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ALTERNATIVE ROAD NETWORKS  
FOR A SOUTH DAKOTA TOWNSHIP

by

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## ALTERNATIVE ROAD NETWORKS FOR A SOUTH DAKOTA TOWNSHIP

### Introduction

The network of roads within any defined region is necessarily connected to the network of each adjacent region. Therefore, sections of road which might be added to, or deleted from, the existing network can result in changes in consumers' travel and routing and their use of the remaining network. This can result in significant changes in the costs and benefits of the network for consumers and major changes in the cost of supplying the road network services.

The study of the adequacy of a rural road network is therefore necessarily a study of a complex, interdependent system. Consideration of the adequacy of a network of rural roads requires an initial definition of the concept of adequacy. To economists, the definition must incorporate the wishes of consumers for the services made available by alternative road systems and those consumers' willingness and ability to pay. These make up the demand side of the economist's model. The supply side of the model must consider the costs of providing the alternative road system's services.

To consider some methods of studying the adequacy of such a rural road network, an initial analysis was carried out using the rural road network in a single township. A township was selected which contained no commercial centers and no major state or federal highways. The township's road network layout was a one square mile grid pattern. The township choice was made to minimize the number

of factors which would complicate the study when examining the impacts of alternative road system changes on users and providers.

With no major through roads or commercial centers in the township, the road network was used primarily by residents. The residents could be identified and surveyed concerning their use of, and opinions about, the network. Most nonresident traffic such as farm supply, school bus, and postal service road users which served residents could also be included in the study. Some nonresident road users, such as seasonal hunters, could not be identified and surveyed.

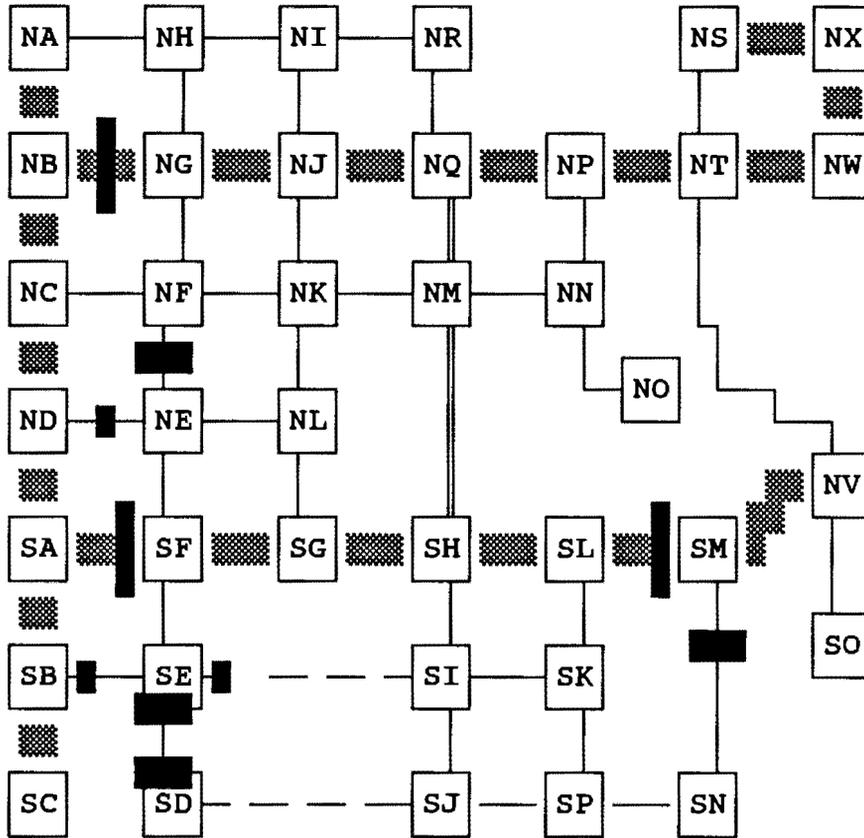
In South Dakota, county or township government is required to provide at least one access road for each farm in the township. A lightly used mile of road serving a farm cannot be eliminated from the network unless an alternative access road is available. While the number of farms has decreased over the long term, the actual choice of farms abandoned has been the outcome of a random process of retirement, bankruptcy, merger, and sale. Therefore, this legal constraint makes it difficult for township or county government to undertake long term planning for the restructuring of the rural road network. Any road system restructuring will either be a passive response to the privately made choices about farm location and abandonment, or an active use of governmental efforts to influence these location decisions. In either case, any restructuring will be the result of a lengthy evolution rather than a well planned design to meet foreseeable needs.

### Current Road Network

As shown in the Current Conditions figure below, the current road system in the selected township consists of thirty-five miles of township gravel surfaced roads, three miles of county gravel highway, and twenty miles of county oil surfaced highway. The county gravel highway runs north and south in the center of the township connecting the two east-west oil highways. The three mile section of county gravel highway does not provide access to any farms and is not on any school bus or postal service route. Twenty miles of the township gravel roads also provide no farm access.

The southwest sections of the township contain streams as indicated by the number of bridges. The unimproved sections of road in this area also reflect roads which have been allowed to deteriorate due to light traffic use and higher maintenance cost caused by water. These roads provide no farm access and are not on school bus or postal service routes. These sections of road are bladed annually to fill potholes and retain some usefulness but they are neither graveled nor kept open in winter.

Township Current Road Network



**KEY:**

- NA — township gravel road with intersection identification letters
- — bridge
- — county oil highway
- — county gravel highway
- — township unimproved road

### Current Conditions Road Costs

Cost data for maintenance of the current road network were obtained from county and township records for 1988. The costs are summarized by road surface type in the Current Conditions Cost table below. Representing only a single year, these data require some simplifying assumptions before they can be considered to represent the supply of road services in the network.

First, 1988 costs are assumed to be representative of the annual maintenance costs incurred each year. Thus, these costs are treated as fixed costs like the annualized rental cost of investment in long lived assets. Since road maintenance work can be accelerated or deferred, this assumption may be unrealistic but county and township officials report that 1988 was a typical year for road work in the township.

A second assumption is that the cost for each type of road surface is spread evenly over the number of miles of the corresponding type of road. This may be relatively accurate for such expenses as grading, sealing, and plowing. It is certainly inaccurate for expenses which involve any reconstruction of sections of road or where bridge maintenance or repair is involved. County and township officials state that no significant bridge work was done in 1988. This suggests that the costs were roughly evenly spread over miles of road but understates true annual costs and fails to recognize actual differences in costs for different sections of roads.

Third, it is assumed that the cost per mile for each type of road surface is constant regardless of the number of miles of the given surface type. Thus, for each type, the average cost per mile is assumed to be the same as the marginal cost of adding or abandoning a mile of road. While the maintenance costs are treated as the annual flow of fixed costs, they are also regarded as costs which vary as the size of the road network is changed.

Current Conditions Costs

Type of Cost	Cost	# of Miles	Cost Per Mile
Township gravel	18,000.00	35	514.29
County gravel	1,190.45	3	396.83
County oil hwy	10,053.54	20	502.68

Current Road Use

Survey forms were sent to the thirty-one township resident households. Nineteen usable completed surveys, sixty-one percent, were returned. Information requested included frequency and routing of trips, network travel habits, vehicle types used, service traffic received, and opinions concerning the quality and cost of service provided by the existing network.

Few respondents indicated any difficulty using the road system with personal vehicles. One noted some difficulty driving on the unimproved roads and one mentioned that passing was difficult on

some parts of the county oil roads. Some indicated that they believed snow removal was slower than desirable.

Some problems were noted for the travel of agricultural vehicles due to weight and width limitations. One felt that the roads were too narrow for large trucks with semi-trailers and cattle loaders. One noted that weight limits on many bridges did not allow newer farm equipment to cross.

Eighty-five percent of the respondents rated the road system to be good or excellent and fourteen percent rated it fair. No respondent gave a poor rating to the network. These ratings reflect the regular maintenance and application of new gravel. Generally, respondents recognized the limited funds available and believed that they were receiving good service for the cost involved.

Vehicle types reported by respondents included automobiles; pickup, two-ton, and semitrailer trucks; farm tractors; and combines. Data on the number and routing of trips by school buses and postal service automobiles were also obtained. School and postal service trips were estimated to be 1,800 per year while personal, farm, and supply trips were estimated at 15,111 annually.

Travel Costs

Costs per mile of operating the various types of vehicles on paved and gravel surfaced roads were estimated. Costs included annual vehicle depreciation, insurance, fuel, maintenance, and operator travel time. Cost data were obtained from local vehicle dealers, insurance agents, and parts and fuel suppliers. The differential cost between paved and gravel surface vehicle operation was calculated using a surface adjustment ratio developed by Baumel.

The table below includes the estimated vehicle costs per mile for each type of vehicle.

Estimated Vehicle Cost Per Mile

Vehicle Type	Paved Surface	Gravel Surface
Automobile	\$ .417	\$ .580
Pick-up Truck	.432	.600
2-Ton Truck	.700	1.022
Semi-Trailer	1.059	1.546
Tractor	.886	1.010
Combine	3.162	3.541
School Bus	.961	1.403

The following table shows the estimated total annual travel cost for private and public vehicles on the township's road system. Total costs result from applying the cost per vehicle mile to the

number of miles traveled. Mileage traveled is determined from survey responses describing frequency and routing of trips.

Current Travel Costs

<u>Vehicle Cost</u>	<u># of Trips</u>	<u>Total Cost</u>	<u>Cost Per Trip</u>
School & Postal	1,800	13,840	7.69
Private	15,111	35,457	2.35

Alternative Networks

Using the demand and cost information described above, four alternatives to the current road network were considered. The alternatives were networks based upon the current set of roads. Each alternative was evaluated after a subset of the current system's roads and bridges was eliminated and the resulting change in costs estimated. All of the alternatives retain the county oil highways because of the higher traffic levels on these roads. Also, all roads providing the only access to an established farmstead were retained in each alternative to meet the local governments' legal obligation.

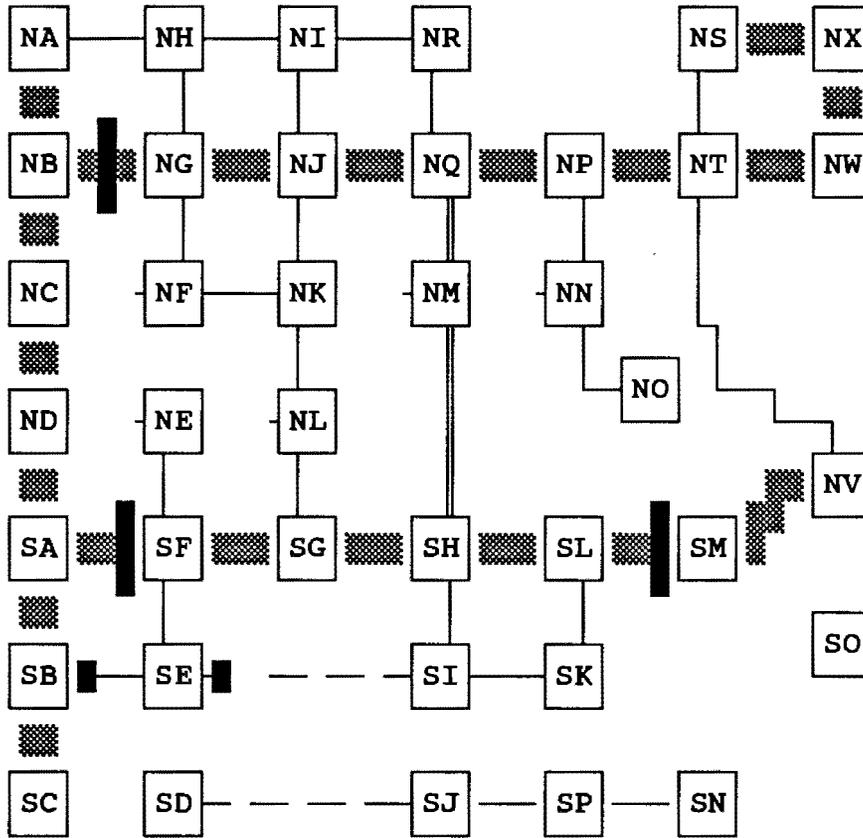
In each alternative network, traffic identified in the survey data is rerouted as necessary when a road or bridge is removed from the network. The rerouting criterion chose the shortest remaining distance between the identified origin and destination. After traffic was rerouted, travel cost was estimated. It was assumed that the additional cost was not sufficient to reduce the number of trips or change the destination of trips. While rerouting of

travel increases the traffic level on remaining roads in a given alternative network, traffic levels remain low enough so that no additional costs are incurred due to congestion, delay, or more intensive road maintenance.

Alternative One: The first alternative network retained the oil highways and farm access roads. It also assumed that current school bus and postal service routes would not be altered and all roads on these routes were also retained. This resulted in eleven miles of township gravel roads being removed from the current network.

Township annual road maintenance costs were reduced by \$5,700. School bus and postal service travel costs were unchanged and private travel costs increased \$4,000. Total annual costs were reduced by \$1,700. This may understate the annual cost reduction, however, because the eleven roads removed from the network included five bridges which have higher long run maintenance and replacement costs.

First Alternative Network



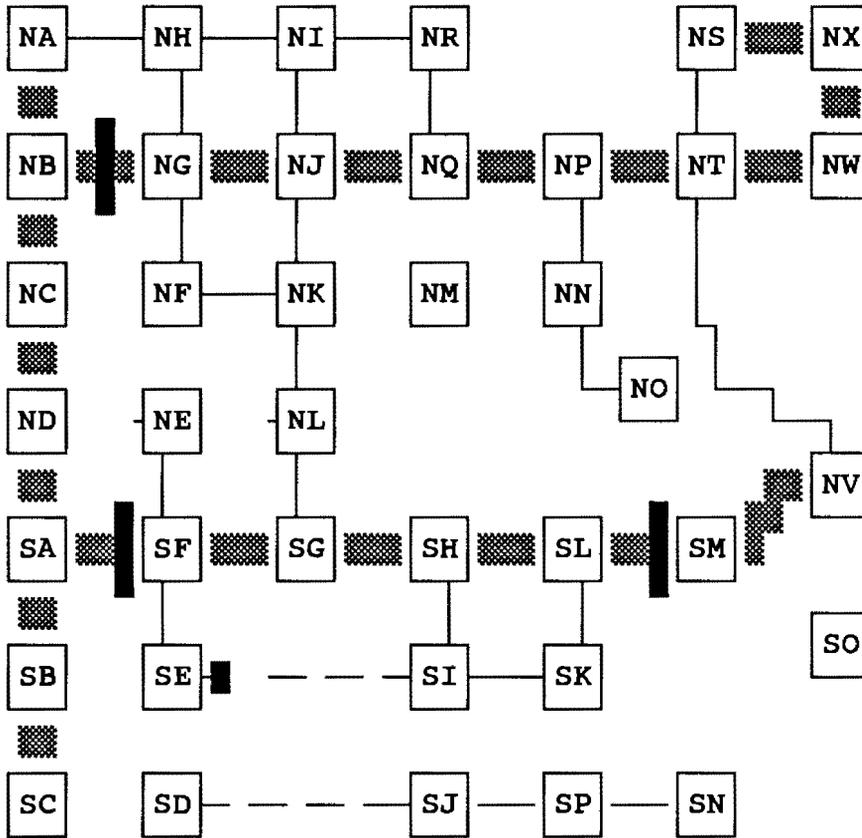
**KEY:**

- **NA** — township gravel road with intersection identification letters
- **■** — bridge
- ▒ county oil highway
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Alternative Two: The second alternative network removed the three miles of county gravel road which provided no farm access and one mile of township gravel road with a bridge in addition to the eleven miles eliminated in Alternative One.

This alternative reduced total annual road maintenance costs by \$7,400 from the current network costs. Rerouting of traffic caused school bus and postal service travel costs to increase by \$400 and private travel costs to increase \$9,600. Total costs increased by \$2,600 over the current road network costs. The three additional roads removed from the network contained one more bridge. Therefore, this network has six fewer bridges than the current network, and the long run annual cost saving is probably greater than the one year estimate generated by the model.

Second Alternative Network



**KEY:**

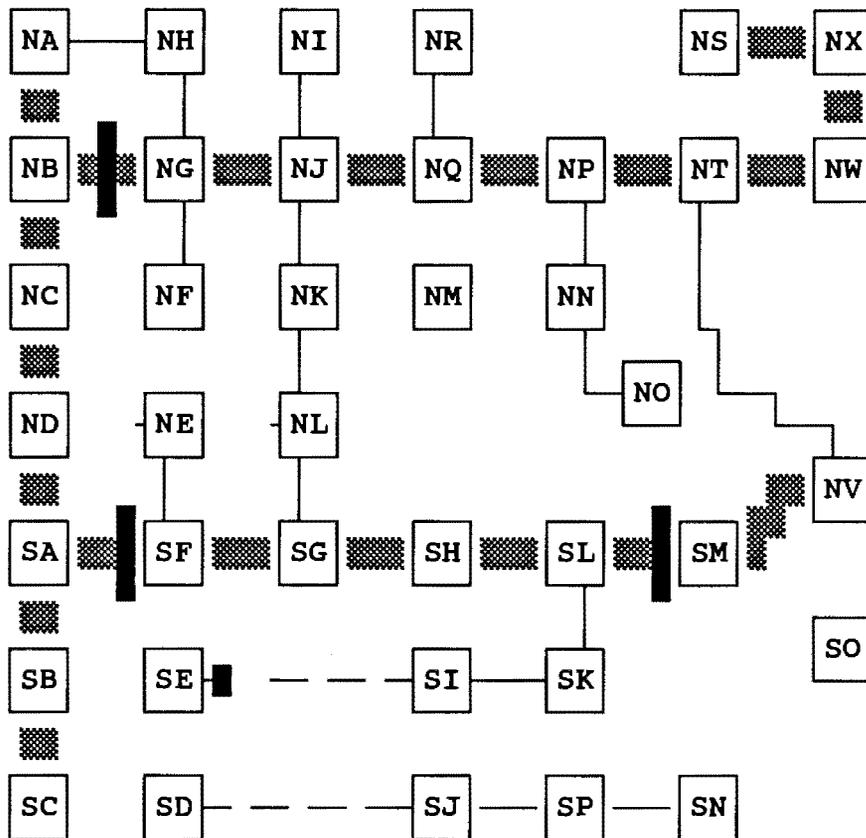
- NA — township gravel road with intersection identification letters
- — bridge
- county oil highway
- county gravel highway
- — township unimproved road

Alternative Three: The third alternative considered a network with no roads which do not currently provide access to farmsteads. This network eliminated six miles of township gravel roads in addition to those roads eliminated in Alternative Two. This network retained the twenty miles of county oil highway and only sixteen miles of township gravel roads. As shown below, this is a severely reduced network which imposed significant rerouting of travel and consequent increases in travel costs.

Annual road maintenance costs were \$11,000 less than the current network costs. School bus and postal service travel costs increased \$1,500 and private travel costs increased \$12,100 due to rerouting of traffic. Combined costs increased \$2,600.

The first three alternative networks removed roads from the current network based on criteria of legally required roads and school bus and postal service routes. These criteria do not seem to lead to a network with annual costs significantly lower than the current network. For the given travel reported by township residents, costs of rerouting their travel when roads were removed from the network tended to quickly offset any saving in public road maintenance costs.

Third Alternative Network



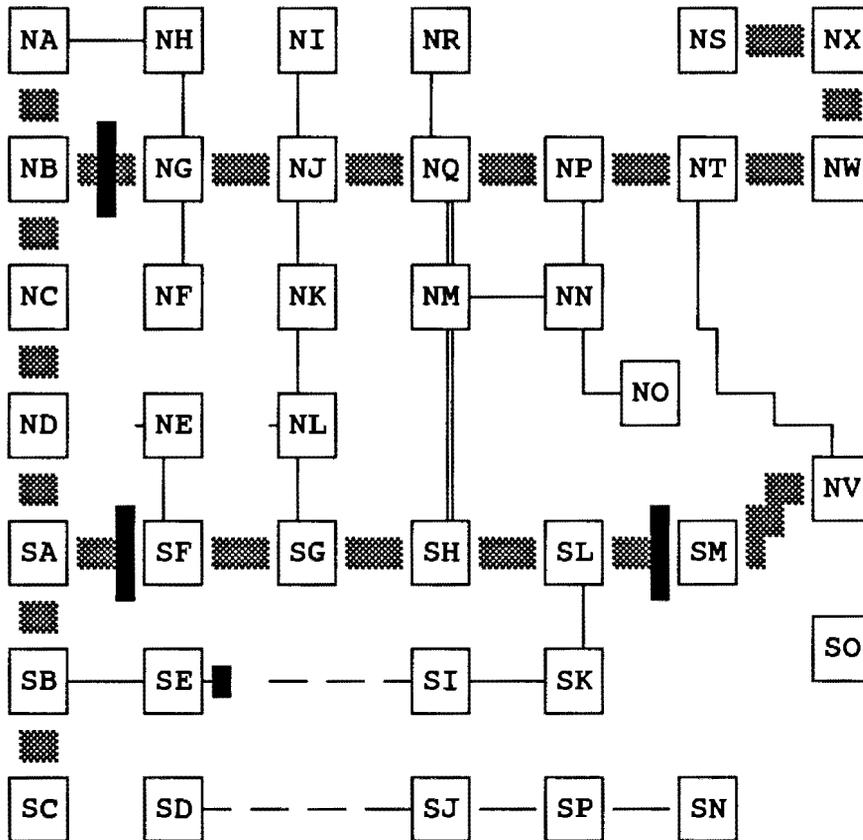
KEY:

- township gravel road with intersection identification letters
- bridge
- county oil highway
- county gravel highway
- township unimproved road

Alternative Four: The fourth alternative network considered retained all roads providing access to farmsteads. Other roads were removed from the network if the annual cost of rerouting that road's traffic was less than \$500. Since the cost of rerouting a road's traffic increases with the amount of traffic and the additional distance traveled, this criterion retained roads which currently carried more traffic or provided a significantly shorter route to a common destination even if the road did not include a farm access. This network removed fifteen miles of township gravel road from the current network.

Annual road maintenance costs were reduced by \$7,700. School bus and postal service routes and costs were unchanged and private travel costs were increased due to rerouting by \$2,600. Consequently, total annual costs were reduced by \$5,100. Therefore, retaining the most important road segments while eliminating fifteen miles of relatively lightly used road provided more significant cost saving than the other alternatives. This network had five fewer bridges than the current network so the long run annual saving may be greater than estimated.

Fourth Alternative Network



KEY:

- NA — township gravel road with intersection identification letters
- — bridge
- county oil highway
- county gravel highway
- — township unimproved road

Summary

The following table summarizes the cost change offered by each of the alternative networks relative to the cost of the current network. Numbers in parentheses represent decreases in costs relative to the current road system costs.

Change in Road Maintenance and Travel Costs

<u>Road Type</u>	<u>First Alternative</u>	<u>Second Alternative</u>	<u>Third Alternative</u>	<u>Fourth Alternative</u>
Township Gravel	(\$5,700)	(\$6,200)	(\$9,800)	(\$7,700)
County Gravel		(1,200)	(1,200)	
County Oil Hwy.				
-----				
<u>Travel Type</u>				
School/Postal		400	1,500	
Private Vehicle	4,000	9,600	12,100	2,600
-----				
Net Change	(\$1,700)	\$2,600	\$2,600	(\$5,100)
-----				

Alternatives Two and Three result in twenty-one and twenty-five percent increases in private travel costs. It is probable that such large increases would cause residents to both reduce the number of trips made and to change the destination of some trips due to the significant additional miles required by rerouting trips to current destinations. Alternative Four retains most of the savings in road maintenance costs achieved by the most drastic

Alternative, Three, but results in much smaller increases in travel costs. This is achieved by retaining the most used and shortest route roads using the \$500 annual rerouting cost criterion. The \$500 cost was an arbitrarily chosen figure to see how the network model would respond. Further study might examine the willingness of residents to trade higher private travel costs for reduced road maintenance tax costs. That is, how much are residents willing to pay for the convenience of a shorter route to their destination?

Alternative Four reduces township road costs by forty-three percent with only a seven percent increase in private travel costs. This alternative appears to improve upon the current network but not by a large amount measured in dollars. An interpretation might be that the local government units have been responsive to residents' road demands and that the current road system is close to optimal given those desires and the costs of providing road service.

This report is on a study which chose a township with a simple road network. Since the township is necessarily part of the larger, more complex network of roads, the travel and road cost estimates fail to include any effect upon the traffic levels and routes in adjacent townships. The results of this study suggest, however, that the method may be useful to township road authorities in considering changes in their local rural road network. A followup study used an alternative method to examine the road network in a larger area of several townships and more complex traffic interchanges.

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