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# An Urban Sufficiency Rating Procedure for Idaho Highways

Robert P. Newell

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# AN URBAN SUFFICIENCY RATING PROCEDURE

# FOR IDAHO HIGHWAYS

by

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Engineering Experiment Station
College of Engineering
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In Cooperation With

IDAHO DEPARTMENT OF HIGHWAYS

and the

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# FOREWORD

This report is essentially the thesis of Robert P. Newell prepared in fulfillment of the research and thesis requirements for the degree of Master of Science of Civil Engineering at the University of Idaho.

The investigation was supervised by C. W. Hathaway, Associate Professor of Civil Engineering. Advice, recommendations, and coordination of the considerable assistance from personnel of the Idaho Department of Highways was provided by L. F. Erickson, Research Engineer for the Department. Robert Thompson assisted with the field studies, Robert Turner prepared the illustrations and Margaret Barackman and Dorothy Pease typed the manuscript.

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# SUMMARY


The Idaho Department of Highways has used for several years a single sufficiency rating formula as part of its basis for programing rural and urban highway improvements. Increases in urban traffic volumes have necessitated considerations orientated more directly to urban travel characteristics, however.

The purpose of this project, and the subject of this report, is to formulate and recommend a sufficiency rating procedure specifically adapted to urban travel characteristics on Idaho Highway System. The investigations consisted of a literature study followed by formulation of several pilot rating procedures and subsequent testing in the field. An opinion poll was solicited as a guide in the evaluation of the field test results. This poll was qualified statistically to establish its reliability.

The trial formula having the best correlation with the opinion poll was modified slightly to conform more to what was considered to be the most reasonable rating guides. This modification resulted in the discovery of compensating errors, and the formula was not considered further. The best features of the eleven formulas tested were then incorporated into a recommended formula which retained the three basic categories used originally by the Idaho Department of Highways. Features within these categories were altered extensively, however, in making the adaptation to urban conditions.

# CHAPTER I

# INTRODUCTION

## I. PURPOSE

As part of an overall priority system for programing needed highway improvements and construction in Idaho, the Idaho Department of Highways is utilizing a sufficiency rating procedure adapted from that established in 1946 by Karl Moskowitz then of the Arizona Department of Highways, in cooperation with the U. S. Bureau of Public Roads. This sufficiency rating system is a measurement of roadway features as compared to predetermined standards established primarily by the American Association of State Highway Officials and revised by the Idaho Department of Highways. Deficiencies or inadequacies reduce the perfect highway numerical rating of 100 points by the degree of inadequacies present.

At present the sufficiency ratings used by the Idaho Department of Highways are applied to both rural and urban highways and streets, although the ratings as originally developed, were intended primarily for use on the rural highways alone. Evaluation of the sufficiencies of urban and rural highways is becoming more diverse, however, due to the noticeably increasing differences in the functional purpose of each type of facility. Urban streets are carrying substantially heavier traffic volumes than are rural highways, while travel speeds are mostly higher on rural highways than on urban streets. Access control, turning movements, and parking maneuvers are associated with the flow of urban street traffic, while pavement smoothness is more directly associated with the high speed travel of rural highways.

In view of the above observations it has been decided that an evaluation should be made of all factors comprising a sufficiency rating for urban highways. These factors should include those deficiencies which are applicable specifically to urban highways and urban travel requirements, as opposed to the present practice of applying rural highway deficiencies to urban highways.

## II. STATEMENT OF PROBLEM

The object of this study is to develop a feasible sufficiency rating system to apply to urban highways, considering tangible factors that can be compared to predetermined standards. Primary areas of study will be the determination of specific factors to comprise the rating and the relative weight of each factor in the total rating.

A satisfactory rating system will assist highway administrators in arriving at a final urban highway improvement programing schedule. It must be noted, however, that it is not intended to include those factors which require an extensive amount of individual judgement by the administrators alone. Rather it is to be based primarily on tangible aspects of urban highway transportation characteristics that can be readily measured.

## III. DEFINITIONS

The following terms are defined for a common understanding within this report. They are in close conformance with the geometric design policies of the American Association of State Highway Officials (AASHO), (1, 2), the Highway Capacity Manual of the U. S. Bureau of Public Roads, (3), and the traffic engineering syllabus of the Institute of Transportation and Traffic Engineering of the University of California, (4).

Travel Time (or Overall Travel Time) - The total time required for a vehicle to travel a specific route between two terminal points under existing traffic and roadway conditions, including all stops and delays except those stops occurring off the traveled way.

Running Time - The portion of travel time the vehicle is in motion only.

Average Travel Time - The arithmetic mean of several travel time runs by a "floating car", usually from six to twelve of such runs.

Travel Speed (or Overall Travel Speed) - The distance traveled over a specific route between two terminal points divided by the overall travel time required for traversing this distance.

Running Speed - The distance traveled over a specific route between two terminal points divided by the running time of the traveling vehicle.

Delay - The total time lost by traffic due to traffic friction and/or traffic control devices, over which the driver has no control.

Fixed Delay - The time lost by traffic due only to traffic controls, such as stop signs, traffic signals, etc.

Operational Delay - The time lost by traffic due to congestion or operational interference between traffic components; this also includes time lost while waiting at a stop sign for a gap in cross traffic.

Stopped-Time Delay - The time lost by traffic due to any condition forcing the driver to stop his vehicle; in the case of stop signs, it is the time lost in coming to a complete stop only, and does not include that time lost in waiting for a gap in cross traffic.

Traffic Volume (or Volume) - The number of vehicles passing a given point during a specific time span; time spans of one hour and one day (24 hours) are used in this report.

Average Daily Traffic - The volume of traffic during any specific period divided by the number of days in that period; commonly noted as ADT. A period of one year is generally used by most authorities; it is the period used here.

Thirtieth Highest Hourly Volume - The hourly volume that is exceeded only by 29 hourly volumes within a specific year; commonly noted as 30 HV. Usually this is used as a volume criteria in geometric design of a highway or street.

Peak Hourly Volume - The highest hourly volume within an average daily traffic volume; in this report peak-hourly volumes are considered on weekdays only.

Basic Capacity - The maximum volume of traffic that can traverse a lane or roadway under the prevailing roadway and traffic conditions; it is the volume of traffic that cannot be exceeded without changing one or more of the prevailing conditions. In relation to signalized intersection capacity it is the volume of traffic that is accommodated under the prevailing conditions with a continual backlog of waiting vehicles.

Practical Capacity - The volume of traffic that can traverse a lane or roadway without encountering unreasonable delay, hazard, or restriction of freedom of movement under the prevailing roadway and traffic conditions. In regards to signalized intersections it is the volume of traffic that can be accommodated under the prevailing conditions with most vehicles being able to clear the intersection without waiting for more than one signal cycle.

Volume to Capacity Ratio - The peak-hourly volumes within an average weekday divided by the practical capacity of a route in question, as determined by methods outlined in the U. S. Bureau of Public Roads' *Highway Capacity Manual*, (3).

Density - The number of vehicles on a unit length of roadway at any given instant.

# CHAPTER II

## CONCEPTS AND CURRENT PRACTICES

In obtaining information concerning the relatively new field of urban sufficiency ratings, available literature was studied as to each factor that may influence these ratings. Highway agencies, mostly in the west were contacted by mail to determine their current practices and past experiences with urban sufficiency ratings of one form or another, and whether or not they were utilizing them in their programing of urban street improvements. The state highway departments contacted included (in addition to Idaho) Washington, Oregon, Montana, Wyoming, Colorado, Utah, Nevada, California, Arizona, Indiana, Missouri, New Mexico, and Texas. Responses, promptly received from all states, are discussed in this chapter and summarized in Table A-I on page 103. In addition, other agencies including city engineering departments and universities were contacted by mail; these are referred to in the course of the text according to the information received.

### I. PAST AND CURRENT CONCEPTS

This section will be divided into two parts, the first dealing with the concept of urban sufficiency ratings as a whole, and the second dealing with specific factors that could influence the priorities of street improvement in some manner. The material studied will be described briefly, covering only the main concepts, in order that comparisons may be made more readily by the reader.

General Concepts

The purpose and basis for urban sufficiency ratings have been summarized well from various sources by R. H. Mohle in 1958 (5), the more important of which follow:

The concept of urban sufficiency ratings has been described in several forms, two of which are: "...evaluation of a street plan 'according to the ability of each street to handle its present and future traffic safely, rapidly, and economically.' " (from a letter of transmittal by D. Jackson Faustman, "Street Sufficiency Ratings for the city of Vallejo, California", Sacramento, California, June 11, 1956) and " '...a device comparable to the rural sufficiency rating method which would rank urban street sections for the relative adequacy and for the relative urgency in their improvement.' " (from a paper presented at a seminar of the Yale Bureau of Highway Traffic by M. Earl Campbell, "Some Considerations in Rating Urban Streets", Yale University, New Haven, Conn., 1956).

The purpose of urban sufficiency ratings has been summarized as follows:

1. To aid in the assignment of priorities for reconstruction by evaluating the relative adequacy of each street section according to certain prescribed standards.

2. To minimize the element of personal judgement in the assignment of ratings.

3. To evaluate the road sections' ability to carry traffic safely, rapidly, and economically.

4. To hold a minimum political and community pressure in planning and construction.

5. To keep legislative officials advised as to the current status of the street (or highway) plant and the funds that will be required to achieve a given standard of improvement on a statewide basis. The accomplishment of this objective would counteract legislative allocation based on political expediency.

6. To measure at annual intervals the average rating of the urban street system so the rate of progress of the program of urban streets and highways can be determined (the rate of progress, whether plus or minus, provides a means of measuring the adequacy of highway revenues).

7. To budget funds for urban street and highway improvements in the relative order of need, thus protecting the public's investment in urban streets and highways. (4)

Mohle arrived at what he termed two different approaches to urban sufficiency ratings. These are the "acceptable elements" concept and the "acceptable operations" concept. The first of these has to do with the physical elements of a street or highway, such as condition of pavement, lane width, and sight distance. The second is concerned with traffic operations, such as travel times and speeds, volumes and capacities, and accident experience. An example of a rating system based entirely upon the "acceptable elements" principle is the present formula used by the Idaho Department of Highways in its rating of rural highways. An example of a system based entirely on the "acceptable operations" concept is that used by the California Division of Highways, which bases its ratings entirely upon a modified volume-capacity ratio. The Washington State Highway Commission in 1954 utilized a combination of the two concepts by incorporating travel times and pavement design and condition in its urban sufficiency formula.

Mohle concludes that sufficiency ratings alone are not adequate in providing a basis for establishing improvement priorities, and proposes that a priority index might be had from a relationship reported by Harris (6) between sufficiency ratings, cost of project, and volume of traffic:

$$\text{Priority Index} = \frac{\text{Suff. Rating x Project Cost}}{\text{Volume in Veh. miles/day}}$$

A theory advanced by E. C. Carter and Joseph R. Stowers (7) is that urban street improvement priorities should be based upon an overall cost comparison including total cost for the required improvements and costs of vehicle operations, which is essentially a benefit-cost ratio. A rather sophisticated method using statistical application for programing funds for street improvements was advocated as a substitute for reliance on the sufficiency rating concept, as it was felt that sufficiency ratings were not comprehensive enough towards establishing improvement priorities.

Rating procedures for urban intersections were presented by Schenler and Michael (8) as being indicative of urban street adequacies. This is based on the concept that intersections are the primary controlling factor of urban traffic movement. The procedure would assign 70 points par to a physical rating and 100 points to a traffic operations rating. The physical rating is composed of many features, each given relatively small numerical par values. These are surface condition (20 points), rideability (5 points), skid resistance (5 points), intersection geometrics (20 points), visual restrictions (5 points), lighting (5 points), and a curb consistency and drainage rating (5 points). Comparison to established standards of the pertinent items gives the rating of this category. The traffic operations rating is based entirely on delay through the intersections, with the use of prepared graphs to determine the rating value.

A modification procedure was then introduced to give lower ratings to those facilities having excessive delays but moderate physical ratings than to those facilities having moderate delays but poor physical ratings.

A comprehensive system of rating urban streets and highways, by use of an equation has been proposed by Platt of the Ford Motor Company (9). This equation includes both driver operating characteristics and traffic operating characteristics, and also incorporates a traffic flow theory by Greenshield (10). The flow theory states that for maximum volumes, traffic densities must be kept below a critical density value, which is the density at which maximum volume is reached due to a certain average speed (usually about 30 mph); variation of this speed in either way would result in decreased volumes.

The equation components were measured by a specially designed machine in a test vehicle being driven over the streets being rated. Three divisions or ranges were available, dividing the street typs as urban streets, expressways, and freeways. The machine was relatively complicated, being able to measure such quantities as number of applications of brakes, and accelerations, in addition to travel and delay times, and appears to be financially out of reach of most budget limited state highway agencies.

Specific Factors

Sufficiency ratings may be composed of a great number of influencing factors, or may be composed of but one factor, as can be seen in the early urban ratings of Washington (11) and the present urban rating used by California (12). A brief account is given below of some of the more prominent factors, using the three popular categories of condition, safety, and service as guides, but not as limiting elements.

Condition. The condition category pertains to the adequacy of a pavement to accommodate traffic for which the pavement is serving. Evaluation of the category has been associated under the heading of pavement condition in a majority of instances, and includes the total pavement structure as opposed to its separate parts. Some agencies also evaluate such factors as drainage and cost or frequency of maintenance. Others evaluate each component of the pavement structure and may include drainage as well.

Evaluation of the composite pavement structure has been by comparison with design plans or established standards, but mostly by visual inspection in the field. Idaho has been experimenting with a type of profilometer device for possible use in evaluating pavement condition (13). Colorado is anticipating the use of a CHLOE profilometer for the same purpose.

Excessive maintenance costs or frequency can be determined from existing records within the highway agency. Drainage conditions are mostly ascertained visually in the field. These were not used by most agencies.

Economics of road life and a benefit-cost ratio have been mentioned as criteria of a structural sufficiency nature; this was limited, however, mostly to rural situations only. Due to the apparently complicated nature of estimating road life economics this factor was not comprehensively investigated. Benefit-cost ratio is believed to lie outside the scope of a sufficiency formula, as well as road life economics.

Safety. The category of safety has been adaptable to both the operations and elements concepts of urban street adequacy, although association is perhaps more with the operations concept. Components of this category would include such factors as surface or lane width; sight distances, particularly at intersections; alignment and gradient; adequate lighting; presence of on-street parking; presence of median; frequency of intersections; and number of private and commercial driveways, all falling within the elements classification of street safety sufficiency. The operations classification would include such factors as accident experience, and perhaps proper operational control of intersectional traffic as a borderline case.

Two important concepts have been stated concerning urban street safety. Versace (14) has said "...there are more accidents at those places where the situation places great demand on the momentary perceptual-decision-motor capacities of the driver". Schoppert (15) found that "The number of accidents increases with the number of situations presenting a change in conditions and therefore requiring a decision on the part of the motor vehicle operator."

Concerning the factors within the elements concept, lane widths or number of lanes have not been used directly in rating the safety adequacy of urban streets by many of the agencies contacted, nor has this factor been found in direct use in the literature. According to the American Association of State Highway Officials (1) lane widths affect accident rates only moderately. The number of lanes has reduced accidents somewhat as the number of lanes increases, but this was partly because of increased access control accompanying an increase in number of lanes. May (16) of the Michigan State University has related lane widths and number of lanes in a frictional concept employed as an evaluation of urban street safety.

Passing and stopping sight distances have been used, but mostly for rural sufficiency ratings. The need for passing opportunity is not so great on urban streets. Sight distances in urban situations are employed in the design of intersections to enable the motorist to ascertain that it is safe to cross. None of the highway departments contacted has used or considered a factor of this type in rating the safety aspects of their urban streets.

Alignment and gradient are associated mostly with rural sufficiency ratings due to the high standards required in accommodating the higher speeds of rural highways. Urban streets do not serve the same purpose and thus do not require standards as rigid. Also, right of way acquisition is more difficult and costly in urban situations.

Adequate lighting of urban streets has not been the object of study by any of the agencies contacted and none of the agencies used this factor in their urban sufficiency ratings, nor indicated consideration for future use, except the two California cities of Vallejo and Sunnyvale. The method of evaluating adequate lighting was not available.

The presence of dividing medians has not been used directly as a factor in urban sufficiency ratings. In a publication by the Automotive Safety Foundation (17) which summarizes numerous studies concerning accidents, it is reported that for narrow medians (up to 20 feet in width) cross-median accidents increase with increasing traffic volumes. No conclusive or predictable evidence could be given as to the effect of deterring-type medians on total accident rates. The evidence as to the nontraversable type of median has been both positive and negative with resulting inconclusive testimony. The number of head-on accidents has been reduced as median widths increase up to about 50 feet. For greater median widths accident rates remain relatively constant.

The Versace and Schoppert concepts of accident situations discussed previously on page 13 lend themselves to use of such elements as presence of on-street parking, frequency of intersections and commercial driveways, and presence of a median. Although the agencies contacted have not been using these factors as reported in the literature, it is possible that they could be adapted as a suitable means of evaluating urban street safety.

May (16) has enumerated four types of traffic friction as internal, marginal, medial, and intersectional. He has related these types of friction to number and width of lanes (internal friction), existence of on-street parking (marginal friction), presence of median (medial friction), and frequency of intersections (intersectional friction). It is seen that the Versace and Schoppert concepts are thus related, and could be applied on a practical working basis.

Service. Good street service is that characteristic by which motorists are able to travel the facility comfortably without encountering numerous delays and stops due to traffic congestion or traffic control. The motorist is able to maintain a moderate but consistent speed throughout his course of travel. Additionally, good service means that the street is able to accommodate its maximum design traffic volume with a minimum amount of congestion and delay.

Two factors are most noteworthy as indicators of the serviceability of urban streets. These are travel time, which is analogous with travel speed and delay rate, and a ratio of existing peak volumes to computed street capacity. Each of these factors has been used separately or together with other factors in indicating the service category, and in some cases as the street rating.

Travel time, or its equivalent, is evaluated in most cases by the "floating car" technique (19) in which a passenger car is driven over the street section being evaluated at an average speed of the surrounding vehicles. The time interval is that period required to traverse the street section being tested. Required number of test runs differed among those using the technique; the Idaho Department of Highways requires six, plus four additional ones if certain criteria are not met. Washington state, where 75 per cent of the rating is based on a speed rating, stipulates four runs; the Manual of Engineering Traffic Studies (19) stipulates twelve for reasonable accuracy. The technique of maintaining an average speed varies between having the driver use his own judgement and having the driver pass as many vehicles as have passed the test vehicle.

In the volume-capacity ratio technique the street capacity is computed using the method given in the U. S. Bureau of Public Roads' Highway Capacity Manual (3). The volumes generally used are the peak-hourly volumes which normally occur from 4:30 to 5:30 in the weekday afternoon, or the 30th highest hourly volume of a year. A capacity-volume ratio using the 30th highest hourly volumes is used by the California Division of Highways as the sole indication of the adequacy of its streets and highways (12). Colorado Department of Highways uses the peak-hourly volumes in its ratio computations, while New Mexico compares capacities with the 30th highest hourly volumes. Oregon has indicated consideration of a volume-capacity ratio as part of an indication of its urban street condition; Missouri uses a volume-capacity ratio also (5).

Rothrock (20) brings out the point that use of either travel time or volume-capacity ratio alone would tend to be misleading. The sources of delays encountered are sometimes attributed to the wrong factors, which has been substantiated in the U. S. Bureau of Public Roads "Wisconsin Avenue Report" (21). Also, volume-capacity ratios may possibly be misleading in that equal values would not yield equivalent travel speeds on those streets utilizing progressive signaling compared to those streets not having progressive signaling; the affect of constant travel speeds remains as an important criteria of urban street adequacy.

Factors which may be indicative of street serviceability that fall within the element concept of sufficiency ratings may be the simple inclusion of presence of median, adequate lane width, adequate sight distance, and clear and definite channelization of traffic where needed; these will not be elaborated upon as it is considered outside the scope of this report. None of these factors has been found in use in the service category of urban sufficiency ratings.

## II. CURRENT PRACTICES

### Western State Highway Departments

Idaho. As mentioned, the Idaho Department of Highways has adapted the conventional rural highway sufficiency rating procedure for rating urban highway sections. Three categories are rated--pavement condition, safety, and service. Table I shows the factors and corresponding par values of this formula. The final ratings are modified by a traffic volume factor in curve form as shown in Figure 1 on page 20.

In applying the rural sufficiency rating formula to urban highways, the Department has attempted to adapt the rural elements of shoulder width, surface, width, and stopping sight distance for the urban oriented factors of marginal friction, medial friction and intersectional friction, respectively. It was apparent in field inspection that numerous urban highway sections evaluated in these categories as zero have been rated too severely and that urban highways in general are unduly penalized.

In 1959 a modified sufficiency formula within the Idaho Department of Highways was suggested, still primarily concerning rural highways but included some aspects which were to be applied to urban situations also. It was proposed that the service category should be a single factor based on travel time comparisons and having the same par value of 35 points. A straight li e relationship of sub-par values was proposed, giving a zero rating for zero overall travel speed and a 35 rating for a 35 mile per hour travel speed. Preliminary proposals for a safety rating would use a single factor based on accident records and would include consideration for the number of accidents as well as for the type of accident. Comparisons would be made on economic loss basis in terms of dollars per vehicle-mile, using a straight line relationship with zero rating at six dollars loss per vehicle-mile to the full 30 point rating at zero dollars loss per vehicle-mile.

TABLE I

SUFFICIENCY RATING FORMULA FOR

IDAHO DEPARTMENT OF HIGHWAYS

| FACTOR | PAR VALUE | |
|---|---|---|
| CONDITION | | |
| Total Condition | 35 | 35 |
| SAFETY | | |
| Shoulder Width | 8 | |
| Surface Width | 7 | |
| Stopping Sight Distance | 10 | |
| Consistency of Alignment | 5 | |
| Total Safety | | 30 |
| SERVICE | | |
| Alignment | 12 | |
| Passing Opportunity | 8 | |
| Surface Width | 5 | |
| Rideability | 10 | |
| Total Service | | 35 |
| TOTAL PERFECT RATING | | 100 |

Based on Formula:

$$Y = X + \frac{(X-100)\ X}{50\ \log T_s}\ (\text{Log } T - \text{Log } T_s)$$

Where Y = Adjusted Rating; X = Original Rating;
$T_s$ = Average Daily Traffic on System = 1,090 veh.
T = Average Daily Traffic on Road being Rated

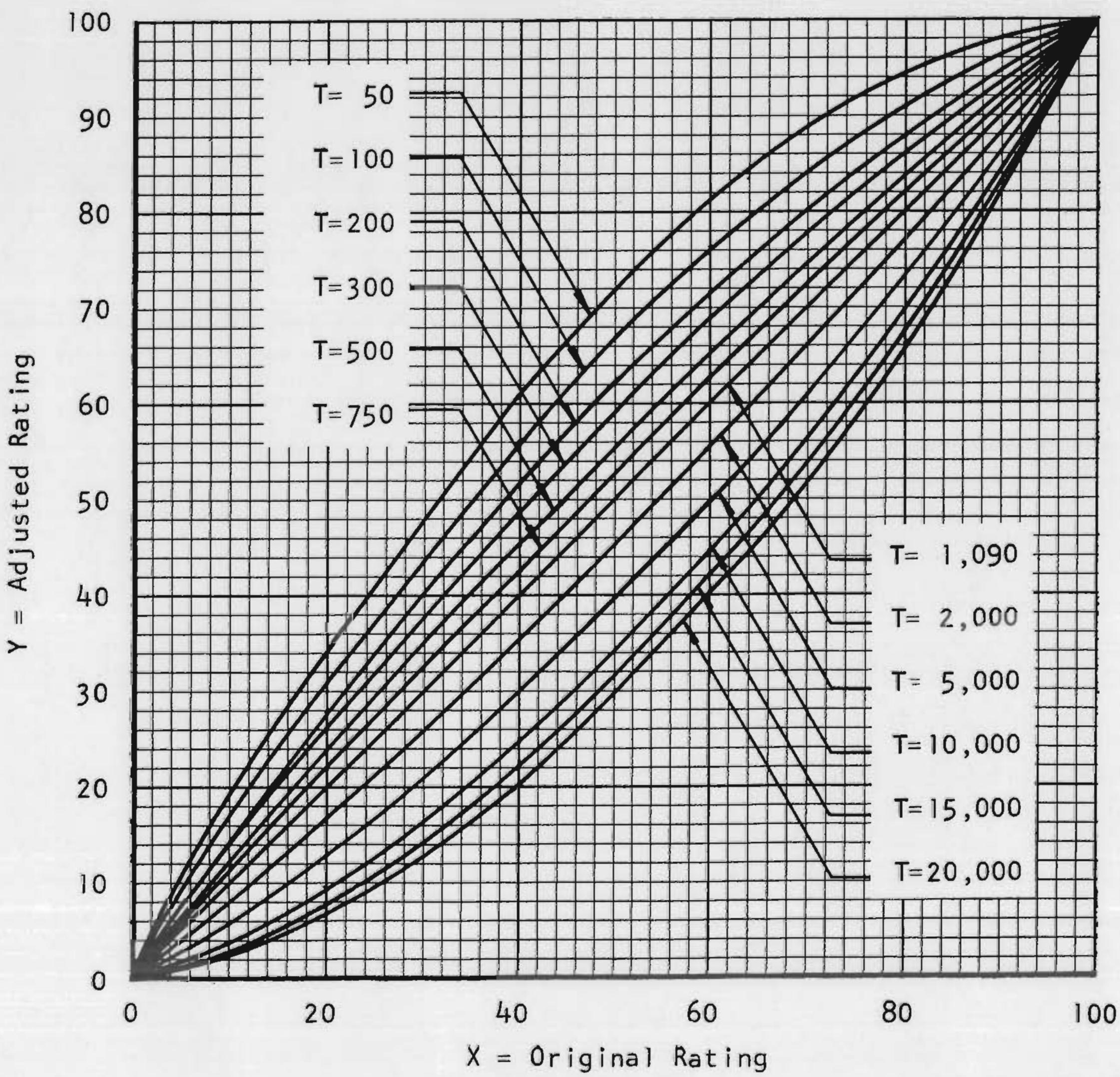


FIGURE 1

SUFFICIENCY RATING ADJUSTMENT
FOR VARIOUS TRAFFIC VOLUMES

Washington. The Washington State Highway Commission used a rating formula in 1951 to rate all urban areas of over 5,000 population (11). They rated many structural and physical features that would affect the street's ability to carry traffic. In addition an existing counted volume was compared to a calculated capacity and this ratio was assigned 20 points par value of the 100 total points of the complete formula.

In 1954, Washington developed and used a substantially more simplified rating formula for rating urban streets, based primarily upon travel time comparisons. Seventy-five points par value were assigned to travel times while a nominal twenty-five points were assigned to the remaining factor of design and condition for a total rating of 100 points par. The former factor was rated primarily upon the judgement of the rater without specified standards available for comparison.

Wyoming. The Wyoming State Highway Department currently uses a separate urban rating formula, based entirely on structural condition, modified by a traffic factor obtained from a curve much the same as that of the Idaho Department of Highways shown in the Figure on page 20. They assign 15 points par to foundation condition and 20 points par to surface condition giving a total of 35 points par for a street in perfect condition. Evaluation is accomplished by visual inspection in the field.

Colorado. The Colorado Department of Highways developed a formula for rating urban facilities for its use in 1962 basing evaluations upon structural condition and a modified volume-capacity ratio. Twenty-five points par were assigned to the former and seventy-five points were assigned to the latter of the two factors. Structural condition was broken down into three components; these were foundation, surface, and drainage conditions. The method of evaluation of these factors was not specified; it was expected in the near future, however, that a CHLOE profilometer would be utilized for a portion of the measurements.

The modified volume-capacity ratio was evaluated by comparing the peak hourly volumes obtained in the Denver Metropolitan Area Transportation Study against the capacities as computed using the method outlined in the Highway Capacity Manual (3). Information from the Study enabled the Department to form some assumptions for use in computing street capacities, thus simplifying the method given in the Capacity Manual to an extent. Their assumptions involved directional division of traffic, per cent trucks, per cent turning movements, and specific traffic signal green time percentages according to the class of intersection being evaluated.

In evaluating rural sufficiency ratings the Colorado Department also used volume-capacity ratios as one of the factors, but to a less extent than on urban sufficiency rating. From the rural studies it was found that when the peak hourly volume equaled the computed capacity the total ratings averaged approximately 74 per cent of par value of the total rating.

The analogy was then applied to the par value of the volume-capacity ratio factor of the urban rating system, with the result that a volume-capacity ratio of unit would automatically give a rating value of 74 per cent times 75 points par value, or 56 points. This would be added to the rating value obtained from structural adequacy evaluation giving the total rating for the section in question. Going further, a curve was developed using essentially this same analogy, to enable a final rating of any computed volume-capacity ratio. Figure 2 shows the general form of this curve obtained from two empirical equations.

The basis of this curve appears questionable to this writer because of the arbitrary proportionate values of the rural rating formula, and because of the difference between the methods of computing practical capacity of rural and urban streets. For example, would the relationship of 74 per cent of par value at a ratio of unity be the same if different proportionate par values had been assigned to the rural ratings, and/or if an identical method of computing practical capacities had been used?

New Mexico. The New Mexico State Highway Commission rated urban streets in 1952 with a formula weighted heavily on physical structural features, but also including a volume-capacity ratio factor. They have not rated urban streets with a sufficiency formula since 1952, as it was believed that too many other factors such as jurisdiction, fund distribution, local ability to participate and traffic engineering considerations, made it impractical to evaluate street sufficiencies on an annual basis. It was apparently felt that these factors were not adaptable to include in an urban rating system. A revised urban rating formula would probably place greater emphasis on a volume-capacity ratio, they said.

The main categories of the 1952 formula were structural features and street capacity. The structural features category, however, included components that seem to be more indicative of safety and service characteristics than of structural characteristics, particularly as related to

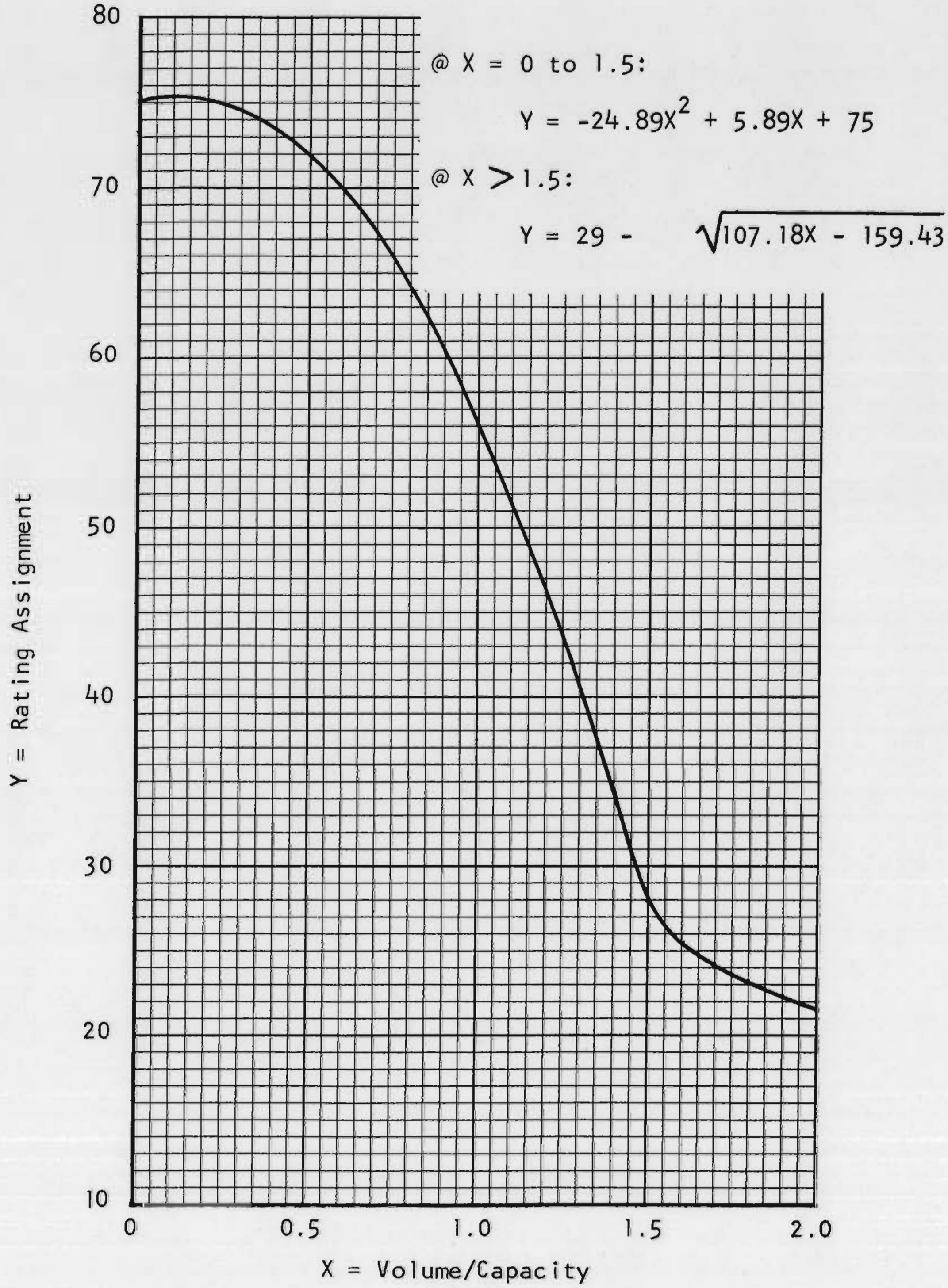


FIGURE 2

CORRELATION OF RATING AND VOLUME-CAPACITY RATIO
AS USED BY COLORADO DEPARTMENT OF HIGHWAYS

rural highways. These components were grade and alignment, each worth 10 points par value, and were evaluated according to the steepness and length of grade encountered, and the number of sight distance restrictions per mile. Other components within the structural features category were condition of surface, base, and drainage. These were evaluated visually and were assigned par values of 30, 10, and 10 points respectively. Par value for the complete structural features category was 70 points.

The street capacity category utilized a volume-to-capacity ratio concept, comparing practical capacity as determined by the Highway Capacity Manual method versus the 30th highest hourly volume of the current year. Ratings were determined from a straight line ratio relationship, giving full value of 30 points for a ratio of volume-capacity of 75 per cent and zero value to a ratio of 125 per cent. Their limits were chosen to correspond with a design capacity of 75 per cent of practical capacity and a possible capacity of 125 per cent of practical capacity. The final rating was then adjusted by the traffic volumes, using the same curve that is used by the Idaho Department of Highways shown in Figure 1 on page 20.

California. The California Department of Highways used what they refer to as "adequacy ratings" for both rural and urban facilities (12). These are essentially the inverse of volume-capacity ratios; the basis of comparison is the 30th highest hourly volume of annual traffic flow. No other factor is used for their rating system; the volume-capacity ratio is the sole indicator of the sufficiency of urban and rural highways. This ratio is also used to estimate the time in years when the computed capacity of a street will be equaled by the acual volumes.

The highway departments of the remaining western states did not use separate urban sufficiency ratings and some did not use rating systems of any type for programing of urban and rural highway improvements.

Indiana. The Indiana State Highway Commission was contacted relative to that agency's practice of improvement programing of Indiana's urban streets. This was prompted by a pertinent paper presented at the 48th Annual Road School at Purdue University by Schenler and Michael (8). They do not utilize a separate rating system of urban streets; rather, a rural rating formula is applied to urban sections with an unspecified emphasis on the volume-capacity ratio. A study is in progress to determine a suitable urban formula that will aid in determining a needs study in addition to the basic purpose of ascertaining a factual basis for street improvement priority.

Selected Cities

A priority rating developed by Faustman is used in both Vallejo and Sunnyvale, California, and is discussed in a paper by Vallejo City Engineer Glen Harris (6). The final form of their rating is given as: priority rating equals sufficiency rating times project cost divided by vehicle-miles per day. It is seen that project costs and traffic volumes are recognized in addition to the sufficiency rating factors. Factors included in the sufficiency rating of Vallejo are grouped into three categories of condition, safety, and service. The first category includes surface condition, drainage, and maintenance costs, while the second category includes accident rates, lighting, and presence of sidewalks as components. Present and future volume-capacity ratios are the components of the service category. The factors in the sufficiency rating of Sunnyvale are essentially the same; differences lie in the proportioning of assigned numerical weights.

A comprehensive study of suitable methods for ascertaining urban street adequacies was recently undertaken in Phoenix and San Diego by Haley, Hall, and Johnson (8). Three formulas were derived and tested in these two pilot cities of the National Committee on Urban Transportation.

The first formula derived and tested in San Diego contained the two divisions of community service and user benefits with 60 per cent of the emphasis given to community service. Cost was brought into the determination of priorities by dividing the cost per vehicle mile of travel by a project benefit index. Factors included in the community service division were pattern and continuity, coordination and timing, roadbed condition, present capacity ratio, and long range future service. All had nearly equal weight except roadbed condition, which was substantially less in weight. Factors included in the user benefits category included present and future delay rate, deficiency duration, accident rate, and time required to amortize investment. Numerical weight distribution was equal on all but the accident rate factor, which had somewhat greater weight.

From the first formula was derived a second, which did not differ essentially from the first. Indeed, the factors and the main divisions were much the same; the proportionate numerical weights were changed, making the major differences from the first formula. Testing of the second formula was done in Phoenix.

It was concluded upon completion of the field testing of these formulas that too much personal judgement was required in evaluating many of the factors. Personal judgement was recognized as a thing to be avoided in obtaining a factual basis for priority programing by use of urban sufficiency ratings.

The third and most promising formula derived and tested subsequent to the earlier two formulas was based heavily upon traffic operational features and could be divided into the three categories of condition, safety, and service. Structural condition was obtained by evaluating the two factors of drainage and surface-subsurface conditions for a total par value of 15 points. Safety was based upon a collision index taken from accident rates, and assigned 15 points par also. Service contained the most numerical emphasis by far and was evaluated from the factors of delay rate and a modified volume-capacity ratio. The delay rating was assigned a par value of 50 points and the volume-capacity ratio was assigned 20 points for a total of 70 points in the service category.

As a method of ascertaining the validity of these formulas, personal opinion ratings were solicited on twenty-five street sections in each of the two cities. A group of eleven people having knowledge and responsibilities in engineering, planning, or administration were selected in the San Diego study; nineteen people of equivalent position were chosen in the Phoenix studies.

## CHAPTER III

## EXPERIMENTAL WORK

The experimental work consisted of formulating several trial sufficiency rating formulas and of testing these formulas using data collected from representative urban streets throughout the state of Idaho. These formulas were established in a manner to evaluate the effects of varying the par values of the various rating factors, and of varying the deductions from the par values in each case. As a basis for establishing these trial formulas the reviewed literature and the practices of other agencies contacted by mail were utilized.

From the literature reviewed, it was decided to retain the use of the three basic divisions of the present Idaho Department of Highways sufficiency formula (22): condition of pavement (called structural adequacy by many sources), safety offered to the road user, and service to the road user. Experimentation involved varying proportionate numerical weights of these factors within a total sum of 100 points par for perfect condition. This was done using four trial groups. Each trial group consisted of two or three separate trial formulas. Components within the three main factors were varied as to proportionate numberical weights, sub-par values, and as to the general composition within the factors. Table II shows the trial formulas and their respective assigned par values.

### I. PAVEMENT CONDITION

As mentioned in Chapter II, pavement condition reflects the adequacy of a pavement to accommodate the traffic for which the pavement was

TABLE II

TRIAL URBAN SUFFICIENCY RATING FORMULAS

AND ASSIGNED NUMERICAL PAR VALUES

| FACTOR | Trial Formula | | | | | | | | | | | Trial II c Revised |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group I | | Group II | | | Group III | | | Group IV | | | |
| | a | b | a | b | c | a | b | c | a | b | c | |
| CONDITION | 20 | 20 | 25 | 25 | 25 | 30 | 30 | 30 | 20 | 20 | 20 | 25 |
| SAFETY | | | | | | | | | | | | |
| Accident History (2 yr. average) | 15 | 15 | 20 | 15 | 10 | 10 | 5 | 20 | 20 | 15 | 10 | 10 |
| Frictional Potential | | | | | | | | | | | | |
| Intersectional | 10 | 10 | 8 | 10 | 15 | 4 | 7 | - | - | 3 | 5 | 15 |
| Marginal | 5 | 5 | 3 | 5 | 5 | 3 | 4 | - | - | 2 | 5 | 5 |
| Medial-Internal | 5 | 5 | 4 | 5 | 5 | 3 | 4 | - | - | - | - | 5 |
| Total for Safety | 35 | 35 | 35 | 35 | 35 | 20 | 20 | 20 | 20 | 20 | 20 | 35 |
| SERVICE | | | | | | | | | | | | |
| Delay Rate | 30 | 30 | 25 | 20 | 20 | 30 | 30 | 25 | 40 | 30 | 40 | 25 |
| Volume-Capacity Ratio | 15 | 15 | 15 | 20 | 10 | 20 | 15 | 25 | 15 | 20 | 20 | 15 |
| Physical Inventory | - | - | - | - | 10 | - | 5 | - | 5 | 10 | - | - |
| Total for Service | 45 | 45 | 40 | 40 | 40 | 50 | 50 | 60 | 60 | 60 | 60 | 40 |
| Total Par Value | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

designed. To facilitate evaluation of pavement condition it was decided to continue the present practice of visual inspection in the field. No other method of evaluation was proposed in addition to the visual inspection; it was felt that comparison with existing plans would not give sufficiently more accurate results. Separate evaluation of each component of the pavement, such as surfacing, base and subbase, was not considered necessary, when considering the small returns for the time involved in the evaluations.

Pavement condition was assigned par values of 20, 25, 30, and 20 points in trial groups I, II, III, and IV, respectively. Four generalized classifications were assigned to indicate sufficiency, and are shown in Table III below.

TABLE III

RATING ASSIGNMENTS FOR PAVEMENT CONDITION

| Pavement Condition | Per Cent of Par Value |
|---|---|
| Good | 75 to 100 |
| Satisfactory | 50 to 75 |
| Unsatisfactory | 25 to 50 |
| Poor | 0 to 25 |

"Good" condition indicates a pavement that is smooth--no cracks or patches are encountered. A pavement having relatively few small cracks would fall in the lower portion of this classification.

"Satisfactory" condition indicates a pavement having some minor cracking, and/or minor, well-finished patchwork, and a reasonably smooth surface.

"Unsatisfactory" condition denotes a pavement having a relatively large amount of cracking, wearing of the surface to the extent of exposed aggregate, some patchwork poorly finished, and/or a relatively rough surface with evidence of failing edges.

"Poor" condition indicates a pavement having much cracking, poor patching or none at all when needed, failing edges, and/or a rough to very rough surface. A pavement poor enough to slow a single passenger car below 20 mph in otherwise unrestricted traffic conditions would be rated as zero.

Recent work has been undertaken by the Research Engineer of the Idaho Department of Highways in the development of a mechanical device to measure the roughness of a pavement (13). Results obtained from this device show pavement roughness in much the same way as the well-known CHLOE Profilometer; the latter, however, is substantially more complicated and expensive. Upon satisfactory establishment of reliability, it is expected that this device could be used to rate pavement condition in place of the presently used and recommended visual inspection.

## II. SAFETY

For a prime indication of the safety sufficiency of an urban street, and at the same time for a relatively simplified appraisal to be had, two main categories were chosen to comprise the safety factor. These are accident history and friction potential. Refer to Table II, page 30, which shows the various par value assignments.

Accident History

Accident history is a comparison between a street section's accident rate and the statewide urban street accident rate for the same time period. The time period recommended as a base is the most recently available two years data. Current accident recording practice in the Idaho Department of Highways will readily permit compilation of the needed data.

Accident data for periods prior to this study did not permit development of statewide urban accident rates and it was necessary to estimate this value. There were 9333 urban accidents in 1960. It is estimated that 485 million vehicles miles were traveled in the urban areas during this same period. The statewide urban accident rate for 1960 would then be 19.1 accidents per million vehicle miles (acc/MVM). Although not precise, this value will serve to show the recommended procedures.

Urban accidents are reported by local authorities and some question has been raised as to the consistency with which authorities of different communities are making their reports. While poor recrods would reflect a favorable accident experience and thereby produce inconsistent results, the increased importance of the accident reports would serve to encourage better reporting. When local authorities become aware that accident records have an influence on the priority their streets have for improvement, reporting will hopefully become more reliable and consistent.

Three curves have been prepared for use on the experimental trial formulas and are shown in Figures 3, 4, and 5, on the following pages. They present the percentage of par values as linear functions of the ratio of accident rate on any given street section to the statewide urban average accident rate. The differences are in the slope of the curve and the

For Use with Trial Formulas
Ia, Ib, IIc, IVa

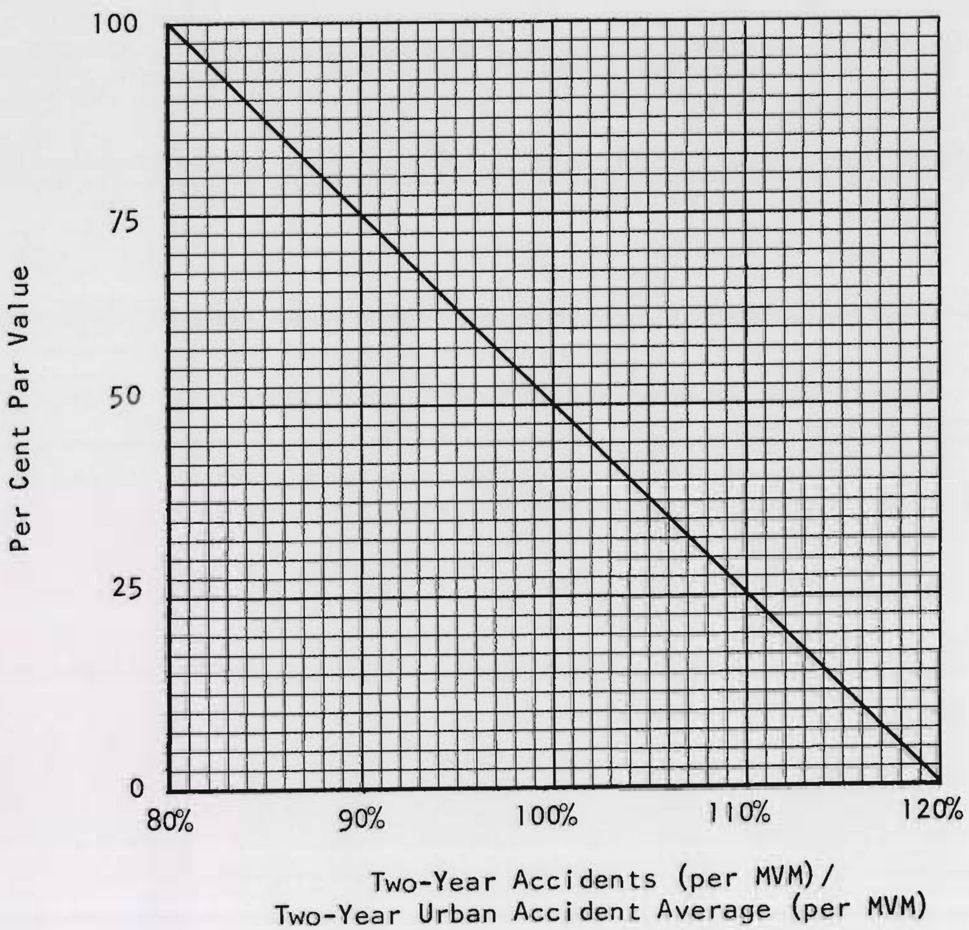


FIGURE 3

ACCIDENT EXPERIENCE RATING CURVE "A"

For Use with Trial Formulas
IIIa, IIIc, IVc

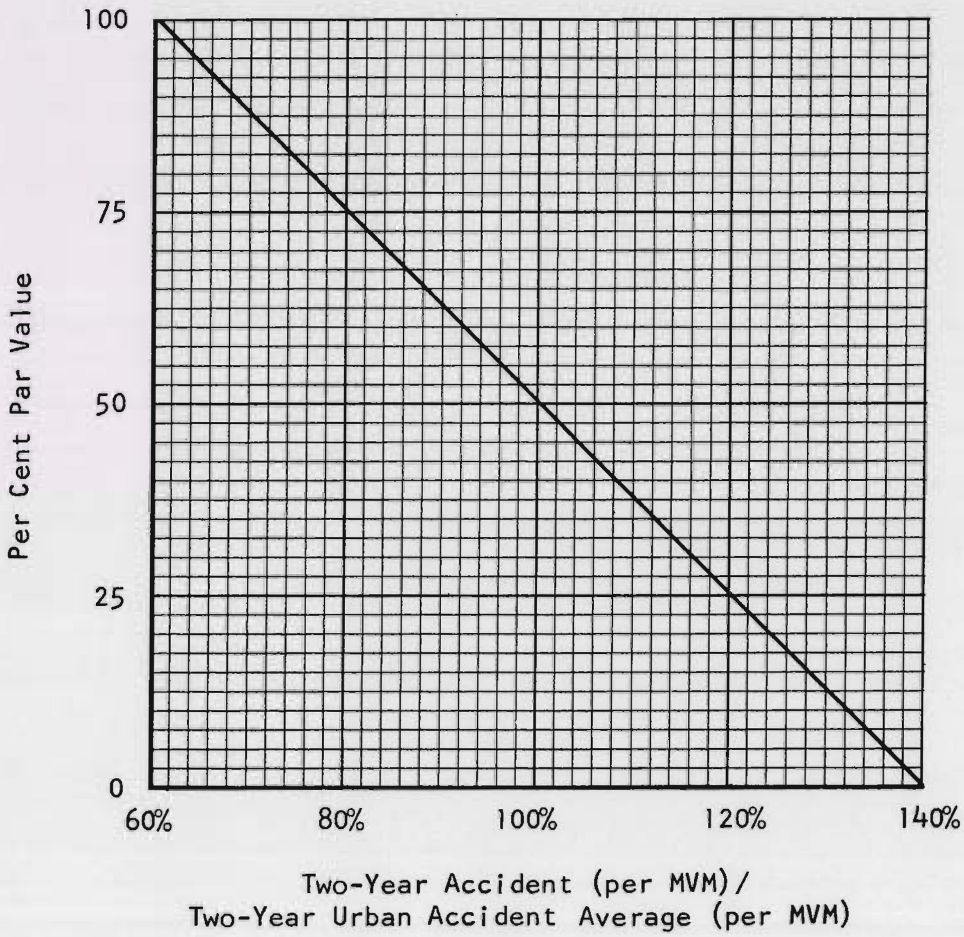


FIGURE 4

ACCIDENT EXPERIENCE RATING CURVE "B"

For Use with Trial Formulas
IIa, IIb, IIIb, IVb

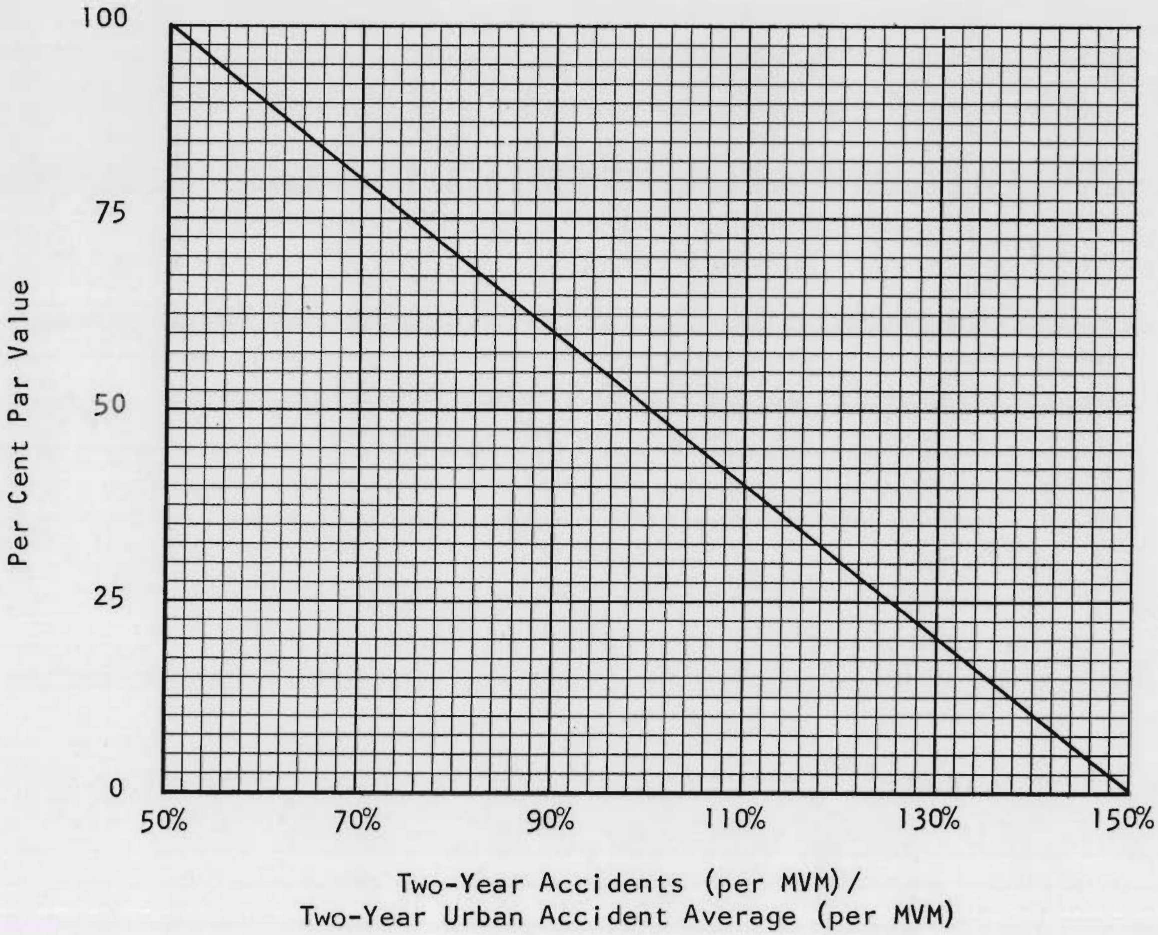


FIGURE 5

ACCIDENT EXPERIENCE RATING CURVE "C"

maximum and minumum limits; the limits are 80% to 120% in curve A, 60% to 140% in curve B, and 50% to 150% in curve C.

It should be noted that a 50 per cent mark-down is assigned to those streets having an accident rate equal to that of the statewide urban average. A constant improvement in accident rates, it is thought, should be expected. A street section having no worse but no better accident history than the urban average should not be given full credit for merely paralleling the average. One possible argument against this reasoning may be that the statewide average could conceivably approach zero; this would result in an excessive penalty levied against any street having a rate equal to or slightly below the statewide rate. It is doubted, however, that the statewide rate would approach a low enough value to validate this argument. Therefore it was considered justifiable to assign at least some penalty to a street section having an accident rate equivalent to the statewide urban rate.

Friction Potential

Friction potential is a term used to denote the potential conflicts of vehicle paths with other vehicle and/or pedestrian paths. This was considered as a good characteristic of street safety in addition to its accident history. This category was divided into four components: intersectional friction potential, marginal frictional potential, medial friction potential, and internal friction potential. The latter two were ultimately combined into a single component due to the relatively small numerical rating values assigned them.

The Automotive Safety Foundation (17) and other informed sources

(16, 23) have found that intersectional friction potential is by far the most prevalent of the four types; this component was numerically weighted accordingly. For a convenient but neaningful way of establishing intersectional friction potential, the following factors were used: type of intersection (i.e., number of approaches and type of traffic control) and frequency of each type per an arbitrary distance of 1000 ft. Table IV, pages 39 and 40, shows sub par assignments for the listed trial formula. The arbitrary value of 1000 ft. was chosen to give a meaningful and readily obtainable comparison value between various street sections rated. The effect of approach speeds, while directly related to intersectional safety, was not considered directly related to intersectional friction potential, per se; hence it was not entered as a factor in this component. It was felt that approach speeds would be adequately reflected in the existing accident record for the particular street in question.

Marginal friction potential is associated with vehicular movements in the areas adjacent to the travel lanes and includes on-street parking of all types plus bus and taxi stops along the travel-way. Table V, page 41, shows the deductions assigned to sub-par conditions as used in the experimentation with the trial formula. The effect of marginal friction, while a nuisance and a source of considerable delay in many instances, is not as critical as that of intersectional friction (16) and was not weighted as strongly as the latter.

Medial friction potential is associated with the effect of the presence or absence of a median barrier and, indirectly, with the width of travel lanes. Several authorities as reported by May (16) have found inconclusive evidence as to the value of a median barrier in reducing

TABLE IV

ALTERNATE DEDUCTION VALUES TO BE APPLIED TO INTERSECTIONAL FRICTION POTENTIAL OF DESIGNATED TRIAL FORMULAS

(See Table II for assignments to specific trial formulas)

| TYPE OF INTERSECTION | PER CENT OF PAR VALUE TO BE SUBTRACTED FROM PAR VALUE | | |
|---|---|---|---|
| Four-leg intersections: | a | b | c |
| No. of signalized intersections/1000 ft. | | | |
| 0 - 1 | 0 | 10 | 10 |
| 1 - 2 | 10 | 20 | 20 |
| 2 - 3 | 20 | 30 | 30 |
| 3 - 4 | 30 | 40 | 40 |
| No. of Stop-controlled intersections/1000 ft. | | | |
| 0 - 1 | 0 | 10 | 10 |
| 1 - 2 | 10 | 20 | 20 |
| 2 - 3 | 20 | 30 | 30 |
| 3 - 4 | 30 | 40 | 40 |
| No. of non-controlled or Yield inters/1000 ft. | | | |
| 0 - 1 | 20 | 20 | 30 |
| 1 - 2 | 40 | 30 | 40 |
| 2 - 3 | 60 | 40 | 50 |
| 3 - 4 | 80 | 50 | 60 |
| No. of Angle intersections less than 60°/1000 ft. with no merging facilities | | | |
| 0 - 1 | 30 | 20 | 30 |
| 1 - 2 | 60 | 40 | 50 |
| 2 - 3 | 90 | 60 | 70 |

Three-leg intersections: use ½ values above, except angle intersections use 3/4 values.

TABLE IV (cont'd)

| TYPE OF INTERSECTION | PER CENT OF PAR VALUE TO BE SUBTRACTED FROM PAR VALUE | | |
|---|---|---|---|
| No. of intersections having more than 4 legs, or more than one approach on a side, per rating section | a | b | c |
| 1 | 50 | 40 | 30 |
| 2 | 100 | 70 | 50 |
| 3 | 100 | 100 | 70 |
| No. of commercial driveways/1000 ft. (optional factor) | | | |
| 0 - 1 | 0 | 10 | 0 |
| 1 - 2 | 10 | 20 | 0 |
| 2 - 3 | 20 | 30 | 10 |
| 3 - 4 | 30 | 40 | 20 |

Trial Group I
- I a Use list 'a' plus list 'a' of commercial driveways.
- I b Use list 'a' plus list 'c' of commercial driveways.

Trial Group II
- II a Use list 'a' and no deductions for commercial driveways.
- II b Use list 'a' plus list 'c' of commercial driveways.
- II c Use list 'b' plus list 'c' of commercial driveways.

Trial Group III
- III a Use list 'c' and no deductions for commercial driveways.
- III b Use list 'b' and no deductions for commercial driveways.
- III c (No friction potential included).

Trial Group IV
- IV a (No friction potential included).
- IV b Use list 'a' and no deductions for commercial driveways.
- IV c Use list 'c' plus list 'c' of commercial driveways.

## TABLE V

## SUB-PAR ASSIGNMENTS FOR MARGINAL FRICTION POTENTIAL

| TYPE OF PARKING | PER CENT OF PAR VALUE TO BE SUBTRACTED FROM PAR VALUE | | | |
|---|---|---|---|---|
| | 2 Lane Street* | | 4 Lane Street* | |
| | a | b | a | b |
| No On-Street Parking Permitted | 0 | 0 | 0 | 0 |
| Parallel Parking One Side Only | 30 | 20 | 10 | 20 |
| Parallel Parking Both Sides | 60 | 40 | 30 | 20 |
| Angle Parking One Side Only | 75 | 40 | 30 | 40 |
| Angle Parking Both Sides | 90 | 40 | 60 | 40 |

* Use List a, Trials II b, c; III b; IV b
Use List b, Trials I a, b; II a; III a; IV c

## TABLE VI

## SUB-PAR ASSIGNMENTS FOR MEDIAL-INTERNAL FRICTION POTENTIAL

| 2 Lane Street | % Par Value to be subtracted from Par Value | 4 Lane Street | % Par Value to be subtracted from Par Value |
|---|---|---|---|
| 10' lanes or less | 60 | 4-10' lanes or less | 60 |
| 11' lanes | 40 | 4-11' lanes | 40 |
| 12' lanes | 0 | 4-12' lanes | 0 |
| 15' lanes | 20 | 2-10'; 2 > 10' | 40 |
| 17' lanes | 60 | 2-11'; 2 > 11' | 20 |
| | | 2 ≥ 15' | 20 |
| | | 2 ≥ 17' | 60 |

the total accident rate. It is true that head-on crashes are reduced, but this seems to be at the expense of internal crashes resulting from vehicles striking the median and bouncing off into the path of other vehicles traveling the same direction.

Internal friction is associated with travel lane width which affects rate of vehicular movement. Extremely narrow lane widths force the driver at times to encroach on adjoining lanes in total or in part. This interfers with the paths of on-coming vehicles or vehicles traveling in his own direction of travel depending on which lane is crossed. Extremely wide lanes provide the possibility for drivers to try to pass other vehicles within their own lanes, often on the right side. Excessive maneuvering width is also associated with wide lane widths at intersections; a high accident rate is associated with these unchannelized movements (23).

As mentioned earlier it was decided to combine the two frictional aspects of medial and internal potential, using lane widths as a single criteria. Points of deduction are assigned to the various trials in a single listing as shown in Table VI, page 41.

## III. SERVICE

Two components were chosen to indicate the serviceability of urban streets, based on operational characteristics. These are travel time and volume-capacity ratio. Also, a few isolated items related to street geometrics were categorized as Physical Inventory and assigned to a few individual trial rating formulas. Table II, page 30 shows the various numerical par values of the two main categories and the trial rating formulas to which they were assigned. Table VII, lists the various isolated items

TABLE VII

PHYSICAL INVENTORY ITEMS ASSIGNED TO

VARIOUS TRIAL RATING FORMULAS

| ITEM | TRIAL FORMULA; PAR VALUE ASSIGNED | | | |
|---|---|---|---|---|
| Yes = full par value<br>No = zero par value | II c | III b | IV a | IV b |
| Presence of Median? | 5 | | 3 | 3 |
| Lanes $\geqq$ 12' and $\leqq$ 15' in Width? | 5 | 2 | 2 | 2 |
| Lanes Plainly Striped? | | | | 3 |
| Good Sight Distance @ Intersections and RR Xings? | | 3 | | |
| Angle Parking Prohibited? | | | | 2 |
| Total Par Value | 10 | 5 | 5 | 10 |

and the trial formulas to which they were assigned, including the par values in each case.

Curves showing assigned numerical values for sub-par conditions of travel times and volume-capacity ratios are described in the following sections.

Travel Time

Travel time is considered by many authorities to be the most singly important factor in rating the sufficiency of an urban street or expressway (24, 18, 25, 26, 11). It is a measure of congestion that is readily obtainable by the "floating car" method. It can also reflect shortcomings in pavement structure providing the structure is in particularly poor condition.

Travel time is often associated with delay time, as the two are directly related. Reference to the definitions in Chapter I gives proper perspective of each concept. Delay time is used as the more directly measurable quantity in comparing different street delays with pre-determined standards in this study.

Three curves showing per cent of par value versus delay rate in vehicle-minutes per mile were composed for use in this experiment. Figures 6, 7, and 8 show curves I, II and III, respectively, and the trial formulas to which these were applied. These were adapted from the work of E. M. Hall and S. George, Jr. for Phoenix (14), but utilized a smaller degree of delay more applicable to Idaho's urban scale.

Curves I and II show both a linear deduction rate and anon-linear deduction envelope. Curve III shows a linear deduction only. Each of

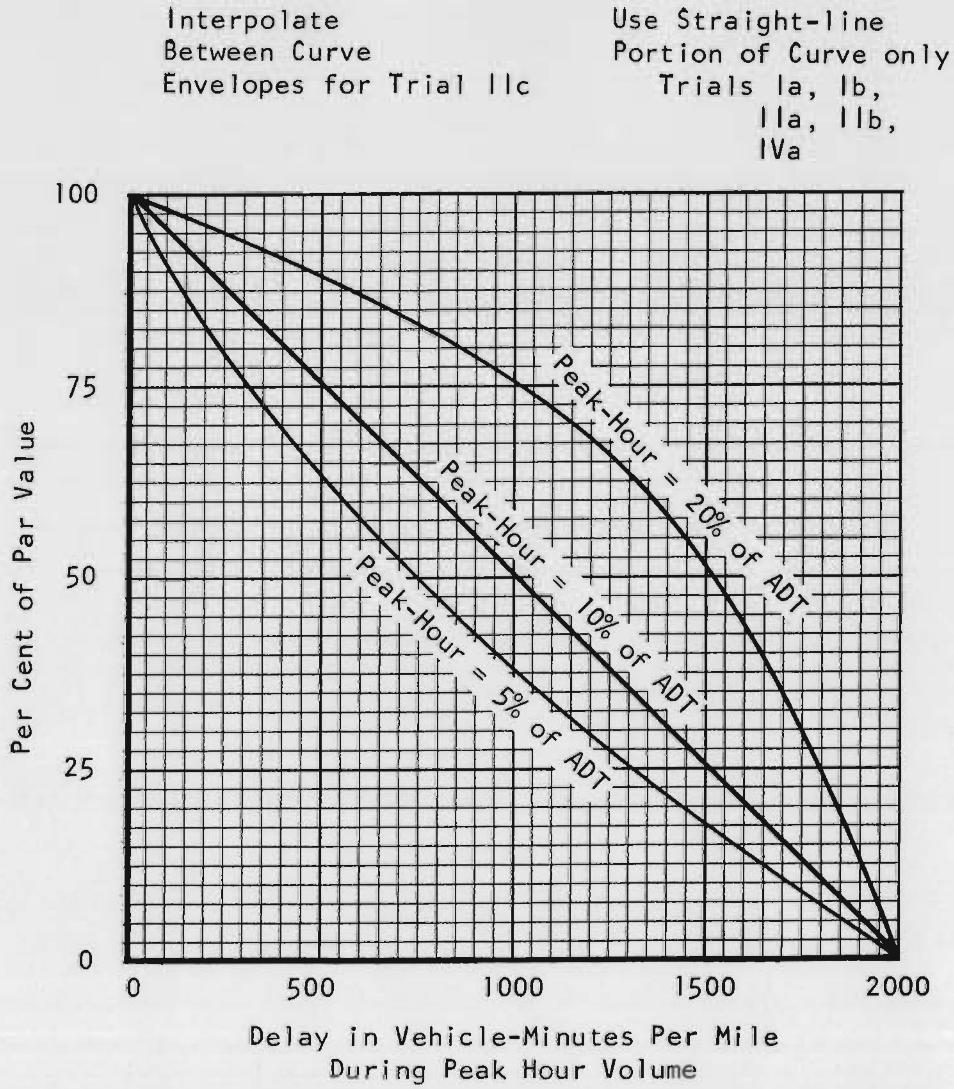


FIGURE 6

DELAY RATING CURVE I

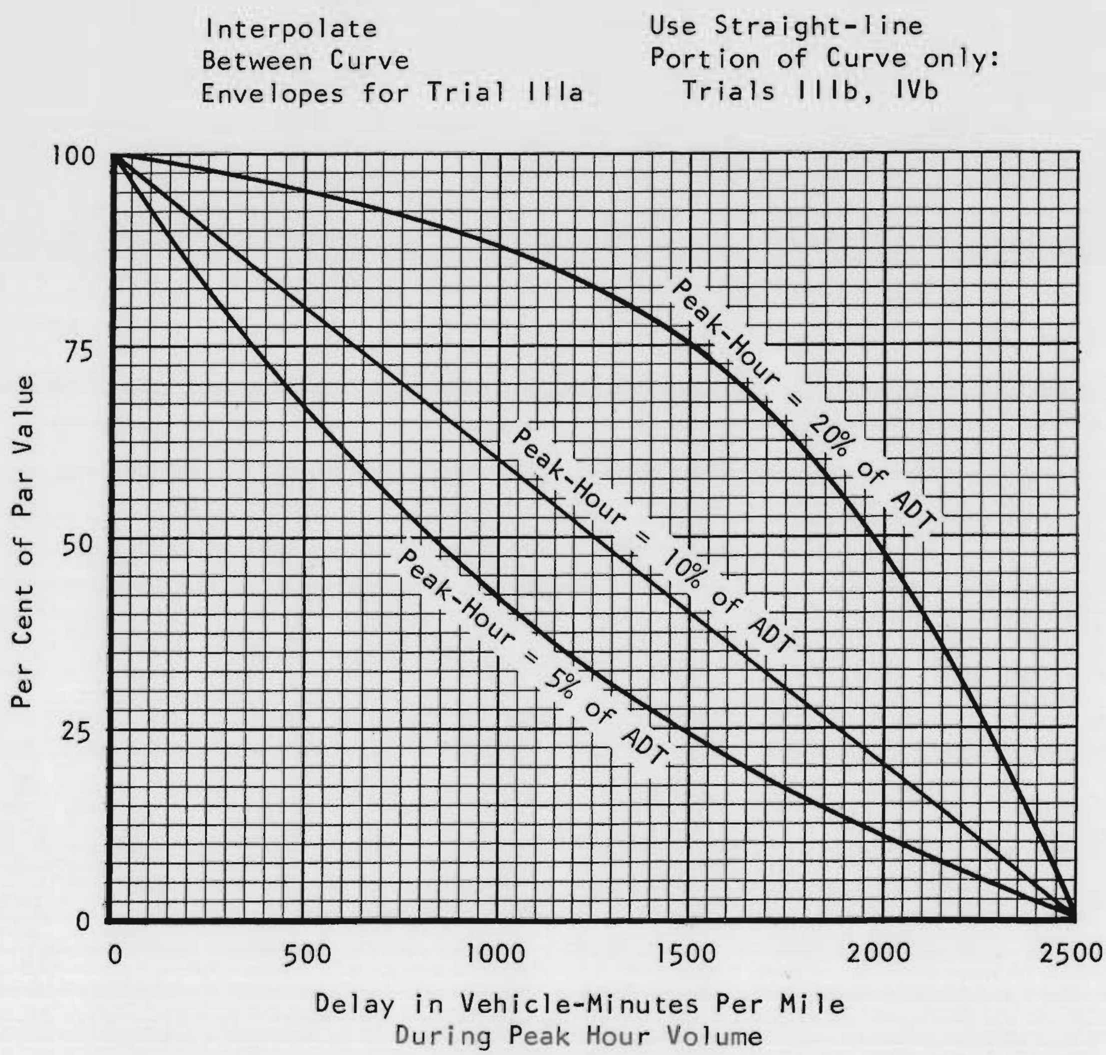


FIGURE 7

DELAY RATING CURVE II

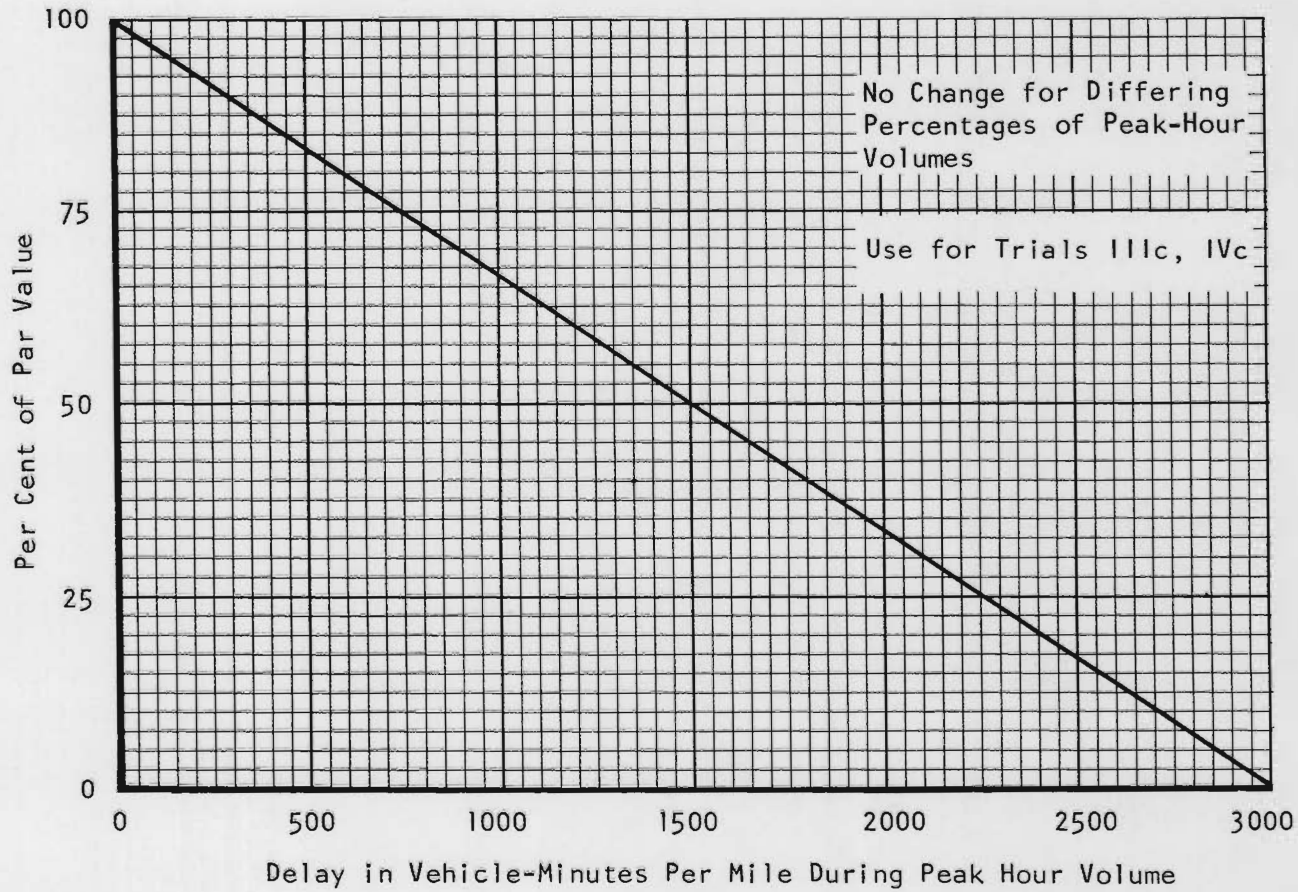


FIGURE 8

DELAY RATING CURVE III

these is to be applied to the trial formulas designed as shown on the curves. The linear reduction rate does not account for the duration of peak-hour volume flow duration, and is to be interpolated according to the (peak-hour) percentage of average daily traffic (ADT). Peak-hour flow durations are not indicated by the linear rates, but are indicated by the envelopes of curves I and II. An illustration would be a smaller town having but one or two main industries producing a ten-to twenty-minute traffic rush home compared with a larger town having several industries producing a longer and larger traffic rush home.

Noting that the Hall and George curve (25) terminated with the maximum penalty at the 4,000 veh-min/mile delay rate, it was decided from field observations to terminate these curves at lower delay rate values. The curve by Hall and George was based on data from Pheonix and San Diego, while the curves in this project were based on data from Idaho cities such as Boise and Coeur d'Alene. Accordingly, the maximum deductions were assigned to 2,000, 2,500, and 3,000 veh-min/mile delay rate in curves I, II, and III, respectively.

Volume-Capacity Ratio

Volume-capacity ratios are used by several agencies as a major indication of the serviceability of urban streets. The California Division of Highways uses this factor as the sole guide in determining the adequacy of both urban and rural facilities. The Colorado Department of Highways also bases the serviceability of urban streets entirely on volume-capacity comparisons. The highway department of Missouri uses volume-capacity ratios as part of its rating procedure. Study of potential use of the volume-capacity comparisons are being considered by the highway departments of New Mexico and Oregon, as well as by Hall, Haley, and Johnson in their study at Phoenix, Arizona, (18).

The greatest congestion and delay on city streets occurs generally at signalized intersections (3, 16, 20). The Bureau of Public Roads (21) and Bergstron (27) have recently presented some evidence to the contrary, however. Both have found that mid-block delays usually prevent the effective use of progressive signals. This possibly suggests that volume-capacity ratios should be obtained at other than intersection locations. Progressive signalization, however, does not necessarily alter the capacity of a street. This can be substantiated by study of the accepted Highway Capacity Manual method of capacity determinations and definitions of urban street capacity (3). Additionally, the Manual theorizes from experience that the maximum average speed through an intersection is approximately 15 mph, regardless of whether the signals are progressively cycled or not, as only one vehicle stopped in the intersection can substantially reduce the effectiveness of progressive signalization. It was decided, therefore, to retain the volume-capacity ratio determinations at signalized intersections only.

Four curves were developed showing sub-par values as percentages of par values versus varying colume-capacity ratios. Figures 9, 10, 11, and 12 on pages 53 to 56 show these as Curves I, II, III, and IV, respectively. The first three curves accounted for variations in the duration of peak-hour flows, characterized by peak-hour volume as a percentage of average daily traffic (24-hour). Curve IV simply disregarded the effect of peak-hour flow duration.

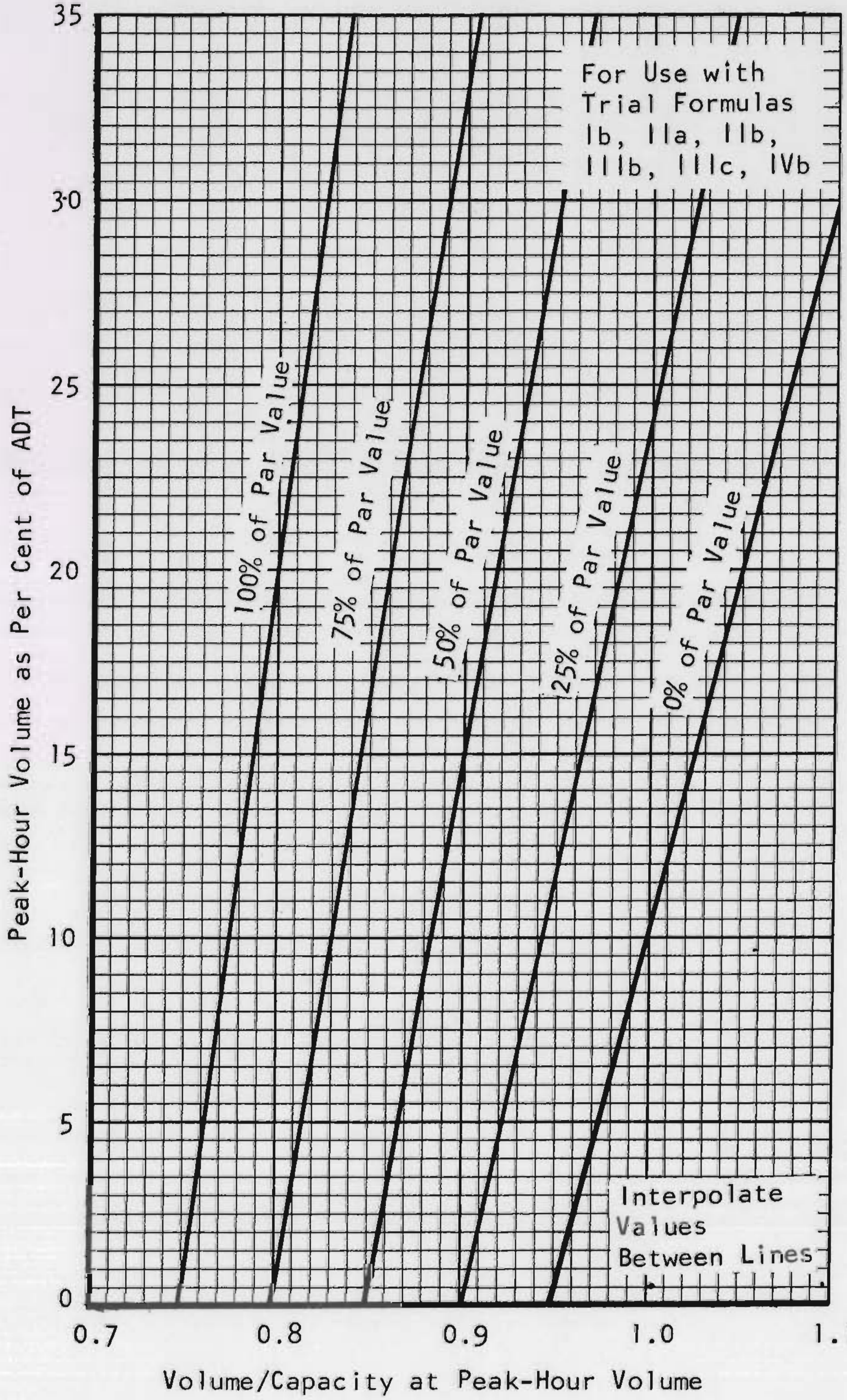


FIGURE 9

VOLUME-CAPACITY RATIO RATING
CURVE I

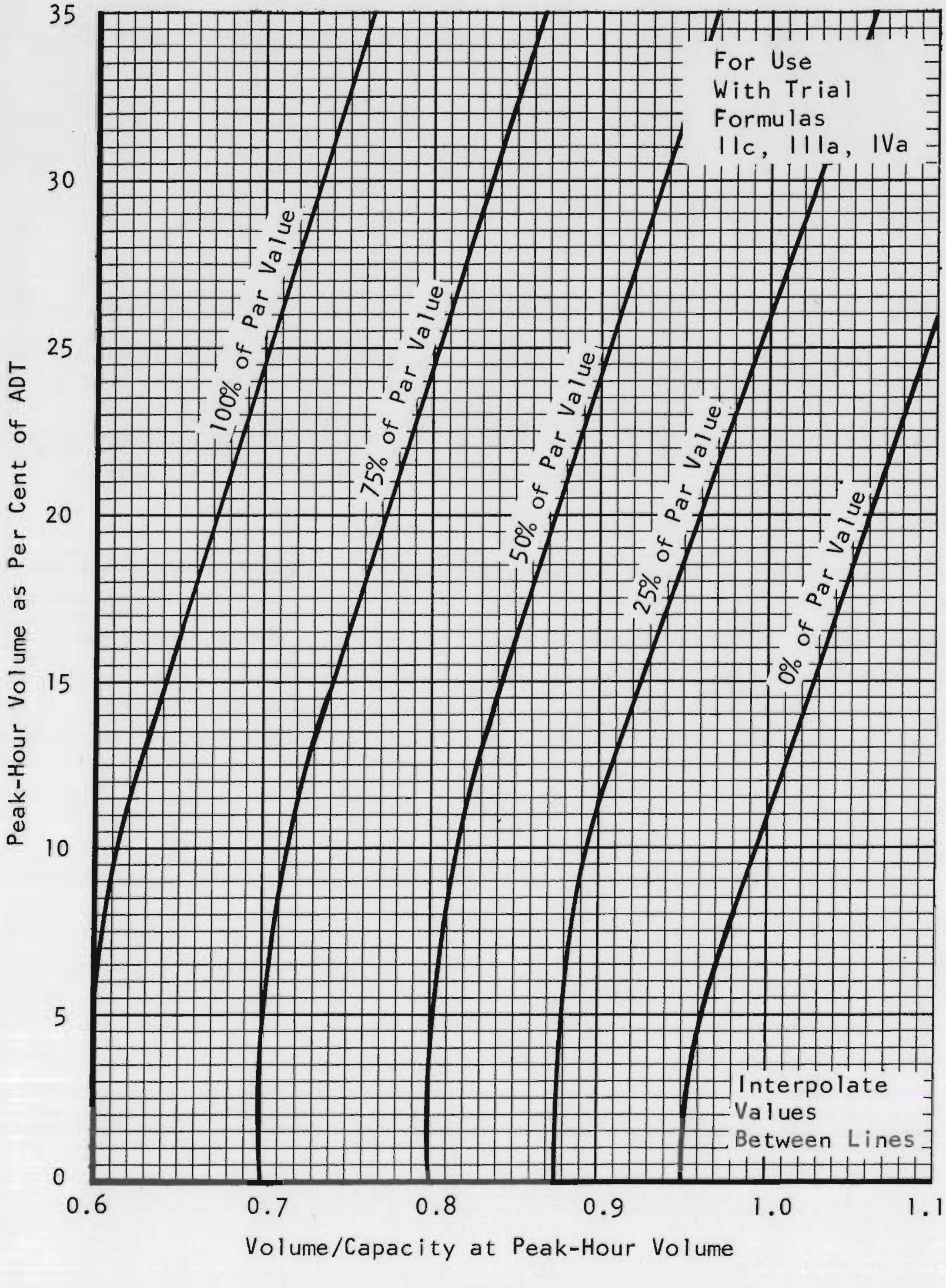


FIGURE 10

VOLUME-CAPACITY RATIO RATING
CURVE II

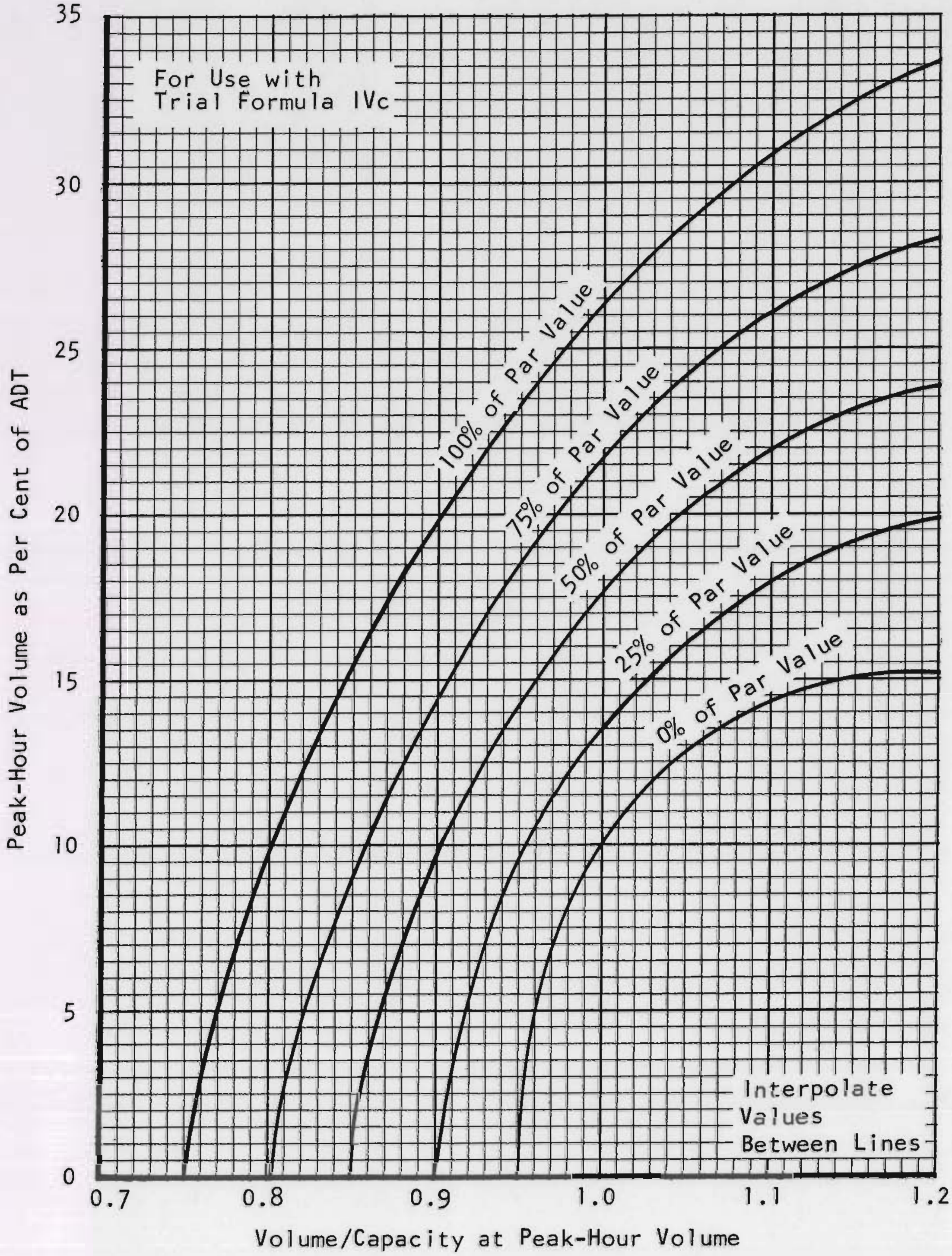


FIGURE 11

VOLUME-CAPACITY RATIO RATING
CURVE III

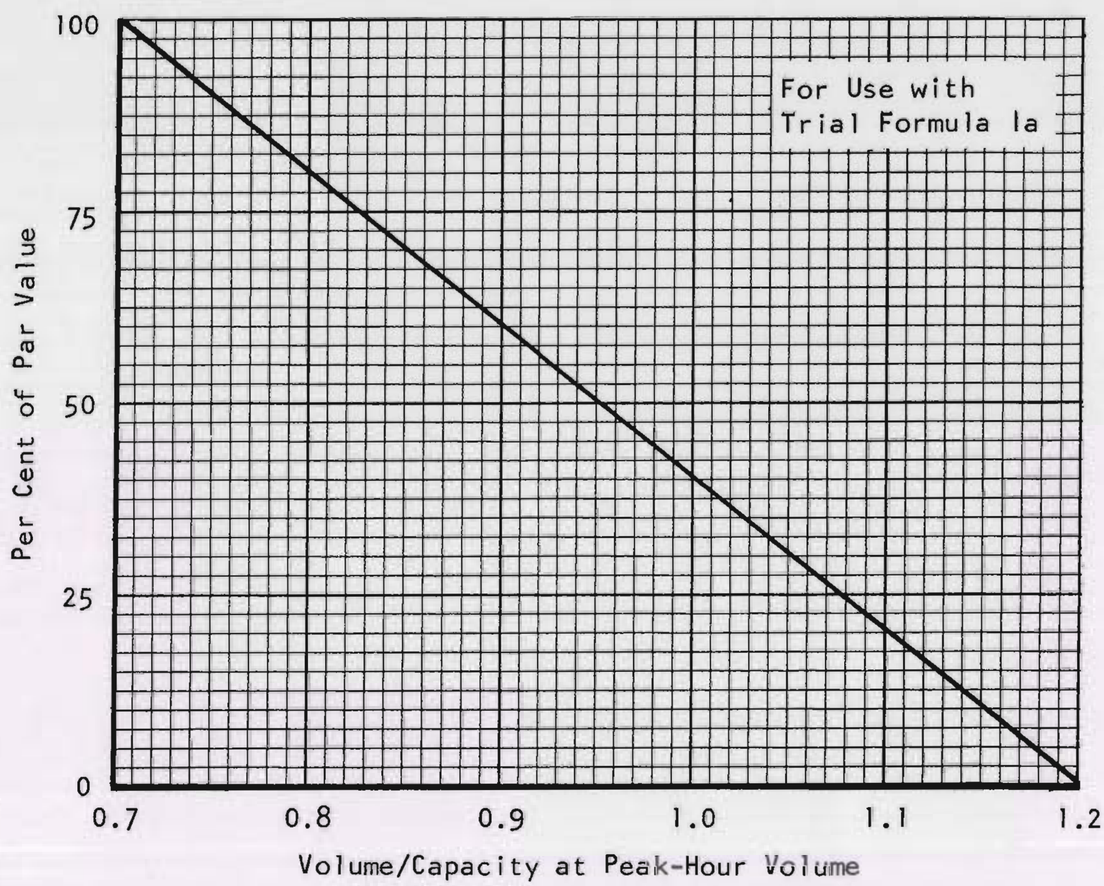


FIGURE 12

VOLUME-CAPACITY RATIO RATING
CURVE IV

Curve I gives full credit for volume-capacity ratios of up to 0.75, and zero credit for ratios of 0.95 and up. Both relationships are at the theoretical point of zero peak-hour volume. At the more realistic value of 10% peak-hour flow of average daily traffic the limits are 0.775 and 1.00. Sub-par values vary almost linearly with decreasing volume-capacity ratios.

Curve II gives full credit for ratios of up to 0.60, decreasing linearly to zero credit at 0.95 at the bottom of the curve (which is the point of zero percentage peak-hour volume of average daily traffic). At the 10% level of peak-hour volumes of ADT the limits are approximately 0.62 and 1.00 for full and zero credit, respectively.

Curve III gives full par values for ratios of up to 0.75 and decreases linearly to zero par value at ratios beyond 0.95, at the level of zero peak-hour volume percentage of ADT. The 10% peak-hour volume level gives corresponding ratio limits of 0.80 and 1.00.

Curve IV differs from the first three curves by not compensating for duration of peak-hour volumes. A straight line reduction from full par value to zero par value is given for corresponding ratios from 0.70 to 1.20.

Physical Inventory

To qualify the serviceability offered by an urban street more accurately, a few individual items were introduced into some of the tiral formulas. Table VII, page 43, lists the various items and the trial formulas to which they were assigned. The label of "physical inventory" is assigned to these various items because of the simplified nature of the evaluation procedures associated with them. These items were isolated because of the fact that none could be very well incorporated into the more comprehensive factors of travel time or volume-capacity ratio--except perhaps presence of angle parking.

## IV. FIELD WORK

The field work consisted of accumulating and processing traffic and street data relative to each street test section chosen to represent the widely differeing conditions of Idaho's urban streets. Traffic data included accident statistics for use in safety studies, travel time studies for use in speed and delay studies, and traffic volume compilations for use in volume-capacity studies. Physical data included pavement condition studies, intersection and commercial driveway counts, parking practice studies for use in traffic friction evaluation and capacity determinations, number and width of lanes, presence of median, and traffic signal timing. The street sections were chosen from cities of varying sizes and consisted of various geometric street types--such as two-lane residential distribution streets, four-lane home-to-work streets, and central business district streets. Table VIII shows the streets and the respective cities used in this study. Traffic volumes ranged from approximately 400 to 28,500 ADT, providing opportunity to evaluate the effect of volume on several of the factors.

Results of the field tests are presented in Chapter IV. Chapter V analyzes the results. A general data form used in all aspects of rating is shown in Appendix B on page 107.

TABLE VIII

STREET SECTIONS RATED IN FIELD TESTING OF

TRIAL URBAN RATING FORMULAS

---

Boise

Capitol Blvd. - Front St. to Boise River Bridge
Capitol Blvd. - Boise River Bridge to College Blvd.
Front St. - Capitol Blvd. to Americana Blvd. (16th St.)
State St. - 23rd St. to 27th St.
State St. - 27th St. to Lander St.
23rd St. - State St. to Fairview Ave.
Warm Springs Ave. - Bruce St. to Coston St.

Meridian

E. 1st St. - Washington St. to Broadway St.

Grangeville

Main St. - Junction St. to Mill St.

Lewiston

Main St. - 1st St. to 9th St.
Main St. - 13th St. to 18th St.
'D' St. - 9th St. to 1st St.

Moscow

Main St. - 6th St. to 1st St.

Coeur d'Alene

Sherman Ave. - 1st St. to 7th St.
Sherman Ave. - 7th St. to 15th St.
Government Way - Indiana Ave. to Harrison Ave.

---

Condition

In accordance with the simplified appraisal of pavement condition, each street was inspected visually for presence of cracking, quality of patching, and other evidence of pavement failure in need of remedy. Smoothness of surface was noted during the travel time test runs by automobile.

The Research Engineer of the Idaho Department of Highwaya has provided "Bumpometer" results of the test streets in Boise. Thses were used in checking the results obtained by visual inspection.

Safety

Computer print-out accident records of the Idaho Department of Highways were used in the majority of the accident rate determinations. The computer records of Boise street accidents were undergoing a revision of street coding and were thus not used as a cross reference of old and new doding was not readily available. Records of the Idaho Department of Law Enforcement were used to determine accident rates on Boise streets instead.

Accident rates were computed from these data in terms of accidents per million vehicles per mile of street section (acc /MVM) on an annual basis. This incorporates the volume of traffic in giving a rate for comparison purposes, thus eliminating the need for a later correction factor to account for volume.

The computed accident rates were compared in ratio form to the estimated 1960 statewide urban average of 19.1 acc/MVM. The ratio values were then entered into the designated curves of sub-par values versus the computed ratios to obtain the percent reductions to be applied to the proper trial formulas. The actual rating values were thus determined for use in computing the total safety rating.

In accordance with the method described on page 40 for establishing friction potential, the number and type of intersections and commercial driveways were ascertained in the field. Lane width and parking provisions were also ascertained for use in evaluating the marginal and medial-internal friction potentials. Where large street plans were readily available, lane widths were scaled from the plans. Remaining lane widths were directly measured in the field.

Service

As one measure of service, travel times were acquired using a method similar to the "floating car" technique (19). This method, as adopted by the Idaho Department of Highways (28), specifies that six to ten test runs be taken, the number of runs varying according to the deviation from the mean result. The former method advocates that the test car pass exactly as many vehicles as pass the test car. The Idaho method, termed the "average speed" method, advocates the use of personal judgement by the test car driver as to maintaining an average speed according to the surrounding traffic speeds.

The test runs consisted of driving a street section at the average speed of the vehicles traveling in the same direction and recording the time required to travel certain sub-sections and the entire section. This was done by a two-man party consisting of a driver and a recorder. Times recorded at the predetermined sub-sections permitted evaluation of the intermediate delay characteristics.

Posted speed limits were used for computing delay rates. Partly as a convenience these limits were chosen as being the optimum speed condition. In more sophisticated cases posted speeds are usually based on the 85th percentile speed for each type of street and probably do represent very nearly the optimum operating speeds (2). Delay rates were computed as being the difference in minutes per mile between the posted speed limit and the average speed obtained from the test runs. This difference was then multiplied by the peak-hour volume with the resulting value being in terms of vehicle-minutes per mile (veh-min/mi). It is seen that the effect of traffic volume is incorporated into this rating factor. The computed delay rates were then entered into the designated curves of per cent of par value versus delay rate. The rating values of the delay rates were thus computed from the various assigned par values of the trial formulas. A sample field form is shown in Appendix B on page 109.

An attempt was made to utilize the travel time data within the Idaho Department of Highways files. The data did not, however, meet the specifications established by the Department. The runs were, in many instances, taken during off-peak hours only and the number of runs was too few to give statistical reliability.

As a second measure of street service, volume-capacity ratios were obtained at signalized intersections. The field work consisted of obtaining peak-hour volume counts traffic operation characteristics and geometric design data necessary for calculating the practical capacity.

It was realized that use of existing volume data on file in the Idaho Department of Highways would save much time and effort in comparison with manually counting the required volumes. To establish reliability of the existing data on file, manual counts were taken at intersections in Lewiston, Moscow, and Coeur d'Alene. Volume-capacity ratios were computed using both volume data sources and were found to agree quite closely. It is thus felt that the existing data on file is adequate for use in the volume-capacity determinations.

The manual counts were taken by a party of two men, each using a form adapted from that of the Idaho Department of Highways. A sample form is shown in Appendix B on page 110. The Department supplied personnel and equipment to assist in manual counting the Lewiston and Coeur d'Alene intersections.

Data required for the calculation of the practical capacity by the method outlined in the USBPR Highway Capacity Manual (3) were type of street (whether one or two-way, whether high-type, etc.), number and width of lanes on each intersection approach, parking provisions, location of bus stops, per cent of vehicles turning right and left, per cent of commercial vehicles, and the timing of the signal cycles. Based on this information, the practical capacity was computed for each intersection studied, and volume-capacity ratios were developed for the route. These ratios were entered into the appropriate curves of per cent of par value versus volume-capacity ratio to obtain the rating value for this factor. A sample calculation of practical capacity and volume-capacity ratio is given in Appendix C on page 113.

In many cases semi-actuated, fully-actuated, or multi-phased signals were installed at intersections of greater complexity or higher volumes and fixed signal cycles were not available for computation of intersection capacity. No well-established method was found in which to arrive at a practical capacity value in terms of vehicles per hour green time. To establish a reasonable value of green time per hour, a fixed-time signal phasing was computed by the method found in the Syllabus of the Institute of Transportation and Traffic Engineering of the University of California (4) and used to compute practical capacities as on the less complicated type intersections. A sample calculation appears in Appendix C on page 114.

The high-type multi-approach intersection of Capitol Boulevard, College Boulevard, and Boise Avenue in Boise, with its traffic-actuated multi-phase signal system, presented a special problem. After consultation with Mr. M. W. Lotspeich, Traffic Engineer of the Idaho Department of Highways, it was decided to base green-time percentages upon volume ratios of intersecting traffic movements. This was done by selecting separate phases of non-conflicting traffic movements, and comparing these volumes to the total volume at all approaches. These ratios were then used as the green time percentages in computing the capacity of Capitol Boulevard.

Items falling under the category of physical inventory were simply observed in the field according to the nature of each item and evaluated in the final ratings as designated by Table VII, on page 43, showing rating values to be applied according to the item involved.

## V. PERSONAL OPINION POLL

As a guide in evaluating the various trial sufficiency rating formulas, personal opinion ratings of several test sections were obtained.

Pertinent criteria of a well qualified personal opinion poll were given in the AASHO Road Test Report Number 5 (29). Two rules which had the most direct bearing on this study were (1) collaboration between persons rating street sections prior to completion of ratings by all raters must be held to a minimum, and (2) a wide range of conditions should be presented to rating personnel for their evaluation. These points were strived for, although the opinion poll of the Idaho study was necessarily less sophisticated than that of the AASHO Road Test.

The distance between the various urban areas used for study required that different personnel be asked to rate the streets in their own local areas. It is noted that the AASHO personnel opinion survey used the same personnel in general throughout their complete study. A similar personal opinion panel used by the city of Phoenix (18) also had a single group of raters giving opinions over all street sections within its study.

The number of opinion ratings received were essentially the same in all cases. The AASHO Road Test Panel of judgment raters was comprised of from ten to thirteen people; the Phoenix study included eleven raters covering one formula being tested and nineteen raters covering another. The ratings of the Idaho study varied from six to ten. A sample questionnaire form is shown in Appendix D on page 123.

Each rater was asked to rate the streets in his area using 10 for a faultless street and reducing this value linearly to zero for a street that had virtually nothing good about it in his opinion. To ascertain some of the basic reasons for the ratings, it was asked that a simple "25 words or less" statement be given as to the reason for the particular rating. The results of these opinions are tabulated in Table IX.

Statistical analysis was performed on the opinions received of each street section to determine their reliability. A sample calculation is included in Appendix C, page 116. Table X, page 65, shows the standard deviation and the 85%, 90%, and 95% confidence limits for each rated street. Figure 13, page 66, depicts these confidence limits in envelope form for comparison with the most promising trial rating formula and with the present system used by the Idaho Department of Highways. The method (30) consisted of performing a 't' distribution operation upon the presumed normally distributed means of the opinions on each street rated. A detailed explanation is shown on the sample calculation sheet. In addition, the differences between the mean opinion rating and the rating from trial formulas were summed for each trial rating formula to ascertain mathematically which trial had the best correlation with the opinion averages for all rated streets.

TABLE IX

OPINION RATING RESULTS RECEIVED

FOR EACH STREET SECTION RATED

| STREET SECTION | INDIVIDUAL RATINGS RECEIVED | MEAN |
|---|---|---|
| Front St., Capitol Blvd. to Americana Blvd. | 6, 6, 7, 5, 7, 5, 6 1/2, 6, 7 | 6.17 |
| Capitol Blvd., Front St. to Boise River Bridge | 5, 9, 8, 8, 8, 8 1/2, 7, 8 | 7.69 |
| Capitol Blvd., Boise River Bridge to College Blvd. | 5, 8, 9, 9, 8, 9, 5, 6 | 7.38 |
| State St., 23rd to 27th St. | 5, 6, 7, 5, 5, 3 2/3, 7, 7, 6, 6 | 5.77 |
| State St., 27th to Lander St. | 5, 7, 7, 7, 9, 7 1/2, 8, 8 | 7.32 |
| 23rd St., State St. to Fairview Ave. | 8, 8, 8, 8, 8, 9, 7, 8, 8 | 8.00 |
| Warm Springs Ave., Bruce St. to Coston St. | 8, 8, 8, 7, 10, 6 | 7.83 |
| E. 1st St., Washington St. to Broadway St. | 8, 5, 5, 9, 9, 8 1/2, 8 | 7.50 |
| Main St., 13th St. to 18th St. | 6, 7, 6, 4, 10, 5, 7 | 6.43 |
| Main St., 1st St. to 9th St. | 3, 5, 4, 2, 10, 4, 7, 7 | 5.25 |
| 'D' St., 9th St. to 1st St. | 2, 4, 3, 3, 2, 1 1/2, 2, 8 | 3.19 |
| Main St., Junction St. to Mill St. | 9, 8, 8, 8, 7, 7, 6, 5, 5 | 7.00 |
| Main St., 6th St. to 1st St. | 5, 8, 8, 7, 6, 4, 5, 4, 8 | 6.11 |
| Sherman Ave., 1st St. to 7th St. | 4 1/2, 5, 4, 7, 7, 7, 6, 7, 6, 5 | 5.85 |
| Sherman Ave., 7th St. to 15th St. | 7, 9, 8, 8 1/2, 8, 8, 6, 8, 10, 8 1/2 | 8.10 |
| Government Way, Indiana Ave. to Harrison Ave. | 9, 10, 7, 9 1/2, 9, 8, 8, 8, 8, 8 | 8.95 |

TABLE X

SUMMARY OF CONFIDENCE LIMITS

AND STANDARD DEVIATIONS OF

OPINION RATINGS

| Street Section | Lower Limits | | | Mean | Upper Limits | | | Standard |
|---|---|---|---|---|---|---|---|---|
| | 85% | 90% | 95% | | 95% | 90% | 85% | Deviation |
| Boise | | | | | | | | |
| Front St.Cap.Blvd-16th | 5.74 | 5.68 | 5.56 | 6.17 | 6.78 | 6.66 | 6.60 | 0.790 |
| Cap Blvd. North Section | 6.95 | 6.84 | 6.63 | 7.69 | 8.75 | 8.54 | 8.43 | 1.268 |
| Cap Blvd. South Section | 6.34 | 6.24 | 5.90 | 7.38 | 8.86 | 8.52 | 8.42 | 1.768 |
| State St. 23rd-27th | 5.21 | 5.13 | 4.98 | 5.77 | 6.55 | 6.40 | 6.33 | 1.100 |
| State St. 27th-Lander | 6.64 | 6.54 | 6.35 | 7.32 | 8.30 | 8.10 | 8.01 | 1.163 |
| 23rd St. State-Fairview | 7.73 | 7.69 | 7.62 | 8.00 | 8.38 | 8.31 | 8.27 | 0.500 |
| Warm Spgs. Bruce-Coston | 6.89 | 6.74 | 6.44 | 7.83 | 9.24 | 8.92 | 8.78 | 1.329 |
| Meridian | | | | | | | | |
| Main St. | 6.33 | 6.21 | 5.88 | 7.50 | 9.12 | 8.79 | 8.62 | 1.756 |
| Lewiston | | | | | | | | |
| Main St. 13th-18th | 5.21 | 5.03 | 4.67 | 6.43 | 8.19 | 7.83 | 7.65 | 1.902 |
| Main St. 1st-9th | 3.73 | 3.51 | 3.07 | 5.25 | 7.43 | 6.99 | 6.77 | 2.600 |
| D Street 9th-1st | 1.96 | 1.78 | 1.43 | 3.19 | 4.95 | 4.60 | 4.42 | 2.103 |
| Grangeville | | | | | | | | |
| Main Street | 6.23 | 6.12 | 5.91 | 7.00 | 8.09 | 7.88 | 7.77 | 1.414 |
| Moscow | | | | | | | | |
| Main Street | 5.19 | 5.06 | 4.81 | 6.11 | 7.41 | 7.16 | 7.03 | 1.691 |
| Coeur d'Alene | | | | | | | | |
| Sherman 1st-7th | 5.26 | 5.19 | 5.02 | 5.85 | 6.68 | 6.51 | 6.44 | 1.156 |
| Sherman 7th-15th | 7.55 | 7.48 | 7.33 | 8.10 | 8.87 | 8.72 | 8.65 | 1.075 |
| Govt.Way Ind.-Harrison | 7.99 | 7.93 | 7.81 | 8.95 | 9.09 | 8.97 | 8.91 | 0.896 |

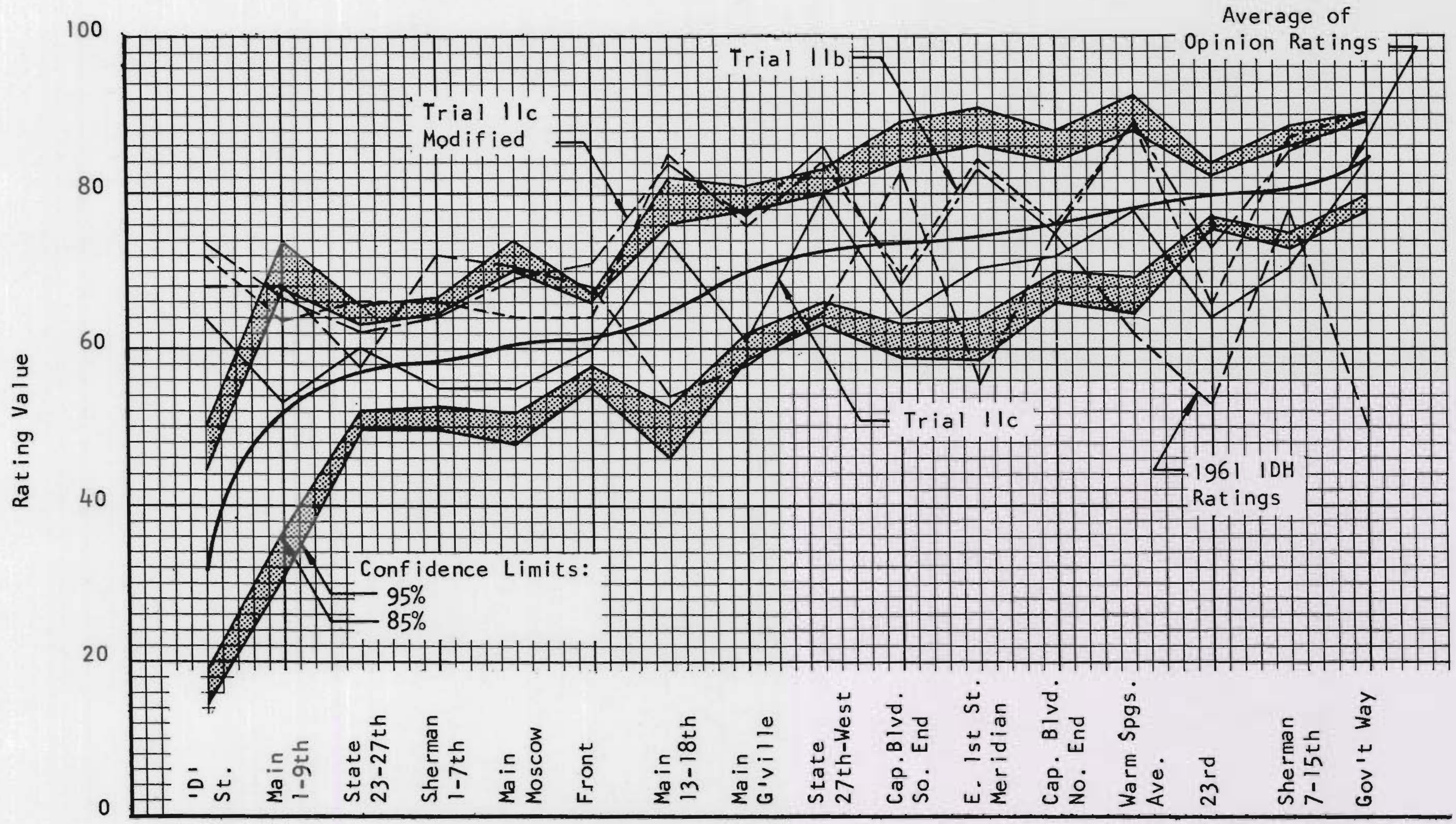


FIGURE 13

URBAN SUFFICIENCY RATINGS AND CONFIDENCE LIMITS
OF OPINION RATINGS OF TEST STREETS

# CHAPTER IV

## RESULTS OF FIELD TESTS

The four trial rating formula groups described in chapter III were tested in the field on the streets listed in Table VIII, page 56. These streets were chosen to represent a range of conditions that may be expected on urban streets of Idaho. The trial formulas tested are shown in Table II, page 30.

Field rating results of the test street sections are tabulated in Table XI. Sub-totals for each category of condition, safety, and service are shown as are the complete totals for each trial rating formula. Analysis of these results is given in the following chapter.

As a guide in the evaluation of the trial formulas personal opinion ratings were solicited and analyzed statistically as described in the preceding chapter. A summary of the opinion ratings for each test street section is given in Table IX, page 64. Table XII on page 69 shows the differences between the average opinion rating and the rating calculated from each trial formula, for use in evaluating the merits of each formula.

Reliability of the ratings of the personal opinion poll must be tempered by the small number of ratings received for each test section. The statistical analysis of these ratings necessarily utilized the "Student's t" distribution, which is an approximation, only, of the more accurate standard normal distribution (30).

A graph of some of the apparently more promising trial formulas

# TABLE XI

SUMMARY OF RATING RESULTS OF EACH

TEST STREET SECTION WITH EACH TRIAL

RATING FORMULA

| Street Section | C=Condition Sa=Safety Se=Service Total Rating | Average Opinion Rating | 1961 IDH Rating | Trial Group I a | Trial Group I b | Trial Group II a | Trial Group II b | Trial Group II c | Trial Group III a | Trial Group III b | Trial Group III c | Trial Group IV a | Trial Group IV b | Trial Group IV c | Trial IIc Revised |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Boise** | | | | | | | | | | | | | | | |
| Front Street | C | | 22/27 (Split @ 10th) | 12 | 12 | 15 | 15 | 15 | 18 | 18 | 18 | 12 | 12 | 12 | 15 |
| Capitol Blvd.- | Sa | 62 | 16/10 | 26 | 26 | 25 | 25 | 23 | 15 | 16 | 15 | 15 | 16 | 14 | 26 |
| Americana Blvd. | Se | | 30/30 | 25 | 27 | 22 | 24 | 22 | 32 | 33 | 35 | 27 | 38 | 45 | 30 |
| | T | | 68/67 | 63 | 65 | 62 | 64 | 60 | 65 | 67 | 68 | 54 | 66 | 71 | 71 |
| Capitol Blvd. | C | | 32 | 18 | 18 | 22 | 22 | 22 | 27 | 27 | 27 | 18 | 18 | 18 | 23 |
| Front St. - Boise | Sa | 77 | 16 | 27 | 28 | 25 | 25 | 24 | 15 | 15 | 13 | 16 | 14 | 13 | 25 |
| River Bridge | Se | | 27 | 27 | 27 | 25 | 28 | 26 | 34 | 35 | 40 | 34 | 44 | 44 | 28 |
| | T | | 75 | 72 | 73 | 72 | 75 | 72 | 76 | 77 | 80 | 68 | 76 | 75 | 76 |
| Capitol Blvd. | C | | 33 | 19 | 19 | 24 | 24 | 24 | 28 | 28 | 28 | 19 | 19 | 19 | 24 |
| Boise River Bridge- | Sa | 74 | 20 | 27 | 27 | 24 | 24 | 22 | 15 | 13 | 17 | 20 | 14 | 14 | 24 |
| College Blvd. | Se | | 30 | 15 | 15 | 15 | 20 | 18 | 22 | 25 | 33 | 17 | 35 | 32 | 19 |
| | T | | 83 | 61 | 61 | 63 | 68 | 64 | 65 | 66 | 78 | 56 | 68 | 65 | 67 |
| State Street | C | | 24 | 14 | 14 | 18 | 18 | 18 | 21 | 21 | 21 | 14 | 14 | 14 | 18 |
| 23rd St. - 27th St. | Sa | 58 | 11 | 32 | 32 | 28 | 28 | 30 | 16 | 15 | 17 | 20 | 16 | 17 | 29 |
| | Se | | 23 | 15 | 15 | 15 | 20 | 12 | 20 | 17 | 25 | 15 | 25 | 20 | 15 |
| | T | | 58 | 61 | 61 | 61 | 66 | 60 | 57 | 53 | 63 | 49 | 55 | 51 | 62 |
| State Street | C | | 21 | 18 | 18 | 22 | 22 | 22 | 27 | 27 | 27 | 18 | 18 | 18 | 22 |
| 27th St. - | Sa | 73 | 15 | 25 | 25 | 28 | 25 | 20 | 17 | 14 | 20 | 20 | 17 | 15 | 24 |
| Lander St. | Se | | 29 | 40 | 40 | 37 | 38 | 38 | 48 | 48 | 48 | 55 | 58 | 57 | 40 |
| | T | | 65 | 83 | 83 | 87 | 85 | 80 | 92 | 89 | 95 | 93 | 93 | 90 | 86 |
| 23rd Street | C | | 26 | 17 | 17 | 22 | 22 | 22 | 26 | 26 | 26 | 17 | 17 | 17 | 22 |
| State St. - | Sa | 80 | 12 | 18 | 19 | 20 | 21 | 17 | 10 | 11 | 7 | 4 | 9 | 9 | 22 |
| Fairview Ave. | Se | | 15 | 37 | 30 | 26 | 22 | 25 | 31 | 34 | 28 | 40 | 39 | 42 | 29 |
| | T | | 53 | 72 | 66 | 68 | 65 | 64 | 67 | 71 | 61 | 61 | 65 | 68 | 73 |
| Warm Springs Ave. | C | | 27 | 17 | 17 | 21 | 21 | 21 | 26 | 26 | 26 | 17 | 17 | 17 | 21 |
| Bruce St. - | Sa | 78 | 13 | 29 | 29 | 31 | 28 | 25 | 16 | 13 | 20 | 20 | 18 | 17 | 28 |
| Coston St. | Se | | 22 | 45 | 45 | 40 | 40 | 32 | 43 | 48 | 50 | 50 | 55 | 60 | 40 |
| | T | | 62 | 91 | 91 | 92 | 89 | 78 | 85 | 87 | 96 | 87 | 90 | 94 | 89 |
| **Meridian** | | | | | | | | | | | | | | | |
| E. 1st Street | C | | 27 | 16 | 16 | 20 | 20 | 20 | 24 | 24 | 24 | 16 | 16 | 16 | 20 |
| Washington St. - | Sa | 75 | 12 | 25 | 26 | 30 | 25 | 21 | 16 | 13 | 20 | 20 | 18 | 15 | 24 |
| Broadway St. | Se | | 16 | 44 | 44 | 40 | 40 | 30 | 50 | 48 | 50 | 55 | 55 | 60 | 40 |
| | T | | 55 | 85 | 86 | 90 | 85 | 71 | 90 | 85 | 94 | 91 | 89 | 91 | 84 |
| **Lewiston** | | | | | | | | | | | | | | | |
| Main Street | C | | 27 (Rated while in | 14 | 14 | 18 | 18 | 18 | 21 | 21 | 21 | 14 | 14 | 14 | 18 |
| 13th St. - | Sa | 64 | 12 3-lane | 30 | 30 | 27 | 27 | 27 | 15 | 15 | 16 | 20 | 16 | 15 | 26 |
| 18th St. | Se | | 15 operation) | 43 | 43 | 39 | 40 | 30 | 49 | 46 | 49 | 54 | 52 | 59 | 40 |
| | T | | 54 | 87 | 87 | 84 | 85 | 75 | 85 | 82 | 86 | 88 | 82 | 88 | 84 |
| Main Street | C | | 25 (Rated as | 14 | 14 | 18 | 18 | 18 | 21 | 21 | 21 | 14 | 14 | 14 | 18 |
| 1st St. - | Sa | 52 | 20 One | 28 | 28 | 29 | 26 | 23 | 15 | 12 | 20 | 20 | 17 | 16 | 28 |
| 9th St. | Se | | 23 Route) | 27 | 27 | 19 | 19 | 12 | 22 | 28 | 27 | 25 | 27 | 42 | 21 |
| | T | | 68 | 69 | 69 | 66 | 63 | 53 | 58 | 61 | 68 | 59 | 58 | 72 | 67 |
| "D" Street | C | | 25 (Rated as | 10 | 10 | 12 | 12 | 12 | 15 | 15 | 15 | 10 | 10 | 10 | 12 |
| 9th St. - | Sa | 32 | 20 one | 29 | 30 | 31 | 29 | 26 | 17 | 14 | 20 | 20 | 18 | 16 | 30 |
| 1st St. | Se | | 23 Route) | 35 | 35 | 30 | 32 | 26 | 38 | 41 | 44 | 40 | 45 | 50 | 32 |
| | T | | 68 | 74 | 75 | 73 | 73 | 64 | 70 | 70 | 79 | 70 | 73 | 76 | 74 |
| **Grangeville** | | | | | | | | | | | | | | | |
| Main Street | C | | 18 | 15 | 15 | 19 | 19 | 19 | 22 | 22 | 22 | 15 | 15 | 15 | 19 |
| Junction St. - | Sa | 70 | 20 | 20 | 21 | 26 | 20 | 16 | 15 | 10 | 20 | 20 | 17 | 14 | 20 |
| Mill St. | Se | | 20 | 40 | 40 | 37 | 37 | 27 | 47 | 44 | 48 | 50 | 47 | 57 | 38 |
| | T | | 58 | 75 | 76 | 82 | 76 | 62 | 84 | 76 | 90 | 85 | 79 | 86 | 77 |
| **Moscow** | | | | | | | | | | | | | | | |
| Main Street | C | | 25 | 20 | 20 | 25 | 25 | 25 | 30 | 30 | 30 | 20 | 20 | 20 | 25 |
| 6th St. - | Sa | 61 | 13 | 14 | 14 | 10 | 13 | 13 | 6 | 8 | - | - | 4 | 6 | 16 |
| 1st St. | Se | | 33 | 33 | 29 | 26 | 26 | 17 | 29 | 35 | 35 | 32 | 40 | 47 | 28 |
| | T | | 71 | 67 | 63 | 61 | 64 | 55 | 65 | 73 | 65 | 52 | 64 | 73 | 69 |
| **Coeur d'Alene** | | | | | | | | | | | | | | | |
| Sherman Avenue | C | | 33 | 17 | 17 | 21 | 21 | 21 | 25 | 25 | 25 | 17 | 17 | 17 | 21 |
| 1st St. - | Sa | 58 | 14 | 18 | 18 | 20 | 19 | 18 | 11 | 12 | 9 | 8 | 10 | 12 | 18 |
| 7th St. | Se | | 25 | 24 | 24 | 23 | 26 | 15 | 30 | 32 | 39 | 28 | 38 | 42 | 26 |
| | T | | 72 | 59 | 59 | 64 | 66 | 54 | 66 | 69 | 73 | 53 | 65 | 71 | 65 |
| Sherman Avenue | C | | 33 | 17 | 17 | 21 | 21 | 21 | 26 | 26 | 26 | 17 | 17 | 17 | 21 |
| 7th St. - | Sa | 81 | 15 | 26 | 26 | 30 | 26 | 21 | 16 | 13 | 20 | 20 | 20 | 18 | 25 |
| 15th St. | Se | | 31 | 44 | 44 | 40 | 40 | 29 | 48 | 48 | 50 | 53 | 55 | 60 | 40 |
| | T | | 79 | 87 | 87 | 91 | 87 | 71 | 90 | 87 | 96 | 90 | 92 | 95 | 86 |
| Government Way | C | | 20 | 18 | 18 | 22 | 22 | 22 | 27 | 27 | 27 | 18 | 18 | 18 | 22 |
| Indiana Ave. - | Sa | 84 | 16 | 30 | 30 | 31 | 29 | 26 | 16 | 14 | 20 | 20 | 19 | 18 | 28 |
| Harrison Ave. | Se | | 14 | 45 | 45 | 40 | 40 | 35 | 50 | 48 | 50 | 58 | 55 | 60 | 40 |
| | T | | 50 | 93 | 93 | 93 | 91 | 83 | 93 | 89 | 97 | 96 | 92 | 96 | 90 |

TABLE XII

SUMMATION OF DIFFERENCES BETWEEN

OPINION RATINGS AND TRIAL FORMULA RATINGS

| Test Street Sections | Trial Group I | | Trial Group II | | | Trial Group III | | | Trial Group IV | | | Trial IIc Rev. | 1961 IDH Ratings |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a | b | a | b | c | a | b | c | a | b | c | | |
| Boise | | | | | | | | | | | | | |
| Front St. | +3 | +1 | +4 | +5 | -2 | +3 | +5 | +6 | -8 | +4 | +9 | +9 | +5 |
| Cap. Blvd. No. End | -5 | -4 | -8 | -4 | -14 | -1 | 0 | +3 | -9 | -1 | -9 | +1 | -2 |
| Cap. Blvd. So. End | -13 | -13 | -11 | -6 | -10 | -9 | -8 | +4 | -18 | -6 | -9 | +9 | +9 |
| State St. E. End | +3 | +3 | +3 | +8 | +2 | -1 | -5 | +5 | -9 | +4 | -7 | +4 | 0 |
| State St. W. End | +10 | +10 | +14 | -22 | +7 | +19 | +16 | +22 | +20 | +20 | +17 | +13 | -27 |
| 23rd St. | -8 | -14 | -7 | -15 | -16 | -13 | -4 | -19 | -19 | -10 | -12 | -7 | -16 |
| Warm Springs Ave. | +13 | +13 | +14 | +11 | 0 | +7 | +9 | +18 | +9 | +12 | +16 | +11 | -20 |
| Meridian | | | | | | | | | | | | | |
| E. 1st. St. | +10 | +11 | +15 | +10 | -4 | +15 | +10 | +19 | +16 | +14 | +16 | +9 | -10 |
| Lewiston | | | | | | | | | | | | | |
| Main, 13th-18th | +23 | +23 | +20 | +21 | +11 | +21 | +18 | +22 | +24 | +18 | +24 | +20 | +16 |
| Main, 1st-9th | +17 | +17 | +14 | +11 | +1 | +6 | +9 | +16 | +7 | +6 | +20 | +15 | +36* |
| D. 9th-1st | +43 | +44 | +42 | +42 | +33 | +39 | +39 | +48 | +39 | +42 | +45 | +42 | +36 |
| Grangeville | | | | | | | | | | | | | |
| Main St. | +5 | +6 | +12 | +6 | -8 | +14 | +7 | +20 | +15 | +9 | +16 | +7 | -12 |
| Moscow | | | | | | | | | | | | | |
| Main St. | +6 | +2 | 0 | +3 | -6 | +4 | +12 | +4 | -9 | +3 | +22 | +8 | -10 |
| Coeur d'Alene | | | | | | | | | | | | | |
| Sherman, 1-7th | 0 | 0 | +6 | +8 | -4 | +8 | +11 | +15 | -5 | +7 | +13 | +7 | +14 |
| Sherman, 7-15th | +6 | +6 | +10 | +6 | +10 | +9 | +6 | +15 | +9 | +11 | +14 | +5 | -3 |
| Gov't Way | +9 | +9 | +9 | +7 | -1 | +9 | +5 | +13 | +12 | +8 | +12 | +6 | -34 |
| TOTAL DIFFERENCE | 174 | 176 | 189 | 185 | 129 | 178 | 164 | 249 | 228 | 175 | 261 | 173 | 214 |
| PLUS DIFFERENCE | 148 | 145 | 163 | 160 | 54 | 154 | 147 | 230 | 151 | 158 | 224 | 166 | 80 |
| MINUS DIFFERENCE | -26 | -31 | -26 | -25 | -75 | -24 | -17 | -19 | -77 | -17 | -37 | -7 | -134 |

*Rated for both ways of one-way couplet system versus each test street section is shown in Figure 13 on page 66. An envelope of computed 85 and 95 per cent confidence limits were superimposed on the same plot for use in evaluating the various formulas, as shown in the same figure.

Upon comparison of the field test results with the opinion rating data it was found that Trial IIc had the highest degree of correlation.

In an attempt to improve the correlation of Trial IIc with the personal opinion poll the formula was modified somewhat, using seemingly more reasonable sub-par values. The modified formula is shown in Table II, page 30. Ratings using this formula were also included in Table XI, page 68.

The degree of correlation of the revised formula decreased substantially, thus voiding any cause for further study of its use.

## CHAPTER V

## ANALYSIS

Three primary categories, pavement condition, safety and service, were chosen to rate the test streets by use of four principle trial rating groups. A more detailed description of the test formulas and of the test streets was presented in Chapter III. Results of the numerical ratings using each of the test formulas applied to all test streets were given in Chapter IV.

### I. CONDITION

Condition of pavement was the most subjective of the three primary categories because evaluation was by visual inspection only. It is evident that a rating based solely on visual inspection by a single individual eludes objective comparisons without the human element entering the rating at some point. The human element is exhibited by some disparity in a few of the opinions of the personal opinion poll and the ratings given to some of the poorer test street pavements.

The effect of varying par values of the condition category cannot be ascertained by itself due to the nature of the rating method of that category. Its effect rather will be reflected as a result of the more objective ratings within the safety and service categories.

### II. SAFETY

Safety to the road user was a more tangible road characteristic to evaluate, because standards could be established for objective comparisons. There were, however, no widely established comparative criteria found in the literature or in current practice and accordingly it was necessary that much of the criteria be based on the writers judgement and experience.

As discussed in Chapter III, the safety category was evaluated via two aspects: accident rate comparisons and friction potential. Par values were varied between and within the trial formulas as shown on Table II, page 30. Three curves relative to par value reductions were used for accident rate comparisons (Figures 3, 4, and 5, pages 34, 35, and 36, and various reduction rates were used in evaluating friction potential (Tables IV, V, and VI, pages 39, 41, and 41.

It is believed that the section of Capitol Boulevard north of the Boise River in Boise should have been rated a bit lower regarding safety than the section of the same arterial south of the river. Ratings from many of the trial formulas were the opposite, however. The accident rate of the south section was a bit lower than the north section, and the friction potential is somewhat less, particularly regarding commercial accesses. On the north section side streets and also the lack of the median which exists on the south section put greater demands on a driver's attention. The five-leg intersection was mostly responsible for the reduced rating given the south section of Capitol Blvd. The angle intersection of Eighth St. on the south section was also a factor in the reduced rating although it was counter-acted by low ratings on the north section for the numerous commercial accesses.

Front Street in Boise and the section of Capitol Blvd. north of the Boise River compared about as expected. Some trial formulas rated Front Street safety slightly lower than the north section of Capitol Blvd., while other formulas rated the two streets oppositely. Accident rates and friction potential were about the same for the two streets. It is believed that Front Street should generally be rated slightly lower than the north section of Capitol Blvd. as there is less control of traffic on Front Street, especially regarding left turn movements.

Twenty-third Street in Boise was rated lower by the formulas in safety than expected. This was due mostly to the relatively high accident rate in the vicinity of the Fairview Avenue and Main Street intersections. The friction potential was relatively low, and the accident rate was lower on the remaining section north of Main Street. More rational ratings would have resulted from a different choice of section limits, excluding the section between Main Street and Fairview Avenue.

Safety ratings of Warm Springs Avenue in Boise were as expected with the exception of trial formulas IIc and IIIb. The street is wide, has little friction potential and a low accident rate. The heavier values given medial-internal friction potential in formulas IIc and IIIb seems to be the responsible factor for the lower ratings of those trials as the street has wide lanes compared to usual standards (2).

Two sections of State Street in Boise bear close examination. The westernmost section from 27th Street to Lander Street has a relative high amount of friction potential due to several angle type intersections and uncontrolled commercial accesses, but a relatively low accident rate. The easternmost section between 23rd and 27th streets has the opposite situation. Both sections have travel lanes and little or no on-street parking. The trial formulas giving greater value to friction potential show the first mentioned section to have a lower safety rating than the 23rd-27th Street section. However, the trial formulas having slight emphasis on friction potential resulted in nearly equal ratings to both sections. This is due mostly to the fact that the accident rate was not too great on the 23rd-27th section, even though the west section had a lower accident rate.

It seems that the west section of State Street is more safe than the 23rd-27th Street section. Lanes are wider, a median exists while the latter section has none, the adjacent roadside appears more open, and volumes are somewhat less over much of the section; in short, there is less apparent constriction on the west section. Accident rate and opinion poll comparisons support this argument.

Sherman Street from 7th to 15th streets in Coeur d'Alene also seems to be a somewhat safer facility than the 23rd-27th streets section of State Street. Accident rates and personal opinions of the opinion poll indicate agreement. Again, friction potential is somewhat higher on the Coeur d'Alene arterial than on State Street, while the apparent constrictive nature of the two facilities favors the Coeur d'Alene arterial. Traffic flow is heavier on the State Street section.

From the above it appears that an urban arterial is less safe and more constricted due to relatively high volumes than due to friction potential such as studied for this project. Friction potential is demanding of a drivers attention but not so demanding as other traffic.

The remaining test streets were rated about as expected in comparison of one another, and in comparison to this writer's personal knowledge of the street sections themselves. The five-leg intersection on Main Street in Grangeville appears to have lowered the rating of that section somewhat further than it should have been. It was expected that the Grangeville street would have been rated comparably to East 1st Street in Meridian, as the two streets were similar in nature at the time the rating was taken.

Rating differences from the three accident rate curves were relatively insignificant as compared with the result of the total differences of the safety category, and thus elude conclusive analysis. Curve A of Figure 3 on page 34 gave heaviest penalties to those streets having accident rates equal or above the statewide urban average rates. Curve C of Figure 5 on page 36, was the opposite, while Curve B, of Figure 4 on page 35, was essentially the same as Curve C. In view of the total safety rating results it is anticipated that the right half of Curve A combined with the left half of Curve B would give the most rational accident rate value. In this manner the effect of friction potential would be dampened to a small extent.

Values assigned to the friction potential factor were quite small when compared to the other rating values, and are thus somewhat difficult to analyze quantitatively. It appears, however, that the more severe penalties for angle intersections and five-leg intersections are somewhat strong to be realistic, as indicated by the low safety ratings of Main Street in Grangeville and the south section of Capitol Blvd. in Boise. A combination of the milder par reductions would seem to be the most rational in assigning friction potential ratings, subject to further investigation.

## III. SERVICE

Service was evaluated by two main divisions, and in some instances by smaller additional isolated factors. Travel times in the form of delay rates and a ratio of counted peak-hour volumes to calculated practical capacity constitute the main evaluations. Par value reduction curves for delay rates are shown in Figures 6, 7, and 8, pages 45, 46 and 47respectively; reduction curves for volume-capacity ratios are shown in Figures 9, 10, 11 and 12, pages 50, 51, 52, and 53, respectively. Detailed discussion of the rating procedures for the service category was presented in Chapter III.

As in the safety rating evaluations, comparison of service ratings of the various test street sections appears to be the most tangible manner of appraising the rating results. Again there are no long-established standards available for comparative analysis, necessitating that criteria be based on the personal experience of this writer.

The section of Capitol Boulevard north of the Boise River had service ratings considerably higher than the section of the same facility south of the river. This was due entirely to the large delay rate encountered at the traffic signal at College Boulevard. The trial formulas having the more evenly divided emphasis between the two service factors gave more accurate comparisons between the two sections of Capitol Blvd. The remaining formulas seemed unrealistic in comparative service values between the two sections, because the high delay rate on the south section applies to one direction of travel only. Travel in the other direction experiences little delay, if any.

Comparison of service ratings on Front Street and the section of Capitol Blvd. north of the Boise River resulted generally as expected, Front Street ratings being slightly lower. The higher volume-capacity ratio on Front Street was mostly responsible for the relationship between the two streets, although there appears to be less control of traffic movements on Front Street in the form of frequent unchannelized left turn movements. The personal opinion poll showed low ratings for Front Street due to delays and left turns for the most part.

The large service rating differential found on the two sections of State Street west and east of 27th Street in Boise was nearly as expected. The delays experienced on the 23rd-27th Street section in both directions of travel were very high comparatively, and the west-bound movements encountered the greatest delay rate of all streets rated. It is felt, however, that the trial formulas having the more evenly divided proportional weights between the two divisions of the service category gave more realistic comparative values of the two street sections. Service provided by the westernmost section of State Street is not generally the better of the two sections to the degree indicated by those trials having greater proportionate weights assigned the delay factor.

Twenty-third Street seemed to be rated excessively low in service. The high volume-capacity ratio at the Fairview intersection was responsible for the low rating. As mentioned earlier, better choice of section limits on 23rd Street would have resulted in more realistic rating values, as the street provides relatively good service, free from excessive delays and heavy traffic volumes.

Service ratings on 'D' Street in Lewiston were in most cases higher than the ratings on Main Street between 1st Street and 9th Street, perhaps to an excessive degree considering the fact that these streets make up a one-way couplet. Delays on both facilities were moderate, while the volume-capacity ratio on the Main Street section was substantially higher than that on the other facility. Opinions of the 'D' Street section were numerically lower than those on Main Street; however this should be tempered, it is suspected, by a lack of aesthetic surroundings. Trial ratings having the greatest proportionate weight assigned to the delay factor, of course, reduced the service rating differential of the two streets, which seems to be more realistic in general. It is suspected that 'D' Street should be rated nearly equal to Main Street as delays and volumes on each are generally equivalent.

Volumes on Main Street section between 13th and 18th streets in Lewiston were low enough to result in what is felt to be a somewhat higher service rating than is warranted. The lanes are narrow and a relatively high crown exists in cross-section. This requires an abnormal amount of effort and attention by motorists to prevent unintentional crossing into other traffic lanes.

Government Way and Sherman Avenue (7th-15th Streets) in Coeur-d'Alene and Warm Springs Avenue in Boise were all rated at full to nearly full par value in service. The isolated items in the physical inventory category penalized ratings to an excessive degree, it is felt. Conditions are such on each of these streets that it is believed that nearly full par values are warranted in comparison to the other street sections rated. Delays are negligible and volumes are sufficiently low so that congestion is virtually absent.

During computations of the service rating data of the test streets it has appeared that the sub par assignment Curve II, Figure 7, page 46, gives the most reasonable indications of delay deficiencies. Curve I (Figure 6, page 45,) being steeper than Curve II, gave more severe penalties in general than warranted. Curve III (Figure 8, page 47,) gave essentially the same rating deficiencies as Curve II as there is little difference in slope between the two.

It has become evident that the volume-capacity ratio values taken from the sub par assignment Curve II (Figure 10, page 51) are too severe, particularly in the 60%-85% range. Streets having a volume-capacity ratio within this range were not as deficient in service as Curve II would indicate. Curve III (Figure 11, page 52) of the volume-capacity ratio sub-par assignments gave too lenient indications as the sloping trend accounting for the peak hour travel duration gave too great a differential between various durations. The straight line reduction of Curve IV (Figure 12, page 53) also gave rather lenient rating values in ~~the higher~~ volume-capacity ratio areas, ~~and~~ is thus considered relatively ineffective in giving a reasonable indication of the effect of those ratios. Curve I, (Figure 9, page 50) gave the most reasonable indications of volume-capacity relationships.

The physical inventory for medians and lane widths was responsible for a considerable mark down of the service ratings. While these factors do affect street service, it is evident that the weight assigned to deficiencies of these items resulted in the reductions from par being too severe. The remaining factors of the physical inventory category proved insignificant so as not to be warranted for use in the service ratings deficiencies.

Relative to overall sufficiency rating, it appears that the numerical weight of 40 points par assigned the service category does give the most rational indication of street adequacy. The heavier assignment of 60 points par for service gave too extreme ratings at either condition; i.e., streets having good service with moderate safety were rated somewhat high (Government Way in Coeur d'Alene, Main Street in Lewiston between 13th and 18th Streets, and Warm Springs Avenue in Boise), and streets having poor service with moderate safety were rated too severely (Main Streets in the Moscow and Lewiston Central Business District). The 50 point par assignment paralleled the above conditions to a less extent, but it is also felt to be somewhat severe in the more extreme ranges. No significant differences in ratings were encountered between the 40 point par assignments and the 45 point par assignments.

## CHAPTER VI

## CONCLUSIONS AND RECOMMENDATIONS

### I. CONCLUSIONS

In drawing from the available literature and from the experiences and practices of the western highway departments, it was confirmed that the use of urban sufficiency ratings is a relatively new and struggling practice. Some agencies are using a rural rating system without ragard for urban traffic conditions, while others are using but one or two main factors adaptable to both rural and urban characteristics. The Idaho Department of Highways, among some departments, is using basically a rural rating formula with some modifications adapting to urban traffic requirements. Others are proposing and/or using formulas specifically designed for rating urban streets.

Two concepts of ratings were pointed out by Mohle (5) that seem most applicable to urban rating systems as found in present practice; these are the concepts of acceptable elements and acceptable operations. The elements concept is applicable to physical aspects of the urban roadway, while the operations concept is applicable to smoothness of traffic flow.

Urban streets are required to accommodate usually much higher volumes of traffic than are rural highways. Therefore, the operational concept of rating systems is more in keeping with the purpose of urban streets, although the physical aspects of urban streets are important to at least a nominal degree. Trial rating systems to be applied specifically to urban streets were formulated as described in Chapter III, Experimental Work.

As constructed, the trial rating formulas in many cases did not differentiate each variable to the extent desirable for effective analysis. Future studies would be desirable for establishing new formulas designed to more distinctly isolate the variables.

The following conclusions apply to the results of the field testing of the various trial formulas:

1. Of the various combinations of numerical proportionate weights of the three rating categories, the assignment of 25, 35, and 40 points for condition, safety and service, respectively, gave the most realistic urban sufficiency ratings of streets in relation to one another. Greater par assignments for the service category resulted in excessively low ratings to the poorer streets and excessively high ratings to the better streets.

2. For those streets having accident rates of 70% to 85% of the statewide urban average, it was found that the safety category was affected very little by altering the balance of proportionate par values between accident record and friction potential. Significantly greater weight placed on either of these two safety factors resulted in illogical safety ratings on streets having accidents outside the 70% to 85% range, however.

3. Definite conclusions favoring any of the accident rate sub par assignment curves was not possible. The results of the different curves were overshadowed by the total variation of the safety category.

4. The milder sub par assignments of the intersectional friction potential gave more realistic safety ratings, particularly regarding the five leg intersections and the intersections having an approach at an oblique angle.

5. Urban streets of high constrictive nature appear to produce more accidents than those of a less constrictive nature, even though the friction potential may indicate slightly the opposite in some cases. Constrictive nature is apparently related to traffic volumes, marginal and medial characteristics, and possibly the roadside characteristics.

6. A relatively even balance of the par value assignments of delay and volume-capacity ratio gave the most realistic ratings of street service in the majority of cases. A significant balance favoring the volume-capacity ratio resulted in excessively high ratings on the test streets having low volumes and moderate delays. The reverse of this gave more rational ratings, however, due to the nature of the sub par assignments within the volume-capacity ratio. The trial formulas having emphasis placed on delay rate par value assignments gave fairly realistic service ratings to the streets having little traffic delays.

7. Where assigned, the items within the physical inventory category resulted in excessive penalties. Streets not warranting these penalties had service ratings much the same from formulas having physical inventory assignments and formulas excluding those assignments.

8. Of the delay rate sub par assignment curves, Curve II gave the most realistic delay rating values. Curve I gave more severe penalties than were warranted, while Curve III in some instances gave somewhat lenient delay ratings.

9. Curve I of the volume-capacity ratio sub par assignment curves gave the best ratings in this category. Curve II gave too severe penalties in the 60-85% range, while Curve III was too lenient in the 10% peak hour portion of ADT. Curve IV was also lenient in rating values and did not account for peak hour traffic duration.

## II. RECOMMENDATIONS

It is believed that the same basic framework as presently used by the Idaho Department of Highways will best fit requirements for rating Idaho's urban streets. However, a complete change of the material within that rating framework will more properly fit those requirements. In this manner, both rating concepts as pointed out by Mohle (5) may be accommodated, with greater emphasis assigned to the operational concept.

Retention of the present sufficiency rating framework of condition, safety, and service categories would simplify the rating procedure without sacrificing the ultimate objective of accounting specifically for urban street characteristics. Also, the pitfalls of relying on but one or two factors as advised against by Rothrock (20) would be avoided.

Commencing on page 86 a Rating Procedure that is recommended for use in rating Idaho's urban streets is given. This Procedure is the result of the findings of this investigation and embodies the most satisfactory combination of techniques and categories tested. The subsequent Tables XIII through XVI and Figures 14 through 16 give the complete breakdown of proportional weights and numerical deductions for deficiencies.

Further study of an urban sufficiency formula is warranted, however, because of the manner in which variations were established in formulating the test formulas. In several instances variations of factors and sub par assignments as a total overshadowed the effects of more specific variations within the sub par assignments. As a result it was not possible to isolate the effect of the specific differences to the extent desirable. New sufficiency formulas established to enable isolation of smaller variables could make use of the same street data and thus provide possibly more accurate results.

# RATING PROCEDURE

## Total Urban Sufficiency Rating
## To be the Sum of Condition, Safety, and Service Ratings

### Condition

To be rated according to individual visual inspection. Full par value represents flawless pavement; low value represents poor pavement with many cracks and/or patches.

### Safety

Accident History: To be rated according to curve on Figure 14, using accidents per million vehicle miles per two-year average as compared with statewide urban average accident rate for same two-year period.

Friction Potential: To be rated according to rating lists of Tables XII, XIII and XIV.

Total of friction potential rating and accident history rating to be used as Safety rating.

### Service

Delay Rate: To be rated according to curve on Figure 15, using the average speed method of the "Floating car" technique for travel times. Delay rates to be computed from difference between posted speed limit (minutes/mile) and obtained travel times.

Volume-Capacity Ratio: To be according to curve on Figure 16. Counted volumes on file to be compared with practical intersection capacity as computed from method of U. S. Bureau of Public Roads Highway Capacity Manual.

Total of delay rating and volume-capacity rating to be used for Service rating.

TABLE XIII

RECOMMENDED URBAN SUFFICIENCY RATING FORMULA

| Factor | | Sub-Par Value | Par Value |
|---|---|---|---|
| Condition | | – | 25 |
| Safety | | | 35 |
| Accident Experience | | 15 | |
| Friction Potential | | 20 | |
| Intersectional | (10) | | |
| Marginal | (5) | | |
| Medial-Internal | (5) | | |
| Service | | | 40 |
| Delay Rate | | 20 | |
| Volume-Capacity Ratio | | 20 | |
| | | TOTAL PAR VALUE | 100 |

TABLE XIV

INTERSECTION FRICTION POTENTIAL

RATING DEFICIENCY ASSIGNMENTS

| Intersection Characteristic | Per Cent of Assigned Par Value |
|---|---|
| No. of Signalized Intersections per 1000 ft. * | |
| 0 - 1 | 100 |
| 1 - 2 | 90 |
| 2 - 3 | 80 |
| 3 and above | 70 |
| No. of Stop-controlled Intersections per 1000 ft. * | |
| 0 - 1 | 100 |
| 1 - 2 | 90 |
| 2 - 3 | 80 |
| 3 and above | 70 |
| No. of Non-controlled or Yield R/W Intersections per 1000 ft. * | |
| 0 - 1 | 70 |
| 1 - 2 | 60 |
| 2 - 3 | 50 |
| 3 and above | 40 |
| No. of Angle Intersections @ Angle less than $60^{o}$ and having no merging facilities per 1000 ft. ** | |
| 0 - 1 | 70 |
| 1 - 2 | 50 |
| 2 - 3 | 30 |
| 3 and above | 10 |

* Three leg intersections: Increase sub-par assignment by $\frac{1}{2}$ the difference of the above assigned values and 100%.

** Three leg intersections: Increase sub-par assignment by $\frac{1}{4}$ the difference of the above assigned values and 100%.

TABLE XV

MARGINAL FRICTION POTENTIAL

RATING DEFICIENCY ASSIGNMENTS

| Type of Parking | Per Cent of Assigned Full Par Value | |
|---|---|---|
| | 2-Lane Street | 4-Lane Street |
| No On-Street Parking Permitted | 100 | 100 |
| Parallel Parking Permitted | | |
| One Side Only | 80 | 90 |
| Both Sides | 60 | 75 |
| Angle Parking Permitted | | |
| One Side Only | 70 | 70 |
| Both Sides | 50 | 50 |

TABLE XVI

MEDIAL-INTERNAL FRICTION POTENTIAL

RATING DEFICIENCY ASSIGNMENTS

| 2-Lane Street | %of Full Par Value | 4-Lane Street | % of Full Par Value |
|---|---|---|---|
| 10' lanes or less | 40 | 4-10' lanes or less | 40 |
| 11' lanes | 60 | 4-11' lanes | 60 |
| 12' lanes | 100 | 4-12' lanes | 100 |
| 15' lanes | 80 | 2-10'; 2 10' lanes | 60 |
| 17' lanes or more | 40 | 2-11'; 2 11' lanes | 80 |
| | | 2 15' lanes | 80 |
| | | 2 17' lanes or more | 40 |

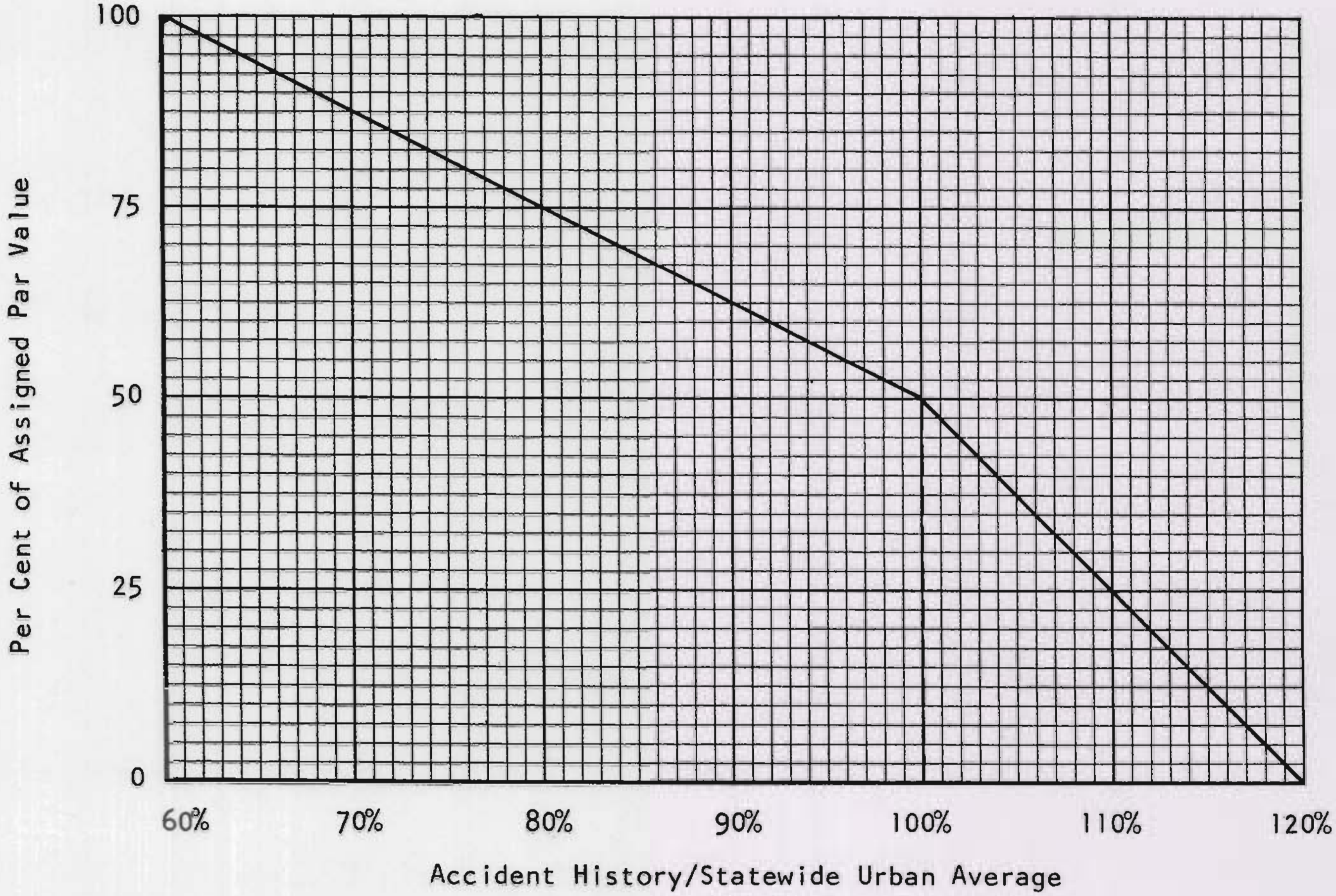


FIGURE 14

ACCIDENT EXPERIENCE RATING GUIDE

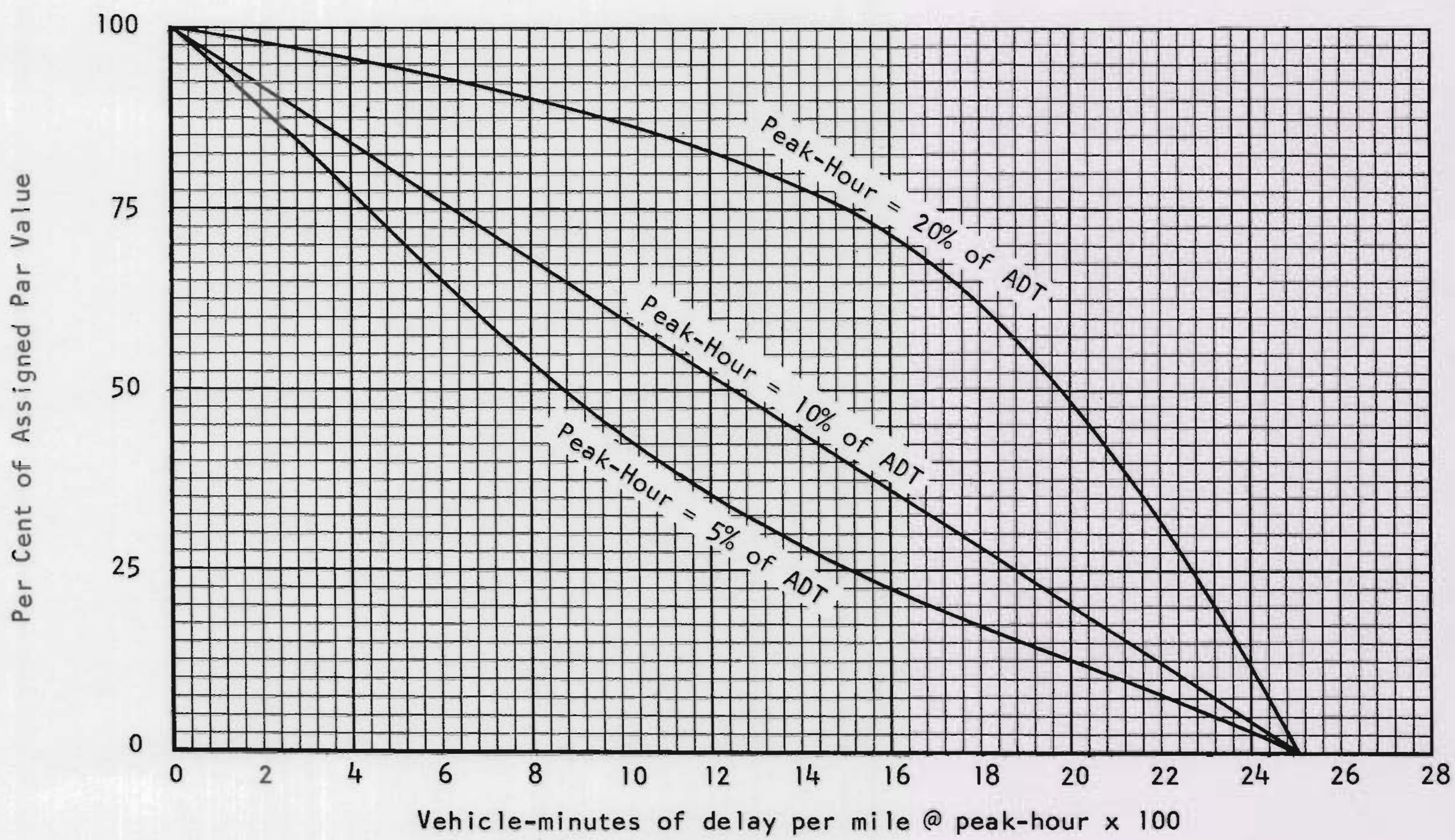


FIGURE 15

TRAVEL TIME DELAY RATING GUIDE

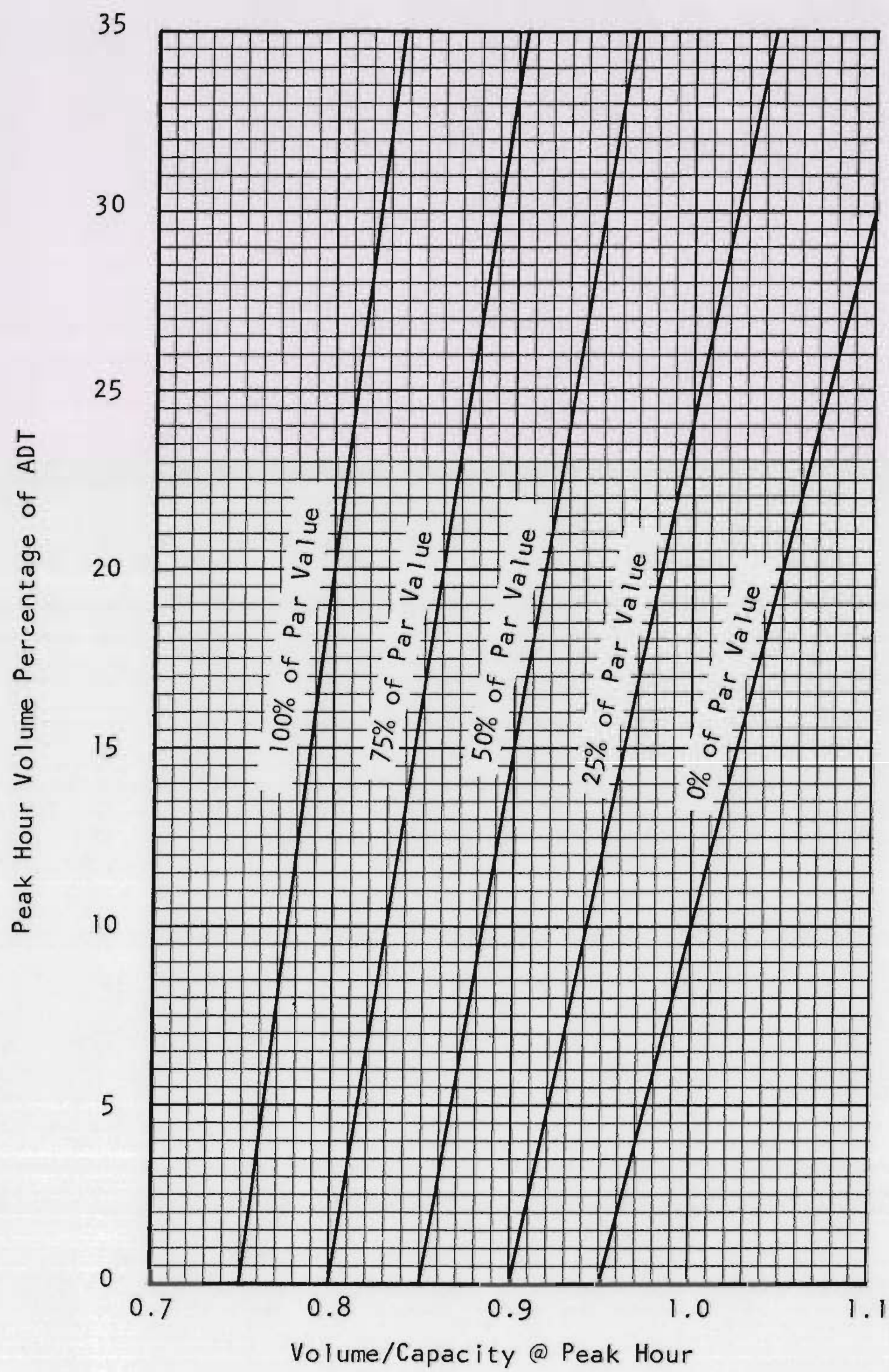


FIGURE 16

VOLUME-CAPACITY RATIO RATING GUIDE

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# REFERENCES CITED


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# APPENDIX A

TABLE A-I
SUMMARY OF WESTERN STATE HIGHWAY DEPARTMENTS
USE OF URBAN SUFFICIENCY RATING SYSTEMS

| STATE | RURAL SUFF. RATING? | SEPARATE URBAN SUFF. RATING? | CONDITION: Surf. | CONDITION: Base | CONDITION: Both Surf. & Base | CONDITION: Drain-age | CONDITION: Main-tenance | CONDITION: Other | SAFETY: Sight Dist. Stop Pass | SAFETY: Wid. Shd. Lane Surf. | SAFETY: Alnts. Amts. Consis. | SAFETY: Accident Rates | SERVICE: Cap. to Volume Ratio | SERVICE: Spd. and Del; T.T. | SERVICE: Surface Wid. or Smooth. | SERVICE: Base | SERVICE: St. Grad. | SERVICE: Alnts. Amts. Cons. | SERVICE: Pass. Opp. | SERVICE: Other | SUMMARY-REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IDAHO | YES | UNDER STUDY | | | | | | | | | | | | | | | | | | | |
| MONTANA | - | NO | | | | | | | | | | | | | | | | | | | |
| WASHINGTON | YES | 1954 only | -Desi | gn and | Condi | tion - | 25 pt | s par- | | | | | | Spd Rate 75 pt | | | | | | | DESIGN & CONDITION 25 pts par<br>SPEED RATING 75<br>100 pts par |
| OREGON | - | UNDER STUDY | | | X | X | X | | | | | X | X | | | | | | | | UNDER STUDY - NO VALUES AVAILABLE AS YET |
| WYOMING | YES | YES (under revision) | X 20 pts par | X 15 pts par | X Total 35 pts | | | | | | | | | | | | | | | | OLD SYSTEM CONSIDERED STRUCTURAL CHARACTERISTICS ALONE. NEW SYSTEM UNDER STUDY. |
| COLORADO | YES | YES | | | X Total 25 pts par | | | | | | | | X 75 pts par | | | | | | | | STRUCTURAL ADEQUACY 25 pts par<br>CAP/VOL 75<br>100 pts par |
| NEW MEXICO | - | 1952 only | X 30 pts par | X 10 pts par | X | X 10 pts par | | | | | | | X 30 pts par | | | | X 10 pt par | X 10 pts par | | | STRUCUTRAL FEATURES 70 pts par<br>VOL/CAP 30<br>100 pts par |
| TEXAS | NO | NO | | | | | | | | | | | | | | | | | | | LEAVES PRIORITY DETERMINATION TO DIST. ENGRS. |
| CALIFORNIA | YES | (same as rural) | | | | | | | | | | | 100% | | | | | | | | CALLED "ADEQUACY RATINGS" |
| ARIZONA | YES | Under Separate study in Phoenix | | | *5 pts par | *10 pts par | | | | | | *15 pts par | *20 pts par | *50 pts par | | | | | | | *UNDER EXPERIMENTATION BY E.M. HALL IN PHOENIX (ONLY), SAN DIEGO & HOUSTON. TOT. = 100 pts par. Note: At present Ariz. rates its urban streets in same manner as rural portions using Idaho system. |
| NEVADA | YES | NO | | | | | | | | | | | | | | | | | | | |
| UTAH | - | NO | | | | | | | | | | | | | | | | | | | |
| INDIANA | YES | Under consideration | | | | | | | | | | | | | | | | | | | STUDY WAITING FOR CONCLUSIVE ANSWERS FROM STATEWIDE METROPOLITAN TRANSPORTATION STUDIES |
| MISSOURI | - | YES | | | 25 pt incl. est. life, ride. | | | | | Surf. Width 25 pts | | | 30 pts | 35 pts | | | | 30 pts | 35 pts | *Oper. Feat.: 10 pts Inc. inade. curb radii, RR grade Xings, grades, park, intersec. frict. channelization, algn., lat. rest., and comm. driveways. | *THIS FACTOR CAN HAVE A VALUE AT -26 pts; THUS IT IS MORE IMPORTANT THAN SHOWN BY BASIC PAR VALUE |

# APPENDIX B

FORM B-1

FIELD RATING FORM

City ____________ Date ___
Street Section ____________
between ____________ and
____________

Condition of Pavement

Check one:
Good ____________
Satisfactory ____________
Unsatisfactory ____________
Poor ____________

Safety

Accident Experience:

____________ Accidents per Million Vehicle Miles for this street, for Two Year Period.

____________ Accidents per Million Vehicle Miles, Average Value for All Urban Streets, for same Two-Year Period.

Friction Potential:

Intersectional
No. 4-leg Stop-controlled Intersections/1000 ft. ____________
No. 3-leg Stop-controlled Intersections/1000 ft. ____________
No. Signalized Intersections/1000 ft. ____________
No. Angle Type Intersections (60° or less)/1000 ft. ____________
No. Intersections Having More Than 4-legs and/or More Than One Leg on Any Side,/1000 ft. ____________
No. Commercial Accesses/1000 ft. ____________

FIELD RATING FORM (page 2)

Street Section ____________________
between ______________________ and
__________________________________

Safety (cont'd)

Marginal Friction Potential:

On-Street Parking Permitted? ____________
Type (Angle or Parallel) ____________

Medial-Internal Friction Potential:

No. Lanes ____________
Lane Widths ____________
Median Present? ____________

Service

Delay Rate: Travel Time ________ Length of St. Section ________
ADT ________ Pk-hr Vol. ________ Delay Rate ________ Veh. min/mile

Vol/Cap. Ratio: % Rt. Turn ______ Bus Stop Location ____________
% Lt. Turn ______ % Comm. Veh. ____________
% Green Time ____ Calc. Vol/Cap Ratio ____________
Approach Distance of Sidewalk to Parking ________ ft.

Physical Inventory:

Median Present? ____________
No. Lanes ____________
Lane Widths ____________
Hazardous Sight Restrictions? ____________
Lanes Clearly Designated? ____________
Angle Parking Permitted? ____________

Form B–2

# FIELD FORM FOR TRAVEL TIME STUDY

PT Form #8

On: ____________________ Weather: ____________ Date: ____________

Between ______________ and ______________ Recorder ____________

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Control Point | Start 1 | 2 | 3 | 4 | Check | 5 | 6 | 7 | Check |
| 2 | Hr. Dist. & Date | | | | | | | | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | Total | | | | Total | | |
| 10 | Extra Runs | | | Average | | | | Average | | |
| 11 | | | | | | | | | | |
| 12 | | | | | | | | | | |
| 13 | | | | | | | | | | |
| 14 | | | | | | | | | | |
| 15 | Total | | | | | | | | | |
| 16 | Average | | | | | | | | | |

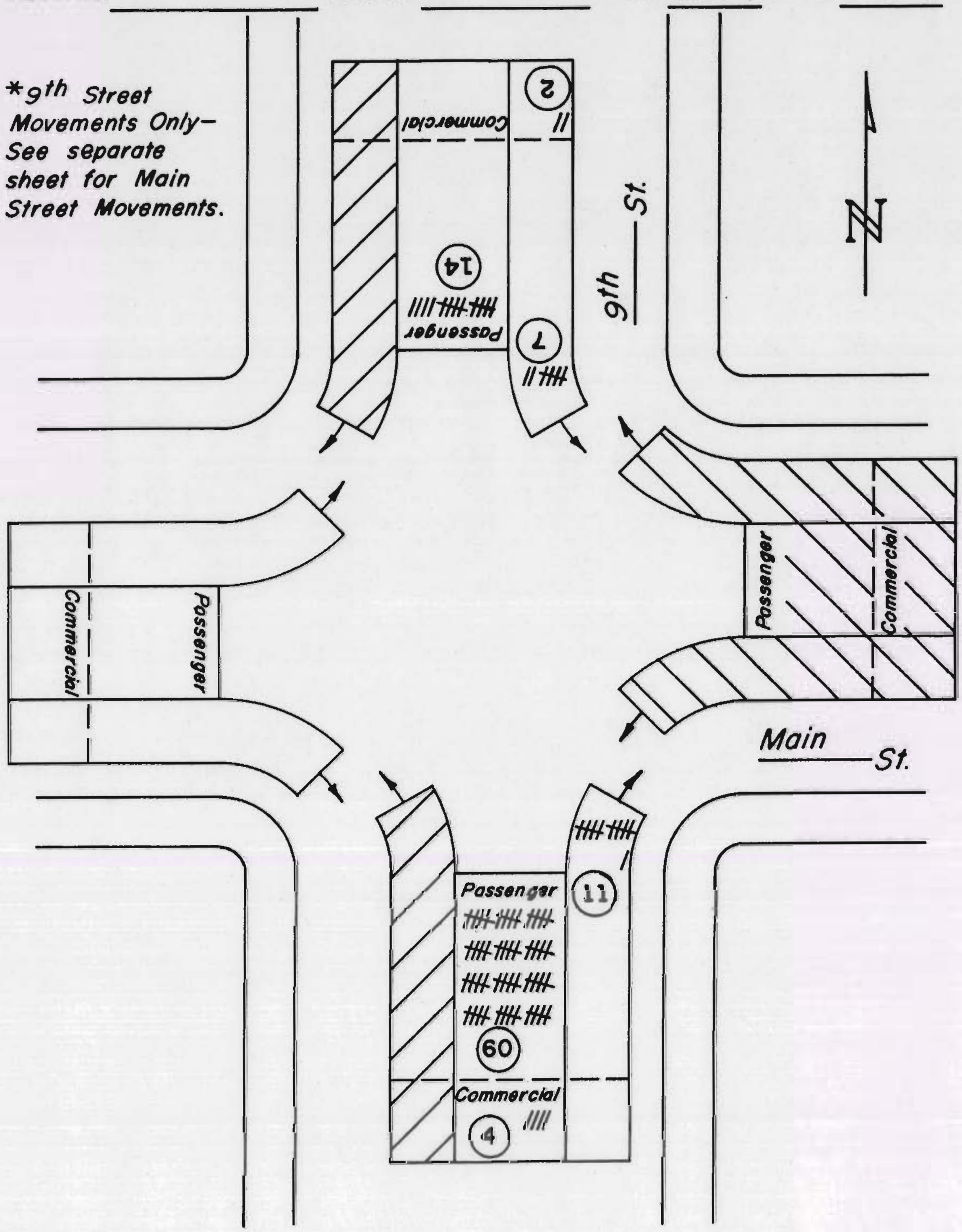
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 17 | Travel Time | | | | | | |
| 18 | Length | | | | | | |
| 19 | Speed | | | | | | |
| 20 | Rate of Motion | | | | | | |
| 21 | Standard Rate | | | | | | |
| 22 | Delay Rate | | | | | | |
| 23 | Volume | | | | | | |
| 24 | Vehicle Delay Rate | | | | | | |

Form B-3

## TURNING MOVEMENT TALLY SHEET

Location *9th & Main, Lewiston Day Wednesday Date 7-31-63

Recorder ______ Weather ______ Time: 5:00 pM. to 5:15 pM.



APPENDIX C

# OPINION POLL QUESTIONNAIRE FOR

# URBAN SUFFICIENCY RATING RESEARCH

In conjunction with a research project sponsored jointly by the University of Idaho and the Idaho Department of Highways designed to create a practical sufficiency rating formula applicable to Idaho's urban streets, it is requested that several personnel of the Idaho Department of Highways be asked to rate by personal judgment the adequacy of the street sections listed on the following sheet. Ten ratings on each section listed is preferred.

As a guide to follow in rating these sections, these objectives should be kept in mind:

Apart from rural highways, urban streets and arterials might be thought of as mass transit systems, in that many thousands of vehicles carrying an average of 2 persons in each, are accommodated on each of these named street sections. High speed is not the ultimate goal of urban streets; conversely, low speed resulting from many delays encountered while traveling a street is regarded as undesirable. Smooth, orderly flow of traffic is the ultimate goal of traffic flow planning; this is commensurate with the concept of mass transit service provided by urban streets.

Each of these street sections should accordingly be rated as to its adequacy in accommodating traffic. In rating these sections each rater should drive over these sections preferably twice during the peak hour flow to get a good idea in mind of the adequacy of each street section. Peak-hour flows in all instances will be found in the 5:00 to 5:30 p.m. time interval. The direction of the main flow of traffic should be the direction driven to facilitate a more accurate opinion of a rating.

To simplify the rating it is suggested that a numerical scale of from 0 to 10 be used. 0 would indicate a street that is impossible in the rater's opinion; 10 would indicate a rating of "smooth sailing", i.e., a street having good sight distance, smooth pavement, wide lanes, no delays experienced, etc.

A single rating would apply to these categories as a group. These are condition of pavement, safety afforded by the facility in operation of vehicles and service offered by the facility in the way of smooth flow and ease of operation.

A simple "25 words or less" explanation is requested to accompany each rating on each street section by the person rating the street. In this way it is felt that rating received can be best correlated to a final urban sufficiency formula.

Rating forms are provided for your convenience. Your time and consideration given this will be appreciated very much.

# STREETS TO BE RATED

## Boise

Capitol Blvd.--from Front Street to North End of Boise River Bridge
from South End of Boise River Bridge to College Blvd.

Front Street--from Capitol Blvd. to Americana Blvd. (16th Street)

State Street--from 23rd Street to 27th Street
from 27th Street to Lander Road

23rd Street---from Fairview to State Street

Warm Springs--from Bruce Street to Coston Street

## Meridian

Main Street--Through limits of central business district

## Grangeville

Main Street--Through limits of central business district

## Lewiston

Main Street--from 1st Street to 9th Street
from 13th Street to 18th Street

"D" Street---from 9th Street to 1st Street

## Moscow

Main Street--from 6th Street to 1st Street

## Coeur d'Alene

Sherman Avenue--from 1st Street to 7th Street
from 7th Street to 15th Street

Government Way--from Indiana Avenue to Harrison Avenue

# URBAN SUFFICIENCY RATING FORM

## PERSONAL JUDGMENT

## RATING

Rating Personnel: ______________________________

Street Rated: ____________________ from ____________ to ____________

Date, Day and Time of Rating: ______________________________
Date Day Time

Rating: ____________________

Remarks: ______________________________

______________________________

______________________________

Rating Personnel: ______________________________

Street Rated: ____________________ from ____________ to ____________

Date, Day and Time of Rating: ______________________________
Date Day Time

Rating: ____________________

Remarks: ______________________________

______________________________

______________________________

Rating Personnel: ______________________________

Street Rated: ____________________ from ____________ to ____________

Date, Day and Time of Rating: ______________________________
Date Day Time

Rating: ____________________

Remarks: ______________________________

______________________________

______________________________