*FORMULATION OF A TECHNIQUE FOR
EVALUATING URBAN HIGHWAY NEEDS*

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Highway
Research
Project*

by
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*PURDUE UNIVERSITY
LAFAYETTE INDIANA*

FORMULATION OF A TECHNIQUE
FOR EVALUATING URBAN HIGHWAY NEEDS

To: G. A. Leonards, Director
Joint Highway Research Project

October 29, 1965

From: H. L. Michael, Associate Director
Joint Highway Research Project

File: 3-3-35
Project: C-36-54II

Attached is a Final Report by Ronald G. Rude entitled "Formulation of a Technique for Evaluating Urban Highway Needs". The research reported was approved by the Board on June 19, 1964 and has been conducted under the direction of Professor J. C. Oppenlander. Mr. Rude also submitted the report as his thesis in his MSCE graduate program.

The report outlines a procedure for obtaining needs estimates for urban street systems using a sampling technique. The results should be of value in the conduct of the Indiana Needs Study now in progress as well as to the preparation of current needs estimates in future years. It may also be possible to utilize the current needs study in Indiana to obtain the additional data in other urban communities as recommended.

The report is presented to the Board for the record and acceptance.

Respectfully submitted,

Harold L. Michael

Harold L. Michael, Secretary

HLM:bc

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Final Report

**FORMULATION OF A TECHNIQUE
FOR EVALUATING URBAN HIGHWAY NEEDS**

by

Ronald G. Rude

Graduate Assistant

Joint Highway Research Project

File: 3-3-35

Project: C-36-54II

**Purdue University
Lafayette, Indiana
October 29, 1965**

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ABSTRACT

Rude, Ronald Gregory. MSCE, Purdue University, January 1966. Formulation of a Technique for Evaluating Urban Highway Needs. Major Professor: J. C. Oppenlander.

Needs studies of urban street systems are costly and time consuming and require a large number of personnel for their performance. Sampling techniques can be used to reduce the expenditure and time necessary to conduct these studies.

Before a procedure could be developed using sampling techniques, it was first necessary to have a complete needs study. This needs study was conducted in West Lafayette, Indiana. The initial approach used in this study was the typical engineering analysis where each section of street and each intersection were thoroughly investigated.

The study process followed in this research consisted of eight basic steps:

1. Classification of streets into systems according to the functions performed in serving traffic demands.
2. Development of design and tolerable standards.
3. Inventory of each street section and intersection to describe its physical characteristics and its traffic load.

4. Determination of present street and intersection deficiencies and those which are expected to develop within the 20-year study period.
5. Determination of the physical improvements needed to overcome the present and future deficiencies.
6. Estimation of the costs of needed improvements.
7. Establishment of priorities for improvements.
8. Application of statistical considerations to determine if reliable cost estimates can be obtained by sampling techniques.

This investigation revealed a very high variability, in regard to improvement costs, in each group of street section and intersection classification. The highest variability was obtained for arterial street sections, and the lowest variation was noted for the intersection of collector streets.

Graphs were prepared showing the percentage of sample size versus the standard error of the mean in terms of improvement costs for each classification of streets and intersections. From these graphs the expected variation in the costs of improving the urban street system, within known limits, can be determined for a given sample size in West Lafayette, Indiana.

If sampling procedures similar to those applied to this study are used in a number of urban communities, it may be possible to develop graphs of the percentage of sample size

versus the standard error of the mean, for various street and intersection classifications, which could be used as standards by cities for determining sample sizes in estimating their street system improvement costs.

INTRODUCTION

A typical city spends between twenty and thirty percent of its operating budget for transportation purposes. Of this amount about seventy percent is spent on the planning, design, construction, operation and maintenance of the street system. (26)* If such large sums of money are to be spent on urban transportation they should be used so as to maximize the benefits derived from them. There should be economical means of determining transportation needs and priorities for their improvement.

Determination of the transportation needs for a city has become a major problem in the past few years. The 1962 Federal-Aid Highway Act specified that Federal-Aid projects in urban areas of over 50,000 population can be approved only if they "...are based on a continuing comprehensive transportation planning process carried on cooperatively by state and local communities...". Included in this transportation planning is a study of street and highway needs. Thus, an efficient, economical and precise method of determining the transportation needs of an urban community is essential

* Numbers in parentheses refer to entries in the Bibliography.

if the urban centers are to solve their ever-increasing transportation problems in a rational manner.

Most cities have attempted to solve their transportation needs problems with a typical engineering approach, which requires a detailed evaluation of all facilities. That is, each section of the street system is analyzed in detail to determine the structural, geometric and safety deficiencies. This procedure is very costly and time consuming and should be continually updated. Most cities have neglected this phase of urban planning because of the excessive manpower and cost requirements. Thus, it has become increasingly important for highway engineers, governmental officials, planners and traffic engineers to have a rapid, accurate and inexpensive means of determining urban transportation needs.

Some new concepts are evidently needed in the field of urban needs studies if cities are to solve their transportation problems. The major objectives of this study were as follows:

1. Make a complete inventory and traffic evaluation of the arterial and collector streets in West Lafayette, Indiana.
2. Determine the cost of eliminating the deficiencies in the major street system at five-year intervals over a twenty-year period.
3. Evaluate the use of sampling techniques as applied to this needs study to determine if reliable cost estimates can be obtained.

There are many advantages to be gained through progress in the field of urban transportation needs studies. Efficient and economical techniques can be developed for determining municipal needs. Current data can be provided concerning the urban street network by means of sampling procedures. The information obtained in urban areas can be used as part of a statewide needs study. Urban needs studies will aid in the prediction and planning of future land use within a city. Needs studies will also assist in making expenditure estimates so that proper financial planning can be accomplished.

REVIEW OF LITERATURE

The subject of needs studies has appeared frequently in highway and traffic engineering literature. The phases of needs studies discussed in this literature review are those which are directly connected with this research. The topics considered are the history of needs studies and the use of sampling techniques as applied to highway and urban street needs.

Needs Studies

The need for comprehensive appraisals of highway and street systems has been realized for many years. To meet this need initially, the state highway departments in cooperation with the Public Roads Administration (now the U.S. Bureau of Public Roads) developed the highway planning surveys in the middle 1930's. The purpose of these surveys was to make a complete study of the entire highway system and its relation to all other forms of transportation within the state. These early reports consisted of the collection, analysis, interpretation and summarization of data concerned with construction, maintenance, operation and administration of all phases of the highway system. Most studies were conducted under the auspices

of a specially created highway study committee of the state legislature, with cooperation from each level of government that had jurisdiction over highway transportation facilities. (16)

F. B. Farrell stated in his article, "Conducting Long-Range Highway Needs Studies", that those studies conducted in the 1930's consisted of the following three basic phases: (16)

1. The engineering study - involved an engineering appraisal of the improvements needed and the costs required to bring the highways up to adequate standards.

2. The finance and taxation study - included studies of methods for financing the program and the determinations of responsibility of fiscal support for various classes of roads and streets.

3. The administrative study - included appraisal of the administrative relationships and controls necessary for orderly prosecution of the program and of the organizational structures and operating practices of various governmental units having jurisdiction over highways. These three steps still form the basis of most highway needs studies.

The great increase in motor-vehicle travel after World War II directed public attention to the many deficiencies in the highway and street systems in this country. Most states realized that further investigation and analysis of their highway plants were essential if safe, efficient and convenient transportation was to be provided. Most states undertook

highway needs studies in these early years after the war. The first comprehensive engineering studies covering all highway systems in the state were "Engineering Facts and a Future Program" submitted to the California legislature in 1946 and "Highway Needs in Michigan" prepared by the Michigan Good Roads Federation in 1947. (16) A great number of reports prepared by various states have been completed since these initial studies.

Since the late 1940's, the Automotive Safety Foundation has taken a leading role in needs investigations by acting as a consultant for many studies. The Foundation provided direction for the study and for all engineering procedures, standards, methods of analysis, review of interpretation, conclusions, recommendations and contents of the final report.

The studies made in the 1930's and 1940's afforded a large backlog of information from which current and future needs could be accurately estimated for rural highways. However, a practical system of fact collection and analysis was not available for the urban areas. This deficiency led, in 1954, to the organization of the National Committee on Urban Transportation. This group initially consisted of representatives from the American Municipal Association, International City Managers' Association, American Society of Planning Officials, National Institute of Municipal Law Officers, American Public Works Association and Municipal

Finance Officers Association. Later the U. S. Bureau of Public Roads, the Canadian Federation of Mayors and Municipalities and the National Association of County Officials also accepted membership. The American Association of State Highway Officials and the American Transit Association are now cooperating actively. (5) This organization has prepared several procedural publications showing how transportation data could be collected, analyzed and evaluated in the urban area.

From the middle 1950's to the present time most states, which have conducted needs studies, have divided the work into three distinct categories; state route needs, county road needs and municipal street needs.

In the past few years states have published manuals containing procedures and instructions for determining needs. (13,14,15,19,29) These guides state the objectives of the study and the procedures to be followed in conducting the work.

To meet the requirements of a sound transportation system, the needs study should be designed to achieve the following basic objectives: (33)

1. Provide a factual summary of realistic needs.
2. Determine future travel patterns to aid in the design and location of streets, highways and other transportation facilities.

3. Develop an economic transportation system which is integrated with the land use plan and public facility plan. The transportation system should be designed so that private and public development can proceed with the confidence that plans for mass transportation, streets and highways will not be radically changed in the years ahead.
4. Develop a street and highway system that provides for the safe and rapid movement of people and goods.
5. Disclose the extent of public investment required for transportation facilities over a reasonable period of time.
6. Establish priorities and permit continuous financial programming on a factual basis.
7. Establish the procedure so that transportation needs studies can be a continuous process.

The study procedure for an urban area generally consists of the following steps: (13,29)

1. Classification of streets into systems according to the way in which they best serve traffic needs.
2. Inventory of the special characteristics and existing conditions for each street section, structure and railroad crossing.
3. Determination of the character and degree of the existing and future deficiencies and estimation of the time period in which the improvements should be made.

4. Determination of the improvements needed to overcome the deficiencies.

5. Estimation of the costs of needed improvements.

The above outline and procedures have dealt with what is commonly known as the engineering approach to highway and street needs determination. There are two other techniques which are used to determine physical and financial needs. These methods are the investment analysis and capacity-deficiency approaches. (17,5)

In the article, "The Investment Analysis Approach to Estimating Highway Needs", F. B. Farrel states:

This principle is based upon the premise that under a condition of sustained traffic increase over a period of several years, there should be a corresponding increase in the investment (cost-new less depreciation) in the highway plant. (17)

Thus, if the future level of traffic is predicted, then the level of highway investment needed in the future can also be determined. The annual capital cost necessary to raise the depreciated investment from one level to the next can be computed if the existing level of investment and the future level of needed investment are known. (17)

The capacity-deficiency approach is used primarily in the urban area. This procedure indicates where deficiencies exist and the type and location of needed facilities. A series of screen lines which cut corridors of traffic are established and a cordon line is set up around the central

business district. For a small city the business district cordon may not be necessary. The street capacities across these lines are determined and compared with estimated future traffic that is predicted from origin-destination studies. With this information it is possible to identify any needed adjustments or extension of the urban street system. (5)

Sampling Applied to Highway and Street Needs

Previous applications of sampling techniques to the highway and street needs problem have been limited. D. O. Covault conducted one of the most complete studies in this field. (8,9 and 10) His research was concerned with the use of sample survey techniques to determine the county highway needs in Michigan and Minnesota. The highway systems in each of these states were composed of separate highway, bridge and railroad crossing populations. The needs characteristics of each of these populations and the variances of these characteristics were calculated from available state data. From this information sample sizes were computed for various combinations of margin of error and α risk (level of significance) for each population. The sampling plans used in that research were as follows: (9)

1. Simple random sampling,
2. Stratified random sampling with optimum and proportional allocation,

3. Simple cluster sampling, and
4. Stratified cluster sampling with optimum and proportional allocation.

The following several subsets, which were delineated as populations, were considered in this research: (9)

<u>Road System</u>	<u>Population</u>
Rural	1. All Highway Sections
	2. All Bridges
	3. All Railroad Crossings
Urban	4. All Highway Sections
	5. All Bridges
	6. All Railroad Crossings

In connection with urban areas, two results were drawn from this study. Covault concluded:

1. The respective urban separate populations for the Michigan data required a large proportion of the population to be sampled if the estimate of total cost for all orders of accuracy for the sampling methods studied i.e., simple and stratified random sampling.
2. The urban separate highway populations for the Minnesota data required a small sampling rate for the estimate of total cost for the lower orders of accuracy. However, large sampling rates were required for the estimate of bridge and railroad crossing costs for all orders of accuracy. (9)

Sample survey techniques were considered to be feasible for the cost estimation of needs on rural two-lane and urban county primary highways in Michigan and Minnesota.

In 1957 C. Burnes reported the results of a study designed to determine if total county and township road needs could be estimated from a sample. Two methods of

sampling were explored, and the results of these samples were compared with the complete data of a comprehensive needs study made in Minnesota in 1954.

Each sampling method consisted of selecting one county from each of the eight highway districts in the state. One sample chosen by an engineer familiar with the state highway system and its condition was to be representative of the average needs in the respective districts. The second sample of eight counties was randomly selected from each district.

The expanded sample selected by the engineer was 3.0 percent in error as compared to the deficient miles estimated by the comprehensive study. A variation of 5.3 percent was noted in the random sample.

The following recommendation was reported in this study:

If time and cost are important considerations in the estimate procedure, if the desired result is to obtain a long range estimate of the total needs of a large area, and if the estimate is to be used for long range financial planning which is flexible rather than rigid, then it is entirely feasible and desirable to resort to sampling techniques as an economy measure. (7)

Some states are now using sampling methods to determine municipal needs on a state-wide basis. For example, in the 1960 Michigan Needs Study conducted in cities under 5000 population, a stratified sampling technique was used to estimate physical and financial needs. A total of 188 communities were selected for the analysis from the 407 municipal areas

with populations less than 5000. The sampled cities represented various populations and geographic areas. The street systems in the sample cities were inventoried, deficiencies were determined and the costs of correcting these deficiencies were estimated. Costs in these sample cities were expanded to obtain the present needs in all municipalities under 5000 population. (19)

DESCRIPTION OF STUDY AREA

The city selected for this study was West Lafayette, Indiana. Organized in 1866 under the name of Chauncey, West Lafayette became a town in the late 1880's and was incorporated as a city in 1924. (22) This educational community is located in the northwestern quarter of the state, 60 miles northwest of Indianapolis and 125 miles southeast of Chicago. The general location of West Lafayette in the state of Indiana and an outline of West Lafayette and Lafayette are shown in Figure 1. West Lafayette was chosen as the study site for two basic reasons: 1) the street and highway patterns of the city are typical of those in most cities of this size in the Midwestern section of the country; and, 2) being the city in which Purdue University is located, the collection of all pertinent data was simplified with regard to time and manpower.

The community is located in a temperature zone which is subject to neither extremely hot nor severely cold weather. The average temperature for the year is 51.7 degrees with the monthly averages varying from 26.5 in January to 75.6 degrees in July. The average annual precipitation is 38.26 in. (21)

The 1960 Census population of West Lafayette was 12,680. The population is expected to reach 18,400 by 1980. (31) Between 1962 and 2000 the population of West Lafayette

FIGURE 1 LOCATION OF WEST LAFAYETTE IN INDIANA

is expected to excel all other communities in Indiana on a percentage-wise basis. Much growth will come by in-migration as a result of the accelerated scientific and educational programs in the Purdue University complex. (3)

West Lafayette is primarily an educational and research center. Purdue University, which is located in this city, is the Indiana link in the chain of 68 land-grant colleges and universities throughout the nation. Purdue's 1965 graduate and undergraduate enrollment was over 18,500 on the West Lafayette campus. The University is planning its physical facilities for more than 30,000 students by 1975. The 2,200 faculty members teach and conduct research in over 70 principal buildings on the 8000 acres controlled by the institution. (23, 24)

McClure Research Park is also located in West Lafayette. The industries in the park manufacture no products of any kind because they are devoted entirely to research. The research site covers an area of about 85 acres that are located in the northwest corner of the city. New companies are now constructing buildings in the park, and existing industries are expanding their facilities.

The basic street pattern of West Lafayette is generally rectangular in the older sections of town but is without uniformity as to length or width of blocks. The Wabash River, Purdue University, a railroad and a ravine have forced

some modification in the north-south and east-west orientation of streets and in street continuity. Recent residential street design has been more curvilinear or organic in nature with varied block lengths and lot arrangements.

Six major highways lead into West Lafayette, - two federal routes, U.S. 52 and U.S. 231, and four state roads, Indiana 26, 43, 126 and 443. These highways have had some effect on the direction, type and intensity of growth. Unless brought under more stringent zoning control, the potential benefits of the U.S. 52 By-Pass, in the northern portion of the city, will not be realized. The improvements scheduled for this By-Pass, unless protected against encroachment, will soon lose the benefits to be gained by its widening.

West Lafayette is the smaller of the two connected cities, West Lafayette and Lafayette. These cities are divided by the Wabash River, and all traffic between them is carried by four bridges. Thus, the streets around these bridges create some of the major traffic problems in the study area. These bridges are the U.S. 52 By-Pass Bridge (two lanes), the William Henry Harrison Bridge (four lanes divided), the Brown Street Bridge (two lanes) and the State Street Levee Bridge (four lanes undivided).

The traffic volumes in the area consist of the typical three peaks - morning, noon and evening. The major portion of the traffic is created by the faculty, staff and students

of Purdue University with the exception of the through traffic which normally uses the U.S. 52 By-Pass.

A summary of the land use in West Lafayette, as it existed in 1960, is shown in Table 1. The University and the land north of the U.S. 52 By-Pass are not included in this table.

TABLE 1. WEST LAFAYETTE LAND USE - 1960

USE	AREA IN ACRES	% LAND	% DEVELOPED
Residential			
Single Family	549.55	50.00	53.6
3 and 4 Family	33.16	3.00	3.2
Boarding and Rooming	0.26	0.00+	0.0+
Commerical	21.23	1.90	2.1
Parking	9.09	0.80	0.9
Industrial	6.52	0.60	0.6
Parks	47.50	4.30	4.6
Public Schools	50.00	4.60	4.9
Streets	307.05	28.00	30.0
TOTAL DEVELOPED AREA	1024.36		100.0
Vacant	75.14	6.80	
TOTAL AREA	1099.50	100.00	

Reference (3).

PROCEDURE

This section of the report describes the procedures which were used in conducting the study. The design of the study, the methods employed in the data collection and the analysis of the data are discussed in detail. The facilities analyzed in this investigation were the arterial and collector streets and the major intersections in West Lafayette, Indiana.

Design of Study

The initial approach to this investigation was similar to that followed in most previous urban needs studies - the typical engineering analysis in which each section of street and each intersection were thoroughly analyzed. That is, all physical dimensions, signing, parking conditions, etc. were recorded in detail. The following major items were considered on all arterial and collector street sections and at each important intersection:

1. Volumes - present and future.
2. Character of traffic.
3. Travel time and delay.
4. Parking.
5. Accidents.

6. Traffic signs and markings.
7. Traffic signals.
8. Channelization.
9. Geometric design.
10. Street and intersection lighting.

The appraisal procedure involved a section by section analysis of the system to determine the costs of improving all deficient streets and intersections to design standards adequate for present and future traffic. The objective of the engineering study was to determine the most economical long-range solution to urban needs problems which exist at the present time or are expected to occur during the next twenty-years for urban state highways, arterial and collector streets and major intersections in West Lafayette.

The study process consisted of the following basic steps:

1. Classification of streets into systems according to the functions performed in serving traffic demands.
2. Development of design and tolerable standards.
3. Inventory of each street section and intersection to describe its physical characteristics and its traffic load.
4. Determination of present street and intersection deficiencies and those which are expected to develop within the 20-year study period.

5. Determination of the physical improvements needed to overcome the present and future deficiencies.
6. Estimation of the costs of needed improvements.
7. Establishment of priorities for improvements.
8. Application of statistical considerations to determine if reliable cost estimates can be obtained by sampling techniques.

The following portions in this section of the report describe the classification of the street systems, the development of design and tolerable standards and the method used to project future traffic volumes.

Functional Classification

An investigation of existing street usage is the first step in a comprehensive urban needs study. Street classification is the orderly grouping of street sections into systems which provide similar services. A functional classification provides the basis upon which financial plans can be devised, management requirements defined, street responsibilities established and improvement programs formulated.

For this study the streets were grouped into the three functional categories of arterial, collector and local streets. Many studies include expressways as a fourth category, but in this investigation no existing street sections were classified under this heading. The four categories of streets are described below:

1. Expressways. This group of facilities is used exclusively for traffic movement through the city and between its major elements or most important traffic generators. This classification is usually made up of multilane, divided routes with few, if any, intersections at grade. Expressways are characterized by at least some degree of access control.

2. Arterials. Arterials are divided into two major groups - primary arterials and community arterials. The primary arterials serve to move through traffic to major traffic generators and from community to community. These routes form a framework of facilities upon which traffic can be controlled and protected so as to provide maximum movement within the city.

The community arterials collect and distribute traffic between higher type facilities and less important streets. These streets also serve to move traffic from neighborhood to neighborhood within a community. In both groups of arterials abutting property usually has free access, although parking and loading may be restricted or eliminated to improve capacity.

3. Collectors. This class of streets collects and distributes traffic between arterial routes and local streets. In addition, these facilities serve neighborhood traffic generators. The collector streets provide access to abutting property as well as serving local traffic movement. In this

investigation collector streets were divided into two groups based upon design speeds of 30 and 40 mph.

4. Locals. Local streets primarily provide access to property in business, industrial and residential areas. These streets serve as tributaries to collector streets and discourage through traffic flow.

The street classification for this study was based on the Urban Arterial Plan for Lafayette and West Lafayette, Indiana, as adopted by the Tippecanoe County Area Planning Commission in February 1963. Some additional sections were added to this classification to account for recent development in the community.

The facilities studied in this investigation were all the arterial and collector streets in the city, and all of the intersections where studied streets crossed or meet. A few other intersections were also included, because they were considered to be important locations with regard to traffic functions. The arterial and collector street systems and the intersections studied are indicated in Figure 2. Those streets which are not marked were all considered to be local-service streets. The characteristics of the urban streets used are summarized in Table 2.

For study purposes the streets under investigation were divided into 69 control sections and 38 intersections. Control sections were street segments having similar

FIGURE 2 STREET AND INTERSECTION CLASSIFICATION IN
WEST LAFAYETTE

TABLE 2. CHARACTERISTICS OF URBAN STREETS

<u>CHARACTERISTIC</u>	<u>EXPRESSWAYS</u>	<u>ARTERIALS</u>	<u>COLLECTORS</u>	<u>LOCALS</u>
TRAFFIC SERVICE	Optimum mobility	Traffic movement primary consideration	Traffic movement and land access of equal importance	Traffic movement secondary consideration
LAND SERVICE	No access	Land access secondary consideration		Land access primary consideration
ADT - RANGE	Over 20,000	5,000 - 30,000	1,000 - 12,000	Not applicable
TRAFFIC FLOW	Free flow	Uninterrupted flow except at signals and cross-walks	Interrupted flow	Interrupted flow
AVERAGE RUNNING SPEED OFF-PEAK	45 - 55 mph	25 - 35 mph	20 - 30 mph	15 - 20 mph
VEHICLE TYPE	All types up to 20% trucks	All types up to 20% trucks	All types	Passenger and service vehicles
PERCENTAGE OF MILES	Up to 10	30 Approx.		70 Approx.
PERCENTAGE OF VEHICLE-MILES	0 - 50	25 - 65	20 - 30	2 - 10
CONNECTS TO	Freeways Arterials	Freeways Arterials Collectors	Arterials Collectors Locals	Collectors Locals
USE BY TRANSIT	Express	Regular	Regular	None except C.B.D.

characteristics with regard to traffic, land use and geometrics. The following items were given consideration in selecting the control sections for this study:

1. Terminals - the ends of most control sections were intersecting streets.
2. Traffic service - traffic volumes were about equal along the entire section. Traffic controls such as speed limits, parking restrictions, etc., were about the same throughout the section.
3. Geometrics - the geometric design or physical dimensions of the section were substantially the same throughout its length.
4. Street use - a given control section was within only one street classification.
5. Land use - the land use was consistent throughout the control section.

To aid in cross-referencing and indexing the survey results, the control sections and intersections were each assigned a code number. The coding system used for street control sections was as follows:

1. Each control section was assigned a six-digit number (for example 1-011-02).
2. The first digit denoted the street classification (1 - arterial, 2 - collector and 3 - local).
3. The second, third and fourth digits denoted the exact street. These streets were assigned alphabetically under each classification.

4. The fifth and sixth digits indicated the specific control section on the facility.

The coding system used for intersections was as follows:

1. Each intersection was assigned a three digit number (for example 1-09).
2. The first digit represented the class of intersecting streets (1 - arterial arterial, 2 - arterial collector, 3 - arterial local, 4 - collector collector, 5 - collector local and 6 - local local).
3. The second and third digits denoted the exact intersection. These intersections were arranged alphabetically.

The arterial and collector street control sections, their terminal points and their code numbers are shown in Tables 3 and 4. The intersections which were investigated and their code numbers are shown in Tables 5, 6, and 7, respectively, for the classifications of arterial-arterial, arterial-collector and collector-collector intersections.

Design and Tolerable Standards

Webster defines standards as "that which is set up and established by authority as a rule for the measure of..., value or quality." (41) This statement could be used as a brief definition for design and tolerable standards of streets

TABLE 3. ARTERIAL STREET CONTROL SECTIONS

<u>STREET</u>	<u>FROM</u>	<u>TO</u>	<u>CODE</u>
Cherry Lane	West City Limits	Northwestern Ave.	1-001-01
Cumberland Ave.	East End	Salisbury St.	1-002-01
Cumberland Ave.	Yeager Rd.	U.S. 52	1-002-02
Fowler Ave.	Northwestern Ave.	Littleton St.	1-003-01
Northwestern Ave.	State St.	North St.	1-004-01
Northwestern Ave.	North St.	Grant St.	1-004-02
Northwestern Ave.	Grant St.	Stadium Ave.	1-004-03
Northwestern Ave.	Stadium Ave.	Meridian St.	1-004-04
Northwestern Ave.	Meridian St.	Cherry Lane	1-004-05
Northwestern Ave.	Cherry Lane	Lindberg Rd.	1-004-06
Northwestern Ave.	Lindberg Rd.	U.S. 52 By-Pass	1-004-07
Northwestern Ave.	U.S. 52 By-Pass	Cumberland Ave.	1-004-08
River Road	South City Limits	Wood St.	1-005-01
River Road	Wood St.	State St.	1-005-02
River Road	State St.	Howard Ave.	1-005-03
River Road	Howard Ave.	U.S. 231 (Bridge)	1-005-04
River Road	U.S. 231 (Bridge)	Robinson St.	1-005-05
River Road	Robinson St.	Happy Hollow Rd.	1-005-06
River Road	Happy Hollow Rd.	Catherwood Dr.	1-005-07
Robinson St.	River Rd.	Stadium Ave.	1-006-01
Robinson St.	Stadium Ave.	Salisbury St.	1-006-02

TABLE 3 (continued)

<u>STREET</u>	<u>FROM</u>	<u>TO</u>	<u>CODE</u>
Salisbury St.	Meridian St.	Grant St.	1-007-01
Salisbury St.	Grant St.	Lindberg Rd.	1-007-02
Salisbury St.	Lindberg Rd.	U.S. 52 By-Pass	1-007-03
Salisbury St.	U.S. 52 By-Pass	Cumberland Ave.	1-007-04
State St.	East City Limits	River Rd.	1-008-01
State St.	River Rd.	Northwestern Ave.	1-008-02
State St.	Northwestern Ave.	Grant St.	1-008-03
State St.	Grant St.	Marsteller St.	1-008-04
State St.	Marsteller St.	Russell St.	1-008-05
U.S. 52 By-Pass	East City Limits	Happy Hollow Rd.	1-009-01
U.S. 52-By-Pass	Happy Hollow Rd.	Salisbury St.	1-009-02
U.S. 52-By-Pass	Salisbury St.	Northwestern Ave.	1-009-03
U.S. 231	East City Limits	Littleton St.	1-010-01
Vine St.	North St.	Wiggins St.	1-011-01
Vine St.	Wiggins St.	Fowler Ave.	1-011-02
Wiggins St.	Northwestern Ave.	Littleton St.	1-012-01

TABLE 4. COLLECTOR STREET CONTROL SECTIONS

<u>STREET</u>	<u>FROM</u>	<u>TO</u>	<u>CODE</u>
Chauncey Ave.	Wood St.	State St.	2-001-01
Chippewa St.	Nava jo St.	Happy Hollow Rd.	2-002-01
Grant St.	South City Limits	Williams St.	2-003-01
Grant St.	Williams St.	Wood St.	2-003-02
Grant St.	Wood St.	State St.	2-003-03
Grant St.	State St.	Northwestern Ave.	2-003-04
Grant St.	Northwestern Ave.	Stadium Ave.	2-003-05
Grant St.	Stadium Ave.	Meridian St.	2-003-06
Grant St.	Meridian St.	Leslie Ave.	2-003-07
Grant St.	Leslie Ave.	Salisbury St.	2-003-08
Happy Hollow Rd.	River Rd.	Laurell Dr.	2-004-01
Happy Hollow Rd.	Laurell Dr.	U.S. 52 By-Pass	2-004-02
Indian Trail Dr.	Lindberg Rd.	Nava jo St.	2-005-01
Lindberg Rd.	West City Limits	Northwestern Ave.	2-006-01
Lindberg Rd.	Northwestern Ave.	Salisbury St.	2-006-02
Lindberg Rd.	Salisbury St.	Indian Trail Dr.	2-006-03
Meridian St.	Northwestern Ave.	Garfield St.	2-007-01
Meridian St.	Garfield St.	Grant St.	2-007-02
Meridian St.	Grant St.	Vine St.	2-007-03
Meridian St.	Vine St.	Salisbury St.	2-007-04
Nava jo St.	Salisbury St.	Indian Trail Dr.	2-008-01
Nava jo St.	Indian Trail Dr.	Chippewa St.	2-008-02

TABLE 4 (continued)

<u>STREET</u>	<u>FROM</u>	<u>TO</u>	<u>CODE</u>
Salisbury St. Salisbury St.	Fowler Ave. Stadium Ave.	Stadium Ave. Robinson St.	2-009-01 2-009-02
Soldiers Home Rd.	U.S. 52 By-Pass	North City Limits	2-010-01
Stadium Ave. Stadium Ave. Stadium Ave.	Russell Dr. Northwestern Ave. Grant St. Salisbury St.	Northwestern Ave. Grant St. Salisbury St. Robinson St.	2-011-01 2-011-02 2-011-03 2-011-04
Wood St. Wood St. Wood St.	Marstellar St. Grant St. Chauncey Ave.	Grant St. Chauncey Ave. River Rd.	2-012-01 2-012-02 2-012-03

TABLE 5. ARTERIAL-ARTERIAL INTERSECTIONS

<u>INTERSECTION</u>	<u>CODE</u>
Cherry Lane-Northwestern Ave.	1-01
Fowler Ave.-Grant St.-Northwestern Ave.	1-02
Fowler Ave.-Vine St.	1-03
North St.-Northwestern Ave.-Vine St.	1-04
Northwestern Ave.-State St.-South St.	1-05
Northwestern Ave.-U.S. 52 By-Pass	1-06
Northwestern Ave.-Wiggins St.	1-07
River Road-Robinson St.	1-08
River Road-State St.	1-09
Salisbury St.-U.S. 52-By-Pass	1-10
Vine St.-Wiggins St.	1-11

TABLE 6. ARTERIAL-COLLECTOR INTERSECTIONS

<u>INTERSECTION</u>	<u>CODE</u>
Chauncey Ave. - State St.	2-01
Cumberland Ave. - Salisbury St.	2-02
Cumberland Ave. - U.S. 52 By-Pass	2-03
Fowler Ave. - Salisbury St.	2-04
Grant St. - Salisbury St.	2-05
Grant St. - State St.	2-06
Happy Hollow Rd. - River Rd.	2-07
Happy Hollow Rd. - Soldiers Home Rd. - U.S. 52 By-Pass	2-08
Lindberg Rd. - Northwestern Ave.	2-09
Lindberg Rd. - Salisbury St.	2-10
Meridian St. - Northwestern Ave.	2-11
Meridian St. - Robinson St. - Salisbury St.	2-12
Northwestern Ave. - Stadium Ave.	2-13
River Rd. - Wood St.	2-14
Robinson St. - Stadium Ave.	2-15
Roebuck Dr. - State St.	2-16
Salisbury St. - Navajo St.	2-17
Salisbury St. - Wiggins St.	2-18

TABLE 7. COLLECTOR-COLLECTOR INTERSECTIONS

<u>INTERSECTION</u>	<u>CODE</u>
Chauncey Ave. - Wood St.	4-01
Chippewa St. - Happy Hollow Rd.	4-02
Chippewa St. - NavaJo St.	4-03
Grant St. - Meridian St.	4-04
Grant St. - Stadium Ave.	4-05
Grant St. - Wood St.	4-06
Indian Trail Dr. - Lindberg Rd.	4-07
Indian Trail Dr. - NavaJo St.	4-08
Salisbury St. - Stadium Ave.	4-09

and intersections in an urban area. The authority which develops these standards is usually the state highway department or a local organization such as the city engineering department or the public works department. The value or quality which is being measured is the ability of the street system to sever its functions adequately and safely. The only misleading word in this definition is rule. Most design and tolerable standards are not intended to be strict rules but rather serve as guiding principles.

Design and tolerable standards were developed in this investigation for the determination of the urban highway needs. Tolerable standards are a set of measurable conditions used to determine the acceptability of a street system. Tolerable standards are not as high as the standards which control new construction or reconstruction but are scaled - down versions of construction standards and provide for acceptable conditions and reasonable, economical and safe travel. (42)

Design standards are a set of street and intersection design practices which are used on all new construction and on the reconstruction of inadequate facilities. The standards used throughout this study were developed from a number of sources which included the American Association of State Highway Officials standards and the recommendations of the National Committee on Urban Transportation. After reviewing the many sets of references the values which seemed most

applicable to the West Lafayette area were selected for each item in the standards. A complete summary of design and tolerable standards for arterial, collector and local streets, design standards for expressways, types of pavement design and design vehicles used for intersection construction are shown in Appendix A.

Forecasts

The steady growth in the use of motor vehicles has compounded the problem of traffic congestion in urban areas. This increase in automobile usage has an effect on the present street system as well as greatly influencing the size and type of new facilities needed to meet future demands. Improvements in an existing street system are difficult and expensive unless proper plans are provided prior to their construction. To determine the improvements required and the traffic demands on the transportation system of the future, it is necessary to have an accurate estimate of future traffic volumes.

A review of the literature and work performed in the past indicate that most traffic forecasts have been far too conservative. The estimates for a 20-year period have often been reached in five or ten-years after the completion of the new facility. For the purposes of this investigation, all forecast items were expanded on a straight-line basis. No consideration was given to the reduction of the growth rate

with an increase in time. This technique has often been employed in past forecasting studies. If a lower traffic volume actually became the case in the future it would be to the advantage of a long-range plan rather than a disadvantage. For an estimate below the actual traffic volumes new facilities would not be designed to handle the increased requirements.

The method used to predict the traffic increase in this study was based on the three component factors of population, motor-vehicle registration and motor-fuel consumption. The predicted increase in traffic flow equals the product of the estimated increases of the three individual factors during the 20-year study period. Factors were also obtained for five-, ten- and fifteen-year periods.

Population increase. United States Census population figures are shown in Figure 3 for the State of Indiana. An examination of the population growth evidences a slightly parabolic form of increase from 1910 to 1964. Thus, in applying a straight-line estimate from 1964 to 1985, the line was extended at a steeper slope than that observed for any period in the past. The same technique was applied to the data for West Lafayette, and the population was estimated to increase from 12,680 in 1964 to 20,000 in 1985.

Motor-Vehicle Registration Increase. From records of the Indiana Bureau of Motor Vehicles motor-vehicle registration for the State were available for the period from 1940

FIGURE 3 ACTUAL AND ESTIMATED POPULATION OF INDIANA

to 1964. These values are plotted in Figure 4. Registration has increased in a reasonably straight-line fashion except for the period during World War II. Thus, for an estimate of the registration from 1964 to 1985, the past trend was simply extended to 1985. Similar data were also available for the City of West Lafayette from the 1956 and the 1964 Auto Registration Listings prepared by the Greater Lafayette Credit Bureau. Using the same procedure for West Lafayette as that used for the state-wide data, vehicle registrations were anticipated to increase from a 1964 total of 5723 to 10,000 in 1985.

Motor-fuel Consumption. The records of the Motor Fuel Tax Division of the Indiana Department of Revenue provided this investigation with the total number of gallons of motor fuel consumed annually by motor vehicles in the State of Indiana for the period from 1940 to 1964. The actual and estimated motor fuel consumptions are shown in Figure 5. The trend from 1947 to 1964 was projected in a straight-line to 1985 to estimate future fuel consumption. Figures for fuel consumption were available only on a state-wide basis, and values for West Lafayette are not presented.

The following procedure was used to calculate the State traffic growth factor for the period from 1964 to 1985.

FIGURE 4 ACTUAL AND ESTIMATED VEHICLE REGISTRATION IN INDIANA

FIGURE 5 ACTUAL AND ESTIMATED MOTOR FUEL CONSUMPTION IN INDIANA

Population Factor

Estimated 1985 population	= 7,515,000
1964 population	= 4,932,000
Factor that 1985 is of 1964	= 1.52

Vehicles Per Capita Factor

Estimated 1985 vehicle registration	= 4,660,000
Estimated 1985 population	= 7,515,000
Estimated 1985 vehicles/capita	= 0.620
1964 vehicle registration	= 2,528,000
1964 population	= 4,932,000
1964 vehicles/capita	= 0.513
Factor that 1985 is of 1964 ($\frac{0.620}{0.513}$)	= 1.21

Motor Vehicle Use Factor (Measured by Fuel Consumption in Gallons)

Estimated 1985 fuel consumption	= 4,020,000,000
Estimated 1985 vehicle registration	= 4,660,000
Estimated 1985 fuel consumption/vehicle	= 863
1964 fuel consumption	= 1,978,000,000
1964 vehicle registration	= 2,528,000
1964 fuel consumption/vehicle	= 782
Factor that 1985 is of 1964 ($\frac{863}{782}$)	= 1.10

Increase of 1985 Traffic Over 1964

Population Factor X Vehicles Per Capita

Factor X Motor Vehicle Use Factor = Traffic

Volume Factor for 1985 over 1964

$$(1.52) (1.21) (1.10) = 2.02$$

A summary of the estimated traffic growth factors is presented in the following outline for five-year time intervals. Each factor was calculated using the same procedure described above for the 1985 value. This information is also shown in graphic form in Figure 6.

Year	Growth Factor (1964-Base Year)
1964	1.00
1970	1.29
1975	1.54
1980	1.79
1985	2.02

These growth factors represent a traffic increase of approximately 3.5 percent per year between 1964 and 1985.

The traffic growth factors used in this study were all based on state-wide data because of the lack of information on fuel consumption for the City of West Lafayette. The State factors were considered as reasonable for use in this investigation because of the close comparison of the population and registration factors of the City with those of the

FIGURE 6 ESTIMATED TRAFFIC VOLUMES EXPRESSED AS PERCENTAGE OF 1964 VOLUMES

State. The population factor for Indiana was 1.52, and for West Lafayette this value was 1.46. The vehicles per capita factor for Indiana was 1.21, and for West Lafayette it was 1.20.

Collection of Data

The data collection phase of this investigation consisted of gathering various traffic and physical road information for each street control section and each major intersection. The basic data included the physical inventories of the street sections and intersections, volume counts, speed and delay information and accident characteristics. The same study procedures were used at all locations to provide uniform conditions under which the data were obtained.

Much data collected and used in this report were obtained during 1964, although some street and traffic deficiencies were noted in the early months of 1965 and have been given consideration in this study. The following four sections of this report describe the procedures used in the data collection phase of the study.

Physical Inventories

The purpose of an inventory of an urban street system is to provide a complete record of the physical features and the service demands on each section of street and at each

intersection. Information of this nature is essential if accurate needs estimates and the location of necessary improvements are to be determined. The critical conditions in the street system are usually not evident until a complete physical and operational record of the street system is obtained. Thus, complete and precise inventories are essential for the effective planning, design and operation of transportation systems in urban communities. All pertinent information with regard to street condition and the service which the street performs was described in detail.

In this study four separate inventory forms were prepared to obtain all necessary information concerning the street system. These inventory sheets are the Arterial Street Evaluation Form, the Local Street Evaluation Form, the Intersection Evaluation Form and the Arterial Structure and Railroad Evaluation Form. These forms and the instructions for completing them are shown in Appendix B. The sheets for arterial streets and arterial structures and railroad crossings were used for all arterial and collector streets. The form for intersections was used for all intersections investigated regardless of their classification. A form for local street sections, which were not included in this investigation, was developed to afford a guide for future studies which are designed to include the local street system.

The major divisions of the information recorded on the inventory forms includes the identification of the section being studied, classification of the street section in accordance with defined groupings, existing conditions, traffic data, deficiencies, proposed improvements and cost estimates. The first step in collecting the necessary data to complete the inventory forms was to gather all the information that could be obtained from office records. In this investigation data on street classification were obtained from the Tippecanoe County Planning Commission. The West Lafayette City Engineer's Office supplied the study with the methods of construction used in this area, year different street sections were resurfaced and unit construction and maintenance costs. Traffic accident records were provided by the West Lafayette Police Department.

The needed information which was not available from the above sources was secured by making field measurements. The field data were collected by means of two-man crews. One man recorded the information while the second aided in measuring and observing conditions. The data obtained in the field included such items as surface type, street width, location of utilities, type of parking, etc. The following equipment was used by each field crew:

1. 50-ft metallic cloth tape.
2. Clip-board.
3. Inventory forms.

4. Yard-stick.
5. Marking keel.
6. City street map.

Each major intersection in the city was measured in detail, and all buildings, utilities and traffic control devices were located on scaled drawings of the intersections. These drawings provided a working diagram from which deficiencies could be determined when combined with the intersection inventory forms. An example of one of the 38 intersections is the drawing presented as Figure 7.

Because of the relatively small size of this project, all information was left on the inventory forms for the final analysis. In many communities it has been found useful to transfer the inventory data to punched cards allowing analysis to be performed more rapidly with a computer.

Volume Study

This section describes the organization of the traffic volume study which is a very important phase in the determination of present and future street needs. Volume data is used in specifying the size of the geometric design of facilities, in determining the degree of congestion on the city street system and in the location of various traffic control devices. An increase in volume on a given facility over a period of time produces an increase in travel time, an increase

FIGURE 7 INTERSECTION DIAGRAM

in accidents and a reduction in operating efficiency. Thus, all possible measures should be taken to relieve congestion, and a street network should be designed to handle adequately the traffic which is expected to occur in the future.

Two control stations were established in the traffic counting procedure - one on an arterial street and the other on a collector street. According to the National Committee on Urban Transportation, for the proper location of control stations the following questions should be answered in an affirmative manner: (28)

1. Is there sufficient capacity to allow normal peaks to develop now and in the reasonable future?
2. Is the pattern of traffic free of purely localized distortions such as a nearby factory parking area?
3. Does the location provide convenient positions for counters, including servicing?

These three conditions were satisfied at both control stations selected for this study. The arterial control station was located on Northwestern Avenue between Garden Street and Oakhurst Drive, and the continuous counts made on this section were used as the basis for all counts made on arterial street sections. The other control count was made on Salisbury Street between Stadium Avenue and Oak Street. These counts formed the basis for volume estimates on the collector streets. The control counters were in operation from September 17 to 27, 1964. At each of the two control stations a record of 15-min counts was printed for an 11-day period.

Two counters were used at each station in order to measure the traffic flows in each direction. The traffic variations at these two control stations are shown in Figures 8 and 9 for the weekday period studied (Monday through Friday). All traffic counts were made while Purdue University was in session.

On the remaining street sections considered in this investigation, a sampling technique was employed to ascertain the 24-hr traffic volumes. Manual counts were made on each of the street sections shown in Tables 3 and 4. All short counts were made during the period in which the control stations were in operation. Two one-half hour counts were made on each street section - one between 7:00 a.m. and 12:00m. and the other between 12:00 m. and 7:00 p.m. The two one-half hour counts were converted to average daily traffic values using the control counts as a base. The form which was used to convert the one-half hour counts to average daily traffic figures is presented in Figure 10. The following is a description of the terms used in this procedure:

ADT_c = The average daily traffic for the control station (4764 vpd for the arterial and 1674 vpd for the collector).

K_{am} = The correction factor for the morning one-half hour count (obtained by dividing the total volume of traffic at the control station for the day the one-half hour count was made on the given street section by ADT_c)

FIGURE 8 AVERAGE WEEKDAY TRAFFIC FLOW AT ARTERIAL STREET CONTROL STATION

FIGURE 9 AVERAGE WEEKDAY TRAFFIC FLOW AT COLLECTOR STREET CONTROL STATION

- K_{pm} = The correction factor for the afternoon one-half hour count (calculated in the same manner as K_{am}).
- 1 and 2 = The direction of traffic flow (either north and south or east and west).
- S_{sam} = The morning one-half hour count made on the street section.
- S_{spm} = The afternoon one-half hour count made on the street section.
- S_{cam} = The number of vehicles passing the control station in a given direction during the same period that S_{sam} was obtained.
- S_{cpm} = The same as S_{cam} except that it is compared with S_{spm} .
- ADT_1 = The calculated average daily traffic on the street section in one direction.
- ADT_2 = The calculated average daily traffic on the street section in the opposite direction of ADT_1 .

After the average daily traffic volumes were estimated for each street section, a smoothing-out process was applied to each value. The purpose of this procedure is to logically distribute traffic flows among the various street sections. The process was accomplished as follows: (40)

1. All average daily traffic estimates were posted on a map.

2. Each successive street section was then compared with the adjacent street sections.
3. If the difference between traffic volumes on two successive sections of street appeared to be too large for the existing circumstances, the traffic volumes were adjusted to give a more logical distribution. This adjustment was accomplished by increasing or decreasing the volume on one or both sections.

The average daily traffic volumes which were used in this investigation after the smoothing-out process are shown in Figure 11 as a traffic-flow diagram.

Other volume information which was collected for this study included turning movements at all major intersections and the percentage of commercial vehicles on each street section. All turning movement counts were made during the evening traffic peak period (usually between 4:30 p.m. and 5:30 p.m.). All turning counts were for periods of 1 to 4 hr. Commercial vehicles were counted during the two one-half hour counts on each street section. The percentage of commercial vehicles and the turning movements were used in the determination of street deficiencies and needs.

FIGURE II AVERAGE DAILY TRAFFIC FLOW IN WEST LAFAYETTE

Speed-delay Study

The automobile driver often measures the desirability of a route by the time required to reach his destination; that is, he usually selects the route which minimizes the travel time. Thus, travel time studies are important in the determination of the adequacy of a street system. Travel time and delay studies provide information concerning the amount, cause, location, duration and frequency of delays as well as travel time between various terminals. Travel time and delay data can also be used to determine where various deficiencies exist in the street network and may indicate the type of improvement required.

There are many uses for travel time and delay information. Such data can be used to evaluate congestion by providing information on the amount, location and cause of delay. Before-and-after studies may utilize data of this type by investigating various traffic engineering changes in the street system. Trend studies make use of speed and delay information in connection with the changing level of service of a street system over a period of time. Speed and delay data may also be used in such areas as traffic assignment, economic studies, sufficiency ratings and congestion indices.

Various types of delay are evaluated in speed and delay studies. Fixed delay is the delay to which a vehicle is subjected regardless of the amount of traffic volume and

interference present. Operational delay is the delay caused by interference from other components of the traffic stream. Time losses resulting from congestion, parking maneuvers, pedestraints and turning movements are all examples of operational delays. Travel time delay is the difference between the actual time required to traverse a section of street and the time corresponding to the average speed of traffic at a point of uncongested flow on the section. This type of delay includes acceleration and deceleration delay in addition to stopped-time delay. Stopped-time delay is the time a vehicle is actually standing still because of any influencing factor. All these types of delay were recorded in this investigation.

(27)

The "average speed" method was used to obtain the speed and delay data for this study. The driver of the test car in this technique travels at a speed that, in his opinion, is representative of the speed of all the traffic at the time of the test run. The runs were made under normal weather conditions in the direction of the predominant peak-hour flow (usually between 4:30 p.m. and 5:30 p.m.). The evening peak-hour was selected for the trial runs on the basis of volume counts. These counts indicated that the evening traffic volumes were generally the highest and thus the most critical. All runs were made on a weekday (Monday through Friday) so traffic conditions were about the same for each test run.

The terminals of the test run sections were in general the same as those used for the street inventories (see Tables 3 and 4). In some cases two or three of the street sections were combined into one travel time section to provide reliable travel time data. A total of 44 travel time street sections were evaluated in the urban needs study for West Lafayette.

The equipment used in the study was as follows:

1. Automobile.
2. Stop-watch.
3. Clip-board.
4. Field forms.
5. Tape recorder.
6. Power converter.

The power converter permitted the tape recorder to be operated from the electrical system of the automobile. The technique required only one man in the car during the test runs. The stop-watch was controlled by the driver, and the times were recorded on tape when the vehicle passed control stations and when delays were encountered. The cause of each delay was also recorded along with any other pertinent information. The data were transcribed from the tape, and all information was tabulated on the Travel Time Study Form shown in Figure 12.

The following discussion describes each of the items, A through H, that were filled out on the Travel Time Study Form:

TRAVEL TIME DATA

Street _____ Classification _____

Direction _____ Code _____

Control Points _____ Driver _____

Start _____

Finish _____

Trip No.	Date	Day	Start Time	Elapsed Time		Stopped Time		Cause of Stops	No. of Stops
				Min.	Sec.	Min.	Sec.		
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

A. Travel Time	
B. Length	
C. Speed	
D. Rate of Motion	
E. Standard Rate	
F. Delay Rate	
G. Volume	
H. Vehicle Delay Rate	

FIGURE 12. TRAVEL TIME STUDY FORM

- A. Travel time - the total elapsed time of travel, including all stops and delays, necessary for a vehicle to travel from one point to another over a specified street section under existing traffic conditions. It is the average in minutes of the ten runs made over each section.
- B. Length - distance over the travel time section in miles.
- C. Speed - the average speed over the section in miles per hour.

$$V = \frac{60 \times \text{LENGTH (MILES)}}{\text{TRAVEL TIME (MIN)}}$$

- D. Rate of motion - the travel time expressed in minutes per mile.

$$R. M. = \frac{60}{\text{SPEED}}$$
- E. Standard rate of motion - the selected desirable rate, in minutes per mile, that can be obtained while traversing a given street section. In this investigation these values ranged from 3.00 to 1.33 min/mile (20 to 45 mph). Personal judgment was used to select this value for a given street section.
- F. Delay rate - difference between the rate of motion and the standard rate of motion expressed in min per mile.
- G. Volume - one-directional, peak-hour volume in vehicles per hour.

H. Vehicle delay rate - the total time lost, in vehicle-minutes per mile, by vehicles in the traffic stream because the street section does not meet the suggested minimum standards. The vehicle delay rate is obtained by multiplying the one-directional, peak-hour volume by the delay rate.

The cumulative speed curve for the 44 travel time street sections is plotted in Figure 13. The median speed (50th percentile) for all street sections was observed to be 22 mph and the 85th-percentile speed was 31 mph.

Accident Study

Analysis of accidents is an important phase in an urban needs study. The location and type of accidents are major indicators of where deficiencies exist in the street network. Through accident studies overall geometric design can be improved to make it more difficult for drivers to get into trouble. For example, the studies may indicate where medians, access control, signs or signalization are required. Other uses of accident studies include application in evaluating different designs, in before-and-after studies and in the computation of economic losses due to the lack of safety.

The six basic steps followed in the study of accident experience at the selected locations in West Lafayette were:

1. Obtaining adequate vehicle accident reports.

FIGURE 13 CUMULATIVE SPEED CURVE FOR 44 STREET SECTIONS

2. Selecting high-accident locations.
3. Preparing collision and condition diagrams for each location.
4. Summarizing the accidents along the street sections.
5. Supplementing accident data with field observations during hours when most collisions occurred.
6. Analyzing the summarized facts and field data to prescribe remedial treatment.

In this study accident reports were collected for the three-year period of 1961 through 1963. All accident records of the West Lafayette Police Department were made available for this investigation. The reports were on forms like the one shown in Figures 14 and 15. Each accident form was studied for the three-year period, and the following information was recorded for further investigation: 1) type of accident, 2) time of day, 3) location, 4) weather and road condition, and 5) if there was property damage, an injury or a death. Each accident was typed according to the following possible categories:

1. Right angle.
2. From same direction - both (or all) going straight.
3. From same direction - one turning, one straight.
4. From same direction - one stopped.
5. From same direction - one backed into other.
6. From same direction - sideswipe.
7. From opposite directions - both going straight.

Mall Report To: INDIANA STATE POLICE, INDIANAPOLIS 4, INDIANA

DO NOT WRITE IN THIS SPACE	
(8) TYPE _____	(19) SOURCE _____ (10-11) ANALYSIS _____ (12-13-14-15) LOSS _____ (16) LOCATION _____ (2-3-4-5-6-7) ACCIDENT NO. _____
TIME _____	(17-18) DATE OF ACCIDENT _____ (19-20) DAY OF WEEK _____ (21) TIME OF DAY _____ (22-24) _____
LOCATION _____	(25-26) PLACE WHERE ACCIDENT OCCURRED: _____ (27) COUNTY _____ (28-29) CITY OR TOWN _____ (30-31) TOWNSHIP _____ (32-33-34) ROAD ON WHICH ACCIDENT OCCURRED _____ (35-36) CITY OR TOWN _____ (37-38-39-40) AT ITS INTERSECTION WITH _____
(32-33-34) ROAD ON WHICH ACCIDENT OCCURRED _____	(35-36) CITY OR TOWN _____ (37-38-39-40) AT ITS INTERSECTION WITH _____
IF NOT AT INTERSECTION, FEET _____ OF _____	
Show nearest intersection, house number, or other identifying landmark.	
VEHICLE 1: (41) YEAR _____ (42-43) MAKE _____ TYPE _____ Sedan, Truck, Bus, etc. (44) LICENSE PLATE _____ Number _____ State _____ Year _____ DRIVER (Print) Last Name _____ First _____ Middle _____ ADDRESS (Print) Street or R.F.D. _____ (45-46) City _____ (47) State _____ BIRTH DATE _____ AGE _____ SEX _____ (48) DRIVER'S LICENSE _____ Number _____ State _____ Type _____ (49) OWNER _____ Last Name _____ First _____ Middle _____ ADDRESS _____ Street or R.F.D. _____ City _____ State _____ PARTS OF VEHICLE DAMAGED _____ ESTIMATE OF REPAIR \$ _____ VEHICLE REMOVED TO _____ BY _____ (53-54) (55) NAME (Print) Last Name _____ First _____ Middle _____ AGE _____ SEX _____ ADDRESS _____ (56) Street or R.F.D. _____ City _____ (57) State _____ DRIVER _____ PASSENGER _____ IN VEHICLE NUMBER _____ PEDESTRIAN _____ Other (EXPLAIN) _____ NATURE AND EXTENT OF INJURIES _____ Injured (51) _____ Total Number Killed (50) _____ Total Number Killed (50) _____	VEHICLE 2: (41) YEAR _____ (42-43) MAKE _____ TYPE _____ Sedan, Truck, Bus, etc. (44) LICENSE PLATE _____ Number _____ State _____ Year _____ DRIVER (Print) Last Name _____ First _____ Middle _____ ADDRESS (Print) Street or R.F.D. _____ (45-46) City _____ (47) State _____ BIRTH DATE _____ AGE _____ SEX _____ (48) DRIVER'S LICENSE _____ Number _____ State _____ Type _____ (49) OWNER _____ Last Name _____ First _____ Middle _____ ADDRESS _____ Street or R.F.D. _____ City _____ State _____ PARTS OF VEHICLE D-MAGED _____ ESTIMATE OF REPAIR \$ _____ VEHICLE REMOVED TO _____ BY _____ (53-54) (55) NAME (Print) Last Name _____ First _____ Middle _____ AGE _____ SEX _____ ADDRESS _____ (56) Street or R.F.D. _____ City _____ (57) State _____ DRIVER _____ PASSENGER _____ IN VEHICLE NUMBER _____ PEDESTRIAN _____ Other (EXPLAIN) _____ NATURE AND EXTENT OF INJURIES _____
1. _____ 2. _____ 3. _____ 4. _____	1. _____ 2. _____ 3. _____ 4. _____
DAMAGE TO OTHER PROPERTY _____ Name of Object (s) _____ Owner's Name and Address _____ Nature of Damage _____ ESTIMATE OF REPAIR \$ _____	

This form is approved by the Superintendent, Indiana State Police, pursuant to Burns Indiana Statutes 47-1918, Acts 1939, Ch. 48.

FIGURE 14 INVESTIGATING OFFICERS ACCIDENT FORM - SIDE ONE

<p>(19) CHEMICAL TEST Driver 1 Ped 2 (Check one) 0. No test offered 1. Test offered but refused 2. Breath test given 3. Blood test given 4. Urine test given</p>	<p>INDICATE ON THIS DIAGRAM WHAT HAPPENED</p> <p style="text-align: right;">DRAW DIAGRAM TO SCALE</p>	<p style="text-align: center;">Indicate North by arrow</p>	
<p>(60) ARREST—(Check one) Driver 1 2 0. Not arrested. 1. Arrested for D.U.I. 2. Arrested for other violation</p>	<p>DESCRIBE WHAT HAPPENED: Refer to vehicle by number</p>		
<p>(21) SPEED LIMIT MPH (22) SPEED BEFORE ACCIDENT Veh 1 MPH Veh 2 MPH</p>			
<p>(61) CONTRIBUTING CIRCUMSTANCES INDICATED Driver 1 2 1. Speed too fast. 2. Failed to yield right-of-way 3. Drove left of center 4. Improper overtaking 5. Passed stop sign. 6. Disregarded traffic signal. 7. Followed too closely. 8. Made improper turn 9. Other improper driving 10. Inadequate brakes 11. Improper lights 12. Had been drinking</p>	<p>WHAT DRIVERS WERE GOING TO DO BEFORE ACCIDENT: (62) Driver No 1 was headed N S E W on _____ (Name or number of street or highway.) Driver No 2 was headed N S E W on _____ (Name or number of street or highway.) (Check applicable items for each driver.) Driver 1 Driver 2 Driver 1 Driver 2 0. Passing 2. Backing 5. Start from parked position 1. Turn right 3. Slow or stop 6. Avoiding veh., obj., ped. 1. Turn left 4. Going straight ahead 7. Skidded before applying brakes. 1. Make U turn 5. Start in traffic lane 9. Skidded after applying brakes. 1. Other defects</p>		
<p>(64) VEHICLE DEFECTS Driver 1 2 0. No defects 1. Brakes defective 2. Lights defective 3. Defective steering 4. Puncture or blowout 5. Other defects</p>			
<p>(65) VISION OBSCURED Driver 1 2 0. Not obscured. 1. By building/s. 2. By embankment. 3. By signboard. 4. Trees, crops, etc. 5. By hillcrest 6. _____ (Specify other)</p>	<p>WHAT PEDESTRIAN WAS DOING BEFORE ACCIDENT (67) Pedestrian was going N S E W across or into _____ Street or Highway From _____ to _____ (N E corner to S E corner or from West side to East side, etc.) (Check one) 0. Not in roadway 5. Other working in roadway 1. Walking in roadway with traffic 7. Playing in roadway 2. Walking in roadway against traffic 8. Other (Specify actions) 3. Pushing or working on vehicle 11. Crossing or entering not at intersection 4. Getting on or off vehicle 12. Crossing or entering at intersection. 5. Standing in roadway</p>		
<p>(72) TRAFFIC CONTROL Driver 1 2 0. Police officer 1. Automatic signal 2. Yield right-of-way sign 3. Center line marked 4. Other lane markings 5. Stop sign 6. Warning sign or signal 7. No passing zone 8. All others</p>			
<p>(73) CHARACTER (74) (Check two) 1. Straight. 2. Curve 1. Level 2. On grade 3. Hillcrest</p>	<p>(76) SURFACE (Check one) 1. Concrete 2. Blacktop 3. Sand or dirt 4. Gravel 8. Other</p>	<p>(78) CONDITION (Check one) 1. Dry 2. Wet 3. Snow/ice 8. Other</p>	
<p>(77) WEATHER (Check one) 1. Clear 2. Rain 3. Snowing 4. Fog 8. Other</p>	<p>(78) LIGHT (Check one) 1. Daylight 2. Dusk 3. Dawn or dusk 8. Other</p>	<p>(78) KIND OF LOCALITY (Check one to show that area adjacent to roadway for 300' was primarily 1.) 1. School or playground. 2. Industrial or business. 3. Residential. 4. Open country.</p>	
<p>(80) ROAD DEFECTS 1. Foreign material on surface 2. Loose sand, gravel, etc. 3. Holes, ruts, dips, bumps, etc. 4. Defective shoulders 5. Obstruction not lighted or signaled 6. Standing water, landslide, etc. 7. Obstructed by previous acc. 8. All other defects</p>	<p>WITNESSES Name _____ Address _____ Location _____ Name _____ Address _____ Location _____</p> <p>POLICE ACTION Name _____ Charge _____ Name _____ Charge _____</p> <p>INVESTIGATION: Time notified of accident _____ AM _____ PM Time of arrival at the scene _____ AM _____ PM Where else was investigation made? _____ Is investigation complete? Yes _____ No _____ Were photographs taken? Yes _____ No _____ Driver report form furnished to driver No. 1 _____ driver No. 2 _____ *SIGNATURE _____ Date of report _____</p>		

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FIGURE 15 INVESTIGATING OFFICERS ACCIDENT FORM—SIDE TWO

FIGURE 16 ACCIDENT LOCATION MAP FOR THE MAJOR INTERSECTIONS IN WEST LAFAYETTE FOR THE YEAR 1963

FIGURE 17 INTERSECTION CONDITION DIAGRAM

FIGURE 18 COLLISION DIAGRAM FOR NORTHWESTERN, STATE & SOUTH—1961

FIGURE 19 COLLISION DIAGRAM FOR NORTHWESTERN, STATE & SOUTH - 1962

FIGURE 20 COLLISION DIAGRAM FOR NORTHWESTERN, STATE & SOUTH-1963

8. From opposite directions - one left other straight.
9. From opposite directions - one stopped.
10. From opposite directions - sideswibe.
11. Pedestrian.
12. Run off road.
13. Hit fixed object.
14. Hit parked car.
15. Out of control.
16. All other.

The accidents of major concern in this study occurred within 200 ft of each of the 38 intersections under investigation. A spot map of the accidents at these intersections for the year 1963 is presented as Figure 16. Similar maps were prepared for the years 1961 and 1962. A condition diagram showing all physical features and three collision diagrams (one for each year studied) were also drawn for each intersection. An example of one of the 38 condition diagrams is given in Figure 17, and Figures 18, 19 and 20 show the collision diagrams for the three-year accident experience at this intersection.

Accident summary sheets were also available from the West Lafayette Police Department. These data were used to summarize accidents over the three-year period (1961 through 1963) along street sections with unusually high accident rates. The topics into which these sheets are divided were as follows: 1) type of accident, 2) street classification,

3) age of casualty, 4) time of day, 5) pedestrian actions by age, 6) age of driver, 7) sex of driver, 8) residence of driver, 9) contributing circumstances, 10) type of motor vehicle, 11) surface condition, 12) light condition, 13) geographic location and 14) road characteristics. These summary sheets were used to study accident patterns and traffic hazards in the street system. The methods used to analyze the accident data and to determine deficiencies on the basis of this analysis are discussed in the section on Determination of Deficiencies and in the Results of this report.

Analysis of Data

This section of the study deals with three basic topics; determination of deficiencies, cost estimates and sampling techniques. The methods by which the collected data were used to determine street system deficiencies are described. Techniques are also discussed for calculating the cost of street needs for various future time periods. The final portion in the analysis phase deals with the development of sampling procedures for estimating municipal street improvement costs.

Determination of Deficiencies

The process by which the data collected in this study were analyzed to determine the deficiencies in the city street system is developed in this portion of the report. Separate files were compiled for each of the 69 street sections and 38 intersections. The primary data in each of the street section files, before an analysis had been made, included the inventory sheet, the estimate of the average daily traffic and information on travel time and delays over the section. The information in the intersection files consisted of the inventory sheet, estimated approach volumes on each branch of the intersection, peak-hour turning movements, a three-year accident summary, collision diagrams, signal-timing chart and a scaled drawing of the intersection. The following sections provide a description of the manner in which each item of information in the files was used to determine street and intersection deficiencies.

Inventory. The deficiencies were determined by comparing the inventory data with the corresponding tolerable standards given in Appendix A. These comparisons indicated whether or not the street sections or intersections were presently deficient. It was assumed that reconstruction could not be economically justified if the section or intersection under study could still serve traffic in an economic and safe

manner, that is, if the section was within the limits of the tolerable standards. The nature and time of expected future deficiencies were estimated for those sections which were tolerable but did not meet the design standards (see Appendix A for design and tolerable standards). To determine these future needs use was made of various road-life studies and the traffic growth forecast for the city. All sections which were not tolerable in accordance with the specified standards were designated as being deficient at the present time. Present deficiencies should ideally be reconstructed to design standards if the financial resources are available. Exceptions to this principle were cases where it was impractical to bring existing facilities up to design standards. In these situations reconstruction should be at least to the level of the tolerable standards.

All physical features of the street system, including everything within the right-of-way such as curbs and gutters, sidewalks, utilities, traffic-control devices, sight distances, etc., were given consideration in this physical needs determination. Where these items did not meet the proper standards, corrective measures were recommended to eliminate the existing deficiencies.

A portion of the data from the street inventory and condition survey are summarized in Figure 21 which gives the miles of street by surface type for each classification. A total of 21.43 miles of arterial and collector streets were studied in this investigation.

FIGURE 21 MILES OF STREET BY SURFACE TYPE AND CLASSIFICATION

Traffic Movement. The same procedure which was used for the inventories was applied for the determination of deficiencies in connection with traffic movement. The existing conditions were compared with the developed tolerable standards to determine the present needs. The basis for all future estimates were the traffic growth factors developed in this report (see Figure 6). These growth factors were applied to all present traffic volumes, and volume estimates were obtained for five-year periods up to 1985. On the basis of these traffic estimates a determination was made as to when future improvements are needed in the street system.

The items which were investigated on each street section and at each intersection were volumes, turning movements, percentage of commercial vehicles and the results of the speed-delay study. Volumes were studied on each street section and compared with the practical capacities of each street and intersection approach. Where the capacities were exceeded or are exceeded at some time in the future, necessary improvements, such as elimination of parking, street widening, rerouting of traffic or the establishment of one-way streets were specified to eliminate the capacity deficiencies. Turning movements were investigated at each intersection with consideration given to signing, pavement markings and the possibility of eliminating some turns to provide safer and faster traffic flow. An investigation of the speed-delay study revealed locations where street improvements and

traffic control devices could be employed to move traffic in a more efficient manner.

Accidents. The accident analysis which was conducted in West Lafayette indicated that many accidents were related to a probable cause. Using all available information, an attempt was made to define accident patterns and traffic hazards at each of the study locations.

The collision and condition diagrams for each of the 38 intersections were very useful in revealing accident types and causes. Collision and condition diagrams were also drawn for a few street sections which had an unusually high number of accidents. These diagrams were useful in identifying accidents of the following types, which aided in determining needed traffic improvements:

1. Right-angle collisions - poor sight distance at corners is often the cause of this type of accident.
2. Left-turn collisions involving vehicles approaching from opposite direction - improper lane markings, signs and signalization may produce these accidents.
3. Rear-end collisions - in most cases these accidents are the fault of the driver, although lane markings and signs may have some effect.
4. Vehicle and pedestrian accidents - properly marked crosswalks and signal phases for pedestrians may be needed.

5. Collisions involving turning, lane-changing, or sideswiping between vehicles traveling in the same direction - lane markings and over-head signs well in advance of lane changes and turning lanes are usually required to avoid accidents of this nature.
6. Head-on collisions - jogs at intersections or improperly maintained center lines may cause accidents in this class.
7. Vehicles running off the road - sharp curves and high speeds are the major factors in these accidents.
8. Collisions with fixed objects - accidents of this designation may be caused by obstacles too near the roadside or improperly placed at intersections.
9. Collisions with parked vehicles - parking permitted too close to an intersection or on streets which are too narrow for proper traffic movement often produce this type of accident.

Field studies were made at each high accident location with the collision and condition diagrams and accident summaries used as references. Actual traffic movements were observed during the hours when the highest number of collisions had occurred. These observations were particularly valuable in the accident analysis because they indicated where improvements were required. The following questions were given consideration during these field studies at each critical location: (25)

1. Are the accidents caused by the physical conditions of the street or adjacent property?
2. Is traffic properly channelized?
3. Is parking in the area contributing to accidents?
4. Is a blind corner responsible for accidents?
5. Are the existing signs, signals, and pavement markings doing the job for which they were intended?
6. Are there adequate advance warning signs of route changes so that the proper lanes may be chosen by approaching motorists well in advance of the area?
7. Are night accidents far out of proportion to daytime accidents, when they are based on traffic volume, indicating the need for special nighttime protection?
8. Would accidents be prevented by the prohibition of any single traffic movement, such as a minor left-turn movement?
9. Do conditions show that additional traffic laws or selective enforcement are required?
10. Can part of the traffic be diverted to other thoroughfares where the accident potentialities are not as great?

After the necessary information was collected (collision and condition diagrams, summary reports and field observations), an analysis was made of each location. Accidents were summarized by type for each intersection (see Table 8), and this classification indicated in many cases the causes

TABLE 8. SUMMARY OF INTERSECTION ACCIDENTS BY TYPE FOR 1961, 1962 and 1963

INTERSECTION*	TYPE OF ACCIDENT															
	ANGLE	FROM SAME DIRECTION				FROM OPPOSITE DIRECTIONS					PEDESTRIAN	OFF ROAD	HIT OBJECT	PARKED CAR	LOST CONTROL	ALL OTHER
		STRAIGHT	TURNING	STOPPED	BACKING	SIDESWIPE	HEAD-ON	TURNING	STOPPED	SIDESWIPE						
1-01	1	1	1	1	1	1		4			2	2	1			1
1-02	6	9	16	1	3			2			3	2	1			
1-03	3	2	1					2				1	1			
1-04	2			1	2						3	1	1			
1-05	4	4	9		5						2	1	1			
1-06	18		2		1							2	1			
1-07			3	1	2							1	1			
1-08	2	28	23	4	7			1	2		1	1	1			
1-09	6	9		1	1						1	1	1			
1-10	4		1		1											
1-11	34															
2-01	8	2	1	4	3	9		1				1				
2-02																
2-03																
2-04		1	1	1	1											
2-05	3	7	4	13	5			5				1	1			
2-06	2	2														
2-07	3	1	1													
2-08	8	1	5	2	1	1	2	4								
2-09	3	4		1	1											
2-10	1	1														

TABLE 8 (continued)

INTERSECTION	TYPE OF ACCIDENT															
	ANGLE	FROM SAME DIRECTION				FROM OPPOSITE DIRECTIONS				PEDESTRIAN	OFF ROAD	HIT OBJECT	PARKED CAR	LOST CONTROL	ALL OTHER	
		STRAIGHT	TURNING	STOPPED	BACKING	SIDESWIPE	HEAD-ON	TURNING	STOPPED							SIDESWIPE
2-11	2	1		1				3		2	1		1			
2-12	6	1		2	1			10		1						
2-13	2	3	6	9	1											
2-14	1		3	5				1								
2-15	2		1					4			2	2				
2-16	9	11	5		1	4	2									
2-17											1	1	1			
2-18	7	2	2					2								
4-01	3										1		1			
4-02	1															
4-03	3				1											
4-04	5				1								2			
4-05	1	2	1	2	2	1		1					1			
4-06	6					1							2			
4-07	9															
4-08	1					1							1			
4-09	14	2		1				2			1	1				
TOTAL	171	93	39	97	24	43	6	43	1	9	5	24	15	16	5	8

* For intersection location see Tables 5, 6, and 7.

and necessary remedies. An attempt was then made to determine the best corrective measures desirable at each location.

Priority Rating

The street sections and intersections investigated in this study were arranged in the order in which they should be improved. The rating method used was the Street Improvement Priority Rating developed for West Lafayette, Indiana. The system set up by this city was revised for the purposes of this study so intersections could be rated as well as street sections. The form used for the improvement priority rating and the instructions for completing it are shown in Appendix D.

A separate form was prepared for each of the 69 street sections and 38 intersections. The possible points for the priority rating range from +100 for the highest priority to -100 for the lowest priority. Lists of street sections and intersections were then prepared for use as tools in determining the priority of improvements.

Cost Estimates

After the deficiencies were computed for each street section and intersection, the costs of the needed improvements were estimated to determine the financial needs. A list was made of the needs for each section and the time by

which they should be completed was determined. The cost of each required improvement was then calculated using 1964 prices.

Most unit costs were obtained from the City Engineer's Office of West Lafayette. Additional figures were supplied by the West Lafayette Water Company, General Telephone Company of Indiana, Public Service of Indiana and various references. (32,35,36) A listing of the unit prices used in this study to estimate the cost of the municipal street improvements are presented in Table 9.

Development of Sampling Techniques

Sampling procedures were applied to the improvement costs required for the street sections and intersections in the year 1965. Sampling of the street sections and intersections was not investigated for the other time periods considered because of the insufficient number of cost values. This same restriction was applicable to the structure and railroad crossings for all time periods.

The purpose of the statistical considerations was to determine if reliable cost estimates could be obtained by sampling techniques. It was desired to estimate the total cost of improving the street sections and intersections in a given classification by determining the cost for a random sample of these locations. To obtain the total cost of a

TABLE 9
ESTIMATED IMPROVEMENT COSTS USED FOR MUNICIPAL STREET IMPROVEMENTS
TYPICAL UNIT COSTS AT 1964 PRICES[†]

ITEM	UNIT	UNIT COST
Local Streets-New Construction (6 in. in place)		
Bituminous surface.....	Sq. Yd.	\$4.25 to \$ 4.50
Concrete.....	Sq. Yd.	4.90 to 5.00
Arterial and Collector Streets (in place)		
Soil cement (12% cement).....	Sq. Yd./In.	1.60
Crushed stone or gravel type 53 or No. 63 subbase in compacted condition.....	Sq. Yd./6 In.	0.70
Subbase pit-run in compacted condition.....	Sq. Yd./6 In.	0.35
Binder (100 lb./sq. yd./in.).....	Ton	11.00
Surface (100 lb./sq. yd./in.).....	Ton	12.00
Prime (0.5 gal./sq. yd.).....	Gal.	0.20
Tack (0.2 gal./sq. yd.).....	Gal.	0.20
Asphalt stabilized base.....	Sq. Yd.	0.80
Bituminous Asphalt Patching Material.....	Ton	7.50
Curb and Gutter		
Remove old.....	Lin. Ft.	0.75
Construction new.....	Lin. Ft.	2.50
Sidewalks		
Remove old.....	Sq. Ft.	0.10
Construction new.....	Sq. Ft.	0.60
Medians		
4-ft. wide.....	Lin. Ft.	7.20
6-ft. wide.....	Lin. Ft.	8.30
10-ft. wide.....	Lin. Ft.	10.50
20-ft. wide.....	Lin. Ft.	16.00
Excavation		
Used as fill.....	Cu. Yd.	0.75
Hauled away.....	Cu. Yd.	2.00
Fill.....	Cu. Yd.	1.00
Street Removal		
Bituminous.....	Sq. Yd.	2.50
Concrete.....	Sq. Yd.	12.00

TABLE 9 (continued)

ITEM	UNIT	UNIT COST
Shoulder		
Pit-run subbase in compacted condition.....	Sq. Yd./6 In.	\$ 0.35
Bituminous treatment*.....	Sq. Ft.	0.40
Clear and Grub*		
Wooded area.....	Acre	250.00
Tree.....	In. Dia.	5.00
Shrub.....	Each	\$ 30.00 to 50.00
Raise Man Hole.....	Each	50.00
Fire Hydrant Relocation ^{††}	Each	450.00 to 500.00
Drainage		
Catch basin (in place where sewers exist).....	Each	150.00
Pipe culvert 18 in.*.....	Lin. Ft.	5.50
Pipe culvert 36 in.*.....	Lin. Ft.	14.00
Sodding*.....	Acre	300.00
Parking Meter Removal		
In pavement.....	Each	10.00
In soil.....	Each	7.50
Traffic Signal		
New.....	Each	400.00
Relocate.....	Each	75.00
Street Light**.....	Each	375.00
Utility Pole Relocation ^{†††}		
Pull 25 in. pole.....	Each	5.25
Pull 30 in. pole.....	Each	8.62
Relocate pole.....	Each	25.00
Signs***		
Move.....	Per Post	2.50
Erect.....	Per Post	1.00
Stop sign 30 in.x 30 in.	Each	7.50
Standard sign 24 in.x 30 in.	Each	6.00
Steel channel sign post 10 ft. long.....	Each	4.25
Sign brackets for poles 3 in. to 8.5 in.	Pair	1.85

TABLE 9 (continued)

ITEM	UNIT	UNIT COST
Painting		
White line (paint).....	Ft.	\$ 0.07
Yellow curb (paint).....	Ft.	0.10
White line (permiline).....	Ft.	0.35
White paint (plain).....	Gal.	2.50
White paint (glass beads)....	Gal.	3.95
Yellow paint (plain).....	Gal.	2.60

+ All items not referenced were obtained from the City Engineer's Office of West Lafayette, Indiana.

++ West Lafayette Water Co., Inc.

+++ General Telephone Co. of Indiana.

* Reference (32).

** Public Service of Indiana, Inc.

*** References (35) and (36).

population, the mean of the sample was calculated and multiplied by the number of sections in that particular category.

The following populations were investigated in this study:

1. Intersections of collector streets.
2. Intersections of arterial streets.
3. Intersections of arterial and collector streets.
4. All intersections in 1, 2 and 3.
5. Collector street sections.
6. Arterial street sections.
7. All street sections in 5 and 6.

The populations were sampled separately because of the large variability in the cost values between the different categories.

Each of the above populations was sampled, and the results of 1, 2, 3, 5 and 6 or 4 and 7 were added to estimate the present total cost of improving the street system in West Lafayette. To increase the precision of an estimate, the sample size must be increased.

The standard deviation of each population was calculated by the following equation:

$$\sigma = \sqrt{\frac{\sum (x_i - \bar{X})^2}{N - 1}}$$

where;

σ = Standard deviation of the population in dollars.

x_i = Individual cost value of present improvements required for a street section or intersection in dollars.

$\bar{X}$ = Mean cost value of present improvements required of all street sections or intersections in the given category in dollars.

N = The total number of street sections or intersections in the given population.

The population means, standard deviations and total number of street sections or intersections in each category are listed in Table 10.

Samples of size 10, 20, 30, 40, 50, 60, 70, 80 and 90 percent were considered for each population. For each sample size in a given population class the standard error of the mean was obtained using the following equation:

$$\sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}} \sqrt{\frac{N-n}{N-1}}$$

where,

$\sigma_{\bar{X}}$ = Standard error of the mean for a given sample size in terms of dollars.

σ = Standard deviation of the population in dollars.

n = Sample size - number of street sections or intersections taken from the total population.

N = Population size - number of street sections or intersections in the given population.

TABLE 10. POPULATION CHARACTERISTICS

POPULATION	TOTAL NUMBER OF UNITS	MEAN (DOLLARS)	STANDARD DEVIATION (DOLLARS)
Collector collector intersections	9	1959.00	930
Arterial arterial intersections	11	2475.32	2661
Arterial collector intersections	18	3051.83	4003
All intersections	38	2626.12	3109
Collector street sections	32	3285.58	3937
Arterial street sections	37	6954.20	11629
All street sections	69	5252.81	9058

$\left(\frac{N - n}{N - 1}\right)$ = Finite population correction factor - this term was used because of the small population sizes.

The percentage of sample size versus the standard error of the mean, in terms of the cost of improvement, is shown in graphic form for each of the populations in the Results of this report. Using these graphs it is possible to predict the amount of error to be expected in estimating the total cost of improving a given class of streets or intersections using a known sample size in West Lafayette, Indiana.

RESULTS

This section of the report summarizes the major findings in connection with the physical street system needs in West Lafayette and the financial requirements necessary to improve present and future deficiencies within this community. The priorities for improvement are also discussed along with the sampling techniques applied to the needs study. The sampling study investigated the reliability of estimating total financial needs with a sample survey of randomly selected street sections and intersections.

Physical Needs

A portion of the data from the street inventory and condition survey are summarized in Figure 22. Of the 21.43 miles of arterial and collector streets in the West Lafayette system, 4.04 miles or approximately 19 percent were rated as needing resurfacing, reconstructing or widening at the present time. Within the next 20 years an additional 8 percent of these streets will require reconstruction or widening. Curbs and gutters need replacing along many street sections and at some of the intersections. Sidewalks are needed along many streets where they do not exist, and at some locations

FIGURE 22 MILES OF NEEDED WORK
IN WEST LAFAYETTE

the sidewalks need replacing. A description of the physical needs on each street section and at each intersection are given in Appendix C.

One major need in connection with traffic movement is the elimination of on-street parking along many street sections. This need for eliminating parking will increase with time as the volumes of traffic on the streets increase. The largest traffic volumes at the present time exist along State Street. This facility is operating near possible capacity during the peak-hours of traffic flow. The expected increase in future traffic can not be carried by this street section alone. A portion of the future traffic volume will be required to use Fowler Avenue and Wiggins Street in moving between West Lafayette and Lafayette.

There was a total of 1667 accidents in West Lafayette during the three-year period (1961 through 1963). An example of a high accident section was the State Street Levee between the Wabash River and the intersection of State Street, Brown Street and the River Road. The accidents along this section amounted to 173 between 1961 and 1963, or 10.35 percent of the total number of accidents in the city for that period. The summarizing facts prepared for street sections and intersections were the number of accidents by time of day, number of accidents by month of year and number of accidents by age of driver. Summary graphs for the State Street Levee

are shown in Figures 23, 24 and 25. About 35 percent of the drivers involved in accidents along the State Street Levee were between the ages of 20 and 24 (see Figure 23). The highest accident month for this location is shown in Figure 24 to be October. The largest number of accidents occurred during the afternoon and evening hours of the day (see Figure 25). These results have been presented with specific values for the State Street Levee, although the trends are typical for the city as a whole.

About 40 percent of the accidents occurring in West Lafayette during the three-year study period took place at the 38 intersections under investigation and along the State Street Levee. All of these accidents and their causes were given consideration in the determination of the needed improvements to the street system in West Lafayette.

Priorities

Using the Street Improvement Priority Rating developed for West Lafayette, Indiana, lists of street sections and intersections were prepared as tools in determining priorities of improvement. The results of this sufficiency rating system are presented in Tables 11 and 12 for street sections and intersections, respectively. The location of a portion of the priorities are also shown in Figures 26 and 27.

FIGURE 23 NUMBER OF VEHICLES INVOLVED IN ACCIDENTS BY AGE OF DRIVER
ON STATE STREET LEVEE FOR THE PERIOD 1961 THROUGH 1963

FIGURE 24 NUMBER OF ACCIDENTS BY MONTH OF YEAR ON STATE STREET
LEVEE FOR THE PERIOD 1961 THROUGH 1963

FIGURE 25 NUMBER OF ACCIDENTS BY TIME OF DAY ON STATE STREET LEVEE FOR THE PERIOD 1961 THROUGH 1963

TABLE 11. ARTERIAL AND COLLECTOR STREET IMPROVEMENT PRIORITIES

STREET	FROM	TO	CODE	PRIORITY RATING	PRIORITY
River Road	South City Limits	Wood St.	1-005-01	+72	1
Salisbury St.	Lindburg Rd.	U.S. 52 By-Pass	1-007-03	+48	2
U.S. 52 By-Pass	Salisbury St.	Northwestern Ave.	1-009-03	+38	3
River Road	Happy Hollow Rd.	Catherwood Dr.	1-005-07	+36	4
Robinson St.	Stadium Ave.	Salisbury St.	1-006-02	+35	5
Salisbury St.	Grant St.	Lindberg Rd.	1-007-02	+34	6
U.S. 52 By-Pass	Happy Hollow Rd.	Salisbury St.	1-009-02	+32	7
Stadium Ave.	Russell Dr.	Northwestern Ave.	2-011-01	+32	8
River Road	Wood St.	State St.	1-005-02	+30	9
Grant St.	State St.	Northwestern Ave.	2-003-04	+28	10
Northwestern Ave.	State St.	North St.	1-004-01	+27	11
Robinson St.	River Rd.	Stadium Ave.	1-006-01	+26	12
Salisbury St.	Stadium Ave.	Robinson St.	2-009-02	+25	13
State St.	Northwestern Ave.	Grant St.	1-008-03	+24	14
Grant St.	Wood St.	State St.	2-003-03	+23	15
Happy Hollow Rd.	River Rd.	Laurel Dr.	2-004-01	+23	16
Salisbury St.	Fowler Ave.	Stadium Ave.	2-009-01	+23	17
State St.	River Rd.	Northwestern Ave.	1-008-02	+20	18
Wood St.	Grant St.	Chauncey Ave.	2-012-02	+20	19
U.S. 52 By-Pass	East City Limits	Happy Hollow Rd.	1-009-01	+19	20
Wood St.	Marstellar St.	Grant St.	2-012-01	+19	21
Salisbury St.	U. S. 52 By-Pass	Cumberland Ave.	1-007-04	+17	22
Grant St.	Northwestern Ave.	Stadium Ave.	2-003-05	+17	23
Salisbury St.	Meridian St.	Grant St.	1-007-01	+16	24
State St.	Marstellar St.	Russell St.	1-008-05	+16	25
Vine St.	North St.	Wiggins St.	1-011-01	+16	26
River Road	Robinson St.	Happy Hollow Rd.	1-005-06	+15	27
Lindberg Rd.	Northwestern Ave.	Salisbury St.	2-006-02	+14	28
Wood St.	Chauncey Ave.	River Rd.	2-012-03	+14	29
Stadium Ave.	Grant St.	Salisbury St.	2-011-03	+13	30
Northwestern Ave.	North St.	Grant St.	1-004-02	+12	31

TABLE 11. (continued)

STREET	FROM	TO	CODE	PRIORITY RATING	PRIORITY
Northwestern Ave.	U.S. 52 By-Pass	Cumberland Ave.	1-004-08	+11	32
Northwestern Ave.	Lindberg Rd.	U.S. 52 By-Pass	1-004-07	+10	33
Cherry Lane	West City Limits	Northwestern Ave.	1-001-01	+ 9	34
State St.	East City Limits	River Rd.	1-008-01	+ 9	35
Stadium Ave.	Northwestern Ave.	Grant St.	2-011-02	+ 8	36
State St.	Grant St.	Marsteller St.	1-008-04	+ 6	37
Vine St.	Wiggins St.	Fowler Ave.	1-011-02	+ 6	38
Stadium Ave.	Salisbury St.	Robinson St.	2-011-04	+ 4	39
Northwestern Ave.	Cherry Lane	Lindberg Rd.	1-004-06	+ 3	40
Northwestern Ave.	Grant St.	Stadium Ave.	1-004-03	+ 2	41
Fowler Ave.	Northwestern Ave.	Littleton St.	1-003-01	0	42
River Road	U.S. 231 (Bridge)	Robinson St.	1-005-05	0	43
Wiggins St.	Northwestern Ave.	Littleton St.	1-012-01	0	44
Meridian St.	Vine St.	Salisbury St.	2-007-04	0	45
Northwestern Ave.	Meridian St.	Cherry Lane	1-004-05	- 2	46
River Road	State St.	Howard Ave.	1-005-03	- 2	47
Northwestern Ave.	Stadium Ave.	Meridian St.	1-004-04	- 4	48
Happy Hollow Rd.	Laurell Dr.	U.S. 52 By-Pass	2-004-02	- 5	49
Grant St.	Meridian St.	Leslie Ave.	2-003-07	- 6	50
Grant St.	Leslie Ave.	Salisbury St.	2-003-08	- 7	51
River Road	Howard Ave.	U.S. 231 (Bridge)	1-005-04	-10	52
U.S. 231	East City Limits	Littleton St.	1-010-01	-15	53
Soldiers Home Rd.	U.S. 52 By-Pass	North City Limits	2-010-01	-17	54
Chauncey Ave.	Wood St.	State St.	2-001-01	-23	55
Grant St.	Williams St.	Wood St.	2-003-02	-23	56
Indian Trail Dr.	Lindberg Rd.	Navajo St.	2-005-01	-24	57
Grant St.	Stadium Ave.	Meridian St.	2-003-06	-31	58
Meridian St.	Northwestern Ave.	Garfield St.	2-007-01	-34	59
Lindberg Rd.	Salisbury St.	Indian Trail Dr.	2-006-03	-35	60
Navajo St.	Indian Trail Dr.	Chippewa St.	2-008-02	-36	61
Meridian St.	Garfield St.	Grant St.	2-007-02	-38	62

TABLE 11. (continued)

STREET	FROM	TO	CODE	PRIORITY RATING	PRIORITY
Grant St.	South City Limits	Williams St.	2-003-01	-43	63
Meridian St.	Grant St.	Vine St.	2-007-03	-43	64
Nava Jo St.	Salisbury St.	Indian Trail Dr.	2-008-01	-47	65
Chippewa St.	Nava Jo St.	Happy Hollow Rd.	2-002-01	-50	66
Lindberg Rd.	West City Limits	Northwestern Ave.	2-006-01	-55	67
Cumberland Ave.	Yeager Rd.	U.S. 52	1-002-02	-68	68
Cumberland Ave.	East End	Salisbury St.	1-002-01	-70	69

TABLE 12. INTERSECTION IMPROVEMENT PRIORITIES

INTERSECTION	CODE	PRIORITY RATING	PRIORITY
Meridian St.-Robinson St.-Salisbury St.	2-12	+38	1
Happy Hollow Rd.-River Road	2-07	+36	2
Northwestern Ave.-U.S. 52 By-Pass	1-06	+35	3
Happy Hollow Rd.-Soldiers Home Rd.-U.S. 52 By-Pass	2-08	+33	4
River Road-Wood St.	2-14	+30	5
Salisbury St.-U.S. 52 By-Pass	1-10	+28	6
Lindberg Rd.-Salisbury St.	2-10	+28	7
Robinson St.-Stadium Ave.	2-15	+27	8
Northwestern Ave.-State St.-South St.	1-05	+25	9
Grant St.-State St.	2-06	+24	10
Salisbury St.-Stadium Ave.	4-09	+22	11
River Road-State St.	1-09	+21	12
North St.-Northwestern Ave.-Vine St.	1-04	+17	13
Grant St.-Wood St.	4-06	+17	14
Grant St.-Salisbury St.	2-05	+15	15
Vine St.-Wiggins St.	1-11	+12	16
Northwestern Ave.-Wiggins St.	1-07	+9	17
Chauncey Ave.-State St.	2-01	+9	18
Fowler Ave.-Salisbury St.	2-04	+9	19
Northwestern Ave.-Stadium Ave.	2-13	+9	20
Grant St.-Stadium Ave.	4-05	+7	21
Fowler Ave.-Vine St.	1-03	+5	22
Fowler Ave.-Grant St.-Northwestern Ave.	1-02	+4	23
Roebuck Dr.-State St.	2-16	+3	24
Chauncey Ave.-Wood St.	4-01	+3	25
Meridian St.-Northwestern Ave.	2-11	+1	26
Cumberland Ave.-U.S. 52 By-Pass	2-03	0	27
River Road-Robinson	1-08	-5	28
Lindberg Rd.-Northwestern Ave.	2-09	-7	29
Salisbury St.-Wiggins St.	2-18	-7	30
Salisbury St.-Nava Jo St.	2-17	-16	31

TABLE 12 (continued)

INTERSECTION	CODE	PRIORITY RATING	PRIORITY
Chippewa St.-Happy Hollow Rd.	4-02	-17	32
Cherry Lane-Northwestern Ave.	1-01	-19	33
Indian Trail Dr.-Lindberg Rd.	4-07	-23	34
Cumberland Ave.-Salisbury St.	2-02	-30	35
Grant St.-Meridian St.	4-04	-32	36
Chippewa St.-Navajo St.	4-03	-44	37
Indian Trail Dr.-Navajo St.	4-08	-46	38

FIGURE 26 LOCATION OF STREET SECTIONS IN THEIR ORDER OF IMPROVEMENT PRIORITY

FIGURE 27 LOCATION OF INTERSECTIONS IN THEIR ORDER OF IMPROVEMENT PRIORITY

Financial Needs

The improvement costs for all arterial and collector street sections and the 38 intersections investigated are given in Tables 13 and 14. These tables show the costs required to improve the street sections and intersections for five-year periods from 1965 to 1985. All of the costs are based on 1964 price values. The total cost required to improve all present deficiencies in the arterial and collector streets and at the 38 major intersections in West Lafayette was calculated to be \$462,236.00. An additional \$79,051.50 will be needed during the next 20 years to meet the future demands of the traffic in this community.

Sampling

The results of the sampling survey, as applied to this needs study, are shown in graphic form in Figures 28 through 34. These graphs present the percentage of sample size versus the standard error of the mean in terms of the cost required to improve the present deficiencies in the street sections and intersections for each of the seven populations investigated.

To use these graphs in the determination of the sample size required to estimate the total cost of improving the street sections or intersections in a given category, a

TABLE 13. IMPROVEMENT COSTS FOR STREET SECTIONS AT FIVE-YEAR INTERVALS

STREET	FROM	TO	COST (DOLLARS)			
			1965	1970	1975	1980
Cherry Lane	West City Limits	Northwestern Ave.	5858.50			135.00
Cumberland Ave.	East End	Salisbury St.	15275.00			
Cumberland Ave.	Yeager Rd.	U.S. 52	1535.50			
Fowler Ave.	Northwestern Ave.	Littleton St.	1500.00		95.00	
Northwestern Ave.	State St.	North St.	3697.00			
Northwestern Ave.	North St.	Grant St.	1213.00			
Northwestern Ave.	Grant St.	Stadium Ave.	1301.00			
Northwestern Ave.	Stadium Ave.	Meridian St.	333.00			
Northwestern Ave.	Meridian St.	Cherry Lane	5197.00			
Northwestern Ave.	Cherry Lane	Lindberg Rd.	14208.00			
Northwestern Ave.	Lindberg Rd.	U.S. 52 By-Pass	1394.00			
Northwestern Ave.	U.S. 52 By-Pass	Cumberland Ave.	10.00		6821.50	
River Road	South City Limits	Wood St.	29962.50			
River Road	Wood St.	State St.	1300.00			
River Road	State St.	Howard Ave.				

TABLE 13 (continued)

STREET	FROM	TO	COST (DOLLARS)		
			1965	1970	1975 1980 1985
River Road	Howard Ave.	U.S. 231 (Bridge)	775.00		
River Road	U.S. 231 (Bridge)	Robinson St.	625.00		
River Road	Robinson St.	Happy Hollow Rd.		36302.00	
River Road	Happy Hollow Rd.	Catherwood Dr.		2199.00	
Robinson St.	River Rd.	Stadium Ave.	1843.00		45.00
Robinson St.	Stadium Ave.	Salisbury St.	10213.00		135.00
Salisbury St.	Meridian St.	Grant St.	1559.50		135.00
Salisbury St.	Grant St.	Lindberg Rd.	3746.50		
Salisbury St.	Lindberg Rd.	U.S. 52 By-Pass	51755.00	56.00	4083.00
Salisbury St.	U.S. 52 By-Pass	Cumberland Ave.	21776.00		
State St.	East City Limits	River Rd.	13060.50		
State St.	River Rd.	Northwestern Ave.	1187.00	224.00	
State St.	Northwestern Ave.	Grant St.	2653.50		920.50
State St.	Grant St.	Marstellar St.	31.50		
State St.	Marstellar St.	Russell St.	1944.00		

TABLE 13 (continued)

STREET	FROM	TO	COST (DOLLARS)		
			<u>1970</u>	<u>1975</u>	<u>1985</u>
U.S. 52 By-Pass	East City Limits	Happy Hollow Rd.	2947.50		
U.S. 52 By-Pass	Happy Hollow Rd.	Salisbury St.	35573.00		
U.S. 52 By-Pass	Salisbury St.	Northwestern Ave.	22469.00		
U.S. 231	East City Limits	Littleton St.	1590.00		
Vine St.	North St.	Wiggins St.			
Vine St.	Wiggins St.	Fowler Ave.			
Wiggins St.	Northwestern Ave.	Littleton St.	772.00	71.00	
Chauncey Ave.	Wood St.	State St.	120.00		
Chippewa St.	Navajo St.	Happy Hollow Rd.	3026.00		
Grant St.	South City Limits	Williams St.	4680.50		
Grant St.	Williams St.	Wood St.	3814.00		
Grant St.	Wood St.	State St.	1009.50		
Grant St.	State St.	Northwestern Ave.	11000.00		
Grant St.	Northwestern Ave.	Stadium Ave.	942.50		
Grant St.	Stadium Ave.	Meridian St.	386.00		

TABLE 13 (continued)

STREET	FROM	TO	COST (DOLLARS)			
			<u>1965</u>	<u>1970</u>	<u>1975</u>	<u>1980</u>
Grant St.	Meridian St.	Leslie Ave.	2858.00	352.00		<u>1985</u>
Grant St.	Leslie Ave.	Salisbury St.	1433.50			
Happy Hollow Rd.	River Rd.	Laurell Dr.				
Happy Hollow Rd.	Laurell Dr.	U.S. 52 By-Pass				
Indian Trail Dr.	Lindberg Rd.	Navajo St.	17020.50			
Lindberg Rd.	West City Limits	Northwestern Ave.	1925.00			
Lindberg Rd.	Northwestern Ave.	Salisbury St.	4686.50			
Lindberg Rd.	Salisbury St.	Indian Trail Dr.	65.00	429.00		
Meridian St.	Northwestern Ave.	Garfield St.	1263.50			
Meridian St.	Garfield St.	Grant St.	2477.50			
Meridian St.	Grant St.	Vine St.	4183.50			
Meridian St.	Vine St.	Salisbury St.	11992.00			
Navajo St.	Salisbury St.	Indian Trail Dr.	6251.00			
Navajo St.	Indian Trail Dr.	Chippewa St.	7935.50			
Salisbury St.	Fowler Ave.	Stadium Ave.	4198.50			

TABLE 13 (continued)

STREET	FROM	TO	COST (DOLLARS)			
			<u>1970</u>	<u>1975</u>	<u>1980</u>	<u>1985</u>
Salisbury St.	Stadium Ave.	Robinson St.		5595.50		
Soldiers Home Rd.	U.S. 52 By-Pass	North City Limits		313.50		
Stadium Ave.	Russell Dr.	Northwestern Ave.	1551.00			
Stadium Ave.	Northwestern Ave.	Grant St.	1272.50			
Stadium Ave.	Grant St.	Salisbury St.	1883.50			
Stadium Ave.	Salisbury St.	Robinson St.	662.50			
Wood St.	Marstellar St.	Grant St.	509.50			
Wood St.	Grant St.	Chauncey Ave.	309.50			
Wood St.	Chauncey Ave.	River Rd.	1772.50	6725.00		
TOTALS			362444.00	781.00	52,493.50	5138.50 427.50

TABLE 14. IMPROVEMENT COSTS FOR INTERSECTIONS AT FIVE-YEAR INTERVALS				
<u>INTERSECTIONS</u>	<u>COST (DOLLARS)</u>			<u>1985</u>
	<u>1965</u>	<u>1970</u>	<u>1980</u>	
Cherry Lane-Northwestern Ave.	815.00		5673.00	
Fowler Ave.-Grant St.-Northwestern Ave.	6725.50	200.00		
Fowler Ave.-Vine St.	18.00	11.00		
North St.-Northwestern Ave.-Vine St.	2382.50			
Northwestern Ave.-State St.-South St.	4859.50	288.00	896.00	
Northwestern Ave.-U.S. 52 By-Pass	576.00	461.00		
Northwestern Ave.-Wiggins St.	1008.50	11.00		
River Rd.-Robinson St.	1542.50			
River Rd.-State St.	4024.00			
Salisbury St.-U.S. 52 By-Pass	4607.00			
Vine St.-Wiggins St.	670.00	58.00		
Chauncey Ave.-State St.	2378.50	582.50		
Cumberland Ave.-Salisbury St.	2266.50	2919.00		
Cumberland Ave.-U.S. 52 By-Pass				
Fowler Ave.-Salisbury St.	524.50	22.50		

TABLE 14. (continued)

INTERSECTIONS	COST (DOLLARS)			
	<u>1965</u>	<u>1970</u>	<u>1975</u>	<u>1980</u> <u>1985</u>
Grant St.--Salisbury St.	1557.00			851.00
Grant St.--State St.	7164.00			320.00
Happy Hollow Rd.--River Rd.			5356.50	
Happy Hollow Rd.--Soldiers Home Rd.--U.S.52 By-Pass	16679.00			
Lindberg Rd.--Northwestern Ave.	812.50			
Lindberg Rd.--Salisbury St.	6887.50	70.50		918.50
Meridian St.--Northwestern Ave.	1619.00			
Meridian St.--Robinson St.--Salisbury St.	4872.50			
Northwestern Ave.--Stadium Ave.	1111.50			
River Rd.--Wood St.	3209.00		1465.00	
Robinson St.--Stadium Ave.	2748.50	74.50		11.00
Roebuck Dr.--State St.	1210.00			
Salisbury St.--Navajo St.	1327.50			
Salisbury St.--Wiggins St.	565.50		22.50	
Chauncey Ave.--Wood St.	1720.50			

TABLE 14. (continued)

INTERSECTIONS	COST (DOLLARS)			
	<u>1965</u>	<u>1970</u>	<u>1975</u>	<u>1980</u> <u>1985</u>
Chippewa St.-Happy Hollow Rd.	546.00			
Chippewa St.-Nava Jo St.	1376.00			
Grant St.-Meridian St.	2949.00			
Grant St.-Stadium Ave.	2062.50			
Grant St.-Wood St.	1114.50			
Indian Trail Dr.-Lindberg Rd.	2020.50			
Indian Trail Dr.-Nava Jo St.	2225.50			
Salisbury St.-Stadium Ave.	3616.50			
TOTALS	99792.50	144.50	11397.00	8658.50 1.00

FIGURE 28 PERCENTAGE OF SAMPLE SIZE VERSUS THE STANDARD ERROR OF THE MEAN
IN TERMS OF THE COST OF IMPROVEMENT PER INTERSECTION FOR
COLLECTOR COLLECTOR INTERSECTIONS

FIGURE 29 PERCENTAGE OF SAMPLE SIZE VERSUS THE STANDARD ERROR OF THE MEAN IN TERMS OF THE COST OF IMPROVEMENT PER INTERSECTION FOR ARTERIAL ARTERIAL INTERSECTIONS

FIGURE 30 PERCENTAGE OF SAMPLE SIZE VERSUS THE STANDARD ERROR OF THE MEAN IN TERMS OF THE COST OF IMPROVEMENT PER INTERSECTION FOR INTERSECTING ARTERIAL AND COLLECTOR STREETS

FIGURE 31 PERCENTAGE OF SAMPLE SIZE VERSUS THE STANDARD ERROR OF THE MEAN IN TERMS OF THE COST OF IMPROVEMENT PER INTERSECTION

FIGURE 32 PERCENTAGE OF SAMPLE SIZE VERSUS THE STANDARD ERROR OF THE MEAN IN TERMS OF THE COST OF IMPROVEMENT PER STREET SECTION FOR COLLECTOR STREETS

FIGURE 33 PERCENTAGE OF SAMPLE SIZE VERSUS THE STANDARD ERROR OF THE MEAN IN TERMS OF THE COST OF IMPROVEMENT PER STREET SECTION FOR ARTERIAL STREETS

FIGURE 34 PERCENTAGE OF SAMPLE SIZE VERSUS THE STANDARD ERROR OF THE MEAN IN TERMS OF THE COST OF IMPROVEMENT PER STREET SECTION FOR ARTERIAL AND COLLECTOR STREETS

decision must first be made as to the amount of error which can be tolerated. After the tolerable error for the total cost is determined, this value is divided by the number of street sections or intersections in that classification. This figure is the allowable error per street section or intersection and represents the product of the standard error of the mean and the Student's t deviate for the confidence interval involved in the desired estimation. This allowable error per street section or intersection can be represented by the following equation:

$$T = k S_{\bar{x}}$$

where:

T = Tolerable error per street section or intersection.

K = Student's t deviate for a given confidence interval (this value is also a function of the sample size). Student's t tables with various probabilities can be found in most elementary statistics text books. (30)

$S_{\bar{x}}$ = Standard error of the mean.

Thus, the tolerable error per street section or intersection (T) is divided by the Student's t deviate to obtain the standard error of the mean which is noted on the proper graph and projected up to the curve. From this point on the curve a line is projected to the percentage of sample size scale

on the left side of the graph. This percentage value indicates the size of sample needed to make a reasonable estimate of the total cost required to improve the present deficiencies in the street sections or intersections being investigated.

The use of the graphs is illustrated by means of the following example. It is desired to estimate the cost of improving the present deficiencies on all of the collector streets in West Lafayette, Indiana. The collector street system is divided into 32 control sections. The cost estimate is to be made from a sample of the street sections because there are insufficient funds and manpower to make a complete investigation of the entire system. The total estimate is required to be within \$40,000 with a 95-percent confidence coefficient.

$$\text{Allowable error} = \$40,000$$

$$\text{Total number of street sections} = 32$$

$$\text{Student's } t \text{ value} \approx 2.00$$

$$\frac{\$40,000}{32} = \$1250 \text{ per street section}$$

$$\frac{\$1250}{2.00} = \$625 \text{ (standard error of the mean per street section)}$$

Using Figure 32 for collector street sections and with a standard error of the mean of \$625, the percentage of sample size required is 56.5. Thus, the required sample size is 56.5 percent of 32 or 18 street sections.

Each graph in Figures 28 through 34 has a dashed line to indicate the lower limit of sample normality. Below this line the sampling distribution significantly departed from a normal distribution. The normality of the distribution was tested by using the Kolmogorov-Smirnov goodness of fit test at a significance level of 5.0 percent. (30)

The sample-size graphs developed in this report are only valid for the situation in West Lafayette, Indiana. If a number of similar studies were performed in various cities, the suitability of these charts for use in other communities could be ascertained.

This investigation revealed a very high variability, in regard to improvement costs, in each category of street section and intersection classification. The highest variability was observed for arterial street sections, and the lowest variation was noted for the intersection of collector streets.

SUMMARY OF FINDINGS AND CONCLUSIONS

The following conclusions were derived from the results of this needs study which was conducted in West Lafayette, Indiana. The major findings in connection with the sampling techniques as applied to this needs study are also presented. These conclusions are valid only for the West Lafayette study area, but through further research the findings of this investigation could be used with reasonable success in most urban communities.

1. A complete physical inventory and traffic evaluation was made for all of the arterial and collector streets and major intersections in West Lafayette, Indiana. The basic procedure utilized in this investigation consisted of the following steps:
 - a. Classification of the street system.
 - b. Physical inventory and traffic evaluation of the street sections and major intersections.
 - c. Development of tolerable and design standards.
 - d. Determination of the street and intersection deficiencies which exist now and may be expected to develop within the next 20 years.
 - e. Determination of the improvements required to overcome these deficiencies.

- f. Estimation of the costs of needed improvements.
 - g. Establishment of priorities for improvements.
2. The physical street system needs and traffic requirements in West Lafayette appear to be similar to those in most communities of its size. Many streets require resurfacing, but very few sections need rebuilding. Curbs and gutters and sidewalks are needed at many locations. On-street parking should be eliminated along many major streets.
3. The total cost required to improve all present deficiencies in the arterial and collector streets and at the 38 major intersections in West Lafayette was calculated to be \$462,236.00. Of this total amount required to eliminate present deficiencies, \$122,100.00 is needed for the construction of new sidewalks and the replacement of existing ones. The cost of these sidewalks is the responsibility of adjacent property owners. An additional \$79,051.50 will be needed during the next 20 years to meet the future demands of the traffic in this community.
4. The priority rating system used in this investigation seemed to provide reliable results for the first portion of the street sections and intersections. That is, the first 30 street sections and the first 15 intersections seemed to be in a logical order.

5. A wide variation was noted in West Lafayette among the improvement costs required for each classification of street section and intersection. The cost variations are a function of many factors, including the maintenance practices of the particular city, funds available in the past for street needs, the design and tolerable standards established by the community and construction and maintenance cost fluctuations. The variation in these improvement cost may change for different cities.

In conclusion, it may be possible to develop standards for the percentage of sample size required for various street and intersection classifications to estimate street system improvement cost, if sampling procedures similar to those applied in this investigation were used in a number of communities in connection with urban needs studies.

SUGGESTIONS FOR FURTHER RESEARCH

The results of this research have indicated several areas in which further studies are required. Additional investigation in urban needs studies and sampling procedures applied to these needs studies are recommended as follows:

1. The sampling techniques analyzed in this investigation should be used in conjunction with urban needs studies in other communities. Through studies of this type it may be possible to develop graphs of the percentage of sample size versus the standard error of the mean for various street and intersection classifications. These charts could be used in determining the sample size requirements for estimating street system improvement costs.
2. Before-and-after studies should be conducted in conjunction with city street improvement programs to determine the precision of sampling procedures and cost estimates in connection with urban needs.
3. Sampling procedures should be investigated in connection with local street sections as well as arterial and collector streets to obtain more complete information on urban street system needs.

4. Some of the procedures proposed and used in this investigation have been based on arbitrary judgment. It is recommended that studies be conducted to refine these procedures and develop improved techniques for use in urban needs studies.

BIBLIOGRAPHY

LIST OF REFERENCES

1. A Policy on Arterial Highways in Urban Areas, American Association of State Highway Officials, 1957.
2. A Policy on Geometric Design of Rural Highways, American Association of State Highway Officials, 1954.
3. A Summary of the Comprehensive Plan for: Lafayette and Tippecanoe County, Indiana, Tippecanoe County Area Planning Commission, June, 1963.
4. Baerwald, John Edward, "Rural Highway Classification and Evaluation Procedures for Indiana Counties," A Thesis Submitted to the Faculty of Purdue University in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Civil Engineering, January, 1956.
5. Better Transportation for Your City, A Guide to the Factual Development of Urban Transportation Plans, National Committee on Urban Transportation, 1958.
6. "Building Traffic Safety into Residential Developments," Urban Land, Vol. 20, No. 7, July-August, 1961.
7. Burnes, Clint, "Analysis of Sampling County Road Needs in Minnesota," Highway Needs Studies 1957, A Symposium, Highway Research Board Bulletin, No. 158, 1957.
8. Covault, Donald O., and Michael, Harold L., "Estimation of County Primary Road System Needs by Sample Survey Methods," Highway Needs and Programming Priorities, Highway Research Board Bulletin, No. 249, 1960.
9. Covault, Donald O., "Estimation of Highway Needs for County Road Systems in Michigan and Minnesota by Sample Survey Methods," A Thesis Submitted to the Faculty of Purdue University in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Civil Engineering, January, 1959.

10. Covault, Donald O., "The Use of Sample Survey Methods to Estimate Highway Needs," Traffic Quarterly, April, 1960.
11. "Design Standards for City Streets," Public Works, May, 1963.
12. Design Standards for Major and Secondary City Streets in the State of Washington, State of Washington Design Standards Committee, April, 1962.
13. Engineering Procedures and Instructions for Determining City Street Needs, Mississippi Highway, Road, and Street Engineering Study, 1961.
14. Engineering Procedures and Instructions for Determining City Street Needs in Places Over 5000, Missouri Highway, Road, and Street Needs Study, 1960.
15. Engineering Procedures and Instructions for Determining Municipal Street Needs, Wyoming Highway Classification and Needs Study, 1959.
16. Farrell, Fred B., "Conducting Long-Range Highway Needs Studies," Public Roads, Vol. 25, No. 6, December, 1948.
17. Farrell, Fred B., "The Investment Analysis Approach to Estimating Highway Needs," Proceedings, Highway Research Board, Vol. 35, 1956.
18. Inventory of the Physical Street System, Procedure Manual, National Committee on Urban Transportation, Manual 5A, 1958.
19. Iowa Manual of Engineering Procedures for Determining Arterial Street Needs, Iowa Highway Study Committee, Ames, Iowa, 1959.
20. Iowa Manual of Engineering Procedures for Determining Residential Street Needs, Iowa Highway Study Committee, Ames, Iowa, 1959.
21. Kast, Mart, "The Estimated Effects of Four Proposed Shopping Centers on Metropolitan Lafayette," A Thesis Submitted to the Faculty of Purdue University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering, August, 1957.
22. Lafayette - West Lafayette Indiana Traffic Survey Report, Division of Planning, Indiana State Highway Commission, 1964.

23. Lohr, Alan F., "Early Impact of a Highway Improvement on an Urban Area," A Thesis Submitted to the Faculty of Purdue University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering, May, 1962.
24. Manual of Geometric Design Standard for Canadian Roads and Streets, Geometric Design Committee, Canadian Good Roads Association, 1963.
25. Manual of Traffic Engineering Studies, Institute of Traffic Engineers, Third Edition, 1964.
26. Marsh, Bernard L., and Seburn, Thomas J., Urban Transportation Administration, Bureau of Highway Traffic, Yale University, 1959.
27. Measuring and Using Travel Time, Traffic Operations Conference, Purdue University, October 23, 1963, Unpublished.
28. Measuring Traffic Volumes, Procedure Manual, National Committee on Urban Transportation, Manual 3A, 1958.
29. Michigan's Highways 1960-1980 Needs, A Technical Engineering Report, Michigan State Highway Department, 1962.
30. Ostle, Bernard, Statistics in Research, Second Edition, The Iowa State University Press, 1963.
31. Preliminary Population Study for Lafayette, West Lafayette and Tippecanoe County, Tippecanoe County Area Planning Department, August, 1961.
32. Procedural Outline For Major Thoroughfare Planning, Harland Bartholomew and Associates, September, 1964.
33. Prospectus for the Continuing Comprehensive Transportation Planning Process for the Rockford Urbanized Area, State of Illinois, Department of Public Works and Buildings.
34. Purdue Handbook 1964-1965, Purdue University Bulletin, Vol. 65, No. 1, July, 1965.
35. SASO Rainbow Signs, Sargent - Sowell, Inc., Catalogue, 1964.
36. Signs for the 60's by Lyle, Official Manual, Lyle Signs, Inc., 1964.

37. Specifications for Workmanship and Materials, City of West Lafayette, Indiana, Office of City Engineer.
38. Standards for Street Facilities and Services, Procedural Manual, National Committee on Urban Transportation, Manual 7A, 1958.
39. "Tentative Standards for Subdivision Streets," Traffic Engineering, September, 1964.
40. Traffic Volume Counting Manual, United States Department of Commerce, Bureau of Public Roads, May, 1963.
41. Webster's New Collegiate Dictionary, 1958.
42. Woods, K. B., Highway Engineering Handbook, McGraw-Hill, 1960.

GENERAL REFERENCES
(Not Cited in Text)

1. Advance Reports Final Population Counts, Indiana, 1960
Census of Population, United States Department of
Commerce.
2. Baerwald, J. E., "Improvement Priority Rating for Local
Rural Roads in Indiana," Proceedings, Highway Research
Board, Vol. 35, 1956.
3. Blackman, L. W., "Manitoba's Highway Needs Study," Canadian
Good Roads Association Proceedings of the Forty-Second
Convention, 1961.
4. Buckley, J. P., and Fritts, C. E., "Objectives and Findings
of Highway Needs Studies," Proceedings, Highway Research
Board, Vol. 27, 1948.
5. Cochran, W. G., Sampling Techniques, John Wiley and Sons,
1963.
6. Covault, D. O., "Indiana's Highway Needs Study," Highway
Needs Studies 1958, Highway Research Board Bulletin, No.
194, 1958.
7. Deen, Thomas B., "The Use of Travel Time As a Factor in
Rating Urban Streets," Traffic Engineering, January, 1960.
8. Desrosiers, Richard D., "Speed Estimation on Residential
Streets," Public Roads, Vol. 32, No. 3, August 1962.
9. Determining Street Use, Procedure Manual, National Committee
on Urban Transportation, Manual 1A, 1958.
10. Determining Travel Time, Procedure Manual, National Committee
on Urban Transportation, Manual 3B, 1958.
11. Donnell, Philip M., and Tuttle, Lawrence S., "Priorities
Determination and Programming in Tennessee," Highway
Needs Studies 1957, A Symposium, Highway Research Board
Bulletin, No. 158, 1957.
12. Donnell, Philip M., "Tennessee's Programming Study: First
Year's Experience and Techniques for Updating," Highway
Needs Studies 1958, Highway Research Board Bulletin, No.
194, 1958.
13. "Evaluation of Traffic Engineering Performance," Traffic
Engineering, March, 1964.

14. Fay, Gordon M., "A Correlated Method of Highway Programming," Public Works, December, 1962.
15. Foster, J. A., Humphrey, H. A., "What Should Highway Needs Study Reports Contain?" Highway Needs Studies 1958, Highway Research Board Bulletin, No. 194, 1958.
16. Fulton, W. J., "An Outline of the Highway Needs Studies," Canadian Good Roads Association Proceedings of the Thirty-Seventh Convention, October, 1956.
17. George, S., Jr., and Hall, E. M., "Travel Time - An Effective Measure of Congestion and Level of Service," Proceedings, Highway Research Board, Vol. 38, 1959.
18. Greenshields, Bruce D., and Weida, Frank M., Statistics With Applications to Highway Traffic Analyses, The ENO Foundation for Highway Traffic Control, Saugatuck, Connecticut, 1952.
19. Grunow, R. N., "Vehicle Delay at Signalized Intersections as a Factor in Determining Urban Priorities," Highway Needs Studies 1958, Highway Research Board Bulletin, No. 194, 1958.
20. Haley, Charles E., Hall, Edward M., and Johnson, Arnold A., "Travel Time - A Measure of Service and a Criterion for Improvement Priorities," Travel Time and Vehicle Speed, Highway Research Board Record, No. 35, 1963.
21. Hall, Edward M., and Hixon, C. Dwight, Urban Street Programming-The Use of a Priority Formula, Paper Presented at 43rd. Annual Meeting of Highway Research Board, January, 1964, Unpublished.
22. Joers, Charles E., "Street Sufficiency Study," Public Works, June, 1959.
23. "Large Metropolitan Areas Currently Conducting Urban Transportation Studies," Public Works, February, 1963.
24. Levinson, Herbert S., Votaw, David F., Jr., Elementary Sampling For Traffic Engineers, The ENO Foundation for Highway Traffic Control, 1962.
25. Michael, Harold L., Planning For County Highways, Purdue University Engineering Reprint, December, 1959.
26. "Observations Concerning Urban Traffic Volume Patterns in Tennessee," Bureau of Public Roads, Public Roads, December, 1958.
27. "Overlay Pavements," (Appendix D), Thickness Design-Asphalt Pavement Structures For Highways and Streets, The Asphalt Institute, March, 1964.

APPENDICES

APPENDIX A
DESIGN AND TOLERABLE STANDARDS

APPENDIX A

Design and Tolerable Standards

The design and tolerable standards used in this investigation were prepared by using many national and local standards as references. Construction standards for use in West Lafayette are presented for expressways, and arterial, collector and local streets in Tables 15, 16, 17 and 18. The design vehicles used for determining the curb radii at intersection corners are shown in Table 19. Tolerable standards for arterial, collector and local streets are presented. Classes and types of pavement design are also listed.

Tolerable Standards

Arterial and Collector Streets*.1. Surface Type

Streets should be paved full width, class 2 or class 3 pavement (see "Classes and Types of Pavement").

2. Surface Width

Have at least two moving traffic lanes regardless of volume. Minimum considerations in unusually restrictive situations would indicate an absolute minimum

TABLE 15. CONSTRUCTION STANDARD FOR EXPRESSWAYS

DESIGN FEATURE	EXPRESSWAYS
SURFACE TYPE*	Class 3
LANE WIDTH	12 ft.
SURFACE WIDTH	Controlled by predicted future traffic volumes and operating conditions - 4 lane minimum.
CURB AND SIDEWALK	Not required: Pedestrians not permitted, pedestrian crossings to be provided where needed.
SHOULDER WIDTH	12 ft.
MEDIAN WIDTH	Minimum 4 ft. if not mountable, otherwise 20 ft.
PARKING	Not permitted.
ILLUMINATION	Continuous
INTERSECTION TREATMENT	Full access control
STRUCTURE WIDTH	Under 100 ft. long - full roadway width, over 100 ft. - pavement width plus 6 ft. plus median.
VERTICAL CLEARANCE	15 ft.
LOADING	AASHO H-20-S-16
RAILROAD CROSSING SEPARATION	At all railroad crossings
STOPPING SIGHT DISTANCE	350 ft.

TABLE 15. (continued)

DESIGN FEATURE	EXPRESSWAYS
DEGREE OF CURVE	7.6
GRADE	3%

* See "Classes and Types of Pavement".

TABLE 16. CONSTRUCTION STANDARDS FOR ARTERIAL STREETS

DESIGN FEATURE	DOWNTOWN	INTERMEDIATE	OUTLYING
SURFACE TYPE*	Class 3	Class 3	Class 3
NUMBER OF LANES	Controlled by predicted future traffic volumes and operating conditions		
CURBS AND SIDEWALKS	Yes	Yes	As required
SHOULDER WIDTH	-	-	8 ft.
MEDIAN WIDTH	6 ft. minimum where design hour traffic volume exceeds 750 if feasible		
PARKING	For streets having a design hour traffic volume exceeding 750 parking is generally discouraged, with parallel parking permitted only during off-peak hours. Parallel parking permitted for lesser traffic volumes.		
ILLUMINATION	Continuous	At intersections	At intersections
INTERSECTION TREATMENT 10% OR MORE OF TRAFFIC ON INTERSECTING STREET	Progressive traffic signal system or fixed signal where warranted. Stop sign control for lower volumes.		
LESS THAN 10% OF TRAFFIC ON INTERSECTING STREET	Traffic or pedestrian actuated signals where warranted or stop signs.		
STRUCTURE WIDTH	28 ft. minimum between curbs with sidewalks extra.		
VERTICAL CLEARANCE	15 ft.	15 ft.	15 ft.
LOADING	For heavy commercial traffic AASHO H-20-S-16 other H-20		

TABLE 16. (continued)

DESIGN FEATURE	DOWNTOWN	INTERMEDIATE	OUTLYING
RAILROAD GRADE CROSSING PROTECTION	Flashing light signals at all crossings without watchman or flagman and where average daily traffic x number of trains = 3500 or more.		
STOPPING SIGHT DISTANCE	200 ft.	275 ft.	300 ft.
DEGREE OF CURVE	21.0	11.3	6.9
GRADE	7%	6%	5%
DESIGN SPEED	30 mph.	40 mph.	50 mph.
RIGHT OF WAY	80 ft. min.	80 ft. min.	80 ft. min.
MINIMUM NUMBER OF TRAFFIC LANES	4	4	4
MINIMUM TRAFFIC LANE WIDTH	12 ft.	12 ft.	12 ft.

* See "Classes and Types of Pavement".

TABLE 17. CONSTRUCTION STANDARDS FOR COLLECTOR STREETS

DESIGN FEATURE	COLLECTOR (30)	COLLECTOR (40)
SURFACE TYPE*	Class 2	Class 2
SURFACE WIDTH (C TO C)	40 to 46 ft.	40 to 46 ft.
CURB AND GUTTER	Yes	Yes
SIDEWALK	Yes-5 ft. min.	Yes-5 ft. min.
ILLUMINATION	Yes-intersections	Yes-intersections
STOPPING SIGHT DISTANCE	200 ft.	250 ft.
DEGREE OF CURVE	21.0	11.3
GRADE	8%	7%
DESIGN SPEED	30 mph.	40 mph.
RIGHT OF WAY	60 to 66 ft.	60 to 66 ft.
MINIMUM NUMBER OF TRAFFIC LANES	2	2
MINIMUM TRAFFIC LANE WIDTH	11 ft.	11 ft.
TRAFFIC CONTROL DEVICES	Traffic or pedestrian actuated signals where warranted or stop sign.	
PARKING	Parallel parking permitted until capacity is exceeded. When capacity is reached, parking permitted only during off-peak hours.	

* See "Classes and Types of Pavement".

TABLE 18. CONSTRUCTION STANDARDS FOR LOCAL STREETS

DESIGN FEATURE	HIGH DENSITY	MEDIUM TO LOW DENSITY	BUSINESS AND INDUSTRIAL
SURFACE TYPE*	Class 2	Class 1	Class 2
SURFACE WIDTH (C TO C)	34 ft. to 36 ft.	32 ft.	40 ft.
CURB AND GUTTER	Yes	Yes	Yes
SIDEWALK	Yes	As required	As required
PARKING	Parallel parking permitted until capacity reached. When capacity is exceeded, parking permitted only during off-peak hours.		
ILLUMINATION	No	No	Yes
TRAFFIC CONTROL DEVICES	No	No	Yes**
STOPPING SIGHT DISTANCE	160 ft.	160 ft.	160 ft.
GRADE	17%	12%	12%

* See "Classes and Types of Pavement".

** Traffic or pedestrian actuated signals where warranted or stop sign control.

TABLE 19. DESIGN VEHICLES FOR INTERSECTION CONSTRUCTION

TYPE OF INTERSECTION	DESIGN VEHICLE
Arterial-Arterial	C-50
Arterial-Collector	
Collector-Collector	
	C-43 or SU - Determined by predicted future traffic conditions
All Other	SU

C-50 = Large-size semitrailer combination, over-all wheelbase of 44 feet and a total length of 50 feet.

C-43 = Medium-size semitrailer combination, over-all wheelbase of 35 feet and a total length of 43 feet.

SU = Single-unit truck or bus

Reference (1).

width of 24 ft if parking is eliminated and 30 ft if occasional peak-hour loading and unloading is expected.

3. Surface Condition

Street surfaces should be sufficiently smooth to support speeds of at least 30 mph, and should be uniform in riding qualities across the entire width.

4. Surface Crown

Street crowns should be sufficiently flat to permit full use of the paved width for vehicular traffic.

5. Intersection Crown

Intersection crowns should not result in abrupt dips.

6. Curbs, Gutters and Sidewalks

Curbs, gutters and sidewalks in all developed areas.

7. Drainage

Drainage should be such that standing water is prevented except for short periods during storms.

8. Continuity of Design

Streets should have reasonable continuity of design. Abrupt jogs, sharp curves and limited sight distance should be avoided.

9. Illumination

Street illumination should be continuous in business districts and in areas of high traffic density. Intersection illumination should be provided in areas having moderate traffic usage.

10. Traffic Capacity

Traffic capacity shall be considered tolerable if the present design hour volume traffic count does not exceed the calculated practical capacity.

11. Traffic Control

Where congestion exists and available traffic control measures have not been implemented, then existing traffic control measures are inadequate. Absence of any of the following measures which would eliminate or reduce congestion, will result in traffic control being declared below minimum conditions considered tolerable.

- A. Parking regulation - removal of parking at peak-hour or all day may gain sufficient capacity to avoid or delay need for widening.
- B. One-way streets - conversion from two-way to one-way operation will increase capacity. A pair of one-way streets also has the advantage of distributing heavy traffic loads over two streets.
- C. Signal timing - interconnection of traffic signals to provide progressive movement of traffic may increase capacity.
- D. Turn controls - prohibition of turns, particularly left turns, generally provides for more uninterrupted traffic flow and thereby increases capacity.

Turning may be abolished at peak-hours only or at all times.

- E. Lane stripping - lane stripping helps to organize the traffic load thereby promoting increased efficiency.
- F. Truck routes - the reduction of the number of large trucks increases traffic capacity. Thus, the segregation of through trucks on proposed truck routes would increase the passenger car capacity of some of the principal city streets.
- G. Channelization - channelization of complicated intersections, or intersections where turning movements are frequent may improve capacity.
- H. Reversible lanes and streets - on wide streets it may be possible to reverse the direction of one or more lanes between the a.m. or p.m. peaks. In some situations an entire street may be reversed.

* References (1,2,6,11,12,13,14,15,19,24,29,38,39,42).

Local Streets*.

1. Surface Type and Condition

In residential areas streets should have at least a class 1 surface (see "Classes and Types of Pavement"). All paved surfaces should be reasonably smooth and free of defects.

2. Sidewalks

Sidewalks are not always necessary in residential areas. In developed areas where there are many pedestrians, such as in the vicinity of schools, or business establishments, the absence of sidewalks should be considered a deficiency.

3. Drainage

Drainage should be such that standing water is prevented except for short periods during storms, in order to avoid interruption in traffic movement, and to avoid damage to adjacent property.

4. Width

Local streets should be wide enough to carry two moving lanes of traffic.

* References (1,2,6,11,12,13,14,15,19,24,29,38,39,42).

Classes and Types of Pavements (37)

Class 3.

Arterial - Rigid Type Pavement: consists of a nine (9) in. reinforced air-entrained Portland Cement Concrete pavement placed on a 6 in. Indiana State Highway Standard Type gravel base compacted to at least 100 percent Standard AASHO specification. The top 6 in. of the subgrade compacted to at least 100 percent Standard AASHO specification.

Arterial - Flexible Type Pavement: consists of 3/4 in. Hot Asphaltic Surface (dense graded) over two (2) in. of Hot Asphaltic Concrete Binder on a base of 6 in. crushed stone or gravel conforming to Indiana State Highway Standard Type 53 compacted to at least 100 percent Standard AASHO density. This base to be placed on a subbase ten (10) in. thick conforming to Indiana State Highway Standard No. 63 but in addition should have no more than 12 percent fines and the top nine (9) in. of subgrade shall be compacted to at least 100 percent AASHO density.

Class 2.

Collector - Rigid Type Pavement: consists of an eight (8) in. reinforced air-entrained Portland Cement Concrete pavement placed on a 6 in. Type I base compacted to at least 100 percent Standard AASHO specification. The top 6 in. of subgrade shall be compacted to at least 100 percent Standard AASHO specification.

Collector - Flexible Type Pavement: consists of 3/4 in. Hot Asphaltic Surface (dense graded) over two (2) in. of Hot Asphaltic Concrete Binder on a six (6) in. base conforming to Indiana State Highway Standard Type 53 and shall be compacted to 100 percent Standard AASHO density. This base to be placed upon a subbase nine (9) in. thick conforming to Indiana State Highway Standard No. 63 and shall be compacted to at least 100 percent Standard AASHO density.

Class 1.

Local - Rigid Type Pavement: consists of six (6) in. plain air-entrained Portland Cement Concrete Pavement. The top six (6) in. of subgrade shall be compacted to at least 100 percent Standard AASHO specification.

Local - Flexible Type Pavement: consists of 3/4 in. of Hot Asphaltic Concrete Surface (dense graded) over two (2) in. of Hot Asphaltic Concrete Binder on a five (5) in. base of Indiana State Highway Standard Type 53 gravel compacted to at least 100 percent Standard AASHO density. This base to be placed on a subbase six (6) in. thick conforming to Indiana State Highway Standard No. 63 and compacted to at least 100 percent Standard AASHO density. The top six (6) in. of subgrade shall be compacted to at least 100 percent Standard AASHO density.

APPENDIX B
INVENTORY INSTRUCTIONS AND FORMS

APPENDIX B

Inventory Instructions and Forms

Instructions for Completing Arterial Street Evaluation Form

The Arterial Street Evaluation Form was used to inventory all of the arterial and collector street control sections. The following instructions refer to item numbers appearing in Figure 35.

Item No.

1. Name of city in which study is being conducted.
2. Population of city from latest U. S. Census.
3. County in which study city is located.
4. Street control section number as given in Table 3 or 4.
5. Length of control section in feet.
6. Official name of street and concise description of termini of street control section in item 4.
- 7-8. Check appropriate boxes. If Federal-aid System classification is unknown leave item 7 blank.
9. Number of lanes for moving traffic.
10. Present surface type classified according to given definitions (see "Classes and Types of Pavement").
11. Average or nominal width of street surfacing. In most cases this will be the curb to curb width.

IDENTIFICATION			
1. CITY _____		2. POPULATION _____	
4. STREET SECTION NO. _____		3. COUNTY _____	
6. STREET NAME _____		5. LENGTH _____ FROM _____ TO _____	
CLASSIFICATION			
7. EXISTING FEDERAL AID SYSTEM		8. STUDY SYSTEM	
INTERSTATE HIGHWAY ☐		URBAN STATE PRIMARY ☐	
PRIMARY ☐		URBAN STATE SECONDARY ☐	
SECONDARY ☐		ARTERIAL PRIMARY ☐	
NON FEDERAL ☐		ARTERIAL COMMUNITY ☐	
		COLLECTOR (30) ☐	
		COLLECTOR (40) ☐	
EXISTING STREET AND TRAFFIC DATA			
9. NO. OF LANES _____		23. FIRE HYDRANTS NONE ☐ 1 SIDE ☐ 2 SIDES ☐	
10. SURFACE TYPE _____		24. UTILITY POLES ☐	
11. SURFACE WIDTH _____ FT.		25. CURBS ☐	
12. RIGHT OF WAY WIDTH _____ FT.		26. DITCHES ☐	
13. BUILDING SETBACK _____ FT.		27. SIDEWALKS ☐	
14. ESTIMATED ADT _____ VPD		28. PARKING ☐	
15. ESTIMATED DHV _____ VPD		29. IF PARKING PERMITTED	
16. PRACTICAL CAPACITY _____ VPD		PARALLEL ALL TIME ☐ OFF PEAK ONLY ☐	
17. % COMMERCIAL VEHICLES _____ %		DIAGONAL ALL TIME ☐ OFF PEAK ONLY ☐	
18. YR. PVT. OR LAST RESURFACED _____		30. STORM SEWERS NONE ☐ IN PLACE ☐	
19. ESTIMATED REMAINING SURFACE LIFE _____ YR.		31. STREET LIGHTS	
20. SPEED LIMIT _____ MPH		NONE ☐	
21. NO. OF TRAFFIC SIGNAL		INTERSECTIONS ☐	
FIXED TIME _____		CONTINUOUS ☐	
PROGRESSIVE _____		32. STREET OPERATION	
TRAFFIC ACTUATED _____		ONE-WAY ☐	
PEDESTRIAN _____		TWO-WAY ☐	
22. STOP SIGNS DIRECTED TO ARTERIAL TRAFFIC (NO. OF INTERSECTIONS)		33. TYPE OF ACCESS CONTROL	
4-WAY _____		NONE ☐	
2-WAY _____		PARTIAL ☐	
		FULL ☐	
DEFICIENCIES			
	PRESENT	5 YR.	TIME OF IMPROVEMENT 10 YR. 15 YR. 20 YR. OVER 20 YR.
34. SURFACE TYPE	☐	☐	☐ ☐ ☐ ☐
35. SURFACE WIDTH	☐	☐	☐ ☐ ☐ ☐
36. SURFACE CONDITION	☐	☐	☐ ☐ ☐ ☐
37. BASE CONDITION	☐	☐	☐ ☐ ☐ ☐
38. CROWN	☐	☐	☐ ☐ ☐ ☐
39. INTERSECTION CONTOUR	☐	☐	☐ ☐ ☐ ☐
40. CURBS	☐	☐	☐ ☐ ☐ ☐
41. DRAINAGE	☐	☐	☐ ☐ ☐ ☐
42. ILLUMINATION	☐	☐	☐ ☐ ☐ ☐
43. SIDEWALKS	☐	☐	☐ ☐ ☐ ☐
44. TRAFFIC CAPACITY	☐	☐	☐ ☐ ☐ ☐
PROPOSED IMPROVEMENTS			
DESIGN DATA		DESCRIBE	
45. TYPE OF WORK			
RESURFACE _____ MI.			
WIDEN _____ MI.			
BASE & SURFACE _____ MI.			
NEW CONSTRUCTION _____ MI.			
46. TOTAL LENGTH _____ FT.			
47. WIDENING WIDTH _____ FT.			
48. SURFACE TYPE _____			
49. SURFACE WIDTH _____ FT.			
50. NO. OF LANES _____			
51. ESTIMATED 1985 DHV _____ VPH			
52. ESTIMATED 1985 ADT _____ VPD			
53. NO. OF STRUCTURES _____			
54. CURBS YES ☐ NO ☐			
55. SIDEWALKS YES ☐ NO ☐			
56. PARKING YES ☐ NO ☐			
57. ACCESS CONTROL (TYPE) _____			
58. DRAINAGE _____			
59. ILLUMINATION _____			
COST ESTIMATES			
		DOLLARS	
60. RIGHT OF WAY _____			
61. GRADE & DRAINAGE _____			
62. BASE & SURFACE _____			
63. STRUCTURES _____			
64. TRAFFIC CONTROL _____			
65. OTHER _____			
66. TOTAL _____			

FIGURE 35 ARTERIAL STREET EVALUATION FORM

Item No.

12. Existing average right-of-way width in feet.
13. Average building set back in feet from right-of-way line.
14. Estimated average daily traffic from traffic counts.
15. Estimated high hour traffic count.
16. Calculated practical capacity using; (1) type of operation, (2) parking condition, (3) percent of signal green time, (4) type of area, and (5) street width.
17. Estimate of percent of dual-tired commercial vehicles in traffic stream.
18. Year last resurfaced, including work done by maintenance forces. Do not consider seal coat as resurfacing. If not resurfaced enter year of construction.
19. Estimated remaining years of surface life based on field check of conditions.
20. Posted speed limit.
21. Number of locations along street section controlled by each type of traffic signal shown.
22. Number of stop signs along control section directed to the traffic on that section.
- 23-33. Check appropriate boxes.

Item No.

- 34-44. Indicate the time by which the various deficiencies should be improved. Estimates as to the time period of future needs should be based with tolerable standards and on predicted traffic growth.
- 45-47. Indicate the type of work and the length. Where more than one type of work is proposed the length of each type should be recorded.
- 48. Type of new surface (see "Classes and Types of Pavement").
- 49. Width of new surface.
- 50. Number of lanes after new construction.
- 51. Estimated design hour volume for 1985 on the street section.
- 52. Estimated average daily traffic for 1985 on the street section.
- 53. Number of structures to be improved along control section.
- 54-55. Indicate if curbs or sidewalks are to be constructed or reconstructed.
- 56. Indicate if parking is to be allowed or prohibited.
- 57. Type of access control along street section after improvement.
- 58-59. Indicate type of drainage and illumination to be provided.

Item No.

Describe: Briefly give reasons for and nature of proposed improvements.

60-66. Cost estimates for the various items listed should be entered to the nearest dollar. Estimated costs are based on unit price tables (see Table 9).

References (4,13,14,15,19,20)

Instructions for Completing Local Street Evaluation Form

The Local Street Evaluation Form should be used to inventory all local street sections in residential, business and industrial areas. This form is also used as an inventory for all structures and railroad grade crossings on local streets. The following instructions refer to item numbers appearing in Figure 36.

Item No.

1. Name of city in which study is being conducted.
2. Population of city from latest U. S. Census.
3. County in which study city is located.
4. Street control section number.
5. Length of control section in feet.
6. Official name of street and concise description of termini of street control sections in item 4.
7. Indicate class of street.

Note: Items 8-14 apply to street sections only.

IDENTIFICATION			
1. CITY _____		2. POPULATION _____	
4. STREET SECTION NO. _____		5. LENGTH _____	
6. STREET NAME _____		3. COUNTY _____	
		FROM _____ TO _____	
CLASSIFICATION			
7. STUDY SYSTEM			
LOCAL RESIDENTIAL		☐	
LOCAL BUSINESS		☐	
LOCAL INDUSTRIAL		☐	
EXISTING STREET CONDITION			
8. SURFACE TYPE _____		12. CURB & GUTTER NONE ☐ 1 SIDE ☐ 2 SIDES ☐	
9. SURFACE WIDTH _____ FT.		13. SIDEWALKS ☐	
10. RIGHT OF WAY WIDTH _____ FT.		14. DITCHES ☐	
11. STORM SEWERS NONE ☐ IN PLACE ☐			
EXISTING STRUCTURE CONDITION			
15. ROADWAY WIDTH _____ FT.		18. LOAD LIMIT _____	
16. LENGTH _____ FT.		19. CONDITION _____	
17. VERTICAL CLEARANCE _____ FT.			
EXISTING RAILROAD GRADE CROSSING PROTECTION			
20. NUMBER OF TRACKS _____			
21. TYPE OF PROTECTION			
CROSS-ARMS ONLY		☐	
FLASHING LIGHTS		☐	
FLASHING LIGHTS & AUTOMATIC GATES		☐	
ADVANCE WARNING SIGNS		☐	
DEFICIENCIES			
STREET ONLY		TIME OF IMPROVEMENT	
	PRESENT	5 YR.	10 YR.
22. SURFACE TYPE	☐	☐	☐
23. SURFACE WIDTH	☐	☐	☐
24. SURFACE CONDITION	☐	☐	☐
25. BASE CONDITION	☐	☐	☐
26. CURBS	☐	☐	☐
27. SIDEWALKS	☐	☐	☐
28. DRAINAGE	☐	☐	☐
STRUCTURE ONLY		15 YR.	20 YR.
29. WIDTH	☐	☐	☐
30. VERTICAL CLEARANCE	☐	☐	☐
31. CONDITION	☐	☐	☐
32. OTHER(SPECIFY)	☐	☐	☐
PROPOSED IMPROVEMENTS			
STREET ONLY		STRUCTURE ONLY	
33. TYPE OF WORK		40. TYPE OF WORK	
RESURFACE _____ MI.		RECONSTRUCT EXISTING	
WIDEN _____ MI.		STRUCTURE	
BASE & STRUCTURE _____ MI.		NEW STRUCTURE	
NEW CONSTRUCTION _____ MI.		41. LENGTH _____ FT.	
34. TOTAL LENGTH _____ MI.		42. WIDTH _____ FT.	
35. SURFACE TYPE _____ FT.		43. LOADING _____ FT.	
36. SURFACE WIDTH _____ FT.		44. VERTICAL CLEARANCE _____ FT.	
37. DRAINAGE TYPE			
38. CURBS			
39. SIDEWALKS			
YES ☐ NO ☐			
YES ☐ NO ☐			
COST ESTIMATES			
		DOLLARS	
45. RIGHT OF WAY		_____	
46. GRADE & DRAINAGE		_____	
47. BASE & SURFACE		_____	
48. RAILROAD PROTECTION		_____	
49. STRUCTURE		_____	
50. TOTAL		_____	

FIGURE 36 LOCAL STREET EVALUATION FORM

Item No.

8. Present surface type classified according to definitions (see "Classes and Type of Pavement").
 9. Average or nominal width of street surfacing. In most cases this will be the curb to curb width.
 10. Existing average right-of-way width in feet.
 - 11-14. Check appropriate boxes.
- Note: Items 15-19 apply to structures within the street section. If no structures, leave all items blank.
15. Street width over structure in feet.
 16. Length of structure measured along centerline to the nearest whole foot, measured between the faces of abutments.
 17. Minimum vertical distance above roadway surface to lowest point of overhead obstruction, in feet.
Enter "None" for deck type structures with no overhead obstructions.
 18. Posted load limit if given.
 19. Indicate the condition of the structure as good, fair, or poor using the following guides:
 - A. Good - condition of structure similar to a new or nearly new structure.
 - B. Fair - some rust, cracking, spalling or rotting but not sufficient to affect structural strength of members.

Item No.

C. Poor - severe rusting, cracking, spalling or rotting which results in weakening of main members, or piers or abutments causing a weakening in support.

Note: Items 20 and 21 apply to railroad grade crossings within the street section. If no crossings exist, leave these items blank.

20. Number of separate tracks at the crossing.

21. Indicate existing type of protection.

22-32. Indicate the time by which the various deficiencies should be improved. Estimates as to the time period of future needs should be based on present conditions in comparison with tolerable standards and on predicted traffic growth. Street sections which fail to meet tolerable standards should be rated deficient now.

33-34. Indicate type of work and length for street sections. Where more than one type of work is proposed on a street section, the length of each type of improvement should be entered.

35. Type of new surface (see "Classes and Types of Pavement").

36. Indicate pavement width after improvement.

37. Indicate type of drainage to be provided.

Item No.

- 38-39. Indicate if curbs or sidewalks are to be constructed or reconstructed.
40. Indicate type of work on structures.
41. Total centerline length of improvements to structures.
42. Width of pavement on structural improvements.
43. Load limit which structure is designed to carry after improvement.
44. Vertical clearance after improvement.
- 45-50. Cost estimates for the various items listed should be entered to nearest dollar. Estimated costs are based on unit price tables (see Table 9).

References (4,13,14,15,18,19).

Instructions for Completing Intersection Evaluation Form

The Intersection Evaluation Form was used to inventory each of the major intersections in the study city. The following instructions refer to item numbers appearing in Figure 37.

Item No.

1. Name of city in which study is being conducted.
2. Population of city from latest U. S. Census.

IDENTIFICATION						
1. CITY _____	2. POPULATION _____					
3. COUNTY _____						
4. INTERSECTION NO. _____						
5. INTERSECTING STREETS _____						
CLASSIFICATION						
6. STUDY SYSTEM	☐					
ARTERIAL AND ARTERIAL	☐					
ARTERIAL AND COLLECTOR	☐					
ARTERIAL AND LOCAL	☐					
COLLECTOR AND COLLECTOR	☐					
COLLECTOR AND LOCAL	☐					
OTHER	☐					
EXISTING INTERSECTION DATA						
7. SURFACE TYPE						
8. SURFACE CONDITION						
9. CURB RADIUS FOR RIGHT TURNS						
10. CURBS						
11. DRAINAGE						
12. VISUAL RESTRICTIONS						
13. LIGHTING						
14. STREET OPERATION						
15. TYPE OF SIGNALIZATION						
16. STOP OR YIELD SIGNS						
17. APPROACH VOLUMES						
ACCIDENTS						
18. NUMBER FOR 1961-1963	COMMENTS					
REAR END _____						
TURNING _____						
OTHER _____						
DEFICIENCIES						
	PRESENT	5 YR.	TIME OF IMPROVEMENT			
			10 YR.	15 YR.	20 YR.	OVER 20 YR.
19. SURFACE TYPE	☐	☐	☐	☐	☐	☐
20. SURFACE WIDTH	☐	☐	☐	☐	☐	☐
21. SURFACE CONDITION	☐	☐	☐	☐	☐	☐
22. CROWN	☐	☐	☐	☐	☐	☐
23. CURBS	☐	☐	☐	☐	☐	☐
24. DRAINAGE	☐	☐	☐	☐	☐	☐
25. ILLUMINATION	☐	☐	☐	☐	☐	☐
26. SIDEWALKS	☐	☐	☐	☐	☐	☐
27. TRAFFIC CAPACITY	☐	☐	☐	☐	☐	☐
28. CHANNELIZATION	☐	☐	☐	☐	☐	☐
29. PARKING	☐	☐	☐	☐	☐	☐
30. VISUAL RESTRICTIONS	☐	☐	☐	☐	☐	☐
PROPOSED IMPROVEMENTS						
	DESCRIBE					
31. SURFACE TYPE	☐					
32. SURFACE WIDTH	☐					
33. CURBS	☐					
34. SIDEWALKS	☐					
35. PARKING	☐					
36. DRAINAGE	☐					
37. ILLUMINATION	☐					
38. CHANNELIZATION	☐					
39. CAPACITY	☐					
COST ESTIMATES						
	DOLLARS					
40. RIGHT OF WAY	_____					
41. BASE & SURFACE	_____					
42. TRAFFIC CONTROL	_____					
43. OTHER	_____					
44. TOTAL	_____					

FIGURE 37 INTERSECTION EVALUATION FORM

Item No.

3. County in which study city is located.
4. Intersection code number as given in Table 5, 6, or 7.
5. Official names of the streets forming the intersection.
6. Indicate the appropriate intersection classification.
7. Type of surface or surfaces of the intersecting streets (see "Classes and Types of Pavement").
8. Condition of intersection pavement.
9. Indicate curb radius on all corners.
10. Indicate if curbs exist, and if so what condition they are in.
11. Type of drainage, and location of areas of standing water after storms.
12. Location and type of any sight restrictions.
13. Amount of street lighting.
14. Indicate for each branch of the intersection if it is one-way or two-way operation.
15. Type of signalization, if any, and its timing.
 - a. Fixed time
 - b. Progressive
 - c. Traffic Actuated
 - d. Pedestrian Actuated

Item No.

16. Indicate branches of intersection which are controlled by stop or yield signs.
 17. Estimated average daily traffic approach volumes from traffic counts for each branch of the intersection.
 18. Indicate type of accidents for the three year period (1961 through 1963).
 - 19-30. Indicate the time by which the various deficiencies should be improved. Estimates should be based on present conditions in comparison with tolerable standards and on predicted traffic growth.
 - 31-39. Indicate the improvements which are proposed for the intersection.
- Describe: Briefly give reasons for and nature of proposed improvements.
- 40-44. Cost estimates for the various items listed should be entered to the nearest dollar. Estimated costs are based on unit price tables (see Table 9).

References (4,13,14,15,18,19)

Instructions for Completing Arterial Structure and Railroad
Evaluation Form

The Arterial Structure and Railroad Evaluation Form was used to inventory structures and railroad grade crossings on arterial and collector street sections. The following instructions refer to item numbers appearing in Figure 38.

Item No.

1. Name of city in which study is being conducted.
2. Population of city from latest U. S. Census.
3. County in which study city is located.
4. Street control section number, as given in Table 3 or 4, on which the structure or railroad crossing is located.
5. Bridge number starting with "1" for each street section.
6. Railroad crossing number starting with "1" for each street section.
7. Official name of street on which bridge or railroad crossing is located.
8. Overall length of bridge in feet, back-to-back of abutments. For railroad grade crossings leave blank.
- 9-10. Check appropriate boxes. If Federal-aid System classification is unknown leave item 9 blank.

Note: Items 11-20 apply to structures only.

IDENTIFICATION	
1. CITY _____	2. POPULATION _____
4. SECTION NO. _____	3. COUNTY _____
7. STREET NAME _____	5. BRIDGE NO. _____
6. R.R. CROSSING NO. _____	
8. BRIDGE LENGTH _____ FT.	
CLASSIFICATION	
9. EXISTING FEDERAL AID SYSTEM	10. STUDY SYSTEM
INTERSTATE HIGHWAY ☐	URBAN STATE PRIMARY ☐
PRIMARY ☐	URBAN STATE SECONDARY ☐
SECONDARY ☐	ARTERIAL PRIMARY ☐
NON FEDERAL ☐	ARTERIAL SECONDARY ☐
	COLLECTOR (30) ☐
	COLLECTOR (40) ☐
DATA ON EXISTING CONDITION OF STRUCTURE	
11. TYPE OF SERVICE	13. NUMBER OF LANES _____ FT.
STREAM CROSSING ☐	14. CLEAR ROADWAY WIDTH _____ FT.
R.R. UNDER HIGHWAY ☐	15. VERTICAL CLEARANCE _____ FT.
R.R. OVER HIGHWAY ☐	16. SUB-STRUCTURE CONDITION _____
HIGHWAY SEPARATION ☐	17. SUPER-STRUCTURE CONDITION _____
THRU LANES OVER ☐	18. SIDEWALKS YES ☐ NO ☐
THRU LANES UNDER ☐	19. SAFE LOADING _____
12. TYPE OF STRUCTURE	20. ADT _____ VPD
TIMBER ☐	21. DMV _____ VPH
CONCRETE SLAB ☐	22. YEAR BUILT _____
CONCRETE I-BEAM ☐	
STEEL I-BEAM ☐	
STEEL GIRDER ☐	
STEEL TRUSS ☐	
OTHER (SPECIFY) ☐	
DATA ON RAILROAD GRADE CROSSING	
23. NUMBER OF TRACKS	25. APPROXIMATE SPEED OF TRAINS
MAIN _____	PASSENGER _____
SIDINGS _____	FREIGHT _____
24. NO. OF TRAINS PER DAY	26. EXISTING TYPE OF PROTECTION
PASSENGER _____	SIGNS ONLY ☐
FREIGHT _____	SIGNS ☐
	SIGNS & GATES ☐
	WATCHMAN ☐
CHARACTER OF DEFICIENCIES	
STRUCTURES	TIME OF IMPROVEMENT
27. ROADWAY WIDTH	PRESENT 5 YR. 10 YR. 15 YR. 20 YR. OVER 20 YR.
28. VERTICAL CLEARANCE ☐	☐ ☐ ☐ ☐ ☐
29. STRUCTURAL CONDITION ☐	☐ ☐ ☐ ☐ ☐
30. TRAFFIC CAPACITY ☐	☐ ☐ ☐ ☐ ☐
31. OTHER (SPECIFY) _____ ☐	☐ ☐ ☐ ☐ ☐
RAILROADS	
32. GRADE CROSSING PROTECTION ☐	☐ ☐ ☐ ☐ ☐
PROPOSED IMPROVEMENTS - STRUCTURES	
33. TYPE OF SURFACE _____	DESCRIBE
34. LENGTH _____ FT.	
35. WIDTH _____ FT.	
36. NO. OF LANES _____	
37. LOADING _____	
38. TYPE OF WORK	
RECONSTRUCT EXISTING STRUCTURE ☐	
REPLACE EXISTING STRUCTURE ☐	
NEW STRUCTURE ☐	
PROPOSED IMPROVEMENTS - RAILROAD PROTECTION	
39. TYPE OF WORK	DESCRIBE
SIGNS ONLY ☐	
SIGNS & GATES ☐	
COST ESTIMATES	
40. STRUCTURE _____	DOLLARS
41. RAILROAD PROTECTION _____	

FIGURE 38 ARTERIAL STRUCTURE & RAILROAD EVALUATION FORM

Item No.

- 11-12. Check appropriate boxes.
 13. Number of lanes of moving traffic under or over the structure.
 14. Roadway width, curb to curb. For highway underpasses (railroad over highway) width between abutments or piers.
 15. Minimum vertical distance above roadway surface to lowest point of overhead obstruction, in feet. Enter "None" for deck type structure with no overhead obstruction.
 - 16-17. Indicate the condition of the sub-structure and super-structure as good, fair or poor using the guides given for item 19 of Instructions for Completing Local Street Evaluation Form.
 18. Indicate if sidewalks exist.
 19. The loading that the structure will safely handle in its present condition.
 20. Estimated average daily traffic from traffic counts.
 21. Estimated high-hour traffic count.
 22. Year structure was constructed.
- Note: Items 23-26 apply to railroad grade crossings only.
- 23-25. Enter appropriate values.
 26. Indicate existing type of protection.
 - 27-32. Indicate the time by which the various deficiencies should be improved. Estimates as to the time period of **future** needs should be based on present conditions

in comparison with tolerable standards.

Note: Items 33-38 apply to structures only.

33. Type of new surface (see "Classes and Types of Pavement").
34. Total centerline length of improvement.
35. Width of pavement on structural improvement.
36. Number of lanes of moving traffic on structure after improvement.
37. Load limit which structure is designed to carry after improvement.
38. Indicate type of work on structure.

Describe: Briefly give reasons for and nature of proposed structural improvements.

39. Indicate type of railroad protection to be provided.

Describe: Briefly give reasons for and nature of proposed railroad grade crossing improvements.

- 40-41. Cost estimates for the structural and railroad protection improvements should be entered to the nearest dollar.

References (4,13,14,15,18,19).

APPENDIX C

RESULTS OF 1965 NEEDS STUDY IN WEST LAFAYETTE, INDIANA

APPENDIX C

Results of 1965 Needs Study in West Lafayette, Indiana

The following is a summary of the physical and traffic needs in West Lafayette, Indiana as determined by this needs study. A brief description is given of the improvements required at each of the 69 street sections and 38 intersections investigated. The time by which each improvement will be needed is also given. The street sections and intersections are indicated in this summary by their code numbers. The location of each of these street sections and intersections can be obtained by referring to Tables 3 thru 7 in this report. The costs of the improvements required at each location are given in Tables 13 and 14.

Arterial Street Section Needs

1-001-01

1965 - 1680 ft of sidewalks along north side.

1980 - eliminate parking on both side, 12 "No Parking" signs.

1-002-01

1965 - 1170 ft of curb and gutter, 745 ft of sidewalk,
7 street lights, 2 "Speed Limit 30" signs, 2
"School Zone" signs, 1320 sq yd of new pavement.

1-002-02

1965 - Excavation and sodding.

1-003-01

1965 - 4 street lights.

1975 - 11 "No Parking" signs.

1-004-01

1965 - Replace 360 ft of curb and gutter, replace 650
ft of sidewalk, remove 20 parking meters, 6 "No
Parking" signs.

1-004-02

1965 - Replace 75 ft of curb and gutter, replace 105 ft
of sidewalk, 3 "No Parking" signs, resurface 180
sq yd of pavement.

1-004-03

1965 - Replace 100 ft of curb and gutter, replace 110 ft
of sidewalk, 4 "Speed Limit 30" signs, resurface
7 sq yd of pavement.

1-004-04

1965 - Replace 10 ft of curb and gutter, replace 85 ft
of sidewalk.

1-004-05

1965 - 1550 ft of new sidewalk, 55 ft of new curb and
gutter.

1-004-06

1965 - 4270 ft of new sidewalk, replace 45 ft of curb and gutter, rebuild 225 sq yd of pavement.

1-004-07

1965 - Replace 230 ft of curb and gutter, 160 sq yd of new pavement at intersection corners and median crossings.

1-004-08

1965 - Replace "Speed Controlled by Radar Patrol" sign.

1975 - Resurface 10,650 sq yd of pavement.

1-005-01

1965 - Replace 225 ft of sidewalk, relocate 2 utility poles, 2150 ft of new curb and gutter, 6 "No Parking" signs, widen pavement from 18 to 40 ft.

1-005-02

1965 - Replace 115 ft of sidewalk, replace 75 ft of curb and gutter, remove 3 parking meters, 3 "No Parking" signs, resurface 920 sq yd of pavement.

1-005-03

None

1-005-04

1965 - 310 ft of new curb and gutter.

1-005-05

1965 - 250 ft of new curb and gutter.

1-005-06

1965 - Remove 23 trees, clear one-half acre, fill 4680 cu yd, relocate 16 utility poles, install 40 ft of culvert, replace 85 ft of curb and gutter, widen pavement from 26 to 48 ft.

1-005-07

1975 - Relocate 2 utility poles, one "Pavement Narrows" sign, build shoulder on east side, 775 sq yd of pavement.

1-006-01

1965 - 3 "No Parking" signs, 2 "Speed Limit 30" signs, 165 ft of sidewalk.

1970 - Resurface 2880 sq yd of pavement.

1985 - 4 "No Parking" signs.

1-006-02

1965 - 115 ft of new curb and gutter, 1355 ft of new sidewalk, 13 "No Parking" signs, resurface 7660 sq yd of pavement.

1985 - Eliminate parking on east side, 12 "No Parking" signs.

1-007-01

1965 - 150 ft of new sidewalk, replace 90 ft of curb and gutter, 14 "No Parking" signs.

1985 - Eliminate parking on both sides, 12 "No Parking" signs.

1-007-02

1965 - Replace 15 ft of curb and gutter, resurface 53 sq yd of pavement, 955 ft of new sidewalk, eliminate parking on east side, 5 "No Parking" signs.

1975 - Eliminate all parking, 5 "No Parking" signs.

1980 - Resurface 6380 sq yd of pavement.

1-007-03

1965 - Widen surface from 21 to 48 ft, relocate 15 utility poles, relocate fire hydrant, excavate 2780 cu yd, 2800 ft of new curb and gutter, 3530 ft of new sidewalk.

1985 - Eliminate parking on east side, 10 "No Parking" signs.

1-007-04

1965 - 1900 ft of new sidewalk, 980 cu yd of fill, widen surface from 19 to 24 ft, resurface old pavement, build shoulder on west side.

1-008-01

1965 - Eliminate all parking, 12 "No Parking" signs, replace 2215 ft of sidewalk, replace 1595 ft of curb and gutter.

1-008-02

1965 - Eliminate all parking, 14 "No Parking" signs, replace 105 ft of sidewalk, replace 195 ft of curb and gutter.

1975 - Resurface 350 sq yd of pavement.

1-008-03

1965 - Replace 365 ft of curb and gutter, replace 470 ft of sidewalk, 2 "Speed Limit 20" signs.

1980 - Resurface 1360 sq yd of pavement.

1-008-04

1965 - 4 "Speed Limit 30" signs.

1-008-05

1965 - Eliminate all existing parking, 23 "No Parking" signs, replace 115 ft of sidewalk, replace 180 ft of curb and gutter, resurface 200 sq yd of pavement.

1-009-01

1965 - Resurface 970 sq yd of pavement, 90 cu yd of excavation, build new shoulder.

1-009-02

1965 - Add 900 ft of curb and gutter, new shoulder on south side, resurface 8330 sq yd of pavement.

1-009-03

1965 - Widen from 22 to 48 ft, replace 50 ft of curb and gutter, resurface 4560 sq yd of pavement, build shoulder on both sides.

1-010-01

1965 - 8 "No Parking" signs, 4 street lights.

1-011-01

None

1-011-02

None

1-012-01

1965 - 2 street lights, 2 "Speed Limit 30" signs.

1975 - Eliminate parking on north side, 8 "No Parking" signs.

Collector Street Section Needs

2-001-01

1965 - Replace 20 ft of sidewalk.

2-002-01

1965 - Eliminate parking on south side, 3 "No Parking" signs, 2 "Speed Limit 30" signs, 990 ft of new sidewalk.

2-003-01

1965 - Build 80 ft turn-around at south end, 100 ft of curb and gutter, replace 60 ft of sidewalk, one "No Parking" sign.

2-003-02

1965 - Eliminate parking on east side, 2 "No Parking" signs, replace 75 ft of curb and gutter, replace 135 ft of sidewalk, resurface 4650 sq yd of pavement.

2-003-03

1965 - Replace 10 ft of curb and gutter, resurface
1520 sq yd of pavement.

2-003-04

1965 - Widen from Oval Drive to Northwestern Ave. from
35 to 48 ft, channelization island at Oval Drive,
replace 60 ft of curb and gutter, replace 120 ft
of sidewalk, 5 "Speed Limit 20" signs, resurface
3990 sq yd of pavement.

2-003-05

1965 - Eliminate parking on east side, 7 "No Parking"
signs, replace 20 ft of curb and gutter, replace
225 ft of sidewalk.

2-003-06

1965 - Eliminate parking on east side, 5 "No Parking"
signs, replace 10 ft of curb and gutter, replace
85 ft of sidewalk.

2-003-07

1965 - Replace 140 ft of curb and gutter, 590 ft of
new sidewalk on east side, 3 "Speed Limit 30"
signs, 2 "No Parking" signs.

2-003-08

1965 - Eliminate parking on east side, 7 "No Parking"
signs, 3 "Speed Limit 30" signs, 300 ft of new
sidewalk on west side, replace 50 ft of sidewalk.

2-004-01

None

2-004-02

None

2-005-01

1965 - Eliminate parking on east side, 14 "No Parking" signs, 6 "Speed Limit 30" signs, one street light, 5460 ft of new sidewalk on one side of street.

2-006-01

1965 - 475 ft of new sidewalk on south side.

2-006-02

1965 - Add 25 ft of new curb and gutter, 1370 ft of new sidewalk on south side.

2-006-03

1965 - Replace 20 ft of curb and gutter.

1970 - Resurface 670 sq yd of pavement.

2-007-01

1965 - 9 "No Parking" signs, 270 ft of new sidewalk, replace 50 ft of curb and gutter.

2-007-02

1965 - Replace 70 ft of curb and gutter, 735 ft of new sidewalk, eliminate parking on north side, 4 "No Parking" signs.

2-007-03

1965 - Replace 10 ft of curb and gutter, add 1265 ft of new sidewalk, 2 "Speed Limit 30" signs, 2 "Street Name" signs.

2-007-04

1965 - Replace 20 ft of curb and gutter, eliminate parking on south side, 6 "No Parking" signs, 2 "Speed Limit 30" signs, 300 ft of new sidewalk on north side, rebuild 1805 sq yd of pavement.

2-008-01

1965 - Eliminate parking on north side, 5 "No Parking" signs, 2065 ft of new sidewalk on south side.

2-008-02

1965 - New sidewalk on both sides 2315 ft, 2 street lights, 4 "Speed Limit 30" signs.

2-009-01

1965 - Eliminate parking on east side, 9 "No Parking" signs, replace 70 ft of curb and gutter, replace 270 ft of sidewalk, resurface 4255 sq yd of pavement.

2-009-02

1965 - Eliminate parking on east side, 12 "No Parking" signs, replace 70 ft of curb and gutter, replace 380 ft of sidewalk, resurface 5360 sq yd of pavement.

2-010-01

1965 - Resurface 490 sq yd of pavement.

2-011-01

1965 - Eliminate all parking on north side, 6 "No Parking" signs, 2 "Speed Limit 20" signs, replace 275 ft of curb and gutter, replace 145 ft of sidewalk, rebuild 25 sq yd of pavement.

2-011-02

1965 - Replace 30 ft of curb and gutter, replace 320 ft of sidewalk, eliminate parking on north side, 5 "No Parking" signs.

2-011-03

1965 - Eliminate parking on north side, 9 "No Parking" signs, 2 "Speed Limit 30" signs, replace 135 ft of curb and gutter, replace 385 ft of sidewalk.

2-011-04

1965 - Eliminate parking on north side, 4 "No Parking" signs, 2 "Speed Limit 30" signs, replace 170 ft of sidewalk.

2-012-01

1965 - Eliminate parking on north side, 5 "No Parking" signs, replace 15 ft of curb and gutter, replace 100 ft of sidewalk, resurface 20 sq yd of pavement.

2-012-02

1965 - Replace 35 ft of sidewalk, resurface 155 sq yd of pavement, eliminate parking on north side, 4 "No Parking" signs.

2-012-03

1965 - Eliminate parking on north side, 7 "No Parking" signs, replace 40 ft of curb and gutter, 400 ft of sidewalk.

1975 - Rebuild 1110 sq yd of pavement.

Intersection Needs

1-01

1965 - Add 270 ft of sidewalk.

1980 - Widen 15 ft of west side of Northwestern Ave. south of intersection, add 4 ft median with left turn lane 265 ft long on Northwestern Ave. south of intersection.

1-02

1965 - Widen Northwestern Ave. 15 ft on north side between Grant St. and Fowler Ave., widen Grant St. 12 ft on west side south of intersection, 420 ft of new curb and gutter, 270 ft of new sidewalk, rebuild median on Northwestern, resurface Grant St. south.

1975 - Left turn phase signal on southwest corner for traffic moving north on Northwestern Ave.

1-03

1965 - Eliminate parking on east side of Vine St., 2 "No Parking" signs.

1975 - Eliminate parking on north side of Fowler Ave., one "No Parking" sign.

1-04

1965 - Replace 165 ft of sidewalk, replace 375 ft of curb and gutter, resurface North St. - 822 sq yd of pavement.

1-05

1965 - Eliminate parking on Northwestern Ave., one "No Parking" sign, replace 50 ft of sidewalk, replace 95 ft of curb and gutter, increase northwest corner to 40 ft radius, move traffic signal, street light and stop sign.

1975 - Resurface State St. east - 450 sq yd of pavement.

1980 - Resurface intersection and State St. west - 1170 sq yd of pavement.

1-06

1965 - Resurface intersection - 900 sq yd of pavement.

1975 - Resurface U. S. 52 north - 720 sq yd of pavement.

1-07

1965 - Replace 85 ft of curb and gutter, replace 210 ft of sidewalk.

1975 - Eliminate parking on north side of Wiggins St., one "No Parking" sign.

1-08

1965 - "Stop" sign at apartment exit, eliminate parking on west side of Robinson St., 4 "No Parking" signs, 90 ft of new curb and gutter, increase northwest corner to 30 ft radius.

1985 - Eliminate parking on east side of Robinson St.

1-09

1965 - Increase southwest and southeast corners to 30 ft radii, replace 560 ft of sidewalk, replace 195 ft of curb and gutter, resurface River Rd. south - 565 sq yd of pavement, 3 overhead lane marking signs for traffic approaching the intersection from the east on State St., 2 "No Parking" signs, one "Center Lane for Left Turn Only" sign.

1-10

1965 - Widen U.S. 52 By-Pass to 48 ft, increase all corners to 60 ft radii, move one fire hydrant and 3 utility poles, resurface U. S. 52 By-Pass and Salisbury St. north - 3280 sq yd of pavement.

1-11

1965 - Increase southeast corner to 30 ft radius, move utility pole, replace 100 ft of sidewalk, eliminate parking on east side of Vine St., 3 "No Parking" signs.

- 1975 - Eliminate parking on north side of Wiggins St.,
2 "No Parking" signs, remove 4 parking meters.

2-01

- 1965 - Eliminate parking on west side of Chauncey Ave.
north of intersection, replace 240 ft of sidewalk,
replace 165 ft of curb and gutter, increase north-
west corner to 25 ft radius, increase southwest
corner to 25 ft radius, increase northeast corner
to 20 ft radius, relocate one street light, resur-
face Chauncey Ave. north - 490 sq yd of pavement.
- 1975 - Resurface intersection and State St. west - 910
sq yd of pavement.

2-02

- 1965 - Widen Salisbury St. from 19 to 24 ft, increase
northeast and southeast corners to 40 ft radii,
2 "Stop" signs for Cumberland Ave., move 3
utility poles, eliminate parking on median side
of Cumberland Ave., 270 ft of new curb and gutter,
build shoulder on west side of Salisbury St.

2-03

- 1975 - Increase corners on Cumberland Ave. to 40 ft
radii, resurface U.S. 52 - 4125 sq yd of
pavement.

2-04

- 1965 - Replace 80 ft of sidewalk, eliminate parking on east side of Salisbury St., one "No Parking" sign, resurface Salisbury St. north of intersection - 220 sq yd of pavement.
- 1975 - Eliminate parking on north side of Fowler Ave., 2 "No Parking" signs.

2-05

- 1965 - Eliminate parking on both sides of Salisbury St. and east side of Grant St., 4 "No Parking" signs, add sidewalk on west side of Grant St. - 50 ft, add sidewalk on north side of Salisbury St. - 170 ft, replace 30 ft of curb and gutters, increase southeast corner to 25 ft radius.
- 1980 - Resurface Salisbury St. - 1330 sq yd of pavement.

2-06

- 1965 - Widen Grant St. 13 ft north of intersection for 150 ft, increase northwest and southwest corners to 35 ft radii, taper southeast corner on State St. and relocate all facilities on this corner, resurface Grant St. - 1205 sq yd of pavement, eliminate all parking on Grant St., 2 "No Parking" signs, 3 overhead lane marking signs for traffic moving east on State St., new traffic signal on southwest corner.

1980 - Resurface State St. east of intersection - 500
sq yd of pavement.

2-07

1975 - Widen River Rd. to 48 ft, move light pole, 165
ft of new curb and gutter, build shoulder on
east side of River Rd.

2-08

1965 - Relocate intersection 315 ft east of existing
center-line of Happy Hollow Rd. and Soldiers Home
Rd., widen U.S. 52 By-Pass west to 48 ft and east
to 46 ft - 1600 sq yd of new pavement and 2255
sq yd of resurface pavement.

2-09

1965 - Add 325 ft of new sidewalk.

2-10

1965 - Widen Salisbury north of intersection from 21 to
48 ft, rebuild channelization island, move fire
hydrant, increase northwest corner to 35 ft
radius, increase northeast corner to 25 ft radius,
add 550 ft of new sidewalk, eliminate parking on
east side of Salisbury St. south of intersection.

1970 - Resurface Lindberg Rd. east of intersection -
110 sq yd of pavement.

1975 - Eliminate all parking on Salisbury St. south of
intersection.

1980 - Resurface Lindberg Rd. west and Salisbury St.
south - 1435 sq yd of pavement.

2-11

1965 - Increase both corners to 70 ft radii, remove 4
trees, add 40 ft of new sidewalk, replace 130
ft of curb and gutter.

2-12

1965 - Increase northwest corner to 20 ft radius,
increase southwest corner to 25 ft radius, re-
locate utility pole, replace 185 ft of sidewalk,
add 85 ft of new curb and gutter, remove 5 trees,
eliminate parking on south side of Meridian St.
and east side of Salisbury St., 2 "No Parking"
signs, resurface Robinson St. and Salisbury St.
south - 1000 sq yd of pavement, rebuild Meridian
St. - 300 sq yd of pavement.

2-13

1965 - Increase southwest corner of 50 ft radius, increase
southeast corner to 25 ft radius, replace 115 ft
of curb and gutter, resurface Allen St. - 520 sq
yd of pavement, eliminate parking on Stadium Ave.
east of intersection.

2-14

1965 - Increase northwest, southwest and southeast corn-
ers to 25 ft radii, widen River Rd. south of
intersection from 18 to 40 ft, replace 50 ft of

sidewalk, relocate fire hydrant and 2 utility poles, add 110 ft of new curb and gutter, eliminate parking on north side of Wood St., one "No Parking" sign, resurface River Rd. north - 510 sq yd of pavement.

1975 - Resurface Wood St. west - 330 sq yd of pavement.

2-15

1965 - Eliminate parking on north side of Stadium Ave. west and west side of Robinson St., 3 "No Parking" signs, 295 ft of new sidewalk, relocate fire hydrant and utility pole, remove 2 trees, increase northwest and southeast corners to 25 ft radii, resurface intersection and Robinson St. north - 1040 sq yd of pavement.

1970 - Resurface Robinson St. south - 117 sq yd of pavement.

1985 - Eliminate parking on both sides of Robinson St., one "No Parking" sign.

2-16

1965 - Increase northwest corner to 25 ft radius, replace 170 ft of curb and gutter, build 30 ft x 3 ft concrete island, "Center Lane for Left Turn Only" sign.

2-17

1965 - 315 ft of new sidewalk, one "Stop" sign on Nancy's Dr. west.

2-18

1965 - Eliminate parking on east side of Salisbury St. north of intersection, increase northeast corner to 30 ft radius, replace 50 ft of sidewalk, resurface Salisbury St. south - 220 sq yd of pavement.

4-01

1965 - Eliminate parking on north side of Wood St., 2 "No Parking" signs, increase southeast and southwest corners to 25 ft radii, remove 7 trees, relocate street light and utility pole, resurface Chauncey Ave. south of intersection - 595 sq yd of pavement.

4-02

1965 - Increase corners to 30 ft radii, eliminate parking on south side of Chippewa St., one "No Parking" sign, sidewalks both sides of Chippewa St. - 120 ft.

4-03

1965 - Eliminate parking on south side of Chippewa east, one "No Parking" sign, 455 ft of new sidewalk.

4-04

1965 - Increase all corners to 30 ft radii, eliminate parking on east side of Grant St. north, 2 "No Parking" signs, eliminate parking on north side of Meridian St. west, relocate utility pole, remove tree, replace 45 ft of curb and gutter, 480 ft of new sidewalk.

4-05

1965 - Eliminate parking on east side of Grant St. and north side of Stadium Ave., move parking back 200 ft from corner on west side of Grant St. north of Stadium Ave., 4 "No Parking" signs, remove 3 trees, one street light, replace 100 ft of curb and gutter, replace 315 ft of sidewalk.

4-06

1965 - Eliminate parking on north side of Wood St. and east side of Grant St., 3 "No Parking" signs, increase northeast corner to 30 ft radius, remove 2 trees, replace 15 ft of sidewalk, resurface Grant St. - 1060 sq yd of pavement.

4-07

1965 - Eliminate parking on east side of Indian Trail Dr. and south side of Lindberg Rd., 435 ft of new sidewalk, resurface Lindberg Rd. - 1055 sq yd of pavement.

4-08

1965 - Eliminate parking on north side of Navajo St. east and east side of Indian Trail Dr. south, 2 "No Parking" signs, increase southeast and southwest corners to 30 ft radii, 555 ft of new sidewalk.

4-09

1965 - Eliminate parking on east side of Salisbury St., 4 "No Parking" signs, eliminate parking on north side of Stadium Ave., remove 8 trees, relocate light pole and fire hydrant, increase northeast, northwest and southeast corners to 30 ft radii, replace 105 ft of sidewalk, resurface Salisbury St. - 780 sq yd of pavement.

APPENDIX D
PRIORITY RATING

APPENDIX D

Priority Rating

The instructions given in this appendix refer to the Street and Intersection Priority Rating Form shown in Figure 39. Data for completing the form are to be obtained from inventory information, traffic volumes, aerial photos, city maps and personal evaluation. The individual preparing the form and the date it is prepared are to be entered on the first line. The other items are completed as follows:

1. Identification - Check one of the two boxes, either street section or intersection, depending on which is being rated. After checking a box fill in the information under it.
2. Code Number - Enter the code number of the street section or intersection. (In this study the code numbers are given in Tables 3, 4, 5, 6 and 7).
3. Classification - Enter the classification of the street section or intersection as given below. Definitions are given under "Design of Study" in this report.

STREET AND INTERSECTION IMPROVEMENT PRIORITY RATING

Prepared By _____ Date _____

1. Identification

Street Section ☐

Name _____

From _____

To _____

Intersection ☐

Street Names _____

2. Code Number _____

3. Classification _____

4. Importance Rating

5. Condition Rating

	Data Points		Data Points
Travel Volume	_____	Width	_____
Service	_____	Surface Condition	_____
Importance	_____	Curbs and Gutters	_____
Total	<input type="text"/>	Structural Adequacy	_____
		Total	<input type="text"/>

6. Priority Rating

FIGURE 39. STREET AND INTERSECTION IMPROVEMENT PRIORITY RATING FORM

Street Sections

- A. Arterial Primary
- B. Arterial Community
- C. Collector (30)
- D. Collector (40)
- E. Local

Intersections

- A. Arterial - Arterial
 - B. Arterial - Collector
 - C. Arterial - Local
 - D. Collector - Collector
 - E. Collector - Local
 - F. Local - Local
4. Importance Rating - Use the point system given in the following pages and enter the sum of the traffic volume, service and importance ratings in the total box. The maximum value for the Importance Rating is 100 points.
5. Condition Rating - Use the point system given on the following pages and enter the sum of the width, surface conditions, curbs and gutters and structural adequacy ratings in the total box. The maximum value for the Condition Rating is 100 points.

6. Priority Rating - To obtain the Priority Rating the Condition Rating is subtracted from the Importance Rating and the answer with its sign (+ or -) is entered in the box provided on the form.

From the Priority Rating a list of street sections and intersections can be prepared and used as a tool in determining priority of improvement. The higher the arithmetic value of the Priority Rating the higher the priority of improvement suggested by this sufficiency rating toll.

The Importance Rating and Condition Rating are to be determined as follows:

Importance Rating

Traffic Volumes (maximum 60 points) Basis: ADT volumes for street sections and average ADT volumes for all approaches for intersections.

<u>ADT Volume</u>	<u>Points</u>
3,000 and above	60
2,500	50
2,000	40
1,500	30
1,000	20
500	10
0	0

Route Service (maximum 20 points) Basis: Percentage of development along street sections and 200 feet back on each approach for intersections

<u>Percent of Development</u>	<u>Points</u>
100	20
75	15
50	10
25	5
0	0

Importance (maximum 20 points) Basis: Importance as a connecting link in street system.

<u>Rating</u>	<u>Points</u>
Very Important	20
Quite Important	15
Important	10
Little Importance	5
No Importance	0

Condition Rating

Width of Street (maximum 20 points) Basis: Inventory width curb to curb for street sections, for intersections average the point rating for each approach.

Width, feet

<u>Arterial or Collector</u>	<u>Local</u>	<u>Points</u>
44	34	20
42	32	16
40	30	12
36	26	8
32	22	4
28	18	0

Surface Condition (maximum 20 points) Basis: Rating based on inventory data and personal evaluation.

<u>Rating</u>	<u>Points</u>
Excellent	20
Good	15
Fair	8
Poor	0

Curbs and Gutters (maximum 20 points) Basis: Inventory Data.

<u>Type</u>	<u>Points</u>
Standard	20
Stone on Concrete Vertical	15
Cobblestone	5
None	0

Structural Adequacy (maximum 40 points) Basis: Inventory data and personal evaluation.

<u>Rating</u>	<u>Points</u>
Adequate	40
Doubtful Adequacy	30
Inadequate	20
Unimproved	10
Unopened	0