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Determining Transportation and Development Impacts of Consolidated Schools in West Virginia

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Abstract

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School consolidation has become commonplace in the West Virginia, with a declining student population as West Virginia has lost population over the last several decades. Consolidated schools offer school districts the opportunity to provide greater offerings in terms of coursework and extracurricular activities, while also allowing a reduction in some operating costs since fewer facilities are maintained and few administrative staff are needed to operate them. Consolidation also has impacts on school transportation, both in terms of time and mode choice, as well as the impact on land use patterns around the consolidated school facility.

This research seeks to help quantify those above mentioned variables for 5 rural school facilities at several different grade levels in different geographic regions of the state. Two high schools (one county, one sub-county), one county middle school, and two combined elementary/middle schools were chosen. Data were obtained from each facility for both the bus travel time and transportation mode choice for typical daily school travel. These data were then compared to state travel guidelines and national averages regarding mode choice. Aerial photography was also obtained for the area around each of the facilities both before and after the construction of the schools. A comparison was then made between housing units in the area before and after the construction of facility to determine if these schools encourage sprawl-style development. These housing numbers were also compared to population trends in the county to see if overall population trends matched the housing unit trends.

The results quantified some of the transportation and land use issues present with consolidated schools. In all cases, the growth in number of housing units either significantly exceeded the population growth or grew significantly in spite of population loss in the counties where the school was located, indicating that these schools may serve as the impetus for some sprawl-style growth. With regards to school travel, 4 of the 5 schools had average travel times that exceeded the state-prescribed travel times for each grade level, with significant percentages of stops over those travel times. In spite of this, higher percentages of students chose busing as their primary mode of school transportation than were present in other studies on school transportation. Study recommendations include giving additional consideration to bus transportation times and costs in school consolidation decisions and facility planning, as well standardizing the tracking process for logging bus travel times.

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Chapter 1 - Introduction

School consolidation in West Virginia has the potential to impact land use patterns and transportation choices for the affected areas. These impacts may include decisions on residential location, travel times to school and the subsequent mode choice in reaching school, and development of different types of infrastructure (water/sewer, electric, roadway, etc.). Further school consolidation is under consideration to reduce the costs of operating a school system, including building maintenance and operation, teacher salaries, and administration costs. This project seeks to investigate the impact that consolidated school facilities generates, from the standpoints of both land use and transportation. Land use impacts may include the decision to renovate existing structures versus building anew, as well as school acreage needs and their impact on school facility siting. On the transportation side, impacts may include longer student travel times, increased transportation costs, and fewer mode choices. More specifically, do these school facilities promote sprawl-style development away from established urban areas, and how does the location of these school facilities impact the travel time and mode choice of students reaching school?

1.1. Background

It is important to explain what school consolidation is and what has driven its implementation. School consolidation is the closing of two or more school facilities and the consolidation of their student bodies into one or more combined facilities. School consolidation is driven by the desire of school systems to reduce overall costs. By consolidating enrollments into one facility, the school system needs only one staff, as opposed to several pre-consolidation, to administer the facility. Maintenance costs are reduced as there are fewer facilities to maintain. By placing more students and faculty in one facility, more diverse offerings, both curricular and extracurricular, can be offered that were not feasible at the individual schools. Part of what has driven consolidation in West Virginia is a reduction in general population and the resulting reduction in student enrollment. In the twenty-year period between 1980 and 2000, approximately 300 schools were closed in West Virginia as part of consolidation efforts. The reasoning behind many of these closures was that individual schools which formerly had larger enrollments now had enrollments which were too small to continue operating the facility efficiently, and overall costs would be reduced with consolidation.

There are potential negative effects to consolidation, as well. In many cases, the consolidated school facility is located in as central a manner as possible to the entire student body. In West Virginia there are several cases where one school serves an entire county for several grade levels. Students most often face longer travel times to and from consolidated schools as compared to their former, non-consolidated facility. Transportation mode choice for many students is limited to either bus or personal automobile. School systems must provide larger bus fleets that travel more miles after consolidation, as well. This can result in heavy costs to the school administration, in West Virginia's case the county school board. These costs may even counter the cost-saving measures resulting from school consolidation. There are additional safety concerns in placing students in transit to and from school for a longer amount of time, given that additional travel time, by bus or personal automobile, may provide additional exposure for vehicle crashes. The facility may also serve to encourage sprawl-type behavior in residential decisions (moving closer to the school facility and away from the urban core) and automotive usage (reinforcing automobile dependence due to the travel distances to school).

Land use patterns for most of the United States have followed a pattern of outward migration and suburbanization since World War II. Policy measures instituted after the war made home ownership in outlying areas more affordable to soldiers returning home. Another factor in the decision to migrate away from and out of the established urban boundary was the construction of new high-speed, high-capacity roadways that enabled quicker travel for more vehicles from outlying suburban areas, where residences were springing up, to urban areas, where the bulk of employment opportunities still existed. This development resulted in what is defined as sprawl, marked by low-density residential and commercial development and auto-dependency. West Virginia, with the exception of a few areas within the state, has not faced major problems with suburbanization. The urban areas within the state have seen limited outgrowth from the urban core, with areas in the Eastern Panhandle, North Central West Virginia, the Beckley area, the Teays Valley region, and along Appalachian Highway System Corridor G in the Charleston metropolitan area beginning to experience the initial stages of extensive suburbanization. The lack of major metropolitan areas served to limit this, as well as the mountainous terrain and a general desire by the population to maintain a rural landscape. As a result, some of the characteristics of sprawl synonymous with suburbanization, such as major traffic congestion and heavy "big-box" commercial development, have not been extensively present within the state.

School facilities, both in West Virginia and nationally, however, have somewhat mirrored this outward pattern of development, away from the urban core. Traditionally, schools were "neighborhood" facilities, serving a relatively small geographic area. In West Virginia, these could be both in the form of more urban neighborhood schools or even "one-room school" type facilities in more rural areas. By serving a smaller geographic area, with short travel distances, schools offered students a choice in modes of transportation, including non-motorized modes such as cycling and walking. The urban neighborhoods where some of these schools were often located featured sidewalks and low traffic speeds which also encouraged walking and biking. Due to their land-constrained urban locations, these urban neighborhood schools usually provided limited or no parking, which discouraged personal automobile use to reach the facility. The rural one-room schools were often located within a range from the students' homes that allowed non-motorized transportation. These school facilities tended to be vertical in their constructed nature, requiring a small footprint in terms of land development. Since each individual school served a small geographic area, many schools were needed within a region to adequately serve student enrollment. Each school had to be staffed and maintained, with additional administrative and maintenance costs resulting for each school.

As many areas within West Virginia lost population due to economic decline, county school boards began to make adjustments in the nature, size, and location of their school facilities. In some areas, as the population base shifted outward from the city/town or just left altogether, local schools lost enrollment and often consolidated with other schools facing a similar situation. With more land available in the outlying areas, the need to provide a facility centrally located to both communities, and the necessity of a larger facility to meet the larger enrollment demands of a consolidated facility, many schools built facilities with a larger physical footprint, more horizontal and sprawling in nature and with more parking facilities provided. These facilities had the capability to serve a larger student enrollment, and were located as centrally as possible within the geographic area served. The consolidated school's location, in trying to serve a larger geographic area, was often located in an outlying area. This resulted in a facility where the dominant travel modes were automotive, both personal and publicly-provided transit. This was reinforced by the built nature of the community, as the only way to access the schools were often roadways, with few sidewalks or trails provided for alternative transportation modes. Abundant parking needed to be provided to handle the automobile traffic, resulting in a more sprawling facility. While not driven by the same forces, many of these characteristics mirrored the process of suburbanization. This indicates that schools may have the capability to induce sprawl-style development patterns.

Consolidated schools have the potential to impact the residential development, population density, and land use patterns of a community. Since a consolidated school is a combination of previously separate school facilities that served different geographic areas, the location of the consolidated school can have an impact on the development pattern of a community. Locating a consolidated school facility in a geographic location that is central to the entire population within the county boundaries can result in a school placed somewhat equidistant to and subsequently outside the established urban communities within a county. Living close to a school facility is a determinant in residential location, and an outlying school facility may encourage residents, as well as commercial and retail interests, to also locate in outlying areas, as well, contributing to school-induced sprawl. In West Virginia, some of the rural areas chosen for consolidated school location may have previously had little to no supporting infrastructure, such as electric, water, and sewer facilities. School construction, and the installation of this infrastructure, may encourage further residential and commercial development, due to the sudden viability of the area for growth.

Transportation to and from school may also be impacted by school consolidation. The closing of neighborhood schools, which were accessible by multiple transportation modes, often results in larger, more remote facilities, accessible only by motor vehicle modes, either personal automobiles or buses. Longer bus rides may also result for some students, long enough to potentially force them to drive to cut down on travel time and provide more flexibility in personal schedules. Mode choice is thus potentially affected by the closure of neighborhood schools and the opening of a consolidated facility. Consolidated school facilities may also serve as significant traffic generators. If proper roadway capacity is not provided, traffic congestion can result on local road networks around the facility. Additional safety concerns can result from placing students on the road for a longer period of time. A statistically high-risk driving group – teen drivers - may be encouraged to drive to consolidated schools. Depending upon the location of the facility relative to the residential location of students, travel times may be significantly increased for students throughout the county. One other potential impact is the increased transportation costs that the school board must bear due to longer travel distances and larger vehicle fleets, and subsequent increased fuel and vehicle maintenance costs.

There are potentially negative impacts to this type of relocation of schools. From a transportation standpoint, as mentioned above, non-motorized transport becomes more difficult, given the travel distances inolved and the lack of infrastructure (e.g. trails and sidewalks) to accommodate such travel. As the nation grapples with an epidemic of physical inactivity (and its consequences such as obesity and chronic diseases) for the population generally and particularly for young people, active transport to school and the inability to do so with newer, more remote schools has been cited as a significant concern. Construction of new schools in undeveloped areas away from the established population base reinforces the dependency on motorized transport and discourages students and their parents from pursuing active transport in school-related travel.

Another factor is the potential impact of these facilities on the natural environment. Often, due to acreage requirements or school planning policies, these consolidated schools are located in rural and exurban areas with little or no adjoining or nearby development. These school facilities, with their expansive campuses and significant acreage requirements, often intrude on or significantly alter former green spaces, including farmland, forested areas, and natural wildlife habits. With the sprawling buildings and large paved areas associated with them, such development may increase emissions, create 'heat island' impacts and increase stormwater runoff.

Policy measures, primarily related to school construction and siting, are also relevant to the school consolidation discussion. The exact nature of the measures and some of their impacts are discussed further in the literature review. What is important to note is that many policy measures have made it seemingly easier and more affordable, from a financial cost standpoint, to build new outlying school facilities, as opposed to renovating older urban structures. Many states have also instituted school construction policies with regards to acreage and setback requirements that severely limit site availability in urban areas, forcing new school construction to occur in outlying areas. In West Virginia, due to the lack of local zoning authorities, county school boards are often able to pursue their own course of action in school construction, provided it meets state standards for setback, acreage, square footage of classroom space, etc. Given West Virginia's primarily rural nature, site availability for these physically large schools is not a concern in most areas.

There are sound reasons to consolidate school facilities, namely reduced administration and facility maintenance costs, as well as the potential to offer additional curricular and extracurricular offerings. However, it is not clear that the transportation impacts of consolidated schools, including longer travel times for students and additional transportation costs to the school boards have been assessed. Similarly, the effect of school consolidation on development patterns has not been examined objectively.

1.2. Problem Statement

This investigation seeks to determine whether consolidated schools and their location impact land use and residential development patterns, and if there is an impact, its extent. This investigation also seeks to determine, if any, the impact of consolidated schools on several different facets of school transportation, including travel times, mode choice, and school transportation budgets. At the same time, this investigation looks to analyze the validity of several types of data to studying transportation and land use issues.

1.3. Research Objectives

Project Objectives Include:

- Review relevant transportation engineering/planning and school location (including planning and design/transportation) literature
- Identify appropriate parameters to use as measures of the impacts of consolidated schools and determine their availability for West Virginia schools
- Assess the accuracy/validity/reliability of sources of data
- Identify schools/school complexes to evaluate as case studies
- Acquire the appropriate data for the selected school facilities
- Analyze the data qualitatively and quantitatively to identify explicitly transportation and development impacts of consolidated schools
- Prepare a final report documenting the results of the study

1.4. Organization of the Report

The report will begin with a Literature Review compiled from some of the various sources mentioned above to provide background on the topics of school consolidation, school transportation, and land use impacts from school facilities. The Project Methodology, including justification for inclusion and exclusion of certain sources of data, will then be detailed. A summary of the Data and Observations included in the report will be provided. The analyses of these data will then be discussed, including any trends gleamed from the data collection and analysis. Finally, the findings and conclusions will be detailed.

In answering these questions, the investigation will have two steps. The first of these steps will identify potential data and qualify which of these data can provide an accurate representation of land use patterns and travel behavior. There are several types of data which may have relevance to the study, from Census data to aerial photography to school parking data and bus travel logs. Determining the accuracy and importance of this data, as well as finding suitable case studies, will determine what subsequent analysis will take place in the second step. Both quantitative data, such as some of the data sources mentioned before, and qualitative data, such as that from on-site observations and surveys or interviews with key school personnel, will also be evaluated. In establishing case studies, consolidated schools will be used as the test cases to determine the land use and transportation impacts of suburban or exurban school facility, while more traditional, urban school facilities will be used as the control cases for comparison.

Chapter 2 - Literature Review

2.1. Introduction

The consolidation of school facilities in West Virginia has potentially significant impacts on the land use patterns and transportation choices of the affected area. These impacts may include decisions on residential location, mode choice in reaching school, as well as the placement of different types of infrastructure (water/sewer, electric, roadway, etc.). As education budgets tighten, further school consolidation may be forthcoming to reduce the costs of operating a school system, including building maintenance and operation, teacher salaries, and transportation costs among other factors. This project seeks to investigate the impact that consolidated school facilities generate, from the standpoints of both land use and transportation. Land use impacts may include the decision to renovate existing structures versus building anew, as well as school acreage needs and their impact on siting. On the transportation side, impacted areas may include travel times, busing costs, and mode choice. More specifically, do these school facilities promote sprawl-style development away from established urban areas, what is the impact on travel time to school, and how does the location of these school facilities impact the mode choice of students reaching school?

In answering these questions, the investigation will have two steps. The first step will qualify which available data can provide an accurate representation of land use patterns and travel behavior. There are several types of data which may have relevance to the study, from Census data to aerial photography to school parking data and bus travel records. Determining the accuracy and importance of this data, as well as finding suitable case studies, will determine what subsequent analysis will take place in the second step. Both quantitative data, such as some of the data sources mentioned before, and qualitative data, such as that from on-site observations, surveys, and phone interviews will also be evaluated. In establishing case studies, consolidated schools will be used as the test cases to determine the land use and transportation impacts of the suburban or exurban school facility, while more traditional, urban school facilities will be used as the control cases for comparison.

This literature review examines school consolidation and associated land use and transportation impacts in three parts. The first is a discussion of the land use issues related to consolidated school facilities. This includes a historical look at suburbanization, a process which may mirror some of the land use and residential decision impacts of school consolidation. Included in this discussion is a review of school acreage policies, school construction policies and their impact on the decision to renovate an older school facility versus new school construction, as well as a history of consolidation and the policies involved. In looking at the transportation impacts of consolidated school facilities, several topics are addressed, including mode choice, travel times to and from school, safety concerns, trip generation, bus costs, and school transportation policy. Finally, an analysis of the viability, or questionability, of the data available to complete the study will be presented. These data sources include aerial photography for an overview of development and land use patterns in a community, U.S. Census Data for school financial information, data from county school boards on student bus travel times, and parking or personal survey data to determine mode choice between busing and personal automobiles. Each data source has both potential benefits as well as limitations in its use.

Several different types of literature were reviewed. The scholarly works were available primarily from transportation engineering and planning sources, including journals and references from professional societies. These included studies related to school travel, relating land use patterns and distance to school facilities to both traffic impacts and mode choice. There was also literature reviewed on the topic of school building policies and their impact on school construction trends and school location. Some scholarly work also focused on the transportation impacts, in terms of financial cost, of school location and consolidation cost. School building guidelines, in terms of physical size and location, and consolidation policies provided by state school boards or school building authorities were also reviewed. Specific to West Virginia, a series of newspaper articles on school consolidation and the transportation and education impacts and costs associated with it were also included in the review. In seeking to compile the resources for the literature review, several different search terms were used to find appropriate literature. General literature was searched for using keywords related to school transportation, school consolidation, school construction, and school consolidation policy. Some of the databases used included Google Scholar, the Rural Preservation Trust, Council of Educational Facility Planners International (CEFPI), Transportation Research Information Service (TRIS), Bureau of Transportation Statistics (BTS) and the Transportation Research Board (TRB). A full list of applicable search terms is attached in Appendix I.

2.2. A Historical Look at Suburbanization and Sprawl

Since World War II, there has been a general outward migration of the population base away from the established urban core. This migration can be traced to several causes, including the development and expansion of the Interstate Highway System and policy measures that made home ownership more feasible for the middle class. As pointed out in Duany et al's *Suburban Nation* (2001), expansion of the Interstate Highway System made previously inaccessible areas available for development and residential habitation. These high-speed roadways allowed relatively easy access from the suburbs to the urban areas where the bulk of employment opportunities still existed in the early days of suburbanization. TRB Special Report 298 prepared by the TRB Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption (2009) indicates that in recent years some of this trend may have begun to reverse, but that a multitude of factors play into where people choose to locate. This study also pointed out that increased density does necessarily lead to less automobile usage, since this is heavily influenced by neighborhood and infrastructure factors. Specifically within West Virginia, the expansion of the Appalachian Highway Corridors has allowed previously isolated, rural areas the opportunity to develop. Duany, et al (2001) point out that policy measures passed following World War II made financing home ownership much more affordable, and for the first time the middle class could afford to move away from the urban core. The effects of this population migration were damaging to urban areas, with the erosion of the resident urban tax base and the subsequent urban blight that followed. This spurred further outward migration, as most of the urban population that could afford to move out did so (termed in some locations as 'white flight'). As the population bases have moved outward, many facilities that previously were present in the densely populated urban areas moved or expanded into new suburban population centers to follow the shifting population base. This movement resulted in what is characterized as sprawl-style development.

In some areas, traditional neighborhood schools have combined with other school facilities to create consolidated schools, often located outside the urbanized area. Everett, Ryan, and Smith's study (2005) points out that living close to a quality school facility is a major determinant in housing choice and subsequently, real estate value. Yang, et al. (2010) at the University of Oregon researchers completed a survey of the parents of schoolchildren which indicated that 78% considered their children's mode of transportation in reaching school when choosing their current residential location. This Oregon study also pointed out parents, with a preference for active school transport (walking or biking to school), viewed the environmental factors for active school transport more important than the home-to-school distance. Sharp's 2008 study on local governments and schools revealed that some parents even base their perception of the quality of the school on how recently it was built or established. Others who choose to remain in their current residential location face longer commute times to and from school. In this way, consolidated schools may serve to promote sprawl-type behavior, either through encouraging residential development in outlying areas, closer to newer school facilities, or reinforcing auto-dependency with longer travel distances to school. The Michigan Land Use Institute's study (2004) has shown that new schools constructed at the far suburban edge of established communities serve to bring development to previously undeveloped areas.

Before discussing some of the land use impacts that literature has identified school facilities as potentially having, it would be advisable to present what physical aspects characterize most suburban development in the United States today, as well as define the term sprawl. Most suburban communities are built under zoning standards that require a spatial separation of different land uses. This means that residential communities are built separate from retail and commercial uses, as well as any industrial or institutional uses. Some of this zoning serves to separate land uses that function poorly together or near each other, such as industrial and residential. As a result, these land uses are located at some distance from each other, most often at a distance outside the accessible range to walk or bike to reach these destinations, as Duany, et al. (2001) point out. This is in contrast to older, more urban developments which were much denser, both from a population standpoint and with regards to the built environment, with different land uses being mixed together and in much closer proximity to each other. Duany, et al. (2001) discussed how these urban developments allowed for a choice in transportation mode, with multiple land uses within walking or biking distance. Duany also points out that one of the defining characteristics of most suburban development is a reliance on the personal automobile for almost all travel. The different land uses in suburban-type development are connected by roadways, with little or no provision for any other type of modes. The encroachment of these roadways, as well as other infrastructure resulting from the school construction into previously undeveloped areas should be expected to open these areas up to development. Schweitzer and Schexnayder's (1994) study of expected development around a newly constructed roadway in a National Park in Tennessee displays that single unit housing would be expected to grow in the newly accessible area. Seto and Liu (2003) point out that a suburban pattern of development in the United States is often a linear outgrowth along a roadway or other infrastructure. This outgrowth into new areas for development is sometimes termed sprawl. The simplest definition of sprawl, as provided by the National Safety Council's Environmental Safety Center, is that sprawl is "unplanned development of open land." Burchell, et al., in their report *The Costs of Sprawl Revisited* (1998), used a more detailed definition first provided by Ewing, defining sprawl as "the spread-out, skipped-over development that characterizes the noncentral city metropolitan areas and nonmetropolitan areas of the United States. Sprawl is one- or two-story, single-family residential development on lots ranging in size from one-third to one acre (less acreage on the West Coast), accompanied by strip commercial centers and industrial parks, also two stories or less in height and with a similar amount of land takings."

2.3. Land Use Issues Related to Consolidated Schools

There are several notable land use issues surrounding the construction of suburban or rural schools. One of these is the acreage requirements for building new schools, set by school building authorities or state and local school administrations. School facilities in urban settings have a relatively small footprint in terms of the land taken up by the facility. As Beaumont and Pianca (2002) pointed out, these neighborhood schools were vertical in terms of their construction, allowing for more classroom space within a small property footprint. Minimum acreage requirements serve to limit site availability for new school construction, often forcing the school to move outside the urban area and into large, undeveloped lots commonly found in suburban and rural areas. The ability to acquire a parcel of land in urban areas of the sizes recommended by school building policies is often prohibitive, both in terms of cost and acquisition. Beaumont and Pianca (2002) reveal the alternative is to look for more affordable land situated in less densely developed or rural areas. New school facilities are subject to minimum acreage requirements, as well as coverage and setback standards. These standards are prescribed by each individual state, and can differ radically from state to state. An international organization, the Council for Educational Facility Planners, International (CEFPI), provides a general standard of 30 acres for a high school facility, plus an additional acre for each 100 students attending. For instance, a high school with 800 students, under CEFPI guidelines, should have a minimum acreage of 38 acres. While this is a recommended guideline, it is not a legally binding standard, and states can and do create their own school building acreage policies. A summary table provided by CEFPI (2003) shows that several states, including Maryland and Massachusetts, potentially as part of a Smart Growth initiative or in an effort to protect older neighborhood schools, choose to set no minimum acreage requirements, while others, such as Ohio and Minnesota, institute larger acreage standards than those recommended by CEFPI. Kouri's (1999) research in South Carolina indicates that schools constructed after 1980 were, on average, on significantly larger sites than the state minimum requirements, a sharp departure from the pre-1970 period. Most states have wording in their policies to allow for deviations from the guidelines. From an acreage standpoint, the past standard from the West Virginia State School Building Authority had set a minimum value of 15 acres for a secondary school facility, with an additional acre needed for each 100 students over an enrollment of 800, as specified by CEFPI. More recent standards from the West Virginia Board of Education are based on total student enrollment and a sliding scale of square footage per student based on enrollment, and published in Title 126.

Another issue in school construction and siting is the decision of whether to renovate an older facility or construct a new facility. Many states use a mathematical cost relationship, sometimes known as a "two-thirds" or "one-half" rule. As discussed in the Beaumont and Pianca study (2002), the rule states that should the ratio of the cost to renovate an existing structure to meet established standards versus the cost for construction of a new school exceed a specified ratio, such as two-thirds or one-half, then the new school alternative will be preferred. One of the complications of this rule is the application of new building or legal requirements to urban, neighborhood schools built before the establishment of such guidelines. As discussed by Beaumont and Pianca (2002), in determining a cost comparison between renovation of an existing facility or new construction, the cost to acquire land may or may not be included in the costs of renovation, and non-inclusion of this in funding formulas may rule out school renovation.

The decision whether to build or renovate can also be influenced by the fact that in some cases, developers will donate the land in order to reduce the costs to the school district associated with new school construction upon it, subsequently increasing the real-estate value of the surrounding land for the developer (Beaumont and Pianca, 2002). School systems are more willing to build a new facility when the land on which to construct the facility is free, and parties interested in development of an area may seek to push development in this direction. These school construction and funding policies and developer self-interests have created an environment where it is difficult to maintain land-constrained urban school facilities to modern standards, and have increased the number of schools being constructed in outlying areas. Conversely, as Wagner (2009) points out, a school facility can also serve to drive development, as developers are aware that locating near quality school facilities makes for a great advertisement for their particular venture. In the case of West Virginia consolidated facilities, the relative lack of nearby comparable facilities may serve to drive development in much the same way.

Another factor in the decision to renovate or build anew is the lack of oversight that governmental planning authorities have over school planning bodies. Steiner, Crider, and Betancourt (2006) revealed that in many states, including West Virginia, school planning/building authorities and boards are exempt from county, state, or municipal zoning regulations or comprehensive planning. This can lead to the construction of facilities that are not in coordination with existing transportation and land use plans and zoning regulations, if those plans do exist. In West Virginia, many areas either do not have local planning authorities or have an opposition to any sort of central land planning authority. This leaves the school board or school planning/building authority to make its own decisions on the new facility's location, without taking into consideration the larger impacts on land use or traffic. Wagner's study (2009) in Georgia indicated that some school districts cooperated with local governments, while others were less than cooperative. His study's interviews with school districts revealed that there was some disagreement on whether schools drove development, or development drove a need to construct new schools.

A final issue in this land use discussion is the policies behind the decisions to consolidate schools. In West Virginia, these policies are based on student enrollment figures as a percentage of the operational enrollment capacity of the current school facility, as detailed in Title 126-6204. If the current or expected enrollment falls below that percentage for a period of time, the administrative body of the school will look to close that facility and either combine it with another nearby, or look to combine both student bodies into a new consolidated facility. The methods used in estimating future enrollment can be complex statistical relationships, using both current enrollment, expected or estimated future enrollment, past attrition rates, and regression analysis to produce estimated future enrollment. A study of these methods is outside the scope of this report, but a point is to be made that these consolidation processes may or may not take into account the distribution of where students live, the travel times incurred in reaching the new consolidated facility, and the potential land use impacts that a new school facility may exert on the area.

Nationally, school location and siting is seen as a major factor in residential development in a community. As W. Cecil Steward (1999), Dean Emeritus of the College of Architecture at the University of Nebraska said, "the public school…is the most influential planning entity, either public or private, promoting the prototypical sprawl pattern of American cities." The term "school-induced sprawl" refers to sprawl relating to the construction of a new school facility on land that was previously undeveloped, and potential development that may occur as a result. Wagner's study (2009) indicated there is a correlation between location of a school facility and the development of the area around the school. In this same study, development increased following the construction of the school facility for rural districts close to and in a mid-range distance from the school facilities, while decreasing far from the rural school facilities.

A University of California Berkeley study (Katz, 2009) indicated that school systems are favoring construction of new, larger schools over renovation of smaller existing school facilities. School districts have and are continuing to look toward consolidation, as a 2003 EPA study showed that the number of schools has declined by approximately by 70 percent since World War II. The same study also found that school enrollment size, and the land area used for a school facility, have increased at the same time, with the average enrollment nearly five times that of the average school just after World War II. A study in Maine (Richert, 1997) revealed that over $700 million was spent on new school construction, while student population declined by 27,000. In West Virginia, consolidation has meant major changes to county schools, with the closing of over 300 schools, as Eyre and Finn's 2002 study points out. Part of this is related to a population and enrollment decline in several areas of the state. This has resulted in a proliferation of 'county' high schools, with one high school serving an entire county. Due to the distances that students must travel to reach the school facility, especially by those on the outer fringe of the school district, this creates a school transportation system based entirely on buses or automobiles.

2.4. Transportation Impact of Consolidated Schools

Beyond the land use impacts, consolidated schools also influence travel getting to and from school. Older, more urban schools drew primarily from the surrounding neighborhood or neighborhoods. The distance between school and home was relatively short, since the school drew from a relatively densely populated neighborhood. This small geographic area means students had a choice of transportation modes, including walking, biking, or transit. The layout of these traditional neighborhoods also promoted a choice in modes, given that sidewalks were common and low traffic speeds meant that students had a safer environment in which to bike or walk, as Ewing, Forinash, and Schroeder (2005) discuss. A 1972 USDOT-FHWA (Beschen, 1972) study showed that a significant proportion (42%) of students surveyed and studied walked or biked to school. The 2005 Ewing, et al. study mentioned above verified that students in these traditional neighborhoods are still more likely to choose alternative modes to the automobile than those living in suburban-type neighborhoods.

Schools in suburban or exurban areas were often built under zoning restrictions that required a strict separation of uses. Institutional facilities, such as schools, were separated from residential areas, which in turn were separated from commercial areas. The long distances between different land uses encouraged that most, if not all, trips be made by automobile. For most newer schools, motor vehicle transportation, whether by private automobile or bus, is the dominant mode of travel. These newer schools often are accessible only by roadway, creating an environment where bicycle or pedestrian transportation is difficult if not dangerous. Thus, compared to the pre-1972 period, only a small percentage of students in these suburban neighborhoods walk or bike to school today. In the 2005 Ewing, et al. study, for the outlying school facility, none of the trips at the facility surveyed were done by walking or biking. A 2002 TRB study on school transportation has found nationally that approximately 10 % of trips students make to school are walking, with some minor variations amongst differing age groups. In another study (Eyler, et al., 2008) on the success of active-transport-to-school programs, school siting was seen as a major factor on these programs and their ability to promote walking as a viable mode choice to school.

The availability of both motorized and non-motorized transport infrastructure also plays a role in the mode choice decision. Sidewalks and trails may make non-motorized transport more feasible, while the absence of these facilities may serve to further encourage motorized transport to school. The Eyler, et al. (2008) study on active transport to school measures indicated that even where sidewalks were available, parents were hesitant to allow students to walk to school, given that the sidewalk network may have been incomplete, adjacent to roads with high-speed traffic, or areas of the sidewalk network were not properly cleared of snow or leaves in various seasons. Eyler, et al.'s (2008) study also found some were also concerned about safety of the children on the way to school in terms of abduction or harm from strangers, an important non-transportation factor in the mode choice decision. Another area of concern was the street network and parking available around the school, as lot size and queuing room for student pick-up and drop-off influence the perception of safety for not only motorized but non-motorized transport to the facility.

Rhoulac (2004) provided information from North Carolina on mode choice relative to grade level. On the whole, students are more likely to bus to school in elementary and middle school, with more students of age to drive in high school, as well as additional after-school extracurricular activities necessitating driving to school. Middle school students were the most likely group to take the bus, with high school students the only age group more likely to drive or be driven. At all grade levels, minimal percentages (=<6%) used non-motorized transportation in the North Carolina study. Additional factors involved in the mode choice decision mentioned by respondents in this study included the perceived consistency in terms of time of arrival for the bus, personal availability of an automobile, and potential conflicts with work schedules. In Kouri's study (1999) on South Carolina school facilities, students were 4 times more likely to walk to a school constructed pre-1983, as opposed to post-1983.

An additional factor in this discussion is the establishment in some school districts of 'no-transport' zones, or areas where bus service is not provided. In many school districts, a certain 'radius' around or distance from a school is established within which the school system provides no transportation to and from school. Eyler, et al.'s (2008) study pointed out this range can be as short as 1 mile in certain areas, while extending to longer distances in other areas. Depending on the length of this radius and the transportation network surrounding the school, this 'zone' and policy of not providing busing within it may encourage additional personal vehicle transportation to school. Eyler, et al.'s (2008) study also pointed out that in suburban areas with higher speed roadways and limited or no sidewalks, students living within a feasible range may be discouraged, due to the lack of non-motorized transportation facilities, from using non-motorized transportation. Both Kouri's (1999) and Rhoulac's (2004) studies found some areas may provide some form of 'hazard' transportation, or transportation for students living within a close range of the school, but with a non-motorized trip to school deemed too dangerous by the school authority. With no busing option available, these students have no choice but to drive or be driven to school. If population within this 'no-transport' zone is dense enough, schools may be encouraging a significant amount of vehicle trips to their facilities. Hoelscher's (2010) study as to the congestion impact of this no-transport zone completed at 2 schools within close proximity to each other in Texas indicated that an overwhelming majority of the students within this area (2 miles) were driven to school by parents or as part of a carpool.

Consolidated schools also affect student travel times going to and from school. As schools consolidate and neighborhood school facilities close, travel times may be increased due to the location of the new consolidated facility, as discussed in Eyre and Finn's 2002 series on West Virginia school consolidation. This can depend on the proximity of the school facility to established population bases. For students located at the fringes of the drawing area of the district, this can mean significant travel times between home and school. There are some noted consequences from increasing the travel time to and from school for students. The Eyre and Finn study (2002) stated students who have longer travel times to school show a decrease in academic performance. The additional travel times these students face often result in having to wake considerably earlier than students living closer, as well as arriving home considerably later at the end of the school day. The fatigue and reduced time to complete homework are seen as potentially detrimental to performing well in school. This 2002 study also points out students facing long travel times are less likely to participate in extracurricular activities. Many schools, because of the costs involved and distances covered, cannot provide additional transportation to outlying areas for those participating in after-school activities. This leaves the students unable to participate unless they have a personal car, are able to carpool, or are able find a parent willing to pick up the students from the activity.

As discussed in the 2002 TRB study on school travel safety, all school-related travel has travel safety concerns involved, including that to consolidated schools. With students spending more time on the school bus in reaching school, the chances of a crash are increased. This study reported that buses are still a relatively safe option for school travel, with only 2 % of student fatalities occurring while on a school bus, as compared to 75 % of student fatalities occurring in other motorized modes of transportation to school. For those that choose to drive to school, there is a potential safety concern involved with placing teen drivers on the roads for a longer time getting to and from school and providing additional exposure to potential crashes. Teenagers make up only 6.7 percent of the driving population, but are involved in 14 percent of fatal crashes, nationally, according to the National Highway Traffic Safety Administration (2007). Dodson and Garrett (2004), in their study on the economics of school consolidation, points out that the more time teen drivers, a high risk driving group, are on the road on the way to school, there is additional risk they are going to be involved in a transportation-related accident. An additional factor that plays into this is the perception of the safety of a particular mode of school transportation, especially parental perception. Rhoulac (2004), in surveys of school parents as part of her study of school transportation in North Carolina, noted that while the above statistics show school buses to be far safer than personal automobile transportation, more parents still believe the automobile to be safer.

Related to the mode choice decision is the recent overall decline in teen driving. Several factors may be tied into this trend. Neff's 2010 article discussed that some believe it to be due to the growth in digital interaction among teens, with social interaction being completed primarily through cell phone and internet conversation. The various smart tools available to teens (texting, mobile TV, etc.) are difficult to utilize while driving. E-commerce also contributes to a reduced need to drive to the mall or other shopping complex. Gregory's (2010) article points out another factor is a national increase in graduated driver's licenses. Many states have increased the initial requirements for teen drivers to acquire their license, with expanded supervised driving under a permit, or higher age restrictions. In West Virginia, teens are eligible to receive their permits at 15, and obtain their intermediate license at 16, but not able to obtain their senior driving license until age 17, at minimum. A final factor is the financial burden associated with buying and maintaining a personal vehicle. Halvorson's 2010 article reveals that fewer teens working in addition to the factors above all contribute to making it difficult for teens to purchase and maintain a vehicle, potentially making them less likely to obtain their license, or at the very least, minimize their driving. Given the relatively recent development of this trend, little research has been done into regional breakdowns of this trend or the prevalence in urban or rural areas. Therefore, it may be difficult to determine how far this trend has spread among West Virginia teenagers.

There is an additional safety concern in the amount of vehicular traffic that uses local roadways as a result of locating schools in outlying areas. Schools are recognized as traffic generators for planning purposes, are referenced in the ITE Trip Generation Manual as such, and their placement along roadways formerly handling low traffic volumes can create significant operational and safety problems, especially when school entry and exit times may coincide with commuter peak periods, depending on school start and dismissal times. The number of trips a school generates may also create congestion issues for street networks around the school, as well as at entry and exit points of the school campus. This is combined with the situation where a significant percentage of the drivers involved are teenagers, statistically among the most dangerous drivers on the road, as pointed out before. With consolidated school travel, as with all school-related travel, travel safety can be a major concern.

Roadway capacity near the facility and the traffic impact of school facilities may factor into the consolidation decision. Very little research has been completed in assessing the relationship between available existing roadway capacity and school location decision-making. Anecdotal evidence in the Michigan Land Use Institute (2004) study shows that congestion can be severe and issues can arise if proper roadway infrastructure is not part of the planning process. In review of WVBE Title 126, Series 172, it seems that while roadway capacity and conditions for a proposed school facility or renovation of an existing school building are to be considered in the educational facilities plan, nowhere in the policies is it stated that a formal traffic impact study is needed for new school construction. Throughout WVBE Title 126, Series 172 mentions are made to consider roadway conditions (geometry, driveway locations, parking access) in the area of the proposed facility.

On the basis of above, it would be expected that consolidated schools generate more vehicle trips compared to traditional schools. The Institute of Transportation Engineers (ITE) Trip Generation Manual provides some data to inform this discussion. This manual is a comprehensive resource that provides trip generation rates for a variety of land uses, including schools. For the purposes of comparison, the group used will be students driving on a weekday, but the Manual also provides an employee rate and gross floor area rate, as well. According to the 9th Edition of the Manual, the trip rate for a public high school facility is 1.71 trip ends per student, from a sample size of 51 schools. This is in comparison to an average weekday trip rate of 1.97 trip ends per student in French, Eck, and Balmer's (2000) study of travel to consolidated high schools in West Virginia, based on a sample size of 7 schools. One can conclude from this that rural, consolidated schools in West Virginia generate more trips per student than urban, neighborhood school facilities, due in part to the inability to reach the consolidated school by any alternative mode.

It is also interesting to trace the development of the trip rates for public schools over time, as more schools have moved away from the urban core and become larger. For example, in the 4th Edition of the ITE Manual, published in 1987, a trip generation rate of 1.385 trip ends per student was recommended for all public high schools, based on a sampling of 27 schools. For the 5th Edition, published in 1991, the rate is adjusted to 1.38, again using a sample size of 27 schools. As mentioned above, in the most recent edition, the 9th, the rate is 1.71. This rate may be increasing due to the increasing number of consolidated and non-urban school facilities being constructed. It is also interesting to note that trip generation rates are provided for the high school for both Saturday and Sunday, with peak hour rates also provided for each of those days. This speaks to the idea that the high schools serve as important centers of activity even on non-school days. Weekend activities at consolidated facilities may either increase the necessary travel required to attend and participate, or serve to exclude those that cannot make the additional travel commitments, or even represent a different population if the same type of community function is taking place. For a full summary of ITE trip rates and their evolution over time, see Tables 1, 2 and 3 below. These rates are still less than the rates from the West Virginia study mentioned above, indicating that West Virginia's consolidated facilities may encourage more personal auto usage.

Table 1 – ITE Manual Summary – Average Trip Ends/Weekday

Average Trip Ends per Weekday (with # studies in sample size)		
	Employee	# Studies
Consolidated High School-WV	24.58	7
Consolidated Middle School-WV	16.68	2
Consolidated Elementary School-WV	26.96	4
Public High Schools-4th Edition ITE	16.793	27
Public Elementary Schools-4th Edition ITE	13.099	40
Public High Schools-5th Edition ITE	16.79	27
Public Elementary Schools-5th Edition ITE	13.39	39
Public Middle Schools/Junior High-6th Ed. ITE	Not Provided	Not Provided
Public High Schools-6th Edition ITE	19.98	45
Public Elementary Schools-6th Edition ITE	13.13	25
Public Middle Schools/Junior High-7th Ed. ITE	Not Provided	Not Provided
Public High Schools-7th Edition ITE	19.74	51
Public Elementary Schools-7th Edition ITE	15.71	31
Public Middle Schools/Junior High-8th Ed. ITE	16.39	16
Public High Schools-8th Edition ITE	19.74	51
Public Elementary Schools-8th Edition ITE	15.71	31
Public Middle Schools/Junior High-9th Ed. ITE	16.39	16
Public High Schools-9th Edition ITE	19.74	51
Public Elementary Schools-9th Edition ITE	15.71	31

Table 2 – ITE Manual Summary – Average Trip Ends/Student

Average Trip Ends per Weekday (with # studies in sample size)		
	Student	# Studies
Consolidated High School-WV	1.97	7
Consolidated Middle School-WV	1.71	2
Consolidated Elementary School-WV	2.87	4
Public High Schools-4th Edition ITE	1.385	41
Public Elementary Schools-4th Edition ITE	1.032	41
Public High Schools-5th Edition ITE	1.38	27
Public Elementary Schools-5th Edition ITE	1.09	40
Public Middle Schools/Junior High-6th Ed. ITE	1.45	16
Public High Schools-6th Edition ITE	1.79	45
Public Elementary Schools-6th Edition ITE	1.02	26
Public Middle Schools/Junior High-7th Ed. ITE	1.62	20
Public High Schools-7th Edition ITE	1.71	51
Public Elementary Schools-7th Edition ITE	1.29	33
Public Middle Schools/Junior High-8th Ed. ITE	1.62	20
Public High Schools-8th Edition ITE	1.71	51
Public Elementary Schools-8th Edition ITE	1.29	33
Public Middle Schools/Junior High-9th Ed. ITE	1.62	20
Public High Schools-9th Edition ITE	1.71	51
Public Elementary Schools-9th Edition ITE	1.29	33

Table 3 – ITE Manual Summary – Average Trip Ends/1000 Square Feet Gross Floor Area

Average Trip Ends per Weekday (with # studies in sample size)		
	1000 SF GFA	# Studies
Consolidated High School-WV	13.38	7
Consolidated Middle School-WV	13.41	2
Consolidated Elementary School-WV	26.33	4
Public High Schools-4th Edition ITE	Not Provided	Not Provided
Public Elementary Schools-4th Edition ITE	Not Provided	Not Provided
Public High Schools-5th Edition ITE	10.9	20
Public Elementary Schools-5th Edition ITE	10.72	39
Public Middle Schools/Junior High-6th Ed. ITE	11.92	16
Public High Schools-6th Edition ITE	13.27	38
Public Elementary Schools-6th Edition ITE	12.03	25
Public Middle Schools/Junior High-7th Ed. ITE	13.78	20
Public High Schools-7th Edition ITE	12.89	43
Public Elementary Schools-7th Edition ITE	14.49	31
Public Middle Schools/Junior High-8th Ed. ITE	13.78	20
Public High Schools-8th Edition ITE	12.89	43
Public Elementary Schools-8th Edition ITE	15.43	34
Public Middle Schools/Junior High-9th Ed. ITE	13.78	20
Public High Schools-9th Edition ITE	12.89	43
Public Elementary Schools-9th Edition ITE	15.43	34

Another issue to be addressed in assessing the transportation impacts of consolidated schools is the cost of providing transportation to and from school, i.e. school buses. As Dodson and Garrett (2004) point out, one of the major arguments in favor of school consolidation is that, based on economies of scale, school operating costs, such as administration costs or educator salaries, as well as maintenance costs, due to fewer facilities, will be reduced as educational services are consolidated into fewer facilities and there is a need for fewer administrative positions. However, in some of the research that has been completed, it appears that nationally, transportation costs are growing faster for districts than the growth rate for attending students and the growth rate for bused students, as Killeen and Sipple discussed in their study. Killeen and Sipple (2002) also pointed out that per-pupil transportation costs are higher in rural as opposed to urban and suburban locations. There has been limited study done nationally on this topic, but some work has been completed for West Virginia. Eyre and Finn's 2002 study expectedly revealed some counties in West Virginia have found significantly greater transportation costs after consolidation, in spite of transporting fewer students. Transportation costs have become a major concern in recent years, as fuel costs have increased. Transportation costs can be expected to increase with a new school facility, as a larger vehicle fleet is required to drive more miles and transport more students from a wider geographic area. Duncombe and Yinger (2001), in their criticism of school consolidation, cited one of the most common diseconomies of scale is higher transportation costs.

An additional factor to take into consideration is the contracting out of school busing to private operators in certain areas, versus the school administration maintaining a vehicle fleet and employing the necessary operators and maintenance staff. Some states are able to contract this service out to a private contractor, while others maintain and run an active bus fleet themselves, either by choice or by legislative mandate. A review of the literature on this topic revealed a political focus (government involvement/service provision vs. privatization/free market) in much of the research completed. In West Virginia, Eyre and Finn's (2002) study has found that school districts spend a greater percentage of school budgets on transportation than any other state in the nation. In the study, the researchers infer that this is due to the distances some students must travel to school, and subsequently, the additional fuel and maintenance costs incurred from those additional miles. In the report completed by Eyre and Finn (2002) for the Charleston Gazette, it is estimated that busing costs in the state doubled in the 10 years between 1992 and 2002, despite the fact that the student population had decreased by approximately 25,000.

In total, Eyre and Finn (2002) estimated that the overall cost of consolidation and providing the appropriate infrastructure and school construction costs has cost the State of West Virginia approximately $1,000,000,000 over the decade prior to the study's publication. Some states, in recent years, have begun to recognize the potential for the long-term costs of consolidated and outlying school facilities and have developed comparisons for up-front renovations of older urban facilities to the long term transportation costs of non-centrally located school facilities, such as the State of Maine's Department of Education, School Facilities Services (2005) in their comparison worksheet. These comparisons look to evaluate the cost of retrofitting and renovating existing schools against the annual future costs to provide, operate and maintain busing and transportation services for the school district, as well as changing local tax revenue. Wagner's (2009) study noted that other states, such as Maryland and Florida, have incorporated their school facility planning and funding policies into larger 'smart growth' measures.

Some work has been completed on studying transportation costs in consolidated school districts. It would make sense that transportation costs may increase after consolidation, since a larger student body is being transported a longer distance. However, Duncombe and Yinger's 2001 study of New York schools indicated that consolidation could result in transportation cost savings. This study looked at a variety of consolidations, not just rural. Killeen and Sipple (2002) looked primarily at rural school facilities, and found that expenditures were rising faster than students transported, and that rural districts were the worst victims of this.

Future research could provide more insight in terms of looking at where transportation costs are directed (daily travel versus extracurricular, sensitivity to fuel costs, legacy costs, capital/equipment expenditures), as the limited data provided by the schools did not illuminate much on this topic. Another interesting comparison could come from looking at transportation costs in urban and rural/consolidated districts of a comparable size, and the impacts of 'no-transport' zones on costs.

2.5. Data

There are numerous data sources that potentially can be used in studying the travel behavior and land use characteristics of an area. One of these data sources is aerial photography, which presents an overview of the location of development in a community, as well the proximity of that development to established institutions, like the public school facility. Census Bureau data provides demographic information on communities, as well as information specific to schools. School district data can provide detailed travel times and information for students, as well as more localized data regarding budgets than the other sources. Each of these data sources presents strengths and weaknesses in the accuracy of specific types of information ascertained.

Aerial photography is one of these data sources. Aerial photographs are often used to determine the present location and condition of transportation facilities, while also identifying potential areas for new facilities. When combined with more detailed traffic information, needs in the network can be determined for planning purposes. Aerial photography also presents an overview of the level of development present in an area, in terms of land use, as well as where that development is taking place, relative to previously established urban and residential areas, as well as encroachment on to previously open land. Aerial photography allows a comprehensive look at land use as it relates to the location of transportation and institutional facilities. Using archived photographs, it is possible to track historical land development patterns, as well as the impact of a change in location of different types of facilities on commercial and residential location. Included in this is the potential to determine school-induced sprawl. One strength of this data is its objectivity; the data available from aerial photography is observation without bias, as opposed to respondent survey information, for example. The photos present a clear picture of the activity going on in the area at a specific point in time. This objectivity, however, also provides a weakness in cases where the development pattern is not clearly explained, or what other force may be at work in shifting land development. Anderson, et al. (1976) point out that larger scale (>1:10000) aerial photography has proven useful in the past for obtaining general information such as tax districts or road centerlines, but more detailed, higher-spatial-resolution (<1x1 m) photography is better for determining rural-suburban-urban distinctions. This 1965 study also points out that the appropriate spatial resolution for a USGS Level 2 Land Use/Land Cover analysis lies in the 5-20 m range.

Another data source that can be utilized is data from the U.S. Census Bureau. This data provides information on several different topics, ranging from school enrollment and districts to the income and poverty levels present in a community. This information is publicly available online. With regards to information pertaining directly to schools and transportation, the Census keeps a database of cartographic school boundaries, as well as demographic information, such as income levels, ethnic background, and family make-up for school districts in the United States. State and county data can provide population densities and land area data.

The Census also provides a Census Transportation Planning Package, a grouping of statistics designed to aid transportation planners. This package provides information on residence location and transportation choice in going to and from work, also publicly available online. While not providing direct data about travel to school, inferences can be made about the nature of travel in a community, as well as the travel choices made in relation to residential location. School financial information is presented that has been collected by the Census Bureau, and can provide information on the amount of money being spent on school transportation, both total and per-pupil, as well as the share of the total budget spent on transportation. One general advantage to the use of Census data is the ability to track historical trends on selected data, and to see the impacts of certain external influences, such as the type of zoning present in an area or the level of economic development or decay. One potential weakness lays in the lack of direct school travel data available. To utilize this data on a project such as this, inferences have to be made about travel behavior that may not be completely accurate in representing actual travel patterns. Little research has been completed in assessing the accuracy or weaknesses of the types of Census data that could be utilized in this investigation.

The school districts, both with locally kept records and anecdotal evidence, can provide a data source. Before discussing this potential data source, however, it is important to note there can be difficulty in obtaining this information. Some schools will be hesitant to make data publicly available, in order to avoid potential litigation. As highlighted by Eyre and Finn (2002), there is also concern over the quality, or lack thereof, in recording and reporting this information, as well the potential for school districts to avoid recording altogether. As pointed out in another article from the Eyre and Finn study (2002), all school districts in West Virginia, as of 2002, are responsible for charting school bus travel time for students by tracking bus route arrival times. This was in response to concern about inaccurate estimates of travel times for public school students in more recently consolidated school districts. The information for the Eyre and Finn (2002) study was released by the state only after the Freedom of Information Act was invoked. Bus reports, filed monthly, provide an insight into the amount of travel school buses make, how that travel is broken down (field trips, regular daily travel, athletics, etc.) how much they spend on fueling, and the number of pupils transported. Schools also have historical data on enrollment trends and budgets that can provide information on facility closure or consolidation, as well. School operating budgets, in particular transportation expenditures, when adjusted to a constant year dollar value, allow analysis of the validity of the argument that school consolidation saves on transportation costs, in cases where data is available from a before- and after-consolidation period. A comparison can also be made between the relative percentages of operating budgets spent on school transportation before and after the consolidation, provided the data is available in some sort of time series, and provided some consistent measures are evaluated. As pointed out before, one study has found West Virginia spends more proportionally as a part of its budget on school transportation than any other state. Data and information collected by school districts provide information specific to the geographic areas and school districts being studied, one potential strength over broader, more national data sources discussed earlier.

There are other potential information sources to utilize in the completion of a study of this nature. Specific to West Virginia, there are documents detailing the decision-making process that went into recent school consolidation efforts throughout the state. These documents help to identify the reasons behind some of the closure or consolidation decisions made with respect to specific facilities and districts. However, as Eyre and Finn (2002) discuss, this data has not been released to the public and there are some questions as to whether it is going to be made available. While it is not within the scope of this study to suppose the reasons for this inability to access the data, it displays some of the complications present in a study such as this. School consolidation, as a whole, is a very politically charged issue, and school transportation is just one topic within that discussion.

2.6. Concluding Remarks

The literature review revealed many things about the existing research completed on the topic of school transportation. Much of the research completed focused on traditional urban/suburban school systems or looked at some of the important factors from a state or metropolitan area-wide perspective. While useful, some of this information may not be reflective of expected trends in West Virginia, given the rural nature of the state and some of the case studies (covered in the following section). Some of the research reviewed (but not necessarily cited) was influenced by political biases or sought to push forth an agenda, but did provide an insight into the political and emotional responses tied to this issue of school consolidation. Reviews of the various state and jurisdictional policies showed the variance from state to state and area to area in acreage standards, busing times, and other measurable attributes for school facility construction and transportation. Overall, while considerable research has been completed in the area of school consolidation and its impacts, there are still many areas with limited work.

Chapter 3 - Methodology

Given the many different areas that school location and consolidation can impact in transportation and land use, several different types of data need to be collected. Aerial photography, especially when used in a historical series and at a proper scale and resolution, can indicate the distribution of residential and commercial location over time, including any change in that development pattern possibly impacted by the location of a new school facility. Using Census data, information on school budgeting and enrollment can be obtained to investigate expenditures on school transportation and their relation to school consolidation, as well as some of the physical characteristics of the district, including geographic area and enrollment. School districts and county school boards can provide data on expected school travel times, as well as potentially providing more localized data related to mode choice and busing.

3.1. School Selection

In choosing the facilities for this study, several factors were considered. Every public school in the state of West Virginia was considered. For the high and middle schools, the school was preferred to be a consolidated or county school facility. In many cases, counties were geographically relatively large, making it necessary to have several consolidated facilities, each serving a portion of the county. In West Virginia, consolidated high and middle schools are often designated by the county name or a directional location within a county. Consideration was given to any school facility of this type, including middle schools, junior and senior high schools. Consideration was also given to facilities that were consolidated from a grade standpoint, such as placing a junior and senior high school or an elementary and middle school in a single school facility.

In the case of elementary schools, it was rare to find only 1 or 2 schools serving an entire county. This may be in part due to the different time limitations on travel for elementary students as opposed to middle school and high school students, as detailed in the literature review. Another contributing factor may be a desire on the part of school administrators to keep classes smaller at a younger grade level, leading to less consolidation at those grade levels.

On a county by county basis, facilities were chosen based on the enrollment of the school and number of schools within the county. For instance, a county with fewer schools and a larger average enrollment would indicate a greater chance of a consolidated facility or facilities as opposed to a county of several more schools with smaller enrollments per school. Consideration was also given to elementary schools with a much larger enrollment than the other elementary schools in the county, potentially indicating a consolidated elementary school. Consideration was not given to schools which were not the only public schools at that grade level within a city or town; that is, there was more than 1 public school at a particular school level (senior high, junior high, middle school, etc.) in a city or town. The information for this portion of the investigation was available through the State School Directory, which is published annually and provides contact information for each school in the state, as well as enrollment numbers for the majority of schools.

Only public school facilities were considered for all levels, given that different funding and policies govern private school transportation. Vocational facilities were excluded from this study, given that vocational facilities tend to draw from a larger geographic area, in some cases several different counties. Vocational facilities may also have different schedules (half-day, internships and apprenticeships, etc.) than regular school facilities, leading to distinctly different travel patterns to and from the facility.

For the purposes of this study, school facilities in all types of land uses were considered, but preference was given to schools located in rural areas. Schools in these rural locales would better exhibit any land use and transportation impact than those located in urban or suburban areas, closer to the bulk of the general and student population. Given the general lack of land use restriction and zoning within West Virginia, schools serving areas where there were limits placed upon where development could occur, most often due to the presence of national or state parks and recreation areas of significant size, or due to urban zoning requirements, were not preferred for this investigation. Given the rural nature of West Virginia, as well as a general lack of governmental land use control and planning in many rural areas, these situations often provided the only form of "zoning" or land use control in many of the more rural areas within the state. The level of economic development or depression within an area was not a consideration in school selection, given that the greater portion of the state has faced economic situations which have led to a decreased general population and a subsequent need for school consolidation due to reduced student enrollment.

There were no limitations placed upon school enrollment or the size of geographic area served by the school. Google Earth, a mapping software tool, provides a Geographic Information Systems (GIS) feature which allows a user to do an overhead search with the location of school facilities labeled on the aerial photo. Using the Google Earth software tool, the geographic locations of these schools were evaluated as to the general land use in the area (rural, suburban, urban, etc.) in which they were located. In cases where the Google Earth tool had not been updated to the current conditions as indicated in the School Directory, county school maps, available for download through the State GIS Center, were used to clear up any confusion as to the location of the facility, then TerraServer was used for a final land use clarification. One potential complication was the age of the TerraServer aerial photos. Many of these aerial photographs were shot approximately 15-20 years ago, and may not represent updated, current conditions for more recently constructed school facilities and their surrounding areas. The Rahall Transportation Institute at Marshall University has provided a more detailed, higher resolution update to the Google Earth tool, specific to the state of West Virginia. This update allows better-quality imagery with the combined database capabilities of Google Earth. This tool was used to provide the final determination.

The age and availability of the aerial photography for the land use analysis served to further limit the number of schools available. It is desirable to have photography before and after the construction of the school, with additional photography preferred to attempt to complete a time series analysis. Subsequently, schools for which photography was not available both before and after the construction of the school were not preferred, given the inability to assess their land use impacts after construction, as well as the conditions in the area prior to the construction of the school. Information on the opening date for the operation of the school facility was obtained either from direct contact with county school board or school facility personnel, or from the county or school facility's website.

It was sought to have 5 school facilities total, with a mix of the different school types (high school, junior high school/middle school, elementary/primary school) that the public school system offers in West Virginia. Given the guidelines adhered to in school selection, some combined grade-level facilities were considered for selection. It was also sought to have schools in different regions of the state. This is also related to the lack of publicly available information on school transportation and the labor-intensive nature of the related data collection. Due to the lack of or difficulty in obtaining large databases of information related to school transportation, especially within the state, the data collected at each of these school locations will be compared to state-prescribed guidelines and standards, or prior averages from other research to determine the relative impacts of school consolidation on transportation to and from school facilities. In the completion of the project, five facilities were selected, with a mix of different grade levels. High schools represented 2 of these facilities, with 1 county and 1 sub-county consolidated high school, each containing grades nine through twelve. One county middle school facility, with grades 5-8, was also selected. Two combined middle school/elementary schools, both sub-county facilities, were selected, as well, with a total of 9 grade levels ranging from pre-kindergarten to grade eight.

Future research could expand the scope of the study to include more school facilities, or potentially focus on only one type of school (elementary, middle/junior high, senior high). More detailed comparisons could also be provided by comparing across different land types (rural versus suburban, etc.) and determining if the nature of the area surrounding the school factors impacts development patterns.

3.2. Data Collection

3.2.1. Assessing Land Use Impacts

One way to evaluate land use patterns, especially over significant periods of time, is to use aerial photography to track the development of a community or area. Using this data also allows some quantification of the impact of the physical movement of certain facilities, including school consolidation. Aerial photography is objective and not subject to personal bias; thus, the data are free from any sort of personal influence. There are potential weaknesses associated with aerial photography, as well. When doing historical analysis, it is important to match up the area being analyzed as closely as possible, given that different sources may provide overviews of different areas, using different photo heights, scales and resolutions. These various photo heights and scales show differing levels of detail and resolution, which can affect the analysis of those photos in the determination of ground features. Exclusively using aerial photography for a land use analysis without including other pertinent data that may affect land use, such as movement of a critical facility (a school, a major employer, etc.) may ignore the impact that other influences have on land use and residential and commercial development within a community.

Different classifications of aerial photography are available, defined by their scale and the resolution that they allow users to view images. In a land use analysis, it is important to properly define the limitations and precision of the scale and resolution of the photos being used in the analysis, so as to be able to properly distinguish land uses and identify necessary features, such as school facilities, housing and commercial properties in this instance.

For determining the potential impact of a school facility on land use patterns within a community, using a Level II to III classification system, as defined by Anderson, et al. (1976) for the USGS, is appropriate. At the Level II classification, the institutional land use is segregated, with Level III allowing for more detailed classification as discussed by Anderson, et al, (1976). This allows for a range of scales from 1:15000 to

1:50000, with varying time periods of collection depending on the type of data sought. Favoring the larger scales may allow for better feature identification. Terraserver, a publicly available online database of aerial photography using United States Geological Survey (USGS) aerial photographs, provides information at a variety of scales and resolutions that are user-defined. The State GIS Center, a database of maps and geographic information resources, also offers many aerial photographs focusing exclusively on West Virginia and many areas within the state, including updated aerial photos for some areas of the state for the years 2010 and 2012. These photographs had varying scales and were not shot for the entire state.

The United States Department of Agriculture (USDA) has traditionally offered photographs that are updated at certain intervals (8-10 years) focusing primarily on agricultural features, such as crop coverage. The range and resolution at which some of these aerial photos are taken, however, provides an effective tool for a land use analysis. Older Farm Service Agency (FSA) photography covered much of the state with aerial photography available at a range of 1:20000, often taken in approximately 10 year intervals for the counties of the state. In West Virginia, some photos are also available through the State Geological Survey, in a historical series dating back to the 1930s, at ranges from 1:20000 to 1:40000 with a 60% overlap. These photos are available based on quadrant within a 7.5 minute quadrangle. The most recent round of these photos were taken in 1996-97, making before-and-after analysis of any facilities constructed after this time period impossible. In some areas, there is also intermittent data, with certain periods of photography missing or not available. In obtaining these State Geological Survey photos, it is possible to have them scanned and magnified for a more detailed look at certain areas. This could prove useful in focusing on an area and better identifying features around a certain point, such as a school facility.

For the purposes of this investigation, a combination of Farm Service Agency and State Geological Survey aerial photography will be used in attempting to create a time series both before and after the construction of the facility. Due to the available photographs, the aerial photography utilized will be in irregular intervals, as opposed to a common time interval. There will be differing numbers of photographs for each site, as well, given that there are periods of missing or destroyed photography depending on the area, as well as photography for certain years at too small a scale for this type of analysis. Multiple photographs will be used for a specific year and site where it is necessary to combine photography to encompass the entire analysis area. The stereo magnification will also be used, where applicable on smaller scale photography, to help better identify housing units and provide a better detailed look at the analysis area around the school. As mentioned previously, the availability of photography both before and after the construction of the school was a determinant in facility selection.

3.2.2. School Budget Expenditures

School budgetary information, including the costs of school transportation, is available through the U.S. Census Bureau. When combined with other information about the school (geographic location, enrollment, etc.) it is possible to evaluate the impact of the physical location of the school facility on the cost to transport the student body to and from school. In evaluating the financial impact of consolidation and school location on school transportation, a constant year needs to be used to provide a constant dollar value across the districts being studied.

This Census data provides school budgetary information at both the state and, in the case of West Virginia, county levels. Many line items within the budget are mentioned to provide a breakdown of overall education spending, including pupil transportation. The values are also denoted as being adjusted by the Census or being self-reported by the individual school unit, in West Virginia's case the county school board. These budgetary values are available for each county school board within the state, at the time of this writing updated for the Census Year 2010 values. One potential weakness here lies in the lack of detailed transportation data available from these data sets. The breakdown of where these expenditures are going to within school transportation, be it for field trip and athletic buses, fueling for daily school travel, or constant maintenance, is not categorized. One budget classification is given per county to transportation, with no division between bus fueling and maintenance costs, or the costs at different facilities within the county. Given the yearly changes in a school's make-up, using information that is several years old may not accurately represent current transportation spending in the selected schools.

More intensive data with more detailed expenditures on transportation is available through the state's Educational Information Services Web, an online, limited-access database covering such details as fleet usage and fueling costs. Access to this database is permitted only to employees of the State Board of Education, and employees are allowed to access only information in their county of employment. A Monthly School Bus Operator's Form is required by the state from each bus operator and is used to gather some of this information. This form includes total mileage, mileage breakdowns by type of use (field trip, regular daily use, etc.), fuel usage, as well as measures on the number and type of pupils transported in the month of October.

3.2.3. School Travel Times

Another factor impacted by school consolidation is the time it takes to get to and from school. As school districts consolidate their facilities, travel times can be significantly impacted for those both in locations closer to the school and at the fringes of the geographic area the county school district serves. County school boards in the state of West Virginia are responsible for tracking, but not reporting, actual school travel times for all routes. These data, while recorded for many areas, have not been reported by some school districts or has not been accurately recorded, leading to some variability in the accuracy and validity of the travel data reported. Some school districts tabulate by hand-recording, while some have installed Global Positioning Systems (GPS) devices to track bus travel. The availability of this data to the general public is varied, as well. The State Report displays the percentage of students whose travel times are greater than state-prescribed averages, but does not provide much more in the way of detailed school travel time data, such as actual travel times by route or how far above the state-prescribed averages students are traveling. School districts may tabulate average travel times on their own to compare to state-prescribed standards, while some are only concerned with the number traveling over the state guidelines. While this is effective for individual school districts, when comparing numerous school districts, the size of both the geographic area and the student body being served must be taken into account. Counties within West Virginia can vary significantly in size and terrain, as can the capacity and condition of the roadway network serving the area and school. Population distributions within a county can impact travel times, as well, given that schools may be located near the greater concentration of the population, or may be located centrally among several towns or cities. Using average travel time in conjunction with some measure of the geographic area and local enrollment served by the bus network would provide a more accurate picture of the impact of school consolidation on school travel times.

One method of measure to obtain average travel time involves physically driving the routes to school themselves. The actual bus routes and stops are either publicly available or can be obtained from the school and/or county school board, in most cases. Driving these can provide an estimate of travel times, as well as how accurate schools are in estimating bus travel times, as many bus route listings include approximate pick-up times. School travel time estimations may be part of the issue in school consolidation, as underestimating or not measuring this travel time accurately may result in the assignment of bus routes that are actually longer than state guidelines. This is a rather intensive method of data collection that serves to limit the case studies studied as part of the investigation. Driving the routes for the collection of this data could also prove potentially inaccurate, given the inability to physically drive the routes in a school bus, as well as a lack of familiarity with the local road networks serving the school facilities that an experienced bus driver in the district would have. Individual schools may also be able to provide route- and school-specific data based on recorded data. Many schools in West Virginia develop expected travel schedules that are distributed to students, either privately or by way of local newspaper or website, to provide an estimation of bus arrival times at individual bus stops. One potential weakness in these data may arise from the method of collection of arrival times, as the technology used in collecting this data may range from high-tech GPS units performing continuous in-route monitoring to paper recording of a select set of timepoints, with different data storage systems used, as well.

For this study, the publicly-posted expected pick-up times (morning bus runs) for each route will be analyzed. These times are based on past travel patterns developed over years of driving the routes, and provide what the school would expect as a normal or average busing pattern. The morning routes are being used since some schools may adjust afternoon bus services based on activities keeping more students after school or additional pickups at technical schools serving the county. Time points are also not provided in all cases for afternoon busing drop-offs. The author's personal experience also indicates bus drivers may not be as inclined to meet performance/time standards on afternoon routes, since there is no 'morning bell' that drivers are attempting to arrive in time to meet. Individual discretion was used in determining which listings within the bus routes were actual stops versus directional guidance. Special needs busing was not considered given the heavy attention paid to meeting the needs of the individual students, and not travel time standards, in special needs transportation. The morning bus routes were obtained either from local newspapers or directly from the school or county school board. In two of the case studies, additional supplemental information related to travel times was provided by the contact at the selected school. This information is used to clear up any confusion in the path assignment process, as well as adjust some of the expected travel time data from what is publicly available.

3.2.4. Mode Choice

Another aspect of school transportation impacted by consolidation and school location is student mode choice. As school facilities consolidate and/or move, the mode choices available to students may change as the distance to travel to school changes. These data could be obtained in a few ways.

One potential method is a parking survey to determine the number of personal vehicles driven to school. This provides a direct measure as to the number of cars arriving each day. A parking survey, however, may fail to take into account the number of individuals in each vehicle or the student population that is driven to school and dropped off, with no vehicle remaining at the school. Solely using this measure also ignores the portion of the student population that uses the bus to get to school. Parking surveys also serve little to no purpose at the school facilities where the student body is too young to drive.

Another method is to review school bus records to determine how many students utilized transit to get to school. When combined with attendance records of how many students attended school, these bus records allow a profile of students who chose transit over the personal automobile, in the form of driving or being driven. While attendance records are generally accurate, school bus records may have some variability in their accuracy or even in their existence. Drivers may not prioritize the keeping of these records, or view keeping them as an impediment to performing their first duty, safe and efficient transport of students to school. Obtaining these records from the appropriate school authorities can also be difficult, given privacy concerns about school-age children and teenagers. A study such as this also does not account for being driven versus driving, or the distribution of students arriving in personal automobiles (carpooling, being dropped off, etc.).

Personal survey data could alleviate some these concerns, provided an appropriate sample size is selected to give an accurate cross-section of the student body. Many variables may affect mode choice, including family income and the availability of an automobile, age of the student and the ability to drive, extracurricular activities, or several others. Legal concerns over privacy and dealing with human subjects make this sort of personal survey difficult to pursue with high school students.

School administrators, in particular, county transportation directors or school principals, may be able to provide additional insight, in terms of parking passes/permits distributed, school facility circulation issues resulting from significant numbers of students driving or being driven to school, as well as any bus ridership data that are collected. In addition, these individuals take an active part in managing transportation on a day-to-day basis at their facilities, and may be an excellent source of intangible, non-measurable information observed at their respective school. County transportation directors are responsible for putting together the bus reports regarding time in transit for the state transportation reports. Some districts do record the individual students riding the bus to school each day in conjunction with their Bus Operator forms. These records may or may not be available to the public due to individual privacy concerns, while some districts may not save the attendance records beyond a short time period.

For this study, data and information made available from the school facilities and their administrators will be used, including bus ridership records, records of parking pass distribution if available, and anecdotal evidence from school personnel to determine an approximation of those who ride the bus versus those that drive or are driven to school. Subsequently, some of these data will be estimations from school administrators as to the number of students on each mode, as well as potential estimates on parking demand and supply. This study is more concerned with the percentage of students arriving at school each day by way of a mode, as opposed to other studies that may be more concerned with the number of vehicles arriving at school each day. Time and cost limitations, as well as legal and privacy concerns, also limit the types of surveys (parking and student) that can be undertaken. In a couple of cases, data provided by the school contact related to bus travel times, including the number of students on the bus, are available to assist in providing an estimate of the mode choice of the student body.

3.3. Data Analysis

3.3.1. Land Use Impact

In determining if the construction and location of school facilities has an impact on the land use behavior of an area and attempting to quantify that impact if it exists, an analysis of aerial photography will be completed. Using aerial photography at the scales provided by the State Geological Survey and the Farm Services Agency allows for a better identification of features and types of land uses. This enables a counting of individual housing units on each photograph within a certain distance of the school facility. When using a historical series of photography with this type of analysis, the number of housing units within a certain distance of the school facility can be traced over time to see if the presence of the school correlates with more residential location and construction closer to the school facility. Another potential analysis lies in assessing other types of development, namely commercial. Commercial uses can possibly be identified at the ranges the photography presents in much the same way as the housing mentioned previously. It may also be possible to assess the overall development occurring in the selected area by way of a land coverage analysis, determining the percentage of land under development or built upon. In largely rural areas, such as those in which many of these schools are located, the construction of the school can have a significant impact on the land coverage percentage, given the necessary size of the school and additional facilities (parking facilities, athletic fields, auditoriums, etc.). This sort of analysis may be too blunt and simplistic with regards to investigating commercial and residential location decisions as a result of school construction.

Establishing a proper area for analysis is also important. Prior studies dealing with school mode choice have often focused on non-motorized vs. motorized transportation modes in more urbanized neighborhoods and areas. Consequently, the radii around the school are smaller (approximately 0.5-1 mile) than would be needed for a study such as this. Establishing the radius in this case seeks to approximate the area around the school in which residents and businesses would seek to relocate or move as a result of and to be close to the location of the school. Given the general lack of precedent in this sort of study, the analysis area may seem to be an arbitrary approximation at what could be an effective area. The location of these schools, in rural locations often with little provision made for trails or non-motorized paths, indicates that serious consideration of non-motorized transportation would seem to be impractical. In determining an appropriate area of analysis, the decision has to be made on what is considered ‘close’ from a motorized transportation standpoint. Also, ‘close’ from a distance standpoint may not correlate with a shorter trip in terms of time, depending on the accessibility of the local road network or the nature of school bus transportation in the area.

For the purposes of this investigation, a square area 3 miles per side with the school at the center will be used as the analysis area. This measurement is somewhat arbitrary, but is dictated by time limitations as well photography acquisition. For the schools drawing upon a larger area (cases 1-3), a second square 5 miles on side was sought to be set up as a sort of perimeter analysis area to determine if the larger drawing area of the school may result in a larger definition of the area considered "close" to school, from a transportation standpoint. Due to photography acquisition costs, this option is only feasible for the county high school case study. Single housing units are to be counted within this area for each photo in the historical series. This adds potential bias into the data analysis, given that reviews of the maps by two different individuals may result in 2 different results. Therefore, a standard deviation is to be applied to these numbers to provide a range of results. A comparison can then be provided between the photography of different years, and a percentage growth rate determined. Comparisons will be made between population trends (available via both State and US Census resources) and the housing data analyzed.

3.3.2. School Travel Times

Analyzing the expected travel times for each of the school facilities requires several steps. After receiving and reviewing the bus reports, it is important to properly detail the potential transfers that may need to be completed in traveling to school. For the facilities serving a large geographic area, such as an entire county, transfers could be involved in the daily bus trip. For several of the cases in assigning routes, the choice was either to minimize transfers along a route at the expense of additional travel time, or minimize travel time via a bus transfer. In some cases, transfers were explicitly defined as to which routes or buses were exchanging students, while in some cases there were several options available to a student and were not explicitly defined by the bus schedules. Students in some instances could have transferred and arrived at school earlier, or stayed on the same bus and arrived later. In the cases where students had a potential choice in transfers, the arrival times at transfer stations and departure destinations were used to assign a 'path' or expected transfer pattern to student bus travel. For all instances of this type, the path was assigned to minimize travel time for the student, which may have included a transfer. For a few of the case studies, there were no transfers present.

Another issue in calculating average travel times was the distribution of students throughout the geographic area served by the school, and subsequently their distribution on the bus routes. In cases where several school facilities within a county shared bus routes, the grade level distribution of students is difficult to ascertain, and changes annually. There is no guarantee that any students from the facility being studied are actually present at certain stops. Given privacy concerns, it was difficult to determine the exact number of students and their respective grade level riding for explicit times from a specific bus stop. Students for which a stop may be accounted for in the school's records may choose not to ride the bus to school and seek some other mode of transportation. Recognition of differing population densities within a county also makes it difficult to attempt to assign a number of students to a particular stop. An approach that attempts to assign students to stops based on averages over an entire county may only serve to "assign" more students at stops in outlying areas with lower population densities, potentially increasing the calculated proportion of students riding above the state-advised time guidelines.

Subsequently, the data for student enrollment at a facility will be used in conjunction with the expected time data from the schools, but students will not be assigned to routes. The measures used in evaluating school travel times will be the percentage of stops along routes heading to the school or transferring to reach the school that are over the state-advised standards, along with averages of the longest potential travel times. Several other data can also be put together from some of these sets, including average route time, overall average time for the entire school facility, as well as several others.

3.3.3. Mode Choice

In analyzing the mode choice decision for students, the analysis will be combined with data from earlier findings and be compared from school to school. That is, the number of students choosing to utilize school-provided transit will be looked at in conjunction with the bus travel time data from that facility to determine if school facilities with longer bus rides may deter students from riding the bus to school and instead choosing to drive or be driven in personal automobiles. Some prior research has established average percentages of students riding the bus to school, and these values may be offered as a comparison to the values from the selected facilities. Since much of this information is going to be based either on estimates by on-site school personnel or bus reports that are not publicly accessible, it will be difficult to develop a correlation whether distance to school, both in terms of time and distance, affects mode decision on an individual basis. That is, a direct tie between distance/time to school and mode choice will be nearly impossible due to student privacy concerns. Rather, this will be evaluated from a more holistic point of view regarding a school-wide mode choice preference and the overall travel time profile of the bus system.

In several cases, the only mode choice information made available was based on estimates by either principals or transportation directors. In other cases, the mode choice information was inferred from bus travel time data which detailed the number of students riding on each route.

3.4. School Contact

At the five selected school facilities, letters were sent to the respective principals to ask for much of information detailed previously. A copy of the text of the letter is attached in Appendix II. These letters were sent out in the spring of 2007. For a few of the school facilities, the letters were followed up with phone calls to contact the school principals. In discussions with some of the principals, they placed the author in contact with the county transportation officials for the various school districts. It was through these discussions that much of the data not publicly available was obtained and that some of the anecdotal information was discussed. A full recap of which data sources were obtained from each facility is included in the Case Study Profiles.

Chapter 4 - Case Study Profiles

Below are profiles of each of the schools selected for this investigation. Included in these profiles is information on the area served by the school facility, the population density of the county in which the school is located, as well as information on other school facilities that may share bus routes with the school. Information on the current enrollment of the school and the history of school consolidation, where available, is also included. A brief description of the data sources for each school is also included. A summary of background information for each of the schools is included in Appendix III.

4.1. Case 1- County High School

The first case study focuses on a consolidated county high school in the state's Eastern Panhandle. The county has a total geographic area of 641 miles and a population of approximately 22,000 residents, leading to a population density of 31.5 persons per square mile, the lowest for any of the selected school facilities. This is the only high school in the county, serving an enrollment of 1104 students in grades 9-12 for the 2006-2007 school year. This high school was formed in 1964 from the consolidation of 2 high schools in the larger towns of the county. The high school is located in the west central portion of the county. Of the schools considered in this investigation, this high school has the largest geographic area to serve, as well as the largest student body in terms of students to transport.

4.1.1. Aerial Photography and Housing Data

For this case study, aerial photography was available from the WVGEIC only after the construction of the consolidated high school. For 1971, the photography was available at a scale of 1:24,000, allowing analysis without any magnification of the analysis area. One photo was adequate for covering the entire analysis area. For 1996, a combination of 2 photos was used. These photos had a scale of 1:40,000, meaning that for a better analysis and determination of the number of housing units within the analysis area, some digital magnification was done to improve the view of the area around the school facility. In order to obtain aerial photography from before the construction of the facility, United Stated Department of Agriculture-Farm

Service Agency (USDA-FSA) photography, available for the county (Hampshire County) from 1955 at a scale of 1:20,000, was utilized in this case study to provide a comparison of the analysis area before school construction. A hard copy was obtained from the USDA-FSA and analyzed 'by hand,' using a magnifying glass to assist in the determination.

4.1.1.1. 5 Mile x 5 Mile Square Area

For the 1955 photography, 87 housing units were counted in the study area. The population in this county for 1955 was 12,141, according to the US Census Data. The school opening date for this facility was 1964, with a population estimate of 11,707. In 1971, the photography showed 389 housing units in the study area. The population in the county for 1971 was 12,026. This shows a population decay of approximately 3.5% from 1955 to the school opening year, but an almost equivalent population growth from the school opening to first year of photography available after the school opening. Population in 1996 was 18,721. In 1996, 540 housing units were counted within the 5 mile x 5 mile square area, a 151 unit increase from 1971, and a 453 unit increase from the beginning of the photography in 1955. Assuming a linear growth rate, new housing units would be completed at a rate of approximately 11 per year. Population in the county over this time period (from 1971 to 1996) grew 60%.

4.1.1.2. 3 Mile x 3 Mile Square Area

For the 1955 photography, 59 housing units were counted in the study area. The population in this county for 1955 was 12,141, according to the US Census Data. The school opening date for this facility was 1964, with a population estimate of 11,707. In 1971, the photography showed 148 housing units in the study area. The population in the county for 1971 was 12,026. This shows a population decay of approximately 3.5% from 1955 to the school opening year, but an almost equivalent population growth from the school opening to first year of photography available after the school opening. Assuming a linear growth rate, new housing units would be completed at a rate of approximately 7 per year. Population in 1996 was 18,721. In 1996, 347 housing units were counted within the 3 mile x 3 mile square area, a 199 unit increase from 1971, and a

288 unit increase from the beginning of the photography in 1955. Population over the time period from 1971 to 1996 grew 60%.

4.1.2. Bus Travel Times

Students riding the bus to this school facility ride on shared bus routes; that is, students from all public schools in the county at all grade levels, from the elementary school level to the high school, ride on the same bus routes. Due to this shared busing arrangement, there is the potential to stop at other school facilities and transfer points on the way to the high school. Some students must transfer from one bus to another to complete the trip to school, either at another school facility or at a specific transfer point. Given that this is the only public high school in the county, every student in the entire county in grades 9 through 12 must travel to the centrally located public school. Taking into account the size of the county, this can result in long (both in terms of time duration and mileage) bus rides. The state guideline for travel to high school states that students should face rides no longer than 60 minutes one-way to school.

For the bus listings for this school, each stop, noted by address or intersection, was detailed with an expected arrival time, as well as which stops were at transfer points. Each route also provided an indication as to what facilities' students (high school, middle school, elementary school) were being carried on that particular route. Using this information and the transfer point data, it was possible to derive the longest possible travel route for each route and transfer, and the number and percentage of stops over the one hour guideline. If a bus route did not indicate there were high school students present, or did not allow for a transfer to a route stopping at the high school, it was not considered in this analysis. The bus listings for this school were available in a local newspaper for the area. This information was supplemented by additional information provided by the county transportation director, which included updated information on bus arrival times, as well as the number of students getting on and off the bus at specific points.

Considered in this analysis were 27 routes that ran directly to the high school, as well as 12 routes that transfer to one of the direct routes traveling to the high school. The total trip time (first denoted stop to arrival at the school) ranged from 11 minutes for the shortest direct trip to the high school to 94 minutes for the longest trip involving a transfer. The longest potential direct trip was 80 minutes long. For the direct trips, the average total time length of the route was 49 minutes. For the transfer routes, an approximate average total length of approximately 58 minutes was calculated, using the assumption that the shortest path was taken when transferring. Combining these values, the average overall time length for all routes was approximately 51 minutes. Of the 789 stops total on the routes considered, 526 were located on direct routes. Based on the expected arrival time data from the bus schedule, it can be calculated that approximately 12 percent of the bus stops that could contain high school students were scheduled to travel for 1 hour or more on the trip to school. Of these stops that were a 1 hour ride or longer from school, slightly fewer stops were located on direct routes (42) as were located on routes that transferred (47). This indicates that a greater percentage of the stops along transferred routes faced rides of 1 hour or longer. This is not unexpected given that one would expect the direct routes to have a shorter average trip. Twelve (12) direct routes and five (5) transfer routes contained stops over 1 hour in length from the high school.

4.1.3. Mode Choice

The mode choice data for this school was based on several reports provided by the county transportation director related to school bus travel. This information provided the number of students riding on each bus route on average, allowing for the typical mode split to be determined, based on the 2006-2007 enrollment at the school. By summing the typical number of students located along each route, an average percentage of the student population riding to school on the bus could be calculated. Given that no students were indicated by the school personnel as taking non-motorized transportation (walking or cycling) to school, it was then possible to compute the mode split between personal automobile travel and bus travel. Based on the report provided by the county transportation director, 533 students, on average, rode the bus to school on a typical day. Using the overall enrollment of the school (1,104), it can be computed that 571 students drive or are driven to school on a typical day with full enrollment. Using percentages, the approximate split is 48/52, bused students versus driving/driven students.

4.2. Case 2- Sub-County Consolidated High School

This case is a consolidated high school serving a portion of a county in the north central region of the state. This high school covers much of the county outside of an urban area of approximately 20,000 residents in the county's eastern end. The overall county population is approximately 56,000 residents in a geographic area of 309 square miles, leading to a population density of 182.6 persons per square mile, the highest of any of the areas under consideration. This high school serves the more rural, less densely populated areas of the county, along with some smaller towns in the county. In general, the north central portion of the state, with several of the larger population centers within the state, is the most developed of any of the areas included in this analysis. The enrollment in grades 9-12 for this facility is 905 students for the 2006-2007 school year, making this the second largest school in terms of enrollment in the study. This high school was constructed in 1979, and its enrollment has resulted from the consolidation of 6 former high schools from the smaller towns and outlying areas in the county.

4.2.1. Aerial Photography and Housing Data

From the WVGEIC, there was photography available both before and after the construction of the facility. The "before" set of photography was from 1967, and was available at a scale of 1:20,000, requiring no magnification. A combination of 6 photos were used for this year. The final set was available from 1996, after the construction of the facility. Three photos covered the entire analysis area, at a scale of 1:40,000, requiring some magnification.

For the 1967 photography, shot 12 years before the school opening in 1979, 289 single housing units were counted within the study area. The population for 1967 was 62,064 residents. For the after case, the 1996-97 aerial photography, shot 17-18 years after the school opening, displayed 332 housing units counted within the study area. This is a net change of 43 housing units over 30 total years, or approximately 1.5 units per year. Overall, this is 8.43 percent growth in housing units in the study area. In 1979, the county population was estimated at 65,346 people. For 1996-97, the last available year of aerial photography, the population was 56,793, a drop of approximately 13% since the opening of the facility, and 8% over the full range of the aerial photography.

4.2.2. Bus Travel Times

As with the consolidated county high school mentioned above, students of this high school ride on shared bus routes with students from 4 other elementary and middle schools in the county. As compared to the county high school study, the geographic area being served is much smaller, and the county has a much higher population density. Subsequently, the expected travel times are less than the previous case. The maximum travel time analysis for this bus system is also simpler, given that almost every route in the system stops at the high school facility at one point during the trip. There was only one transfer that needed to be accounted for in the busing schedule. The bus listings for this school facility were provided on the school's website.

In the bus listings for this school, each stop was detailed with an expected arrival time. Some of the routes included times for the expected departure time from the bus garage. These times were not included for purposes of determining the number of stops along a route. On occasion, in reading the bus listings it was difficult to determine which lines were directions and which were expected arrival times for a physical stop. To simplify, all time listings after the initial departure from the bus garage were considered as stops. The bus listings for this school were available from the county school board website.

For this case study, 30 direct routes were considered, along with 1 transfer route. Along these routes there were a total of just over 500 stops. Approximately 2 percent of the stops located along routes traveling to the high school faced an expected trip of 1 hour or more to the high school. Only 3 of the 30 direct routes contained stops with a ride of one hour or longer to the school facility, with the lone transfer route falling under the 1 hour threshold. Subsequently, it can be assumed that nearly all of the high school students ride the bus for less than the state-advised 1-hour duration. The length of rides ranged from 17 minutes for the shortest ride to 80 minutes for the longest. The average maximum time length of all bus trips was approximately 38 minutes.

4.2.3. Mode Choice

The mode choice information for this facility was available through discussions with the county school board's transportation director and administrative personnel at the high school. In conversations with both individuals, two potential sources of data were mentioned that would be able to provide information on the modal breakdown in getting to school. The county transportation administrator believed that the high school's record of distributed parking passes would provide an appropriate representation of the travel patterns to school, with the number of parking passes corresponding to an approximate number of students on each day not using the bus system. The administrative personnel at the high school indicated that, while the parking passes would provide an adequate percentage of students driving to school on a typical day, the issuing of these parking passes was seasonally dependent. The passes were issued on the basis of activity schedules, with students in fall sports and activities receiving passes for the duration of their sport or activity, and a similar pattern emerging for winter and spring sports and activities. The high school administrative personnel indicated that the overall number of parking passes for the year exceeded the number of available spots, but due to the seasonal variation, demand or usage would not exceed parking supply. The high school personnel indicated they thought a better measure would be the county bus records of who rode the bus to school each day. The high school was able to provide estimation that, on average, 100 students drove to school each day. They also indicated that no students were traveling using non-motorized transportation, since travel of this sort is not permitted to the high school facility.

4.3. Case 3- Consolidated County Middle School

This case is a consolidated middle school serving an entire county in the north central portion of the state. The county has a population of 16,291 residents in a geographic area of 172 square miles, a population density of 93 persons per square mile. The middle school enrollment in the county, grades 5-8, is 743 students for the 2006-2007 school year. The middle school is located in the central portion of the county, several miles outside of the largest town in the county.

4.3.1. Aerial Photography and Housing Data

For this middle school facility, aerial photography was available from the WVGEIC for one instance both before and after the construction and opening (1985) of the school facility. Before the construction of the school, the photography is available from 1967, with a combination of 2 photos being used at a scale of 1:20,000, requiring no adjustment or magnification. After the construction of the school, a combination of 2 photos was available from 1997, at a scale of 1:40,000, requiring some digital magnification.

For the 1967 photography, shot 18 years prior to the opening of the consolidated middle school, 137 housing units were counted within the study area. After construction of the facility, the 1997 photography displayed 221 housing units. The 1967 population data provided a county population of 14,218. This results in a population percentage change of 4%. In 1989, Census data estimates the population at 15,288, while estimating a 1997 population of 15,806. This results in a population increase of 3% between the opening of the school and the year of the last available aerial photography, or basically a static population base between photography dates. Overall, the population change is approximately 11% over the full period covered by aerial photography. This compares with a 61% change in housing units over the same period.

4.3.2. Bus Travel Times

The students of this facility ride on shared bus routes. Given that there are only 5 public schools in the county, many of the transfers occur at these school facilities, with few transfers occurring at other points in the bus network. Some of the bus routes continue past the public school facilities to carry students to a shared technical school in a neighboring county. The state guideline for middle school students is to provide a school bus ride of 45 minutes or less.

In the bus listings for this school, each stop was detailed with an expected arrival time and the last name of a student. Some of the routes included times for the expected departure time from the bus garage. These times were not included for purposes of determining the number of stops along a route. As with the listings from one of the high schools above, some of the individual times detailed directions along the bus route, while others detailed specific stops. As with the previous case, to simplify, all time listings after the initial departure from the bus garage were considered as stops. The bus listings for this school were made available by the county school board's central transportation office, and included mileages for the routes, as well.

For this school, 20 direct routes were considered, as well as 10 transfer routes. Analysis of these routes was somewhat complex in that almost every route stopped at the middle school, but opportunities for transfers existed that could have cut travel times. Amongst the routes considered were close to 660 total stops. Travel times ranged from 22 minutes for the shortest direct route to one transfer route traveling 72 minutes. The longest direct route ran 69 minutes. Based on expected travel times, approximately 22 percent of the stops for this facility are located such that a trip from them would result in a trip of 45 minutes or more. These stops are located in equal number along both routes requiring a transfer and routes that travel directly to the school. When looked at in proportion to total stops however, it is seen that for around one-third of the stops on routes that must transfer, students face rides of 45 minutes or longer. In terms of average maximum time lengths, the direct routes averaged approximately 48 minutes, while the transfer routes averaged 60 minutes in length. When combined, the average maximum time length for all routes was approximately 51 minutes. In total, 13 of 20 direct routes and 7 of 10 transfer routes contained trips over the state recommendation of 45 minutes.

4.3.3. Mode Choice

For the mode choice information, the school principal provided estimates based on mode choice patterns for normal weather travel. Given the rural nature of the area in which the school was located, however, the principal indicated there could be significant variations in the expected pattern when weather played a significant role. On the average school day with no significant weather or event impacts, the principal indicated that approximately 600 of the 740 students (81%) rode the bus to school. He also indicated that despite the school's rural location, between 5 and 10 students walk to school, weather permitting, each day. This leaves the remainder of the students to be dropped off, and approximately 130 students (18%) are driven to school on an average day with minimal weather concerns or other activities. Given that the school serves grades 5-8, students driving and parking were not a concern. This means that despite bus travel times averaging over the state guidelines for a middle school, approximately 80 percent of the student body still uses the bus to get to school on an average travel day. An additional note, each bus route averaged close to 25 miles of travel per day one-way to or from the school facility, based on transportation information provided by the school district.

4.4. Case 4- Combined Elementary/Middle School

This facility is a case of grade level consolidation, with a middle school and elementary school in the same facility. The county is located on the western border of the state, just south of the Northern Panhandle. The county population is 17,117 residents in a geographic area of 359 miles. Subsequently, the population density is 49.3 persons per square mile, the middle density amongst the counties of the five selected schools. The school is located towards the central southern portion of the county, away from the larger towns and population bases in the county along the Ohio River. The enrollment of the school facility, grades preK-8, is 493 students for the 2006-2007 school year.

4.4.1. Aerial Photography and Housing Data

As with the middle school photography, one set of the WVGEIC photography was available both before and after the construction and opening of the school facility. Before the school construction, there was a group of 5 photos from 1956-57, all taken at a scale of 1:31,000, which may require some magnification. A single photo was used in the analysis. For after the opening of the facility, 2 photos at a scale of 1:40,000 are available from 1997, and may need adjustment and magnification.

For the first year of available photography, 1957 (21 years before the school opening date), 95 housing units were counted in the study area. The county population was 19,589. For the 1997 photography, 19 years after the school opening, 209 housing units were counted. For the year of the school opening, the county population was estimated (based on Census data) to be 21,562. For 1997, the county population had decreased to 18,163, a 16 % decrease from the school opening date. Over the full period of aerial photography coverage, population decreased 7% while the number of housing units in the area increased 120%.

4.4.2. Bus Travel Times

This school features shared bus routes; the buses carry students from both the selected elementary/middle school facility and a 9-12 high school facility (enrollment: 223) located in the area. Every route within the bus schedule stops at both the high school and the combined elementary/middle school. There are no transfers detailed in the bus schedule, and given that every route stops at the necessary school facility, it is assumed that none occur. A few of the stops were labeled as (9-12), which denotes that there may only be students from the high school traveling from this stop. These stops were not considered as part of this analysis. The state-advised guideline for elementary school bus travel is no student should travel more than 30 minutes one way to school; as mentioned before, the middle school guideline is 45 minutes. The bus listings for this school were provided by the assistant principal.

For this school, 9 direct routes were considered in the analysis. This school uses fewer buses and routes than the other facilities which results in longer routes to encompass the area served by the school and longer times to reach the school facility. Nearly 250 stops were along these routes included for analysis. Some of the stops were labeled as containing only students from grades 9-12, and were not considered in this analysis for the elementary/middle school. There were no transfers to consider in the analysis. Over half (57.8%) of the stops fall outside of the 30 minute ride recommended as a maximum for elementary school students, and approximately a third(33.6%) of the stops have rides of 45 minutes or longer in reaching the school, exceeding the middle school guidelines. Every route contained stops that resulted in rides longer than the state guidelines. The average maximum travel time for the routes was almost 70 minutes.

4.4.3. Mode Choice

The mode choice information from this school was available from discussions with administrative personnel at the school, since the principal providing the information regarding the busing information had left the school for other opportunities. When asked for information regarding the mode choice at the school, the administrative personnel revealed that no students were regularly dropped off at school on a typical school day, and that all students typically rode the bus to school. They did indicate that when inclement weather became a factor, a small percentage (an exact percentage was not provided) would be driven to school by parents. Given that this is a combined elementary/middle school, it can be assumed that no students are driving to school themselves. This school did have a zone in the immediate vicinity of the school where no bus transportation was provided (a radius was not provided). As a result, 3 students walked to school on a typical school day.

4.5. Case 5- Combined Elementary/Middle School

This is another case of grade level consolidation, as before, with the combination of a middle school and elementary school in the same facility. This county is located in the west central portion of the state, approximately halfway between the Northern Panhandle and the southernmost point of the state. The county population is 15,407 residents in a geographic area of 483 square miles, a population density of 31.9 persons per square mile. Subsequently, this school is located in the county with the second lowest population density of the cases being studied. The school is located in the southeastern portion of the county. The enrollment of the school facility, grades preK-8, is 349 students for the 2006-2007 school year.

4.5.1. Aerial Photography and Housing Data

There was one set of photography available both before and after the construction of this school from the WVGEIC. The photography from before the opening of the facility was shot in 1962, at a scale of 1:27,000, with a combination of 2 photos needed to address the entire analysis area. After the construction of the facility, a group of 3 photos at a scale of 1:40,000 was available. These photos were shot in 1996.

For the first year of available photography, 1962 (19 years before the school opening date), 74 housing units were counted in the study area. The population for 1962 was 15,398 residents. For the 1996 photography, 15 years after the school opening, 166 housing units were counted. For the year of the school opening, US Census data places the population for the county at 15,869. For 1996, the county population was 15,316, a 3% decrease in population since the opening of the school facility. Over the full photography period, there was a net population decrease of less than 1%, while housing units in the area increased approximately 125% over the same time period.

4.5.2. Bus Travel Times

As mentioned previously, the maximum rides advised for elementary and middle school students are 30 and 45 minutes, respectively. For this case study, the bus times were derived from the data used to compute the information needed in compiling the state school bus travel time report. With all the previous studies, the data was given in terms of a time and stop format. These data were assembled by the county transportation director for this selected facility.

Data were provided for 11 routes that carry elementary and middle school students. Two of these routes did not carry elementary and middle school students during the morning, but did during the afternoon. For the 9 morning routes, the nine routes considered ranged in length from 25 to 56 miles, and in duration from 14 minutes to 125 minutes. The averages were 41 miles and 58 minutes respectively. The routes averaged 20 stops per route. It was found that 29% of the stops picked up students for rides in excess of 30 minutes, and 25% of stops were for rides in excess of 45 minutes. For the 11 afternoon routes, the routes ranged in length from 15 to 56 miles, and in duration from 17 to 85 minutes. The averages were 37 miles and 45 minutes, respectively. The afternoon routes averaged 16 stops per route. Approximately 20% of the stops were found to exceed a 30 minute ride to the destination, and approximately 12% exceeded 45 minutes.

4.5.3. Mode Choice

The mode choice for this school facility was available from in the bus report. In it, the transportation director made an estimate, on the basis of his daily observance, that 98% of the students at the combined elementary/middle school facility used the buses for daily transportation. That means that less than 10 students, on average, used private transportation on a daily basis to reach the school. Given that this is a middle and elementary school, this means these students are being driven to school. There was no mention of carpooling or ridesharing in the report. There was also no mention made of any non-motorized transportation to the school facility.

Chapter 5 - Findings

5.1. Housing Units

Aerial photography was obtained for a certain area around each school facility. For each facility, photography was obtained before and after the opening of the school facility. In some areas, photography was limited to one source before and one source after the opening the facility. Single unit housing was then counted on each of the photographs. Some subjectivity was used in identifying a single-family residence, such as surrounding infrastructure, parking lots vs. a single driveway tying into an enclosed parking facility, and other factors. A linear rate of growth (or decay) was assumed for the both the population and the housing, since official U.S. Census and West Virginia DHHR population numbers were only available in 10-year intervals, and in all cases the years for the photography did not correspond to the years in which the Census was completed. A table summarizing these rates is provided in Table 4.

From a population standpoint, three of the five counties lost population over their respective photography analysis periods, ranging in decay rates from approximately 0.5 to 8.5 percent. The area around each school facility showed an increase in single family housing units ranging from 15 to 125 percent over the same period. This provides a broad measure over a longer range of time, but perhaps a more concise analysis comes from a comparison of rates before and after the school opening.

There are several factors in these areas that may be contributing to this population decay in these counties, as well as the ‘bounce-back’ of the population in some of the other areas. In many areas throughout the state, the prominence of the coal industry in the local economy (and the subsequent impact of a mine closure) could lead to significant impacts on local population. Citizens could either be coming into the area when an opportunity for work was made available in a reopened or new mine, or conversely exit when a mine closed and there were no other opportunities available.

For the consolidated sub-county high school facility, the overall population decay was 8.5 percent. Population actually increased prior to the school opening, with a growth rate of 5.3 percent, while population decayed 13.1 percent after the opening of the school facility. This compares with housing unit increases of 6 percent and 8.4

percent before and after the school opening respectively. It appears that prior to the school opening, the housing unit growth was in line with general population trends in the county, while after the school facility opened, it was in direct contrast.

The other cases where the county population decayed over the full photography range were the consolidated middle and elementary schools. Overall population decay in these areas was 0.5 and 7.3 percent over the full photography range. As with the sub-county high school facility, population growth was indicated prior to school opening with a growth rates of 3.7 and 10.1 percent, while the decay rates were 4.1 and 15.8 percent after the schools opened. The housing unit increases at the same time were estimated at 35 and 32 percent after the schools opened, respectively. Again, the number of housing units in the area near the school facility seems to contrast the general population trends in the area.

The other two counties showed population increases of 11.2 and 54.2 percent over their respective photography periods. At the same time, the housing units near the school facility grew from approximately 61 to approximately 500 percent. Once again, looking at population trends before and after the opening of the facility would serve to provide a more concise analysis.

For the consolidated county high school, population increased 54.2 percent over the full photography range. Housing units in the area near the school increased 488.1 % for the 3 mile x 3 mile area over the full photography time period, and 520.7 percent for the full 5 mile x 5 mile area. Prior to the school opening, population growth was estimated at 3.6 percent for the county, while after the population growth was 59.9 percent. This compares to housing growth of 81.4 percent before the facility opening and 224.3 percent after for the 3x3 area and 151.9 percent before the facility opening and 146.4 percent after for the 5x5 area. While both population and the housing in the area of the school both grew, the housing unit growth significantly outpaced the population growth in the area. One factor that may be impacting this population growth is the overall growth and development taking place in the Eastern Panhandle of the state. While the county discussed here is not at the central core of where this development is taking place, it can be expected that there is some residual impact to the area that would contribute the population growth discussed above.

For the consolidated middle school, population growth over the full photography range was 11.2 percent, while the housing units near the school grew by 61.3 percent. Population growth prior to school opening was 7.5 percent, as opposed to 3.4 percent following the school opening. This contrasts with growth rates of 36.8 and 17.9 percent for the housing units in the area near the schools. Once again, the housing unit growth has outpaced the population growth.

Table 4 – Housing Unit Data Summary

School Case #	% Housing Units Change (prior to opening)	% Population Change (prior to opening)	% Housing Units Change (after opening)	% Population Change (after opening)	% Housing Units Change (over full photography range)	% Population Change (over full photography range)
1-3x3	81.4	3.6	224.3	59.9	488.1	54.2
1-5x5	151.9	3.6	146.4	59.9	520.7	54.2
2	6	5.3	8.4	-13.1	14.9	-8.5
3	36.8	7.5	17.9	3.4	61.3	11.2
4	63	10.1	35	-15.8	120	-7.3
5	69.5	3.7	32.4	-4.1	124.3	-0.5

For each of these schools, one set of photography was available both before and after the opening of the school facility. The ‘before’ photography was available from 12 to 21 years before the opening of the facility and from 8-19 years after the facility opening. It was felt that this provided a broad enough range after the facility opened for any significant residential shift and housing construction to take place. Based on the numbers presented, in all cases, the number of housing units in the area near the school grew at a significantly higher rate than the population in the county, or in contrast to the county population trend of decay. While some development can be anticipated over time, the difference in the population and housing rates can lead one to conclude that building of the school facilities in these outlying areas induces development that may not otherwise occur in these locations. This presents the idea that the location of these school facilities induces new residential development or potentially, residential relocation, based on the analysis performed above. Given the rural and outlying locations of these facilities, this may serve as an impetus to sprawl-style development. Future research, with access to photography over a longer range of time following the opening of each of the facilities, or a photography series with shorter time gaps might be able to better establish a relationship regarding sprawl and consolidated schools. Another aspect of this that could be further investigated is development of adjacent land uses and businesses (including convenience stores, day care facilities, and office complexes) after construction of the school.

A full summary of the aerial photography for each school facility is included in Appendix IV.

5.2. School Bus Maximum Travel Time

At all of the facilities, the maximum travel times to school during the morning arrival period were tracked. Additionally, the number of stops over the various state school travel guidelines for each grade level was determined from the bus data. Many schools also provided afternoon departure information, but the morning was analyzed since afternoon schedules were often impacted by attempting to combine multiple grade levels on to the same route. The afternoon routes often did not leave from the studied facility at the end of the school day, waiting for students from other school facilities in the same county. Afternoon travel times were also significantly impacted by a reduced number of stops due to extracurricular and other after-school activities. Each school provided this information, most often in the form of a schedule with an expected time for each stop along the route. It was from this information that the maximum length of ride and the numbers of stops over the state guidelines were calculated. A summary of the results is shown in Table 5.

All of the schools investigated as part of this study contained bus stops that were scheduled for travel times over the state-recommended travel time guidelines for their particular grade level. Three of the school facilities had *average* maximum travel times for the facility that exceeded these recommended guidelines. The average bus rides at the five schools ranged from 38 to 70 minutes in length. The schools ranged from having 2% of their stops over these guidelines to potentially having 58% exceeding these values. One difficulty in analyzing these data arose from the inability to obtain which student (or how many) or which grade level was getting on the bus at each stop. Understandably, this is due to privacy concerns on the part of the schools. The state-prescribed guidelines break out separate standards for elementary, middle, and high school facilities, but in some of the cases grade level consolidation was present. Since bus schedules can have a high degree of variability from year to year as students advance in grade level or move in and out of the district entirely, this was not seen as a major detriment to the data collected. However, it only allows for consideration of a potential excessive amount over the recommended guidelines, since for combined middle and elementary schools (as well as combined middle and high schools, which were not a part of the study) these guidelines vary depending on the grade level of the student.

There was some correlation between the provided guidelines for each grade level and the average travel time at each facility. The two high school facilities were the only ones with maximum average bus rides under the state-recommended times, by 9 and 22 percent individually. These were also the two facilities with the largest student bodies to transport. One counter to this is that since a significant percentage of high school students are in the process of or have learned how to drive and may possess licenses or permits, many students may choose to drive to school, cutting down on the demand for bus service, and allowing for faster service with fewer boarding stops. In fact, at the one high school just over half of the students (52%) drove to school, while at the other 11% drove to school.

All of the middle and elementary school facilities exceeded these recommended times with their maximum bus travel times by 13 to 133 percent. The percentage of students being driven to school ranged from almost 0 to 18 percent, a significantly lower percentage than those exhibited at the high school facilities. Obviously, this is impacted by the inability of any members of the student body to drive and reduced number of extracurricular activities requiring special transportation considerations. Parents, based on work or other commitments, are limited in their availability to drive students to school. This may or may not be exacerbated by the long distances, travel times, and higher fuel costs incurred in traveling to consolidated, less localized school facilities. These factors may combine to induce a higher percentage of students to ride the bus, leading to more stops and potentially slower operation.

From the standpoint of scheduled stops exceeding the state guidelines, all of the facilities had stops exceeding the recommended travel times. The high school facilities had the lowest percentage of their stops exceeding these values, at 2 and 12 percent. The middle school facilities had between 22 and 34 percent of their stops exceeding these values. The two facilities with elementary school students had 29 and 58 percent of their stops exceeding these values.

Table 5 – Bus Travel Time Summary					
School Case #	Average Maximum Travel Time (min.)	State Recommended Maximum (min.)	Difference (min)	Difference (%)	% of Stops Over
1	51	60	-9	-15	12
2	38	60	-22	-36.7	2
3	51	45	6	13.3	22
4-MS	70	45	25	56	34
4-ES	70	30	40	133	58
5-MS	58	45	13	29	25
5-ES	58	30	28	93	29

Results indicate that bus transportation for consolidated school students, due primarily to large service areas, often exceeds the state maximum travel times as set by the state. As will be discussed later, however, this does not necessarily serve to reduce demand for bus services or decrease ridership.

A future improvement to these data may involve tracking the numbers of students getting on and off at each stop to determine how many students are actually riding over the state guidelines. Uniformity in the data between schools would also provide better analysis. In terms of bus performance, several of the schools operated combined busing routes between multiple facilities. Running exclusive bus routes to each school might provide shorter travel times. However, this cannot be conclusively stated since which students from each facility was not available, and can vary from year to year. Future school planning should conclusively look at coverage areas and estimated travel times when establishing consolidated school location.

A full summary of the bus data for each school facility is included in Appendix V.

5.3. Mode Choice Data

This data source was the most varied in terms of methods of obtaining the data. Due to the inability to physically visit each school facility and obtain counts of each mode arriving and individuals per vehicle, the schools were asked to provide any mode choice data, including first person anecdotal reports, which would provide an insight into the modal choices by students. Through these reports, it was hoped that any significant occurrence of non-motorized transportation or ride sharing and carpooling among privately transported students would be identified by the school personnel. In some of the bus reports provided by principals and county transportation officials, numbers of students riding each route were available, and using the enrollment at that facility for the year, the percentage of students busing versus driving/being driven could be calculated. In some cases, estimates were provided by the principals or transportation directors due to concerns about providing bus records containing students' names. Results are summarized in Table 6.

As expected, a significantly higher percentage of students chose to drive or be driven to school at the two high school facilities. This matches with national trends for this type of school facility. As stated before, a significant number of students at the high school are of legal driving age and if able to procure a vehicle, may find traveling by private vehicle to be a more attractive alternative. At both high school facilities, large surface parking lots were present, most likely in part to accommodate this larger driving population. At the county high school, over half of the students arrived by private vehicle, while at the other high school facility, 11.5% arrived in private vehicles. This disparity may be tied into the shorter average bus rides at the sub-county high school, and the smaller area served by the facility. Economic conditions in the areas around the schools may also tie into this, though determining the level of poverty and affluence, and indirectly the ability to procure a private vehicle, are beyond the scope of this study. Significantly fewer bus stops were over the 1-hour travel time at the sub-county facility, as well.

At the elementary and middle school facilities, the number of students arriving in private vehicles was, for the most part, less than those at the high school facilities. This is in line with national trends, given that the student body is unable to drive themselves to any of these facilities, and parents may have concerns regarding bus travel, be it travel time or safety. The percentage of students arriving via private vehicles ranged from 17.5% at the middle school facility to approximately 2 and 0 percent at the consolidated middle/elementary schools. One of the facilities indicated that no students were actually dropped off on a typical school travel day. An indication is also given that, in spite of the long travel times, many students are choosing the buses, whether by necessity (inability to access another mode) or choice. Non-motorized transportation played a minimal or no role at several of the facilities, with one of the schools actually not permitting cycling to school.

The remote location for these facilities means that non-motorized transportation is not an option for a significant portion of the student body. In addition, at the elementary school and, to an extent, at the middle school, non-motorized transport has to occur under supervision. Given the travel times and distances involved, parents are also limited in providing private automobile transport. Providing more efficient bus operation with shorter travel times might shift some of the high school students away from driving, particularly at the county high school.

For purposes of comparison, the mode choice data from this study were compared to those from 2 other studies related to school transportation. One of these was the Rhoulac study (2004) in North Carolina which included schools in rural, suburban, and urban areas. The other was a TRB study (national in scope) related to the risks of school travel completed in 2002 and incorporating data from a wide variety of school facilities. All of the facilities included in this study had significantly higher percentages of their students riding the buses than in any of the previous studies, in spite of potentially long bus travel times. This is interesting given the national study (TRB, 2002) took into account a wide variety of schools (both from a grade level and land use perspective) and the Rhoulac study (2004) included schools from rural, suburban, and urban areas. The county high school was the only one with percentages within 15% (plus or minus) of the rates from the Rhoulac study. The national percentage of student passenger trips taken by car, from the TRB study, is not an exact comparison. However, it does provide a measure of national auto dependence to school at a wide variety of facilities and displays, in comparison, the relative reliance on the buses in West Virginia, in spite of the above-mentioned long travel times. Given the lack of non-motorized transportation at the schools studied, no real comparison was applicable.

A full summary of the mode choice data for each school facility is included in Appendix VI.

Table 6 – Mode Choice Summary						
School Case #	% Students Bussed	Rhoulac (2004) Study (for grade level)	% Students Being Driven	Rhoulac (2004) Study (for grade level)	National Average % of Passenger Veh. Trips During School Hours (for grade level)	% Students Using Non-Motorized
1	48	35	52	63	80*	0
2	88.5	35	11.5	63	80*	0
3	81	63	18	34	47*	1
4-MS	100	63	0	34	47*	0
4-ES	100	52	0	42	60*	0
5-MS	98	63	2	34	47*	0
5-ES	98	52	2	42	60*	0

*High School = 16-18 year old, Middle School = 11-15 year old, Elementary School = 5-10 year old

5.4. Weaknesses in the Data Sources and Analysis

Due to both the scope of the study and reluctance by some of the selected school facilities to share certain information, there are some weaknesses within the data analysis. One of these was the lack of uniformity in the data between facilities. This is due in part to the differences in record keeping and data collection methods between each of the school facilities. Several other weaknesses specific to each data measure are provided below.

5.4.1. Aerial Photography

Since the aerial photography was available for various years, it was impossible to establish a consistent analysis period before and after the opening date of each facility. Several different photography sources were utilized to obtain before-and-after data for each of the facilities, taken at non-uniform periods. By assuming a linear growth rate, it was hoped to minimize these impacts on the data analysis. A linear growth rate may serve to oversimplify some of the complexities that can impact residential development patterns. Population data were also subject to some linear interpolation, since the Census is only taken each decade. A series of photography for each facility would have been preferred, since some of the 'ebbs and flows' of development patterns may have been better observed.

Another difference was the magnification and resolution of the photography available for each facility. Since some of the facilities required the acquisition of aerial photography from the 1950's, the resolution of the photography was obviously of a lower quality than that of the more modern photography shot in the mid-1990's with better equipment. By using a magnified view when analyzing the photography, any impacts from this were minimized. Some subjectivity also played a role in analyzing the photography and determining the number of housing units.

5.4.2. Bus Travel Time Data

Given the reluctance of some schools to release their school transportation information, some of the bus information had to be obtained from easily accessible public sources, such as local newspapers or the county school board or school facility website. Since this information was publicly posted, it was assumed to have an acceptable degree of accuracy. Some of the schools were more willing to provide more in-depth information detailing transfers, bus mileage, and other relevant busing information. However, not having this information for some of the facilities meant that some assumptions had to be made regarding the bus travel at each facility, including transfers.

Due to privacy concerns, none of the schools were able to provide a detailed record of how many students were getting on at each stop, making it difficult to analyze the number of students riding for longer than the school specified guidelines, and leaving the analysis to be based only on stop times. Not having this data may exaggerate (or minimize) the number of students at the fringe of the school's service area, and subsequently the count of the number of students traveling for excessive times. Population dispersions within school districts are not uniform, and determination of these impacts could be more complex.

5.4.3. Mode Choice

These data sources provided the greatest variability of information. In one instance, a school district provided information on the number of students traveling on average for each bus route. In other instances, school administrators provided an average number of students traveling via private vehicle, bus, or a non-motorized travel mode. Other schools merely provided a number of students or number of vehicles arriving on a typical school day. As a result of the lack of uniformity, the various sources of data were all massaged to provide a single uniform measure of comparison between the facilities. Since the sample size and data collection methods from each school were highly variable and subsequently had to be massaged in several cases, these data may not be completely reflective of everyday conditions at the school facilities. This effect may not be critical, however, since seasonal variations in sports and other after school activities may serve to ensure there is no true 'typical' travel day for a school. Another factor that several schools mentioned was the impact of weather on the mode share. Due to the terrain and potential for hazardous road conditions due to weather, several schools indicated that winter driving conditions could result in a 'spike' in parents or students driving to school.

Chapter 6 – Conclusions and Recommendations

This study examined several transportation-related consequences of school consolidation in West Virginia. As a result of the research, several conclusions have been drawn and recommendations made. Overall conclusions are presented first followed by recommendations.

6.1. Conclusions

In light of the policies and bodies which govern their planning and construction, new school facilities are often pushed toward open, undeveloped land. Many jurisdictions have minimum acreage requirements which force new school facilities away from the developed core, while others have cost-based policies which tend to favor new construction over renovation of existing facilities. An exemption from planning and zoning requirements may also contribute to school construction and consolidation in undeveloped areas. Developer interests can also serve to drive the school facility towards a new development.

The development of consolidated schools also impacts school transportation. Older school facilities, most often in urban areas or closer to the student population and serving a smaller area, had more students utilizing non-motorized transportation. Newer school facilities, generally built with a strict separation of land uses, saw more students reliant on busing or personal automobile to reach the school. The type of transportation infrastructure available (sidewalks versus high-speed roadways) plays a role in this mode choice decision. Even where active-transport-to-school programs were available, school siting impacted the transportation mode decision. The presence of a no-transport zone also impacts school transportation decisions.

Consolidated schools, due to their extended service area, and the relative centrality of the consolidated facility to the student population, may result in significant travel times for students. Longer travel times also mean additional crash exposure (additional time and distance in transit) for all students traveling to school, whether by bus, personal automobile, or non-motorized mode. School consolidation also has the potential to significantly impact transportation costs for the impacted districts. Transportation costs have been rising for all school facilities, in part due to higher fuel costs. A study in West Virginia revealed transportation costs had increased significantly after a large scale school consolidation.

In this study, aerial photography analysis was completed to attempt to analyze land use patterns before and after construction of the school facilities. A 3-mile x 3-mile area displayed significant housing unit growth after the construction of the consolidated schools, while the 5-mile x 5-mile area for the consolidated county high school indicated housing unit growth also occurred at a rate exceeding that of general population growth. Based on the results, it was felt that the photography, both in terms of area and time range, was adequate to display long-term changes in development patterns resulting from construction of these school facilities, and, when compared to population trends, served to provide a measure of the potential for the school facility to induce development, whether or not there were other impacts to the land use in the area.

The number of housing units present within the communities surrounding the schools grew significantly over the full range of aerial photography obtained. This growth rate far exceeded the population growth rate or even contrasted with the population decay in the counties in which these schools were located. Therefore, it was concluded that, absent some other significant change which would lead to development in these areas, construction of the school facilities served as an impetus to new sprawl-style development away from traditional urban cores and other previously established population centers in the counties where these school facilities were located. It was concluded that for the consolidated high school facility, some of development may have to do with the overall development and population increase taking place in the state's Eastern Panhandle, and would most likely be contributing the extremely high housing unit growth. For the other facilities, however, this sort of population and development boom was/is not present in the other areas, and the school would serve as a primary impetus to the growth in housing units around the school.

Bus data was provided in several forms from the schools. The percentage of bus stops for the morning commute over the state guidelines for each grade level was established as the measure for bus travel times. It was felt the bus stops provided an indirect measure of the number of students traveling over these state guidelines and whether (potentially) significant numbers of students at each facility faced significantly long travel times. Overall, this was felt to provide an accurate measure since these were either publicly provided bus records accessed from newspapers or school websites, or detailed bus reports provided by county school transportation personnel. The school facilities studied had a percentage of stops ranging from 2 percent to 58 percent over the state maximum travel times for their particular grade level. The high school facilities had the lowest percentage of stops over the state maximum travel time, in spite of the county high school facility having the largest student body to transport. The two high school facilities were also the only facilities to have their average maximum bus ride fall under the state maximum value for their grade level, in spite of having the largest student bodies of any schools in the study. This most likely has to do with each of their student bodies being of the age to drive to school, and the number of students driving most likely reduces the bussed student population, reducing the number of stops and improving bus operation times. Some elementary school students potentially faced travel times double the state maximum travel time for their grade level. Many students in consolidated schools at these grade levels (K-8) are facing significant bus travel times in excess of the state guidelines. The geographic areas served by these facilities may be too large to provide busing in accordance with the state guidelines.

Mode choice data was available via anecdotal evidence from school personnel or provided transportation reports. In all cases, the facilities had percentages of students significantly above the averages found in the Rhoulac study (2004) riding the bus to school, where it was found travel time did not play a key role in determining travel mode. In fact, with the exception of the consolidated county high school, all other facilities had less than 20 percent of their students traveling to school via personal automobile. This subsequently meant that fewer students were being driven to school than both the numbers found in the Rhoulac study or national averages. When combined with the bus travel time from above, it does indicate that, in spite of the potentially long travel times, students are still riding buses, possibly out of necessity. Non-motorized transport was minimal or non-existent at all of the school facilities, either due to travel distances, unsafe conditions for non-motorized travel, or school policy which prohibited walking or biking to school.

6.2. Recommendations

As a result of the research completed in this study, several recommendations were identified. One group of these is for implementation by school administrative bodies since they may improve current consolidated school transportation operations or aid in planning future facilities. The other group of recommendations provides guidance for future research on or related to the topic.

For school administrative bodies:

- Log bus travel time data using standard forms, and ensure that bus operations are periodically evaluated by appropriate county school personnel. While the interviewed schools indicated they were aware of certain routes exceeding the state guidelines, yearly re-evaluation (if not already in place) and re-organization of routes may serve to shorten travel times for students. Included in this might be an evaluation of where driven students are coming from, and if that practice results from a lack of coverage or other issue in the school bus network.
- Future school planning should evaluate travel times comprehensively and formally as part of school consolidation planning. While mentioned in the school planning guidelines as a variable to be considered in school site evaluation and consolidation decisions, perhaps a formal planning study of travel routes and times for students should be implemented in studying any future school facility.
- Given tightening public budgets, comprehensive cost analysis of future transportation costs related to school consolidation should be formally factored into the school consolidation decision, beyond the school construction costs or new construction versus renovation. These transportation costs will serve as 'legacy' costs for the facility, and could outweigh the savings in initial construction or renovation costs.
- Consider approaches to utilizing long student travel times in ways to benefit their overall education. Given advances in technology, there appear to be opportunities to make the school bus a learning center
- Consider taking a comprehensive, systematic approach that includes factors not previously considered in developing school transportation plans. School transportation has many facets to consider including pupil

safety, quality of the student educational experience, operational costs, employee costs (both immediate and legacy), and equipment maintenance, among others. Each of these should be considered in the decision making process.

For future research:

- With regards to school transportation costs, there is potential for significant future research on this topic, including breakdowns of where transportation costs are allocated in consolidated schools, the impacts of fuel and equipment costs on overall costs, how fuel cost fluctuations impact school transportation costs, and comparing transportation costs at school facilities in differing areas.
- Using more sites would provide a larger data set to make conclusions. However, schools built in or near existing developed areas would provide little additional value since the area surrounding the school would have significant existing development. Comparing facilities in different land uses could also provide some additional value in determining land use impacts of different school facilities.
- Greater uniformity of bus data would provide a better comparison between facilities, but by comparing to averages from other studies that were larger in scope, an effective comparison could be provided.
- An additional topic of study would relate to determining how many students are riding for which stops at the studied facilities. Privacy concerns prevented the schools from being able to provide this information, but obtaining this would allow for a more comprehensive study of how many students are riding for how long, and provide a more robust picture of how many students are facing bus trips longer than the state guidelines at each grade level. Travel time research for students being driven would also inform this discussion, as well.
- In future studies, standardizing the data as best as possible may provide for more precise measures of specific factors related to the consolidated school transportation discussion. Several times throughout the study, one of the potential weaknesses in the data lay in the lack of uniformity, either in source from different school facilities, or timeframe, such as the photography.

- This study focused primarily on rural consolidated school facilities. Further research may focus on urban and suburban consolidated facilities and potential transportation issues they may face, or as a comparison to the rural cases presented in this study.
- From a data access standpoint, future research should attempt to access centralized data resources at the state level. As mentioned regarding the data uniformity, gaining access to these resources would provide a more uniform source for purposes of comparison. The author was unable to access any of these data resources.

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Appendix I –
List of Applicable Search Terms

- school transportation
- school bus operations
- land use
- school consolidation
- school consolidation policy
- sprawl
- personal transportation
- transportation mode choice
- school location
- school acreage requirements
- school building policy
- school facility planning
- teen driving
- aerial photography

Appendix II –
Contact Letters to Schools

HIGH SCHOOL LETTER

Hello,

My name is Bradley DiCola and I am currently a graduate student in the Department of Civil and Environmental Engineering at West Virginia University, working under my advisor Dr. Ronald Eck. As part of the completion of my master's degree, I am required to prepare a thesis. My thesis is on the topic of transportation impacts of consolidated and rural schools, entitled *Determining Transportation and Development Impacts of Consolidated Schools in West Virginia*. Based on available information, we have selected your high school as a potential case study in our research. We are contacting you in order to ask if you would like to participate in the study, and if you are interested, to notify you as to some of our potential data needs. Since this project is seeking to examine school transportation from several different viewpoints, there are several data resources that could be useful to us that you might be able to provide:

- School travel time data: individual bus route travel times, routes, and physical lengths(miles)
- Busing Reports: Usage breakdown of mileage traveled(daily school travel vs. field trips vs. athletics, etc.), fuel usage/costs
- Mode choice: Number of students riding buses, number of students riding buses per route, number of parking passes issued, policies pertaining to driving to school and parking, number of students arriving in personal automobiles, information on carpooling and being driven to school
- Parking facilities: parking lot dimensions (physical area), number of parking spaces, breakdown of type of parking (faculty/staff lots vs. student lots)

Some of this data is required for state reporting, while some of it may or may not be tabulated by individual counties and schools. We may also ask to speak with you personally for any qualitative information about school transportation at your school facility. Any further questions can be addressed to me at ___-___-____ or ________________, or Dr. Ronald Eck at ___-___-____ x ____, ______________. We hope you will be willing to participate and cooperate in this project, and look forward to working with you.

Sincerely,

Bradley DiCola
Graduate Research Assistant
West Virginia University

Dr. Ronald Eck
Professor, Department of Civil Engineering
West Virginia University

ELEMENTARY/MIDDLE SCHOOL LETTER

Hello,

My name is Bradley DiCola and I am currently a graduate student in the Department of Civil and Environmental Engineering at West Virginia University, working under my advisor Dr. Ronald Eck. As part of the completion of my master's degree, I am required to prepare a thesis. My thesis is on the topic of transportation impacts of consolidated and rural schools, entitled *Determining Transportation and Development Impacts of Consolidated Schools in West Virginia*. Based on available information, we have selected your school as a potential case study in our research. We are contacting you in order to ask if you would like to participate in the study, and if you are interested, to notify you as to some of our potential data needs. Since this project is seeking to examine school transportation from several different viewpoints, there are several data resources that may be useful to us that you might be able to provide:

- School travel time data: individual bus route travel times, routes, and physical lengths
- Busing Reports: School Bus Operator Monthly Reports, which includes: usage breakdown of mileage traveled(daily school travel vs. field trips vs. athletics, etc.), fuel usage/costs
- Mode choice: Number of students riding buses, number of students riding buses per route, number of students being driven to school in personal automobiles, any information on carpooling, any policies pertaining to walking, biking, or being driven to school
- Parking facilities: parking lot dimensions (physical area), number of parking spaces

Some of this data is required for state reporting, while some of it may or may not be tabulated by individual counties and schools. We may also ask to speak with you personally for any qualitative information about school transportation at your school facility. Any further questions can be addressed to me at 724-689-9722 or bradleydicola@gmail.com, or Dr. Ronald Eck at 304-293-3031 x 2627, Ronald.eck@mail.wvu.edu. We hope you will be willing to participate and cooperate in this project, and look forward to working with you.

Sincerely,

Bradley DiCola
Graduate Research Assistant
West Virginia University

Dr. Ronald Eck
Professor, Department of Civil Engineering
West Virginia University

Appendix III –
Summary of Selected School Background Data

Selected Schools - Background Data						
School Case # (Year Opened)	2006-2007 Enrollment	Grade Levels	Students/ Grade Level	Area of County (Square Miles)	2006-2007 County Population	Population Density (People/Square Mile)
1 – County High School (1964)	1104	9-12	276	641	22025	31.5
2 – Sub-County Consolidated High School (1979-1980)	905	9-12	226	309	56509	182.6
3 – Consolidated County Middle School (1989)	743	5-8	186	172	16291	93
4 – Combined Elementary/ Middle School (1978)	493	PreK - 8	55	359	17117	49.3
5 – Combined Elementary/ Middle School (1981)	349	PreK - 8	39	483	15407	31.9

Appendix IV –
Breakdown of Aerial Photography Data

School Case 1 – 3 Mile x 3 Mile Area										
Year of Photography	Years Before or After School Opening	Population	Housing Units	Net Change	# of Units/ Year	% Growth Overall	% Housing Growth Before School Opening	% Housing Growth After School Opening	% Population Growth Before School Opening	% Population Growth After School Opening
1955	9	12141	59	-	-	-	-	-	-	-
1971	7	12026	148	+89	6	-	-	-	-	-
1997	33	18721	347	+288	7	488.1	81.4	224.3	3.6	59.9

School Case 1 – 5 Mile x 5 Mile Area										
Year of Photography	Years Before or After School Opening	Population	Housing Units	Net Change	# of Units/ Year	% Growth Overall	% Housing Growth Before School Opening	% Housing Growth After School Opening	% Population Growth Before School Opening	% Population Growth After School Opening
1955	9	12141	87	-	-	-	-	-	-	-
1971	7	12026	389	+302	19	-	-	-	-	-
1997	33	18721	540	+453	11	520.7	146.4	151.9	3.6	59.9

School Case 2										
Year of Photography	Years Before or After School Opening	Population	Housing Units	Net Change	# of Units/ Year	% Growth Overall	% Housing Growth Before School Opening	% Housing Growth After School Opening	% Population Growth Before School Opening	% Population Growth After School Opening
1967	12	62064	289	-	-	-	-	-	-	-
1996-1997	17-18	56793	332	+43	1	-	6.0	8.4	5.3	-13.1

School Case 3										
Year of Photography	Years Before or After School Opening	Population	Housing Units	Net Change	# of Units/ Year	% Growth Overall	% Housing Growth Before School Opening	% Housing Growth After School Opening	% Population Growth Before School Opening	% Population Growth After School Opening
1967	18	14218	137	-	-	-	-	-	-	-
1997	8	15806	221	+84	3	-	36.8	17.9	7.5	3.4

School Case 4										
Year of Photography	Years Before or After School Opening	Population	Housing Units	Net Change	# of Units/ Year	% Growth Overall	% Housing Growth Before School Opening	% Housing Growth After School Opening	% Population Growth Before School Opening	% Population Growth After School Opening
1957	21	19589	95	-	-	-	-	-	-	-
1997	19	18163	209	114	3	-	63.0	35.0	10.1	-15.8

School Case 5										
Year of Photography	Years Before or After School Opening	Population	Housing Units	Net Change	# of Units/ Year	% Growth Overall	% Housing Growth Before School Opening	% Housing Growth After School Opening	% Population Growth Before School Opening	% Population Growth After School Opening
1962	19	15398	74	-	-	-	-	-	-	-
1996	15	15316	166	+92	3	-	69.5	32.4	3.7	-4.1

Appendix V –
Breakdown of School Bus Stop Data

School Case 1									
Source of Bus Data	Grade Levels	# of Routes	# of Direct Routes	# of Routes Involving Transfer	Maximum Ride Guideline	# of Routes Over Guideline	Length of Maximum Route (min)	Average Maximum Length of Route (min)	% Stops Over Guideline
Public Posting in Local Newspaper	9-12	42	27	15	60 min	16	90	51	11.4

School Case 2									
Source of Bus Data	Grade Levels	# of Routes	# of Direct Routes	# of Routes Involving Transfer	Maximum Ride Guideline	# of Routes Over Guideline	Length of Maximum Route (min)	Average Maximum Length of Route (min)	% Stops Over Guideline
School Website	9-12	30	29	1	60 min	3	80	38	2.3

School Case 3									
Source of Bus Data	Grade Levels	# of Routes	# of Direct Routes	# of Routes Involving Transfer	Maximum Ride Guideline	# of Routes Over Guideline	Length of Maximum Route (min)	Average Maximum Length of Route (min)	% Stops Over Guideline
County Transportation Office	5-8	30	20	10	45 min	20	72	52	22.4

<table>
<tr><th colspan="10">School Case 4</th></tr>
<tr><th>Source of Bus Data</th><th>Grade Levels</th><th># of Routes</th><th># of Direct Routes</th><th># of Routes Involving Transfer</th><th>Maximum Ride Guideline</th><th># of Routes Over Guideline</th><th>Length of Maximum Route (min)</th><th>Average Maximum Length of Route (min)</th><th>% Stops Over Guideline</th></tr>
<tr><td rowspan="2">School Principal</td><td>PreK-5</td><td rowspan="2">9</td><td rowspan="2">9</td><td rowspan="2">-</td><td>30 min</td><td>9</td><td rowspan="2">88</td><td rowspan="2">70</td><td>57.8</td></tr>
<tr><td>6-8</td><td>45 min</td><td>9</td><td>33.6</td></tr>
</table>

School Case 5									
Source of Bus Data	Grade Levels	# of Routes	# of Direct Routes	# of Routes Involving Transfer	Maximum Ride Guideline	# of Routes Over Guideline	Length of Maximum Route (min)	Average Maximum Length of Route (min)	% Stops Over Guideline
School Principal	PreK-5	9	9	-	30 min	7	125	58	28.9
	6-8				45 min	5			25.6

Appendix VI –
Breakdown of Mode Choice Data

School Case 1										
Source of Mode Choice Data	Grade Levels	# of Students	Students Driving?	# of Students Bussed	% of Students Bussed	# of Students Driving/ Driven	% of Students Driving/ Driven	# of Students Walking/ Biking	% of Students Walking/ Biking	'Blackout Area?'
Reports Provided by County Transportation Director	9-12	1104	Yes	533	48	571	52	0	0	NO

School Case 2										
Source of Mode Choice Data	Grade Levels	# of Students	Students Driving?	# of Students Bussed	% of Students Bussed	# of Students Driving/ Driven	% of Students Driving/ Driven	# of Students Walking/ Biking	% of Students Walking/ Biking	'Blackout Area?'
Discussions with County Transportation Director, other administrative personnel	9-12	905	Yes	805	89	100 (approx.)	11	Not permitted	Not permitted	NO

School Case 3										
Source of Mode Choice Data	Grade Levels	# of Students	Students Driving?	# of Students Bussed	% of Students Bussed	# of Students Driving/ Driven	% of Students Driving/ Driven	# of Students Walking/ Biking	% of Students Walking/ Biking	'Blackout Area?'
Reports from County Transportation Office	5-8	740	No	600	81	130	17	10 (approx.)	2	NO

School Case 4										
Source of Mode Choice Data	Grade Levels	# of Students	Students Driving?	# of Students Bussed	% of Students Bussed	# of Students Driving/ Driven	% of Students Driving/ Driven	# of Students Walking/ Biking	% of Students Walking/ Biking	'Blackout Area?'
Reports from County Transportation Office	PreK-8	490	No	487	99	0	0	3	1	YES

School Case 5										
Source of Mode Choice Data	Grade Levels	# of Students	Students Driving?	# of Students Bussed	% of Students Bussed	# of Students Driving/ Driven	% of Students Driving/ Driven	# of Students Walking/ Biking	% of Students Walking/ Biking	'Blackout Area?'
Reports from County Transportation Office	PreK-8	342	No	335	98	7	2	0	0	NO

Vita

Bradley Joseph DiCola was born in Latrobe, PA on December 30, 1982. He was raised in Latrobe, PA and graduated from Greater Latrobe High School in 2001. He received his Bachelor of Science in Civil Engineering from the University of Pittsburgh in 2005. Currently, he is a Master of Science Candidate in Civil Engineering at West Virginia University, specializing in transportation engineering.