**SCHOOL CONSOLIDATION, BUS ROUTING AND GIS**
**THE PENDLETON COUNTY, WV CASE STUDY**

by

Dennis Everett Mitchell

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APPROVED:

L. W. Carstensen, Chairman

R.W. Morill

S. Booker-Gross

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(ABSTRACT)

With the demise of the one-room school house, the issue of school consolidation has become very prevalent. Many have been reluctant to embrace this movement because with consolidation comes an increase in transport time for most students. Until recently, bus routing to new school sites could not easily be modeled. The positioning of a new school was also made without knowing the benefits or drawbracks of that site with respect to the bus routing for its service area. Calculations for routing were done by hand, and many times the routing was less than efficient. This thesis explores the uses of GIS to examine the changes that consolidation brings. In particular, the placement of a new school and its accompanying bus routes and how it will affect the commuting times of its students. The test area for this study was Pendleton County, a rural county in the Eastern panhandle of West Virginia, that is facing the possibility of consolidation. The results were also used to examine the feasibility of state recommendations and parental expections of student travel times for a consolidated school system.

# ACKNOWLEDGMENTS

I would like to thank several people that have helped to construct this thesis. First of all, I'd like to thank Mr. Paul Clayton and the bus drivers of Pendleton County for their assistance in obtaining data for the computer database. Thanks also to the citizens of Pendleton County, who participated in the survey. I would also like to thank my committee members, Bob Morrill, Susan Booker-Gross and especially Bill Carstensen. My greatest gratitude though, goes to my parents, Everett and Erma Mitchell, who sometimes prodded and also gave me much support during the long thesis process.

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# INTRODUCTION

The consolidation of schools has been a heavily debated issue in the nation over the past several decades. The total number of public school districts has dwindled considerably since the early 1960's(see figure 1.). Many rural areas have been especially hard hit with net out-migration and overall aging of their populations. Pendleton is a rural county in West Virginia, in these circumstances, facing the possibility of consolidation of its two high schools and some of the five elementary schools. The purpose of this study is to determine whether a Geographic Information System is efficient and useful in helping to decide the benefits or drawbacks of school consolidation. Pendleton County, and its current situation, served as the study area for this research.

The issue of consolidation has faced many school districts since the turn of the century. The problem facing smaller

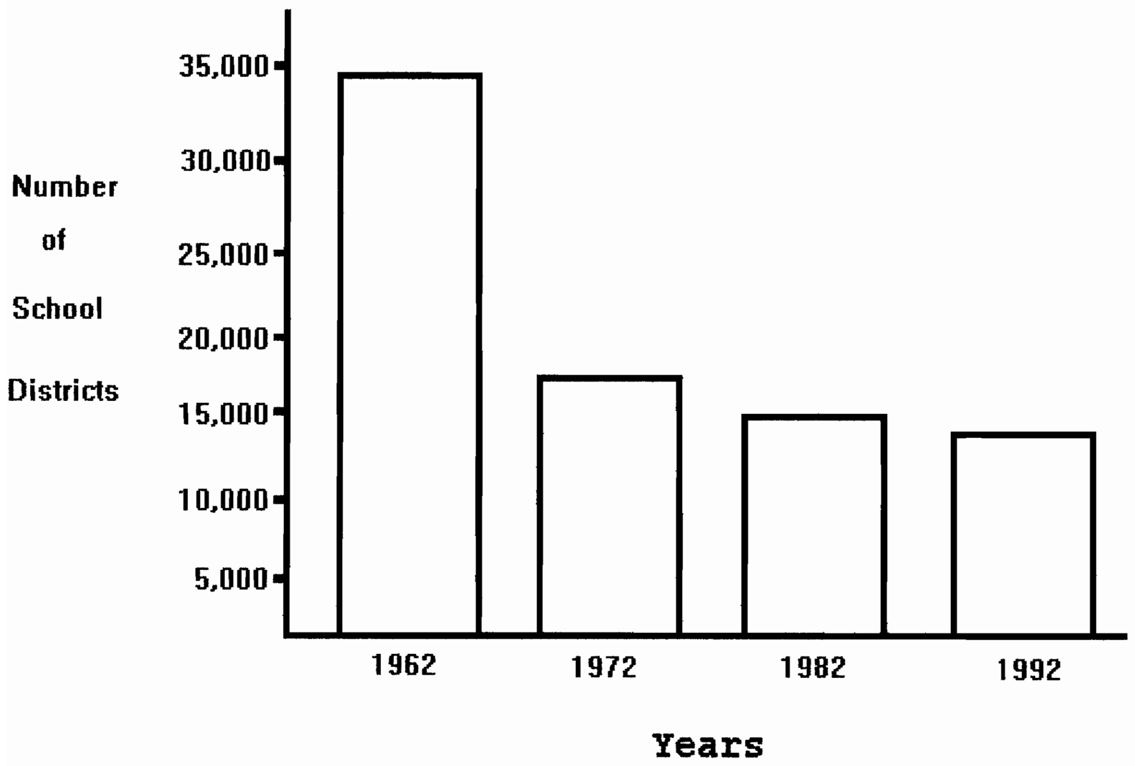



FIGURE 1. DECREASING NUMBER OF SCHOOL DISTRICTS, 1962-1992.

schools has been the increasing cost of education, including building maintenance and operation, additional teachers needed to teach more subjects, non-academic staff and personnel to run the school, and higher transportation costs, at the same time as a reduction in government education expenditures. Supporters and opponents of consolidation offer many reasons for their positions. The following gives some of the reasons given by each side.

Consolidation advocates point out that students are exposed to a larger variety of subjects. The consolidation of schools reduces the teaching of repetitive subjects at different school locations. This reduction allows teachers to be hired who specialize in subjects that couldn't be offered prior to the consolidation. Many also point to more effective grouping of students. With larger student bodies, students with specific needs can be grouped together where their special needs can be met. Supporters argue that consolidation establishes better facilities. Money used on several schools can be concentrated on one school building allowing more timely upkeep and purchases of new and better educational equipment. Student contact with better teachers is also an argument of supporters. With consolidation reducing the total number of teachers, the school system can offer higher overall salaries to attract better teachers. Many believe that consolidation offers students opportunities to participate in a wider variety of extracurricular activities, and wider social experiences. With one student body more activities can be offered and supported. By having more activities, more students can take part. Finally, supporters believe that the parents and community benefit through reduced education expenditures and the creation of closer ties between neighboring communities. The consolidation of several schools into one allows school systems to reduce expenditures on the heating/cooling and maintenance of several buildings. The number of teachers and support personnel is also reduced. Consolidation also creates a single rallying point for the whole community that tends to bring citizens closer together (Campbell 1964). Even in 1947 it was calculated to be 1.25 times more expensive to educate students at several smaller schools as opposed to one large school (McLure 1947).

Defenders of smaller school systems believe that consolidation creates more problems than it solves. Many point to the loss of contact with local teachers who know the community and the families within it. Consolidation of schools leads to larger individual classes, which tends to allow less student/teacher interaction. Opponents also argue that there are fewer opportunities to participate in extracurricular activities. When schools are combined, so are sports and other teams, effectively reducing the number of students who can participate in many activities. Consolidation opponents also point to the losses to parents and community. Parents lose the opportunity to participate in the control of their schools. The community suffers through the loss of facilities of an active school that often serve as a cultural and educational center, and the deterioration of community cohesion and participation, especially in youth activities(Campbell 1964). Probably the biggest problem opponents point out is increased time spent in commuting which might be used with greater profit on other activities. Farmer(1975) states that bus routes with excessive mileage often denote inferior service. Children transported on such routes are: (1) often subject to unnecessary hazards, (2) frequently unruly and fatigued, and (3) either delivered to school centers too early or retained in transit too long for their own welfare. The effect of school consolidation on student commuting times is a topic that is particularly well suited for analysis by a Geographic Information System.

## GIS: A PLANNING TOOL

A Geographical Information System (GIS) is a relatively new and powerful tool for geographic analysis and planning. GIS stores geographic information (maps) in conjunction with data(map attributes) related to features on the map. Before the advent of GIS, in the 1980's, computer cartography was used to store geographic data, but attributes concerning map features either had to be placed on the map as symbols or stored in a separate database. GIS map features and attributes are stored and manipulated together, which adds great efficiency and versatility to geographic analysis and planning processes. A GIS's basic function is to replicate the real world in digital format. A GIS describes features in the world in terms of (A) their position with respect to a known coordinate system, (B) their attributes that are unrelated to the position(such as color, cost, pH, incidence of disease, etc.) and (C) their spatial interrelations with one another (topological relations), which describe how they are linked together or how one can travel between them (Burrough 1986). This research project will focus on the last aspect of a GIS explained above, that is, the aspect of travel between the topological features of home and school.

**OBJECTIVES AND QUESTIONS**

The major question of this research is: is GIS a useful and efficient tool in producing timely information for use in the consideration of school consolidation? In particular, information concerning bus routing and site selection where effects on student commuting time are emphasized. Other objectives of the research include: providing an overview for others interested in network analysis and using Arc/Info network analysis capabilities, examining the feasibility of the inclusion of perceptions' of parents and state authorities of student commuting times, and finally providing specific information for use in Pendleton's deliberation of consolidation. Chapter two discusses the basic elements of network analysis. In chapter three, North Carolina attempt at computerized network analysis is examined. The fourth chapter discusses how Arc/Info is designed to analyze network models. Chapter four describes how Pendleton was modeled and analyzed. Chapter five discusses the results of the analysis, and finally, chapter six describes conclusions on the efficiency of computer analysis.

Ancillary information for the study was obtained through a telephone survey. Parents were asked questions to obtain an overall perception of consolidation and student travel time expectations. A sample of the questionnaire and the responses given is found in the RESULTS chapter. Because of the expected difference of opinion within the county, the survey was a stratified random sampling within the two high school service areas: North Fork and South Branch/South Fork. Approximately thirty samples were taken in each high school area, for a total of sixty phone interviews.

**SITUATION OF STUDY AREA**

Pendleton is a rural county located in the eastern panhandle of West Virginia. It is a quiet place where in many ways time seems to stand still. However, in this ever changing world this small community may be forced into taking a giant step into the future that will change it forever. Pendleton, like many rural counties, is facing the possibility of school consolidation because of budget constraints. Today Pendleton maintains two high schools and five elementary schools, serving a county that is areally quite large (Figure 2). With a land area of 707 sq. miles Pendleton ranks fifth in the state in size, but is sparsely populated with a total of only 8,200 people.

Franklin High School is the larger of the two high schools, its present building having been constructed in 1930. The school has 471 students, and is located in the county seat, Franklin. Franklin High serves approximately two-thirds of the county's population including the South Branch and South Fork areas of the county. Circleville High School, is located in the town of Circleville. The school was constructed in

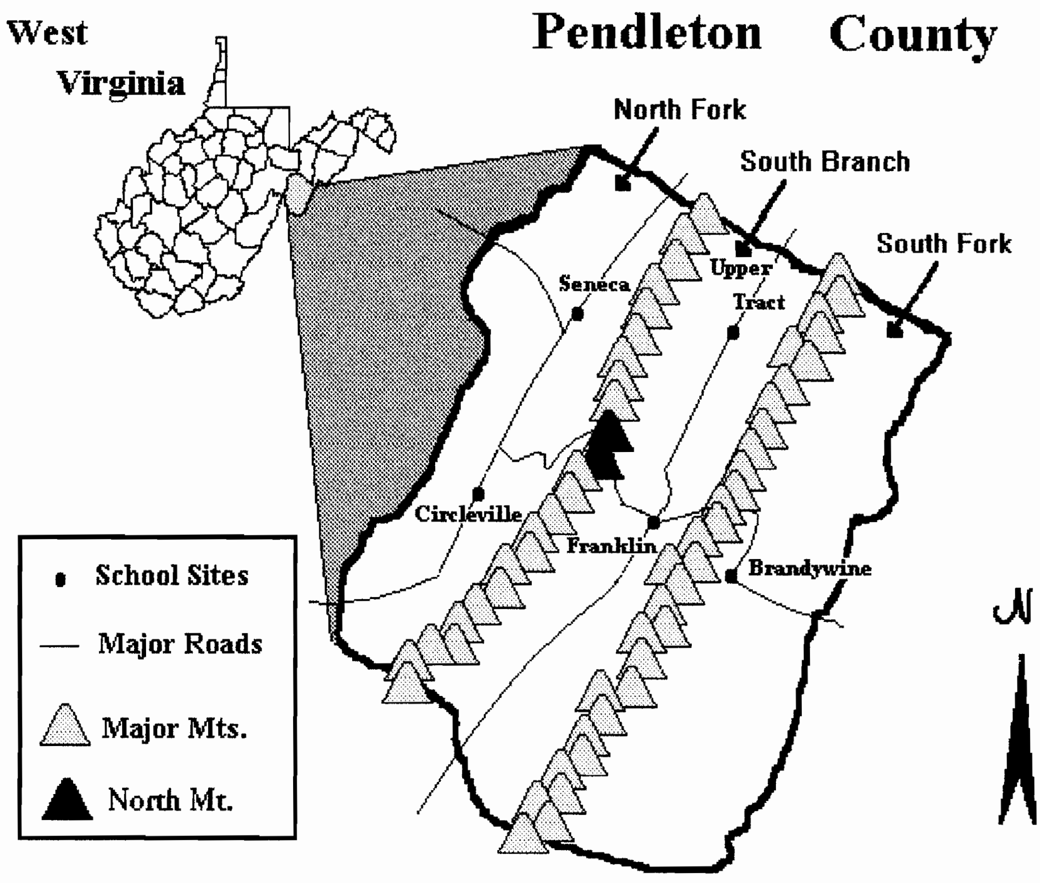



FIGURE 2. LOCATION AND BASIC FEATURES OF PENDLETON COUNTY.

1936 and serves the northwestern third of the county called the North Fork area. The Circleville school facility is a combined high school and elementary school serving 279 students from kindergarten through twelfth grades.

A proposal by Dr. Alan Cononico in 1992, a former superintendent of schools, to consolidate the two high schools, received bitter opposition from some county residents and the board of education. The proposal, supported by the state, called for the closing of both high schools and the construction of a new high school in the Franklin vicinity. The state has offered Pendleton grants exceeding ten million dollars to construct a new high school. North Fork citizens are especially opposed because of extended student travel time and hazardous winter travel across North Mountain to reach the proposed new high school location. Historically, the North Fork area has been isolated from the rest of the county because of the North Fork Mountain Range. There are only two single lane roads connecting the North Fork to the eastern portion of the county. The better of the two roads must cross North Mountain at over 4000 feet elevation. Some of the area's citizens travel to more accessible neighboring counties, rather than to Franklin to purchase food and other necessities. Many residents believe consolidation will end the community activity and pride that Circleville High has provided for many generations in the North Fork area.

The former county Board of Education, working with Dr. Cononico, was opposed to the consolidation proposal. Three members of the board were residents of the North Fork area and the other two were residents of the South Branch and South Fork areas. Board of Education members are elected officials who serve six year terms. The consolidation proposal is on the agenda again with the election of a new school board in 1994, which now has a majority from the South Branch and South Fork areas. A new superintendent, Dr. Charles Smith, has also been hired. Because of the possibility of consolidation, timely information to make decisions is a necessity, one that this study will show can be served efficiently by a GIS.

**STUDY'S IMPORTANCE TO AUTHOR**

The author was raised and educated in Pendleton County. The author spent many hours traveling to and from school on a ride that was an hour and twenty minutes each way. In this instance the author can sympathize with the students whose rides consolidation would lengthen and with the parents worried about the winter hazards of crossing the North Mountain. While growing up, the author can recount numerous times his bus got stuck in the snow and one or two of the older children had to run to the nearest house (over a mile away) to get help. The author also understands the need for new school facilities because the two high schools were constructed in the 1930's. Although the structures have been improved over the years they lack many benefits offered by more modern schools. Two other factors aiding the author in the study are that his father is a retired bus driver for the county and that the author has also performed substitute teaching at several of the county schools and is acquainted with many school officials.

# TRANSPORTATION MODELING

Transportation models are based on the geography of movement. Movement in this study is the transporting of children to school. This chapter provides the reader with the basic concepts and elements of transportation modeling and how some of these concepts relate to this study.

## NETWORK ELEMENTS

The basic element of a model is the node. A node has the capacity to serve several functions. The first function is the representation of an origin or a destination. Nodes can secondly serve as a relay point whose job is receiving and transmitting flows in order (Lowe 1975). The origin and destination nodes are both necessary elements in any study of a network transportation system. In this study the starting point of the bus and the school represent the origin and destination. The relay function of the node serves to represent stops along the bus routes. Besides having specific functions, the node also possesses other attributes. Nodes are situated in relative locations. Node distribution follows three basic patterns: clustered, uniform, and random. The clustered pattern, as the name denotes, occurs where several nodes are closely grouped together. Examples of this pattern would be department stores, gas stations, and car dealerships. The uniform pattern is much less prevalent than the clustered pattern and is found in gridiron city streets and the township and range farm plots in the Mid-west. The random pattern best illustrates the nodes in this study. Random nodes are situated in a pattern where one node is not located in any position because of the direct influence of any other node(Lowe 1975).

The second element of a transportation model is the route. A route is a channel along which interaction between any two nodes takes place(Lowe 1975). A route can be a fixed or flexible entity. Roads, railways, and canals are examples of fixed routes, while airplane routes and ship routes are more flexible. Whether fixed or flexible they seek to be the shortest or least costly path. A highway or railroad is often built on the banks of a river when traveling through mountainous terrain. This path allows for a fairly level gradient and little in the way of major soil and rock removal, which keeps construction costs at a minimum. Airplanes and ships also seek the least costly paths, by using winds and ocean currents. A plane will take a flight path that takes advantage of tailwinds even if it isn't the shortest path based on mileage as, by using tailwinds, the plane will save fuel and arrive more quickly than if it had taken the more direct route.

Routes, like nodes, have many functions. First, they contribute to movement efficiency by structuring flow. Secondly, they accommodate many types and purposes of movement. Thirdly, they maximize the use of space. Lastly, they identify a portion of space(Lowe, 1975). Without routes, travel between different locations would be extremely difficult. Routes facilitate the spatial interaction between two areas. As additional routes are constructed to an area, the accessibility of that area increases compared to others that have few routes in their proximity.

**Network Models**

Models allow the user to analyze the real world without all of its inherent complexity. In this instance, the model represents a transportation network. Transportation networks have numerous attributes. A highway network can contain roads of many various types. Roads have different numbers of lanes, sections with different speed limits, sections where only cars are allowed, and so on, yet only some attributes are important for certain analysis processes. This generalization of real world features allows model users a faster and easier analysis capability. In this study the road network in Pendleton County was generalized to include only roads with school bus stops or roads capable of being traversed by a bus.

**Distance: Its Effect on Network Transportation**

In a network, often the distance is thought of as point to point mileage, the old adage being that the shortest distance between two points is a straight line. However, it depends on the definition of distance being used. In today's world, time is often more important than mileage as a distance consideration. In the case of ambulances, school buses and commuters, the quickest route is usually the most desirable. Even if the definition of distance is synonymous with mileage, a straight line is still not always the shortest distance. In mountainous areas it may be a shorter distance to go around the mountain rather than over it. This is due to the fact that the road has to wind back and forth numerous times in order to make a travelable grade, thus the distance ends up being as long or longer than if you went around. In other instances a straight line path is not possible because of obstacles like mountains, lakes, or traffic jams. Although based somewhat on time and mileage measures there are economic and perceptual measures of distances that offer a slightly different perspective of how distance can be viewed(Lowe 1975). Economic measures of distance are based on the method of transportation and location that transporting is occurring. For example, air fares between cities are usually more expensive than bus fares between the same cities. Also, bus fares may cost more in one country than another for the same mileage traveled. Probably though, the most important distance concept for this study, in conjunction with the factor of time, is perceptual distance. Typically the perception of a distance takes precedence over the mileage or time factors. Perception of distance could be a big factor in the consolidation debate in Pendleton because the citizens of the North Fork perceive the distance across North Fork Mountain to be great. If the distance to a place is perceived a certain way it biases one's view toward the actual distance.

**Techniques of Solving Shortest Path Problem**

Several methods have been used through the years to determine the shortest path between two points in a network. Most techniques involve complicated mathematic processes, and until the recent development of fast computers with large memory capacities, these techniques had been very tedious to use in network analysis process.

One of the techniques that has been used for network analysis is linear programming. However, in many instances, standard linear programming is inefficient in solving shortest path problems(Daskin 1995). Another method of finding the shortest path is known as matrix multiplication, which calculates the distance between all nodes in a network simultaneously. Its problem is that the number of variables that need to be dealt with, depending on the size of the network, can run in the millions(Nordbeck 1969). The tree searching methods are another way of finding the shortest path. Dijkstra's algorithm is in this category. This algorithm looks at the link cost and predecessor node of each intermediate node as a path is sought between the origin node and destination node. The least cost path can then be determined by the total cost of each node and its predecessor nodes.

# COMPUTER-ASSISTED ROUTING

The state of North Carolina has been at the forefront of computer-assisted routing and scheduling. The humble beginnings of this effort started in the early 1980's. A somewhat limited routing program was produced in BASIC that was used to schedule school busing for the Charlotte-Mecklenburg Schools. The goal of this program was to reduce the number of buses transporting pupils. During this same period Wake County decided to develop a totally new set of bus routes. Ecotran Systems of Cleveland, Ohio, was hired to provide routing optimization software and technical support. Although several problems with the computer-generated routes occurred, the county continued to modify routes and work with the system for another two years. The University of North Carolina at Charlotte also became interested in the possible benefits of route scheduling. By 1982 Dr. Scott Iverson, Assistant Professor of Civil Engineering had developed a computer program for optimizing bus runs. He and Dr. Wayne Walcott, Professor of Geography, had performed a pilot project with Iredell County schools. The program required a matrix of distances from each bus stop to every other bus stop. It soon became apparent that this was unfeasible. The number of stops considered by other stops was reduced to make manageable calculations. The program did produce bus runs, but is turned out to be more of a sequencer of given bus runs rather than as a method of grouping stops into runs and then sequencing. In 1983 at North Carolina State University, the development of two scheduling and routing programs was completed. Derek Graham, working with Dr. Henry Nuttle developed the software SAM or Scheduling Assistance Model. SAM produced good results but wasn't able to show its true potential. The pilot area in Guilford County turned out to be a poor testing site because route management had been a high priority of the county. During the same period the RAM or Routing Assistance Model was produced at University of North Carolina at Charlotte's Geography Department by Paul Smith and Wayne Walcott. The RAM also produced good results, it gave many insights on how their routing might be changed. The major drawback was that stops could not be added, deleted, or manipulated which soon made the system's output obsolete.

In the fall of 1985, the North Carolina Department of Education, after viewing the many successful pilot projects, decided to get involved in the area of computer-assisted routing and scheduling. The Department of Education together with the ITRE or Institute for Transportation Research and Education constructed and issued a Request For Proposals (RFP) to seek a comprehensive design for a TIMS or Transportation Information Management System. The RFP had two necessary criteria for the new software, this included have a Geocoding subsystem and a Routing and scheduling subsystem. The geocoding subsystem was required to have the capabilities to create and maintain, through manual and automatic means, Geographic Base Files, which contain node and segment information. The purpose of the routing and scheduling subsystem was to manage pupil transportation and reduce state transportation costs. Four distinct functions were required of the routing and scheduling subsystem: student assignment, transportation eligibility and stop determination, routing and scheduling. Five vendors provided software offerings. None of the vendors met all the requirements. The Educational Logistics (Edulog) company's software most closely matched the proposal requirements. Edulog later met those requirements by enhancing their software by enabling the geocoding system to include curved streets, and an interactive mechanism for adding, deleting, and editing street data.

**TIMS SYSTEM**

The TIMS system consists of five major processes: the encoding of street networks (geocoding), entering of transportation information, matching students to the geocode, production of maps and reports, and optimization.

The geocoding process in many counties was performed by digitizing street networks in each school district. Counties entering the system at a later date have obtained geocoding information from DIME(Digitally Integrated Map Encoding) files and TIGER (Topographically Integrated Geographic Encoding and Referencing) files. The result is a network of nodes and street segments. Each street segment is stored with attribute data including street name, range of house numbers, bus travel speed, hazard designations, one-way indicators, and no-bus travel specifications.

Bus stop information is kept in the transportation database and is concurrent with the geocoding. Each stop is located as a street address, street intersection, or map location. Each stop also retains the total students it serves. The

TIMS system also shares and correlates information with the stare student database called SIMS (Students Information Management System). School officials are then able to determine whether there are any missing streets or address problems in the geocode.

There are several output functions of the TIMS system including maps and reports. Reports such as the Driving Directions Report gives a word description of any route. The report also gives the time taken along each point of the route, the number of students at each stop, a cumulative total of students with each successive stop, and each stop's identification number. Bus route maps are also available with individual routes or entire route systems for a particular school. There is also a Bus Run Roster that provides information of each student including: morning and evening bus stop locations, pickup times, bus numbers, phone number, and address. TIMS also has the capability to analyze the make-up of students in any geographical area. It can also provide Student Tally Reports and produce Student Location and Density Plots.

The final part of the TIMS system is the optimization phase. School districts wanting to look at "what if" situations now have that capability. Stop optimization is used to look at home-to-stop walk distances. TIMS will create the fewest stops possible allowed by the distance constraints. Run optimization involves assigning bus stops to bus runs. Existing bus routes are erased and stops are regrouped and new routes formed.

**TIMS'S COSTS AND SAVINGS**

The cost of the TIMS system is estimated around 4.2 million. Included in the cost was software, support equipment, staff (salary, travel, and supplies), and system installation. The saving come as a reduction in total buses by 472. With a replacement cost of $30,000 per bus the state saved about $14 million. Fuel consumption was also reduced by 1,269,353 gallons per year which saved over a million dollars itself. As is evident by the above figures the system has more than paid for itself already(Graham 1993).

Other areas outside of North Carolina are also working on bus route analysis. Currently, two school systems in Virginia are using computerized route/scheduling systems; they are Hampton City and Isle of Wright Schools. Also three professors at the University of Waterloo in Canada have constructed an algorithm for bus routing with maximum student travel time as a basic criteria(Bowerman 1994).

# ARC/INFO MODELING

The ARC/INFO NETWORK module is used in modeling spatial networks. NETWORK models a network as a system of linear features that are interconnected, and through which transportation or communication takes place. The NETWORK data model is designed to replicate the characteristics of a real-world system in computer simulated form. The network model consists of several features including: network links, network nodes, stops, centers and turns. In order to model network data correctly, the relationships between real-world features and computer representations of those features must be understood.

The basic structures of the network model are links. Links are actually ARC/INFO arcs that represent interconnected linear features. The network links are real-world representations of highways, rivers, even communication or electrical lines, anything over which goods or services is transported. Arcs representing the features and their attributes are kept in the network coverage's arc attribute table, or AAT (Table 1 and Figure 3 detail an AAT.).

The second element of the network model is the network node. The network nodes represent the endpoints of network links. Network nodes also serve as connection points between network links. For example, highway intersections, or pipe connection points can be represented by network nodes. Network nodes are modeled as standard ARC/INFO nodes stored along with their attributes in the network coverage's node attribute table, or NAT (Table 2 illustrates a NAT.). Nodes also serve to model three other network features: stops, centers and turns; these features have individual attributes and are kept as separate INFO files not part of the network coverage AAT or NAT.

One of the network model elements modeled by the node is the stop. A stop represents a location of goods or resources that are being transported from one place to another. A good example of a stop is a bus stop, where people are picked up and transported to another location. Stops are maintained in INFO files referred to as STOPS files.

TABLE 1. ELEMENTS OF AN AAT

| FNODE # | TNODE # | LENGTH | COVER-ID | COVER # | F_T_IMP | T_F_IMP | DEMAND |
|---|---|---|---|---|---|---|---|
| 250 | 253 | 2100.06 | 45 | 45 | 35.0 | 44.0 | 8 |
| 251 | 254 | 3235.61 | 46 | 46 | 22.0 | 24.0 | 3 |
| 253 | 255 | 2549.32 | 49 | 49 | 27.0 | 25.0 | 5 |

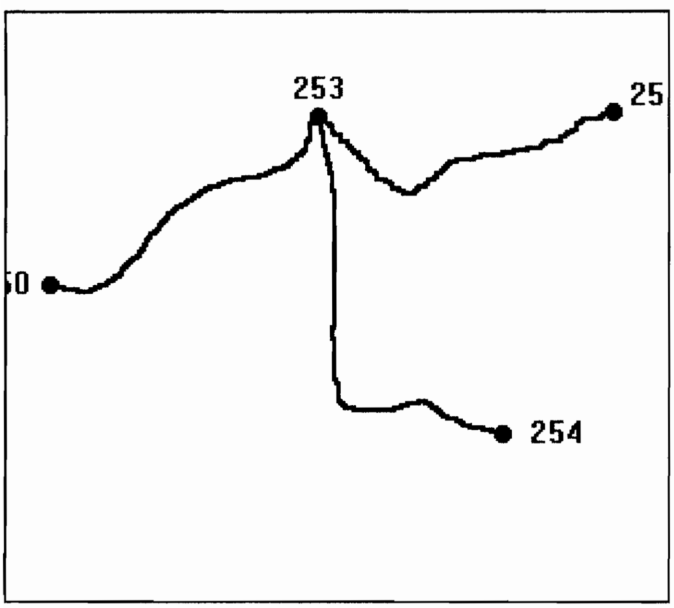



FIGURE 3. ROAD SEGMENTS WITH NODES

TABLE 2. ELEMENTS OF AN NAT

| **ARC #** | COVER # | COVER-ID |
| --- | --- | --- |
| 27 | 45 | 45 |
| 32 | 46 | 46 |
| 15 | 49 | 49 |

The network center is a feature also represented by a node. (Figure 4 shows network elements.) A center represents a location from which resources are supplied. Examples of a center would be schools, malls, warehouses or towns and cities. Allocation and spatial interaction procedures use centers in the analysis process. Centers are also kept in INFO files called center files.

The final network element modeled at a node is a turn. A turn is used to represent connections from one network link to another. Turn representation can be very important in networks with high traffic volumes. Making a turn against oncoming traffic can take significantly longer than making a turn with oncoming traffic. The turn also allows one-way streets to be modeled. Turns are kept in an INFO file that is called a TRN file (Figure 5 illustrates turns.).

A network model is a conglomeration of arcs and nodes together with special network elements for stops, centers and turns. All features must be abstractly represented by one of the model elements.

Network links are represented as arcs, therefore a network coverage is a line coverage and must have an AAT. Each arc in the coverage has a unique id for assigning attributes.

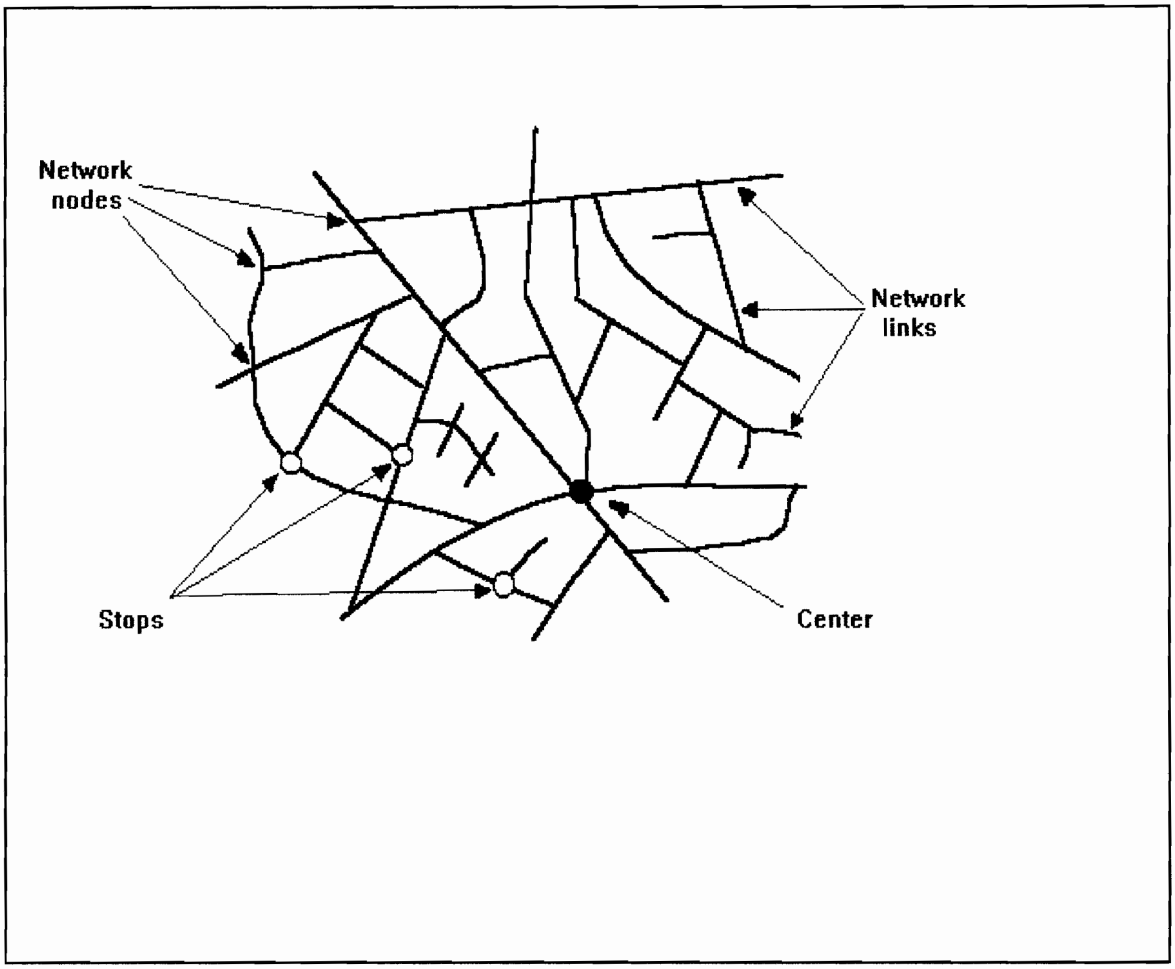



FIGURE 4. NETWORK ELEMENTS

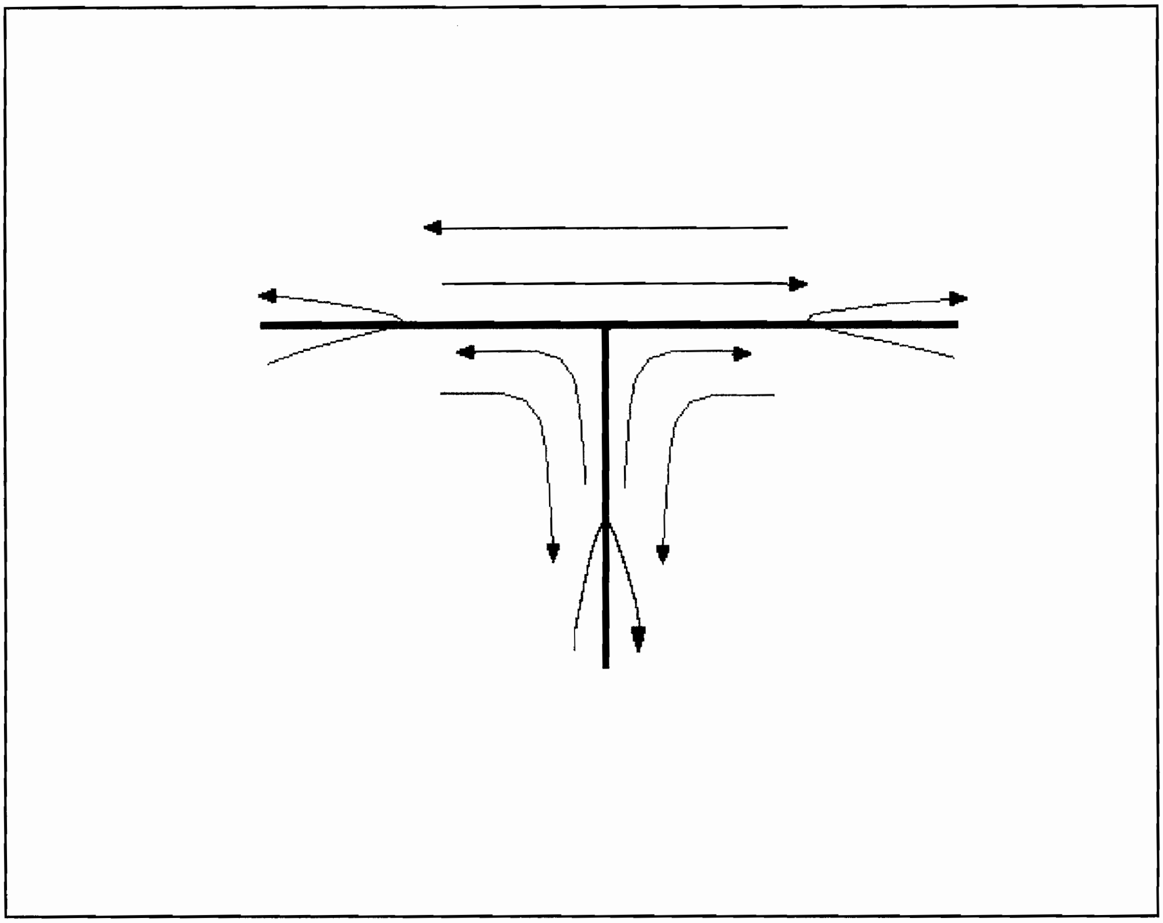


FIGURE 5. TURN MODELING POSSIBILITIES

One attribute assigned to an arc describes how a network link can be traversed. A network link can allow movement in none, one or both directions. Directional attributes are termed link impedances. Link impedances are representative of the cost, usually in units of time, which it takes to traverse a network link. The link impedance is stored by elements in the network coverage's AAT called the from-to-impedance (F_T_IMP) and the to-from-impedance (T_F_IMP)(See Table 1). The from-to-impedance is used when moving from the FNODE to the TNODE (Figure 6). FNODES and TNODES are also elements of the AAT, and define the beginning and ending points of a network link. The to-from-impedance is the opposite of the from-to-impedance; it is used when traveling from the TNODE to the FNODE. A link impedance is a user defined element of the network coverage AAT and is used by the allocation, pathfinding and spatial interaction analysis processes. A negative value link impedance signifies that the link cannot be traversed in that direction, and is useful in modeling one-way streets.

Another link attribute is the link demand, which represents a reduction in supply required to assign a network link to a center. For example, a school is a center that has a limited number of seats, therefore total demand cannot exceed the total number of seats the school has available.

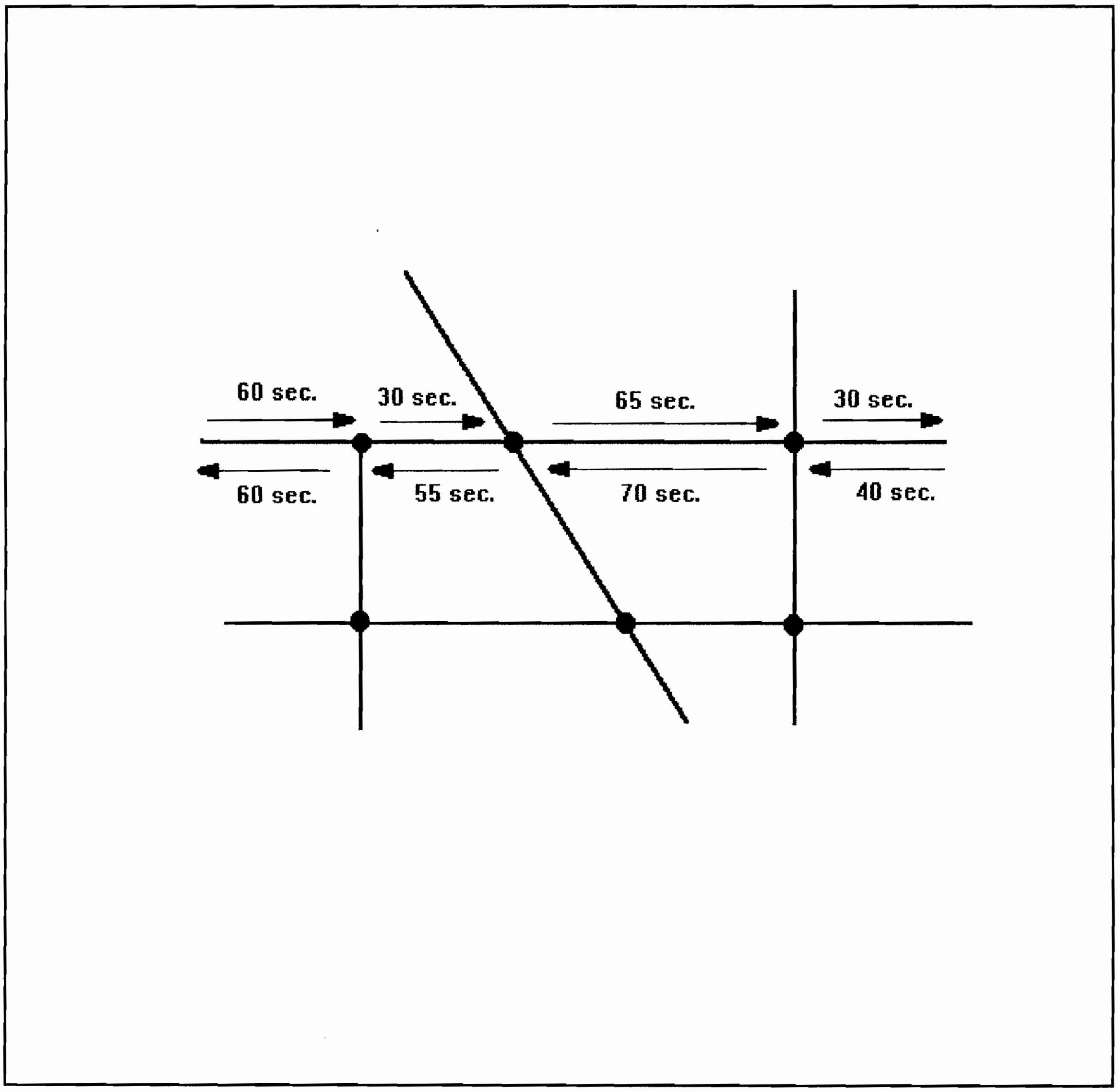



FIGURE 6. LINK IMPEDANCES

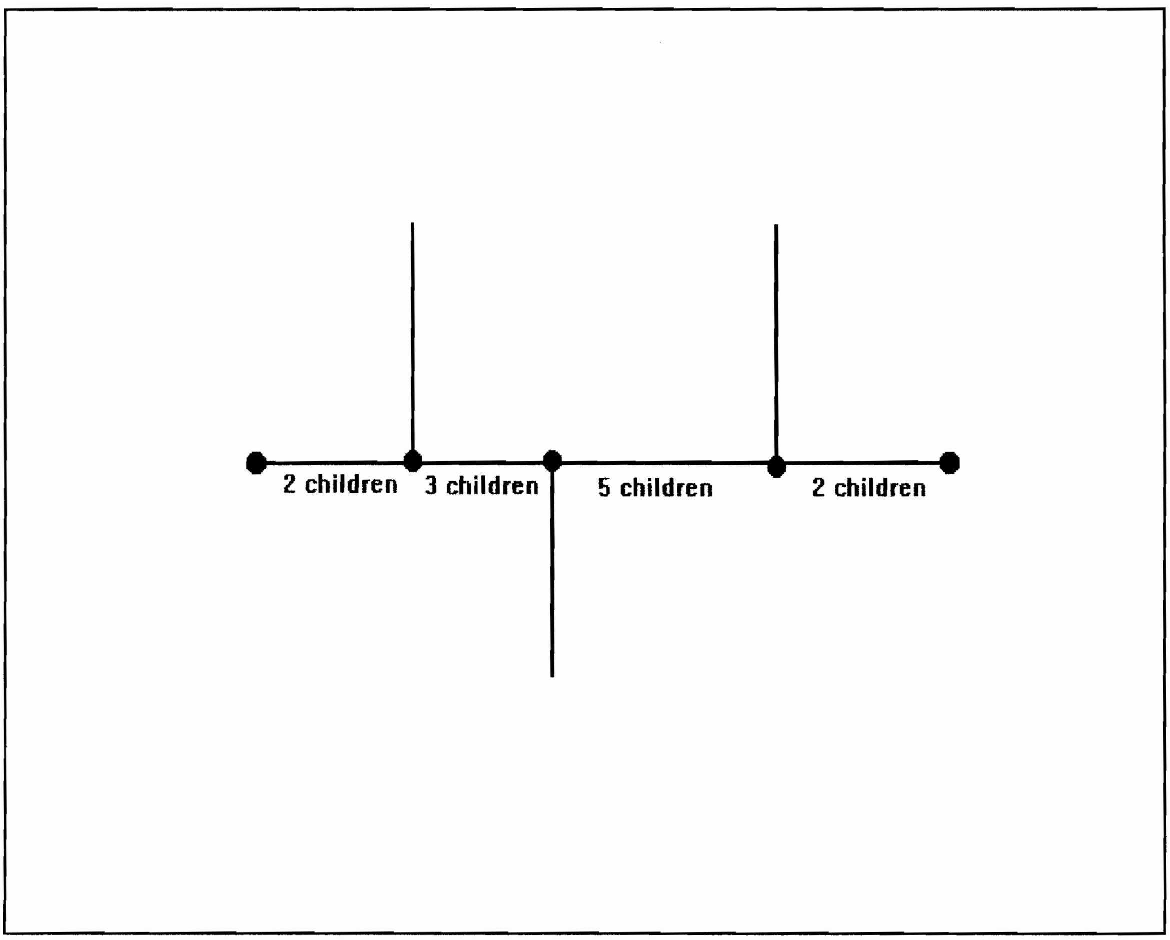



FIGURE 7. LINK DEMANDS

Each link has a certain number of students along it, thus adding a link assigns its students to a school, and reduces the number of empty seats available (Figure 7).

**ARC/INFO Analysis Tools**

One basic question of network analysis is to find the optimal route between points. In ARC/INFO, the arcs of a network coverage are used to represent roads, and stops are used to represent locations in the network that must be visited. Once the computer has determined the shortest path between stops in the network it stores the selected path as a route in a route-system. Results may be displayed graphically using commands in ARCPLOT. The NETWORK commands PATH and TOUR are used to find shortest path routes.

The PATH command finds the shortest distance between stops to be visited in a predetermined order. An example is an ambulance that must reach an accident scene.

The TOUR command is slightly different from the PATH command. TOUR is used to determine in what order stops should be visited and the shortest path between those stops. The "traveling salesman" problem is a good example for which

TOUR can be used. The salesman must visit a certain number of clients in a predetermined area. The salesman must find the best sequence in which to visit his clients that will minimize his total travel time. TOUR uses an heuristic (informed guessing) approach to approximate the best tour (Environmental Systems Research, Inc. 1992).

Another method of pathfinding and stop ordering can be found by using SPATIALORDER AND COLLOCATE. SPATIALORDER is used to cluster stops in proximity to one another. Stops are grouped by their relative closeness in two-dimensional space, with no regard to network connectivity. The COLLOCATE command can use the output from SPATIALORDER to cluster the stops based on a preset capacity. For example, a bus can only seat a certain number of passengers, or a truck only has the capacity to haul a limited amount of freight. The TOUR command can be used to optimize COLLOCATE results by finding the shortest routes between the stops within a cluster.

Allocation is another network analysis tool that can be utilized in ARC/INFO. The ALLOCATION command is used to assign parts of a network to a center of facility. The allocation analysis process is based upon supply, demand, and impedance. Supply is the amount of a resource available at a center. The demand is the amount of that resource that each part of the network uses as it is assigned to a center. A good example is a school. Schools can only handle a certain number of students because of seating and other constraints. Streets surrounding the school form the network, and the students that live along those streets form the demand. The allocation process for a center stops when the demand equals the supply of the center. An impedance item can also be used by ALLOCATION. Using the school again as an example, any student living beyond a certain distance or taking over a given amount of time to reach the school might not be assigned to that school.

Spatial Interaction can also be used in network analysis by ARC/INFO. ARC/INFO utilizes two tools in the study of spatial interaction, they are ACCESSIBILITY and INTERACTION. ACCESSIBILITY measures how accessible one location is to other locations. Measuring is based the number access routes and speed with which a location can be reached from any other location. INTERACTION, the other command, is used to compute the quantity of interaction possible between two locations. This tool is very useful for locating potential business sites.

**Pathfinding Algorithm**

Three of ARC/INFO's network analysis tools (PATH, ALLOCATION, and TOUR) directly rely on the optimal routing algorithm. TOUR is the foundation of this study. The algorithm is a iterative method to find the least-cost path. NETWORK makes use of what is known as Dijkstra's algorithm (Environmental Systems Research, Inc. 1992). The problem with finding least-cost paths is that there can be hundreds or even thousands of possibilities, depending upon network size and complexity.

In order to understand the algorithm there are several terms to keep in mind.

**Origin Node** - the node at which the algorithm starts.
**Adjacent Nodes** - nodes at the end of arcs connected directly to node presently occupied.
**Reached Node** - any node arrived at by the least-cost path. The node with the lowest cumulative travel time of a set of scanned nodes(definition below) becomes the **Reached Node.**
**Reached Table** - a table that records nodes that have been reached by the least-cost path.
**Scanned Node** - any node not reached but that is adjacent to a reached node.

**Scanned Table** - the table that contains a record of scanned nodes. A scanned node may appear more than once on the **Scanned Table**, because a node can be adjacent to more than one node and therefore it may be scanned more than once.

**Outline of Algorithm**

The algorithm begins with the user defining the origin and destination nodes. The algorithm scans nodes adjacent to the origin node and calculates which is the closest. Scanned nodes are then placed in a scanned table which is kept in computer memory. The scanned table also keeps track of cumulative impedance of each node scanned, as well as the previous node in that path. Then, the algorithm moves to the node with the least scanned cumulative impedance, this node is now termed a reached node. Reached nodes are placed in a reached table which is kept in computer memory. The reached table also keeps track of cumulative impedance and the previous node in that path. Once a node is reached it is removed from the scanned table. The scanning and reaching of nodes continues until the destination node is reach with the least cumulative impedance path.

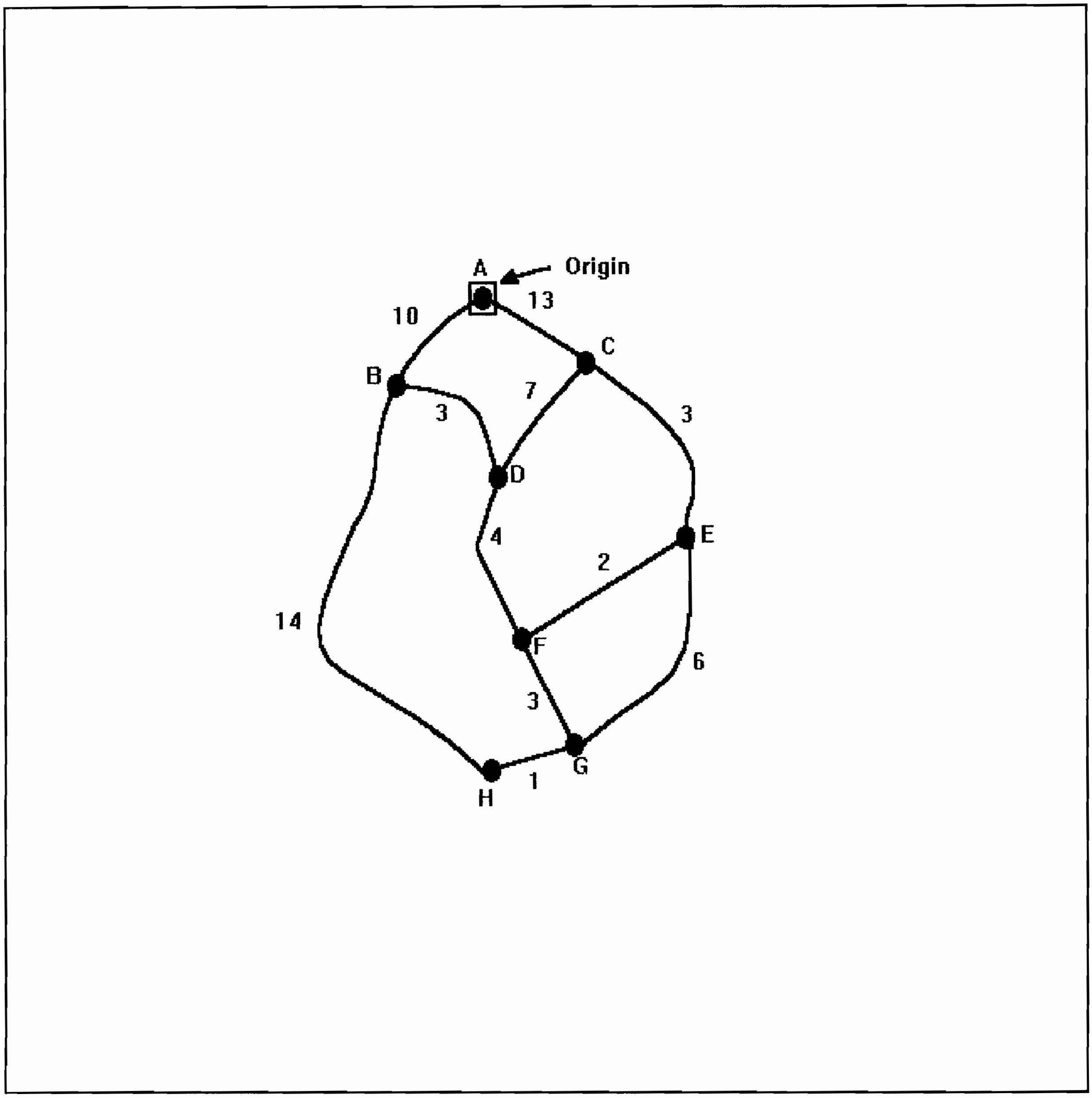



FIGURE 8. ORIGIN NODE

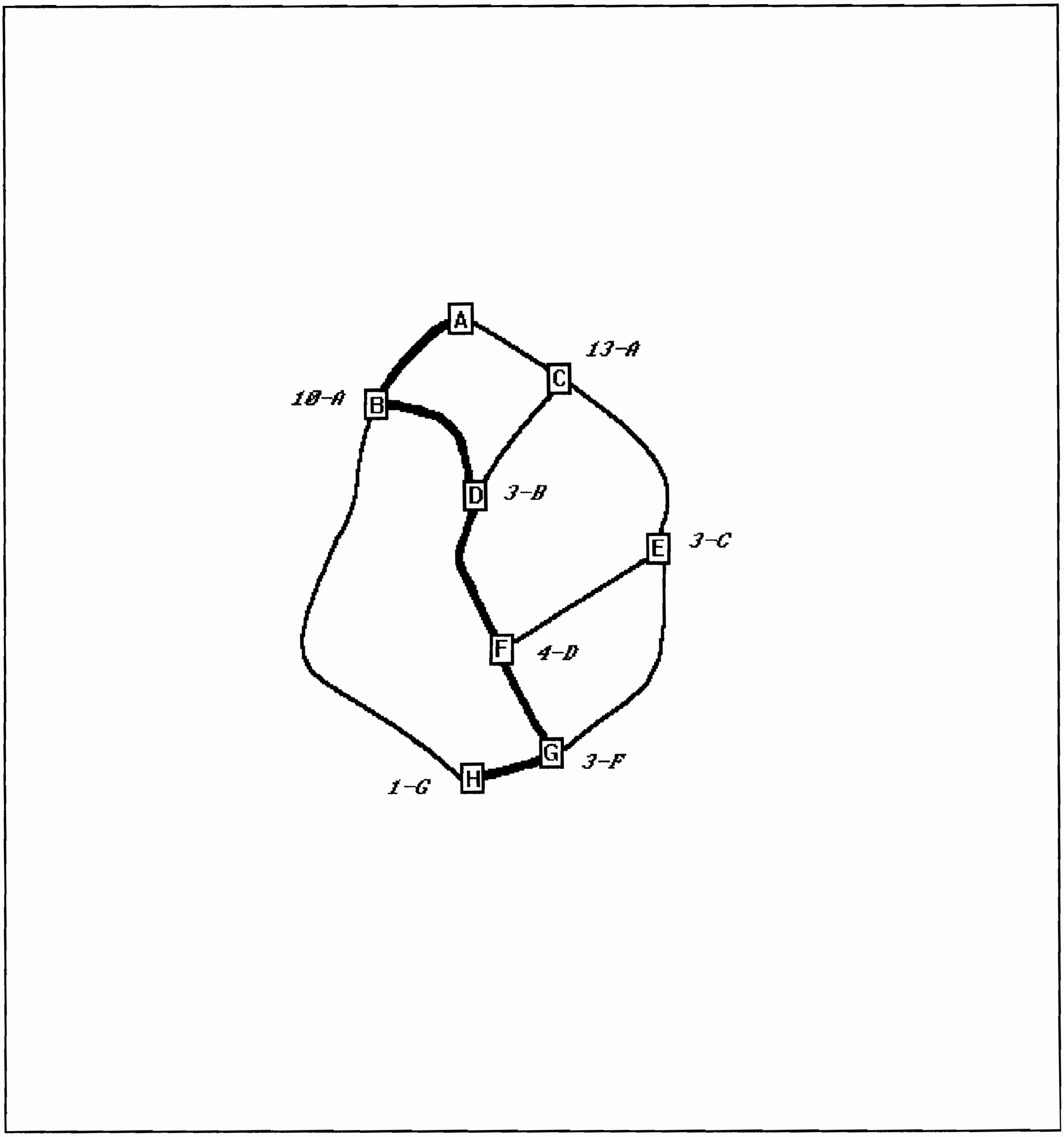



FIGURE 9. DEFINING PATH

In order to determine the path the previous node information is used. In this test node H is preceded by node G, node G is preceded of node F, node F is preceded by node D, node D is preceded by node B, and node B is preceded by the origin, node A. The path is [A,B,D,F,G,H] (Figure 9). If two paths both are equal and have the least cumulative path, then the program arbitrarily chooses one of the paths.

The previous description is a simplified example of the pathfinding process. Several other program details like turn impedances, from-to versus to-from impedance, and previous arc are not detailed in the preceding example, but are clearly defined in the Arc/Info manuals.

# METHODOLOGY

This chapter is designed to show the basic steps taken in the computer analysis to produce timely information for the study of specific issues involved in school consolidation. Pendleton serves as the model for this analysis process. The following also describes some difficulties encountered during the analysis process.

## Data Acquisition and Preparation

The first step of the study was to obtain TIGER digital map data from the VPI Library, for Pendleton County. These digital maps are at 1:100,000 scale and were used to provide the county road network. Sixteen 7.5 minute U.S. Geological quad sheets of the county were then purchased. These maps provided most housing locations in the county. Next the school bus schedules for the entire county were acquired from the county school bus transportation director. The transportation director then assisted the author by distinguishing the bus routes presently used. The author was then able to make copies of the U.S.G.S maps each route covered. The drivers were then asked to use the map copies to mark the stops along their routes. This was accomplished by taking the number of the stop from the bus schedule and placing it on the map where the stop was located. After the maps were collected from drivers, the stop locations were digitized into the geographic database. When all stop locations were digitized the road networks and stop locations were registered by using latitude and longitude control points. Information was then entered into the INFO database concerning the number of students per stop and the time on the road between stops.

## Calibration of Model

The first step in model testing was to construct road segment travel times in the database. As each bus schedule lists the time that each student is picked up by the bus, the difference between stop times gives the amount of time it took the bus to get from one stop to the next. However, this does not give the actual road segment time because the bus had to accelerate from a stationary position at the first stop and decelerate to a complete stop at the second. After consultation with the transportation director who had studied this problem, a deduction of .37 minutes was made to each road segment to measure segment travel time without stopping. This operation was performed because many times two buses may traverse the same road but one may not be picking students up on that road. The time it takes at each stop, .37 minutes is then kept as another item in the database and is added when the bus actually stops. This step took a considerable amount of time because the entire county has several hundred road segments, especially considering that segments are parts of complete roads that have been divided by both intersections and bus stops.

The next step was to test computed times for all twenty-eight runs to check for any input errors in the database. No route deviated more than two minutes from the recorded schedule times, thus the impedances were determined to be of sufficient accuracy for use in the study.

**Survey Preparation and Administration**

While the previous steps were being completed, the survey of selected Pendleton County citizens began. The survey questioned approximately thirty individuals from each of two districts for a total of about sixty people. The individuals selected were parents with students in the ninth through eleventh grade. All candidates were numbered and then picked at random by using computer generated random numbers. The survey's primary goal was to ascertain the peoples' ideas concerning the amount of time they believed it should take to transport their children to school. Other goals included determining public sentiment toward consolidation, which would likely increase student transport time. A sample of the survey and its results are provided in the Results and Conclusions chapter. The survey was conducted by telephone following methods obtained from Frey (1983).

**High School Site Selection Process**

One difficulty with using Pendleton County as a model is that it is a mountainous area with a limited supply of level land. Although relatively flat land is needed for a prospective school site, there are several other criteria to consider. One factor was the total amount of level land within any given area. West Virginia law requires approximately twenty-five acres for a high school site. Another factor is the proximity to water. Water and sewer service cover a very limited portion of the county . If a proposed site is not close to present day water or sewer lines, then it must be situated near to a river for water supply and treated sewage disposal. Because the author knows the topography very well, initially several probable study sites were chosen. Probable sites were further limited by modeling test bus runs from each of the four corners of the county to a proposed site. This was done to find out the amount of time it would take to drive from each corner to each prospective site. (A further explanation of these tests and their results can be viewed in the RESULTS chapter.)

**New Bus Routing**

In order to accommodate new school sites, new routes were constructed. New routes were made by manually grouping bus stops and then allowing TOUR to order the stops and provide total transport time and total students along the route. Routes were then manipulated and refined both to allow full usage of each bus's seating capacity and especially to minimize the travel time of each route. Stops were switched between routes to achieve the best compromise. Extra drivers and routes were added in some instances to alleviate routes with overly high travel times. The Results chapter contains more information about routing results, and the appendices contain the newly constructed routes.

**Computer vs. Manual**

Finally an average bus route was tested manually. The route tested contained fifty road sections. The travel time of each section along with the numbers students transported were extracted from a base map and were both totaled. The amount of time that it took to perform these tasks was then recorded. This test was performed to compare the time needed to produce a manual product versus one produced by computer modeling.

# RESULTS

This chapter gives a more detailed view of how the computer analysis and modeling of Pendleton County proceeded and what type of information was produced for use in considering the question of school consolidation.

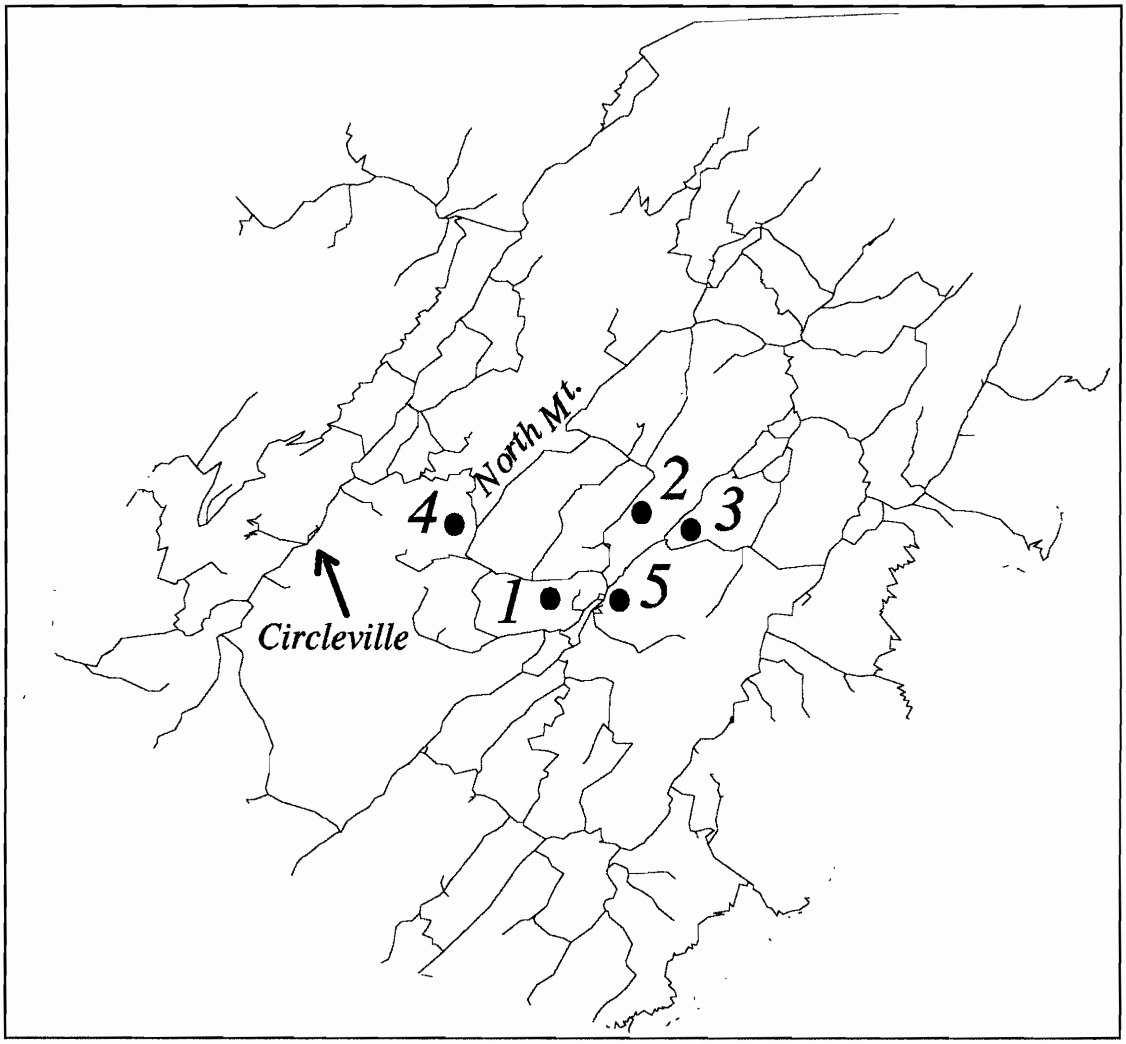
**Site Selection**

During the course of the study it became apparent that analyzing more than one new high school site would be useful and feasible. The ability to test additional sites attested to the efficiency and speed of computer analysis, which allowed the author to provide the citizens of Pendleton some alternate scenarios to consider. The locational requirements for a school are numerous in West Virginia. Probably the most hindering regulation concerns the disposal of treated sewage. Other concerns such as the slope of the land and the parcel's accessibility also restrict possible locations.

State requirements along with student travel times were used in determining possible sites. In order to make student travel times as short as possible, potential new sites needed to be located close to the geographical center of the county.

**Site Testing**

The first step involved finding the relative center of the county. This was not difficult because the county has a square shape. Sites surrounding this area were then chosen by the author. Five locations were picked for primary testing (Figure 10). In order to test these locations' centrality and accessibility, six locations around the county's perimeter where chosen. Arc/Info was then used to test route speeds from each of the perimeter locations to each of the five possible sites. (Figure 11 shows the six perimeter locations and five test sites.) The travel times from each of the six perimeter locations, without stops, were then averaged for each site and compared to one another. (See table 3.) After discussing possible sites with Pendleton's transportation director, three of the original five test sites were eliminated because of restrictive factors. The Franklin test site was eliminated because the only parcel large enough is located too deeply in the flood zone. The site situated on North Mountain




**1** Friends Run Site
**2** Site north of Drive-in
**3** Site adjacent to Bus Garage
4 North Mt. Flats Site
5 Franklin Site

FIGURE 10. TESTED HIGH SCHOOL SITES

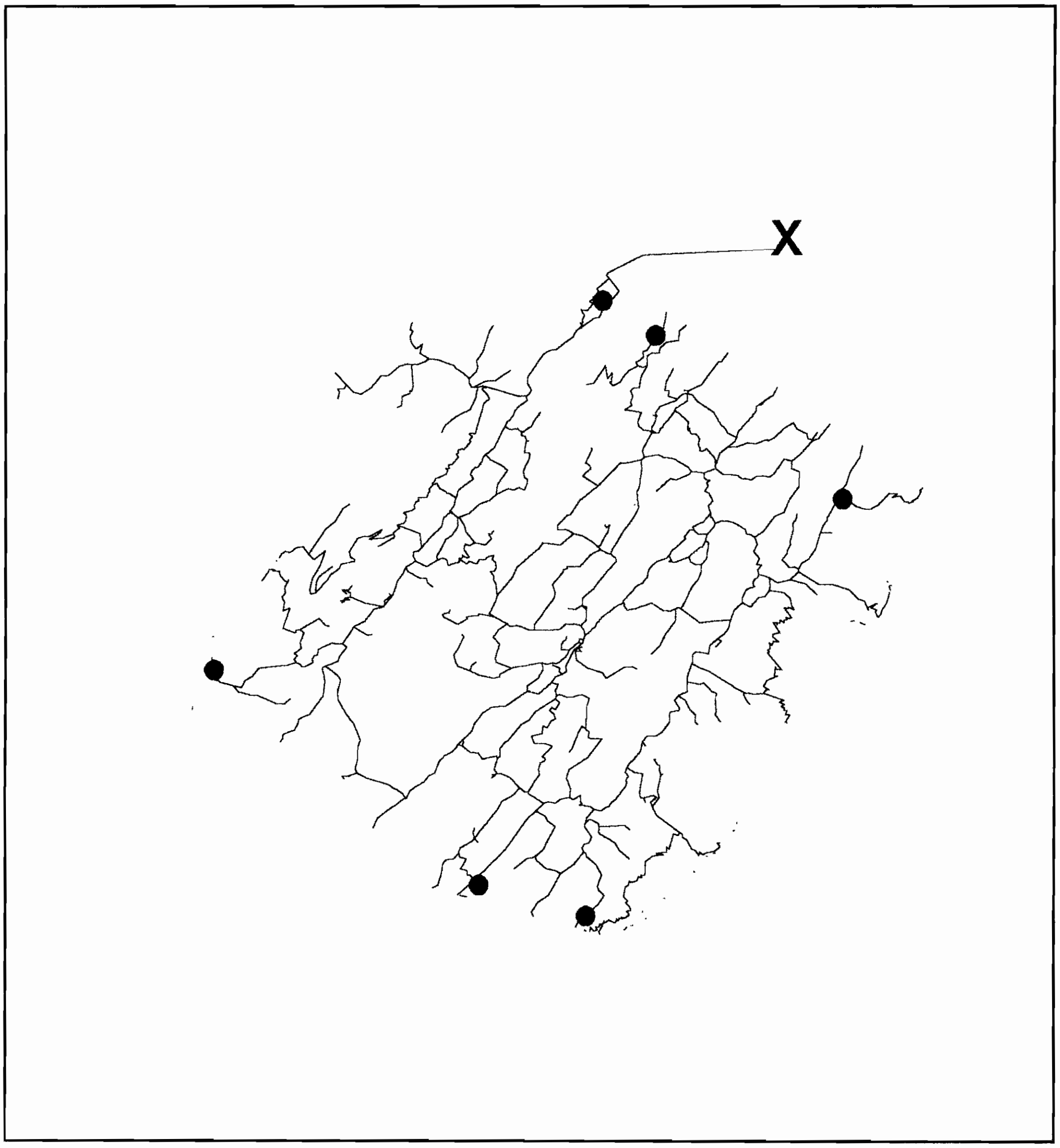



Figure shows perimeter test locations as dots, while the **X** denotes the relative location of Petersburg, Grant County.

FIGURE 11. PERIMETER TEST LOCATIONS

TABLE 3. CENTRALITY TEST RESULTS

| Location | Average Time | Maximum Time | Minimum Time |
|---|---|---|---|
| N.Mt.Flats site | 47.28 min. | 62.83 min. | 39.25 min. |
| Friends Run site | 43.85 min. | 51.47 min. | 32.30 min. |
| Franklin site | 43.74 min. | 57.22 min. | 28.05 min. |
| Bus Garage site | 45.36 min. | 60.46 min. | 26.64 min. |
| Drive-in site | 46.20 min. | 59.26 min. | 31.18 min. |

Table contains travel times of centrality tests between perimeter points and proposed sites.

Flats had to be eliminated because it lacked a river close enough to dispose of treated waste. Finally, the last site to be cut was the site adjacent to the Bus Garage. This location would have made bus routes from the North Fork excessively long.

**Proposed Sites**

The first site selected and tested in detail was the site located in the lower Friends Run area. This site had the lowest travel averages following the Franklin test site. The Pendleton sites were tested using the old high schools as middle schools and the closing and consolidation of Brandywine, Upper Tract, and Seneca elementary schools. The proposed site north of the Drive-in had the bus routing analyzed under the same circumstances. The fastest routes for each proposed site were tested using the constructed data model. Extra routes were added where necessary and some routes combined whenever one could be eliminated. Specific results of route testing for each site are located in the appendices. Appendix A contains the Friends Run and Drive-in site route results. The original routes were all computer tested in order to attest to the accuracy of the data model before any new routing was performed for the new sites.

As a result of public sentiment from the survey and the speed of computer analysis, an additional site was also tested. This test involved only the bus routing for the North Fork area. In this test all bus routes were modeled with high school age students being transported to Petersburg High in Grant County, and the elementary and middle school age children being educated at the Circleville school location. The results of the Petersburg site analysis for the North Fork can be viewed in Appendix B. (Figure 11 displays the relative location of Petersburg.)

**BUS ROUTING RESULTS**

The analysis of three sites established the need for considerable route analysis. Routing analysis was performed for the entire county for both the Friend's Run and Drive-in sites. The Petersburg High site only required additional route analysis of the North Fork area.

Routes were constructed by manually grouping bus stops, then allowing TOUR to order stops and keep track of the cumulative transport and cumulative time of the route. All routes were put through a refining process by transferring stops between routes until travel times were optimized. Additional routes were developed to alleviate high commuting times on some routes. Bus capacities also had to be closely monitored to make sure a route did not have more students than the bus's capacity. On some routes, larger buses in the counties could be implemented, but in many instances the nature of roads did not allow for a bus with large capacity. Under these circumstances stops were made where buses could transfer students to another bus. Smaller buses and contract drivers, who drive their own vehicles to pick up students, had to be used on small secondary roads. The students were then transfered to larger buses at strategic locations. Although routes were refined and added, the recommended travel time of sixty minutes for high school age children, was sometimes unobtainable. Parental expectations of travel times were very rarely obtainable. Additional drivers and routes, in many cases, were not advantageous due to the law of diminishing returns. Even if a bus were provided for each student, some would still be close to the state's recommended time limit.

**Survey Results**

The public opinion survey portion of the study took several weeks to complete and had various complications but gave several important insights into the ideas of the citizens of the county. One of the insights lead to the analysis of Petersburg High School as a possible destination for North

Fork high school age children. Approximately sixty county residents were interviewed, thirty from the North Fork area and thirty from the South Branch and South Fork area. All questions were not answered equally because participants were not required to answer all question if they did not wish to do so.

The following pages contain the survey questions, which are accompanied by the responses given by North Fork and South Branch, South Fork residents. The responses are presented in graphical form for better interpretation.

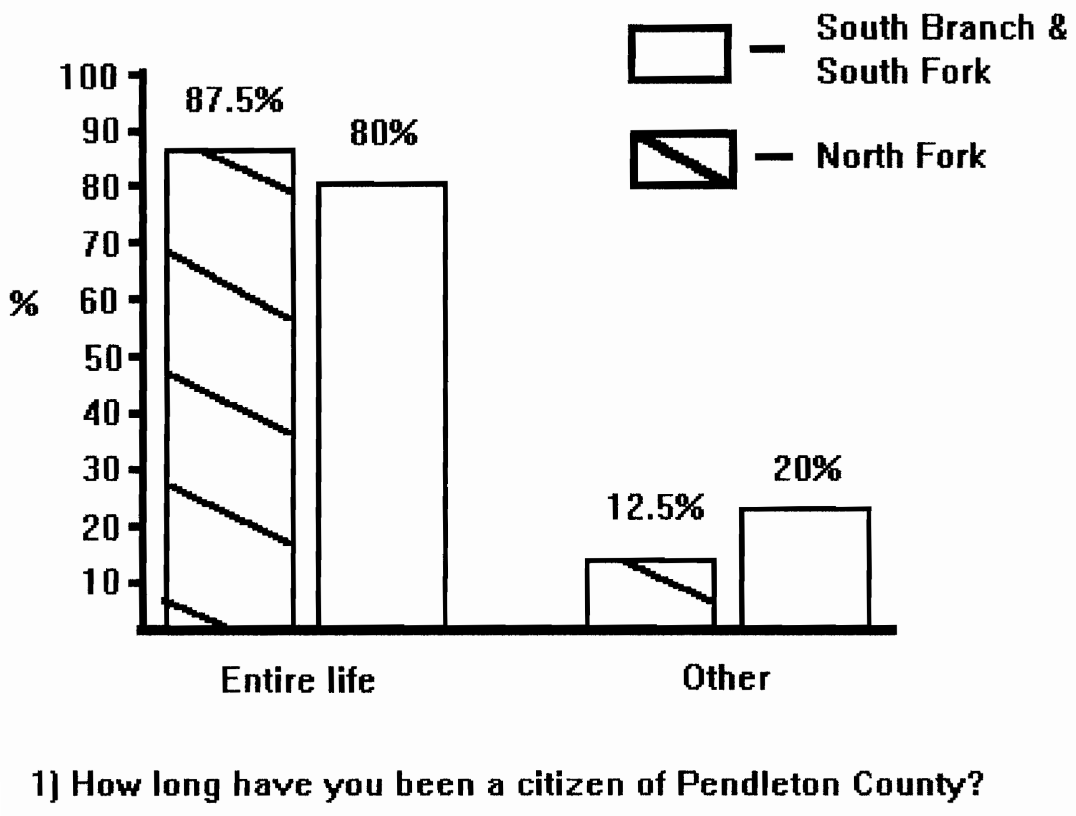
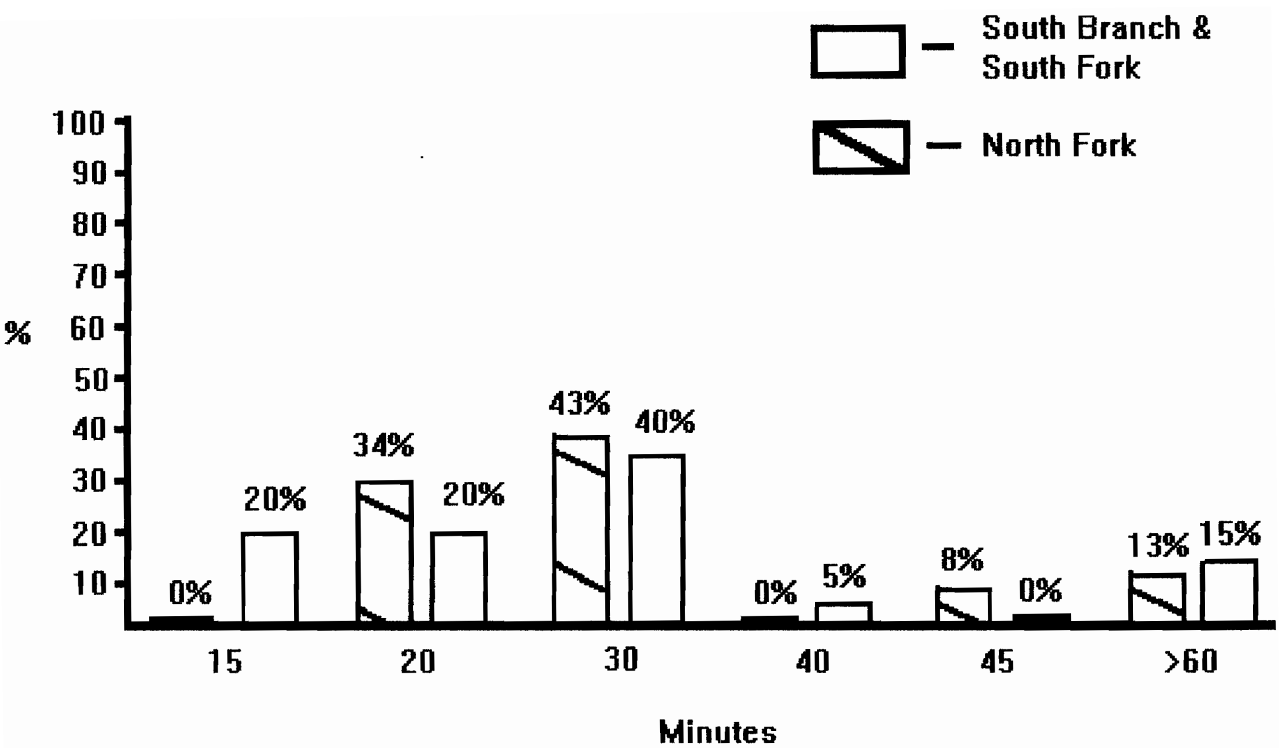
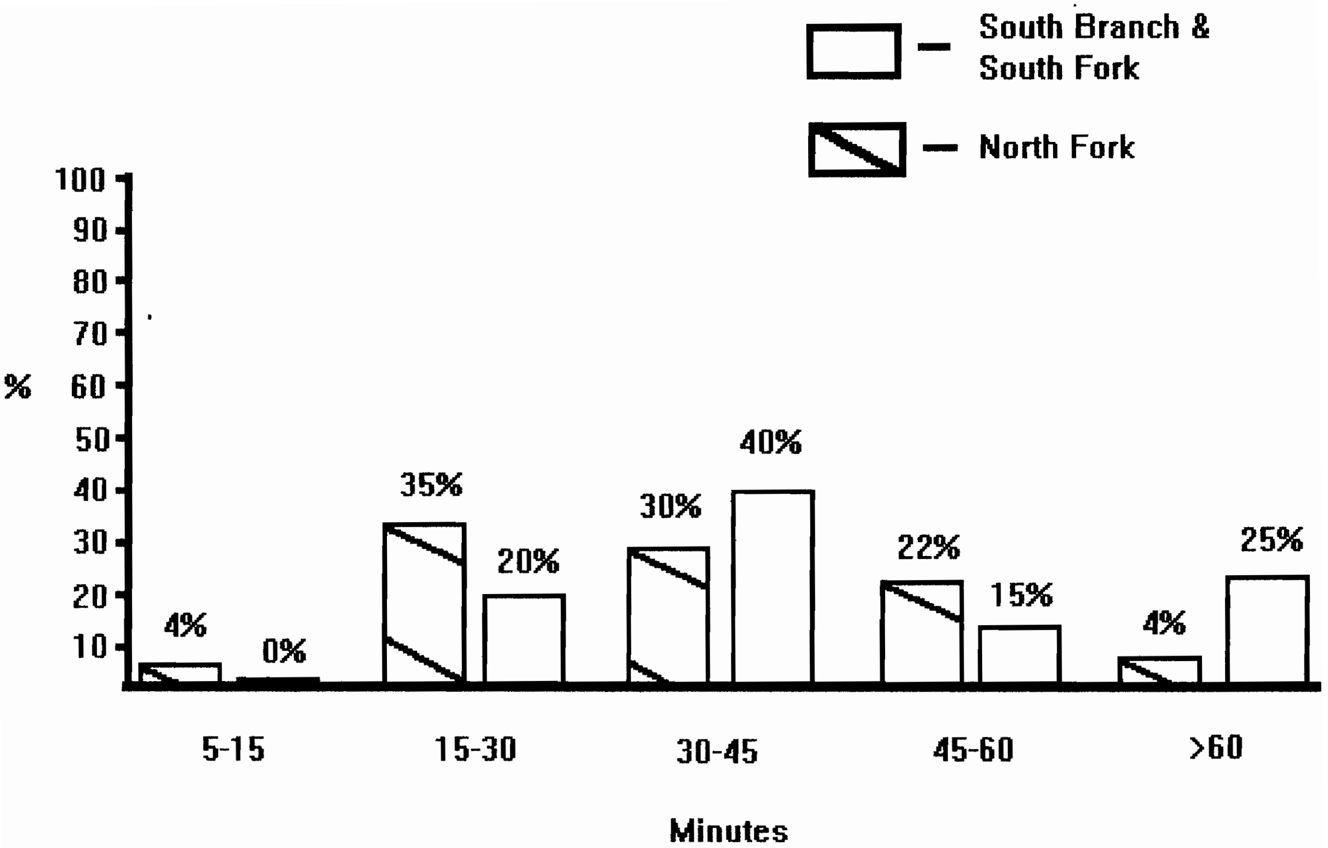



FIGURE 12. SURVEY QUESTION 1




2) What is the longest time period you would like to see your son(s)/daughter(s) have to ride the bus to school?

FIGURE 13. SURVEY QUESTION 2




3) How long is the school bus trip for your son(s)/daughter(s) at the present time?

FIGURE 14. SURVEY QUESTION 3

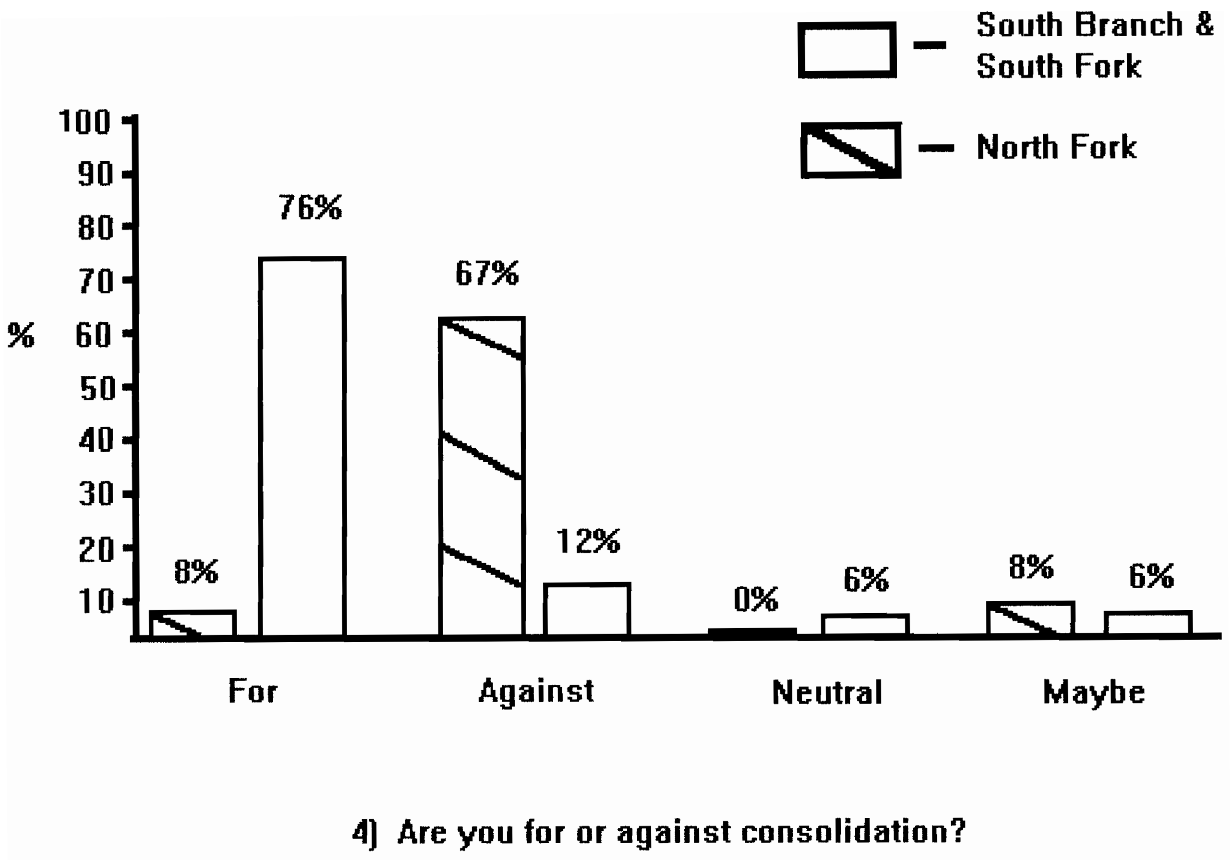
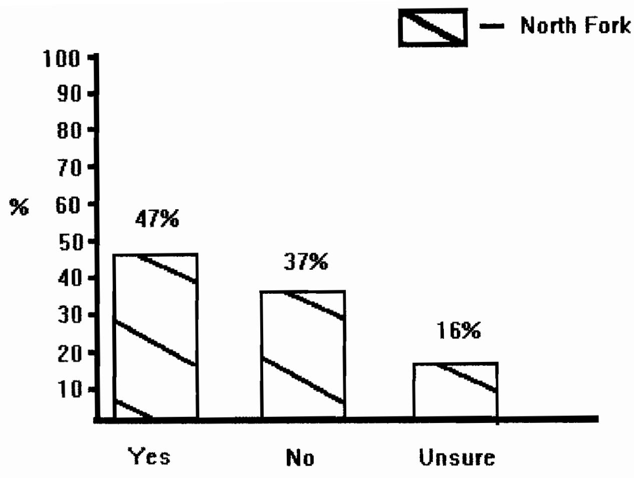
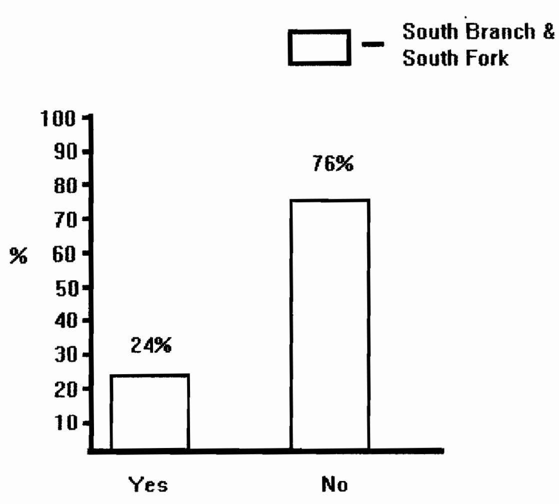



FIGURE 15. SURVEY QUESTION 4



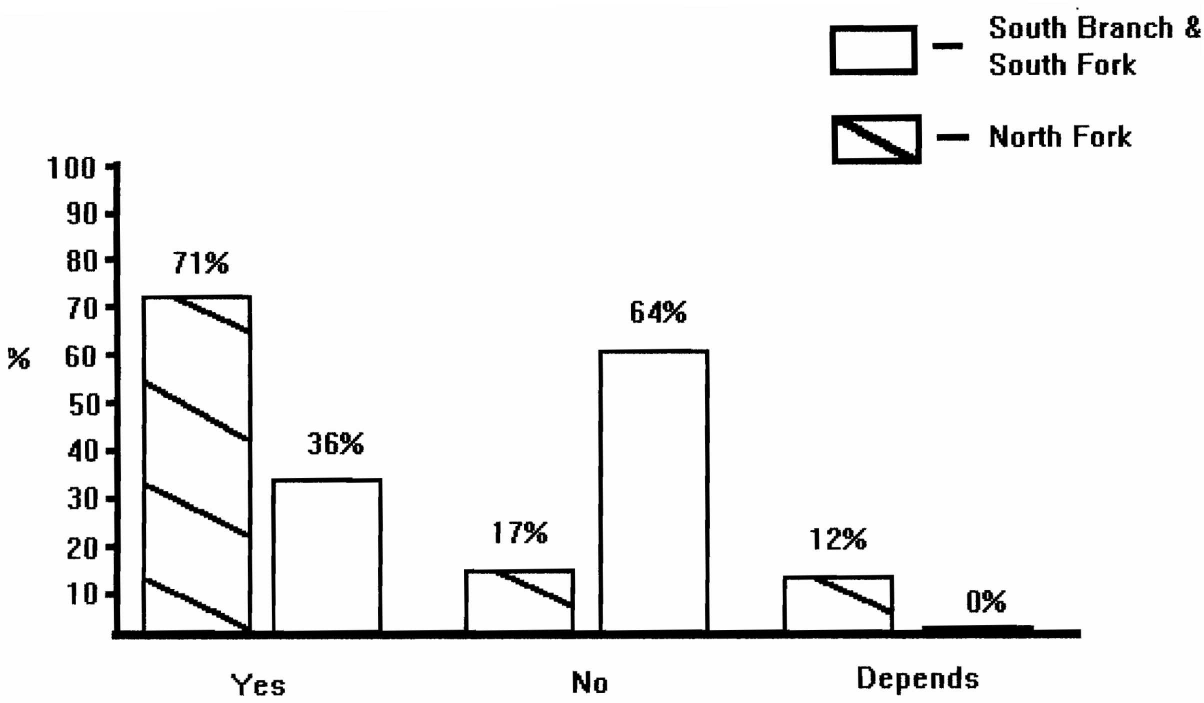

5a) Would you be willing to have a single high school if the travel time for your Son(s)/Daughter(s) was shorter of equal to present time? (North Fork Only)

FIGURE 16 SURVEY QUESTION 5A



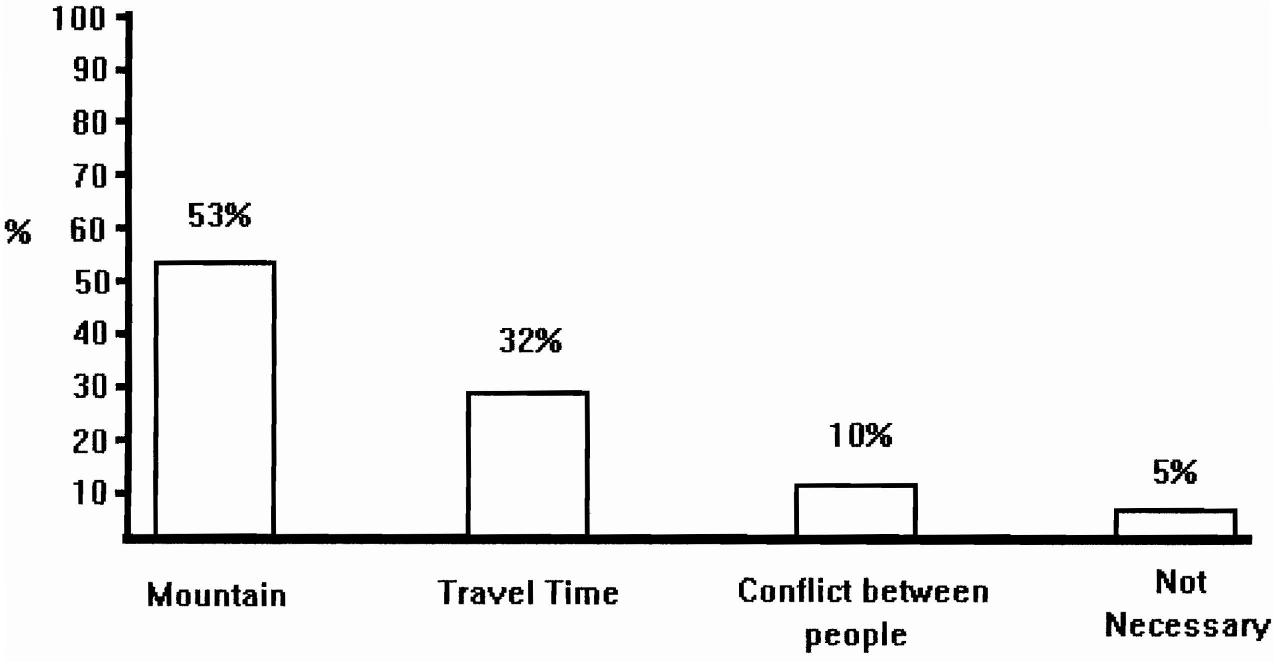

5b) Would you be willing to have a single high school if the travel time for you son(s)/daughter(s) was longer than at present? (South Fork & South Branch Only)

FIGURE 17. SURVEY QUESTION 5B




6) Would you be willing to pay higher taxes if both high schools could be kept open?

FIGURE 18. SURVEY QUESTION 6




7) What do you consider to be the biggest drawback to the proposed consolidation of the high school?

FIGURE 19. SURVEY QUESTION 7

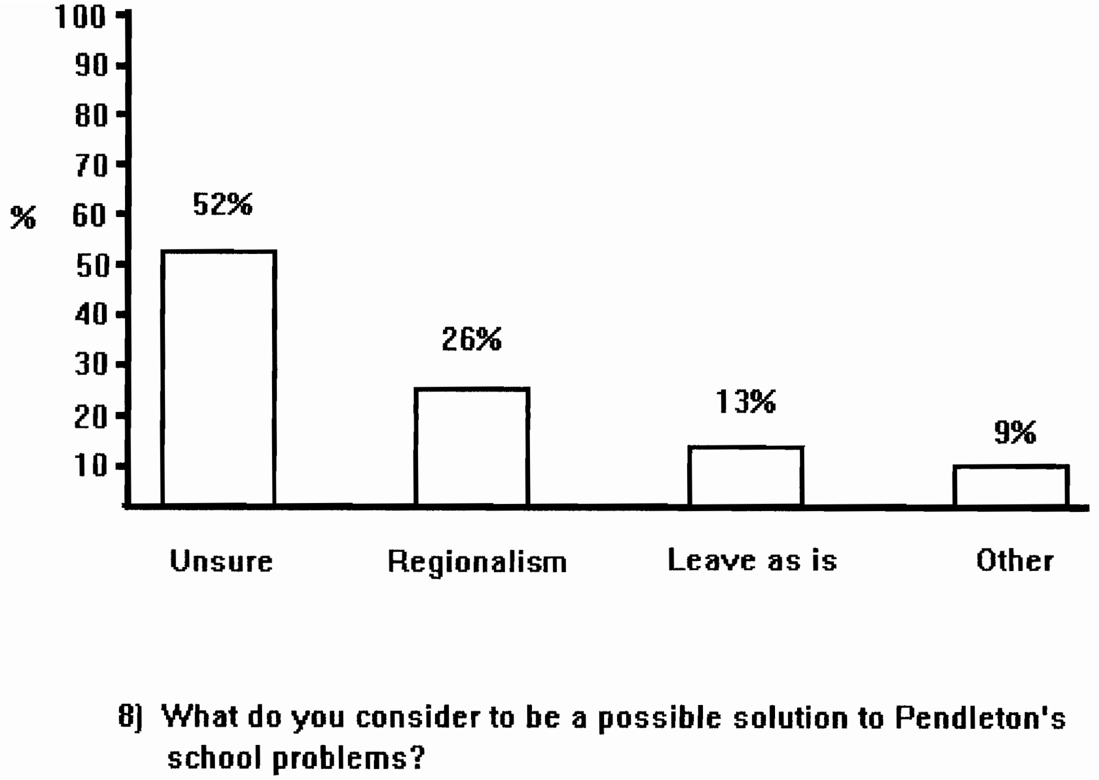



FIGURE 20. SURVEY QUESTION 8

**Interpretation of Survey**

The conducting of this survey has given the author many insights into the perceptions of the citizens of Pendleton County. The following is a discussion of the results of the survey and the author's views on them.

The first question of the survey asked citizens about the amount of time they had lived they in Pendleton. The aim of this question was to see if there was a correlation between amount of their lives spent in the county and the amount of time they believed that their children should be on the bus. The idea was to see if people who moved in from outside the county wanted a shorter travel time than life long residents. Newcomers might be influenced by expectations they might have from a previous place of residence. However, no pattern in the results made this suggestion apparent. This may have been because the majority of those surveyed had spent their entire lives or the majority of their lives in Pendleton.

The second and third questions together yielded quite substantial information. Question 2 was used to find what the maximum time parents wanted their children on the bus, and question three asked the present amount of time that the household's students presently spent on the bus. Although giving the direct information of commuting times, they served another purpose. Having the questions ordered in the manner that they were allowed the author to see which parents were and were not satisfied with the present travel times of their children. Table 4 shows the percent of parents wanting maximum travel times to be more, less, or the same as the present travel times of their children.

Question 4 was used to determine the perception towards consolidation and to see what affect that had on the response to other questions. In many instances there was a direct relationship between the citizen's perception of consolidation and what they felt the students' commuting times should be. Consolidation was not supported by the majority on North Fork, as expected. However, a higher percentage than first suspected supported or said maybe to consolidation.

Questions 5a and 5b were each to determine what citizens might support if changes occurred in the present school system. Question 6a was used to see if travel time was the major reason for not closing Circleville High or if it was just because it was a local landmark. The answers showed

Table 4. COMPARISON OF QUESTIONS 1 AND 2

| | More than #2 | Less than #2 | Same as #2 |
|---|---|---|---|
| North Fork | 39% | 35% | 26% |
| South Branch | 0% | 89% | 11% |

Table 4 illustates the percentage of parents that would allow a longer, wanted a shorter, or was content with the present student travel periods.

that travel time was one of the prime issues, with a majority supporting the idea of a single high school if it could be reached in the same or less time than the present travel times. However, it would be impossible to reach a new high school faster than the old one, unless it was built on the North Fork. Question 5b targeted the South Branch and South Fork areas. This question was to see if parents would mind having their children spend more time on the bus if there was a single high school in the county. What is surprising is that the South Branch and South Fork support consolidation (76% supporting), yet the majority (64%) said they did not want their students to have to ride the bus longer then they presently did.

Question 6 was asked to determine if parents would pay higher taxes if they could keep the schools as they are presently. Expected was the high percent of North Fork people willing to pay higher taxes to keep their school open. However many citizens opposed raising taxes, especially those on the South Branch and South Fork (64% opposing).

Question 7 was used to find out reasons why people were opposed to consolidation without giving any suggestions. As expected by the author, North Fork Mountain was the leading problem stated (53%), with the second ranking response being the problem of increased time of bus rides (32%).

The last question, question 8, was designed to find out if any citizen might have a plausible idea, not yet put forward, that might help solve Pendleton's school situation. Most citizens of were unsure of how to solve the county's school difficulties. However, many people, mostly located on the North Fork, believed that the regionalism of school systems might offer a better solution (26%).

# CONCLUSIONS

The task of designing and testing school bus routing for several possible new school locations, whether it is accomplished manually or with computer assistance, is a tedious proposition. Both manual and computer aided route design begin the same way. Each method requires the construction of a database, whether on paper or in computer memory, containing the traversal times of roads in the area being examined. From this point on the two methods become quite different in technique and amount of time to complete. The manual method requires that each road section of a route be added by hand. There can be anywhere from a few to several hundred sections depending on the level of urbanization in an area. Pendleton's average route had about 50 sections, and this is a very rural area. In a more urbanized setting there would be several hundred if not a thousand sections of road, and a school system might also have a hundred or more different bus routes. With traditional manual methods the resulting bus routes are often not as efficient as possible. To get the most efficient routing, different combinations and ordering of bus stops must be tested to determine least mileage or fastest travel periods, as was the Pendleton modeling goal. Any new combination of stops requires a complete recalculation of the total road sections, which can take a considerable amount of time depending on route length. The more routing efficiency desired, the more combinations of stops must be tested and therefore the more recalculation of road sections is necessary. Manually, this work is very time consuming, but the computer can recompute the route and give results in a matter of seconds. Typically only a few combinations for each route are tested manually because it is just too tedious and time consuming. A good example of this is the TIMS system in North Carolina where the state has saved over 2.6 million miles annually by the increased efficiency of computer tested routes(Graham 1993). Without the ability to produce fast efficient routing, the feasibility of examining school site alternatives is limited. When consolidation of schools is debated, many people want to have information on as many alternatives as possible to make the best choices for their students. The important question arises "what if" a school site was here or there. By studying several alternatives the best possible site can be chosen, because once a new school site is selected and constructed it likely won't be changed for a long time. As the computer analysis of Pendleton shows, the GIS allows ease of analysis for several possible high school sites. Even modeling the transport of North Fork children to Petersburg High School, which was suggested by some citizens in the survey, was feasible. According to authorities on the TIMS system the optimization phase or being able to look at "what if" situations is one of the most powerful benefits of that system(Graham 1993). The savings are evident in the 2.6 million annual mileage reduction by computer analysis in North Carolina, versus original routing that was produced manually. By cutting the mileage 2.6 million the student travel times were also greatly reduced. If the buses averaged about 45 mph on their routes, then the total student travel period in North Carolina has been reduced by almost 59,000 hours annually. With the computer's assistance, the ability to test these "what if" alternatives is both possible and fast, manually it's slow and often not done. In rural settings such as Pendleton similar results might be obtained manually but it would not be done because of the transportation director's limited time. In more urbanized areas with many hundreds of roads intersecting one another, testing of many alternate school sites and routes would require an enormous amount of time. Officials involved in these matters such as assistant principals and transportation directors in these urbanized areas have many responsibilities and would have even less time to perform such a detailed manual analysis.

**COSTS/SAVINGS**

Although computer analysis has some initial costs, the long-term benefits outweigh those costs. The TIMS system has cost North Carolina around 4.2 million but has already saved the state 14 million by the reduction of buses alone(Graham 1993). Computer hardware and software have been expensive propositions in the past, but fast computers are becoming much more affordable. Many school systems already have computer platforms that would be capable of using software such as Arc/Info. Sometimes older software versions are available at reduced cost and still have adequate capabilities. Other unavoidable costs include installation of system, training of personnel to use system, and technical support, but they are small to system benefits.

In the past manual methods have been considered more cost effective, but increasing wages and increasing workloads make computer analysis more feasible. A fifty-section route tested by Arc/Info takes less than two minutes to test graphically. The same route tested manually took twenty-three minutes. A set of one hundred, fifty-section routes would take about 2.5 hours by Arc/Info and around 38 hours manually. That is 38 hours for just a hundred routes, if you wanted to study several alternatives for each, the hours would soon add up. Most of the people whose job it is to construct routing do not have the time in their schedules to devote to a large amount of analysis time. That is exactly the reason the savings in North Carolina are so substantial. The people did not have or take the time to make such a thorough analysis manually. Furthermore, money used to do manual research would serve little future purpose after the analysis was finished, but Arc/Info could continue to help update routes and their efficiencies each year as new students and roads were added. The Info portion of Arc/Info could also be used to keep track of other student information thus eliminating the need for other databases. If lack of initial funds face an individual institute, the solution may be several school systems combining to purchase and share the system. Also, the school system could invite local governments in the region to participate in the purchase and use of a GIS. Because of the versatility of Arc/Info as a whole, many different agencies could benefit from its purchase and use. Shared use greatly reduces cost, and allows personnel from the different agencies to aid one another in the utilization of the system.

**Transportation Director's Opinion of Study**

The author met with Pendleton County's School Transportation Director, Mr. Paul Clayton, to determine usefulness of study results in aiding his job. Mr. Clayton was favorably impressed with the school sites and route development produced by the study. A copy of bus routes developed as a part of the study (located in the appendix section) were given to Mr. Clayton for his use. Mr. Clayton stated that the information would be very valuable in proposing new bus routing to state officials if school consolidation occurs.

**Author's thoughts on Arc/Info**

The preceding study was a long and sometimes tedious process. Collection of data, learning of the system, and finally the manipulation of that data, together can take some time. The hardest part was learning the Arc/Info system, with a great deal of the difficulty arising from the fact that the author was self taught. Data can easily be destroyed or changed in a manner you did not intend while learning the system. A set of test data should be constructed and used while learning the system. Also, it is imperative to have two backup copies of important data. However, once you learn the system the analysis process is quite swift. After computer analysis began some limitations of Arc/Info became apparent. Arc/Info is a very powerful software tool, one of, if not the most powerful software in its class. The limitations partially came from what the author expected the software could achieve, but that point has not quite been reached yet. Many command tools are very useful but need to be enhanced. Two commands in particular were originally expected to be useful in the analysis process but were later found insufficient. The first being the COLLOCATE command, that allows the user to assign people in an area to a bus in a fleet of buses all with the same number of seats. Each bus goes along a route and picks up passengers until the seating is all used, then the next bus continues. This command is not helpful if you have a fleet of buses with different seating capacities. (As does the Pendleton County school system). The command needs to be modified so the user can enter the number of buses in the fleet along with the seating of each. The second command quite limited in its use is SPATIALORDER. This command groups designated locations based on their distance in two-dimensional space. This would be very useful in regions of flat topography but in mountainous areas it is of little use. Two places may be close in two-dimensional space but if separated by a high mountain or a large river they may be quite distant by road mileage and should not be grouped together. The most useful command tool proved to be TOUR. To utilize TOUR to its fullest, the bus stops had to be grouped manually rather than automatically by COLLOCATE or SPATIALORDER, then TOUR could be used to compute the optimal order of stops and find the shortest distance between them. Two other flaws also became apparent to the author while using Arc/Info. When TOUR encountered a bus route that contained a section that had to be retraced, it would pick part of the students up as it went one way and the rest when it came back. There was no apparent reason why some were picked up, while others were left until the bus returned. TOUR should have picked up all the students as it returned along the retraced route. The other problem was that TOUR didn't always find the shortest path. In two known instances the shortest path was not taken; only because the author knew there was a shorter route, was the error caught. The problem seemed to arise when TOUR encountered a single arc that had a much higher impedance than any other arc in that route.

Although Arc/Info can be hard to learn and does have a few shortcomings, it is still a powerful and useful tool. The author has used other modules of Arc/Info that have proven to be more refined than the network analysis module. It is the author's belief that the network module would prove more useful in urban than in rural settings, but if available it can still prove quite useful in providing quick information in rural regions as well.

## AUTHOR'S THOUGHTS ON STUDY

It is the author's belief that several useful products have been created by this study. First, it can serve as a guide for others interested in using the Arc/Info software. It shows some of the potential and limitations of the software, in particular the network analysis capabilities. Secondly, the study shows that often parents and even state officials have unobtainable expectations of student travel times under certain conditions. Even producing the best routes possible with Arc/Info, expectations were often not met. (See appendices section for routing results.) The survey pointed out that some parents want a bus to get their children to school in a period that could only be achieved by driving straight there in a car. Pendleton, even today has several students whose travel time exceeds state guidelines. Yet the state is pushing for the consolidation of the high schools that will cause more students to be outside their guidelines. Finally and most importantly, the study shows that computer network analysis can provide fast efficient and useful information to persons involved the decision making process. This information, if produced manually, would not be nearly as timely or as efficient, nor would alternate site locations or route scenarios easily be modeled. Having these alternatives at their disposal, a school system has the ability to view how consolidation will affect the commuting times of its students.

It is the author's desire that the Pendleton officials ultimately making the decisions will make use of the information constructed as a part of this study, along with consideration of the other issues mentioned in the introductory chapter. Student commuting time is but one, albeit important, of the many elements to consider in deciding the merits of consolidation. But all elements are necessary to make a truly informed decision, and this is one piece of the puzzle that the author is glad his thesis could help provide.

# APPENDIX A

# KEY TO APPENDICES

**ROADCOV-ID** : The identification number for each stop. Exact stop locations are displayed on the large map inside pocket of the back cover.

**ORDER** : The order in which the stop occured as the route was raversed.

**TRANSFER** : The numer of students located at each stop.

**CUM_TRANS** : The total number of students that has accumulated with each stop along the route.

**CUM_IMP** : The total amount of time that has elapsed at each stop along the route.

***** : Designates a school location

*904 Circleville High/Elementary Schools ***(Used as possible middle school site, for North Fork, in this study.)***
*2493 Seneca Elementary School ***(Not used in new routing.)***
*2480 Brandywine Elementary School
*2483 Upper Tract Elementary School ***(Not used in new routing.)***
*2504 Franklin Elementary School
*2477 Franklin High School ***(Used as possible middle school***

***site in this study.)***

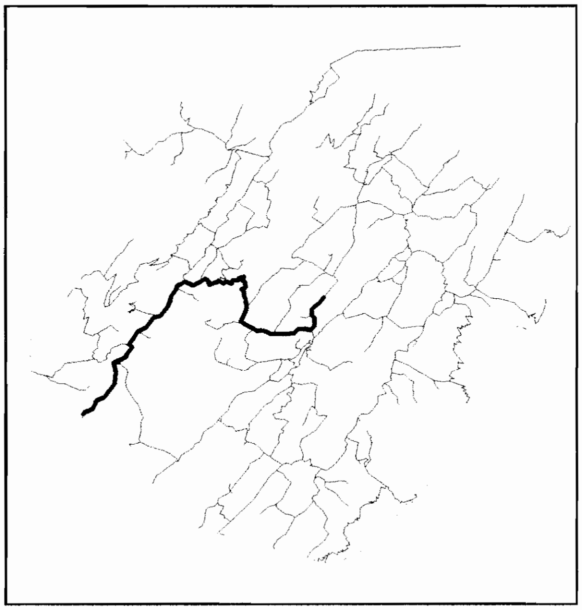
*2506 Proposed Friend's Run High School location

*2507 Proposed High School in Drive-in vicinity

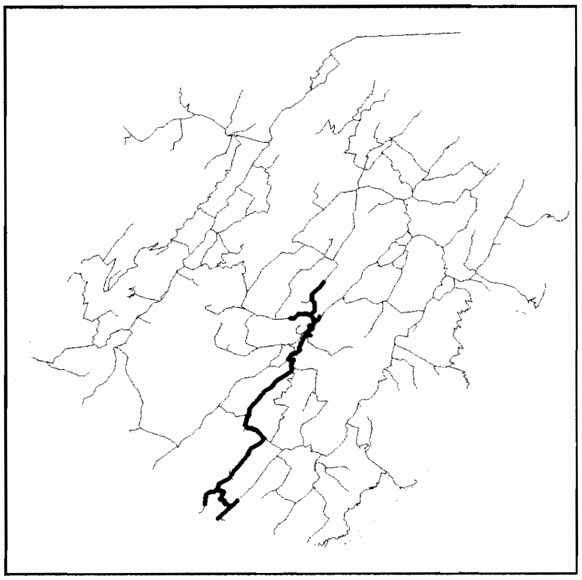
*2505 Petersburg High School site ***(Used in Appendix B only.)***

**Note:** Routes that are the same for the two proposed sites will be listed as the same but with two separate endings. Routes are the same until idential ORDER numbers are listed. See example below.

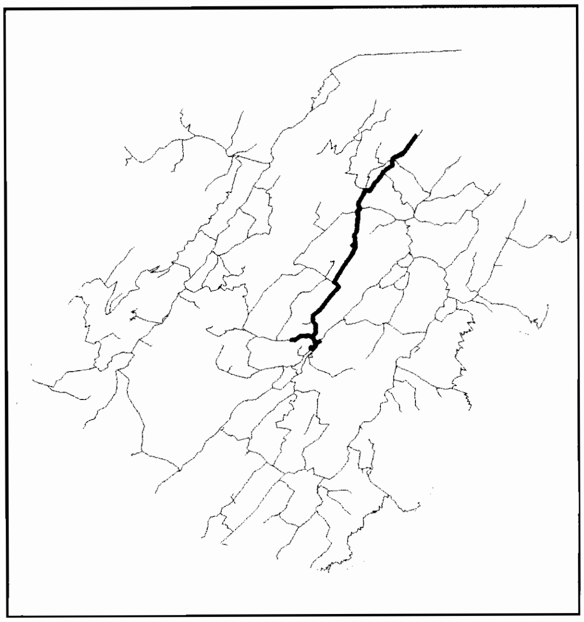
| **EXAMPLE** | Roadcov-id | Order | Transfer | Cum_Trans | Cum_Imp |
|---|---|---|---|---|---|
| | 1002 | 23 | 2 | 45 | 45.03 |
| | 1005 | 24 | 3 | 48 | 46.57 |
| | *2504 | 25 | - | -- | 48.09 |
| With route | *2477 | 26 | - | -- | 49.25 |
| ending at<br>Drive-in site**--->** | *2506 | 27 | - | -- | 54.43 |
| With route **----->**<br>ending at<br>Friend's Run site | *2507 | 27 | - | -- | 52.07 |



| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2131 | 1 | 2 | 2 | 0.57 |
| 2130 | 2 | 4 | 6 | 1.69 |
| 2494 | 3 | 1 | 7 | 2.56 |
| 2128 | 4 | 2 | 9 | 4.08 |
| 2127 | 5 | 4 | 13 | 5.05 |
| 2126 | 6 | 2 | 15 | 7.17 |
| 2495 | 7 | 1 | 16 | 7.99 |
| 2124 | 8 | 7 | 23 | 8.81 |
| 2123 | 9 | 1 | 24 | 9.63 |
| 2154 | 10 | 3 | 27 | 14.75 |
| 1204 | 11 | 13 | 40 | 16.00 |
| 2146 | 12 | 5 | 45 | 16.92 |
| 2144 | 13 | 2 | 47 | 19.04 |
| 1112 | 14 | 2 | 49 | 20.16 |
| *904 | 15 | -12 | 37 | 24.21 |
| 2101 | 16 | 1 | 38 | 25.33 |
| 2099 | 17 | 1 | 39 | 26.35 |
| 727 | 18 | 22 | 61 | 29.40 |
| 2469 | 19 | 2 | 63 | 30.92 |
| 2106 | 20 | 3 | 66 | 36.59 |
| *2506 | 21 | -- | --- | 64.36 |
| *2507 | 21 | -- | --- | 70.12 |

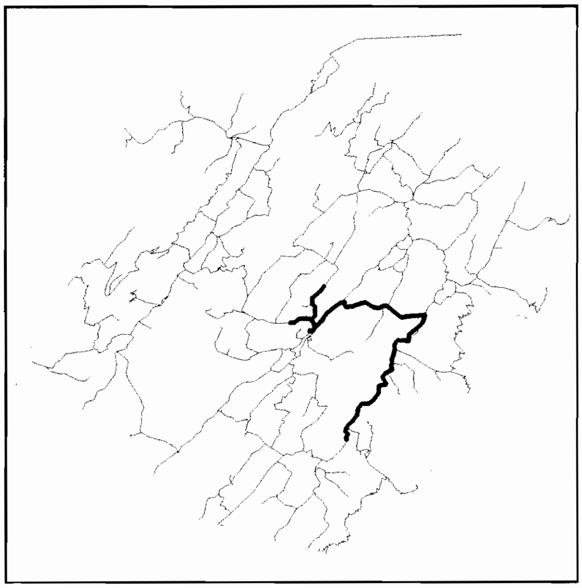


| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2195 | 1 | 1 | 1 | 0.57 |
| 2194 | 2 | 2 | 3 | 1.44 |
| 2193 | 3 | 1 | 4 | 4.11 |
| 2192 | 4 | 1 | 5 | 5.23 |
| 2190 | 5 | 3 | 8 | 7.90 |
| 2191 | 6 | 1 | 9 | 10.57 |
| 2182 | 7 | 4 | 13 | 12.69 |
| 2183 | 8 | 1 | 14 | 14.46 |
| 2184 | 9 | 1 | 15 | 15.58 |
| 2185 | 10 | 2 | 17 | 16.50 |
| 2186 | 11 | 3 | 20 | 17.62 |
| 2187 | 12 | 1 | 21 | 18.74 |
| 2188 | 13 | 2 | 23 | 19.51 |
| 2219 | 14 | 2 | 25 | 20.63 |
| 2220 | 15 | 1 | 26 | 21.55 |
| 2181 | 16 | 1 | 27 | 24.22 |
| 1479 | 17 | 5 | 32 | 25.09 |
| 2189 | 18 | 1 | 33 | 27.44 |
| 2261 | 19 | 1 | 34 | 30.56 |
| 2260 | 20 | 2 | 36 | 31.48 |
| 2259 | 21 | 1 | 37 | 34.60 |
| 2258 | 22 | 2 | 39 | 35.42 |
| 1135 | 23 | 7 | 46 | 46.02 |
| 2362 | 24 | 4 | 50 | 47.49 |
| 1143 | 25 | 10 | 60 | 49.86 |
| 2363 | 26 | 3 | 63 | 52.50 |
| 1138 | 27 | 3 | 66 | 53.66 |
| *2504 | 28 | -- | --- | 56.69 |
| *2477 | 29 | -- | --- | 60.14 |
| *2506 | 30 | -- | --- | 64.10 |
| *2507 | 30 | -- | --- | 64.93 |

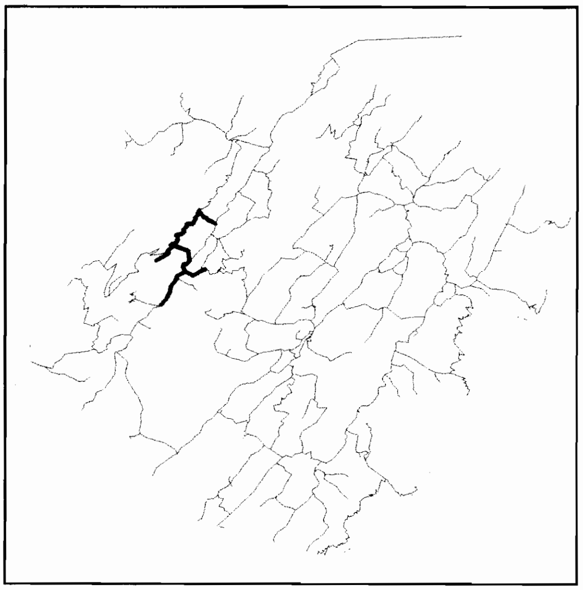


| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2446 | 1 | 0 | 0 | 0.57 |
| 2445 | 2 | 5 | 5 | 3.69 |
| 139 | 3 | 2 | 7 | 4.71 |
| 144 | 4 | 14 | 21 | 5.76 |
| 2484 | 5 | 1 | 22 | 7.23 |
| 2429 | 6 | 3 | 25 | 8.50 |
| 2428 | 7 | 4 | 29 | 9.32 |
| 2448 | 8 | 16 | 45 | 10.92 |
| 2449 | 9 | 3 | 48 | 11.94 |
| 2450 | 10 | 2 | 50 | 12.76 |
| 2451 | 11 | 1 | 51 | 25.27 |
| 2452 | 12 | 1 | 52 | 26.09 |
| 2485 | 13 | 3 | 55 | 26.91 |
| 2454 | 14 | 1 | 56 | 27.73 |
| 2486 | 15 | 2 | 58 | 28.52 |
| 2434 | 16 | 4 | 62 | 29.76 |
| 2433 | 17 | 1 | 63 | 30.53 |
| 2432 | 18 | 1 | 64 | 31.45 |
| 2431 | 19 | 3 | 67 | 32.47 |
| 2430 | 20 | 1 | 68 | 33.29 |
| 2354 | 21 | 1 | 69 | 36.81 |
| 2353 | 22 | 1 | 70 | 37.73 |
| 2352 | 23 | 2 | 72 | 36.75 |
| 2488 | 24 | 2 | 74 | 37.52 |
| 2350 | 25 | 1 | 75 | 38.19 |
| 2349 | 26 | 1 | 76 | 39.01 |
| 2487 | 27 | 1 | 77 | 39.83 |
| 2347 | 28 | 1 | 78 | 40.65 |
| 2346 | 29 | 2 | 80 | 40.62 |
| 2345 | 30 | 1 | 81 | 41.64 |
| 2344 | 31 | 1 | 82 | 42.56 |
| 2343 | 32 | 2 | 84 | 43.48 |
| 2342 | 33 | 2 | 86 | 45.35 |
| *2506 | 34 | – | --- | 53.79 |
| *2504 | 35 | – | --- | 59.71 |
| *2477 | 36 | – | --- | 62.16 |
| 2297 | 34 | 2 | 88 | 47.30 |

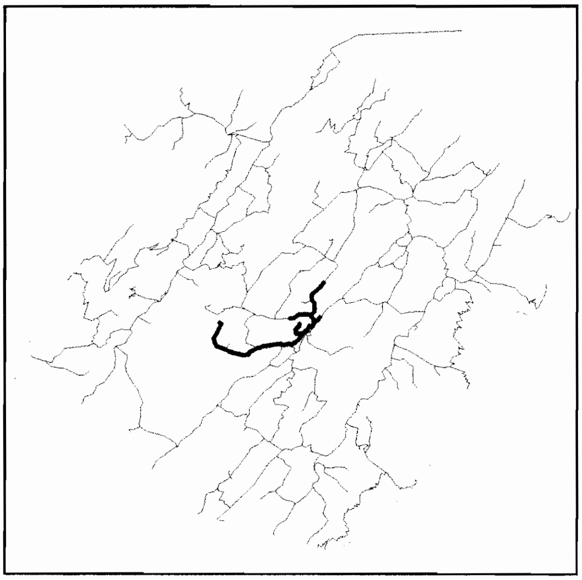
| | | | | |
|---|---|---|---|---|
| *2507 | 35 | -15 | 73 | 48.60 |
| 2296 | 36 | 2 | 74 | 49.37 |
| 2295 | 37 | 2 | 76 | 50.14 |
| 2294 | 38 | 3 | 79 | 51.01 |
| 2293 | 39 | 3 | 82 | 51.78 |
| 948 | 40 | 1 | 83 | 53.19 |
| *2504 | 41 | -- | --- | 58.19 |
| *2477 | 42 | -- | --- | 60.64 |



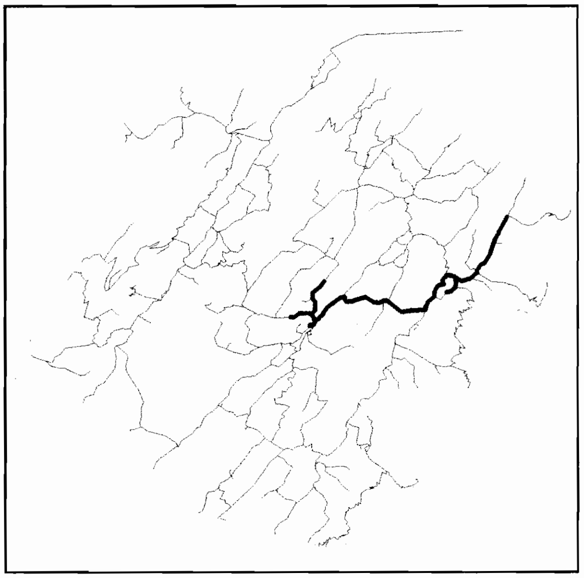
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2228 | 1 | 2 | 2 | 0.57 |
| 2230 | 2 | 3 | 5 | 2.14 |
| 2481 | 3 | 2 | 7 | 3.11 |
| 2304 | 4 | 2 | 9 | 4.23 |
| 2305 | 5 | 3 | 12 | 5.20 |
| 1430 | 6 | 1 | 13 | 7.67 |
| 2458 | 7 | 7 | 20 | 8.69 |
| 2306 | 8 | 47 | 67 | 9.51 |
| 2307 | 9 | 2 | 69 | 12.08 |
| 2308 | 10 | 1 | 70 | 13.05 |
| 2309 | 11 | 2 | 72 | 14.42 |
| 1312 | 12 | 5 | 77 | 15.99 |
| 2471 | 13 | 2 | 79 | 16.76 |
| *2477 | 14 | -- | --- | 41.54 |
| *2504 | 15 | -- | --- | 44.99 |
| *2506 | 16 | -- | --- | 49.86 |
| *2507 | 16 | -- | --- | 50.73 |



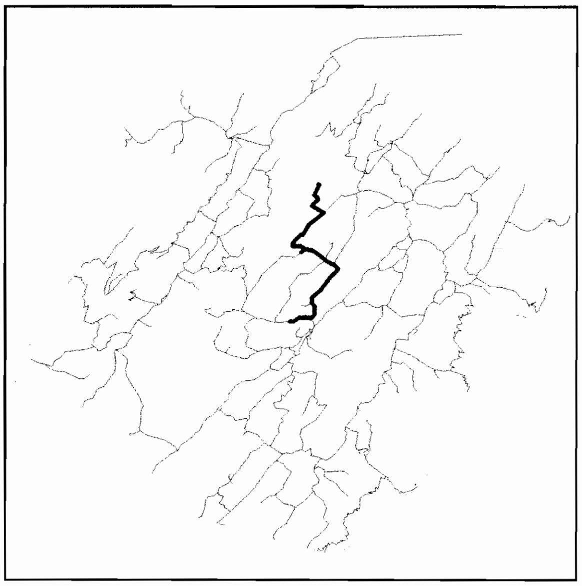
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2072 | 1 | 1 | 1 | 0.57 |
| 2073 | 2 | 1 | 2 | 1.69 |
| 2074 | 3 | 1 | 3 | 2.66 |
| 2076 | 4 | 4 | 7 | 3.58 |
| 2077 | 5 | 2 | 9 | 4.45 |
| 2078 | 6 | 1 | 10 | 6.37 |
| 434 | 7 | 4 | 11 | 8.64 |
| 2082 | 8 | 1 | 12 | 10.76 |
| 2083 | 9 | 2 | 14 | 13.88 |
| 2084 | 10 | 1 | 15 | 16.00 |
| 656 | 11 | 2 | 17 | 25.97 |
| 2108 | 12 | 1 | 18 | 31.09 |
| 2107 | 13 | 2 | 20 | 32.31 |
| 2096 | 14 | 2 | 22 | 40.98 |
| 2094 | 15 | 1 | 23 | 42.00 |
| 727 | 16 | -10 | 16 | 43.54 |
| 2105 | 17 | 4 | 29 | 46.35 |
| 2106 | 18 | 4 | 33 | 48.02 |
| 2104 | 19 | 1 | 34 | 52.24 |
| *904 | 20 | -- | --- | 59.97 |



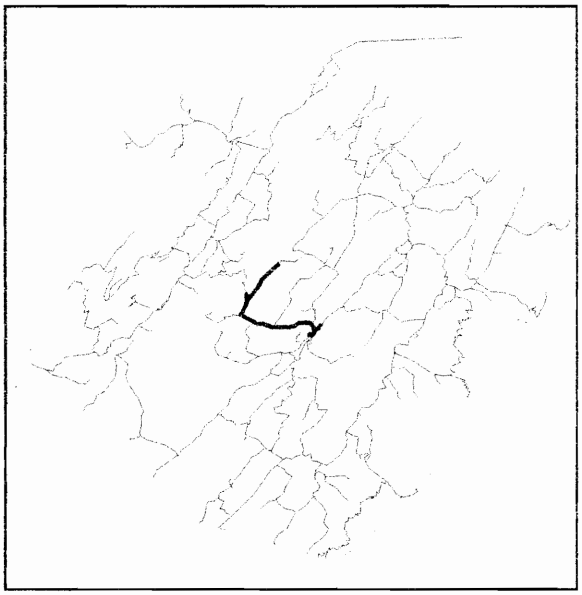
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2247 | 1 | 2 | 2 | 0.57 |
| 2248 | 2 | 3 | 5 | 4.84 |
| 1220 | 3 | 2 | 7 | 7.41 |
| 2250 | 4 | 1 | 8 | 8.23 |
| 2251 | 5 | 2 | 10 | 9.15 |
| 2252 | 6 | 2 | 12 | 11.57 |
| 2253 | 7 | 1 | 13 | 12.49 |
| 1214 | 8 | 6 | 19 | 13.31 |
| 2254 | 9 | 1 | 20 | 14.13 |
| 2255 | 10 | 2 | 22 | 15.00 |
| 2256 | 11 | 3 | 25 | 15.87 |
| 1176 | 12 | 2 | 27 | 18.34 |
| 2299 | 13 | 3 | 30 | 19.11 |
| 2300 | 14 | 1 | 31 | 19.93 |
| 2301 | 15 | 3 | 34 | 20.75 |
| 2302 | 16 | 1 | 35 | 21.67 |
| 2470 | 17 | 2 | 37 | 22.49 |
| 1084 | 18 | 4 | 41 | 25.65 |
| 2272 | 19 | 2 | 43 | 26.57 |
| 2273 | 20 | 3 | 46 | 27.39 |
| 2274 | 21 | 2 | 48 | 28.21 |
| 2275 | 22 | 10 | 58 | 29.03 |
| 2276 | 23 | 1 | 59 | 29.85 |
| 2277 | 24 | 1 | 60 | 30.67 |
| 2279 | 25 | 2 | 62 | 32.50 |
| 2472 | 26 | 1 | 63 | 34.03 |
| *2504 | 27 | -- | --- | 37.46 |
| *2477 | 28 | -- | --- | 40.91 |
| *2506 | 29 | -- | --- | 44.88 |
| *2507 | 30 | -- | --- | 45.70 |



| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2396 | 1 | 1 | 1 | 0.57 |
| 2397 | 2 | 2 | 3 | 1.94 |
| 850 | 3 | 2 | 5 | 4.26 |
| 2398 | 4 | 2 | 7 | 5.83 |
| 473 | 5 | 6 | 10 | 17.60 |
| 2406 | 6 | 1 | 14 | 20.37 |
| 2405 | 7 | 1 | 15 | 21.39 |
| 2404 | 8 | 1 | 16 | 22.21 |
| 2403 | 9 | 2 | 18 | 23.13 |
| 589 | 10 | 2 | 20 | 24.05 |
| 2402 | 11 | 1 | 21 | 26.97 |
| 2401 | 12 | 2 | 23 | 27.79 |
| 764 | 13 | 6 | 29 | 28.66 |
| 798 | 14 | 2 | 31 | 30.68 |
| 792 | 15 | 3 | 34 | 32.80 |
| 2395 | 16 | 4 | 38 | 33.72 |
| 782 | 17 | 7 | 45 | 34.59 |
| 2394 | 18 | 2 | 47 | 35.46 |
| 2393 | 19 | 2 | 49 | 36.23 |
| 2392 | 20 | 2 | 51 | 37.25 |
| 2391 | 21 | 1 | 52 | 38.17 |
| 2390 | 22 | 4 | 56 | 38.99 |
| 2389 | 23 | 3 | 59 | 39.91 |
| 2388 | 24 | 1 | 60 | 40.68 |
| 2387 | 25 | 2 | 62 | 41.50 |
| 2386 | 26 | 1 | 63 | 42.52 |
| 894 | 27 | 3 | 66 | 44.09 |
| 2385 | 28 | 1 | 67 | 45.11 |
| 2384 | 29 | 3 | 70 | 45.93 |
| 991 | 30 | 2 | 72 | 46.70 |
| 2383 | 31 | 9 | 81 | 48.07 |
| 2474 | 32 | 2 | 68 | 49.42 |
| 2381 | 33 | 1 | 69 | 57.46 |
| 940 | 34 | 2 | 71 | 58.22 |
| 2291 | 35 | 1 | 72 | 61.34 |
| *2477 | 36 | 0 | 72 | 65.58 |
| *2504 | 37 | -- | --- | 69.03 |
| *2506 | 38 | -- | --- | 73.95 |
| *2507 | 38 | -- | --- | 74.77 |

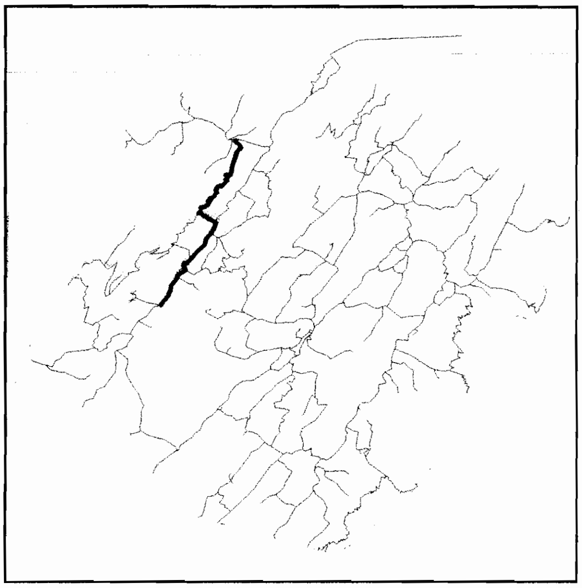


| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2336 | 1 | 1 | 1 | 0.57 |
| 2335 | 2 | 1 | 2 | 2.69 |
| 2334 | 3 | 2 | 4 | 10.91 |
| 2333 | 4 | 1 | 5 | 16.03 |
| 594 | 5 | 1 | 6 | 17.05 |
| 2332 | 6 | 4 | 10 | 21.52 |
| 2337 | 7 | 1 | 11 | 27.99 |
| 655 | 8 | 2 | 13 | 29.01 |
| 2341 | 9 | 1 | 14 | 31.13 |
| 2340 | 10 | 2 | 16 | 32.82 |
| 2489 | 11 | 1 | 17 | 33.62 |
| 2339 | 12 | 14 | 31 | 33.62 |
| 2338 | 13 | 2 | 33 | 34.44 |
| *2507 | 14 | -- | --- | 35.29 |
| 2297 | 14 | 2 | 35 | 35.56 |
| 2296 | 15 | 2 | 37 | 36.63 |
| 2295 | 16 | 3 | 40 | 37.40 |
| 2294 | 17 | 6 | 46 | 38.27 |
| 2293 | 18 | 6 | 49 | 39.04 |
| 2292 | 19 | 1 | 50 | 39.84 |
| 906 | 20 | 2 | 52 | 40.61 |
| 948 | 21 | 2 | 54 | 41.33 |
| *2506 | 22 | -- | --- | 46.04 |
| *2504 | 23 | -- | --- | 51.96 |
| *2477 | 24 | -- | --- | 54.41 |

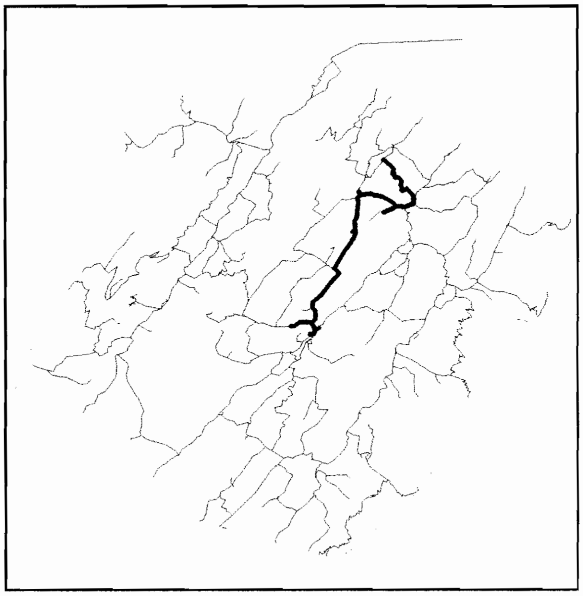


| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2331 | 1 | 1 | 1 | 0.57 |
| 2330 | 2 | 1 | 2 | 2.69 |
| 2329 | 3 | 1 | 3 | 3.81 |
| 2231 | 4 | 1 | 4 | 5.93 |
| 2232 | 5 | 2 | 6 | 10.70 |
| 2233 | 6 | 1 | 7 | 11.82 |
| 2234 | 7 | 1 | 8 | 12.74 |
| 2235 | 8 | 2 | 10 | 13.51 |
| 873 | 9 | 2 | 12 | 14.63 |
| 2236 | 10 | 2 | 14 | 16.75 |
| 979 | 11 | 1 | 15 | 18.87 |
| 1006 | 12 | 3 | 18 | 19.99 |
| 2237 | 13 | 2 | 20 | 20.81 |
| 2238 | 14 | 3 | 23 | 21.63 |
| 2239 | 15 | 3 | 26 | 22.45 |
| 2240 | 16 | 1 | 27 | 23.27 |
| 1057 | 17 | 6 | 33 | 24.09 |
| 2241 | 18 | 2 | 35 | 24.86 |
| 2242 | 19 | 2 | 37 | 25.68 |
| | | | | |
| *2506 | 20 | -8 | 29 | 28.48 |
| 2243 | 20 | 2 | 39 | 29.79 |
| 2244 | 21 | 2 | 41 | 30.71 |
| 1022 | 22 | 5 | 46 | 31.63 |
| 2245 | 23 | 16 | 62 | 32.45 |
| 2246 | 24 | 5 | 67 | 33.27 |
| *2504 | 26 | -- | --- | 37.22 |
| *2477 | 27 | -- | --- | 40.67 |
| *2506 | 28 | -- | --- | 44.64 |
| | | | | |
| 2243 | 20 | 2 | 39 | 29.79 |
| 2244 | 21 | 2 | 41 | 30.71 |
| 1022 | 22 | 5 | 46 | 31.63 |
| 2245 | 23 | 16 | 62 | 32.45 |
| 2246 | 24 | 5 | 67 | 33.27 |
| *2504 | 25 | -31 | 36 | 36.22 |
| *2477 | 26 | -19 | 17 | 39.67 |
| 948 | 27 | 1 | 18 | 43.29 |
| 906 | 28 | 2 | 20 | 44.27 |
| 2292 | 29 | 1 | 21 | 45.04 |
| 2294 | 30 | 3 | 24 | 46.04 |

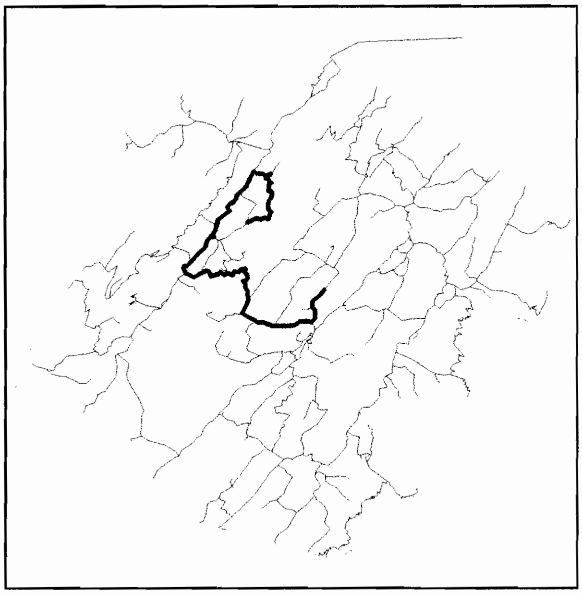
| | | | | |
|---|---|---|---|---|
| 2295 | 31 | 1 | 25 | 46.91 |
| 2296 | 32 | 1 | 26 | 47.68 |
| *2507 | 33 | -- | --- | 47.88 |



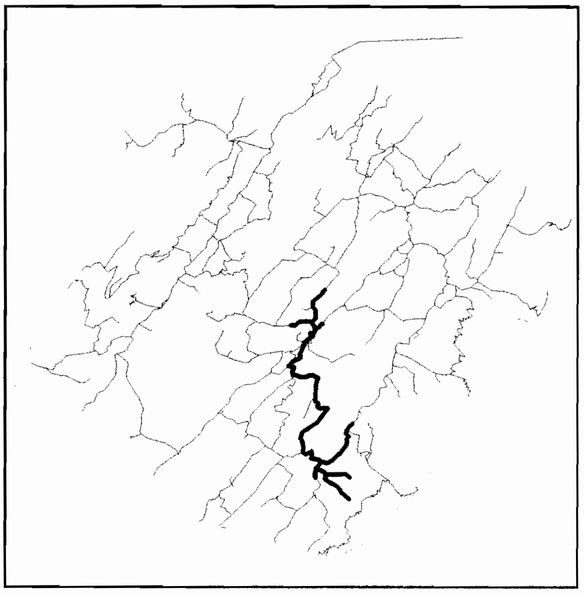
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2036 | 1 | 3 | 3 | 0.57 |
| 2037 | 2 | 1 | 4 | 2.69 |
| 2038 | 3 | 3 | 7 | 4.81 |
| 2039 | 4 | 1 | 8 | 6.93 |
| 2040 | 5 | 1 | 9 | 8.05 |
| 2041 | 6 | 1 | 10 | 10.17 |
| 2042 | 7 | 1 | 11 | 11.29 |
| 2043 | 8 | 1 | 12 | 14.41 |
| 2044 | 9 | 1 | 13 | 16.53 |
| 2045 | 10 | 3 | 16 | 17.35 |
| 2079 | 11 | 4 | 20 | 26.92 |
| 2080 | 12 | 2 | 22 | 28.04 |
| 2081 | 13 | 1 | 23 | 30.16 |
| 727 | 14 | -11 | 12 | 42.80 |
| *904 | 15 | -- | --- | 44.85 |



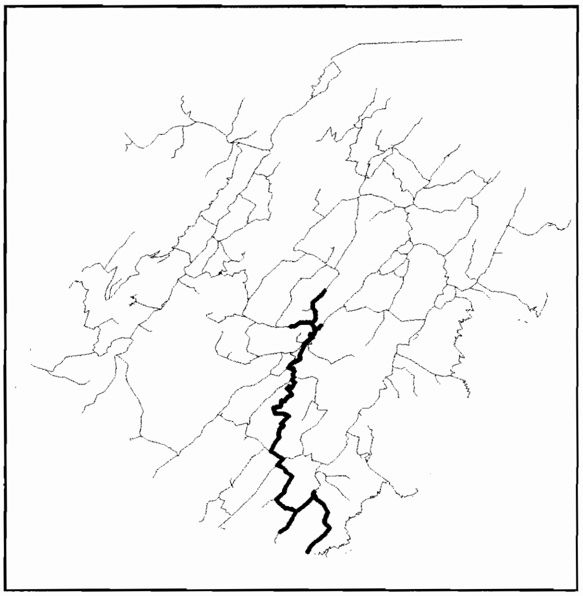
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2427 | 1 | 2 | 2 | 0.57 |
| 2426 | 2 | 2 | 4 | 1.34 |
| 2425 | 3 | 1 | 5 | 2.11 |
| 2423 | 4 | 3 | 8 | 4.08 |
| 2422 | 5 | 1 | 9 | 8.85 |
| 2421 | 6 | 1 | 10 | 11.92 |
| 354 | 7 | 2 | 12 | 14.99 |
| 372 | 8 | 6 | 18 | 16.39 |
| 390 | 12 | 1 | 19 | 18.96 |
| 2355 | 13 | 1 | 20 | 23.43 |
| 2417 | 14 | 1 | 21 | 26.70 |
| 2418 | 15 | 1 | 22 | 27.52 |
| 2419 | 16 | 3 | 25 | 29.69 |
| 2420 | 17 | 2 | 27 | 30.71 |
| 332 | 18 | 4 | 31 | 31.98 |
| *2483 | 19 | 33 | 64 | 33.28 |
| *2507 | 20 | - | --- | 40.41 |
| *2504 | 21 | - | --- | 47.15 |
| *2477 | 22 | - | --- | 49.60 |
| *2506 | 20 | - | --- | 46.17 |
| *2504 | 21 | - | --- | 52.09 |
| *2477 | 22 | - | --- | 54.54 |



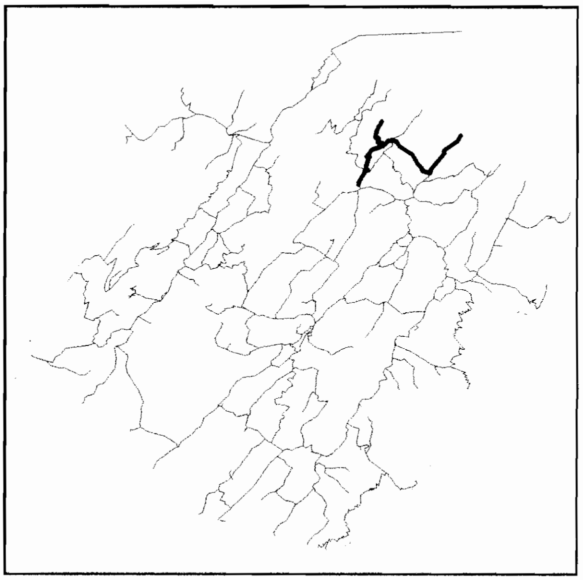
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 464 | 1 | 2 | 2 | 0.57 |
| 2462 | 2 | 1 | 3 | 5.94 |
| 2461 | 3 | 4 | 7 | 9.76 |
| 2460 | 4 | 1 | 8 | 11.33 |
| 284 | 5 | 2 | 10 | 15.00 |
| 2459 | 6 | 1 | 11 | 19.57 |
| 2066 | 7 | 1 | 12 | 27.14 |
| 2069 | 8 | 1 | 13 | 28.14 |
| 516 | 9 | 6 | 19 | 30.60 |
| 2088 | 10 | 4 | 23 | 31.33 |
| 2091 | 11 | 1 | 24 | 32.45 |
| 2092 | 12 | 3 | 27 | 34.07 |
| 2093 | 13 | 1 | 28 | 35.19 |
| 2097 | 14 | 1 | 29 | 36.41 |
| 727 | 15 | 28 | 57 | 38.73 |
| *2506 | 16 | -- | --- | 72.55 |
| *2507 | 16 | -- | --- | 78.31 |



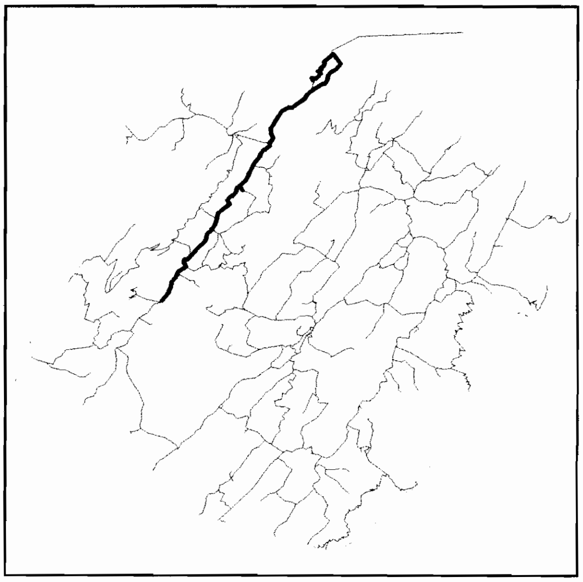
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2364 | 1 | 2 | 2 | 0.57 |
| 2215 | 2 | 4 | 6 | 5.69 |
| 2216 | 3 | 1 | 7 | 6.71 |
| 1683 | 4 | 1 | 8 | 9.83 |
| 2214 | 5 | 4 | 12 | 13.75 |
| 2213 | 6 | 2 | 14 | 14.67 |
| 2482 | 7 | 1 | 15 | 16.54 |
| 1617 | 8 | 1 | 16 | 17.36 |
| 2217 | 9 | 1 | 17 | 18.48 |
| 1627 | 10 | 2 | 19 | 21.02 |
| 2210 | 11 | 1 | 20 | 24.91 |
| 2211 | 12 | 4 | 24 | 26.03 |
| 2212 | 13 | 1 | 25 | 26.95 |
| 2305 | 14 | 3 | 27 | 41.82 |
| 2304 | 15 | 2 | 28 | 42.79 |
| 2481 | 16 | 2 | 37 | 34.83 |
| 2230 | 17 | 3 | 40 | 35.80 |
| 2228 | 18 | 2 | 42 | 37.37 |
| 2227 | 19 | 2 | 44 | 40.24 |
| 2226 | 20 | 1 | 45 | 41.16 |
| 2225 | 21 | 3 | 48 | 42.08 |
| 2224 | 22 | 1 | 49 | 42.90 |
| 1573 | 23 | 3 | 52 | 45.77 |
| 2231 | 24 | 1 | 53 | 51.14 |
| 2267 | 25 | 2 | 55 | 65.81 |
| 2266 | 26 | 2 | 57 | 66.63 |
| 2265 | 27 | 1 | 58 | 68.55 |
| *2504 | 28 | -- | --- | 74.85 |
| *2477 | 29 | -- | --- | 78.30 |
| *2506 | 30 | -- | --- | 82.84 |
| *2507 | 30 | -- | --- | 83.66 |



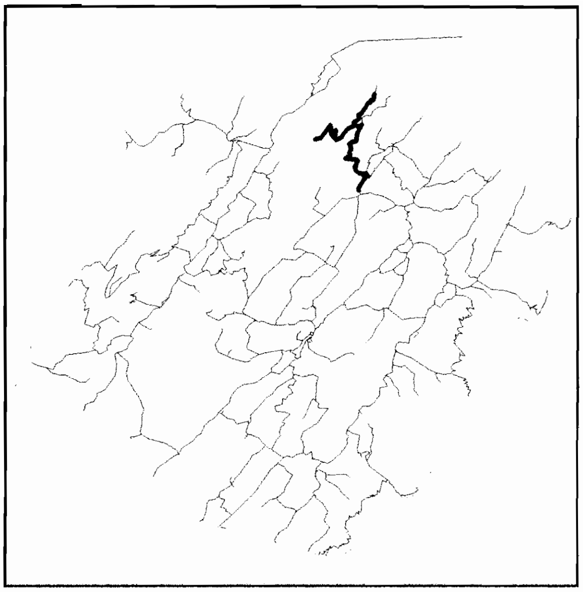
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2201 | 1 | 1 | 1 | 0.57 |
| 2202 | 2 | 3 | 4 | 1.69 |
| 2203 | 3 | 2 | 6 | 3.36 |
| 2204 | 4 | 1 | 8 | 4.48 |
| 2498 | 5 | 2 | 10 | 5.85 |
| 2206 | 6 | 3 | 13 | 7.22 |
| 2207 | 7 | 3 | 16 | 10.34 |
| 2208 | 8 | 2 | 18 | 11.59 |
| 2200 | 9 | 2 | 20 | 17.16 |
| 2199 | 10 | 3 | 23 | 18.28 |
| 2198 | 11 | 2 | 25 | 21.52 |
| 1672 | 12 | 2 | 27 | 27.35 |
| 2197 | 13 | 1 | 28 | 29.27 |
| 2196 | 14 | 1 | 29 | 30.29 |
| 1577 | 15 | 1 | 30 | 34.86 |
| 2221 | 16 | 1 | 31 | 36.93 |
| 2222 | 17 | 2 | 33 | 38.05 |
| 2262 | 18 | 1 | 34 | 40.62 |
| 2263 | 19 | 3 | 37 | 44.09 |
| 2264 | 20 | 3 | 40 | 52.36 |
| *2504 | 21 | -- | --- | 58.06 |
| *2477 | 22 | -- | --- | 61.42 |
| *2506 | 23 | -- | --- | 63.89 |
| *2507 | 23 | -- | --- | 64.37 |



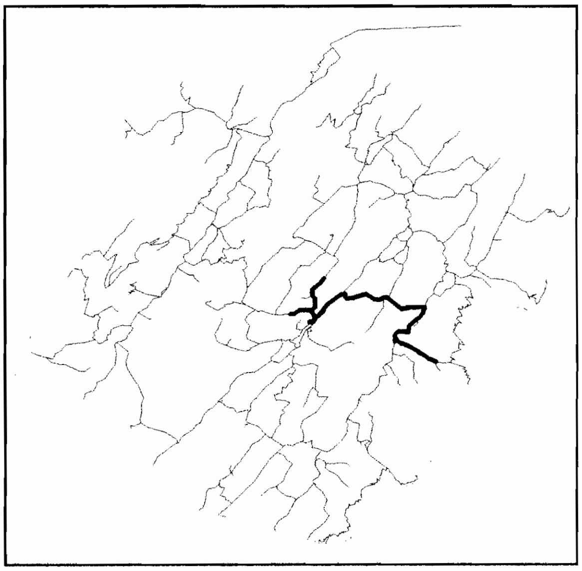
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 129 | 1 | 2 | 2 | 0.57 |
| 2414 | 2 | 1 | 3 | 2.69 |
| 169 | 3 | 5 | 8 | 4.81 |
| 2415 | 4 | 1 | 9 | 6.73 |
| 2416 | 5 | 3 | 12 | 8.65 |
| 2447 | 6 | 2 | 14 | 13.72 |
| 144 | 7 | -14 | 0 | 17.74 |
| 93 | 8 | 3 | 3 | 27.76 |
| 2444 | 9 | 1 | 4 | 29.73 |
| 2443 | 10 | 1 | 5 | 31.30 |
| 2442 | 11 | 2 | 7 | 37.57 |
| 2441 | 12 | 2 | 9 | 38.89 |
| 2440 | 7 | 3 | 12 | 39.04 |
| 2439 | 8 | 3 | 15 | 40.36 |
| 2438 | 13 | 3 | 18 | 41.16 |
| 1991 | 10 | 2 | 20 | 43.88 |
| 1990 | 9 | 1 | 21 | 45.93 |
| 2437 | 14 | 2 | 23 | 46.88 |
| 2436 | 6 | 2 | 25 | 47.22 |
| 2435 | 15 | 1 | 26 | 48.95 |
| *2483 | 16 | -- | --- | 52.35 |



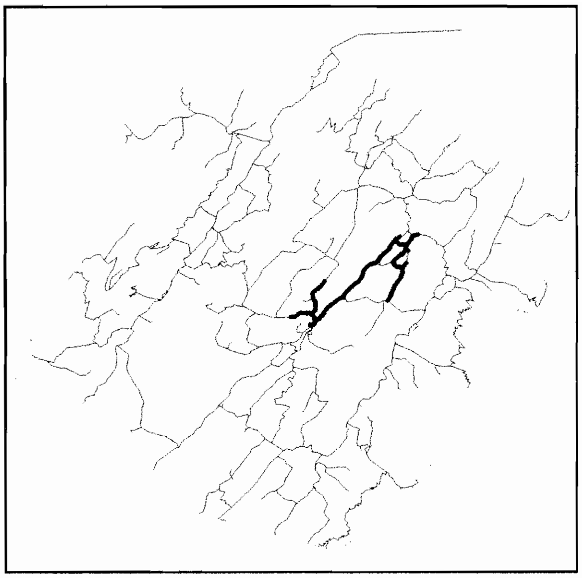
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2007 | 1 | 3 | 3 | 0.57 |
| 2006 | 2 | 2 | 5 | 4.49 |
| 2497 | 3 | 1 | 6 | 5.46 |
| 2004 | 4 | 1 | 7 | 8.43 |
| 2003 | 5 | 2 | 9 | 9.70 |
| 2002 | 6 | 1 | 10 | 10.72 |
| 2001 | 7 | 3 | 13 | 11.84 |
| 2000 | 8 | 1 | 14 | 12.96 |
| 5 | 9 | 2 | 16 | 14.08 |
| 2008 | 10 | 1 | 17 | 16.20 |
| 2009 | 11 | 1 | 18 | 17.12 |
| 2010 | 12 | 1 | 19 | 18.14 |
| 2011 | 13 | 3 | 22 | 18.96 |
| 2012 | 14 | 1 | 23 | 20.63 |
| 2013 | 15 | 4 | 27 | 21.15 |
| 2014 | 16 | 4 | 31 | 22.27 |
| 2015 | 17 | 1 | 32 | 23.09 |
| 2016 | 18 | 1 | 33 | 23.95 |
| 2017 | 19 | 1 | 34 | 24.78 |
| 2018 | 20 | 1 | 35 | 25.60 |
| 2059 | 21 | 8 | 43 | 28.72 |
| 2047 | 22 | 1 | 44 | 32.01 |
| 2050 | 23 | 5 | 49 | 33.00 |
| 2053 | 24 | 1 | 50 | 34.40 |
| 2054 | 25 | 1 | 51 | 35.13 |
| 229 | 26 | 1 | 52 | 36.10 |
| 2057 | 27 | 1 | 53 | 37.12 |
| 2063 | 28 | 1 | 54 | 38.19 |
| 2065 | 29 | 1 | 55 | 40.51 |
| 2064 | 30 | 1 | 56 | 41.33 |
| 2069 | 31 | 2 | 58 | 42.88 |
| 2071 | 32 | 1 | 59 | 44.03 |
| 2086 | 33 | 1 | 60 | 45.58 |
| 2087 | 34 | 1 | 61 | 46.30 |
| 727 | 35 | -12 | 49 | 51.76 |
| *904 | 36 | -- | --- | 53.81 |



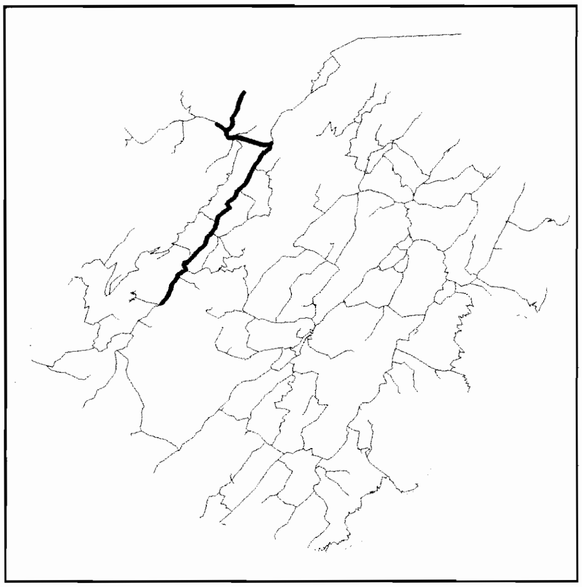
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2455 | 1 | 1 | 1 | 0.57 |
| 2463 | 2 | 2 | 3 | 2.69 |
| 2456 | 3 | 1 | 4 | 13.06 |
| 85 | 4 | 2 | 6 | 23.18 |
| 2457 | 5 | 1 | 7 | 25.30 |
| *2483 | 6 | -7 | 0 | 50.05 |



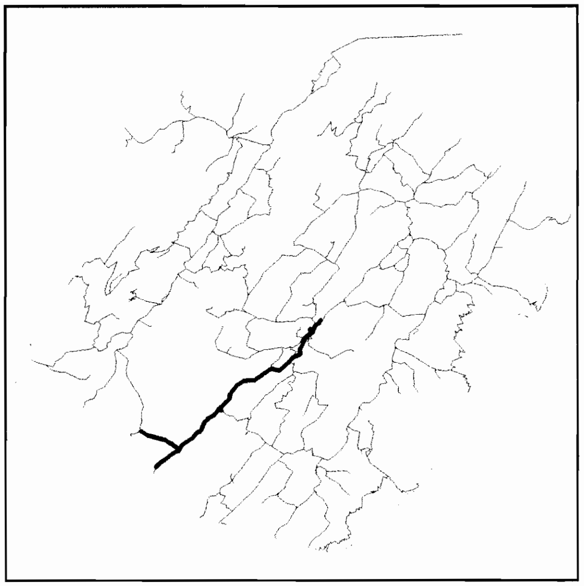
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2325 | 1 | 6 | 6 | 0.57 |
| 2324 | 2 | 1 | 7 | 1.34 |
| 2323 | 3 | 2 | 9 | 2.46 |
| 2322 | 4 | 3 | 12 | 3.38 |
| 2321 | 5 | 4 | 16 | 4.30 |
| 2320 | 6 | 1 | 17 | 5.22 |
| 2319 | 7 | 4 | 21 | 6.34 |
| 2318 | 8 | 1 | 22 | 7.26 |
| 2317 | 9 | 2 | 25 | 8.18 |
| 2316 | 10 | 2 | 27 | 9.30 |
| 2315 | 11 | 11 | 38 | 10.22 |
| 2314 | 12 | 7 | 45 | 11.14 |
| 2480 | 13 | 7 | 52 | 12.99 |
| 2479 | 14 | 1 | 53 | 14.36 |
| 2327 | 15 | 2 | 55 | 15.23 |
| 1091 | 16 | 3 | 58 | 18.35 |
| 2328 | 17 | 2 | 60 | 19.27 |
| *2477 | 18 | -- | --- | 37.29 |
| *2504 | 19 | -- | --- | 41.12 |
| *2506 | 20 | -- | --- | 45.61 |
| *2507 | 20 | -- | --- | 46.27 |



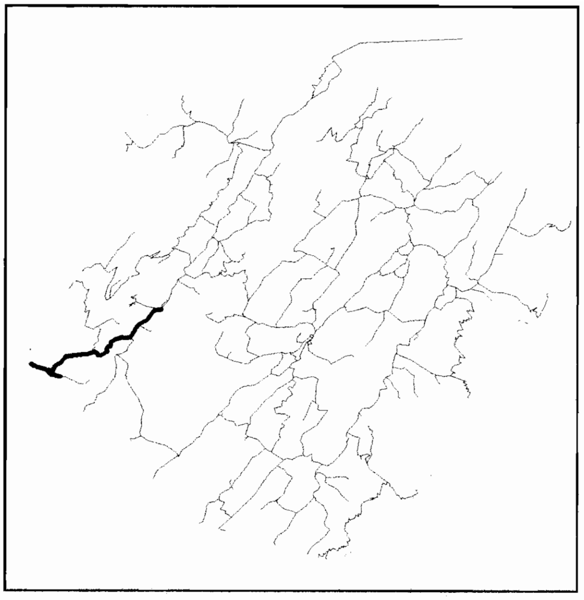
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 931 | 1 | 2 | 2 | 0.57 |
| 2380 | 2 | 2 | 4 | 1.89 |
| 2379 | 3 | 1 | 5 | 4.01 |
| 2378 | 4 | 1 | 6 | 6.13 |
| 2377 | 5 | 2 | 8 | 8.05 |
| 2374 | 6 | 2 | 10 | 9.72 |
| 2376 | 7 | 2 | 12 | 12.39 |
| 2375 | 8 | 1 | 13 | 13.51 |
| 2370 | 9 | 1 | 14 | 14.58 |
| 2371 | 10 | 1 | 15 | 16.70 |
| 2372 | 11 | 3 | 18 | 17.47 |
| 2373 | 12 | 12 | 30 | 19.84 |
| 598 | 13 | 2 | 32 | 21.31 |
| 2409 | 14 | 2 | 34 | 24.68 |
| 2366 | 15 | 2 | 36 | 29.30 |
| 2367 | 16 | 2 | 38 | 30.22 |
| 2368 | 17 | 2 | 40 | 31.09 |
| 2369 | 18 | 1 | 41 | 34.56 |
| 2360 | 19 | 2 | 43 | 36.68 |
| 690 | 20 | 3 | 46 | 37.80 |
| 2359 | 21 | 1 | 47 | 38.72 |
| 2358 | 22 | 2 | 49 | 39.64 |
| 2357 | 23 | 1 | 50 | 40.51 |
| 2356 | 24 | 2 | 52 | 42.63 |
| 2287 | 25 | 4 | 56 | 44.55 |
| 2286 | 26 | 2 | 58 | 45.57 |
| 2285 | 27 | 10 | 68 | 46.59 |
| 2284 | 28 | 1 | 69 | 48.61 |
| 2290 | 29 | 1 | 70 | 49.73 |
| 2473 | 30 | 3 | 73 | 50.50 |
| 2288 | 31 | 2 | 75 | 51.52 |
| 2283 | 32 | 1 | 76 | 52.39 |
| 2282 | 33 | 6 | 82 | 53.16 |
| 2281 | 34 | 1 | 83 | 53.97 |
| 2280 | 35 | 3 | 86 | 54.84 |
| *2477 | 36 | -- | --- | 55.09 |
| *2504 | 37 | -- | --- | 58.63 |
| *2506 | 38 | -- | --- | 63.35 |
| *2507 | 38 | -- | --- | 64..40 |



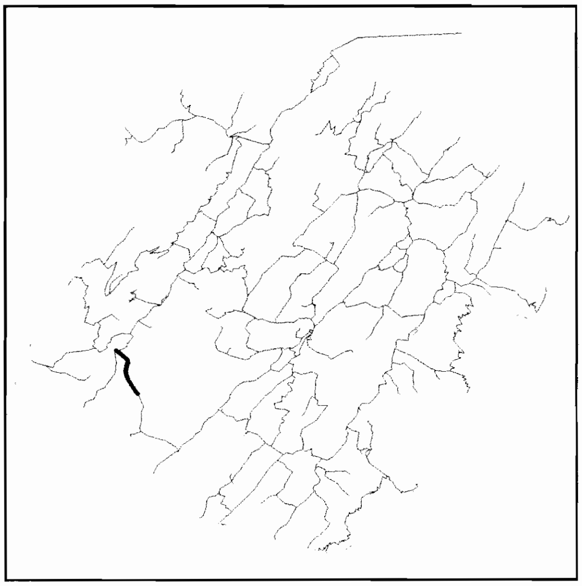
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 29 | 1 | 1 | 1 | 0.57 |
| 2019 | 2 | 2 | 3 | 1.69 |
| 2020 | 3 | 2 | 5 | 3.81 |
| 2021 | 4 | 1 | 6 | 4.93 |
| 2022 | 5 | 1 | 7 | 6.05 |
| 2023 | 6 | 1 | 8 | 7.27 |
| 2491 | 7 | 2 | 10 | 8.49 |
| 2490 | 8 | 6 | 16 | 11.79 |
| 2026 | 9 | 3 | 19 | 12.61 |
| 2027 | 10 | 2 | 21 | 13.43 |
| 2028 | 11 | 1 | 22 | 14.30 |
| 2492 | 12 | 2 | 24 | 15.32 |
| 131 | 13 | 11 | 35 | 17.14 |
| 156 | 14 | 2 | 37 | 22.11 |
| 2061 | 15 | 1 | 48 | 23.03 |
| 2062 | 16 | 1 | 39 | 23.77 |
| 2048 | 17 | 1 | 40 | 25.06 |
| 2050 | 18 | 1 | 41 | 25.88 |
| 2051 | 19 | 1 | 42 | 26.70 |
| 2052 | 20 | 2 | 44 | 27.62 |
| 229 | 21 | 2 | 46 | 29.98 |
| 2063 | 22 | 1 | 47 | 30.50 |
| 2068 | 23 | 1 | 58 | 31.87 |
| 2069 | 24 | 1 | 59 | 32.62 |
| 2070 | 25 | 2 | 51 | 33.39 |
| 657 | 26 | 2 | 53 | 38.16 |
| 727 | 27 | -16 | 37 | 40.93 |
| 2098 | 28 | 2 | 39 | 41.85 |
| 2099 | 29 | 2 | 41 | 43.12 |
| 2100 | 30 | 1 | 42 | 43.94 |
| 904 | 31 | -- | --- | 45.26 |



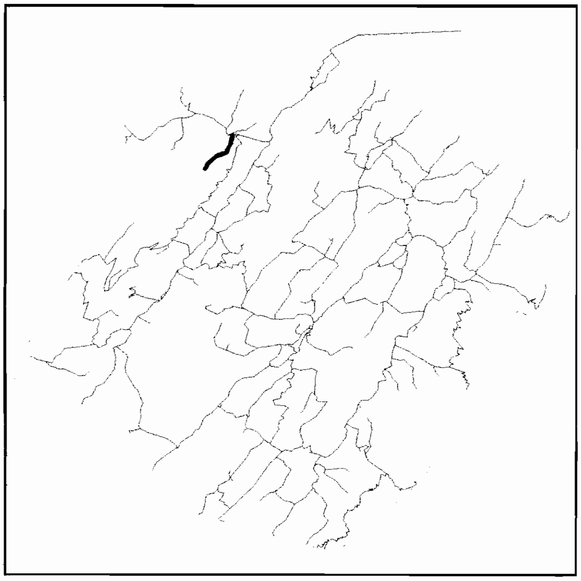
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2155 | 1 | 1 | 1 | 0.57 |
| 2156 | 2 | 2 | 3 | 2.69 |
| 2157 | 3 | 1 | 4 | 4.61 |
| 2158 | 4 | 2 | 6 | 5.53 |
| 2159 | 5 | 1 | 7 | 7.45 |
| 2160 | 6 | 1 | 8 | 8.27 |
| 2161 | 7 | 3 | 11 | 9.34 |
| 2162 | 8 | 1 | 12 | 10.16 |
| 2163 | 9 | 1 | 13 | 11.03 |
| 2164 | 10 | 1 | 14 | 12.00 |
| 2165 | 11 | 1 | 15 | 12.77 |
| 2166 | 12 | 1 | 16 | 13.74 |
| 2167 | 13 | 3 | 19 | 14.56 |
| 2168 | 14 | 1 | 20 | 15.38 |
| 2169 | 15 | 2 | 22 | 16.20 |
| 2170 | 16 | 2 | 24 | 17.02 |
| 2171 | 17 | 1 | 25 | 20.74 |
| 2172 | 18 | 1 | 26 | 22.56 |
| 2173 | 19 | 7 | 33 | 23.43 |
| 2174 | 20 | 2 | 35 | 24.25 |
| 2175 | 21 | 2 | 37 | 25.05 |
| 2176 | 22 | 1 | 38 | 25.97 |
| 2177 | 23 | 2 | 40 | 26.89 |
| 2178 | 24 | 2 | 42 | 27.71 |
| 2179 | 25 | 1 | 43 | 29.78 |
| 2180 | 26 | 4 | 47 | 31.70 |
| 2257 | 27 | 7 | 54 | 36.82 |
| 1281 | 28 | 1 | 55 | 37.69 |
| 2298 | 29 | 4 | 59 | 39.16 |
| 1234 | 30 | 4 | 63 | 40.51 |
| *2504 | 30 | -- | --- | 44.71 |
| *2477 | 31 | -- | --- | 48.16 |
| *2506 | 32 | -- | --- | 52.13 |
| *2507 | 32 | -- | --- | 52.95 |



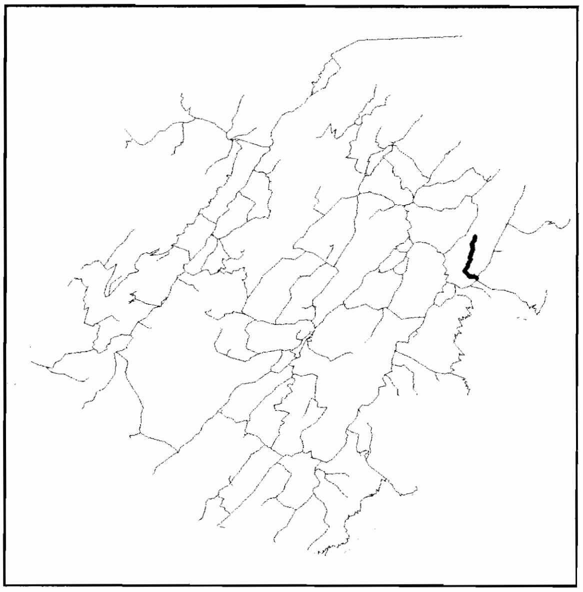
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2112 | 1 | 1 | 1 | 0.57 |
| 2113 | 2 | 2 | 3 | 1.69 |
| 2114 | 3 | 5 | 8 | 2.46 |
| 2115 | 4 | 1 | 9 | 3.23 |
| 2116 | 5 | 4 | 13 | 4.00 |
| 2110 | 6 | 2 | 15 | 9.37 |
| 2109 | 7 | 7 | 22 | 10.49 |
| 2111 | 8 | 3 | 25 | 13.16 |
| 2134 | 9 | 1 | 26 | 24.08 |
| 2135 | 10 | 5 | 31 | 25.05 |
| 2136 | 11 | 1 | 32 | 25.92 |
| 2137 | 12 | 5 | 37 | 26.79 |
| 2138 | 13 | 2 | 39 | 27.58 |
| 2496 | 14 | 3 | 42 | 28.45 |
| 2140 | 15 | 3 | 45 | 29.12 |
| 2141 | 16 | 1 | 46 | 30.04 |
| 2142 | 17 | 3 | 49 | 30.91 |
| 2143 | 18 | 1 | 50 | 31.73 |
| 2147 | 19 | 1 | 51 | 33.05 |
| 2153 | 20 | 3 | 54 | 34.52 |
| *904 | 21 | -- | --- | 35.27 |



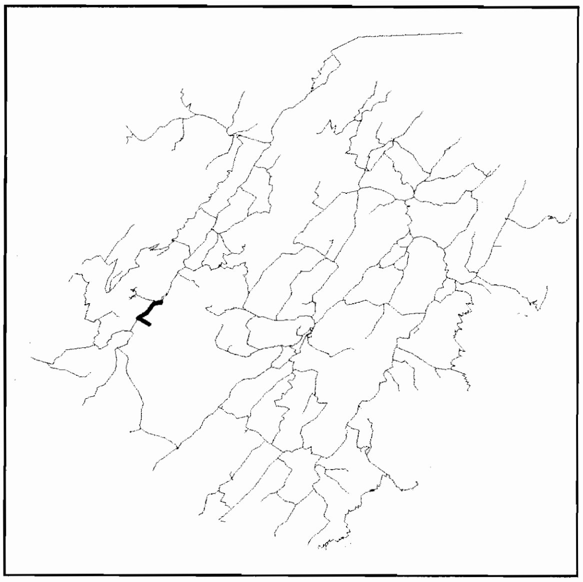
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2120 | 1 | 2 | 2 | 0.57 |
| 1431 | 2 | 2 | 4 | 3.34 |
| 2361 | 3 | 1 | 5 | 4.46 |
| 2122 | 4 | 1 | 6 | 5.58 |
| 2121 | 5 | 2 | 8 | 6.70 |
| 2119 | 6 | 1 | 9 | 9.37 |
| 2118 | 7 | 3 | 12 | 10.49 |
| 2117 | 8 | 1 | 13 | 11.61 |
| 1204 | 9 | -13 | 0 | 16.16 |



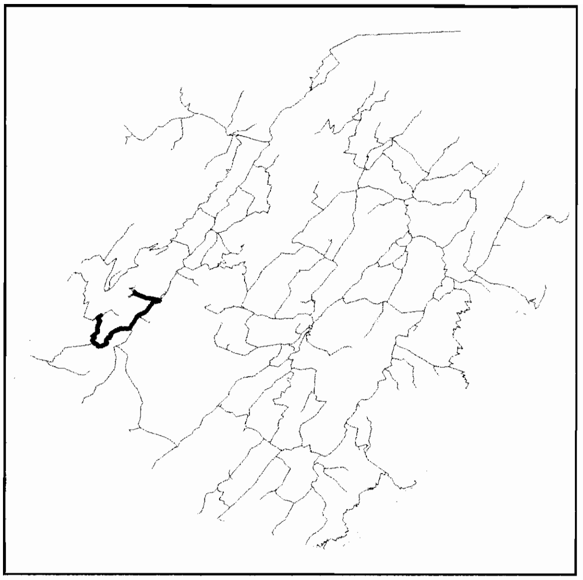
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2035 | 1 | 1 | 1 | 0.57 |
| 2034 | 2 | 1 | 2 | 3.54 |
| 2033 | 3 | 1 | 3 | 4.36 |
| 2032 | 4 | 3 | 6 | 6.48 |
| 2031 | 5 | 2 | 8 | 7.40 |
| 2030 | 6 | 1 | 9 | 8.52 |
| 2029 | 7 | 2 | 11 | 9.44 |
| 131 | 8 | -11 | 0 | 9.99 |



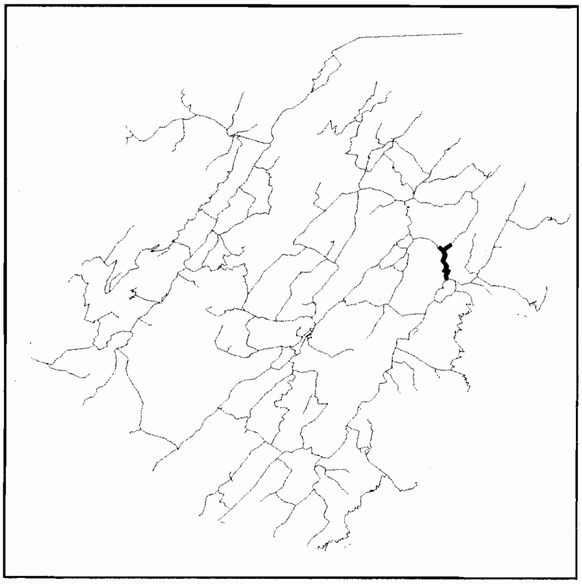
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 526 | 1 | 2 | 2 | 0.40 |
| 2399 | 2 | 3 | 5 | 5.35 |
| 2400 | 3 | 3 | 8 | 9.10 |
| 764 | 4 | -8 | 0 | 11.22 |



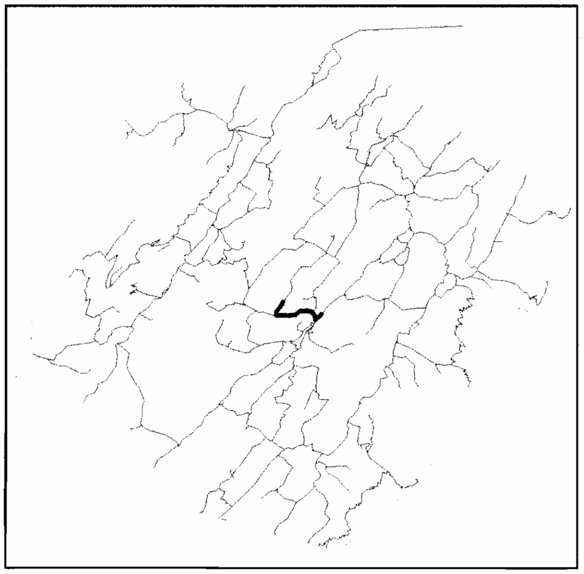
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 1075 | 1 | 2 | 2 | 0.40 |
| 2149 | 2 | 1 | 3 | 1.50 |
| *904 | 3 | -3 | 0 | 13.57 |



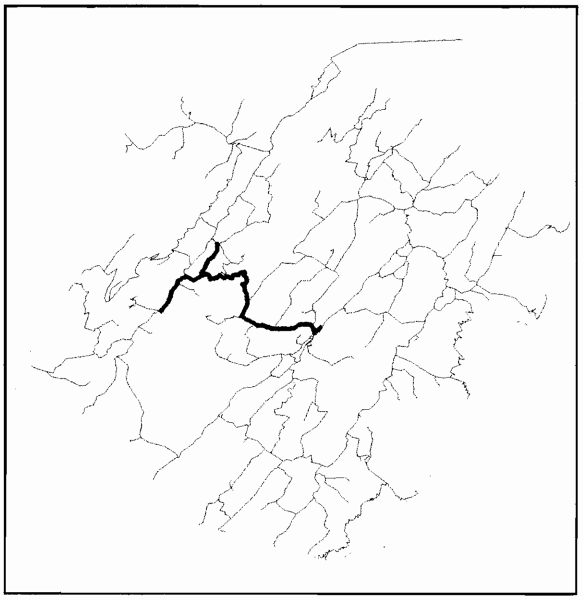
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2132 | 1 | 1 | 1 | 0.40 |
| 1048 | 2 | 4 | 5 | 1.35 |
| 2133 | 3 | 4 | 9 | 3.30 |
| *904 | 4 | -9 | 0 | 9.65 |
| 2150 | 5 | 5 | 5 | 15.20 |
| 2151 | 6 | 1 | 6 | 19.70 |
| 2152 | 7 | 1 | 7 | 20.40 |
| *904 | 8 | -7 | 0 | 21.72 |



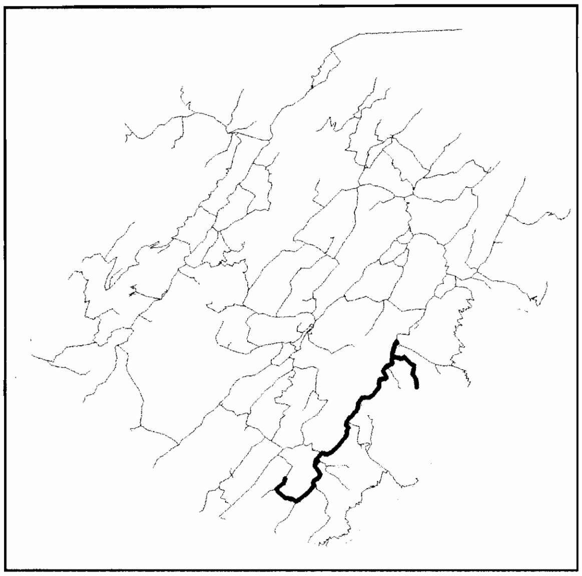
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 609 | 1 | 1 | 1 | 0.40 |
| 2407 | 2 | 2 | 3 | 4.80 |
| 2408 | 3 | 4 | 7 | 11.00 |
| 782 | 4 | -7 | 0 | 20.37 |



| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2268 | 1 | 3 | 3 | 0.40 |
| 2269 | 2 | 1 | 4 | 3.15 |
| 2270 | 3 | 2 | 6 | 6.90 |
| 2271 | 4 | 1 | 7 | 7.65 |
| *2477 | 5 | -3 | 4 | 15.97 |
| *2504 | 6 | -4 | 0 | 18.42 |

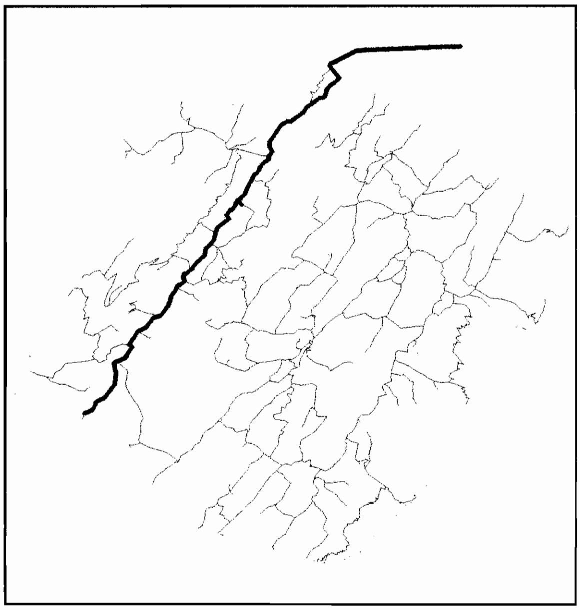


| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2102 | 1 | 3 | 3 | 0.57 |
| 2103 | 2 | 2 | 5 | 3.69 |
| 2089 | 3 | 1 | 6 | 5.81 |
| 2106 | 4 | 4 | 10 | 15.66 |
| 2105 | 5 | 4 | 14 | 17.33 |
| 2104 | 6 | 1 | 15 | 20.45 |
| 2469 | 7 | 2 | 17 | 22.47 |
| 727 | 8 | -6 | 11 | 24.42 |
| *904 | 9 | 4 | 15 | 29.86 |
| *2477 | 10 | -- | --- | 69.70 |

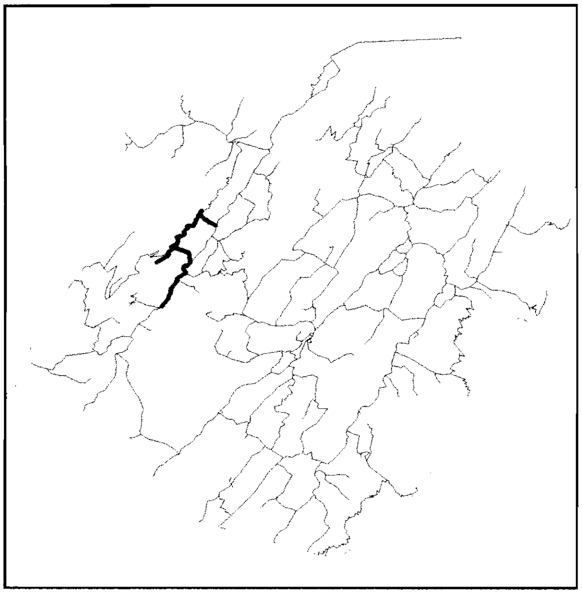


| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 1383 | 1 | 2 | 2 | 0.40 |
| 2311 | 2 | 2 | 4 | 2.35 |
| 2312 | 3 | 2 | 6 | 4.30 |
| 2313 | 4 | 1 | 7 | 5.25 |
| 2480 | 5 | -7 | 0 | 10..62 |

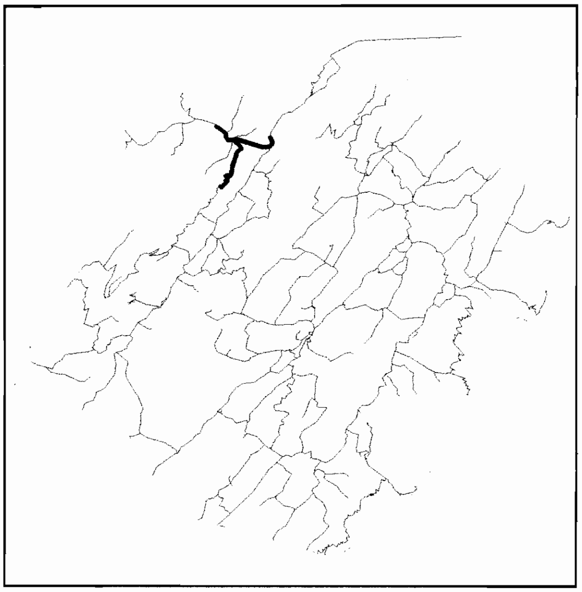
# APPENDIX B



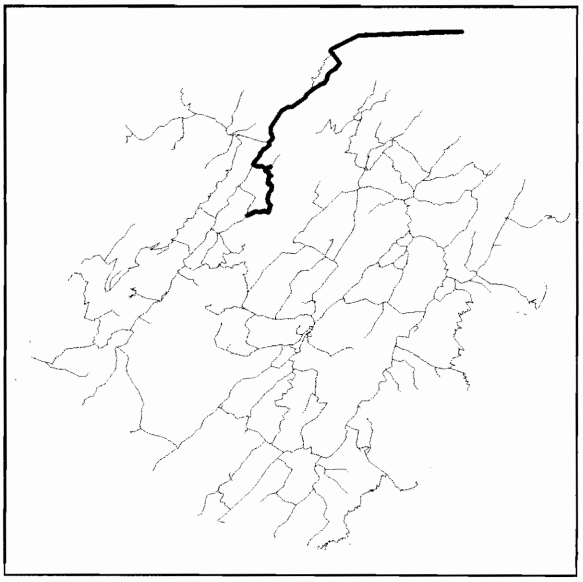
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2131 | 1 | 2 | 2 | 0.57 |
| 2130 | 2 | 4 | 6 | 1.69 |
| 2494 | 3 | 1 | 7 | 2.56 |
| 2128 | 4 | 2 | 9 | 4.08 |
| 2127 | 5 | 4 | 13 | 5.05 |
| 2126 | 6 | 2 | 15 | 7.17 |
| 2495 | 7 | 1 | 16 | 7.99 |
| 2124 | 8 | 7 | 23 | 8.81 |
| 2123 | 9 | 1 | 24 | 9.63 |
| 2154 | 10 | 3 | 27 | 14.75 |
| 1204 | 11 | 13 | 40 | 16.00 |
| 2146 | 12 | 5 | 45 | 16.92 |
| 2144 | 13 | 2 | 47 | 19.04 |
| 1112 | 14 | 2 | 49 | 20.16 |
| *904 | 15 | -12 | 37 | 24.21 |
| 2101 | 16 | 1 | 38 | 25.33 |
| 2099 | 17 | 1 | 39 | 26.35 |
| 727 | 18 | 22 | 54 | 29.40 |
| 2097 | 19 | 1 | 55 | 30.29 |
| 657 | 20 | 1 | 56 | 31.31 |
| 2092 | 21 | 1 | 57 | 32.63 |
| 2088 | 22 | 1 | 58 | 34.80 |
| 516 | 23 | 3 | 61 | 35.53 |
| 2069 | 24 | 1 | 62 | 37.99 |
| 2063 | 25 | 1 | 63 | 39.54 |
| *2505 | 26 | -- | --- | 76.39 |



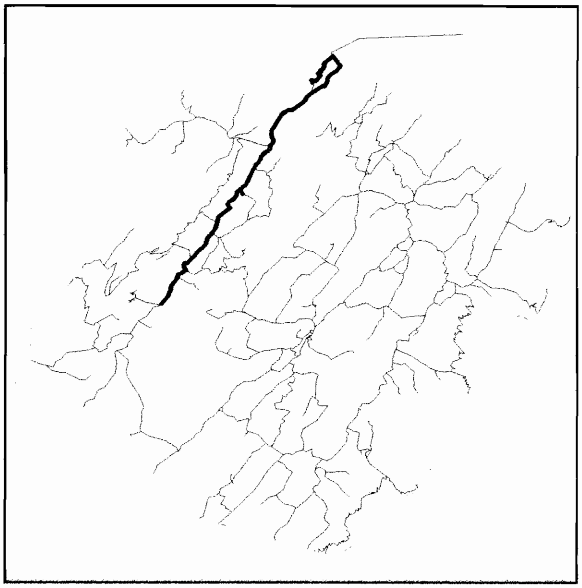
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2072 | 1 | 1 | 1 | 0.57 |
| 2073 | 2 | 1 | 2 | 1.69 |
| 2074 | 3 | 1 | 3 | 2.66 |
| 2076 | 4 | 4 | 7 | 3.58 |
| 2077 | 5 | 2 | 9 | 4.45 |
| 2078 | 6 | 1 | 10 | 6.37 |
| 2079 | 7 | 4 | 14 | 12.72 |
| 2080 | 8 | 2 | 16 | 13.84 |
| 2081 | 9 | 1 | 17 | 15.96 |
| 434 | 10 | 4 | 21 | 18.08 |
| 2082 | 11 | 1 | 22 | 20.20 |
| 2083 | 12 | 2 | 24 | 23.32 |
| 2084 | 13 | 1 | 25 | 25.44 |
| 656 | 14 | 2 | 27 | 35.94 |
| 2108 | 15 | 1 | 28 | 41.06 |
| 2107 | 16 | 2 | 30 | 42.28 |
| 2096 | 17 | 2 | 32 | 50.52 |
| 2094 | 18 | 1 | 33 | 51.44 |
| 727 | 19 | -13 | 20 | 52.98 |
| *904 | 20 | -- | --- | 55.60 |



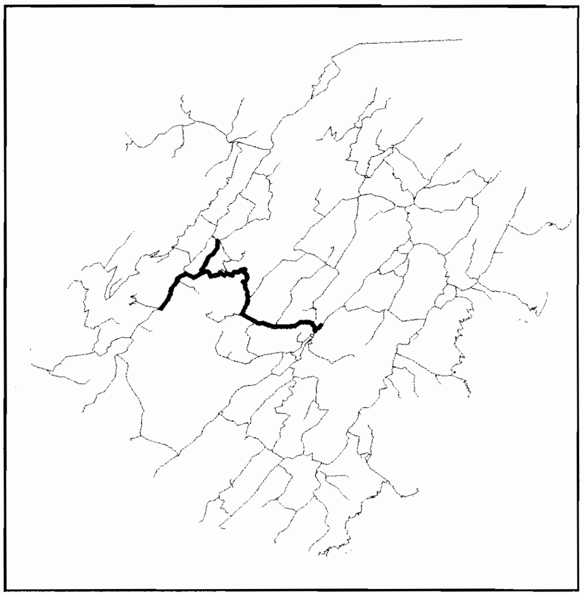
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2045 | 1 | 3 | 3 | 0.57 |
| 2044 | 2 | 1 | 4 | 1.39 |
| 2043 | 3 | 1 | 5 | 5.51 |
| 2042 | 4 | 1 | 6 | 10.13 |
| 2041 | 5 | 1 | 7 | 11.25 |
| 2040 | 6 | 1 | 8 | 14.37 |
| 2039 | 7 | 1 | 9 | 15.49 |
| 2038 | 8 | 3 | 12 | 17.61 |
| 2037 | 9 | 1 | 13 | 19.73 |
| 2036 | 10 | 3 | 16 | 21.85 |
| 125 | 11 | -16 | 0 | 35.40 |



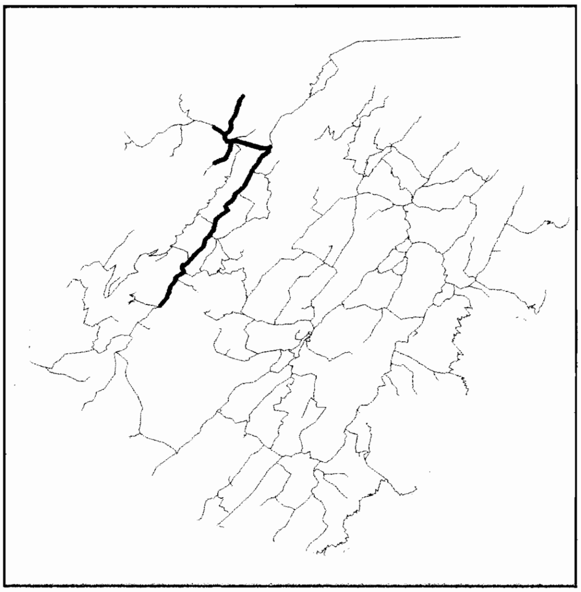
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 464 | 1 | 2 | 2 | 0.57 |
| 2462 | 2 | 1 | 3 | 5.32 |
| 2461 | 3 | 4 | 7 | 8.10 |
| 2460 | 4 | 1 | 8 | 9.05 |
| 284 | 5 | 2 | 10 | 12.15 |
| 2459 | 6 | 1 | 11 | 16.15 |
| 229 | 7 | 1 | 12 | 22.22 |
| 2052 | 8 | 1 | 13 | 23.58 |
| 2051 | 9 | 1 | 14 | 24.50 |
| 2062 | 10 | 1 | 15 | 26.29 |
| 2061 | 11 | 1 | 16 | 27.03 |
| 156 | 12 | 8 | 24 | 27.95 |
| 2059 | 13 | 1 | 25 | 30.17 |
| 2017 | 14 | 1 | 26 | 33.54 |
| 2014 | 15 | 1 | 27 | 34.91 |
| 2013 | 16 | 1 | 28 | 36.03 |
| 5 | 17 | 7 | 35 | 40.25 |
| *2505 | 18 | -- | --- | 63.25 |



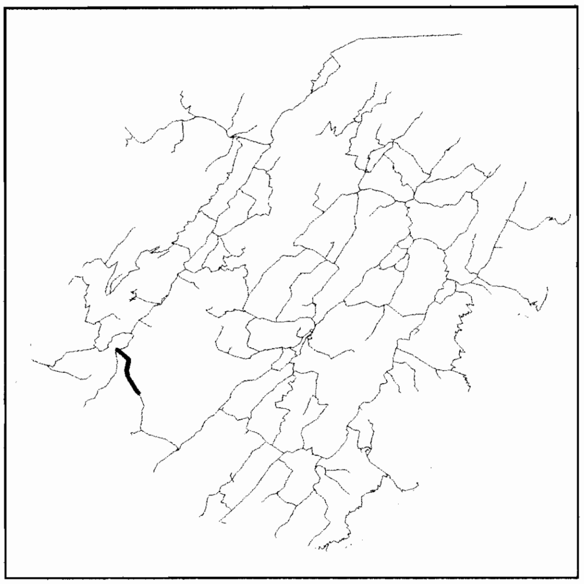
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2007 | 1 | 3 | 3 | 0.57 |
| 2006 | 2 | 2 | 5 | 4.49 |
| 2497 | 3 | 1 | 6 | 5.46 |
| 2004 | 4 | 1 | 7 | 8.43 |
| 2003 | 5 | 2 | 9 | 9.70 |
| 2002 | 6 | 1 | 10 | 10.72 |
| 2001 | 7 | 3 | 13 | 11.84 |
| 2000 | 8 | 1 | 14 | 12.96 |
| 5 | 9 | -5 | 9 | 14.08 |
| 2008 | 10 | 1 | 10 | 16.20 |
| 2011 | 11 | 3 | 13 | 17.82 |
| 2013 | 12 | 3 | 16 | 19.74 |
| 2014 | 13 | 3 | 19 | 20.86 |
| 2015 | 14 | 1 | 20 | 21.68 |
| 2017 | 15 | 1 | 21 | 22.80 |
| 2018 | 16 | 1 | 22 | 23.62 |
| 2059 | 17 | 7 | 29 | 25.74 |
| 2047 | 18 | 1 | 30 | 29.03 |
| 2050 | 19 | 5 | 35 | 30.02 |
| 2053 | 20 | 1 | 36 | 31.42 |
| 2054 | 21 | 1 | 37 | 32.15 |
| 229 | 22 | 1 | 38 | 33.12 |
| 2057 | 23 | 1 | 39 | 34.14 |
| 2063 | 24 | 1 | 40 | 35.21 |
| 2065 | 25 | 2 | 42 | 37.53 |
| 2064 | 26 | 1 | 43 | 38.35 |
| 2069 | 27 | 1 | 44 | 39.90 |
| 2071 | 28 | 1 | 45 | 41.05 |
| 2087 | 29 | 1 | 46 | 42.75 |
| *904 | 30 | 0 | 46 | 48.26 |



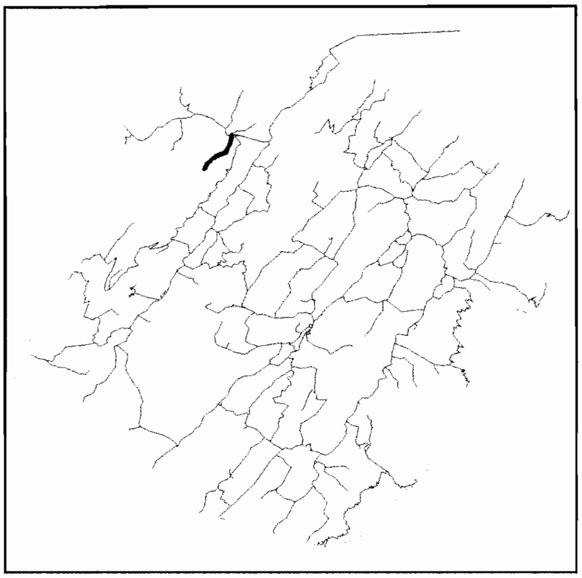
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2102 | 1 | 3 | 3 | 0.57 |
| 2103 | 2 | 2 | 5 | 3.69 |
| 2089 | 3 | 1 | 6 | 5.81 |
| 2106 | 4 | 4 | 10 | 15.66 |
| 2105 | 5 | 4 | 14 | 17.33 |
| 2104 | 6 | 1 | 15 | 20.45 |
| 2469 | 7 | 2 | 17 | 22.47 |
| 727 | 8 | -6 | 11 | 24.42 |
| *904 | 9 | 4 | 15 | 29.86 |
| *2477 | 10 | -- | --- | 69.70 |



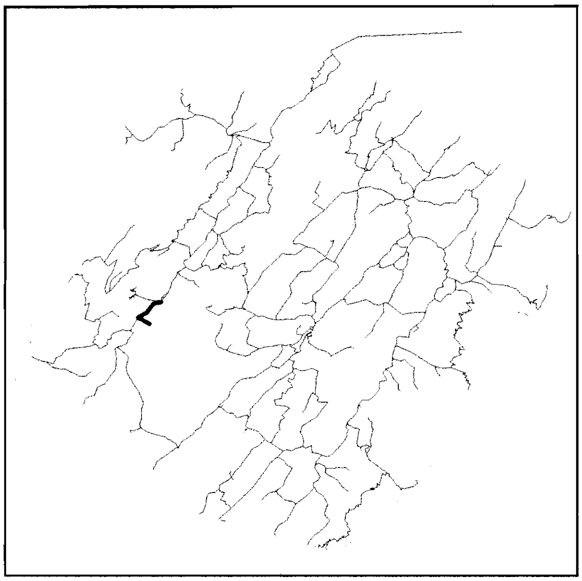
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 29 | 1 | 1 | 1 | 0.57 |
| 2019 | 2 | 2 | 3 | 1.69 |
| 2020 | 3 | 2 | 5 | 3.81 |
| 2021 | 4 | 1 | 6 | 4.93 |
| 2022 | 5 | 1 | 7 | 6.05 |
| 2023 | 6 | 1 | 8 | 7.27 |
| 2491 | 7 | 2 | 10 | 8.49 |
| 2490 | 8 | 6 | 16 | 11.79 |
| 2026 | 9 | 3 | 19 | 12.61 |
| 2027 | 10 | 2 | 21 | 13.43 |
| 2028 | 11 | 1 | 22 | 14.30 |
| 2492 | 12 | 2 | 24 | 15.32 |
| 2032 | 13 | 3 | 27 | 18.51 |
| 2035 | 14 | 1 | 28 | 23.28 |
| 2034 | 15 | 1 | 29 | 26.25 |
| 2033 | 16 | 1 | 30 | 27.07 |
| 2031 | 17 | 2 | 32 | 29.54 |
| 2030 | 18 | 1 | 33 | 30.66 |
| 2029 | 19 | 2 | 35 | 31.58 |
| 125 | 20 | 16 | 51 | 33.63 |
| 2046 | 21 | 1 | 52 | 37.75 |
| 156 | 22 | -8 | 44 | 39.10 |
| 2048 | 23 | 1 | 45 | 40.91 |
| 2050 | 24 | 1 | 46 | 41.73 |
| 2052 | 25 | 1 | 47 | 42.90 |
| 229 | 26 | 1 | 48 | 44.26 |
| 2066 | 27 | 1 | 49 | 46.33 |
| 2068 | 28 | 1 | 50 | 47.15 |
| 2069 | 29 | 1 | 51 | 47.90 |
| 2070 | 30 | 2 | 53 | 48.67 |
| 516 | 31 | 2 | 58 | 50.93 |
| 2088 | 32 | 3 | 59 | 51.66 |
| 2091 | 33 | 1 | 61 | 52.78 |
| 2092 | 34 | 2 | 62 | 54.40 |
| 2093 | 35 | 1 | 63 | 55.52 |
| 657 | 36 | 1 | 65 | 56.29 |
| 2098 | 37 | 2 | 67 | 57.98 |
| 2099 | 38 | 2 | 68 | 59.25 |
| 2100 | 39 | 1 | 68 | 60.07 |
| *904 | 40 | -- | --- | 61.39 |



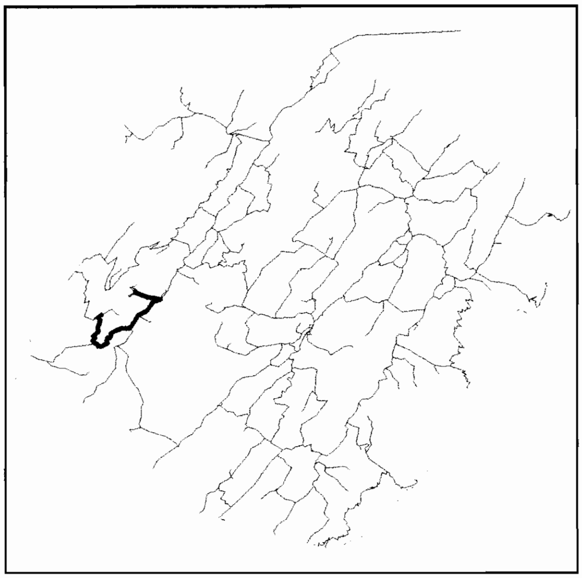
| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2120 | 1 | 2 | 2 | 0.57 |
| 1431 | 2 | 2 | 4 | 3.34 |
| 2361 | 3 | 1 | 5 | 4.46 |
| 2122 | 4 | 1 | 6 | 5.58 |
| 2121 | 5 | 2 | 8 | 6.70 |
| 2119 | 6 | 1 | 9 | 9.37 |
| 2118 | 7 | 3 | 12 | 10.49 |
| 2117 | 8 | 1 | 13 | 11.61 |
| 1204 | 9 | -13 | 0 | 16.16 |



| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2035 | 1 | 1 | 1 | 0.57 |
| 2034 | 2 | 1 | 2 | 3.54 |
| 2033 | 3 | 1 | 3 | 4.36 |
| 2032 | 4 | 3 | 6 | 6.48 |
| 2031 | 5 | 2 | 8 | 7.40 |
| 2030 | 6 | 1 | 9 | 8.52 |
| 2029 | 7 | 2 | 11 | 9.44 |
| 131 | 8 | -11 | 0 | 9.99 |



| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 1075 | 1 | 2 | 2 | 0.40 |
| 2149 | 2 | 1 | 3 | 1.50 |
| *904 | 3 | -3 | 0 | 13.57 |



| ROADCOV-ID | ORDER | TRANSFER | CUM_TRANS | CUM_IMP |
|---|---|---|---|---|
| 2132 | 1 | 1 | 1 | 0.40 |
| 1048 | 2 | 4 | 5 | 1.35 |
| 2133 | 3 | 4 | 9 | 3.30 |
| *904 | 4 | -9 | 0 | 9.65 |
| 2150 | 5 | 5 | 5 | 15.20 |
| 2151 | 6 | 1 | 6 | 19.70 |
| 2152 | 7 | 1 | 7 | 20.40 |
| *904 | 8 | -7 | 0 | 21.72 |

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# VITA

Dennis Mitchell was born on July 1, 1968. Dennis grew up in Pendleton County, West Virginia, approximately 10 miles south of the town of Franklin. He graduated from Franklin High with the distinct honor of being one of the few students in the history of the school system to attend twelve years of school without an absence. He then attended James Madison University in Harrisonburg, Virginia. He graduated Cum Laude in May 1990 with a B.S. in Geography and a minor in Geology. During his tenure at JMU he was awarded the distinguished Geography Service Award and was inducted in the Golden Key Honor Society and the Outstanding College Students of America Organization. Dennis then departed academia for a year to work for TRIAD Engineering as a technician. Graduate study began for Dennis in the Fall of 1991 at Virginia Tech. Graduation for him occurred in December 1995 with an M.S. in Geography.