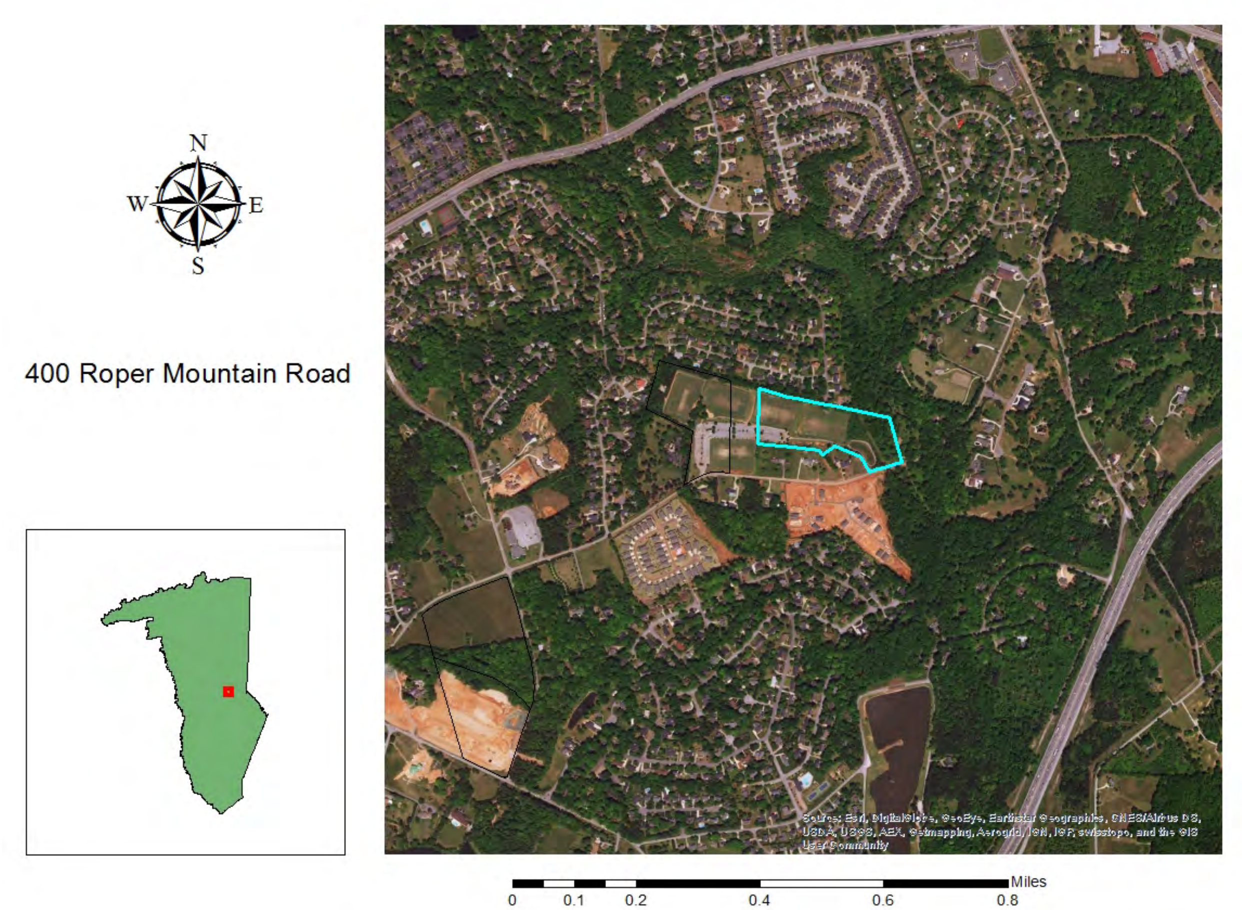

Figure 39 Aerial View of 400 Roper Mountain Road

4.3.2.4. PO Box 17467

PO Box 17467 received the fourth spot in the middle school site selection. This is the only site that was also chosen as a possible elementary school site. The total score for this site came in at 15 out of 20 and is broken down further above in section 4.3.1.4 and the aerial photo can be seen in Figure 35. Again, this sight could be used as a school location.

4.3.2.5. 511 Meece Bridge Road

Rounding out the fifth site selection spot for the middle schools is 511 Meece Bridge Road. This site scored a 15 out of 20 for a total score, with a score of 5 in both accessibility to pedestrians and major road crossing. The shortcomings for the site come from a score of 3 in sidewalk score and a score of 2 in population density. Figure 40 depicts the lack of subdivisions and homes in the vicinity of the site. The population density of this area was only 37-people/ square mile. This score is by far the biggest knock against this sight being used as a school location. However, of the homes in the area there were no paths that crossed major roads and the accessibility level was high with an average of 0.76 miles to walk. Although, this area is less populated than the rest of the site locations, it would still allow the current residents the ability to walk if they wanted. The second drawback to this sight was the total sidewalk score. Only 41% of the roads in the area have sidewalks. This total just barely allowed for the score to be a 3 instead of a 2 in this category. After completing an on-site analysis of the area, it is evident that this site is a good location for a school to be built.

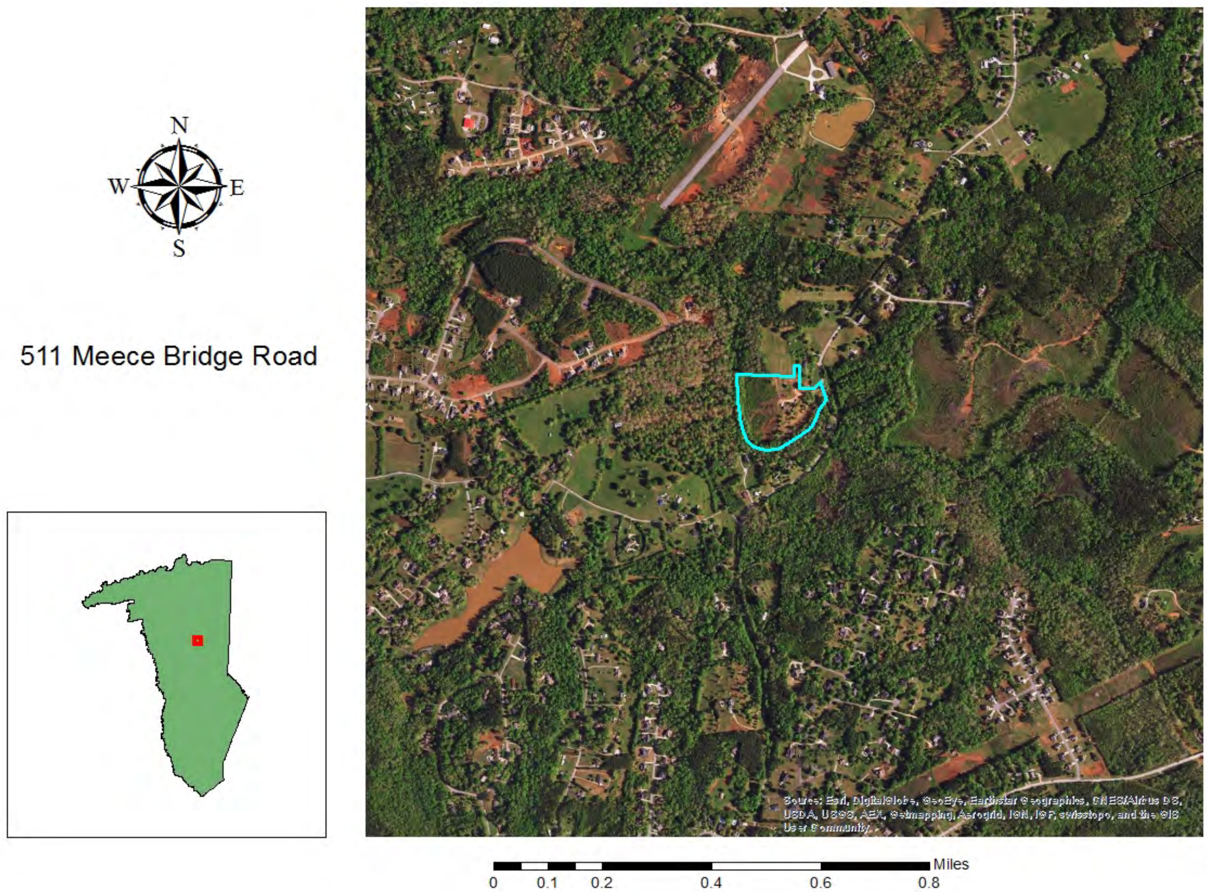

Figure 40 Aerial View of 511 Meece Bridge Road

4.3.3. High School Site Suitability Locations

This section will look at the top five site locations for high schools as determined by the study in ranked order from first to fifth.

4.3.3.1. PO Box 170248

The first site selection for the high school sites is PO Box 170248. With the highest total score of any of the sites looked at in this study PO Box 170248 received a 19 out of 20. The only category this site did not receive a score of 5 in was major road crossing. In the category major road crossing the site received a score of 4 due to the 2% of paths that crossed a major road in its mile and a half area. However, this site is nestled in with eight separate subdivisions in the surrounding area and the highest population density of all of the sites in the study at 188-people/ square mile. The area around this site also boasts the top sidewalk score with 87% of the roads having sidewalks in this area. The accessibility to this site is high with an average walking distance of only 0.32 miles.

This site boasts 13.35 acres with a tax market value of $59,030. From the aerial photo in Figure 41 the area seems to be dense in vegetation, but upon on-site analysis this is not true. Roughly 2/3 of the site is cleared or at least only covered by tall grass, the other 1/3 is still covered with trees, but not as densely as first assumed. This site would be a good choice for a new school.

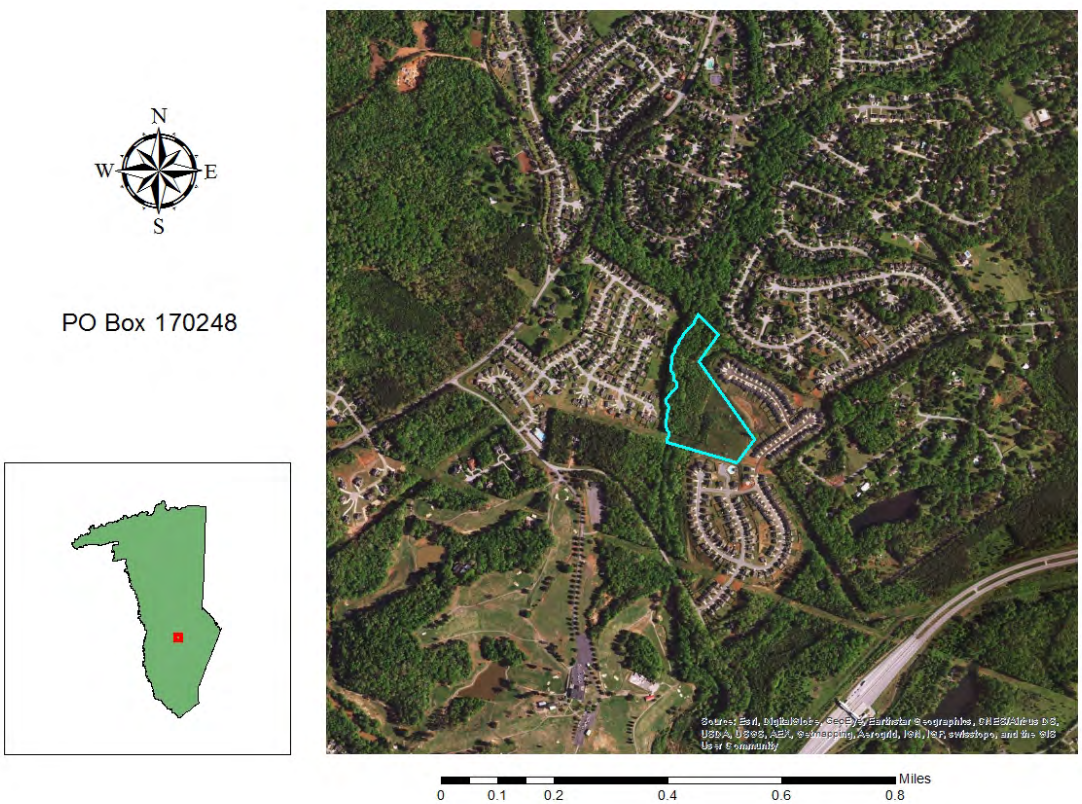

Figure 41 Aerial View of PO Box 170248

4.3.3.2. 4806 Old Spartanburg Road

4806 Old Spartanburg Road received the second spot in the high school site selection. This is one of two sites that were also chosen as possible middle school sites. The total score for this site came in at 17 out of 20 and is broken down further above in section 4.3.2.1 and the aerial photo can be seen in Figure 37. Again, this site could be used as a school location.

4.3.3.3. PO Box 443

PO Box 443 is the third site selected in the high school site selection. This site received a total score of 17 out of 20 with a score of 5 in both major road crossing and population density. The site also received a score of 4 in accessibility to pedestrians and a 3 in sidewalk score. With 13.46 acres and a tax market value of $57,857 this site appears to be a good fit for a new school location. Aerial imagery in Figure 42 shows a large number of the subdivisions surrounding the area and with no major roads to cross the only thing bringing down the score on this site is the lack of sidewalks. This area only has 47% sidewalk coverage. The average walking distance is 0.93 miles, which gives this area a good score in accessibility. After the on-site analysis, this area is very similar to the aerial imagery and has a majority of clear space. This location would be a good selection to build a school.

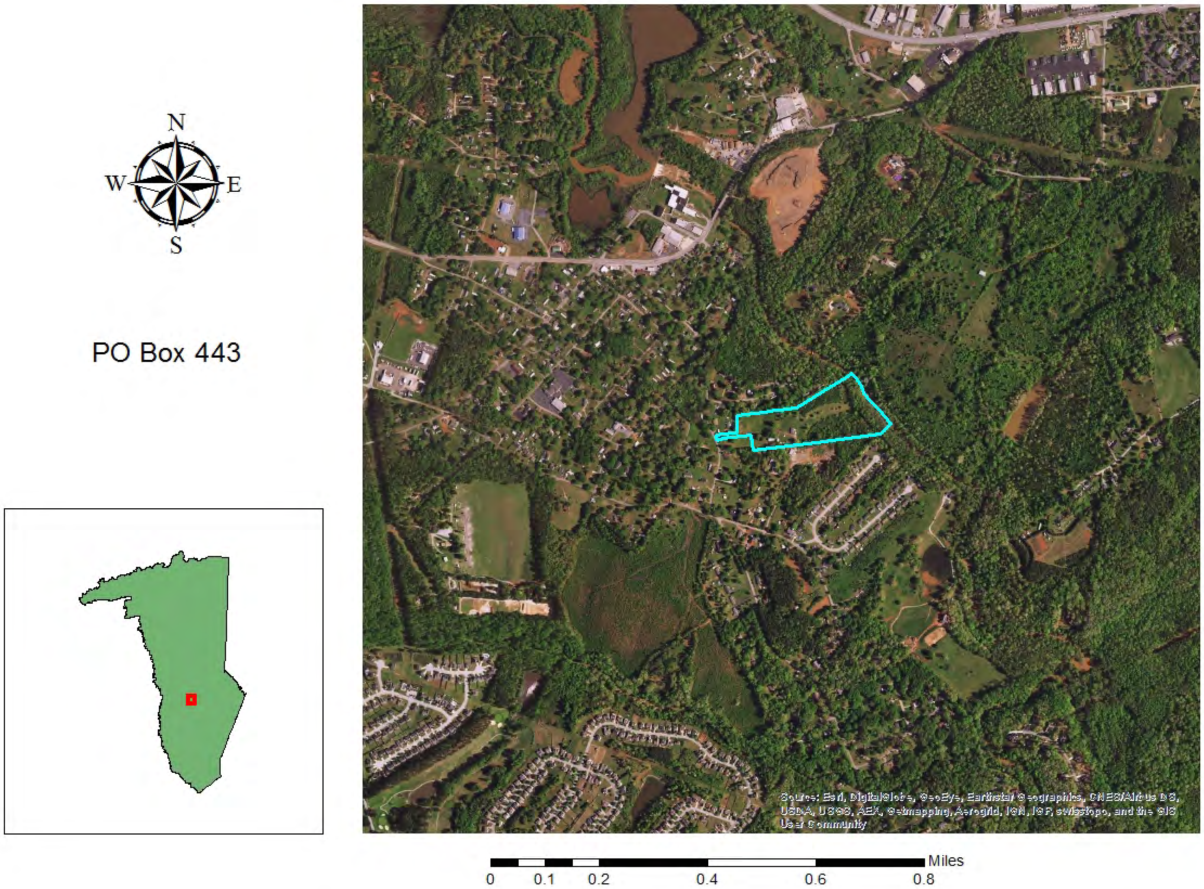

Figure 42 Aerial View of PO Box 443

4.3.3.4. 400 Roper Mountain Road

400 Roper Mountain Road received the fourth spot in the high school site selection. This is one of two sites that were also chosen as possible middle school sites. The total score for this site came in at 17 out of 20 and is broken down further above in section 4.3.2.3 and the aerial photo can be seen in Figure 39. Again, this site could be used as a school location.

4.3.3.5. 388 Old Farrs Bridge Road

The final location for the high school site selection is 388 Farrs Bridge Road. With a total score of 16 out of 20 this site scored a 5 in only the major roads crossing category. It received a 4 in both population density and accessibility to pedestrians and a 3 in sidewalk score. Figure 43 depicts how the site is nestled between a subdivision on the north west side and more loosely scattered housing on the south east side. The population density level of this area is 82-people/ square mile and the average walking distance to the site based on the networked data is 0.84 miles. The area has 56% sidewalk coverage on the roads and none of the paths cross any major roads. This site is 10 acres with a tax market value of $13,884. The site seen next to this one in Figure 43 is Po Box 5835. The reason 388 Old Farrs Bridge Road was chosen over it was because upon on-site analysis the Old Farrs Bridge site was only half covered by vegetation and the cost was almost five times less. This site would be a good location to build a new school.

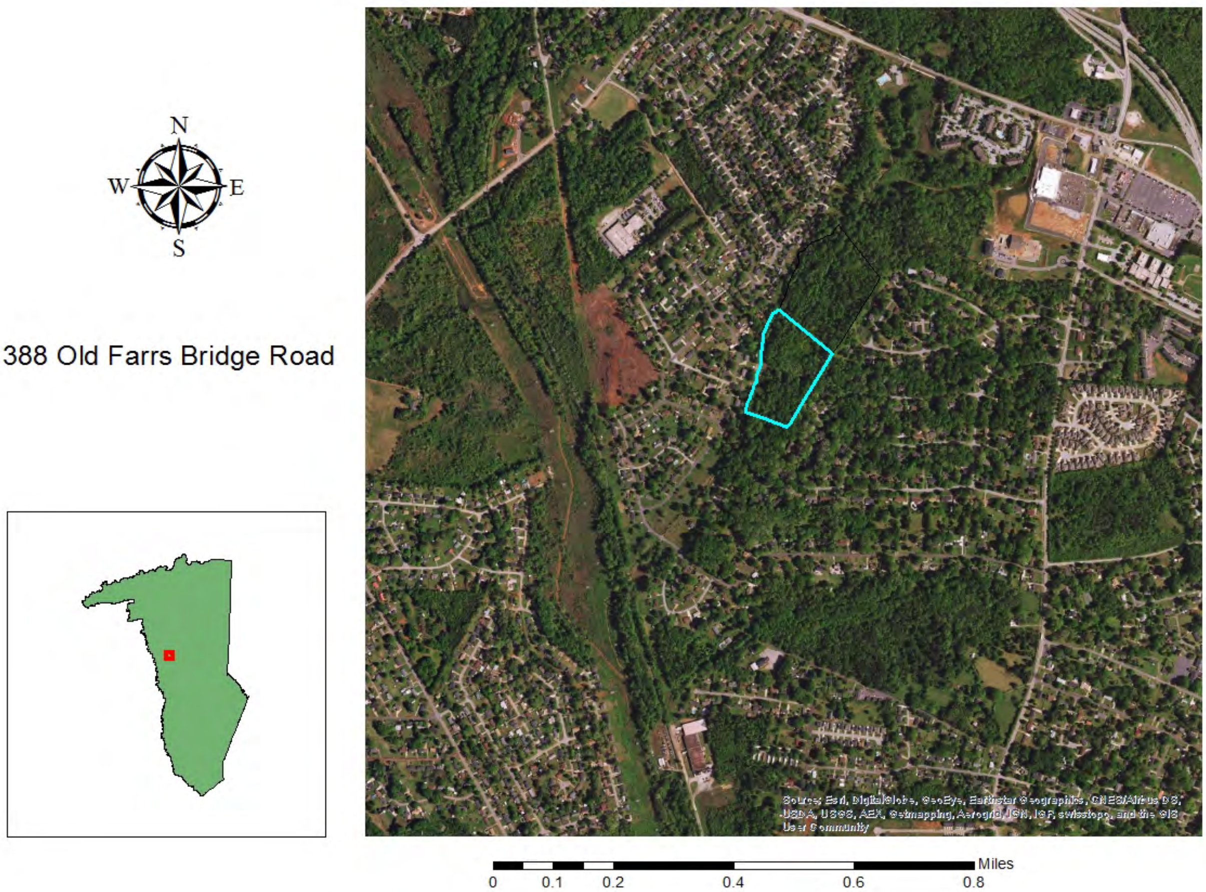

Figure 43 Aerial View of 388 Old Farrs Bridge Road

4.4 Current Greenville County Schools Scores

One of the secondary goals of this study is to examine schools that have already been built in the district and score them using the same standards as the site suitability locations above. Using the same scoring system, each currently built school in the district regardless of grade level was scored and logged. This section will look at the top five pedestrian accessible schools already built in Greenville County as well as the bottom five schools already built. This section is a guide to help determine what schools could be used as a model for placing more schools and which need to be rethought or improved upon in the future.

4.4.1. Top 5 pedestrian Accessible Schools Already Built

After running all of the existing schools in Greenville County through the same scoring criteria that were used on the site suitability selection, Table 8 displays the top five schools and their scores. The overall highest total score for a current school goes to Eastside High School (see Figure 44) with a total of 19 out of 20. Eastside received this score because its current placement is in a high population density area; the average walking distance in the mile and a half area is 0.34 miles. In addition, the area has a sidewalk score percentage of 86% and only 4% of the routes cross a major road.

Hollis Academy, Augusta Circle Elementary, and Hughes Academy all received great scores as well with 18 out of 20 where each was docked one point for sidewalk score and major road crossing. Their sidewalk score percentages were 79%, 74%, and 69% respectively, while their major road crossing percentages were 3%, 6%, and 7% respectively. Rounding out the top five was Brook Glenn Elementary with a total score of 17 out of 20. The only difference from the three schools above it was the areas population density, which sat at 97-people/ square mile and just missing a score of 5. The sidewalk score percentage was 68% and the major road crossing was only 2%.

Table 8 Top Five Total Scores for Already Built Schools in Greenville County

Location	School Level	Population Density Score	Accessible to Pedestrians	Sidewalk Score	Major Road Crossing	Score Total
Eastside High School	High School	5	5	5	4	19
Hollis Academy	Elementary School	5	5	4	4	18
Augusta Circle Elementary	Elementary School	5	5	4	4	18
Hughes Academy	Middle School	5	5	4	4	18
Brook Glenn Elementary	Elementary School	4	5	4	4	17

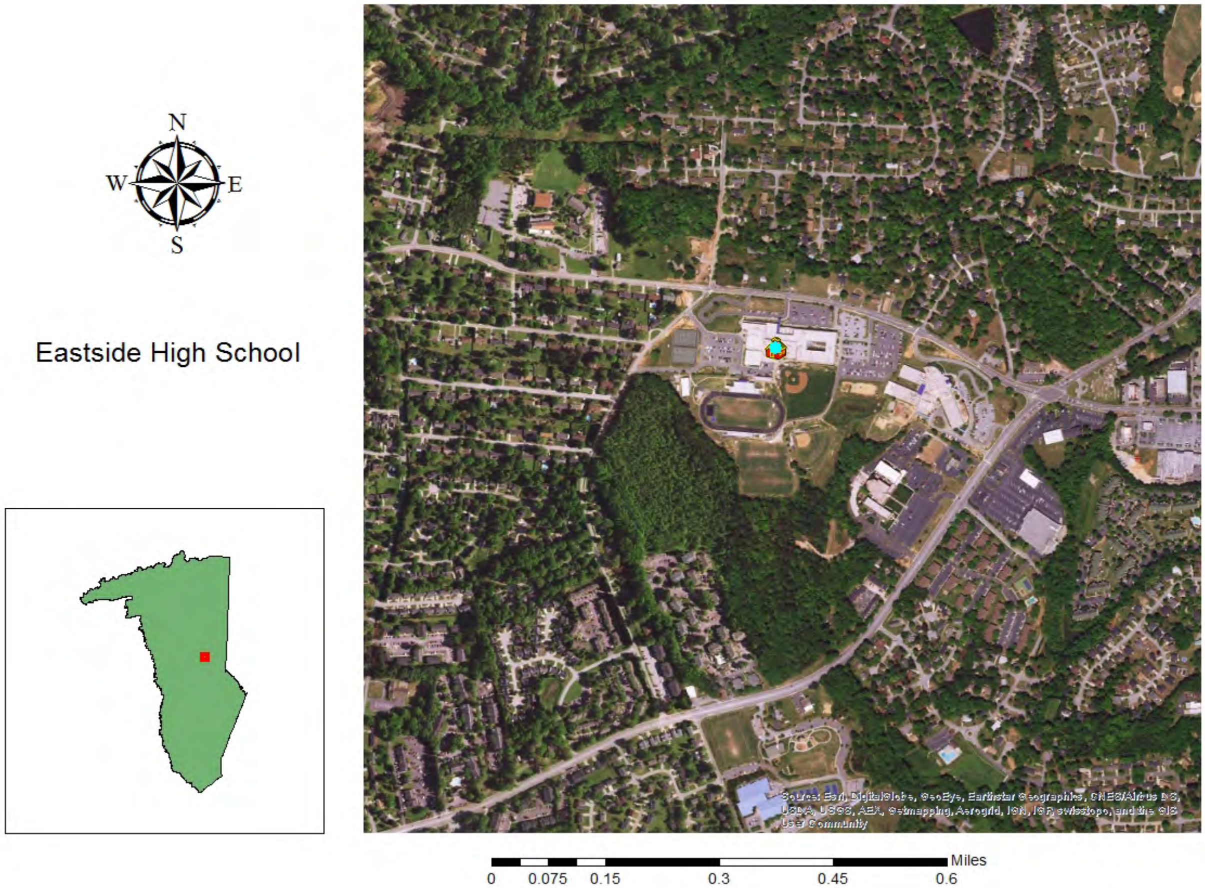

Figure 44 Aerial View of Eastside High School

4.4.2. Bottom 5 Pedestrian Accessible Schools Already Built

On the opposite side of this study are the schools that do not score well on pedestrian accessibility. Using the same scoring criterion as the site selections for the new schools, here is a list of the schools already built in Greenville County that do not measure up. Table 9 displays the bottom five schools beginning with the school that scored the worst.

The lowest scoring school in Greenville County went to Beck Academy for a number of reasons. Beck Academy's total score was 5 out of 20, receiving scores of 1 in three of the four categories. The only category with a 2 was pedestrian accessibility and that is because near the school are two apartment complexes that helped to bring the average walking distance down to 1.49 miles and which is just shy of becoming a 1. The population density of the area is set at 13-people/ square mile. The sidewalk score came in at only 7% of the roads having sidewalks. The biggest drawback to the school is the major road crossing score. This is the lowest score I have seen from any of the schools or sites in contention, 97% of the routes crossed a major road. Nearly every route taken to get to this school crosses a major road; the only routes that do not come from the apartment complex right next door to the school. Figure 45 displays an aerial map of the school and depicts an urban area filled with businesses and major roads. The school is situated a block and a half from one of the most populous shopping areas in Greenville County and has one of the highest traffic flows as well. For this reason, this is just about the worst location for a school.

The other schools to make the bottom list were Woodmont Middle School, Hillcrest High School, Hillcrest Middle School, and Grove Elementary. The biggest problems for each of these were the accessibility to pedestrians and the sidewalk scores. Not one of these schools averaged a walking distance of less than 1.7 miles and all of them had a sidewalk score below 14%. The two Hillcrest schools are also situated between the highway roughly 100 feet away to the southwest and a major road to their northeast, making it very worrisome for students to walk to the school. In short, none of these schools are positioned well for pedestrian accessibility.

Table 9 Bottom Five Total Scores for Already Built Schools in Greenville County

Location	School Level	Population Density Score	Accessible to Pedestrians	Sidewalk Score	Major Road Crossing	Score Total
Beck Academy	Middle School	1	2	1	1	5
Woodmont Middle School	Middle School	1	1	1	4	7
Hillcrest High School	High School	4	1	1	1	7
Hillcrest Middle School	Middle School	4	1	1	1	7
Grove Elementary	Elementary School	1	1	1	5	8

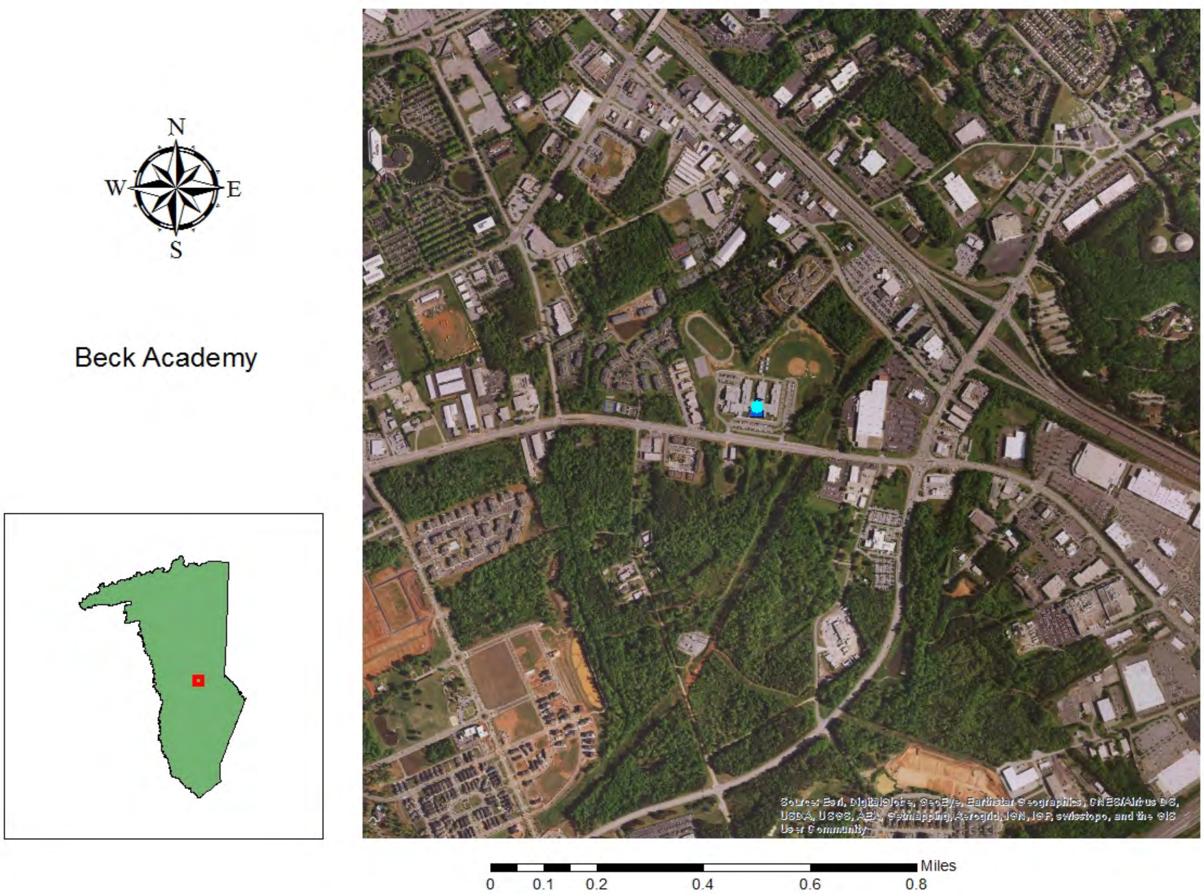

Figure 45 Aerial View of Beck Academy

Table 10 displays the average total scores for all 101 schools already currently in the district of Greenville County Schools. This table demonstrates that like most of the county the sidewalks are well below the other scores when it comes to pedestrian accessibility.

Table 10 Average Total Scores for Already Built Schools in Greenville County

School Level	Population Density Score	Accessible to Pedestrians	Sidewalk Score	Major Road Crossing	Score Total
Average of All Current Schools	3.6	3.4	2.1	3.7	12.8

Chapter 5 Discussion and Conclusion

The goal of this site suitability analysis was to identify the optimal locations for different school levels with the county of Greenville, South Carolina. In particular, it was important to determine where the district should place new schools to optimize the cost and pedestrian accessibility of each location. The analysis was effective in indicating locations that were suitable to fulfill these objectives. Acceptable parcel lots were found that resulted from the devised criteria. These lots were then ranked according to their optimal suitability to fit the needs of the study goal. Overall, the aerial imagery and on-site analysis both revealed that the locations chosen for site suitability were correctly identified and that the approaches used in this study were of sound methodology.

5.1 Key Observations

The final results of this study show that the best locations were nearest the most populated areas in the middle of the county. By ranking site locations using a scoring index, the optimal locations were more easily identified. The benefits to using a scoring index is the ability to allow school districts, counties, and planning committees to determine the best location to place a new school based with the variables used. This study focused on identifying seven criteria to use in which to aid in determining where to locate a new school. The scoring criteria focused on population density and pedestrian accessibility to allow for schools to be built with student walking, biking, and safety at the forefront of the process.

The highest-ranking site locations from the total scores ranking had some commonalities. None of the sites had been located near any of the downtown areas in Greenville County or near any business districts. The best locations were all located near highly populated subdivisions where the parcel was close in proximity to at least five subdivisions. Moreover, upon closer inspection those locations are also underdeveloped compared to the surrounding area. By looking at Figure 4 for the elementary school total score locations, the sites selected are grouped into four main areas. The middle school total scores in Figure 5 are similar in their grouping, but have two more areas for a total of six. Finally, the high school total scores in Figure 6 show that the locations are grouped into five areas. Together these locations are very similar and even have some overlapping. This shows that these areas were the most suitable and met the goals of this site suitability analysis. In addition, these areas all have very similar qualities, which allowed them to be chosen.

While there are many methods to choose a new school location, this study used the criteria proposed by the state of South Carolina combined with other key variables, such as population density and pedestrian accessibility, to determine optimal locations. This thesis built upon ideas in other GIS studies completed for school site selection with their own agendas and decidedly gave a different view of what to identify when building a new school. One variable that was left out of this study was utility services availability such as water and power at the site locations. This variable would have helped to determine the total cost of building a school in the area. The reason this variable was omitted was due to lack of availability of accurate data and the inability of the utility company to share their data.

One of the most important steps in this process was the ability to do on-site analysis. Not only did this allow for a more accurate identification of the site, but also it allowed for ground feasibility to be assessed. By analyzing the site locations on-site, qualitative observations of all of the variables used in the study were able to back up the data used from aerial imagery. In the case of 19 Robinson Road where the aerial imagery revealed two buildings and the on-site observations showed thirteen current buildings and more in the works, this proved invaluable.

5.2 Contrasts with Prior Studies

Every state has a different method of choosing school locations. Therefore, this thesis developed a new method based on multiple studies. The three studies that formed the basis of this project were Svatos (n.d.), Kerkow (2014), and Henninger (2004). Each of these studies looked at different criteria and chose locations that fit their needs. For this study, parts of each of these other three studies were used as guides to begin and build upon their ideas.

A key inspiration for this thesis emerged from the idea of pedestrian accessibility. This is the idea that students could walk or ride their bikes to school and that exercise promotes better health and learning. Within the scope of this framework, the inability to find another case study that focused on this criterion was the deciding factor to frame the study around it. This analysis quantitatively measured the different aspects that make up what is defined as pedestrian accessibility in this study giving the optimal locations based on those scores. Unlike the other three studies stated above, this analysis utilized aspects that were based on more than just the physical landscape of the site. These aspects also focused on the surrounding school area, including the population density, distance walkability, sidewalk safety, and the crossing of major roads.

The most significant difference found between this study and other comparative site suitability studies is the use of network analysis to determine the pedestrian accessibility of the site location. Using network analysis, this study measures the different routes that students use to the new schools and determines the safety, walkability, and population reach of the location in question. This allowed for a quantitative analysis of the aforementioned pedestrian accessibility. Moreover, this ensured that the school districts use a new method to help determine a schools location. This is a key area of growth from the study conducted by Svatos as he was unable to use network analysis in GIS to fully realize the goal he was striving to achieve.

Overall, this study met its goal of analyzing site-location selections for new schools in the Greenville area by using state approved criteria in conjunction with added criterion such as current school locations and population densities. By first understanding the variables associated with selecting a site for a new school and then understanding the variables needed by the people, this study focused on both the building and the student safety and learning.

5.3 Recommendation for Future Research

This study focused on pedestrian accessibility in Greenville County, South Carolina. The study could be used as a model to apply to other school districts. The city used in this study is a well-developed city with a large population and growing area. Future research could apply the ideas in this study to better underdeveloped areas such as a rural location, to determine the best school locations in a less populated area to encourage pedestrian accessibility. The basic methodological framework used in this study provides a way of ranking sites for building schools. In addition, a district could tailor their needs or wants for a school even further.

This project could be used as a guide for planning future development of an area and where to place a school in that area. Counties, cities, school districts, and planning committees can use this as a way to view developing areas and help guide their development of neighborhoods, subdivisions, and the schools that service them. Those organizations could even take the project further and develop more criteria to add to the system to reduce the number of acceptable sites further.

To further this site-suitability analysis a much more in depth cost-analysis could be another further research angle. The locations in this study are all given with their tax market value, but a more in depth look at the cost of not just the parcel, but also the costs of building utility infrastructure, land clearance, grading of the land, and construction could help to determine the actual cost of building on a site.

The next additional idea for future research is that of a community benefit standpoint. This study could be tailored and added upon to determine which areas would have the greatest impact upon the community. Impacts could range from reducing the number of students in a school to placing a school within neighborhoods and away from more dangerous neighborhoods. This could be very helpful to the morale of a city. In truth, the changing of a criterion could greatly alter the outcome of the results and this study focuses on pedestrian accessibility. By tailoring the study to the needs of the user, this study has nearly limitless future analyses.

REFERENCES

Alaska Department of Education. 2011. "Site Selection Criteria and Evaluation Handbook." http://www.eed.state.ak.us/Facilities/publications/SiteSelection.pdf.

Aziz, Azwan. 2004. "Spatial Decision Support System for School Siting." http://core.ac.uk/download/files/452/12219768.pdf.

Bike Walk Greenville. 2013. "Only 20% of Greenville County Elementary Schools Are Walkable." http://www.bikewalkgreenville.org/only-20-of-greenville-county-elementary-schools-are-walkable/.

Bukhari, Z., Rodzi, A. M., & Noordin, A. 2010. "Spatial Multi-criteria Decision Analysis for Safe School Site Selection." International Geoinformatics Research and Development Journal, 1(2), 1–14. http://igrdg.com/2010/IGRDG%20-%20Issue%202%20-%20June%202010%20-%201.pdf.

California Department of Education. 2014. "School Site Selection and Approval Guide." http://www.cde.ca.gov/ls/fa/sf/schoolsiteguide.asp.

Department of Education and Skills. 2012. "Technical Guidance Document TGD-025." *2nd Edition.* https://www.education.ie/en/School-Design/Design-Guidance/bu_tgd_025_rev1.pdf.

ESRI. (2012). "Exercise 3: Finding a Site for a New School." http://resources.arcgis.com/en/help/main/10.1/index.html#//00nt00000008000000.

Federal Highway Administration. 2015. "Pedestrian Accessibility Checklist." https://www.greenvillecounty.org/gcpc/transportation_planning/pdf/pedestrian accessibilitychecklist.pdf.

Georgia Department of Education. 2012. "Guideline for Educational Facility Site Selection." http://www.gadoe.org/Finance-and-Business-Operation/Facilities-Services/Documents/6.%20Guideline%20for%20Educational%20Facility%20Site%20Selection%20051012.pdf.

Greenville Area Development Corporation. 2015. "Demographics." http://www.greenvilleeconomicdevelopment.com/demographics.php.

Greenville County. 2015. "Greenville County." http://www.greenvillecounty.org/AnswerBook/utilities.asp.

Greenville County . 2015. "Long Range Facilities Plan and Capital Improvement Program." http://www.greenville.k12.sc.us/Departments/docs/planning/cip.pdf.

Greenville County . 2015. “School Bus Transportation.” http://www.greenville.k12.sc.us/Parents/main.asp?titleid=transportation.

Greenville County . 2015. “Transportation Department.” http://www.greenville.k12.sc.us/Departments/main.asp?titleid=transp.

Greenville County GIS. 2015. “Greenville County GIS.” http://www.gcgis.org/Index.html.

Greenville County Schools. 2015. “Greenville County School Facts.” http://www.greenville.k12.sc.us/Departments/docs/fastfacts.pdf.

Henninger, Adam. 2004. “Site Suitability Study.” http://www.csun.edu/~aah13199/Lab5/lab%205%20images/Site%20Suitability%20Study.htm.

Kerkow, Luke. 2014. “Site Suitability Analysis for a New School in Brisbane.” http://www.arcgis.com/home/item.html?id=f190fc29aa154829b5ee0a55235132e1.

National Center for Safe routes to School. 2011. “Education: Walkability Checklist.” University of North Carolina Highway Safety Research Center. http://www.saferoutesinfo.org/program-tools/education-walkability-checklist.

NHTSA. 2015. “Pedestrians.” National Highway and Traffic Safety Administration. http://www.nhtsa.gov/Pedestrians.

Office of School Facilities . 2013. “2013 South Carolina School Facilities Planning and Construction Guide.” South Carolina Department of Education. http://www.ed.sc.gov/scdoe/assets/file/agency/os/School-Facilities/documents/Draft2013Guidebook091712clean.pdf.

Pedestrian and Bicycle Information Center. 2015. “The Decline of Walking and Bicycling.” http://www.guide.saferoutesinfo.org/introduction/the_decline_of_walking_and_bicycling.cfm.

Schrader, James G. 1963. “Planning Advisory Service.” American Society of Planning Officials. http://www.planning.org/pas/at60/report175.htm.

State of North Carolina Center for Geographic Information and Analysis. 1994. “A Standard Classification System for the Mapping of Land Use and Land Cover.” http://www.gis.idaho.gov/portal/pdf/Framework/LULC/StdClassLCinNC.pdf.

Svatos, Vern. n.d. “Locating Potential School Sites.” http://www.proceedings.esri.com/library/userconf/proc01/professional/papers/pap618/p618.htm.

US Census Bureau. 2014. "Population Estimates."
http://www.census.gov/popest/about/terms.html.

USDOT. 2008. "NHTS Brief."
http://www.saferoutesinfo.org/sites/default/files/resources/Travel_To_School.pdf.

USDOT. 1972. "Livability." http://www.fhwa.dot.gov/policy/2010cpr/pdfs/chap13.pdf.

United States Environmental Protection Agency. 2011. "School Siting Guidelines."
http://www.epa.gov/schools/siting/downloads/School_Siting_Guidelines.pdf.

Vinther, Dann. 2012. "Children Who Walk to School Concentrate Better."
http://sciencenordic.com/children-who-walk-school-concentrate-better.

Worldometers. 2014. "Countries in the World (ranked by 2014 Population)."
http://www.worldometers.info/world-population/population-by-country/.