Improvement Priority Ratings for Local Rural Roads in Indiana

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Increased public interest in highway improvement programs has intensified the need for the development of rational procedures for the classification, evaluation, and priority ranking of highway sections. The successful development and application of such procedures would result in the following benefits: the assembly of relevant facts in an orderly manner; the elimination or minimizing of personal judgments in the assignment of priority of improvement; the provision of an objective basis for meeting community and political pressure; the provision of an average measure of the adequacy of the existing highway plant and an indication of the progress in highway development; and the protection of the public's investment in the highway system by providing a method for budgeting funds according to the relative order of need.

The Joint Highway Research Project of Purdue University has developed procedures for the classification and evaluation of rural county highway sections in Indiana. These procedures were field tested in a pilot study which was conducted in Allen County (Fort Wayne is the county seat) and were designed to satisfy the basic criteria of simplicity, practicality, flexibility, and economy.

The classification of the rural county highway sections into the three systems (county primary, county secondary, and local service) is based upon knowledge of traffic volumes and characteristics, abutting land use, and community interest under present and future conditions.

The study proposes a method of highway evaluation to establish an impartial priority value which portrays the relative needs of the various highway sections. Priority is based on the formula:

$$\text{Priority Rating} = 2.5\ (\text{Service Rating})^{1.25}\ \text{Log}\left(\frac{100}{\text{Road Rating}}\right)$$

where the priority rating has a practical range from 1 to 100 with a high value indicating a high priority. The service rating ranges from 1 to a maximum value of 50 and is composed of various elements which indicate the need for and use made of a highway section. The road rating ranges from 1 to a maximum value of 100 and is composed of various elements which indicate the physical condition of the highway section. It is believed that this priority rating formula is one of the first, if not the first, rational procedures to be based on the inter-relationship between the need for the highway and the physical condition of that highway. This mathematical relationship was recommended for use in Indiana Counties and it has the following properties which were deemed desirable:

1. Roads which provide a minimum service should have a priority rating which approaches a minimum value regardless of condition.
2. Roads which are ranked near the maximum as to condition (i. e., high road rating)

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should have a priority rating which also approaches a minimum value regardless of the service provided by that road.

3. For a constant service rating, the rate of change of the priority rating should decrease as the road rating increases.

4. For a constant road rating, the rate of change of the priority rating should increase as the service rating increases.

In addition to recognizing the desirability of incorporating cost values in the application of highway evaluation, the study also includes a discussion of some of the highway rating procedures now being used by the various states and counties and compares these procedures with the proposed priority rating method.

RURAL HIGHWAY CLASSIFICATION AND EVALUATION PROCEDURES FOR INDIANA COUNTIES

● THE 92 county highway departments of Indiana which are responsible for over 76 thousand miles of road, may well be described as "big business" enterprises as evidenced by the fact that as a group they received more than $26 million from the Motor Vehicle Highway Account in calendar year 1954. The allocations received by the individual counties in that year ranged from a low value of $62,043.23 (Ohio County) to a high value of $1,402,906.73 (Marion County). If the available funds per county in 1954 are divided by their respective county road mileages for the same period, the available funds per mile of county road varies from approximately $232 to $994 per mile, representing 64 cents (Spencer County) and $2.72 (Marion County) per mile per day, respectively. Ohio County, with the least mileage (180.00 miles) received about $345 per mile, while Allen County, with the greatest county road mileage in the state (1,512.20 miles), received approximately $480 per mile. The statewide average was $341.82 per mile or 94 cents per mile per day.

A brief glance at the above data quickly reveals that the available funds appear to be inadequate if each mile of county highway is to be developed and maintained in such a manner as to satisfy the desires of every taxpayer and motor vehicle operator. In fact, if each mile of county highway had more than a gravel or stone surface, road funds presently available to the counties probably would not be sufficient to properly maintain these surfaces. Thus it is imperative, as in any successful business operation, that the available funds be spent by competent administrators where the greatest benefit will result.

This paper describes the development of rational procedures for the classification and improvement priority evaluation of those rural roads in Indiana which are under county administration. Many of the procedures were developed and field-tested in a pilot study conducted at the request of the Board of Commissioners of Allen County, Indiana. In addition to their use in the pilot study, the completed procedures were evaluated by several national authorities. Certain procedures were also used in the Indiana State Highway Needs Study.

Need for Factual Data

It has often been said that the most important roads in the world to an individual are those roads that are used by that individual. However true this may be, one of the keystones of democratic government is that government funds must be expended in the best public interest. An adequate and unbiased evaluation of what constitutes the public interest has been of great concern to county road officials who must establish a proper balance between rapidly increasing traffic volumes and service requirements on certain highways and the increasing general demand for more and better expenditures on all roads.

The public interest is best served if county highway funds are expended under the direction of competent management. This is rather difficult to achieve in Indiana because there are no professional qualifications for highway supervisors and employment of personnel is often made solely on a political patronage basis. Haphazard budgeting and record-keeping procedures and frequent administration and personnel changes are common. In the 15-year period from 1939 through 1953 there were over 400 county highway supervisors

employed by the 92 counties ranging from 1 in Morgan, Newton, Union, and Wayne Counties to 11 in Martin County. These practices have resulted in a lack of interest on the part of competent engineers and a shortage of an adequately trained work-force.

Furthermore, frequent changes and poorly qualified county highway administrators have often contributed to the absence of programming and long-range planning which are basic elements essential to the development of an efficient county highway system. While certain roads may be developed during one year, entirely unrelated projects are often initiated in the next year with little or no concern for the completion of projects initiated in the previous year. After several years of such chaotic programming, a county may find itself with a non-integrated system of several pavement types in various stages of construction and repair, ranging from sections of narrow, thinly-surfaced gravel roads used by several hundred vehicles a day, to a wide, high-type pavement nearby serving less than 50 vehicles a day.

Most of this inefficient use of highway funds cannot be attributed directly to malfeasance on the part of county officials, but rather to their failure to provide competent engineering management in their county highway departments. It is also recognized that these county officials could improve conditions by insisting upon accurate and pertinent engineering information. All too often the criterion in establishing road projects has been upon the basis of who can shout the loudest or who can bring in the greatest number of petitions requesting the expenditure of highway funds. An undesirable policy such as this should be replaced by recognized engineering and administrative practices similar to those which were recently presented in the form of questions during a discussion of county road administration.

1. Are the roads of the county classified? This is to say, are they divided into groups according to importance or purpose, whatever these groups may be called, so that a basis is established for priority of improvement, standards to be achieved, and method of finance?
2. Is the county road system inventoried? That is to say, does the county know exactly what road system it has, and something about its condition, and is this information kept up to date?
3. Does the county have a plan and a program, are they being continually revised, and is there sufficient record keeping to permit planning and programming with realism?
4. Does the county pay salaries and follow policies which enable it to attract and keep qualified personnel?
5. Are there definite procedures of budgeting, purchasing, and accounting, carried on in accordance with modern practices?
6. Is there a definite set of standards to which various types of road facilities will be constructed? (*1*)

The procedures developed during this study are designed to enable a county using them to give an affirmative answer to several of these questions, especially 1, 2, 3, and 6.

Benefits Derived from Rational Procedures

Rational procedures for classifying and evaluating the current and potential use and the present physical condition of county highways should provide county officials with an administrative tool which serves the following purposes:

1. Relevant facts are assembled in an orderly manner to aid in the establishment of priorities for the construction and reconstruction of highway sections which are unable, according to certain prescribed standards, to safely and economically serve the demands of traffic, abutting property, and the public interest.

2. Personal judgment is minimized or eliminated in the assignment of priorities.

3. An objective basis is provided for meeting community and political pressures in highway planning and construction.

4. Administrators, councilmen, and legislators are provided with an average measure of the adequacy of the existing county highway system and an evaluation of the progress made in the overall highway program. This progress, indicated by increased or decreased highway adequacy through periodic evaluations, provides a means of measuring the adequacy of road funds.

5. The public's investment in the highway system is protected because funds are budgeted according to the relative order of need.

Basic Procedure Criteria

Before procedures for the classification and evaluation of rural county highways can be adopted, they must satisfy certain basic criteria of simplicity, practicality, flexibility, and

economy, all in the proper balance. Involved calculations must be avoided, but an oversimplification of procedures will result in faulty conclusions arrived at as a result of inadequate data. Design standards and mileages of classifications requiring higher type highways must be practical, for if set too high, their attainment will be made prohibitive, but, when standards and mileages are minimized, the only result becomes a definite loss in efficiency and safety. Flexibility in procedures is desirable to enable a wide application without a loss of validity and reliability due to too much latitude. Because economy should ever be the highway administrator's watch-word, these criteria should be balanced with economy of operation. Perhaps it would be better to state that these criteria should be tempered with economy because the most economical procedures may be far from being the best and most reliable methods.

Typical Methods in Use

About half of the state highway departments and the Bureau of Public Roads now use some form of rational method for improvement priority establishment. Many of these methods are similar to, or modifications of, the sufficiency rating procedures which were developed and first used in Arizona in the fall of 1946 (*2*). An excellent discussion of the Arizona Sufficiency Rating method, and the other then existing state highway rating procedures is included in Highway Research Board Bulletin No. 53 (*3*).

Most state highway improvement priority methods were originally applied to the rural state highway primary system. Recent developments have resulted in procedures which are not only adaptable to the various highway systems but also are usable for either rural or urban conditions.

A limited number of counties throughout the United States have developed and published methods for the classification and evaluation of county highways. There is a wide range in the techniques and considerable variation in the contributing factors or elements which are utilized (*4–29*).

Probably the most extensive program to obtain county highway facts is now in progress in California where the Division of Highways and the Bureau of Public Roads assist the counties in conducting inventory programs (*4, 10*). These inventories form the basis for various evaluation procedures.

One of these evaluation procedures, that of Kings County, was described in a paper presented at the 1955 meeting of the Highway Research Board as follows:

> The adequacy rating of a road section should represent, in some measurable form, its actual sufficiency for traffic requirements, the safety of travel, and the service rendered to the public. Numerical point ratings, therefore, become readily adaptable to this purpose, for we can express in percentages the degree of meeting the design requirements.
>
> The basic components rated in the Kings County study were geometric design (par 40), physical design (par 25), safety (par 15), and service (par 20), which were further separated into their elements. Ratings were assigned by uniform and rational methods.
>
> What has been accomplished is a comparison between existing conditions and the design standard which was previously assigned on the basis of average daily traffic for each road section. The theoretical ratings ranged from 0 for a wholly inadequate road to 100 for a perfect section. The adequacy ratings are relative and can be compared directly with those of any other road section, because evaluations were made on the basis of the specific requirements of each road unit.
>
> Bridges, likewise, were compared to their respective design standards and point ratings assigned on the basis of width (par 30), condition (par 20), and structural adequacy (par 50). The lower the adequacy rating, the more deficient the road or structure and the more urgent the programming of reconstruction.
>
> In order to understand fully the proper sequence of road-improvement programming, it is necessary to consider the basic economic factors which influence priorities. Comparison of annual maintenance cost (m) with the annual cost for reconstruction of the road (c) evolved our economic ratio ($e = m/c$). The higher this ratio the higher the priority. Highway-user revenues were then distributed to the road sections on an annual vehicle mile basis, resulting in the revenue index (r). Next, the ratio between earning capacity or revenue index (r) with annual construction cost (c) established the feasibility factor ($f = r/c$). The higher this factor, the more feasible to construct than maintain and the higher the priority.
>
> Ostensibly, the most-deficient road with the highest economic justification should be Number 1 in the improvement program. Therefore, the economic ratio (e) multiplied by the feasibility factor (f) divided by the adequacy rating (a) expressed as a decimal fraction, evolved the theoretical priority number ($p = ef/a$). Priority numbers ranged from 0 for a perfect highway to 13.0 for the highest-priority road sec-

tion. Selection of projects from those roads with greatest justification was made and projected to a 5-year plan, whereby estimated user's funds would be expended in the most-efficient manner. Programming, year by year, will involve adjustments in the order of priority, so that the best interests of the county will be served (*6*).

A rating method has been developed for the county trunk highways in Wisconsin (*23*). This method, which was intended for state-wide application on the county primary highways, was not as inclusive as that reported for Kings County, California. Consideration was given to 10 factors including structural adequacy items of surface condition (par-25), pavement width (par-14), roadway width (par-10), bridges (par-8), ditches (par-6), and anticipated life (par-10); and service and safety items of rideability (par-5), alignment (par-10), restricted vision (par-10), and railroad crossings (par-2).

Washtenaw County, Michigan, has reported a method to establish a priority rating for county highways. The county road system was divided into four groups based on the average daily traffic 0–100, 101–500, 501–1000, and 1001–4000 vehicles per day. Design standards were developed for each of these groups and the existing conditions, as found from a field inventory, were compared with these design standards. The range of the rating scale was from zero to 100 with the value increasing with improved conditions (*22*).

The three principal components and their [assigned] numerical values were:

1. Condition—35 points.
2. Safety—30 points.
3. Service—35 points.

These were further subdivided, defined and weighted into smaller elements to assist in making the field inventory as uniform as possible.

The rating of the condition of a road section was determined by its structural adequacy and an estimate of its remaining life. Structural adequacy was broken down into pavement condition and sub-base and drainage, with pavement assigned a value of 10 percent of the 35 percent, and sub-base and drainage 12 percent. Remaining life of the pavement was assigned a numerical value of 13 percent. To determine the rating for safety, shoulder width was given a value of 8 percent of the 30 percent total, pavement-lane width 7 percent, stopping-sight distance 10 percent and consistency of profile and alignment 5 percent. The service of a road section was determined by assigning alignment a value of 12 percent of the 35 percent total, passing opportunity 8 percent, rideability 10 percent, and pavement width 5 percent.

The sum of the element ratings was called the "basic rating." Two adjustments were made in the basic rating to give weight to traffic volumes and the lack of paved surfacing.

These three county highway rating programs are examples of those currently being used and were briefly discussed to show the variation that may be found among these techniques. Such variation is a natural development because of the many different conditions which exist in counties throughout the nation. A different, but interesting, approach is being tried by the Second Division, North Carolina State Highway Department to determine the priority in which secondary roads are to be surfaced (there are no county highways as such in North Carolina because all roads are maintained by the state).

The selection of which road to improve first is based on the actual service it renders its community.

Each unpaved road in a county is evaluated by specific standards and then placed in its order for improvement. A copy of the priority schedule for improvement is kept in the division office and in the office of the district engineers. The County Commissioners of each county receive a copy also so that they know which unpaved roads are scheduled for improvement, why, and their priority.

The system works like this: Each unpaved road in a county is numbered. Its length and daily traffic count are recorded. Then the road is rated on the following basis: ten points for each school; seven points for each active store, garage, filling station or combination; three points for each cotton gin, corn mill or small plant; three for each school bus passing in one day; three points for an RFD mail route; three points for daily pick-up milk route; three for each industrial bus passing in one day; one point for each two vehicles; and one point for each four vehicles diverted. The one point given for each family dwelling is divided by the mileage.

Every unimproved county road in the Second Division is evaluated on this basis. The road with the most points received first priority and is scheduled first for improvement. The road evaluation system is far from perfect but to date it has worked well in informing not only the Highway Commission but also the County Commissioners as to which roads should be paved first. The priority system also has met with a favorable response from the newspapers and County Commissioners in this Division (*26*).

COUNTY HIGHWAY CLASSIFICATION

Most highway engineers and administrators will agree that it would not only be unnecessary but also completely undesirable to build and maintain all county highways as high-type pavements. Indiana counties have not, nor could they expect to possess, sufficient funds, equipment, materials, and manpower to undertake a highway program of such a magnitude. Consequently, it is necessary that the various highways be designated according to their respective importance. The importance of a given highway will vary among different individuals as their dependence on that highway varies, so it is essential that any designation or classification of county highways be made in the public interest.

Before county highways can be classified into various systems it is necessary to determine how many different systems are practical and necessary. A careful consideration of Indiana governmental, financial, and physical conditions has led to the conclusion that three systems of county highways would be most desirable. The degree to which a highway fulfilled the primary purpose of county highways —which is to serve local traffic, abutting property, and the community—was used for classifying the rural road as a county primary highway, a county secondary highway, or as a local service highway. The ultimate objective of any classification system is to provide a coordinated arrangement of state, county primary, county secondary, and local service highways which will adequately provide for the present and foreseeable future needs of the county.

Traffic volume and character of use should play a major part in the classification of county highways because nearly all Indiana county highway revenues are derived from highway user imposts. On the other hand, the effect of abutting property cannot be completely ignored because of the direct relationship between land use and traffic generation. Community interest is indicated by the service provided by the highway. This service may be measured by a study of the areas or locations which are linked together by the road. Service routes or special use made of the highway may also warrant consideration.

Only a minimum number of miles of county highways should be placed in the county primary and county secondary systems. This is essential because with limited funds, the mileage of routes requiring higher design standards must also be limited. The number of primary or secondary highways in the fringe areas around large cities should also be minimized because of the possibility of future city expansion.

Future growth and development must also be evaluated in order to provide a coordinated highway plant which will provide for future as well as current requirements.

Basic Traffic Information Is Essential

Before a county highway can be classified or evaluated, it is essential that information is available concerning the volume and character of traffic using the road. In 1937, the Indiana State Highway Planning Survey published traffic volume maps showing the daily volume for all county roads in each county. Current maps may be developed by collecting appropriate data from properly selected field stations (manned for at least eight hours except for a few control stations which should be utilized for 24 hours or more) and applying proper expansion factors to provide pertinent information for all rural roads. The selection of these stations may be influenced by the county road mileage and the number of persons available to do the field counting. In the Allen County Study, for example, 125 eight-hour stations (9 a.m. to 1 p.m. and 2 p.m. to 6 p.m.) and five 24-hour stations were used.

A uniform and understandable system of rural road identification is necessary to facilitate the location of the traffic count stations both in the field and during the analysis of the data. A road identification system which utilizes the intersection of township boundaries near the center of the county as the origin of a coordinate system, is most desirable because other useful information, such as census and taxation data, is also tabulated on a township basis (*30*).

Traffic Count Personnel

The 8-hour manual count, or for some other selected period, may be made by volunteers from local organizations such as the Farm Bureau, civic groups, high schools, etc. A responsible person, called the township captain, is placed in charge of each township. This person aids in the instruction of those who are to serve as manual counters and supervises

them during the count period. Transportation is provided to permit him to visit each counter several times during the count period. All completed count forms are collected by the township captain who in turn transmits them to the survey headquarters.

The volunteer counters are assigned to townships other than the one in which they reside. Some persons may object because they will construe this as a questioning of their honesty. Therefore it must be emphasized that the assignments to other townships are being made so that they may become familiar with "the other fellow's" problems.

County officials will find that a volunteer traffic count program can serve as an excellent public relations approach to promote better understanding of local highway problems. Much of this information may be presented during the instruction period for the township captains and in later instruction periods for the manual counters. The completed traffic map (see Figure 1) is based on the data collected during the count period, and should provide an excellent source of public information. For example, it is of interest to observe the changes in traffic volumes on Allen County rural roads as indicated in Table 1. Of special importance is the fact that 400 or more vehicles per day were carried by 4.2 percent and 12.2 percent of the rural county highway mileage in 1937 and 1954, respectively. Almost 13 percent of the rural roads still carry less than 25 vehicles per day.

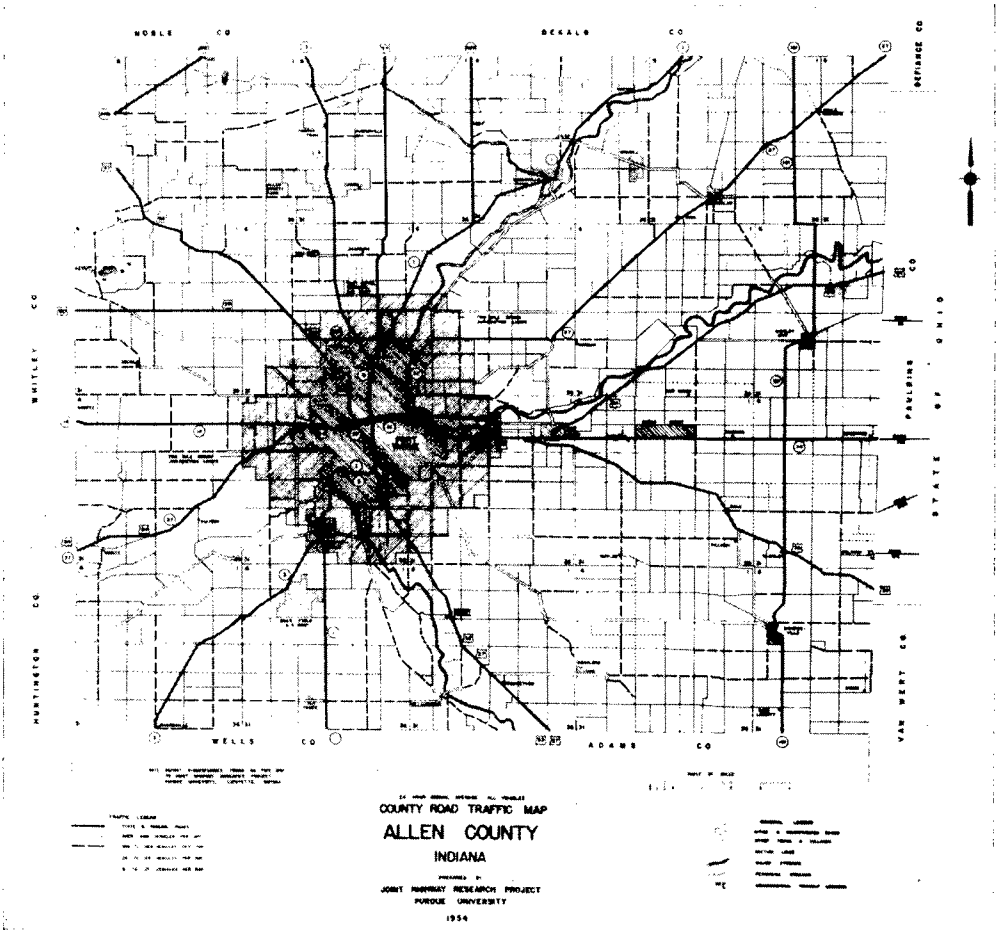

Figure 1. County road traffic map, Allen County, Indiana.

Average daily traffic volumes are generally used to provide limits for design standards. One common practice for local roads is to provide reasonably high standards for average volumes in excess of 400 vehicles per day, intermediate standards for average volumes between 100 and 400 vehicles per day, and lower standards for average volumes less than 100 vehicles per day. These limits have been used in the Illinois, Mississippi, and Ohio highway needs studies and were recommended for use by Indiana counties.

TABLE 1
RURAL ALLEN COUNTY ROAD MILEAGE CARRYING VARIOUS DAILY TRAFFIC VOLUMES IN 1937 AND 1954

Average Daily Traffic Volume (Vehicles per day)	1937 Rural Mileage	1937 Percentage	1954 Rural Mileage	1954 Percentage
0–25	237.83	19.7	156.20	12.8
26–99	629.13	52.2	596.03	48.7
100–399	288.78	23.9	321.93	26.3
400–999	46.60	3.9	113.23	9.2
Over 1000	3.40	0.3	37.80	3.0
Total.....	1,205.74	100.0	1,224.21	100.0

Determination of Abutting Land Use

The necessity for any county highway is directly related to the manner in which the land adjacent to the highway is used. Thus, roads passing through highly productive farmland may have high seasonal, but low annual traffic volumes, while roads through relatively poor farmland, which has been subject to suburban residential development, may serve high daily volumes of traffic. Cultural institutions such as schools are handicapped if the highways serving them are impassable much of the time. Roadside parks and other recreational facilities may be used by highly concentrated traffic volumes only during favorable weather conditions, thereby causing greatly fluctuating traffic volumes on their access roads.

Information concerning the frequency and type of roadside development is obtained in the field and compared with existing records. The field study usually may be made concurrent with the road inventory.

Determination of Community Interest

Community interest may be indicated by the area or locations connected by the highway. A road may serve as a vital connecting link between a small community and a large city or a major traffic artery. Another road may carry high volumes of traffic between two state routes or connect an important or productive area with a distribution center or access highway. This information may be obtained from a study of local land use maps, population maps, and a knowledge of local conditions.

The importance of the various types of service routes such as school or commercial bus, rural mail, milk collection, or heavy trucking routes using the highway varies in each county. In Allen County, for example, so much of the rural mileage carried school bus, milk, and rural mail routes that these service routes were of little value in differentiating between highways for classification purposes. Local school, commercial bus, mail, trucking, and other officials should be consulted for service route information.

The County Primary System

Certain highways, because of their location in the county and method of construction, may have average daily traffic volumes ranging from about 400 vehicles a day to several thousand vehicles a day. These roads may serve to connect a large city with a smaller rural community, or they may serve as a vital connecting link between two state highways or to connect highly productive areas with the highway. Such highways are the type to be considered for inclusion in the county primary system.

The County Secondary System

Roads which carry traffic volumes ranging from 100 to 400 vehicles a day generally belong in the county secondary system. The service provided by the roads, such as connecting less important communities with each other and/or with higher classification roads or highways, should also be considered.

The Local Service System

All remaining low traffic volume rural roads, which, as the designation implies, carry low daily volumes of less than 100 vehicles per day and which primarily serve only the local area, are classed as local service roads. These roads, in general, do not directly serve as

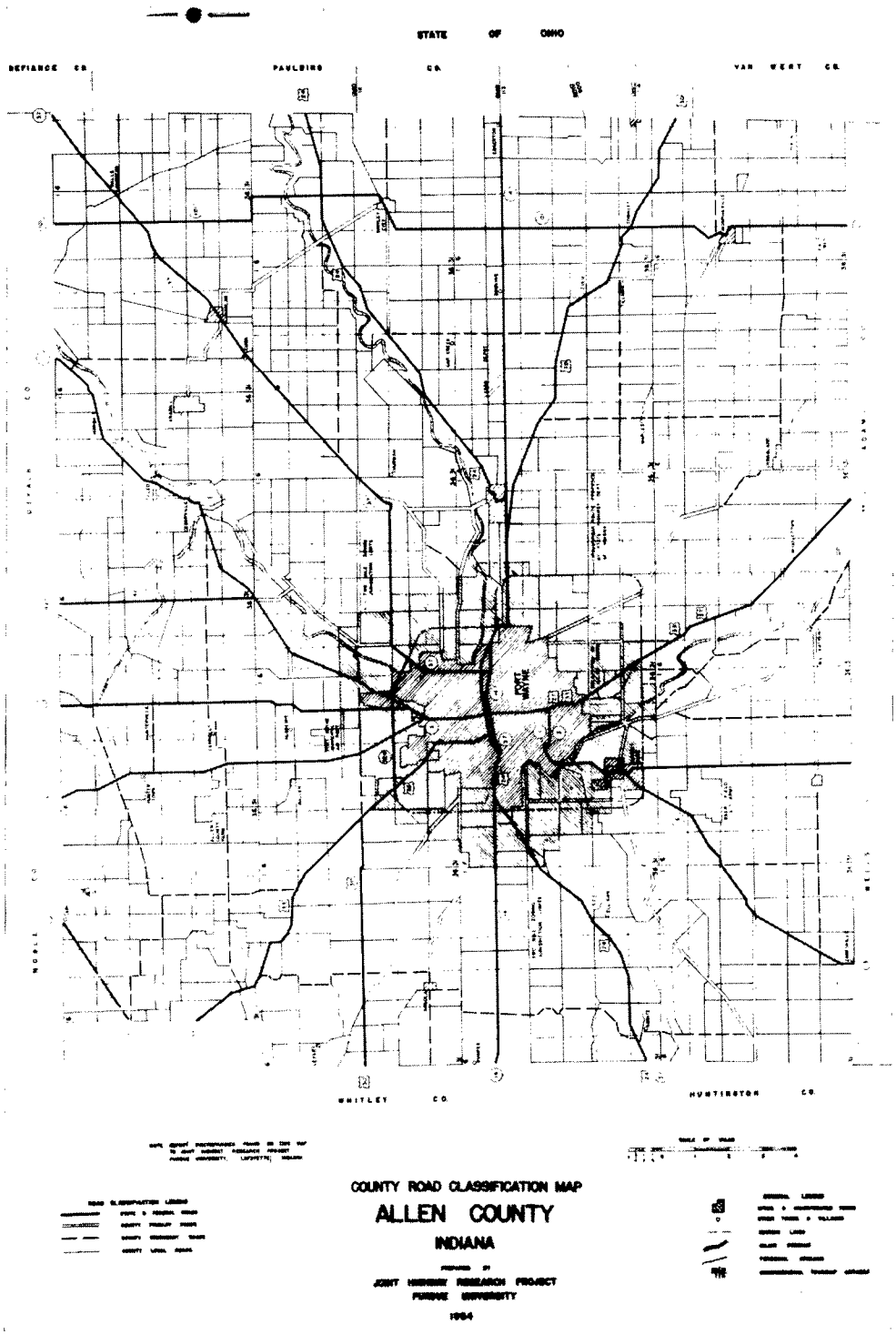

Figure 2. County road classification map, Allen County, Indiana.

many people nor as much of the county and consequently may have a lower design standard.

Highway Classification in Allen County

It may be observed in Figure 2 that a combination of state highways, county primary roads, and county secondary roads has resulted in two access or belt lines fairly near and farther away from Fort Wayne. Various system roads connect these belt lines with the remainder of the county. The rural highway mileage in Allen County was assigned to the following classification systems:

Classification System	Mileage	Percentage
County primary	149.7	12.2
County secondary	137.8	11.3
Local service	936.7	76.5
Total rural county highway	1,224.2	100.0

Although approximately three out of every four rural road miles in Allen County were placed in the lowest classification, it may also be observed in Figure 2 that no location is more than about 2½ miles from either a state, county primary, or county secondary highway.

THE HIGHWAY INVENTORY

An accepted and valuable business practice is that of conducting periodic inventories in order to determine the current status of the business. The county highway administrator, like his commercial counter-part, should have a vital interest in knowing the present status of his business—the county road system. Most citizens have definite opinions concerning what is wrong with the county roads and how these faults are to be corrected. Consequently, when county road administrators are forced to allocate funds on the basis of opinions rather than facts, they can usually expect varied amounts of criticism from disappointed petitioners.

Generally, records describing the existing physical conditions of the county road system are inadequate and often inaccurate. It is therefore essential that the initial inventory be as complete and precise as possible. All pertinent information—such as highway number or name; right-of-way, shoulder, and roadway widths; roadside culture; type and condition of the pavement and surface; topography; horizontal alignment; passing sight distance; stopping sight distance; safe driving speed; and gradient—should be recorded for each tenth of a mile. This record will not only provide county road administrators with a factual record of essential road information, but the location and extent of critical conditions are readily evident. It is imperative, therefore, that the county highways be properly identified through an accepted rural road identification system.

Inventory Procedures

One or more three-man "logging" crews are used to obtain the factual data such as widths, types, etc. One "rating" party may then complete the information, such as condition and adequacy comments, for all the highways. The number of logging parties depends on the available manpower and time, but should be kept to a minimum in order that comparable information may be obtained. Only one rating party should be used to insure the relative evaluation of all highways.

Four forms were developed for use by the inventory parties. These forms, County Highway General Information and Data Sheet, Rural County Highway Inventory Data Sheet, County Highway Bridge Inventory Data Sheet, and County Highway Railroad Protection Data Sheet are shown in Figures 3 to 6. Although the Allen County Pilot study was concerned with only rural highways, a fifth form, Urban County Highway Inventory Data Sheet was also developed for use in urban areas and is shown in Figure 7.

Inventory Items

The highway design and use elements which should be inventoried and considered in establishing priority are many and their importance varies among individuals. In order to obtain a sampling of local opinion concerning these features, a questionnaire was mailed to the 12 state officers of the Indiana Association of County Commissioners and the County Highway Supervisors Association.

The questionnaire included a listing of the basic elements of highway use which contribute to the need for having county highways and the various elements of highway design which contribute to the ability of the road to serve the community. The officials were asked to add or delete elements to the list and to rank the elements "in the order of importance

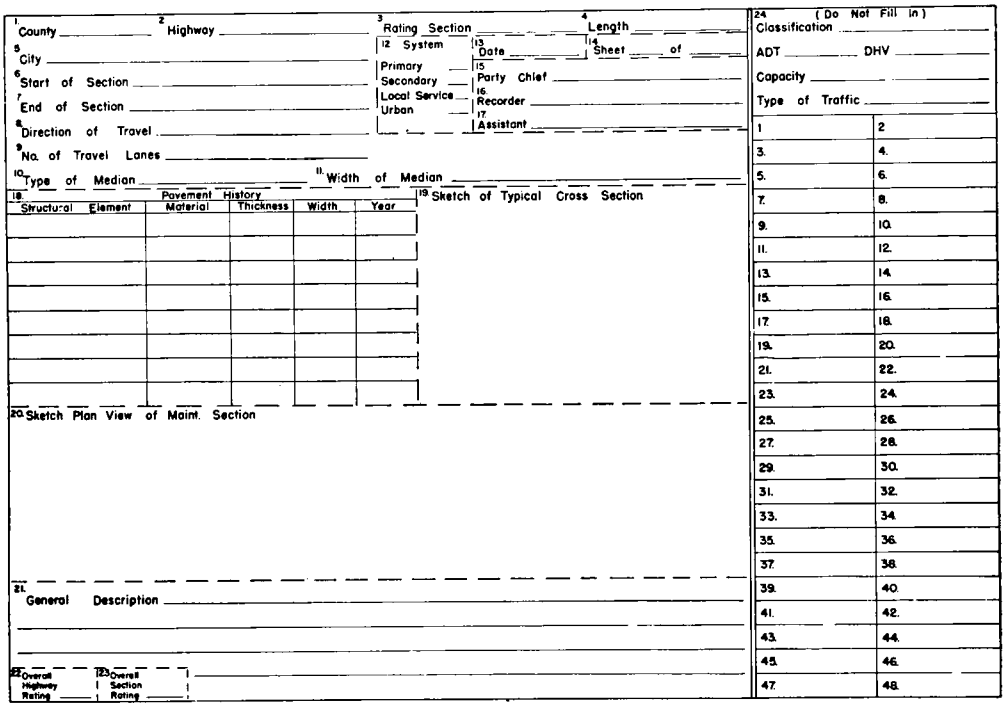

Figure 3. County highway general information and data sheet.

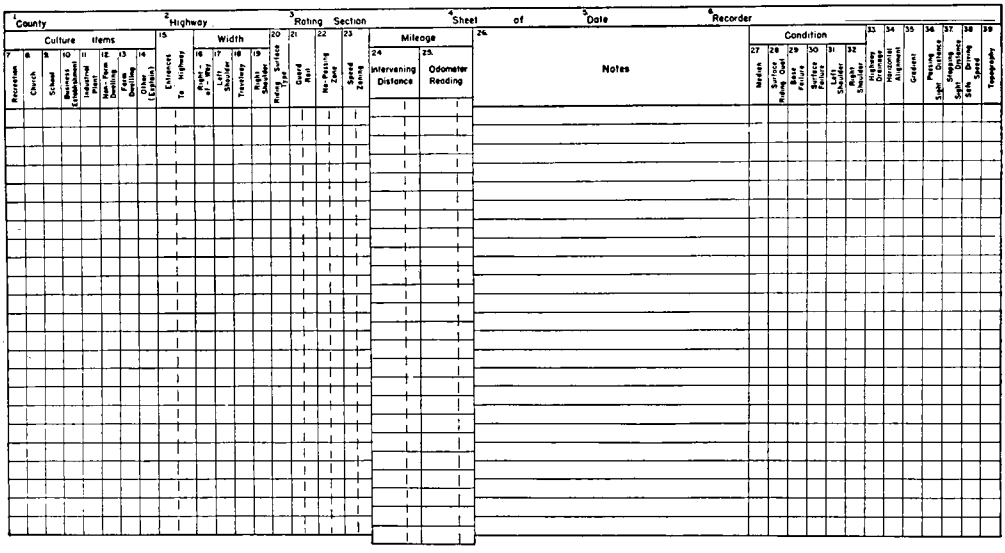

Figure 4. Rural county highway inventory data sheet.

1. Highway _____ 2. Rating Section _____ 3. Sheet _____ of _____ 4. Date _____ 5. Recorder _____

6. Location	7. Odometer Reading	8. Structure Number	9. Contract Number	10. Overall Length	Width		Spans		Superstructure				19. Railing Type	20. Sidewalks	Floor	
					11. Curb to Curb	12. Rail to Rail	13. Number	14. Length	15. Type	16. Material	17. Vertical Clearance	18. Condition			21. Type	22. Condition

6. Location	7. Odometer Reading	Superstructure		Approaches		Clearance		29. Age	30. Estimated Safe Load (Tons)	31. Signing	32. Service	33. ADT	34. Percent Trucks	35. Notes
		23. Type	24. Condition	25. Type	26. Condition	27. Above Bed or Stream or Highway	28. Above High Water							

Figure 5. County highway bridge inventory data sheet.

1. Highway _____ 2. Rating Section _____ 3. Sheet _____ of _____ 4. Date _____ 5. Recorder _____

6. Location	7. Odometer Reading	8. No. of Trains Per Day	No. of Tracks		11. Approx. Speed of		Protection		15. Angle of Crossing	16. Sight Distance 300 FT. from Track		17. Obstructions To Visibility		18. Condition Of Approaches		19. Condition of Crossing	20. Feasibility of Grade Separation
			9. Main	10. Other	Passenger Trains	12. Freight Trains	13. Type	14. Amount		Far	Near	Far	Near	Far	Near		

6. Location	7. Odometer Reading	21. ADV	22. Notes

Figure 6. County highway railroad protection data sheet.

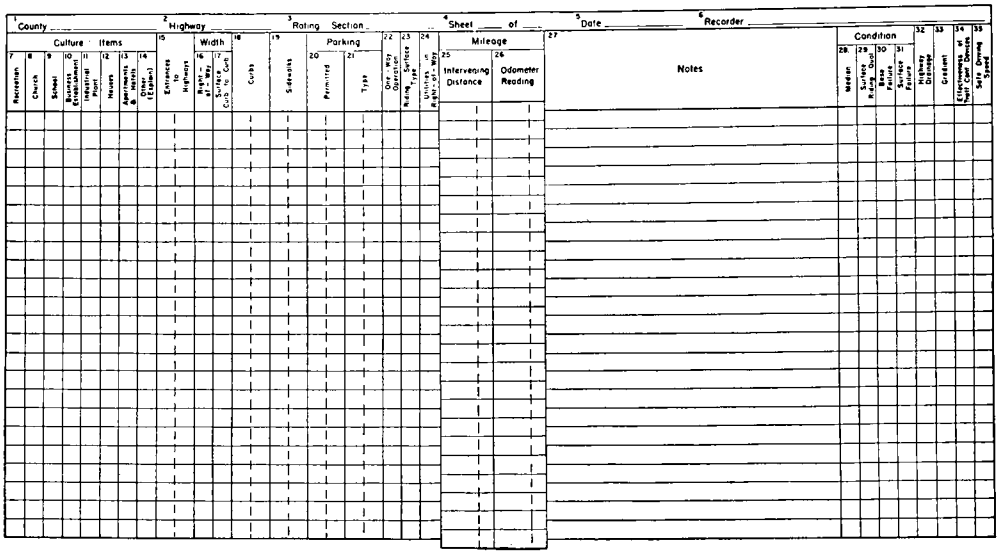

Figure 7. Urban county highway inventory data sheet.

that you feel they influence your decision where highway funds should be expended."

The returns from this survey and the items included in other similar studies were used in selecting the elements to be included in the inventory.

COUNTY HIGHWAY EVALUATIONS

Records showing the use, roadside development, and physical condition of the various county highway sections are of little value unless methods are available for determining how well each section can serve the various demands placed on it. These methods must provide a means for comparing existing conditions with standards which have been established to measure the relative need for and condition of the section.

Design Standards for County Highways

The county highways of Indiana are an accumulation of many years of construction, reconstruction, and maintenance. Some roads originated as Indian trails while others were developed as the need became apparent. Over the years the numbers of vehicles, the types of vehicles and their operating characteristics—speeds, sizes, and weights—have also changed to fulfill the requirements of the road user. These developments have contributed to the need for changes in the methods of road construction and maintenance.

Although an adequate inventory record can provide the highway administrators with facts about the county road network, there still may be considerable question as to what conditions are necessary to provide reasonably satisfactory service. Thus, the administrators are faced with the need for a set of scales with which to measure the ability of a section of highway to provide satisfactory service.

Through cooperative action of many agencies and organizations, nationally accepted design standards have been established for all types of rural roads. These standards were studied and in some cases modified so that they represent values which, if followed, would result in economy, usefulness, and longevity in highway improvements. The design standards recommended for the three county highway classifications are shown in Table 2.

Some county officials may hesitate to approve the adoption of standards such as these because they may appear to be too high. It may be remembered, however, that much of the present congestion on county roads may be attributed to similar arguments of years ago, with the end result that funds were expended on the basis of design standards which

TABLE 2
DESIGN POLICIES FOR RURAL COUNTY ROADS IN INDIANA THE JOINT HIGHWAY RESEARCH PROJECT PURDUE UNIVERSITY—1954

Road classification	Local service		County secondary		County primary	
Hourly traffic volume (vehic./30th highest hr.)	1–15		16–62		63–159	
Average daily traffic volume (veh./day)	1–99		100–399		400–999	
	Minimum	Desirable	Minimum	Desirable	Minimum	Desirable
Design speed (miles/hour)						
Level	35	50	40	60	50	65
Rolling	30	45	35	50	45	55
Hilly	25	35	30	40	40	45
Pavement type	Min. 5″ crushed stone or gravel	Min. 8″ crushed stone or gravel	Min. 8″ crushed stone or gravel	Min. 12″ cr. st. or gr. (stabilized where over 200 VPD)	Pavement on stabilized base	Pavement on stabilized base
Minium width (feet)						
Rt. of way	40	60	50	80	60	100
Shoulder	4	5	5	6	6	8
Surface	16	18	18	20	22	24
Min. sight distance (ft.)						
Stopping						
Level	240	350	275	475	350	540
Rolling	200	315	240	350	315	415
Hilly	165	240	200	275	275	315
Passing						
Level	700	1400	900	2100	1400	2500
Rolling	500	1150	700	1400	1150	1750
Hilly	300	700	500	900	900	1150
Degree and radius of sharpest curve (ft.)						
Level	18° (318)	9° (637)	14° (409)	6° (955)	9° (637)	5° (1146)
Rolling	25° (229)	11° (521)	18° (318)	9° (637)	11° (521)	7° (819)
Hilly	36° (159)	18° (318)	25° (229)	14° (409)	14° (409)	11° (521)
Maximum gradient (percent)						
Level	10	7	8	6	7	6
Rolling	10	8	10	7	8	7
Hilly	12	10	10	8	8	8
Struct.						
Width (feet)	18	22	20	24	24	28
Loading	10 T	15 T	10 T	15 T	15 T	20 T

the county officials "thought" they could afford. Consequently, the cost of providing an adequate highway is now much greater. The multiple costs of delay and lack of safety which result each year while insufficient standards are utilized must also be considered.

These design standards were developed with the help of many persons in the state. Each item was carefully evaluated in respect to conditions and experience in Allen and other counties.

Rural Highway Evaluation Elements

The first step in establishing highway evaluation procedures is to determine which elements are to be included and the relative weights to be assigned to the various elements. Such a selection should be based on engineering judgment and knowledge of existing conditions, materials, and practices. In some cases, decisions concerning certain elements and weights may appear to be rather arbitrary. However, if thorough use in the field has shown certain items to be faulty or impractical, these items may be modified to make them more applicable.

After considerable study of the elements used in other improvement priority methods and consultations with state and national authorities, it appeared that the most representative, realistic, and desirable approach to the procedures for rural county highway evaluation should include a measure of the use or service provided by the highway section under question and a measure of the physical condition of that section.

Service Ratings

As stated previously, the primary purpose of county highways is to serve local traffic, abutting property, and the community. Information concerning the volume and character of traffic is made available through the traffic count, and knowledge of the land use of abutting property can be obtained during the road inventory. Community service is indicated by the use of certain roads for rural mail routes, school or other scheduled bus routes, and other public services. With the daily traffic volume carrying the most weight, it seems obvious that the more of these three elements (volume and character of traffic, abutting land use, and community service) existing along a given section of highway, the more critical is the urgency for providing a satisfactory highway to serve this demand. The combination of the traffic, roadside culture, and service factors is called the "service rating" and can range from zero, which indicates no need, to 50. If two road sections have identical unsatisfactory design features, but one road carries a high daily traffic volume through a region of concentrated roadside development, while the other carries a relatively low traffic volume through undeveloped lands, there seems to be no doubt that the former should have priority. The relative weights allocated to the various elements should be based on judgment which may have to be rather arbitrary because of the lack of reliable information and study in this area.

Road Ratings

The ability of a highway section to satisfy service demands can be measured when the various elements of the three main factors of structural adequacy, geometric design, and safety are compared with design standards. The most important of these factors is structural adequacy. It includes such elements as pavement type, pavement condition, roadside drainage, structures, and railroad grade crossings. If these elements of structural adequacy are in critical condition, especially pavement condition and structures, the ability of that section of road to provide satisfactory service is definitely limited.

Geometric design elements include right-of-way, pavement, and shoulder widths; gradient; and alignment. The most important of these elements is pavement width, and consequently, it received a higher value in the rating process.

The safety factor includes such elements as surface riding condition, shoulder condition, safe driving speed, stopping sight distance, and passing sight distance.

The sum of the respective structural adequacy, geometric design, and safety factors is called the "road rating" and the weights assigned to the various factors are generally consistent with comparable practice in similar studies. The road rating may range from 1, which would indicate a complete lack of desirable conditions, to 100, which would indicate a "perfect" highway.

The field data are summarized on the form shown in Figure 8. This form was developed to provide an expedient means of computing the service rating and the road rating for each highway section. One or more of these forms are completed for each highway studied. The information in items 1 to 7 applies to the entire length of highway being reported on the sheet. Items 8 to 79 refer to rating sections of this highway. These sections are designated so as to make them as homogeneous and consistent as possible. A new rating section is started whenever there is a significant change in the traffic volume or character, in the pavement type, or in the number of traffic lanes. Lines 1*a* and 1*b* are used for the beginning section, lines 2*a* and 2*b* for the next consecutive section, and so on. All factual information, such as traffic volume and inventory data, are listed on the "*a*" lines and all rating values are listed on the "*b*" lines.

PRIORITY ESTABLISHMENT FOR HIGHWAY IMPROVEMENT

The service rating factor is a relative measure of the service furnished by a given section of highway while the road rating factor is a relative measure of the physical condition of that highway section. The relating of these two factors to each other to establish a numerical priority for improvement is a critical requirement. This priority value must be impartial and actually portray the relative needs of the various highway sections. Several ways of showing this relationship were investigated.

One way was to add the two factors. Such a sum, however, would be meaningless because increasing service ratings indicate an increasing

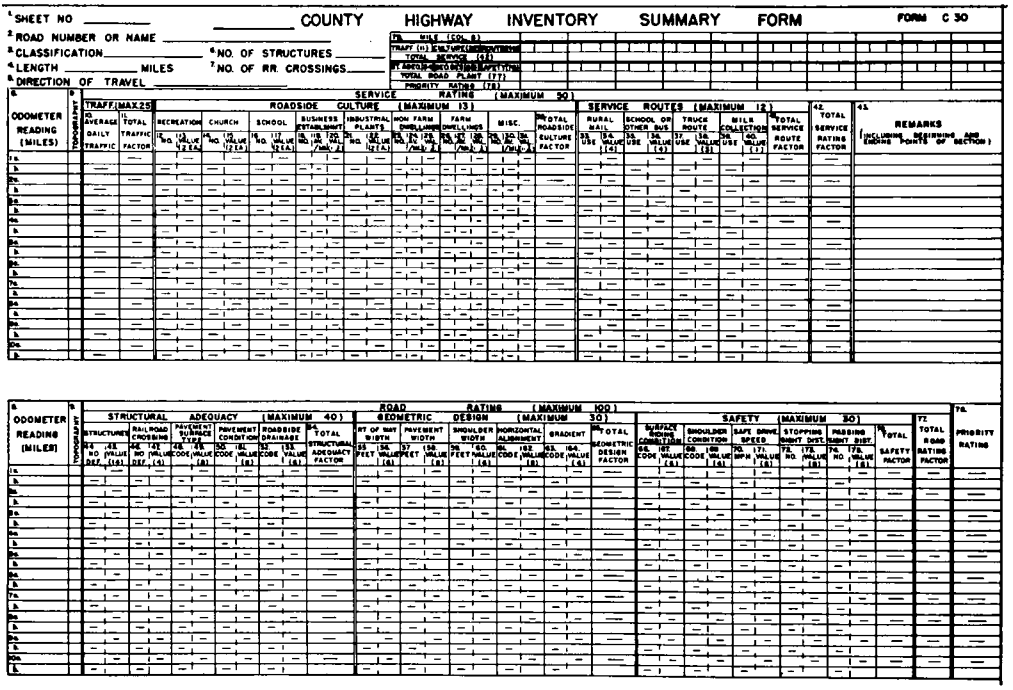

Figure 8. County highway inventory summary form.

need for attention while increasing road ratings indicate a decreasing need for attention. This is illustrated by actual values obtained for the three Allen County primary sections shown below:

Highway Section	Service Rating	Road Rating	Sum of Service and Road Ratings
A	21	71	92
B	32	60	92
C	38	54	92

Each highway section had an identical total of 92 and thus the same priority value. An examination of the respective service ratings and road ratings revealed that Section A had a low service rating and a high road rating which indicated a relatively little-used road in good condition. Section C, on the other hand, had a high service rating and a low road rating which indicated a relatively highly-used road in a more unsatisfactory condition. Section B had a service rating and a road rating which were about midway between these ratings for Sections A and C. The logical ranking of these three sections in the decreasing order of urgency of improvement would be C, B, and A.

Another possibility was to subtract the service rating from the road rating with priority being established in the order of increasing priority for decreasing differences. Application of this relationship to the same three highway sections is shown in the following tabulation:

Highway Section	Service Rating	Road Rating	Difference Between Road and Service Rating
A	21	71	50
B	32	60	28
C	38	54	16

The priority ranking of these sections was then in the desired sequence of C, B, A, if priority is established in the order of decreasing differences. However, suppose that the following hypothetical sections were also to be considered with Sections A, B, and C:

Highway Section	Service Rating	Road Rating	Difference Between Road and Service Rating
D	50	90	40
E	1	41	40

The priority ranking of the five sections was then in the order of C, B, equal ranking of D

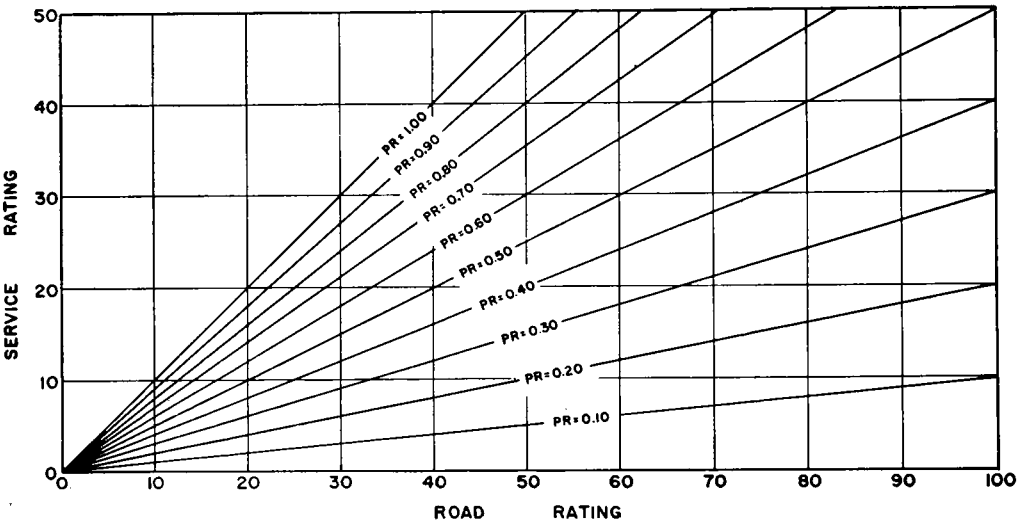

Figure 9. Priority ratio curves. Based on the formula: Priority Ratio = (Service Rating/Road Rating)

and E, and A. Section D did have the maximum service rating which would indicate an extremely important dependency on that section, but its road rating would indicate an almost perfectly constructed and maintained section. Therefore, it would seem reasonable to assume that the section could adequately fulfill its service requirements and consequently should have one of the lowest priority ratings. There is considerable doubt as to the advisability of retaining Section E in the county highway system because of its extremely low service rating even though its road rating indicated a relatively poor physical condition.

The next possible relationship investigated was a direct ratio of the service rating to the road rating. The curves of such a function are shown in Figure 9. A priority ranking of the five example sections by such a relationship resulted in a decreasing urgency sequence of C, D, B, A, and E as determined below:

Highway Section	Service Rating	Road Rating	Ratio of Service Rating to Road Rating
A	21	71	0.30
B	32	60	0.53
C	38	54	0.70
D	50	90	0.56
E	1	41	0.02

It may be observed that Section D had the second highest rank while it should have a low rank as previously described.

Desirable Mathematical Properties

Consideration of the individual properties of the respective service rating and road rating factors led to the establishment of the following general conditions as being desirable in a mathematical relationship to establish an impartial priority value based on the service rating and the road rating.

Let: $P.R. = f(S.R., R.R.)$ where $P.R.$ = Priority Rating; $S.R.$ = Service Rating; $R.R.$ = Road Rating.

$0 \leqq S.R. \leqq 50$, and $0 < R.R. \leqq 100$.

Condition 1. If $S.R. \to 0$, $P.R. \to 0$.

Roads which provide a minimum service should have a priority rating which approaches a minimum value regardless of condition.

Condition 2. If $R.R. \to 100$, $P.R. \to 0$.

Roads which are ranked near the maximum as to condition (i. e. high road rating) should have a priority rating which also approaches a minimum value regardless of the service provided by that road.

Condition 3. $(\partial P.R./\partial R.R.)$ should decrease as $P.R.$ increases.

For a constant service rating the rate of change of the priority rating should decrease as the road rating increases. Thus, $(\partial P.R./\partial R.R.)$ should be negative and increase numerically as $R.R. \to 100$.

Condition 4. $(\partial P.R./\partial S.R.)$ should increase as $S.R.$ increases.

For a constant road rating, the rate of change of the priority rating should increase as the service rating increases. ($\partial P.R./\partial S.R.$) must therefore be positive and increase numerically as $P.R. \rightarrow 100$.

Addition or substraction of the service rating and the road rating did not satisfy any of these conditions for all possible combinations of the two factors.

A direct ratio of the service rating to the road rating satisfied only the first and third desirable conditions, and had the following undesirable characteristics:

1. Road sections which have high road ratings, indicating a highway which has been constructed and maintained to very high design standards, may have a priority rating that is higher than roads which are in inadequate condition as indicated by lower road ratings.

2. For a constant road rating, the rate of change of the priority rating is constant as the service rating increases.

The Priority Rating

There are a large number of mathematical functions which satisfy the general conditions mentioned above. A number of these were investigated and the following function was selected for this investigation:

$$P.R. = K(S.R.)^p \text{ Log } \left(\frac{100}{R.R.}\right)$$

The two constants, K and p, are parameters whose choice will determine the range of values that $P.R.$ will have in the rectangle $0 \leqq S.R. \leqq 50$ and $0 \leqq R.R. \leqq 100$.

This function satisfies the four general conditions as shown below:

Condition 1. If $S.R. = 0$, $P.R. = K\ (0)^p$ Log $(100/R.R.)$ and $P.R.$ is clearly zero for $R.R. > 0$.

Condition 2. If $R.R. = 100$, $P.R. = K\ (S.R.)^p$ Log $(100/100) = K\ (S.R.)^p\ (0) = 0$ for any permissible value of $S.R.$

Condition 3. $(\partial P.R./\partial R.R.) = K\ (S.R.)^p\ (-1/R.R.)$ which is negative and numerically decreasing as $R.R. \rightarrow 100$, providing that K is positive.

Condition 4. $(\partial P.R./\partial S.R.) = Kp\ (S.R.)^{p-1}$ Log $(100/R.R.)$ which is positive, providing that both K and p are positive, and increases as $S.R. \rightarrow 50$, providing that $p > 1$.

The value of K and p may be determined by specifying two independent triples of values ($P.R._1$, $S.R._1$, and $R.R._1$) and ($P.R._2$, $S.R._2$, and $R.R._2$) which, when placed in the function, would yield two independent equations that can then be solved for the two constants K and p.

In determining the constants K and p, it was felt that the priority rating should be expressed in terms of values ranging from 1 to 100. An examination of the Allen County primary and secondary highway service ratings and road ratings shown in Figure 10 revealed that the curve, Priority Rating = 100, would be a practical maximum if it passed in the vicinity of Service Rating = 50 and Road Rating = 50. The practical minimum curve, Priority Rating = 1, should pass in the vicinity of Service Rating = 2 and Road Rating = 70.

The basic equation was rewritten in the form:

$$\text{Log } K + p \text{ Log (Service Rating)} = \text{Log (Priority Rating)} - \text{Log [2-Log (Road Rating)]}$$

Substitution of the limiting values in this equation resulted in two equations:

$$(1)\quad \text{Log } K + p \text{ Log } (50) = \text{Log } (100) - \text{Log [2-Log } (50)]$$

$$(2)\quad \text{Log } K + p \text{ Log } (2) = \text{Log } (1) - \text{Log [2-Log } (70)]$$

These simultaneous equations were solved for K and p. The constants thus obtained were then rounded off to the values $K = 2.5$ and $p = 1.25$. Substitution of these values in the basic equation resulted in a definite relationship to establish an impartial priority value.

The equation became:

$$\text{Priority Rating} = 2.5\ (\text{Service Rating})^{1.25} \text{ Log } \left(\frac{100}{\text{Road Rating}}\right)$$

The equation satisfied the four desirable conditions as indicated by the curves shown in Figure 10.

A different range of priority rating values, if desired, may easily be obtained by substitu-

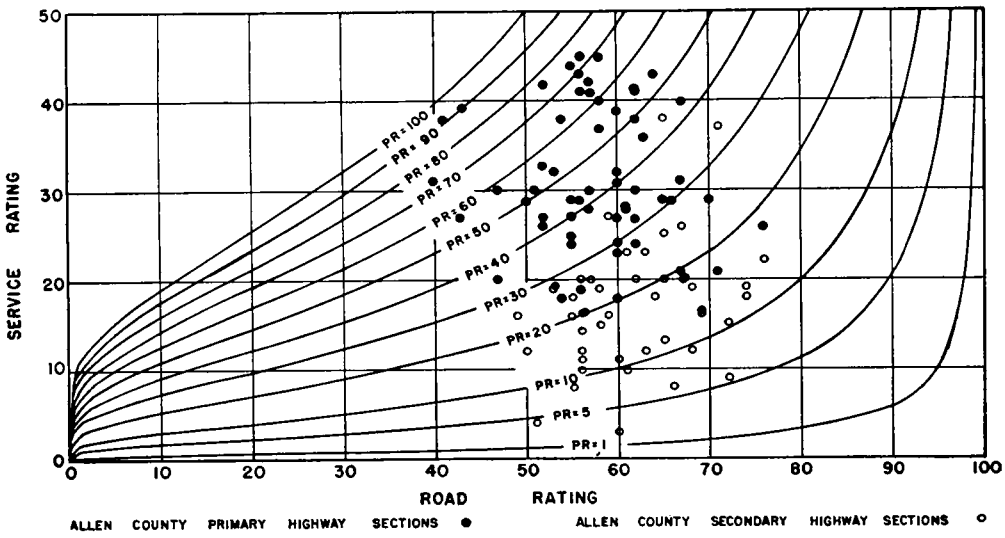

Figure 10. Priority rating curves. Based on the formula: Priority Rating = 2.5 (Service Rating)$^{1.25}$ Log (100/Road Rating).

tion of new limiting values in the basic equation and solving for new values of K and p.

An application of the priority rating formula to the highway sections previously used as examples is shown below:

Highway Section	Service Rating	Road Rating	Priority Rating
A	21	71	17
B	32	60	42
C	38	54	63
D	50	90	15
E	1	41	1

The road sections should then be improved in the order of C first; B second; A third; D fourth; and E last. An examination of their respective service rating and road rating values revealed that, other considerations being equal, these rankings appeared to be logical.

Comparison with Other Priority Procedures

The general sufficiency rating procedures which are used in several states and Kings County, California, establish the basic priority rating on the evaluation of various design features of the highway section. This basic rating is then adjusted to compensate for various traffic volumes (i. e., the basic ratings of roads with high volumes are reduced and the rating on a low volume road is increased). The adjusted rating is then used to rank the highway sections in order of need with the lowest number indicating the greatest urgency. Kings County further modifies the adjusted rating with certain financial factors as described previously. Washtenaw County, Michigan, adjusts its basic rating to give weight to traffic volumes and the lack of paved surface.

The method developed by the North Carolina State Highway Department to establish the priority in which secondary roads are to be surfaced is used only for this purpose. The ranking is established through a measurement of the traffic volume, roadside culture, and service routes found on or along the road. A similar approach has been used for unsurfaced roads in Harford County, Maryland (*15*, *16*).

It is believed that the priority rating formula as herein proposed is one of the first rational procedures, if not the first, to be based on the interrelationship between the need for the highway and the physical condition of that highway. The need is indicated by the service rating, which includes a consideration of traffic volumes, roadside culture, and service routes. The physical condition is indicated by the road rating, which is based on an evaluation of the physical features of the highway.

Comments on the Use of the Priority Rating

The priority rating has been developed to rank highway sections within a given highway

classification. In other words, county primary highways are not to be compared with county secondary or local service highways, or vice versa, because the road ratings are based on different design standards. County administrators should decide how funds are to be allocated between the various classification systems and then the priority rating should be used to establish the urgency of various highway sections within the classification system.

The ranking of the different highway sections should be considered as the important purpose of the priority rating function. Because all rankings of highway sections are relative, it does not matter if the various field evaluations are consistently high or low so long as they are consistent. More experience with the priority rating function is necessary before definite conclusions can be drawn concerning the actual numerical value of a section. Therefore, it should not be assumed that a highway section with a $P.R. = 80$ has twice the urgency of another highway section with a $P.R. = 40$.

The priority rating value is dependent on the service rating and road rating values that are placed in the formula. Thus, any changes either in the methods used to obtain the service rating and/or the road rating values, or due to changing field conditions may result in a different priority rating.

Although a highway section may receive one of the highest priority ratings within a particular classification, this does not necessarily mean that it should be reconstructed immediately to include a high-type pavement. After consideration of the economic facts, and if feasible, the highway should be improved to the highest design standards for that classification. It should not be improved to higher design standards unless there is a distinct possibility that the highway may be reclassified into a higher classification. For this reason, a local service highway which has a high priority rating would, at best, be improved to a minimum of eight inches of crushed stone or gravel because this is the highest, or desirable, design standard for pavement type under the local service classification.

Periodic re-evaluation of the various use and condition elements will enable the determination of new priority ratings and new ranks of the various highway sections. Such re-evaluation will also enable county officials to determine the progress of their highway improvement program provided adequate construction, maintenance, and fiscal records also are available. A summary of the different priority rating mileages (as shown in Figure 11) can be compared with previous summaries to determine whether the mileage of critical sections is increasing or decreasing, following concentrated attention and expenditures on these sections as indicated by the previous priority ratings.

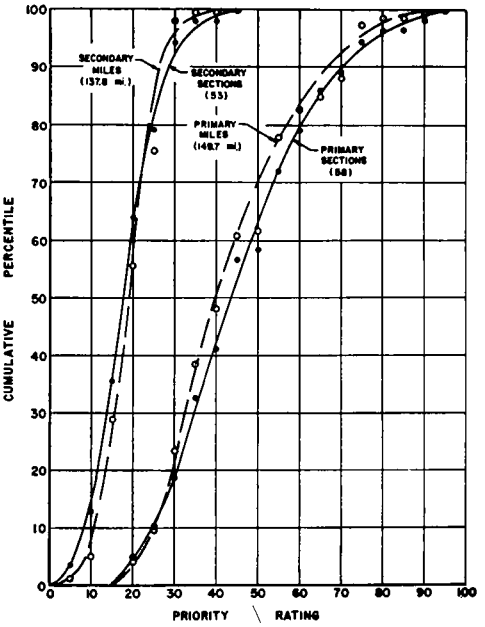

Figure 11. Priority rating accumulation curves for county primary and county secondary highway sections in Allen County, 1954.

Although a listing of the various highway sections in the descending numerical order of their respective priority rating should determine their placement on the priority schedule, attention should also be directed toward sections which have excessively low structural adequacy, geometric design, or safety factors. An analysis of local conditions should be made to determine excessively low values for these factors. A separate ranking tabulation of all structures is desirable.

Improvement and Reconstruction Costs

It is only natural that one of the first questions to arise in the mind of county highway administrators when they are discussing various highway improvement projects is, "What

TABLE 3
PRIORITY RATING SUMMARY

Table ________ Sheet No. ________

Priority Ratings for ______________ Highways in Numerical Order
(classification)

1. Ranking number	2. Priority rating	3. Highway number or name	4. Location	5. Length (miles)	6. Service rating	7. Road rating	Improved to minimum standards			New or reconstruction to desirable standards		
							8. Estimated total cost (dollars)	9. Service unit cost $\frac{\text{Col. 8}}{\text{Col. 6}}$ (dollars)	10. Cost per mile $\frac{\text{Col. 8}}{\text{Col. 5}}$ (dollars)	11. Estimated total cost (dollars)	12. Service unit cost $\frac{\text{Col. 11}}{\text{Col. 6}}$ (dollars)	13. Cost per mile $\frac{\text{Col. 11}}{\text{Col. 5}}$ (dollars)

TABLE _____ SHEET NO. _____

PRIORITY RATINGS FOR _____ (CLASSIFICATION) HIGHWAYS IN NUMERICAL ORDER

_____ COUNTY

1. RANKING NUMBER	2. PRIORITY RATING	3. HIGHWAY NUMBER OR NAME	4. LOCATION	5. LENGTH (MILES)	6. SERVICE RATING	7. ROAD RATING	IMPROVED TO MINIMUM STANDARDS			NEW OR RECONSTRUCTION TO DESIRABLE STANDARDS		
							8. ESTIMATED TOTAL COST (DOLLARS)	9. SERVICE UNIT COST COL. 8 COL. 6 (DOLLARS)	10. COST PER MILE COL. 8 COL. 5 (DOLLARS)	11. ESTIMATED TOTAL COST (DOLLARS)	12. SERVICE UNIT COST COL. 11 COL. 6 (DOLLARS)	13. COST PER MILE COL. 11 COL. 5 (DOLLARS)

Figure 12. Form for tabulating priority ratings in numerical order.

will it cost?" An immediate answer is available if the data for the highway sections are summarized as shown in Table 3. Two estimates of total cost are indicated in columns 8 and 11. The former column lists the estimated total cost if the highway section is to be improved to minimum design standards. Such an estimate may include the cost of improving surface and drainage conditions, pavement and shoulder widths, and structures, but may exclude the cost of changes in gradient or alignment because such changes may only be practical if the highway were completely reconstructed. The latter estimate, listed in column 11, includes the cost of completely improving or reconstructing all necessary features on the existing or on a new location.

Because the total improvement or reconstructuion cost of a project may be of such a magnitude as to discourage further consideration, the total cost is divided by the service rating to express the cost on a service unit basis. These unit costs are listed in columns 9 and 12.

Another means for comparing the costs of improving or reconstructing various highway sections is given in columns 10 and 13, where the average improvement or reconstruction costs per mile are tabulated.

County officials must evaluate these various cost estimates in the light of local conditions. It is neither desirable nor practical to improve only those sections having the lowest cost. Thus, expenditures allocated on a service cost basis may benefit the greatest number of persons per dollar spent. On the other hand, it may be desirable to improve as large a mileage as possible with a given expenditure. If this is the case, low cost-per-mile projects must be studied along with other factors.

CONCLUSIONS AND RECOMMENDATIONS

The increase in the need and demand for adequate county highways in Indiana has been greater than the availability of competent administrators and highway revenues. This condition has necessitated an advancement in the administrative methods and techniques for planning and programming of highway improvements. Two of these techniques, namely, procedures for the classification of highways and procedures for the evaluation or improvement priority rating of highways,

are the subjects of considerable interest at all levels of government, among certain professional societies, and among highway user organizations. The purpose of this study was to develop rational procedures for the classification and improvement priority rating of rural county highways in Indiana. Many of the procedures were developed and field-tested in a pilot study conducted at the request of the Commissioners of Allen County, Indiana. In addition to their use in the pilot study, the completed procedures were evaluated by several national authorities. These procedures should be used to facilitate effective engineering administration of county highway systems.

The development and application of classification and improvement priority rating procedures would result in the following benefits: the assembly of relevant facts in an orderly manner; the elimination or minimizing of personal judgment in the assignment of improvement priorities; the provision of an objective basis for meeting community and political pressure; the provision of an average measure of the adequacy of the existing highway plant and an indication of the progress of highway development; and the protection of the public's investment in the highway system by providing a method for budgeting funds according to the relative order of need.

Before procedures for the classification and evaluation of rural county highways can be accepted, they must satisfy certain basic criteria of simplicity, practicality, flexibility, and economy.

It is essential that information concerning traffic volumes and character, abutting land use, and community interest for both present and future conditions be available before a county highway system can be properly classified or evaluated.

The public interest may be best served if the various rural county highways in Indiana are classified into three systems. In order of importance they are the county primary system; the county secondary system; and, the lowest classification and the system with the greatest mileage, the local service system.

The highway inventory should be obtained for each tenth of a mile thereby providing an immediate indication of the location and extent of critical conditions. One or more field parties may be utilized to obtain the factual information but only one "rating" party should be used to evaluate the relative condition or adequacy features of all the highways.

The service rating is a relative summation of the information describing the need for or use made of a highway section, and the road rating is a relative summation of the information describing the physical condition of that highway section. A mathematical relationship between the service rating and the road rating may be used to establish an impartial priority value which must actually portray the relative needs of the various highway sections. Such a relationship should satisfy the following conditions:

1. Roads which provide a minimum service should have a priority rating which approaches a minimum value regardless of condition.

2. Roads which are rated near the maximum as to condition (i. e. high road rating) should have a priority rating which also approaches a minimum value regardless of the service provided by that road.

3. For a constant service rating the rate of change of the priority rating should decrease as the road rating increases.

4. For a constant road rating, the rate of change of the priority rating should increase as the service rating increases.

The derived formula

$$\text{Priority Rating} = 2.5\ (\text{Service Rating})^{1.25}\ \text{Log}\left(\frac{100}{\text{Road Rating}}\right)$$

satisfies the desirable conditions above and is recommended for use in Indiana Counties. The two constants, 2.5 and 1.25, are parameters which determine the range of the priority rating and were satisfactory for use in the Allen County study. These constants may be modified, if warranted, by conditions in other counties.

It is further recommended that any tabulation of highway sections in a numerical order of priority should include an estimate of the total cost if the section is to be brought up to minimum design standards and an estimate of the total cost if the section is to be reconstructed to desirable standards. These costs should also be presented as the average cost per service unit and the average cost per mile.

The data should be presented in such a man-

ner as to clearly indicate the location and extent of the various degrees of inadequacy. Only highway sections of the same classification are to be compared with each other.

Periodic re-evaluations should be made and will provide a measure of the adequacy of highway funds and the success or failure of the highway improvement program.

Some of the procedures proposed in this paper have been of necessity based on rather arbitrary judgment. It is, therefore, recommended that study be continued to further refine the existing procedures and to develop new techniques or modify existing techniques for use on county highways in urban as well as rural areas. Special study should be directed toward increased use of financial data in these procedures.

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