Indiana's Highway Needs Study

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In 1954 the Research Project was directed to make a study of the needs on the 98,000 miles of roads and streets in Indiana. Inventory, traffic, cost, and an array of other data were collected in 1954 and 1955. Most of the data collection was concentrated on the state highway system and collection of complete data for the county roads and city streets was not possible. Procedures for the gathering and analysis of data were developed by the Research Project and are explained.

The construction and costs required for the various systems are presented for a 15-year improvement program. Special attention is given to the physical and dollar needs of the interstate system because of the uniqueness of these highways. Needs for the county and city systems were determined by a process of estimation but are believed to be realistic and sound.

A comparison of the present and future needs is made with anticipated revenues for the next 15 years. Without a change in present revenue policies, an additional $1.5 billion will be required to eliminate all highway needs.

● FOR MANY years the Joint Highway Research Project of Purdue University has conducted research in various phases of highway engineering in cooperation with the Indiana State Highway Department. In the summer of 1954, the Research Project was directed to make a study of the needs of the 98,000 miles of roads and streets in Indiana (see Fig. 1). It was evident to many people that a great many inadequacies and deficiencies existed in the highway facilities, but definite information was necessary about the specific needs in order to solve intelligently the resulting complex engineering and fiscal problems. Generally, the efforts of the early planning of the work were directed to the solution of the following problems:

1. What are the physical needs?
2. How much will correction of the needs cost?
3. What is the relation of the cost required to eliminate the needs with anticipated sources of income for highway improvement?

The final objective in answering these three basic questions was to develop information that would assist highway and legislative personnel to provide an adequate, efficient, and economical highway system in Indiana.

No attempt was made to solve the financial problems which a study of this nature would reveal. The research was confined primarily to an engineering appraisal of the physical needs and the costs required to eliminate these needs. Other questions which were related to the determination of deficiencies and related costs, however, had to be considered. Economic services of the highway, growth trends, highway classification, accidents, traffic operations, length of program periods, and other problems were evaluated along with the determination of the direct needs.

COLLECTING DATA

During the early fall of 1954 and winter of 1955, a complete physical inventory of the 10,700 miles comprising the state highway system was made by State Highway Department personnel. Each of the six highway districts readily supplied the necessary personnel to complete rapidly this inventory within a few months because of the "slack season" between the 1954 and 1955 construction seasons. By the spring of 1955, all inventories were substantially finished.

The actual procedures and techniques for making the inventory were developed by

Figure 1. Indiana's highway problem.

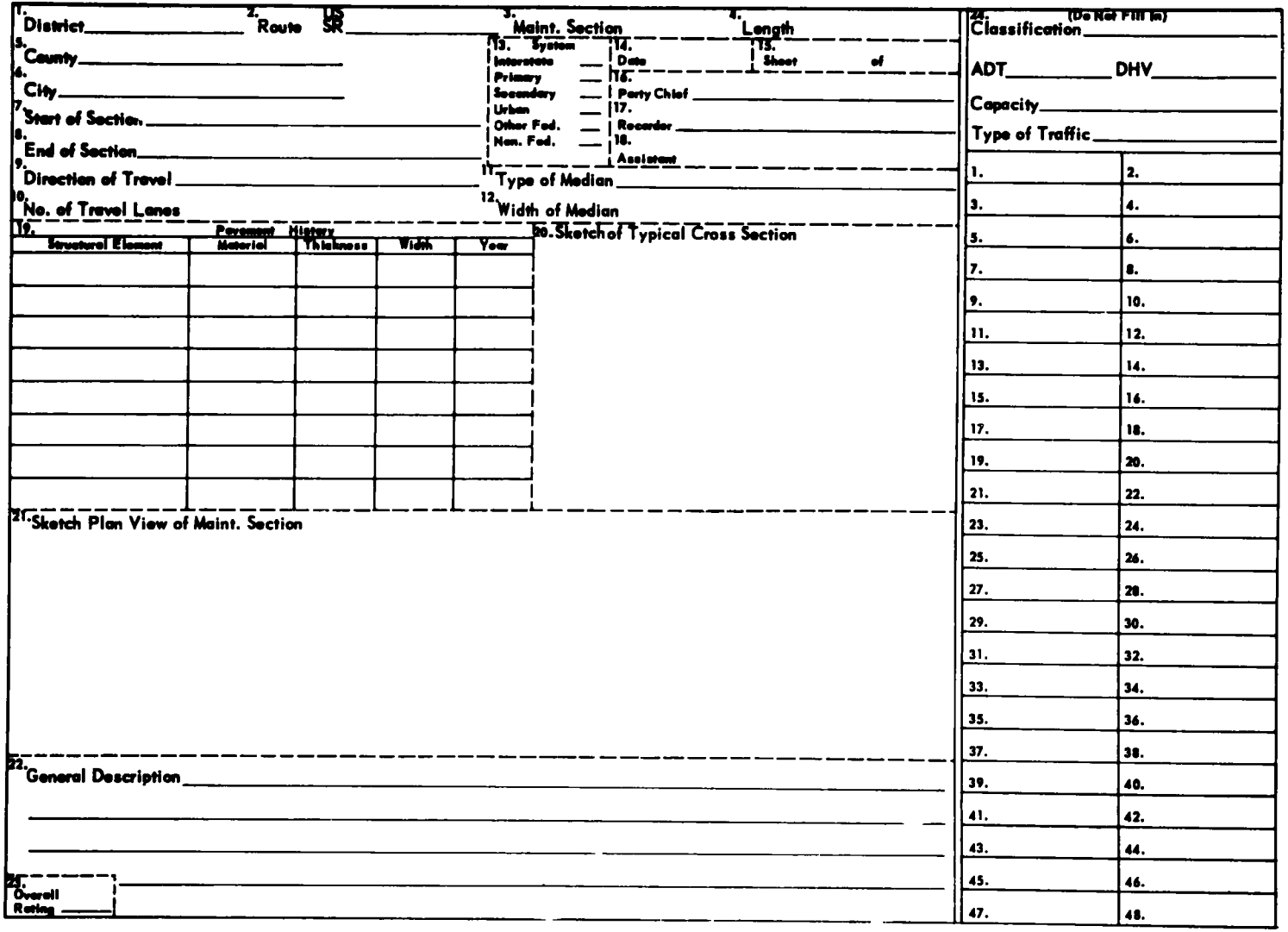

Figure 2. General information and data sheet.

the Research Project. Essentially the information that was required can be broken down into three general categories: (a) road or street information, (b) bridge information, and (c) railroad crossing information.

The road information that was collected is indicated by Figures 2, 3, and 4; bridge information by Figure 5; and railroad crossing information by Figure 6. A great deal more information was collected than was absolutely required for the performance of a needs study. However, this additional information was collected for a definite purpose. For example data concerning roadside development of various types can be used to help determine the service characteristics of the highway and some of the effects of roadside development on the movement of traffic. Sufficiency ratings for the rural highways were also computed from some of the information which was not directly involved in the needs appraisal.

Traffic data for each section of highway were placed on the inventory information. Accident rates per 100 million vehicle miles, were computed from accident records obtained from the State Police Department and traffic data for the particular section of road. This information was also added to the inventory data.

It was not possible to make extensive inventories of the study and city and county systems; and therefore, other sources of data were used to develop and evaluate the needs on these systems.

PROCEDURE OF ANALYSIS OF DATA

State Highway Systems

Before actual study of the data was started, a thorough evaluation of growth trends of population, motor vehicle registration, motor vehicle use, motor fuel consumption, and traffic growth was undertaken. The resulting traffic growth curve for the state highway system is indicated in Figure 7. The upper line indicates the maximum possible growth of traffic, and the lower line indicates its probable average growth. The lower line was computed on the basis of the "least squares method" derived from the extension of past traffic data. The upper line was computed by the "three factor method" which considered the growth of population, motor fuel consumption, and motor vehicle registration.

Development of tolerable and design standards required much thought and work. Many meetings with the State Highway Department and other qualified engineers were necessary to produce an acceptable set of standards for new construction and tolerable conditions. Development of standards for the rural state and county systems was comparatively easy. However, it was not possible to develop a formal set of standards for the urban state highways and city streets because of the complexities of the transportation problem in a great many of these areas. Typical examples comparing some of the elements of tolerable and design standards for the rural state primary and secondary and county primary systems are indicated in Figures 8 and 9.

Construction cost data for the state highway system were based on statewide average costs for various types of highway improvement. These costs were obtained through the cooperation of the State Highway Department. The development of existing cost of maintenance and the cost of adequate maintenance was also accomplished by this organization. Development of cost data for the county road and city street systems, however, was indeed difficult. Cost records were virtually non-existent in many of the smaller cities and most of the counties. It was necessary, therefore, to base most of these costs upon estimation and expert judgment.

Because the inventory was to serve the multiple purpose of providing statistical information for other uses than a needs study, it was decided to place all of the information on IBM punch cards. The punch cards also provided the most efficient and quick means of analysis of the multitude of data necessary to process. Two cards were punched for each highway section containing all pertinent road information. A card was also punched for each bridge and railroad crossing located in the highway section. Additional information which could not be taken by the inventory crews such as traffic capacity, accident rate, and soil type was also determined and punched into the cards.

Work sheets for each section of road and the bridges and railroad crossings located

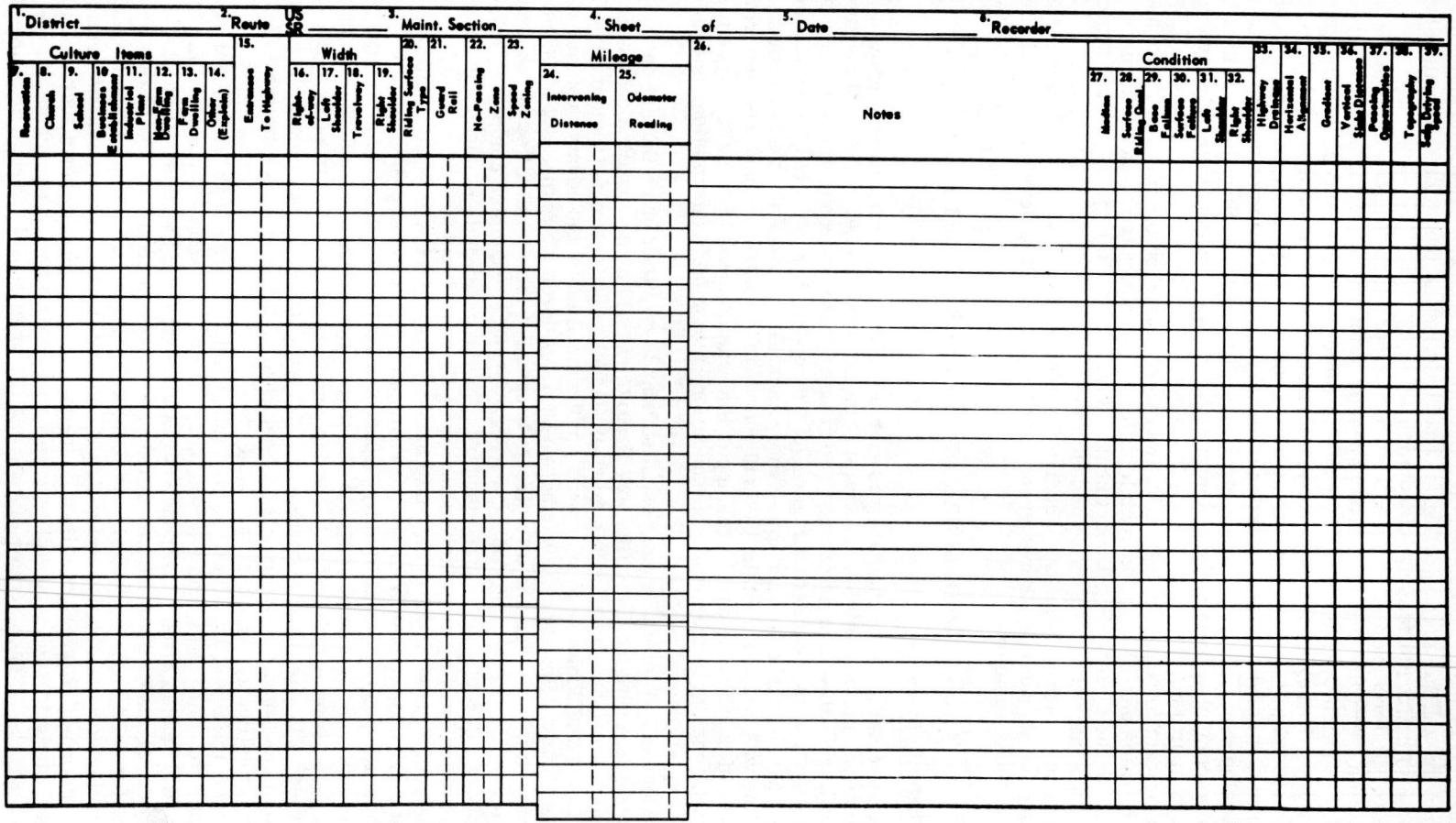

Figure 3. Rural state highway inventory data sheet.

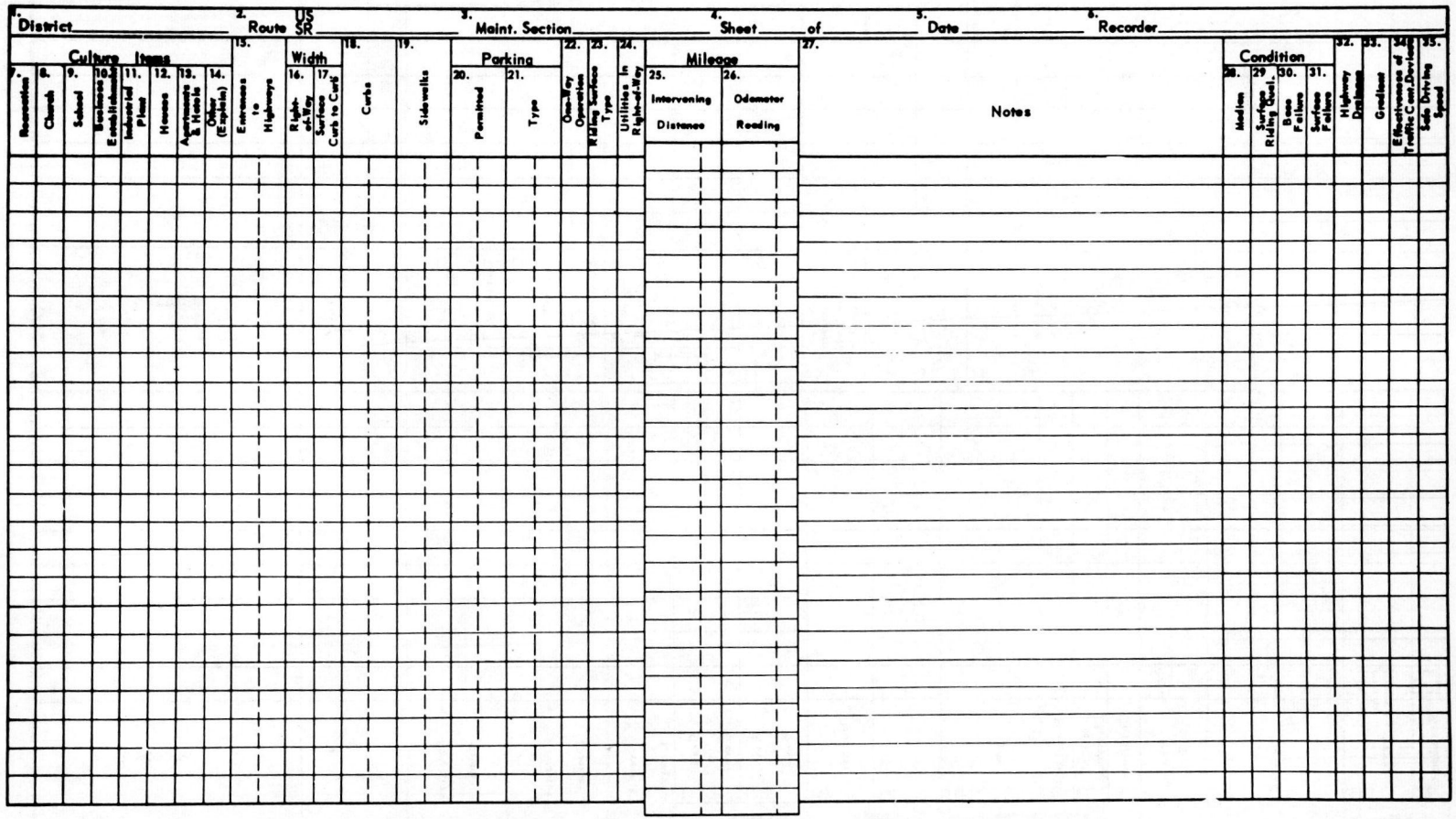

Figure 4. Urban state highway inventory data sheet.

1. Route US SR _____ 2. Maint. 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	Substructure		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 Stream Bed or Highway	28. Above High water							

Figure 5. State highway bridge inventory data sheet.

1. US / Route SR
2. Maint. Section
3. Sheet ____ of ____
4. Date
5. Recorder

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

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

Figure 6. State highway railroad protection data sheet.

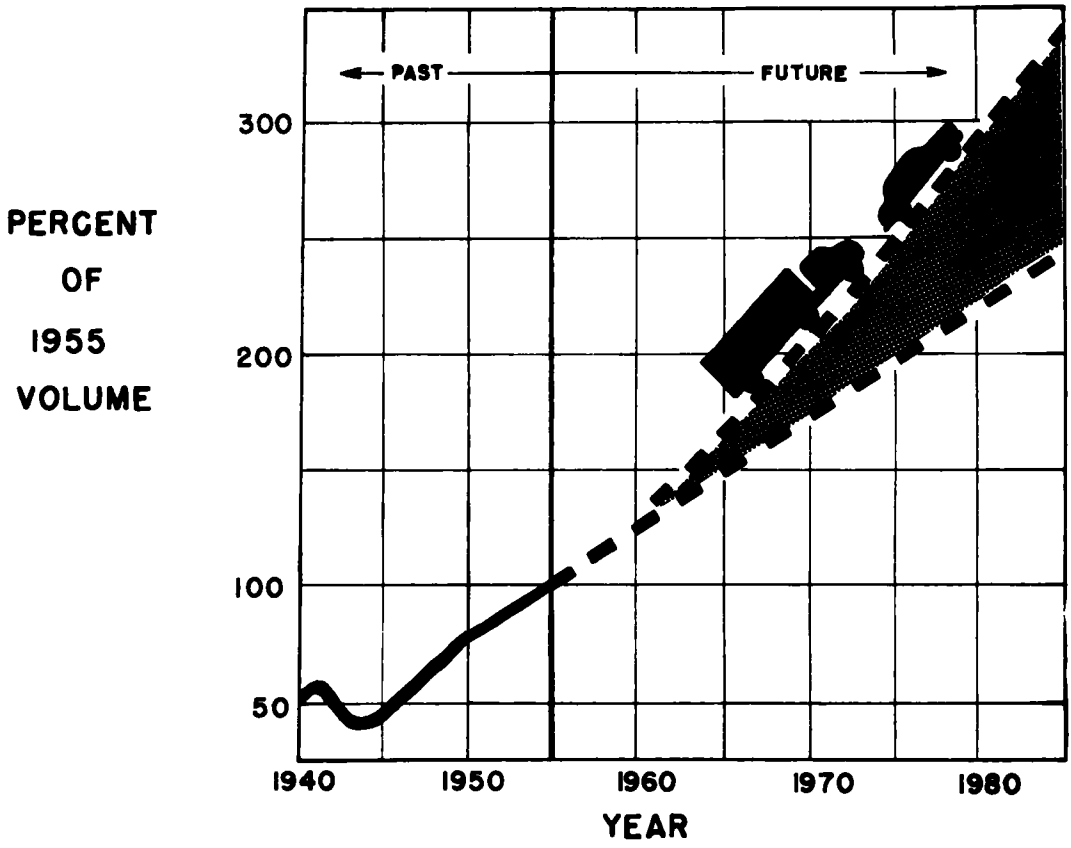

Figure 7. Growth of traffic.

in the section were tabulated as indicated in Figure 10. Existing deficiencies were indicated on the work sheets as well as anticipated future deficiencies. The year of needed improvement was determined and construction recommendations were made. The cost of the improvement was then determined based on average construction costs.

Needs on the interstate system were not developed in this manner because the State Highway Department had nearly 50 percent of the proposed interstate system in the final stages of the preliminary design. Costs that were developed for rural and urban portions of this work were used to determine the entire cost of the system.

Some of the needs on the urban state highways in the larger metropolitan areas were developed on the basis of long-range city plans and recommendations given in several of the recent comprehensive traffic surveys conducted in Indiana. The city planner was found to be an essential individual in the determination of urban needs. His knowledge of urban growth in a particular community greatly influenced the determination of arterial streets and the traffic flows on these streets. Therefore, long-range city plans were used extensively in those cities where such information was developed.

County and City Highway Systems

It was impossible to inventory each mile of the 87,300 miles of county roads and city streets because of time, financial and staff limitations. Furthermore, the available records of construction and plans for county road and city street improvements were found to be inadequate. Usable cost information in most of the counties and small and intermediate size cities was also difficult to locate. This very lack of information indicates one of the major needs on the county and city road systems, although these

needs cannot be directly evaluated in terms of dollars and cents.

To help solve the problem of lack of adequate data, it was decided to use any available information concerning the city and county systems which was accessible. Since most of the county road and city street systems were not classified, the difficulty of this problem was increased.

Therefore, the first step was to classify the 76,000 miles of county roads into primary, secondary, and local service systems. Data from recent road classification studies that were performed in two Indiana counties and other road classification data available from studies made elsewhere indicated that 13 percent of the total county mileage was located on the primary system and 12 percent was located on the secondary system.

Various composite estimates of the dollar needs required on the primary, secondary and local service systems were determined from the information available in these two counties and from a study of county road needs in adjoining states as reported in their recent needs studies.

To classify the 11,300 miles of city streets which were located on the arterial and residential systems, the total mileage on these systems was determined from a sample of cities of various population classes. From this study it was determined that an overall average of approximately 25 percent of the city street mileage was located on the arterial system and the remaining 75 percent on the residential system. Composite needs on these two systems were then determined from various engineering studies made previously of several cities in Indiana and from recent needs studies performed in adjacent states.

Construction of residential streets in new subdivision development in both the counties and cities was not considered as a highway need because laws in these governmental units usually require that these roads and streets be constructed by the land developer or property owner to standards which met the minimum design requirements for this study. Increased maintenance needs, however, were considered because of the growth of mileage on these systems.

Although the county road and city street needs were determined from data which are

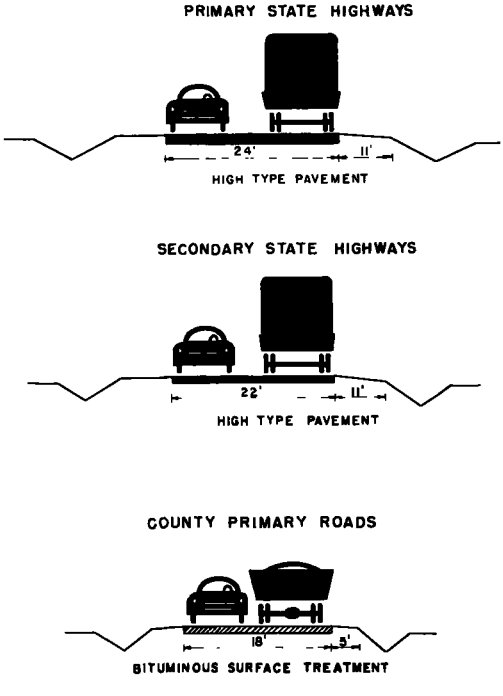

Figure 8. Tolerable standards.

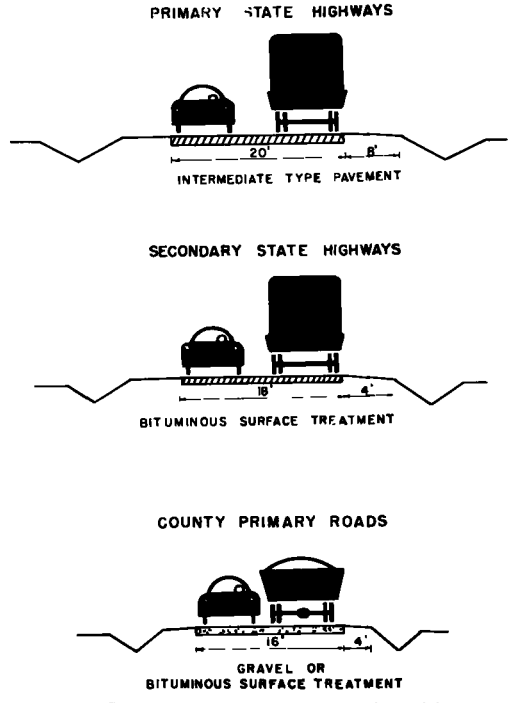

Figure 9. Standards for new construction.

SAMPLE SUMMARY OF I.B.M. TABULATIONS

HIGHWAY INFORMATION

ROUTE NUMBER	MAINTENANCE SECTION LETTER	SUBSECTION NUMBER	HIGHWAY DISTRICT NUMBER	SUBSECTION LENGTH (MILES)	PAVEMENT WIDTH (FEET)	ACCIDENT RATE (NO ACCIDENTS PER 100,000,000 VEHICLE MILES)	CAPACITY (VEHICLES PER DAY)	1956 TRAFFIC (VEHICLES PER DAY)	SOIL TYPE	SURFACE TYPE	RIGID OR FLEXIBLE PAVEMENT	SURFACE THICKNESS (INCHES)	TOTAL THICKNESS OR BASE THICKNESS (INCHES)	YEAR OF MAJOR CONSTRUCTION	YEAR OF SURFACE CONSTRUCTION	SURFACE CONDITION OR FAILURE	SHOULDER WIDTH (FEET)	CURVE	GRADE	RIGHT-OF-WAY (FEET)	TOPOGRAPHY	YEAR CONSTRUCTION NEEDED	TYPE OF CONSTRUCTION NECESSARY
US 41	K-1	1	CRAWFORDSVILLE	2.5	25	181	6,500	15,200	SAND	ASPHALT	FLEXIBLE	2.5	9	UNKNOWN	1940	MEDIUM (5-15%)	—	NONE	0-3%	70	FLAT	1955	RECONSTRUCTION 4-LANE DIVIDED HIGHWAY-LIMITED ACCESS
US 41	K-2	1	CRAWFORDSVILLE	0.5	24	181	6,500	12,400	SAND	ASPHALT	FLEXIBLE	2.5	9	1924	1940	MEDIUM (5-15%)	7	SOME CURVES	0-3%	70	FLAT	1955	RECONSTRUCTION 4-LANE DIVIDED HIGHWAY-LIMITED ACCESS
US 41	K-2	2	CRAWFORDSVILLE	5.3	23	181	4,300	7,800	SAND	CONCRETE	RIGID	9-7-9	UNKNOWN	1919	1924	MEDIUM (5-15%)	7	NONE	0-3%	70	FLAT	1955	RECONSTRUCTION-4-LANE DIVIDED HIGHWAY-LIMITED ACCESS
S.R. 43	H	1	CRAWFORDSVILLE	3.9	20	216	3,500	2,400	ALLUVIUM	CONCRETE	RIGID	9-7-9	UNKNOWN	1917	1931	CRITICAL (over 20%)	11	SOME CURVES	3-6%	60	ROLLING	1956	WIDEN & RESURFACE TO 24'
S.R. 43	H	2	CRAWFORDSVILLE	7.1	20	216	4,000	2,400	ALLUVIUM	CONCRETE	RIGID	9-7-9	UNKNOWN	1917	1931	CRITICAL (over 20%)	11	SOME CURVES	0-3%	60	ROLLING	1956	WIDEN & RESURFACE TO 24'

BRIDGE INFORMATION — RAILROAD CROSSING INFORMATION — COST INFORMATION

BRIDGE NUMBER	TYPE OF STRUCTURE	USE OR SERVICE	CLEAR WIDTH (FEET)	LENGTH (FEET)	NUMBER OF SPANS	POSTED LOADING (TONS)	VERTICAL CLEARANCE ABOVE HIGH WATER (FEET)	VERTICAL CLEARANCE OVER HIGHWAY OR STREAM (FEET)	AGE (YEARS)	YEAR STRUCTURE NEEDED	RAILROAD NAME	1956 TRAFFIC = NUMBER OF TRAINS	TYPE OF PROTECTION	YEAR GRADE SEPARATION NEEDED	HIGHWAY CONSTRUCTION COSTS	BRIDGE CONSTRUCTION COSTS	RAILROAD SEPARATION COSTS	RIGHT-OF-WAY COSTS	RAILROAD PROTECTION COSTS	TOTAL CONSTRUCTION COSTS	MAINTENANCE COSTS	ADMINISTRATION COSTS
UNKNOWN	REINFORCED CONCRETE ARCH	STREAM CROSSING	36	105	1	20	UNKNOWN	14	29	1955	CHICAGO, MILWAUKEE, ST. PAUL & PACIFIC	60, 800 15,200	SIGNALS SIGNALS	1955 1956	$600,000	$113,000	$295,000	$128,080		$1,134,000	$600 PER MILE PER YEAR	6% OF CONSTRUCTION & MAINTENANCE COST
SA76-1-1	REINFORCED CONCRETE ARCH	STREAM CROSSING	24	159	3	20	4	20	29	1955					$120,000	$176,000		$ 28,000		$ 321,000	$600 PER MILE PER YEAR	6% OF CONSTRUCTION & MAINTENANCE COST
41-K-3(28)A	REINFORCED CONCRETE ARCH	STREAM CROSSING	53	67	1	20	6	22	1	1955					$1,270,000	$ 87,000		$265,000		$1,622,000	$600 PER MILE PER YEAR	6% OF CONSTRUCTION & MAINTENANCE COST
															$140,000					$140,000	$800 PER MILE PER YEAR	6% OF CONSTRUCTION & MAINTENANCE COST
109 1089 284-A	STEEL TRUSS REIN. CON. ARCH REIN. CON. GIRDER	STREAM CR STREAM CR STREAM CR	24 24 28	84 60 28	1 1 1	25 25 25	4 5 4	12 10 10	23 23 23	1956 1956 —	PENNSYLVANIA	4,800	SIGNALS	—	$316,000	$130,000		$ 2,000		$468,000	$800 PER MILE PER YEAR	6% OF CONSTRUCTION & MAINTENANCE COST

Figure 10.

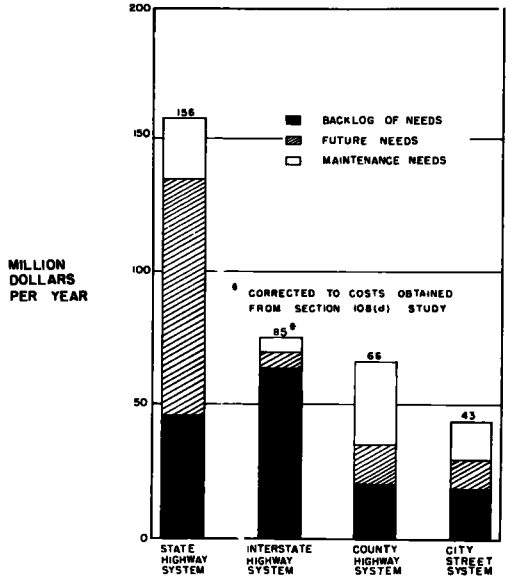

Figure 11. Annual average cost for 15-year program.

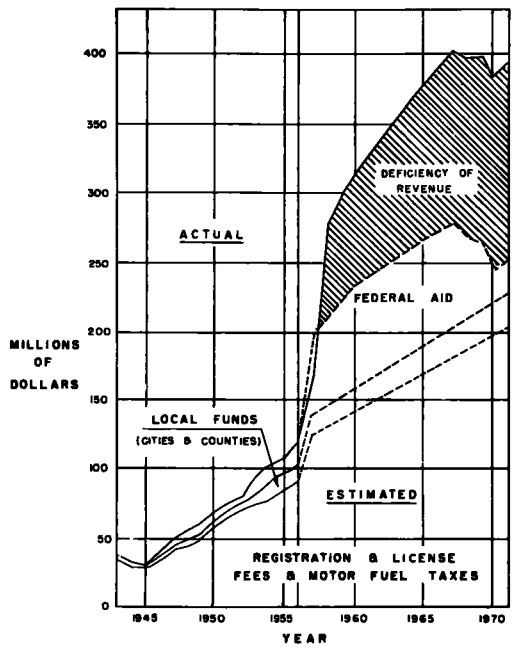

Figure 12. Estimated revenues and needs.

not as objective as that for the state highway systems, the needs were based on the best available information and are considered to be realistic and adequate.

SUMMARY OF RESULTS

Description of Needs, Program Period, and Price Adjustment

Some of the preliminary tabulation of data revealed that the needs on the Indiana system of highways would be great. Inadequate pavement and shoulder widths, inadequate traffic capacity on the major systems, many narrow and overloaded bridges, and several other types of functional and structural obsolescence were indicated. Most of this preliminary data tentatively proved what had been known for many years—many inadequacies existed on the highway system and these deficiencies were great. Furthermore, the needs that would accrue in the future years would create still greater problems.

The physical needs were divided into the conventional categories which had been used in previous work: immediate needs, future needs, and maintenance needs. Included in the future needs were replacement and stop-gap improvements. Maintenance needs also included the administration requirements.

A program period of 15 years was chosen for this study because of influence of the 1956 Federal Aid Highway Act and because it was thought that engineering and construction requirements could be effectively fulfilled during such a program period. A longer or shorter program did not seem practical, and therefore, physical needs and costs were not determined for other periods of time. The estimate of costs for improvements were based on 1955 prices, and adjustments for future price trends were not attempted.

State System

With the exception of the toll road, very few miles of the proposed 1,100 miles of interstate system in Indiana meet approved design standards. Nearly 932 miles of this system must be relocated or rebuilt during the next 15 years. Four-lane divided construction is needed on all rural highways, and in some of the urban areas six-lane freeways are required. According to data developed for this study a total expenditure of $881 million will be required on this system. This cost has been revised to $1,058

million by the recently completed Section 108(d) study.

Needs found on primary, secondary, and urban systems were also great. On the rural systems over 30 percent of the existing mileage is in immediate need of improvement. During the next 15 years an additional 65 percent of the mileage will become inadequate. The complex problem of the urban state highways must be handled boldly and decisively since the present needs are critical. Congestion and delay are becoming more prevalent. During the next 15 years over 200 miles of bypasses will be required around urban areas. Expressway systems are also needed in the large cities of the state.

The total cost of the construction work necessary to eliminate the immediate and future needs on the rural and urban systems is $1,781 million. Additional funds that are required for the maintenance needs amount to $354 million.

County System

As would be expected, the greatest needs on a cost per mile basis occurred on the primary and secondary systems. Generally, these roads carry traffic volumes between 100 and 1,000 vehicles per day and are composed of farm-to-market and other important county traffic flows. The local service system consists mainly of farm access and residential access roads with the origin-destination of traffic being primarily of short, local trips.

In order to eliminate the present and future needs over the next 15 years construction expenditures of $372 million on the primary and secondary systems and $161 million on the local service system are required. An additional expenditure of $458 million is required for maintenance on all systems.

City System

The needs on the urban state highways are not included in this discussion, since they have been reviewed earlier on the state highway system. During the next 15 years, it is estimated that nearly 38 percent of the mileage on the arterial system and 59 percent of the mileage on the residential system must be resurfaced or reconstructed. Nearly $237 million is required for construction on the arterial streets and $207 million is required for construction of the residential streets to eliminate present and future needs. Maintenance will require an additional expenditure of $206 million during the 15-year period.

A summary of the average annual expenditures estimated for the state, county, and city systems for a 15-year program is presented in Figure 11. The costs for the interstate system have been separated from the costs of the other state systems because of its uniqueness and high cost of construction. As can be seen from the chart, the average annual cost for a 15-year program to eliminate the needs on the state rural and urban systems is $156 million; the interstate system, $85 million; the county system, $66 million; and the city street system, $43 million. The total estimated average annual expenditure required for all systems for 15 years is $350 million.

NEEDS VERSUS FINANCES

Indiana obtains revenue for construction, maintenance, and administration of its highway system primarily from motor fuel taxes, license and registration fees, local county or city funds, and federal aid. In 1955 a total of $108 million was available from these sources. With the passage of the Federal Aid Revenue Act of 1956 and a recent two-cent increase in state motor fuel taxes, a significant change has occurred in the availability of highway funds in Indiana. Estimates of revenues during the next 15 years have been developed from present growth trends and revenue policies are shown in Figure 12. The annual highway income is estimated to reach a peak of $28 million by 1967, and will be reduced to $25 million by 1971 because of reduction in federal aid due to the completion of the interstate system.

Superimposed on the estimated income curve is a suggested curve that indicates the annual expenditures required to eliminate the needs. This curve is derived by assuming

that the average yearly income to eliminate the needs minus federal aid will be attained in the middle of the fiscal year 1964 (½ of total 15-year program). The annual state revenue is then assumed to increase at a rate of $12 million a year from this point until the end of the fiscal year 1971, and decrease at a rate of $12 million a year from this point until the beginning of the fiscal year 1957. The upper curve is finally obtained by adding the anticipated federal aid during this program period to the required state revenues necessary to eliminate the needs.

It is obvious from Figure 12 that the required needs will not be satisfied by the anticipated funds. An additional 1.5 billion will be required over and above that which can be provided by present sources of revenue. Either new sources of revenue will be required or increases in old sources will be needed to fill the gap between needs and available finances.

CONCLUSIONS

The concepts and procedures that were used on the needs study along with some of the results have been presented. It is difficult to determine the total impact of an adequate highway system on the general economy of the state but many benefits to the highway user and non-highway user will result.

Although not mentioned specifically in this paper, careful consideration was given to those needs which could not be measured on a monetary basis. Improved traffic operations through effective traffic engineering, wise and efficient use of off-street parking facilities, classification of roads and streets, improved cost accounting, the supply of engineer and technicians, road classification and a number of other problems were evaluated as to the effect on the total needs problem. Having adequate funds and adequate planning to eliminate highway deficiencies is not enough to do a complete job; consideration and solutions to other problems must also be attained.

REFERENCES

1. Branham, A.K., Covault, D.O., and Michael, H.L., "Progress Report on State Highway Needs in Indiana," Proceedings of the 42nd Annual Road School, Purdue University (April 1956).
2. Covault, D.O., Michael, H.L., and Branham, A.K., "Summary Report on State Highway Needs in Indiana," Proceedings of the 43rd Annual Road School, Purdue University (April 1957).
3. Automotive Safety Foundation, "An Engineering Study of Ohio's Highways, Roads, and Streets," (1950).
4. Automotive Safety Foundation, "A Highway Program for Kentucky," (1955).
5. Automotive Safety Foundation, "Modern Highways for Michigan," (October 1955).
6. Automotive Safety Foundation, "Highway Transportation in Tennessee," (November 1955).
7. Indiana State Highway Commission, "Highways of Indiana," (1948).
8. Griffenhagen and Associates, "A Highway Improvement Program for Illinois" (1948).
9. Baerwald, John E., "Rural Highway Classification and Evaluation Procedures for Indiana Counties," Ph.D. Thesis, Purdue University (January 1956).
10. State Highway Department of Indiana, "Richmond, Indiana Traffic Survey Report" (1954).
11. State Highway Department of Indiana, "Evansville, Indiana Traffic Survey Report" (1950).
12. State Highway Department of Indiana, "Princeton, Indiana Traffic Survey Report" (1953).
13. State Highway Department of Indiana, "Calumet District Traffic Survey Report" (1953).
14. State Highway Department of Indiana, "Indianapolis, Indiana Traffic Survey Report" (1952).
15. State Highway Department of Indiana, "Highway Plan for Fort Wayne, Indiana" (1946).