HRB

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A Sufficiency Rating System for Secondary Roads in Iowa

January 1985

Iowa DOT Project HR-264
ERI Project 1654
ISU-ERI-Ames-85178

Sponsored by the Iowa Department of Transportation, Highway Division, and the Iowa Highway Research Board

report

College of Engineering
Iowa State University

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ENGINEERING RESEARCH INSTITUTE
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EXECUTIVE SUMMARY

County engineers in Iowa face the dual problems of rapidly escalating costs and a decreasing rate of growth of revenues. Various priority systems are in use, ranking projects for inclusion in road improvement programs, but they generally have weaknesses when used to compare one project with another in a different location.

The sufficiency rating system has proven to be a useful tool in developing a priority list of projects for primary road systems, but there are none currently in use for secondary road systems. Some elements of an existing system used for primary roads could be modified for use with secondary roads, but would require extensive changes.

The research reported here, sponsored by the Iowa Department of Transportation, was undertaken to develop a sufficiency rating system which could be used for secondary roads in Iowa and to produce the necessary forms and instructions to aid county engineering personnel in their efforts to complete the ratings for roads within their county. If a usable system were available that would yield reasonable results, county engineers would have an additional tool available to assist them in arriving at a defensible road improvement program.

A complete literature search was done, in order to better understand the form and function of the sufficiency rating systems that have been used. Information gathered in this search was used to develop a questionnaire, which was mailed to all county engineers in the state, plus selected engineers from the Iowa Department of Transportation.

The questionnaire included a comprehensive list of commonly used rating criteria, organized by rating category. Respondents were asked to rank the criteria in order of importance (as they perceived them) and also to weight the criteria. Responses were analyzed to determine which of the criteria were judged to be most important and to suggest relative weights for each.

The result is a rating system described in Chapters V and VI of this report. It utilizes fourteen (14) rating criteria, organized into the three categories of:

1. Condition and Maintenance Experience,
2. Safety, and
3. Service.

Relative weights were determined from the responses and applied to each of the criteria.

Chapter VI describes the system in further detail, including an explanation of the proposed scaling factors. Data collection and evaluation forms were also developed. A copy of each is included in Appendix C, along with a guide to their completion.

A brief trial run was completed, using the proposed system and the forms. The sample of secondary road segments included in the trial run was not large enough to fully test the proposed system, but did serve to suggest some changes to the system and to the evaluation procedures. The proposed system described in this report has incorporated these changes. A more complete trial run will be completed on a significantly larger group of road segments at a later date, but not as a part of this contract. Results of this trial run and the attendant recommended changes will be made available to the Highway Division of the Iowa DOT and the Iowa Highway Research Board as soon as they are available.

ACKNOWLEDGEMENTS

The research reported here was carried out by the Engineering Research Institute, Iowa State University. It was sponoered by the Highway Division of the Iowa Department of Transportation, with guidance from the Iowa Highway Research Board.

Valuable assistance during the research effort was provided by Dr. James W. Stoner of the College of Engineering, University of Iowa. His assistance is gratefully acknowledged.

Each County Engineer in Iowa assisted in this research by responding to a telephone inquiry and, in most cases, also completing and returning a questionnaire that provided the basis for the rating model suggested by this research. Their assistance and support is sincerely appreciated.

An Advisory Committee provided the necessary review and comments on the findings of the research. The following persons provided this essential service:

Delano S. Jesperson, Story County Engineer

Robert L. Gumbert, Tama County Engineer

Eldo W. Schornhorst, Shelby County Engineer

Gene R. Hardy, Dallas County Engineer

Lowell E. Richardson, Local Roads, Iowa Department of Transportation

Their assistance is greatly appreciated.

However, the opinions, findings, and conclusions expressed in this publication are those of the author and not necessarily those of the Highway Division of the Iowa Department of Transportation.

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Chapter I

INTRODUCTION

Managers of Iowa's secondary road network are facing the dual problems of rapidly escalating costs and a decreasing rate of growth of revenues. Various priority systems are used to rank projects for inclusion in road improvement programs, but they generally have weaknesses when used to compare a particular project with another in a different location, especially since all worthy projects cannot always be funded.

A useful tool for developing a priority list of projects is a numerical system for rating roads and structures. The Iowa Department of Transportation (DOT) uses such a system, called sufficiency ratings. All primary roads in Iowa have been analyzed using the sufficiency rating system developed by the Iowa DOT and are updated annually. The results are published each year (as provided by law) and used in conjunction with the development of the revised five year construction program.

The sufficiency rating system allows highway administrators to measure a particular road segment and its structures in relation to with all other road segments and associated structures in the state against a selected level of service.[1] The qualitative measures described by a given level-of-service relate mostly to the traffic volumes and operating speeds on a given road segment. The selected level-of-service will vary, according to the relative importance of the given road segment to the entire primary road network. The sufficiency rating represents an evaluation of how well a given road segment meets the necessary requisites for the selected level-of-service.

A sufficiency rating system would be a useful tool for managers of secondary road systems as well, in that it would provide a method for comparing projects throughout a jurisdiction. Since it is impossible to fund all needed projects, sufficiency ratings would provide a numerical system usable for ranking projects in a priority order. Like the sufficiency rating system used for primary roads, it could be used to evaluate the elements of safety, service provided, and condition.

There are additional advantages to the development of such a system:

1. Fewer and less severe accidents should occur on roads that are constructed and maintained in accordance with current design standards and traffic needs.
2. Benefits should be maximized from the expenditure of available funds.

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[1] The level of service selected is a qualitative measure as defined by the 1965 Highway Capacity Manual.

3. Priority decisions could be more easily defended.

These potential advantages could be somewhat difficult to substantiate, and would suggest some additional research topics. At this time, they must be termed as "philosophical" benefits that strongly support the use of a sufficiency rating system.

Some elements of an existing sufficiency rating system, such as that used by the Iowa DOT could be modified to be used for secondary roads, but three serious differences between primary roads and secondary roads preclude direct use without extensive modification. One is the significant difference in the traffic using the roads (primary and secondary), both in terms of traffic volume and in the character and composition of the traffic. The second is in the use of level-of-service as an appropriate measure for secondary roads. Level-of-service normally applies to high capacity, paved roads with significant amounts of traffic. Secondary road traffic volumes are generally low and, quite often, speeds are restricted by geometric design and/or road surface conditions, instead of traffic volume. Therefore, it would seem to be better to use some other qualitative measure for comparisons. The third is in the rating system itself. The Iowa DOT system considers gravel and low type bituminous surfaces to be inadequate as a surface for primary roads and, as such, provides either a very low rating or a zero rating for several criteria rated. Yet, gravel and low type bituminous roads are a significant part of the secondary road systems in Iowa.

There has been some work done in developing sufficiency rating systems for secondary roads. Some details of the results of that work is discussed in the Review of Literature. It is likely that some of the concepts used in the development of these systems could apply to an evaluation of Iowa's secondary roads. Certainly, the goals of the rating systems should be similar to the goals of any numerical evaluation system used for secondary roads.

Chapter II

REVIEW OF LITERATURE

2.1 ROAD RATINGS - PART OF THE PLANNING PROCESS

Road rating makes little sense unless it is placed in the proper perspective and sequence among all the component parts that lead to an approved annual program or so-called "capital budget". It then becomes of value as it helps translate highway needs into a constructive program.

However, prior to rating, it would be desirable to have already created a long-range program with a tentative schedule for completion of its various elements. This suggests that;

1. certain highways have been "justified',
2. they have been classified into systems, and
3. reasonable standards have been established in accordance with the economy.

It would also be helpful if decisions had already been made regarding needs, fiscal capability, and resource allocation.

The first concern of the planning process is to establish goals, considering needs and fiscal capabilities, followed by determination of the means used to reach those goals and the placement (order of achievement) to achieve the highest good. Once the long-range plan has been completed and fiscal arrangements made to assure planned rate of achievement, initial planning for translation of the plan into reality can begin by ranking the sections of highways for improvement. The objective of the initial planning - carry out the master plan in intent and time (Campbell, pp. 75-76).

However, road segments with the most critical deficiencies do not promise the greatest return on investment for the improvement. It also becomes apparent that failing to adhere to the results of the critical deficiency ratings can cause a deviation from stated objectives. The saving aspect is that there is usually a backlog of critically deficient projects, making it possible to select the emergency projects and then add the most economically efficient from the rest.

2.2 PURPOSE OF RATING

Rating systems are used for a variety of purposes. Management may use ratings for part or all of the following ends (Campbell, p. 79):

1. To alert to impending deficiency.
2. To provide warrant for action.
3. To signal shifts in need.
4. To complement road life studies.
5. To show system-wide status.
6. To provide comparative performance records.
7. To provide data for apportionments.

8. To assist comptroller and fiscal planner.
9. To assist in periodic review of needs.
10. To provide data for public information.
11. To enlighten pressure groups.

The first two criteria provide for the isolation of specific deficiencies, suggesting the appropriate remedy.

The list also shows how ratings point toward the ultimate formation of short term programs (of up to five years), but quite often it is for programming for the annual budget.

The critical part of programming is the ranking of needs. This is a requisite so that programming can proceed in a systematic, straightforward manner. It is also important;

1. to assure continuity of purpose and plan,
2. to reduce the need for crash and crisis programming, and
3. to hold the line against pressures when revenues are scarce.

For these reasons, a rating system is needed which is consistent, and which is reproducible -- a rating that would measure the adequacy of a given section of highway in terms of a norm or established standard.

For such a rating to be reproducible, either by the same or different evaluators, it should be a numerical rating with a convenient scale. The component parts to be scored should be (as far as possible) evaluated by a common set of standards.

2.3 PHILOSOPHY OF RATING

If the ratings are reproducible, it is possible to compare the needs of one rated segment of the highway network against another, in that the composite rating for each reveals its relative deficiency as compared to the established "ideal". Final decisions on programming can then be made, based on the combination of;

1. fiscal capability, and
2. conditions existing within sections of the highway network that are considered intolerable.

Note that these elements are not always totally compatible. It is likely that revenues will not match revenue needs -- that is, in a given annual program, some needs will not be filled.

What is needed is a measure of immediacy of needs so that ranking of projects can be made. Need and urgency are relative, and require some qualifying measure to show this. Adjectives can be used, such as vital, great, fair, or casual -- with respect to needs, or immediate, critical, serious, or moderate -- with respect to urgency. Unfortunately, interpretation of these adjectives can be difficult, so a numerical scale is needed to indicate urgency of need.

Psychologically, a number or formula gives the impression of accuracy. It should be realized, however, that there is no particular virtue in numbers or formulae as such. Improperly used, they can be even more misleading than adjectives. Although presentation is mathematical, much engineering knowledge is still descriptive. Information expressed by numbers or formulae is merely an indication of the level of scientific organization of experience. Therefore, numerical data still have no absolute significance. They are useful only insofar as they are suitable to delimit certain classes of phenomena.

Adequacy ratings measured on a reasonably wide scale (usually zero to 100 percent) provide a graduated numerical scoring. The resultant score provides the means for comparison of critically deficient sections,[2] indicating degree of urgency. A rating of 100 indicates that the given road segment completely meets desirable standards. By the same token, a road segment given a rating of 60 is in greater need of improvement than one with a rating of 75.

Relative urgency can be indicated in needs studies by setting up a dividing line between "tolerable" and "intolerable", the "intolerable" sections forming a current backlog of needs. With the passage of time, some of the "tolerable" sections would eventually become "intolerable" and form the basis for future programming.

However, should the backlog of needed projects exceed the current fiscal capability, they may have to be spread through several years. Therefore, individual projects need

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[2] The score can also be used to define the cut-off or demarcation between what is considered critical and non-critical.

to be rated for priority on a year-to-year basis. This requires a still finer scale of values be drawn within the intolerable range and within the tolerable range -- as the more critical needs are filled.

Such a system has been developed. A numerical rating system, called a "sufficiency rating system" was developed by the Arizona Highway Department in 1946. It attracted immediate attention, especially from other states as they faced the post World War II problem of deciding which highway needs should be filled first (Willey, p. 3). Currently, nearly every state uses some form of adequacy (or sufficiency) ratings as a systematic procedure for periodic evaluation of highways for improvement programming (Zegeer and Rizenbergs, p. 15).

2.4 RATING CRITERIA

The sufficiency rating method assigns a point rating to each section of road, based on its actual condition and its ability (or inability) to carry the traffic load in a safe and efficient manner. The "safe and efficient manner" is based on a uniform, current set of standards. The resulting tabulated ratings are used to develop a project priority list, without regard to geographical location or political influence.

Most of the systems developed to date have been done by state highway organizations. They have followed the same pattern and used the categories of Condition (sometimes referred to as structural adequacy), Safety, and Service. Items rated within each category are also similar from state to state. Table 1 represents a list of rating criteria commonly used in sufficiency rating systems.

TABLE 1

Commonly Used Rating Criteria

CATEGORY	ITEMS RATED*
Condition	Foundation*
	Wearing surface (or pavement)*
	Shoulder*
	Drainage*
	Remaining life*
	Maintenance economy*
Safety	Pavement width*
	Shoulder width*
	Stopping sight distance*
	Passing sight distance*
	Hazards
	Alignment consistency
	Traffic control
	Accident rate
Service	Alignment (or curvature)*
	Grade*
	Pavement (or surface) width*
	Passing opportunity*
	Improvement continuity*
	Ride quality (or rideability)*
	Surface type
	Shoulder width
	Alignment safe speed
	Surface volume to capacity

* Items generally used in sufficiency rating systems. Note: the list is a composite of criteria used by state highway organizations in Alaska, Arizona. Illinois, Iowa, Indiana, Maine, Missouri, Nebraska, New Mexico, Oklahoma, Virginia, and Wisconsin.

However, Oklahoma utilizes the general categories of Design and Condition, with criteria used for comparison similar to that of the categories of Safety and Service (Design) and Structural Adequacy (Condition).

Several criteria appear two times - under the categories of Safety and Service. Examples include passing opportunity (or safe passing sight distance), pavement width, shoulder width, and alignment. These criteria also appear under both categories in several rating systems as well, effectively increasing their impact on the final composite rating.

The rating system used by the Iowa DOT is typical of those used. It uses the three major common categories used, plus most of the rating criteria that are encountered. The list of criteria that are rated is shown on Table 2, together with the maximum points allocated to each.

There is one rating criterion that is unique, and that is "safety study". The criterion of "safety study" uses the result of a study of the frequency of occurrence of various types of road hazards along a given road segment. Included are such hazards as narrow structures, bad approach alignment to a structure, blind intersections, and railroad crossings without automatic signals.

An examination of this table also shows that surface width is rated twice. In addition, vertical alignment and horizontal alignment appear to overlap with stopping and passing sight restrictions, but they relate more to operat-

TABLE 2

The Iowa Sufficiency Rating System

RATING CATEGORY	ITEM RATED	MAX. POINTS
Structural:25	Wearing surface	7
	Base and subbase	7
	Drainage	3
	Maintenance economy	8
Safety:40	Surface width	17
	Shoulder type, width	9
	Stopping sight restrictions	8
	Safety study	6
Service:35	Horizontal alignment	8
	Passing sight distance	8
	Vertical alignment	6
	Surface width	8
	Surface driving conditions	5
	Total	100

Source: Iowa Primary Road Sufficiency Log - January, 1982 Prepared by Office of Advance Planning, Division of Planning and Research, Iowa Department of Transportation, Ames, Iowa.

ing speed. The rationale used to explain the second appearance of surface width is that a narrow surface is a safety hazard, but it tends to reduce capacity as well, a function of service.

2.5 RATING SCALE

The sufficiency rating given a road segment is a composite rating, in that it represents the sum of the scores given all criteria rated. Most rating organizations use a maximum composite rating of 100, with each criterion that is to be rated assigned a maximum value, depending on the relative importance given that rating criterion.

There are a few exceptions. The State of Illinois uses a 1000 point scale (1000 point maximum value), with maximum scores for the eleven rated elements ranging from 25 to 150 points. A similar 1000 point scale is used by Del Norte County, California (Nelson, p. 98). An unusual feature of this rating system is the inclusion of a rating element relating to type of traffic of up to 100 points. The further breakdown of this element demonstrates two unique features of the system. First, this element recognizes the existence of school buses, recreation vehicles, and forest product traffic in the traffic stream, and second, provides for maximum ratings of 20, 30, and 50 points, allowing for a rating scale more sensitive to individual variations -- without resorting to fractional points.

The Iowa system, summarized in Table 2, demonstrates how the rating maximum scores reflect current thinking on the relative importance of the rating criteria. While most of the maximum scores range from 5 to 8 points, surface width (included twice) can receive up to 25 points, while drainage is only 3.

An examination of rating scales used in other states shows the same variability in point values. While there are strong similarities in point values chosen for identical rating criteria, there are significant variations as well. For example, both Missouri and Wisconsin use Estimated Life as a rating criterion, with identical maximum values of 10 points. The two states also used a criterion relating to passing sight distance (Wisconsin used the descriptor non-passing zone), but Missouri allocated a maximum of 8 points, while Wisconsin used non-passing in two different categories, with a maximum possible total of 18 points.

Variations in rating formulae between states can be explained in two ways. First, there are differences in conditions existing in a given state, compared to others (Swanson, p. 11). The second relates to valid differences in opinions -- in the perception of relative importance. It is often described as empiric, or based on practical experience (Moskowitz, p. 29).

2.6 CONDITION RATING

Relative weights assigned to the various rating criteria cannot be determined entirely by deductive reasoning. Therefore, gaps in mathematically rational treatment of the problem have been bridged by empirical methods based on judgement and trial and error (Moskowitz, p. 29). Determination of the elements of sufficiency to be evaluated and the assignment of relative importance or weight to each element is the first step in development of a sufficiency rating system. The second step is to develop a method of computing or assigning a value to each criterion for the segment of road being rated.

The first system developed, the Arizona system, used the number 100 for whole sufficiency[3] -- for sake of convenience. The maximum value for each rating element is then assigned to a given rated road segment if it completely meets the standard set for that element. Should it not meet the standard, it would receive a lower score. Therefore, a graduated scale is needed.

The key to a graduated scale is the development of a standard for each rated element. The standard may vary with type of use, but still be considered "ideal" for that use. An example is shoulder width. An unpaved shoulder that is six feet (1.8m) wide may be the desirable width when Average Daily Traffic (ADT) is less than 400 vehicles per day (vpd). Therefore, a road segment with ADT less than 400 and a shoulder six feet (1.8m) wide should receive the maximum score for that rated element.

If the shoulder is less than the standard, then it properly would receive a lesser score. The immediate question would be "how much of the maximum score should the road segment receive?", but the larger question relates to all rated criteria. The answer is really in two parts.

The first part relates to the concept of "tolerability", and was included in the first sufficiency rating system. It works under the premise that (Fritts, p. 36):

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[3] Most sufficiency rating systems developed since have also used 100.

1. Not all road segments will meet the desirable standards for each rating element.

2. In some situations, the cost of the improvement of the rating element to meet design standards may not be justified (economically) compared to other needs.

This suggests that an element not meeting design standards might still meet a "tolerable" standard -- that it is less desirable, but still is safe, -- or provides good service. It also suggests that there is a "tolerable" standard value, that is at the lowest point on the scale permissible under today's highway transportation requirements. It is not determined by funds available, but rather is a point used to isolate and identify those road segments which are so far below design standards that their need for improvement is unquestioned.

The second part of the answer is concerned with scale calibration. Obviously, the beginning point is the maximum value for the rated element. Decreasing values are then set for road segments failing to meet the standard. Rate of decrease of points from the maximum could be either linear or exponential, depending on the rating element. Decisions on rate of decrease are normally made by developers of the rating system based on rating element characteristics and group consensus, based on experience.

Another variation in scale calibration can occur as the rating element drops below what is considered to be the "tolerable" limit. One approach is to evaluate the rated element until it reaches the tolerable limit, then assign it 0 points as it drops below that limit. Going back to the earlier example, a six foot (1.8 m) wide shoulder might receive the maximum of six points, a five foot (1.5 m) shoulder receive five points, and a four foot (1.2 m) shoulder four points. If the four foot (1.2 m) shoulder is considered the narrowest tolerable width, narrower shoulders would receive no points. On the other hand, points could merely decrease as the width narrows, with the intolerable element being regarded as a "warrant for action".

The concept of "warrant for action" is based on the standard set for a given element. Standards are based on the "hoped for" rate of meeting needs under the appraised fiscal capability of the involved governmental agency (Campbell, p. 86) and thus are economic based -- but not necessarily on the economics of the traffic using the facility. The existence of a critical deficiency is a warrant for action, without specifying the action. A "remarks" column records and quantifies the deficiency, naming the category and cause of the deficiency. The appropriate action is chosen by the engineer.

A "warrant for action" is not a priority listing, but shows the need for action. If money based, possibility of eventual action is assured. If not, critical deficiencies may proceed to a state of being only tagged "emergency". If standards are truly based on appraised fiscal capability, funds should be available to match the warrants over a reasonable length of time.

Many rating systems establish a numerical dividing line at some arbitrary point, such as 60, or 65, or 70, as the demarcation between adequate sections and those considered to be critically deficient. The final sufficiency rating automatically places a rated road segment in the adequate or critically deficient category. However, a closer examination of the priority list of projects assigned on the basis of sufficiency ratings may reveal that some road segments with ratings below the dividing line could be considered adequate because of the absence of critically deficient rating elements, while road segments with a sufficiency rating higher than that dividing line may merit a higher priority because of one decidedly critically deficient element.

Recognizing this problem, the State of New Mexico adopted a plan[4] whereby a road segment would be classified as critically deficient when a critical deficiency existed in any of its major characteristics. In effect, the critical deficiency becomes a "warrant for action", placing the rated road segment higher on the priority list.

The key to assignment of scores for the rated elements goes back to the need for reproducibility. For some rating elements, such as those relating to geometric design, this

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[4] The plan was outlined in its 1959 sufficiency report.

is comparatively easy. The shoulder width rating noted earlier is an example. All that is needed is some uniformity in gathering and recording of data. Other rating elements requiring some judgment are more difficult to reproduce. This is made easier by establishment of guidelines for the different ratings and easy-to-follow word descriptions. An example is the condition rating given a pavement section. Severity of failure can be related to a score by use of a word description closely matching the observed condition and applying the designated point value.

2.7 DESIGN STANDARDS - A SET OF SCALES FOR MEASUREMENT

Rating scales are based on two sets of standards. One is the value matched to the maximum value for a rated element. For the shoulder example, it is the six foot (1.8 m) width. In rating a given road segment, even a wider shoulder would not be scored any higher. The standard against which the rated elements are compared may be the design standards used for construction or reconstruction.

These design standards may be those for high-speed roads, using the yellow book[5] or some other standard -- perhaps a state standard. The standards may vary according to the road's functional classification and/or ADT.

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[5] Highway Design and Operational Practices Related to Highway Safety produced by the Special Traffic Safety Committee of the American Association of State Highway Officials (AASHO).

The Iowa DOT provides such a set of standards. A total of 24 different design standards are used, with the variations being based on combinations of functional class, ADT, and type of terrain. Some of the changes are minor -- the only variation in design guides for the first six standards (freeway and expressway/arterial) are maximum degree of curvature (3 to 4), maximum grade (3% to 4%), shoulder type (paved to stabilized) and access control (from full to partial). A copy is included in Appendix E.

A similar set of design standards have been adopted by Del Norte County in California for its secondary roads. Its variations are based on ADT and terrain, with surface type specified for each standard -- based on ADT. Dissimilarity in terrain accounts for most of the differences between the Iowa design standards and the Del Norte County standards.

The U.S. Forest Service approached the problem of design standards from a different perspective. The Service recognized the fact that most roads in the United States are built using the same pavement design practices used for pavements carrying much larger volumes of traffic than the low-volume Forest Service roads. Further, it was noted that economic studies are not applied in the setting of design standards.

It was for this reason that the Forest Service contracted for a study to develop a pavement management system for its low-volume roads, and to include recommendations for the development of appropriate design standards. The rationale used to justify the study include the following factors (Hudson, etal, p. 232):

1. Low volume roads generally carry fewer vehicles per day than major highways, plus have lower loading frequencies.
2. Most of these roads are constructed with on-site or locally available material.
3. Funds and environmental factors permit only restricted earthwork on many low-volume roads, affecting horizontal and vertical alignment plus the ability to remove and replace poor subgrade material.
4. Surfaces of low-volume roads tend to be thinner than that of higher class roads (in the case of hard-surface roads) or consist of nothing more than a gravel or natural soil surface.
5. Because of the nature of the surface material, performance of low-volume roads is influenced to a greater extent by moisture and temperature than higher class roads.
6. Distress problems differ, related to surface materials. For example, surface abrasion leading to dust problems and loss of surface material are more acute on gravel surfaces than on asphaltic concrete surfaces.

7. Minimum acceptable level of serviceability is lower on most low-volume roads than that of higher class roads. This is because the purpose of the road is to provide an economical means of travel from point to point, not so much to provide a smooth riding surface.

This rationale applies to low-volume secondary roads as well, and has lead to numerous calls for development of design standards more appropriate for secondary roads (Baerwold, p. 41; Carlson, p. 2 p. 23), or perhaps reversion to older standards (Harrington, p. 48).

The other set of standards used in the development of rating scales is a set of "tolerable" standards. Setting tolerable standards is an empirical process, based on an evaluation of past design practice and the resulting investment. They are set by informed engineering judgment, using as a goal the definition of existing investment that can be continued in use without creating;

1. congestion detrimental to public welfare,
2. low operating speeds which could lead to unnecessary economic time losses,
3. unreasonable accident rates,
4. unreasonable maintenance costs, and/or
5. higher than necessary operating costs due to circuitous routes, excessive grades, or poor surfaces.

It is unfortunate that there is a lack of information which could be used as guidance in developing tolerable standards, particularly for secondary roads. There have been studies which can assist in this endeavor, at least for some elements. One such study has shown a strong negative correlation between sufficiency ratings and accident rates (Jorgensen, pp. 114-117). This study showed a significant increase in accident rates between the best highways (ratings over 80) to the poorest highways (ratings under 50). The relationship of increase of accidents was linear as the sufficiency ratings of rural highways dropped to 50 for two of the three states studied.[6]

This study (and other studies conducted since) began to pinpoint specific design elements that affect highway safety, in terms of relationships between design elements and accident rates. Elements such as pavement lane width, shoulder width, and horizontal alignment have been shown to have a significant effect on highway safety and design guidelines have been suggested, based on study results (Bissell, etal, pp.1-15).

However, most of the studies have used data from accident records on rural primary highways and have limited applicability on roads carrying less than 1000 vpd.

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[6] The third state involved in the study lacked data for some comparisons.

It would appear that the setting of tolerable standards, at this time, will remain mostly an empirical process, with the potential for some assistance from applicable studies. One likely set of empirical standards would be the "minimum standards" of a set of design standards.

2.8 DATA NEEDS

A large share of the data needed for a sufficiency rating can be gleaned from an up-to-date set of records of the design plans used to build the rated road segment. This can be verified by an examination of any set of criteria used in a sufficiency rating system.

An example is the list of the rating criteria used by the Iowa DOT in preparing sufficiency ratings for the state's primary roads (see Table 2). Of the categories of Safety and Service, only the results of the safety study and data on surface driving conditions cannot be obtained from design plans. However, all of the rating criteria under the Structural category must be evaluated from historical knowledge of the road segment and/or an analysis of the current condition of the various elements of this category based on a field inspection.

Examination of other rating systems will reveal similar data needs (Baerwold, pp. 51,52; Table 1 of this report; Moskowitz. pp. 30,31; Donnell and Tuttle, pp. 65-69; Zegeer and Rizenbergs, pp. 15-19; and Nelson, pp. 98,99). It is therefore apparent that any sufficiency rating system used will require a combination of data which should be permanently on file and situational data gathered expressly for the evaluation.

2.9 TYPICAL SYSTEMS IN USE

Most of the literature on sufficiency rating systems dates back to the years following Arizona's development of its system. In those years, many states developed similar rating systems of their own for use in evaluating their network of primary highways. The emphasis was on the evaluation of primary highway systems, although there were some efforts to apply the concept to secondary roads.

Literature in recent years has been strongly oriented toward the development of a successor to sufficiency ratings for primary highways. To this end, several procedures have been developed, though none have been widely adopted. They all are computerized procedures, designed to take advantage of the computer's speed and flexibility.

They include two procedures developed by the Federal Highway Administration (FHWA); the Priority Planning Procedure (PRIPRO) and the Highway Investment Analysis Package (HIAP). To date, PRIPRO has not been used in any state, but HIAP has been used in Wisconsin and is being considered for use by New Mexico and Idaho (Humphrey, p. 9). The Priority Planning System (PPS) was developed by the Ontario Ministry of Transportation and Communication and is being used by that province to manage a large highway investment portfolio. It is also being used by the Maryland DOT, but only for large capital projects. The Highway Economic Evaluation Model (HEEM) was developed by the Texas State Department of Highways and Public Transportation as a priority planning tool and has been used extensively by that state.

Though none of these models have achieved wide acceptance, another model, a formalized pavement management system (PMS) is gaining proponents. In a way, it is not new. Every highway agency has established a management system. The main difference is that PMS provides feedback concerning the consequences of decisions made on priorities and technical details. Feedback enables decisions to be made with knowledge of the consequences of given trade-offs.

Some sort of PMS has been established in nine states and two Canadian provinces, though not the complete and comprehensive PMS form described in NCHRP Report 215 as the "ideal" PMS. The users of PMS consider it a good analytical tool for one category of improvements that can be used in establishing overall priorities, though not the ultimate solution to priority planning needs.

Some literature is available that describes sufficiency rating systems in place, including a few systems used for evaluating secondary roads. The literature pertaining to the evaluation of secondary roads is briefly summarized below.

2.9.1 Del Norte County, California

In 1966, Del Norte County was faced with a severe problem in the form of inadequate funds for road improvements. Its annual road improvement budget of about $200 000 was less than half the amount needed to solve road deficiencies over the next ten years. There was an obvious need for a way to establish priorities for the use of available funds.

A list of seven criteria was developed for the improvement program (Nelson, p. 98).

1. The program would have to be comprehensive. All pertinent road features would have to be known, and the most important road uses established.
2. It would have to be understandable to the average taxpayer and the Board of Supervisors as well as to the professional engineer.
3. It would have to be economical.
4. The program would have to identify road improvements by priorities, including cost considerations.
5. Separate priorities would be required for the major system of roads and the minor system.
6. Field and office work would have to be performed primarily by maintenance personnel and/or engineering technicians, rather than by engineers.
7. The program would have to lend itself to being regularly updated as improvements were made and as traffic features changed.

The resulting road improvement program was based on priorities set with the aid of a road sufficiency rating system. A dual rating system was developed, based on functional class. One was applicable to collector and arterial roads (slightly less than 20% of the total county highway mileage) and the other to local roads and streets.

The rating system developed was similar to the Arizona[7] system, with service receiving 35% of the rating points, safety 35%, and structural adequacy 30%. The Del Norte County rating system used a 1000 point scale instead of the 100 point scale commonly used and rating elements more appropriate for use in evaluating secondary roads. The complete rating system is shown on Table 3, listing the rating elements and points allocated.

Unique features of the rating system includes recognition of the relative importance of traffic type to the road network (school bus, forest products, and recreation traffic), accident rate, remaining life, and maintenance economy. Consideration of the traffic type element is in recognition of the unique economic base of the county, and its dependence on the lumber industry and tourism. The rating elements of accident rate, remaining life, and maintenance economy are used because of their perceived importance to the evaluation system and the availability of excellent records for all three elements.

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[7] Arizona's system used 35, 30, and 35 for the respective categories.

TABLE 3

Sufficiency Rating Sytem - Del Norte County, California

	MAXIMUM POINTS Collectors and Arterials	Locals
SERVICE: 350		
ADT	150	150
School Bus (20)		
Forest Products (50)		
Recreation (30)	100	100
Passing Opportunity	40	--
Surface Condition	30	50
Type of Surface	30	50
SAFETY: 350		
Accident Rate	100	--
Traveled Pavement Width	100	150
Shoulder Width	50	100
Horizontal Alignment	50	50
Vertical Alignment	50	50
STRUCTURAL ADEQUACY: 300		
Drainage	100	100
Remaining Life	100	100
Maintenance Economy	100	100
Total	1000	1000

The county adopted a set of design standards for its roads prior to the first rating, in order to determine the existence and extent of deficiencies in the road network. A copy is included in Appendix E.

2.9.2 Kings County, California

Kings County began development of a procedure for establishing relative adequacy and priority scheduling upon receipt of the results of a 1953 study of the county's road system. This study concluded that the deficiencies in its road system would cost an estimated $6 million to correct. This greatly exceeded the county's fiscal capability, causing the administration to seek a way to develop priority schedules for road improvement programming that would maximize benefits for all concerned (Carlson, 1955, p. 21).

Administrators felt it was needed to (Carlson, 1953, p. 131);

1. aid the administration in budgeting, based on economic priority,
2. compare each section of road evaluated to its design standards,
3. minimize the element of personal judgment in determining the relative adequacy of a road,
4. keep the Board of Supervisors apprised of the current status of the road improvement program,
5. determine the rate of progress of the road improvement program,
6. aid in explaining the road improvement program to the public, and
7. make it possible to match fiscal capability to definite road standards.

Actual priority determination was made using the sufficiency ratings and an economic analysis. Highest priority for road improvement would be the road segment theoretically considered to be the least adequate with the highest economic justification. Even so, the established ratings were considered to serve only as guides in the development of road improvement programs.

Design standards were developed for the roads, based on the ADT carried by the road. The standards were very similar to those adopted by the County Engineers Association of California. The minimum standard was for roads carrying less than 50 vpd, while the highest standard was for roads carrying 1000 to 4000 vpd. A copy of the standards is included in Appendix E.

The rating elements chosen were similar to those used by other rating systems, with some variations due to local conditions (most of the roads are straight and on flat terrain) and the fact that over 75% of the road mileage carried less than 400 vpd. A total of four rating categories were chosen, with maximum points ranging from 15 to 40 for the categories. A complete list of categories and rating elements is shown in Table 4, together with their maximum points . Ratings were determined by uniform and rational methods (Carlson, 1955, p. 23).

The rating category of Physical Design Adequacy is very similar to Condition in other rating systems, while the category of Service provides an adjustment to the rating based on the relative importance of the rated road segment to the community. Relative importance is based mostly on the type of traffic using the road and its function in connecting communities or highways as opposed to local service.

TABLE 4

Sufficiency Rating System - Kings County, California

CATEGORY	ITEM RATED	MAX. POINTS
Geometric Design Adequacy	Right-of-way width	5
	Roadbed width	10
	Surface width	10
	Gradient	5
	Alignment	5
	Stopping sight distance	5
Physical Design Adequacy	Surface	10
	Foundation	10
	Drainage	5
Safety	Accident factor	5
	Alignment consistency	5
	Maximum safe speed	5
Service	Route Classification	10
	Community service	10
	Total	100

2.9.3 Allen County, Indiana

County highway departments in Indiana faced financial problems similar to that of Kings County and Del Norte County in California. The problem of budgeting available funds was addressed in the development of procedures for the classification and evaluation of rural highway sections by the Joint Highway Research Project of Purdue University in 1954. The procedures were tested in a pilot study conducted in Allen County, Indiana (county seat - Fort Wayne). Allen County had the greatest county road mileage in the state, a total of over 1500 miles (over 2400 km).

A road rating system was developed, along with a service rating system, and used to compute a priority rating, based on a formula developed as part of the project. The priority rating concept was based on the premise that, given a constant road rating, the priority rating should increase as the service rating increases. This would mean that, should two roads be evaluated equally in terms of adequacy ratings, the one with the highest service rating should receive the highest priority for improvement.

The service rating was based on the "need" for service and was computed using the factors of volume and character of traffic, abutting land use, and the use of the rated road for community services, such as rural mail service, school and/or scheduled bus routes, and other community services. The road rating system was a sufficiency rating system using the evaluation categories of structural adequacy, geometric design, and safety.

The priority system developed was deemed to have the following desirable properties (Baerwald, pp. 38,39):

1. Roads which provide a minimum service should have a priority ranking which approaches a minimum, regardless of condition.
2. Roads with a high road (sufficiency) rating should have a priority ranking also approaching a minimum, regardless of service provided.
3. For a constant service rating, rate of change of priority rating should decrease as the road (sufficiency) rating decreases.

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

Therefore, the priority system built in the concept of higher standards for more intensive road use.

The road rating system begins with determination of the primary use of a given highway, to be utilized in its classification as a county primary, county secondary, or local service highway. Classification was carefully done, so as to minimize the mileage in the county primary and secondary system. Because of limited funds, mileage of routes requiring higher design standards was to be limited.

The classifications, similar to current functional classes of trunk, trunk collector, and area service, were primarily based on ADT. Highways with ADT in excess of 400 vpd were considered for the county primary classification, while those with ADT of 100 to 400 vpd were generally considered to be county secondary. Those with ADT of less than 100 were usually classified as local service.

County highway classifications were assigned, using the criteria developed. Initial classification resulted in about 12% of the county highway mileage being classified as primary, 11% secondary, and the remainder as local service. Although over 75% of the highway mileage was classified as local service, no location in the county was over 2.5 miles (4 km) from a state highway or a county primary or secondary highway.

Recommended design standards were developed for each classification, with minimum and desired standards suggested for each component of the set of standards. A copy of these standards is provided in Appendix E. They were set with the expressed goal of establishing a practical standard, balanced with economy of operation.

The rating system was based on the evaluation of three categories of rating elements -- structural adequacy, geometric design, and safety. The complete list of rating elements is shown on Table 5, but not including maximum points.

TABLE 5

Sufficiency Ratings for Secondary Roads -Indiana

RATING CATEGORY	ITEM RATED
Structural adequacy	Pavement type
	Pavement condition
	Roadside drainage
	Structures
	Railroad grade crossings
Geometric Design	Right-of-way
	Pavement width
	Shoulder width
	Gradient
	Alignment
Safety	Surface riding condition
	Shoulder condition
	Safe driving speed
	Stopping sight distance
	Passing sight distance

2.9.4 Kentucky Secondary Roads

In 1976, Kentucky updated its sufficiency rating system (last revised in 1963) to incorporate the latest engineering principles, design standards, and the use of the computer (Zegeer and Rizenbergs, p. 16). New descriptors were included to make evaluation of rural and urban highways more meaningful.

The current rating system contains modifiers to make it possible to evaluate all rural highways, both primary and secondary, and to make meaningful comparisons of the adequacy ratings in both systems. This was accomplished through the use of different design standards for the two systems, based on a combination of design speed and traffic volume. For example, a shoulder two feet (0.6 m) in width would receive the maximum of seven points if it was on a highway carrying less than 100 vpd, while a 12 foot (3.7 m) shoulder is required to receive the seven points if the highway carried an average of 1500 to 7000 vpd.

Adequacy rating elements were taken from the list of commonly used elements from a nationwide survey published in 1973. The rating elements used in the Kentucky system were chosen based on the results of a subjective evaluation of elements from that list. The adequacy rating elements recommended are listed in Table 6, for use with rural highways only.

TABLE 6

Sufficiency Rating System for Secondary Roads - Kentucky

RATING CATEGORY	ITEM RATED	MAX. POINTS
Condition	Foundation	10
	Pavement surface	10
	Drainage	8
	Maintenance economy	7
Safety	Stopping sight distance	8
	Alignment	8
	Skid resistance	7
	Accident experience	12
Service	Shoulder width, condition	7
	Passing opportunity	8
	Rideability	5
	Surface width	10
	Total	100

Note: This table is applicable only to rural highways.

The rating system features guides with word descriptions developed for use by field personnel to aid in evaluation. Graphs are provided for the evaluation of some elements, generally based on traffic (ADT) using the rated highway segment. A copy of the guide is included in Appendix E.

The system also features the use of the computer to determine and provide the results as printed output. The only input into the computer program is the raw data for each highway section. The output for each rating is in a neat, easy-to-read, summary format.

2.9.5 A Sufficiency Rating System for Iowa Secondary Roads

A dispute between a group of residents and the local County Board of Supervisors over priorities in the road improvement program provided the impetus for development of a sufficiency rating system for secondary roads in Iowa in 1960. Although the rating system was never widely accepted, the rationale used in its development is of interest, as well as the final suggested form.

The choice of rating elements and characteristics for inclusion was principally based on (Morris, pp. 48,49):

1. Their simplicity.
2. Their facility for ease of measurement and direct comparison with correspondent values in the standards of assumed "complete adequacy" for each element of the involved highway.
3. Their close association with the obvious reasons for reconstructing or otherwise improving a highway.
4. The importance of their influence on the quality of traffic service provided by the highway.
5. Their degree of tangibility and accessibility to the public and to highway officials for their observation and examination.
6. Their ease of comprehension and evaluation by non-technical staff personnel and highway officials responsible for administration of secondary roads.

7. Their close association with the central theme of the definitions of sufficiency rating as they appear in the glossary of HRB Special Report 62.

Sufficiency rating systems used by other states for secondary roads were examined for potential use in Iowa. However, none were found to be suitable because of;

1. number and complexity of factors,
2. emphasis on factors which are relatively insignificant on roads with small traffic loads, and
3. lack of emphasis on factors most directly and closely related to serviceability of a road to traffic.

The process of developing an appropriate list of rating elements included a careful examination of sufficiency rating systems already in use. The rating elements chosen and their relative weights emphasized the structural category, as can be seen by an examination of Table 7, showing the rating elements and maximum points which could be allocated. The "range" of maximum points which the roadway pavement and the roadway base could receive depended on the materials used. Portland cement concrete pavement could receive as many as 24 points, while asphaltic concrete pavement could only receive a maximum of 16 points. A rolled stone base could receive a maximum of 10 points, but a bituminous treated base could receive as many as 17 points.

No point totals are shown on the table, since the maximum points could vary. Maximum ratings under this system could range from 115 to 130 points.

TABLE 7

Sufficiency Rating System for Secondary Roads - Iowa

RATING CATEGORY	ITEM RATED	MAX. POINTS
Structural Characteristics	Roadbed width	13
	Pavement width	12
	Shoulder width	8
	Ditch depth	8
	Pavement type, thickness	16 or 24
	Base type, thickness	10 or 17
	Subbase depth	8
	Snow storage capacity	5
	Gradient factor	3
	Alignment factor	2
Structural Condition	Roadbed condition	5
	Pavement condition	5
	Shoulders - condition	5
	Ditches - condition	5
General Services	Number of homes	5
	Mail route	2
	School bus route	3

The design standards used for the system were the "Farm-to-Market Road Design Standards, January 1, 1960" as adopted by the Iowa State Highway Commission. A copy can be found in Appendix E. The design standards were based on ADT, with three ranges included. These were 0 to 100, 100 to 400, and 400 to 1000 vpd. Each traffic load category had two sets of standards, a minimum standard and a recommended standard.

A single standard was chosen for the rating system, the recommended standard for 400 to 1000 vpd. The rationale used for this choice was

> -- on the assumption that these standards would provide superexcellent service for traffic volumes under 100 vpd, excellent service for between 100 and 400 vpd, and good service for between 400 and 1000 vpd.

The basic sufficiency rating of the rated highway segment was adjusted by application of a traffic volume adjustment. The equation suggested was developed by the Arizona Highway Department and used to provide a higher priority to those roads carrying higher traffic volumes.

2.9.6 Washtenaw County, Michigan

The Michigan legislature passed a highway act in 1951 which required county road commissions to report mileage and conditions of all highways and structures annually. Reporting the mileage was fairly routine, although the initial report was a time-consuming and tedious job. However, the condition report was more of a problem, since there was little that could be done to substantiate the data in the report without a more complete and formal adequacy survey.

Therefore, an adequacy rating study was initiated to enable the county to meet state reporting requirements. Study objectives were for an adequacy rating system to:

1. Aid in assigning priorities for reconstruction, by comparing each highway segment to a set of prescribed standards.
2. Minimize (or eliminate) the element of personal judgment in the assignment of ratings.
3. Evaluate a road's ability to carry traffic quickly, safely, and economically.

4. Minimize political pressure on the development of planning and construction programs.
5. Keep officials advised of the current status of their highway program.
6. Measure progress in eliminating road deficiencies.
7. Compare one road with another.

A set of design standards was developed, using U. S. Bureau of Public Roads (BPR) and Michigan State Highway Department standards, modified to fit county traffic needs. Final adopted standards were established for four different road designs, based on ADT. Standards were for Group 1 - 0 to 100, Group 2 - 101 to 500, Group 3 - 501 to 1000, and Group 4 - 1000 to 4000 (Minier, p. 42).

The sufficiency rating system that was adopted used the 100 point scale and the three rating categories of condition (par 35), safety (par 30), and service (par 35). Table 8 shows the full list of rating elements used, together with the maximum number of points allocated.

Graphs and tables were set up to help determine the point value of such elements as remaining life and passing opportunity. The sum of all ratings applied to a given road segment was referred to as its "basic rating".

Two adjustments were made to the basic rating to determine its adequacy number. The first adjustment was made for traffic volume and the second applied to roads with granular surfaces. The final adjusted rating for a section of road,

TABLE 8

Sufficiency Rating System - Washtenaw County, Michigan

RATING CATEGORY	ITEM RATED	MAX. POINTS
Condition	Pavement condition	10
	Subbase and drainage	12
	Remaining life(pavement)	13
Safety	Shoulder width	8
	Pavement lane width	7
	Stopping sight distance	10
	Consistency (alignment)	5
Service	Alignment	12
	Passing opportunity	8
	Rideability	10
	Pavement width	5
	Total	100

called its adequacy number, was the sum of its basic rating, the traffic adjustment, and the granular surface adjustment.

The traffic adjustment was made from traffic data gathered for each road and a set of curves constructed according to a method devised by the BPR. Roads carrying traffic in excess of 250 vpd received negative traffic adjustment scores, while roads carrying lighter traffic loads received positive scores.

Granular surface adjustments were made on all roads with a granular surface carrying more than 100 vpd. Deductions were made (on a straight-line basis) of up to 10 points as ADT ranged from 100 to 200.

2.10 CONCLUSION

Sufficiency rating systems have been considered useful tools for priority ranking in the development of road improvement programs. Even though they have been used mostly for evaluation of primary roads, there have been many instances of satisfactory use for secondary roads.

There has been some movement to replace sufficiency ratings with a more sophisticated numerical analysis procedure to aid in decision-making, but this is not because of any gross problems with the rating system. Rather, it is in recognition of its limitations plus the availability of a variety of data relating to such things as maintenance costs, life expectancy, and data relating to the impact of types of traffic on roads. One factor causing this movement is the easy availability of the computer and its value in rapidly accessing road data and its fast response, enabling decision-makers to explore several possible courses of action before settling on one.

The fact that no successor has been widely accepted and that sufficiency rating is still used by most states says much about the system. It is still useful as a decision-making tool and has the potential for wider use by county administrators. Counties have many of the same problems that state highway administrators face and sufficiency ratings can serve the same purposes (Campbell, p. 79).

A sufficiency rating system can provide the appropriate rating criteria, weighted scores, and graduated numerical scoring necessary to compare the relative adequacy of one road segment against another. Criteria can be chosen to fit local variations and perceived levels of importance.

It is also fairly easy to adjust rating values for type and extent of use, recognizing that it is more important to improve a road carrying 500 vpd than one carrying 50 vpd, other factors being equal. This has been achieved by the use of different design standards for different roads and/or modifiers applied to the computed rating before establishment of priorities.

Developers of a new sufficiency rating system do face a series of problems.

1. Choice of the list of rating elements is subjective. However, it can be attained by some sort of consensus among the affected decision-makers. It is subjective, but user experience can narrow the list of possible criteria to a usable one which will yield acceptable results.
2. Choice of relative weights (importance factors) of each criterion is also subjective, but the same consensus can still be achieved. Individual users of the system can vary the weights to attain internal goals.

3. Choosing appropriate design criteria to meet may cause problems, particularly as decisions are made on how to correct for variations in use. On the other hand, this problem has been successfully faced by developers of other rating systems, and the results will provide guidance for new systems.

The greatest problem to be faced is how to devise a system that is usable, yet not too complicated. It is likely that potential users of a new sufficiency rating system will face some of the same problems that the earliest users faced, and that is the lack of data, or data not being in usable form. It does appear that this problem can be solved. The remainder of this document will describe the process used to develop the new system, describe the results, and show how it can be used.

Chapter III

THE PROBLEM

While there has been work done on numerical evaluation systems for secondary roads, none are directly applicable to Iowa's network of secondary roads. There are enough differences between Iowa's network and the road systems evaluated using those results to preclude direct application. On the other hand, there are undoubtedly some elements that are pertinent to Iowa's situation, and these should be isolated and included (in applicable form) in any proposed system for Iowa counties.

There are several questions that need to be addressed by this study. They are based on the assumption that a numerical evaluation system that will accurately describe the adequacy of roads in a county network is necessary or at least desirable. They are summarized briefly below.

1. Are the roads classified (divided into groups) according to importance or purpose logically, so that a rational basis can be established for priority of improvement and standards to be achieved?
2. What relationship should exist between design standards and an adequacy evaluation system? Can selection of the set of design standards help produce a better sufficiency rating system?

3. What evaluation elements are appropriate to rate secondary roads?

4. What weight should be applied to each of the evaluation elements? Does failure to meet the tolerable standard suitably represent the road's ability to serve its desired function?

5. What road system data are available? What additional data will be required for the proposed evaluation system?

This research project represents an attempt to answer these questions. The pages that follow will describe the procedures followed to find the answers and the answers.

Chapter IV

RESEARCH PROCEDURE

The goal of this study is to develop a usable sufficiency rating system for secondary roads. There are several assumptions that have been made at the outset. These are:

1. County engineers currently use at least a limited set of decision criteria to make decisions regarding project priorities.
2. Some degree of consensus exists among the county engineers in terms of which are the most important criteria and that there is some agreement on their relative importance.

Accordingly, a questionnaire was developed which could be used as a survey tool. The results of the survey were used to develop a final list of weighted rating elements which were used as part of the proposed sufficiency rating system.

State and local jurisdictions from other states were also surveyed to determine the status of the use of sufficiency rating systems for secondary roads outside of Iowa and to gather some applicable data.

4.1 SURVEY DESIGN

The data used in this study were the responses from questionnaires sent out to county engineers from all 99 counties in Iowa plus a total of nine sent to engineers in the Planning Division and Local Systems offices of the Iowa Department of Transportation. All county engineers were contacted by telephone before[8] the questionnaire was mailed and provided a brief explanation of the purpose of the questionnaire.

4.2 QUESTIONNAIRE

The purpose of the questionnaire was to determine whether any degree of consensus exists among the county engineers in the form of preference for a set of rating criteria and the relative importance of each. If such a consensus exists, it could be used as a basis for choosing the rating criteria and their relative weights for use in a proposed sufficiency rating system for county roads.

The rating criteria list included in the questionnaire represented a composite list of criteria used by twelve states currently using sufficiency rating systems. They were arranged by the categories of condition, safety,[9] and service. Two lists of the criteria were provided in the

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[8] Except for those on the Iowa Highway Research Board, who were aware of the project.

[9] These were the categories first used in the Arizona rating system and also used in most rating systems developed since that time.

questionnaire, one for roads with the functional classification of either trunk or trunk collector, and one for roads classified as area service.[10] It was anticipated that county engineers would show different preferences of rating criteria for the different functional classes.

One additional element was included in the questionnaire. Most systems developed to date have grouped the rating criteria into the categories of Condition, Safety, and Service. Each respondent was asked to place the categories in rank order first and then to designate how they perceived their relative importance by inclusion of a weighting factor.[11]

This portion of the questionnaire was included in case there was no consensus on the ranking and weighting of the rating criteria. A measure of agreement in the ranking and/or weighting of the rating categories might prove to be useful in identifying the most appropriate criteria to use. A complete copy of the questionnaire is included in Appendix A. A brief description of each of the rating elements was enclosed with the questionnaire to aid the respondents in completing it. A copy of the description follows the ques-

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[10] Most of the paved secondary roads in Iowa are classified as trunk or trunk collector, while very little of the mileage of area service roads are paved (Iowa DOT).

[11] Respondents were asked to rank the categories as 1, 2, or 3, designating the most important as #1, followed by the other two in rank order. Relative importance was to be indicated by assigning the relative weight of ten (10) to the most important category, and smaller relative weights for the other two categories, ranging from nine (9) to as low as one (1).

tionnaire in Appendix A.

4.3 SURVEY - OTHER STATES

It was anticipated that sufficiency rating systems might already be in use for evaluating secondary roads. A review of literature identified such systems in California, Indiana, Michigan, and Kentucky. These states were added to a list of other states using sufficiency rating systems and all were contacted for information regarding any rating system for secondary roads in use. The local jurisdictions were also contacted for information on their systems.

4.4 THE QUESTIONNAIRE - OTHER STATES

A brief questionnaire was developed in order to assure completeness of information and administered by means of a telephone interview. The first contact made was with a state highway official, generally the local systems engineer or state-aid engineer. A copy of the questionnaire that was used has been enclosed in Appendix B.

The initial question posed to the respondent was to determine whether a numerical evaluation system (sufficiency rating or other similar system) was in use in that state to prioritize secondary road projects for planning and/or budgeting. If the answer was affirmative, then additional questions were asked to determine:

1. who used the system (state or local jurisdiction),

2. who gathered the data for the system and how, and
3. what the data sources were.

If a local jurisdiction used the rating system, the appropriate local official was contacted to ascertain;

1. how it is used,
2. whether the state had access to the results,
3. whether the state used the results in any way, and
4. if so, how.

A request was also made for copies of written procedures, forms used and/or any written reports covering any details and/or conclusions drawn from the analysis. Information of this type could prove to be useful in the development of a new rating system.

There were three additional questions included in the state survey. They are listed below, along with brief explanations of their purpose.

1. Who has jurisdiction over secondary roads in that state? If the state has jurisdiction, the appropriate administrator was contacted for further information.
2. Is there any attempt to formally evaluate the surface condition of non-paved roads? If so, an attempt was made to get details. There is a serious shortage of information regarding this important part of sufficiency rating systems.

3. What design standards are used for secondary road design? If a local standard is used, a copy was requested. One question that needs to be addressed in this study is "what is sufficient?" and does this standard apply equally to all classes of use.

The goal of this survey was to gather any information that could prove to be useful in developing a sufficiency rating system for secondary roads in Iowa. Experience that has been gained by other jurisdictions in the application of their system(s) could make the new system easier to develop and easier to use.

4.5 DEVELOPMENT OF MODEL

Results of the county engineers survey were used to develop a model which could be used to compute sufficiency ratings for a given county road network. Details of the model were reviewed by an advisory committee composed of four county engineers and an engineer from the Local Systems Department of the Iowa DOT. Suggestions made by the committee were incorporated into the model's final form.

In addition, a package of written materials has been prepared in anticipation of use of the model by county engineers. Included in in the package is:

1. a complete description of the model and instructions on its use,

2. suggestions on how the necessary data for use with the model might be gathered, and
3. appropriate sample forms which could be used with the model.

A sample of the package has been enclosed in Appendix C.

4.6 TRIAL RUN OF SYSTEM

A limited number of road segments were evaluated to provide an abbreviated trial run of the model and sample forms. The roads that were evaluated were located in a central Iowa county, and ranged from a heavily traveled trunk road to lightly traveled area service roads. The sample was chosen with the expectation that the range of sufficiency ratings would also encompass scores from excellent to ratings suggesting critical needs.

However, the trial run provided only a limited test of the model, and only served to point the need for a more extensive test. This 'more extensive test' is planned, although not as part of this contract. The results and recommendations arising from the more extensive test will be made available as soon as they are complete.

The brief trial run did reveal some potential problems with the rating system. Minor changes were made in the model and evaluation forms to solve the problems encountered. A complete description of the sample evaluations and their effect on the model and the forms appears in Chapter VI of this report.

Chapter V

DATA ANALYSIS

5.1 QUESTIONNAIRE RESPONSE - COUNTY ENGINEERS SURVEY

A total of 108 questionnaires were mailed to county engineers and engineers from the Iowa DOT. Of these 108, 71 were completed and returned, providing a return rate of 67 percent. The 71 received included 66 from county engineers (return rate=67 percent) and five (5) from Iowa DOT engineers (56 percent return). A map of the State of Iowa, showing the political boundaries of the 99 counties, is shown on the next page. Responses were received from engineers in those counties that are shaded.

The map also shows how the responses were distributed geographically. Most of the counties with larger urban areas returned completed questionnaires. In addition, most rural sections of the state are well represented.

5.2 ADVISORY COMMITTEE REVIEW

The completed questionnaires were examined to determine the existence of any consensus among the respondents in the form of preference for a given set of rating criteria. A rough draft of the initial findings and recommendations was presented to the advisory committee for review. The committee

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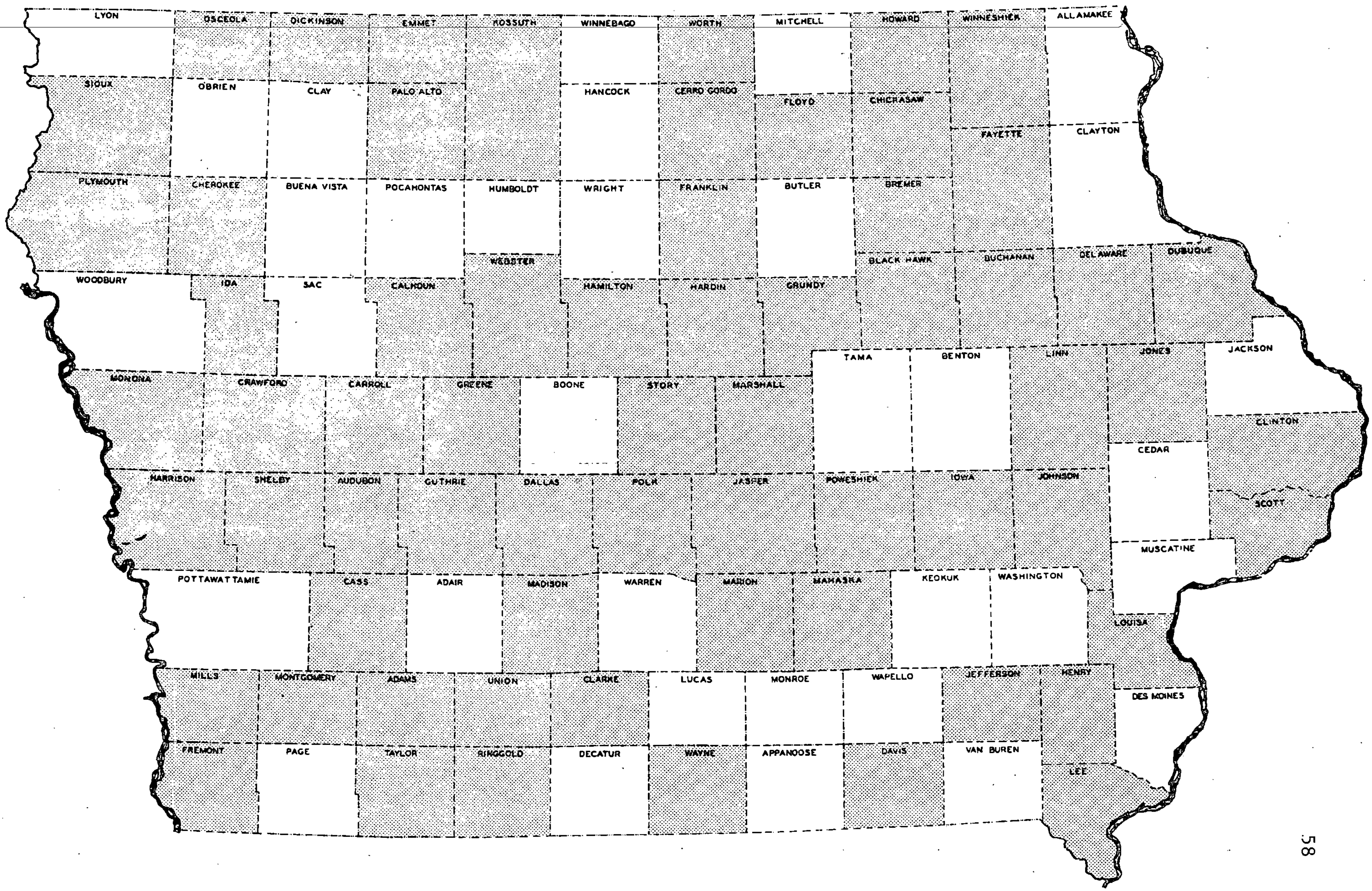

consisted of county engineers from four (4) counties and an engineer from the Office of Local Systems of the Iowa DOT.

The function of this committee was to review the material presented and to provide comments. Suggestions emerging from this review were incorporated into the final form of the model, and outlined later in this report. This final form will be tested on actual road segments to determine their 'sufficiency'.

A draft of the proposed system to be used in 'scaling' the rating elements was also presented to the committee. Committee members were asked to review it and provide written comments to aid in the revision of the final document.

5.3 IDENTIFICATION OF PREFERRED RATING ELEMENTS

The initial step in processing the raw data was to place it in a computer file, using a data processing format.

Frequency distributions were then computed for each rating criterion from Tables 2 and 3 of the questionnaires by category, rank, and weighted rank. The list provided in Table 9 is identical to Table 2 of the questionnaire for trunk and trunk collector roads.[12]

Mean and median scores were also computed for each criterion plus the standard deviation from the mean. Although the mean, median, and standard deviation were of value, frequency distributions were the most useful in isolating those

[12] Table 3 in the questionnaire for area service roads was nearly identical to Table 2.

TABLE 9

Rating Element Weights-Trunk & Trunk Collector Roads

CONDITION	RANK-BY CATEGORY	OVERALL RANK	WEIGHTED RANK
Foundation	____	____	____
Wearing surface	____	____	____
Shoulder	____	____	____
Drainage	____	____	____
Remaining life	____	____	____
Maintenance economy	____	____	____
____	____	____	____
SAFETY			
Pavement width (surface)	____	____	____
Shoulder width	____	____	____
Right-of-way width	____	____	____
Stopping sight distance	____	____	____
Passing sight distance	____	____	____
Hazards (safety)	____	____	____
Alignment consistency	____	____	____
Traffic control	____	____	____
Accident rate	____	____	____
____	____	____	____
SERVICE			
Alignment (horizontal)	____	____	____
Alignment (vertical)	____	____	____
Pavement width (surface)	____	____	____
Improvement continuity	____	____	____
Ride quality	____	____	____
Surface type	____	____	____
Shoulder width	____	____	____
Snow problems	____	____	____
____	____	____	____

rating elements deemed most important by the respondents. As expected, the weighted rank of the rating elements identified the 'preferred' rating elements most clearly. Distribution of the responses are shown in summary form via the bar graphs in Figures 1 through 23 in Appendix[13] D.

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[13] The bar graphs correspond to the frequency distribution of the ranking by respondents for each of the 23 rating elements listed.

The frequency distributions were carefully examined to identify a set of rating elements which consistently ranked high in comparison to all those suggested. Although provision was made on the questionnaire to write in additional rating elements, only one respondent did so. Therefore, only those elements listed on the questionnaire were considered.

An examination of the frequency distributions produced some fairly conclusive findings, in terms of selection of a set of 'preferred' rating elements. The results are described below.

5.4 SELECTION OF PREFERRED RATING ELEMENTS

A total of fourteen (14) rating elements were consistently ranked high by questionnaire respondents. They were regarded as important in evaluating trunk and trunk collector roads as well as area service roads, although there was some variation in ranking for the different road classifications.

Six of the most preferred rating elements received consistently high weighted rankings from respondents for all secondary roads. They were:

1. maintenance economy,
2. foundation,
3. wearing surface,
4. drainage,
5. hazards, and

6. stopping sight distance.

Though not equal, they consistently ranked high in comparison to all other rating elements.

Two additional rating elements were also ranked high for all secondary roads, though at a lower level. They were:

1. traffic control, and
2. pavement width.

However, pavement width was double-listed on the questionnaire, being included under both Safety and Service. An evaluation of the responses showed (when both listings were considered) pavement width (roadbed width) should be considered one of the most important of the rating elements.

A third cluster of rating elements on the 'preferred' list were ranked differently for area service roads than for trunk and trunk collector. These include:

1. passing sight distance,
2. accident rate,
3. ride quality,
4. horizontal alignment,
5. vertical alignment, and
6. snow problems.

The first five were considered to be slightly more important in evaluating trunk and trunk collector roads than for area service roads. On the other hand, snow problems were considered fairly important for area service roads, but somewhat less so for trunk and trunk collector roads. One additional rating element, surface type, was ranked high by respondents for area service roads, but not for trunk and trunk collector roads.

This suggests that there should be some variance between the sufficiency rating system proposed for trunk and trunk collector roads and the system for area service roads. These variations were considered when developing the suggested scales for the rating elements, discussed in the next section.

However, before proceeding, it would be appropriate to make a determination of the logical rating category for each element. This will simplify the weighting procedure.

The first four rating elements - maintenance economy, foundation, wearing surface, and drainage - all relate quite well to the category of Condition. They all are strongly associated with the 'Condition' of the roadbed. Logically, all four should be included with that rating category.

Most of the rest of the 'preferred' rating elements represent some characteristic of safety, and it would be consistent with the premise advanced earlier to include them in that category. The list of rating elements of that type are listed below, together with a brief explanation of the rationale for inclusion.

1. Accident rate is an obvious choice for inclusion under Safety.

2. Hazards is also an obvious choice to be included under Safety. By definition, a hazard represents an accident risk.

3. Stopping sight distance represents a potential for accident, in that, at normal operating speed, a driver cannot see far enough to make an emergency stop.

4. Restricted passing sight distance could present two different problems - one related to Service, in its constraint to traffic capacity, and the other to Safety, in that a driver could take an unnecessary risk in attempting to pass a slower vehicle. Of the two conditions, the threat to safety represents the greatest potential problem (since traffic is usually light on secondary roads), so it has been included under Safety.

5. Traffic control as a rating element is simply the existence of any problem traffic control sites - as potential safety problems.

6. Pavement width or roadbed width has an effect on both Safety and Service. Being too narrow can make driving somewhat hazardous, but it also affects driving comfort and traffic capacity. A decision to place this rating element in either category is arbitrary, but including it under Service seems more appropriate.

7. Ride quality relates mostly to Service, so it has been placed in that category.

8. Horizontal alignment is another rating element that can affect both a road segment's relative safety (by reducing visibility and/or forcing a reduction in speed to safely negotiate a curve) and Service (affecting driver comfort and road capacity). As it was with pavement width, placement is somewhat arbitrary, but the decision in this instance was to include it in the category of Safety.

9. Inclusion of vertical alignment in a rating category presents a dilemma. Poor vertical alignment can result in portions of a road segment with safe stopping sight distance and/or safe passing sight distance problems, but these are elements already included in the proposed rating system. Even though vertical alignment can affect Service (lowered capacity, higher operating costs, and lessened driver comfort), these factors are less important for secondary roads. With the concurrence of the advisory committee, this rating element was not included in the proposed model.

10. Snow problems are associated mostly with Service, in that they can restrict access to a road.

11. Surface type, like ride quality, relates mostly to Service.

The advisory committee suggested the inclusion of one additional rating element, shoulder width. Even though it was not ranked particularly high by questionnaire respondents, the committee felt strongly that it should be included, probably under Safety.

If the rating elements are placed in rating categories as previously suggested, there would be four (4) under Condition, either six (6) or seven (7) under safety, and three (3) or four(4) under Service. Table 10 below shows the suggested breakdown by rating category.

TABLE 10

Proposed Rating Elements - Secondary Roads

RATING CATEGORY	ITEM RATED
Condition and Maintenance Experience	Foundation
	Wearing Surface
	Drainage
	Maintenance Economy
Safety	Accident Rate
	Hazards
	Stopping Sight Distance
	Passing Sight Distance
	Traffic Control
	Horizontal Alignment
	Shoulder Width (paved roads)
Service	Pavement (roadbed) Width
	Ride Quality
	Snow Problems
	Surface Type (unpaved roads)

5.5 PROPOSED RELATIVE WEIGHTS-RATING CATEGORIES

As noted in the Review of Literature, most rating organizations use a maximum composite rating of 100, with each criterion rated assigned a maximum value. Each of the three rating categories were assigned a share of the 100 points, with the rating elements allocated a fraction of that share.

It is proposed that the new rating system also be based on a maximum value of 100, again because it is familiar to most highway engineers. What remains is how to determine the relative share that should be assigned to each category.

The completed questionnaires contain sufficient information to approach this problem from three directions. They are described briefly below as:

1. an analysis of the respondents suggested category rank. Respondents were asked to rank the three rating categories in order of perceived importance. Tables 5 and 6 on the questionnaire were used for that purpose.
2. an analysis of the respondents suggested category weights. After the respondents ranked the rating categories, they were asked to weight each category, relative to the other two.
3. a weighted average, using the 'preferred' rating elements and their relative weights. Some of the rating elements were considered to be more important to the rating system than others. An evaluation of these

differences in 'relative' weights of the rating elements, as combined with others in the most logical rating category, could serve as a guide to the appropriate weights of the three rating categories.

An evaluation of the three approaches yields a reasonable range of values. The following range of values for share of the 100 points were suggested:

1. Condition - 30 to 38 points
2. Safety - 32 to 47 points
3. Service - 20 to 32 points

The first approach suggests a breakdown of 38-37-25 (for trunk and trunk collector roads) and 37-32-31 (for area service roads). An evaluation using the second approach results in a proposed breakdown of 35-35-30 (trunk and trunk collector) and 36-32-32 (area service). The third approach utilized the 'preferred' rating elements, with the rating element of horizontal alignment shifted from Service to Safety. This results in a suggested scale of 30-47-23 (trunk and trunk collector) and 30-44-26 (area service).

The method used in approach #2 best reflects the opinion of the respondents to the questionnaire, in that they were able to 'weight' the rating categories as well as rank them. Moving horizontal alignment from Service to Safety, the addition of shoulder width to Safety, and the deletion of vertical alignment from Service would change the proportions of Safety and Service from 35-30 to 45-20 (trunk and trunk collector), which comes close to that suggested by the third approach. Therefore, the proposed scale would be:

1. Condition - 35 points,
2. Safety - 45 points, and
3. Service - 20 points.

for trunk and trunk collector roads.

Evaluation of area service roads could be accomplished using this breakdown - using either the same point values for the individual rating elements or slightly different values, reflecting the survey results more accurately. An alternative would be to change the rating category weights and make minor changes in the rating scales of the individual elements. The last alternative is recommended for the proposed rating system. There are enough variations in road usage and design standards to justify the existence of two different rating scales.

Data alluded to earlier suggested an increase in the point allocation for Service (for area service roads vs. trunk and trunk collector) and a lesser category weight for Safety. The differential suggested was in the range of two (2) to six (6) points. In addition, the rating element of snow problems was considered to be somewhat more important for area service roads than for trunk and trunk collector.

Therefore, the proposed model for area service roads provides for an increase of five (5) points for the category of Service, with a matching decrease for Safety.

5.6 PROPOSED RELATIVE WEIGHTS-RATING ELEMENTS

The final step in the formation of the proposed models is to ascertain the appropriate maximum point value for each included rating element. The list of 'preferred' rating elements and their relative weights, referred to earlier, were used to resolve this last problem. All that remains is to make such adjustments as necessary to the individual weights to match the category weights in the proposed models.

For example, the proposed weight to be applied to the category of Condition is 35 points (of a possible 100). Four rating elements were included in that category - foundation, wearing surface, drainage, and maintenance economy. Respondents ranked foundation, wearing surface, and maintenance economy about equal, with drainage ranked slightly lower. Dividing the 35 points that were allocated to that rating category among the four rating elements resulted in the following breakdown:

1. foundation - 9 points,
2. wearing surface - 9 points,
3. drainage - 8 points, and
4. maintenance economy - 9 points.

A similar procedure was utilized for the rest of the models, resulting in final proposed models as described in Table 11 for trunk and trunk collector roads, and in Table 12 for area service roads. Scale factors and proposed procedures for use with the models will be discussed in the next part of this report.

TABLE 11

Sufficiency Rating System Model, Trunk & Trunk Collector

RATING CATEGORY	ITEM RATED	MAX. POINTS
Condition and Maintenance Experience 35 points	Foundation	9
	Wearing Surface	9
	Drainage	8
	Maintenance Economy	9
Safety 45 points	Accident Rate	6
	Hazards	9
	Stopping Sight Distance	8
	Passing Sight Distance	5
	Traffic Control	6
	Horizontal Alignment	6
	Shoulder Width	5
Service 20 points	Pavement (roadbed) Width	9
	Ride Quality	6
	Snow Problems	5

TABLE 12

Sufficiency Rating System Model, Area Service Roads

RATING CATEGORY	ITEM RATED	MAX. POINTS
Condition and Maintenance Experience 35 points	Foundation	9
	Wearing Surface	9
	Drainage	8
	Maintenance Economy	9
Safety 40 points	Accident Rate	6
	Hazards	9
	Stopping Sight Distance	8
	Passing Sight Distance	5
	Traffic Control	6
	Horizontal Alignment	6
Service 25 points	Roadbed Width	9
	Ride Quality	5
	Snow Problems	6
	Surface Type	5

The model for use in evaluating area service roads is nearly the same as for trunk and trunk collector roads. Adjustments made to the model for area service roads are as listed below.

1. Delete shoulder width as a rating element under Safety. Few area service roads are paved in Iowa counties. The points allocated to shoulder width will be transferred to Service.
2. Change 'Pavement Width' to 'Roadbed Width'. This better describes that rating element for area service roads and negates the need for consideration of shoulder width.
3. Add the rating element 'Surface Type' to the category of Service. Respondents ranked it at about the same level as ride quality for area service roads.

The proposed model for the evaluation of area service roads is as shown by Table 12, with minor adjustments of maximum point values from that of the model for trunk and trunk collector roads.

5.7 RESULTS OF STATE SURVEY

A total of ten (10) states were contacted. A telephone survey was conducted, using the questionnaire discussed earlier. A sample of the questionnaire has been included in Appendix B.

The states contacted were selected on the basis of:

1. revelation of the previous use of some sort of sufficiency rating system for secondary roads in that state (as the result of the literature review), or
2. state jurisdiction over some or all of the secondary roads within that state.

Not all of the representatives of the state highway organizations contacted were able to respond to the questionnaire and little useful information was received. The information of value that was gathered is summarized briefly below.

1. Two states, Missouri and Kentucky, reported using a sufficiency rating system for secondary roads. Only a small portion of the secondary roads are actually evaluated by the states, generally the Federal Aid Secondary (F.A.S.) under state jurisdiction. No local jurisdictions are reported as using a sufficiency rating system for their secondary roads. Written material was requested and received from these states and proved to be useful in developing the new model.
2. Five of the states reported no use of a sufficiency rating system (or similar system) for secondary roads, including Indiana. Apparently Allen County in Indiana has dropped the system used earlier in that county and no other county in the state has adopted it. Virginia, which has jurisdiction over all secondary roads in the state (except for two urban counties) does not use a sufficiency rating system as

such. They do use a 'tolerable - intolerable' rating system which relates ADT with surface width/surface type.

3. Two other states were contacted. Repeated efforts to reach a person that might have knowledge of possible systems in use failed.
4. Most of the states reported the use of AASHTO design standards for secondary roads in their state or a combination of AASHTO standards and some local standards.

Some of the information received from Kentucky was useful in developing the model and forms included in this report. Most of the information gathered from the state survey was not of value for this project, except to suggest that there is little use of sufficiency rating systems for secondary roads in the United States. Some interest was expressed in the proposed system for Iowa.

Chapter VI

AN EMPIRICAL MODEL

The original model developed by the Arizona Highway Department was 'empirical', or experience based. Subsequent models developed and used by other state highway organizations utilized the Arizona format, with local variations influenced by a combination of local conditions and personal experience.

The model proposed for secondary roads is also empirically based - based on the Arizona format and the experience of local engineering practitioners.

6.1 RATING ELEMENTS SELECTED

Fourteen rating elements have been selected for use with the proposed sufficiency rating system. They have been organized into three categories and assigned relative weights. Table 11 and Table 12 show the proposed list of rating elements, complete with their suggested weights.

6.2 FORM OF MODEL

The basic model for the sufficiency rating system is a simple mathematical model, which can be expressed in the following form:

SR = Sum of Scores of (CRE + SaRE + SeRE)

where SR = the Sufficiency Rating for a given road segment, CRE = all Condition Rating Elements, SaRE = all Safety Rating Elements, and SeRE = all Service Rating Elements.

The maximum possible scores for the selected rating elements have been determined -- from the analysis of the data received. What remains is to solve the problem of how to assign scores when the rated road segment fails to meet the expected standard for a given rating element. To do this requires the answer to two questions.

1. What is a defensible set of standards which could be applied to the rating elements selected?
2. Is there a scaling calibration which can be used with each rating element and that would yield meaningful scores when the rated road segment fails to meet the desired standard?

The answers to these two questions are critical to the problem of the assignment of scores. The next two sections will address the issues raised by the questions and suggest appropriate answers.

6.3 STANDARDS FOR RATING ELEMENTS

The issue of determination of appropriate standards to apply to the rating elements is intermixed with economic and social issues -- what level of financial commitment is the public willing to make to build and maintain the state's transportation infrastructure and what is the dollar value of personal comfort, pain and suffering (due to traffic injury), and human life (when a person is killed in a a traffic accident)?

Though these issues will probably never be really settled, engineering practitioners have adopted standards that are reasonably consistent with prevailing public opinion. Evidence of public opinion is provided in the form of the level of funding which legislative bodies have allocated and in the force of public opinion in the form of individual and group pressures.

The result is a set of design standards which has been adopted by a highway agency (in this case, the Iowa DOT) for use with all the different classes of roads throughout its jurisdiction.[14] The design standards represent prevailing professional opinion on appropriate standards or norms for building a given road to serve expected traffic needs.

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[14] Comparable sets of design standards have been adopted by other state highway organizations, similar in many respects, but also reflecting local conditions.

For the most part, the design standards call for higher standards of construction for roads carrying heavier volumes of traffic (and costing more) and concomitant lower standards for roads carrying less traffic.[15] The lowered standards include the provision for reduced design speeds, with the expectation that vehicles using the road would not be moving at as high a rate of speed as on a road carrying a heavier volume of traffic and built to higher standards.

All this infers that the lowered standards are acceptable to the public and that there is little reason to exceed those standards, except when it can be done at little extra cost. By the same token, an evaluation for 'sufficiency' -- a comparison to established 'ideals,' should be based on the current design standard for that road classification.

Therefore, the proposed sufficiency rating model for secondary roads incorporates applicable design standards from the design guide developed by Iowa DOT staff for the 1982-2001 Quadrennial Needs Study. The guide was developed in consultation with the State Functional Classification Review Board, members of the County Engineers Association, and the League of Iowa Municipalities.[16]

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[15] One of the distinguishing characteristics of the hierarchy of road classifications is the volume of traffic using the facility.

[16] This Guide was chosen in spite of the fact that many county utilize the FARM TO MARKET DESIGN GUIDES. It was chosen because of its breakdown of Area Service Roads into three categories, based on ADT. This provides for lower standards for lightly traveled Area Service Roads.

Failure of a rated road segment to meet a given standard would cause a lowered score for that rating element. Established 'ideals' for rating elements not covered by a design standard are based on current practices as evidenced by a combination of 'standards' utilized with other sufficiency rating systems currently in use and local practices.

6.4 SCALING FACTORS

An assessment of the maximum point value for a given rating element is made when the road segment meets or exceeds the current standard. However, a given rated road segment will meet the current standard for each of the rating elements to a varying degree, making it necessary to develop some sort of scale to describe how close it comes to meeting that standard. Maximum point values for each of the rating elements are listed in Tables 11 and 12, so what is needed is a set of graduated scales for each.

Existing systems utilize, for the most part, a sequence of point values which are approximately linear in character. In most instances, there is a score (often at about the middle of the scale) which represents an 'average' value, below which is considered 'intolerable'. The concept of tolerability, discussed earlier in this report, is based on the supposition that, for each rating element, there is a 'tolerable' standard which is less desirable than the 'ideal', but still considered to be safe, or at least provides good service. It is at the lowest point on the scale permissible under current highway transportation requirements. Below that level, the rated road segment is considered to be 'intolerable' with regard to that rating element.

The calibration system used by the Iowa DOT has established tolerable levels for each rating element in the system used to evaluate primary roads. In each instance, it is 50% of the maximum point value, rounded down to the next digit when the maximum point value is not an even number.

This calibration method is used for the proposed model, graduated linearly with decreasing values below the maximum score. Accompanying statements have utilized descriptors of excellent, good, fair (at 'tolerable' scales) and poor, together with status descriptions for each score. A summary of the proposed scoring method has been included in the next section.

However, there are some rating elements in the proposed model that do not lend themselves as well to the 'linear' scale concept discussed earlier. They include elements grouped under the category of Safety. They are like an 'accumulation of potential safety risks, or hazards' occurring along the rated road segment. Their existence represents a possible safety hazard, or 'deficiency', and tend to be site specific, instead of occurring regularly along the road. The rating elements are the type which could be 'counted' (two narrow bridges are more hazardous than one).

This suggests that part of the score for a rated road segment under the category of Safety could be based on the results of an evaluation of its relative safety, such as is done by the Iowa DOT as part of the sufficiency evaluation for primary roads -- the 'Safety Study'. Deductions from a maximum value would be made for the existence of 'conditions that exist on the road segment that constitute a possible threat to safe operation of the motor vehicle on that road'.

Under this system, deficiency points would be assessed for the existence of a list of 'threats to safe driving', using a predetermined point deduction for each deficiency. Road segments of varying length would be made comparable by the inclusion of an adjustment factor for length.

The next section details the proposed scaling system for the complete model. A brief description of each of the rating elements has been included for clarification.

6.5 RATING SCALE CALIBRATION

A set of scales has been developed for the proposed rating system. This set of scales is described below, arranged in a format similar to the model as shown in Table 11.

CONDITION AND MAINTENANCE EXPERIENCE

1. Foundation - evaluated by considering adequacy of drainage ditches, breakup of surface, non-uniform settlement and lateral support, and condition of foreslopes. Maximum score = 9.

Excellent 8-9. No evidence of base failure, foreslopes in excellent condition.

Good 6-7. Occasional evidence of minor base failure, fully correctable by spot repairs. No need for extensive reworking.

Fair 5. Frequent base failure, requiring heavy maintenance. Causes reduction in traffic speeds below design speed. Should be considered for reconstruction. 'Tolerable.'

Poor 1-4. Severe base failure throughout rated section, extreme 'wash-board' condition. Traffic speeds substantially reduced. Reconstruction necessary.

2. Wearing Surface - evaluated by considering physical defects. For P.C. concrete paved roads, the defects include joint-faults, transverse and longitudinal cracks, non-uniform slab displacement, spalling and disintegration of concrete. Asphaltic concrete pavement defects include transverse and longitudinal cracks, irregular profile and cross-section, alligator cracks, raveling, bleeding, and rutting. Granular surfaces defects include formation of potholes, locations with regular formation of ruts, and transverse 'washboarding'. Maximum score = 9.

Excellent 8-9. Very satisfactory condition. Pavement or granular surface smooth. Granular surface requires only routine blading. No surface failure.

Good 6-7. Occasional spots of surface failure, correctable satisfactorily through normal maintenance. Resurfacing not absolutely necessary.

Fair 5. Frequent spots of surface failure, correctable only by heavy maintenance. Rough surface reduces traffic speeds somewhat below design speed. 'Tolerable.'

Poor 1-4. Severe surface failure over all of rated segment. Resurfacing or reconstruction necessary due to surface condition. Traffic speeds substantially reduced from design speed.

3. Drainage - evaluation based on occurrence of ponding, ditch erosion, culvert silting, scouring of culvert outlets, condition of pipes, and their hydraulic capacity. For unpaved roads, this should include existence of portions of the road with inadequate cross-drainage due to lack of adequate crown (as evidenced by weakened foundation due to rain) or too steep cross-slopes, causing excessive erosion. Maximum score = 8.

Excellent 7-8. Drainage satisfactory. No silting, scouring, significant erosion or ponding. Culverts of adequate design, good condition.

Good 5-6. Occasional ponding due to heavy rains, but quickly drains afterward. Some silting or scouring of culverts occurring which requires light maintenance. Occasional flat (or too steep) crown which needs regrading.

Fair 4. Ponding substantial during heavy rains, sometimes during light rains. Some problems for traffic due to ponding or rough or softened surface or foundation. Maintenance of road and/or drainage facilities becoming excessive. Expensive correction or improvements indicated. 'Tolerable.'

Poor 1-3. Excessive ponding, inadequate drainage, not correctable through maintenance. "Intolerable."

4. Maintenance Economy - based on historical knowledge of the maintenance requirements of the road segment. Maximum score=9.

Excellent 8-9. No expenditures, other than strictly routine. Patching of pavement rarely required. Addition of granular material needed occasionally due to traffic, but not in extraordinary amounts. Blading of non-surfaced road done regularly, but not a particular problem.

Good 6-7. Some expenditures, but not excessive. Some patching required annually. Resurfacing of pavement would help, but not absolutely necessary. Addition of granular material over most of section desirable, but also not absolutely necessary. Spot re-grading of non-surfaced road required. Extra dragging required periodically.

Fair 5. Considerable expenditures of money and material. Considerable patching and crack filling. Addition of supplemental granular material required annually or continuously. Road should be candidate for resurfacing and/or reconstruction. Considered to be 'tolerable'. Many spots of non-surfaced roads need special attention during blading.

Poor 1-4. Excessive expenditures to keep road in serviceable condition. Great amount of patching or addition of supplemental granular material needed regularly. Numerous spots on non-surfaced roads need considerable re-grading. Efforts to repair often inadequate. Should be rebuilt.

SAFETY

Most of the rating of a road segment for the category of Safety is proposed to be based on a safety evaluation. Points would be deducted from a maximum of 35 on a basis of the existence of potentially unsafe elements. Before subtracting the total points from 35, divide by the number of miles in the rated section. Round up to the next even point.

1. Accident Rate. Though considered important in sufficiency ratings, lack of frequency of occurrence on lightly travelled secondary roads limits its viability as a measure of a road's safety. However, the occurrence of an accident on a given road segment raises the issue of safety, even though the proximate cause of the accident cannot be correlated with any definable safety hazard. Therefore, for each recorded property damage accident on that rated road segment within the past 5 years, deduct one point. For each personal injury accident, deduct three points, and for each fatal accident, deduct five.

2. Hazards. This element relates to hazards not already described. They are listed below.

- Structure (bridge or culvert) which restricts roadbed width (less than 20 foot in width).

- structure with bad approach alignment.

- R.R. crossing at grade without automatic signals.

- Other fixed structure extending onto roadbed (for unpaved roads) or to within ten (10) feet of edge of pavement (for paved roads).

- abrupt or severe grade changes.

Deduct two points for each occurrence.

3. Stopping Sight Distance. A stopping sight distance standard exists for each design standard -- based upon design speed. Locations on the rated road segment with inadequate sight distance to see a potential hazard and stop -- at the design speed, is hazardous. Therefore, for each occurrence, point(s) should be deducted. Deduct one point for each occurrence. Also, longer sections of roadway with restricted passing visibility are more hazardous than the shorter ones, suggesting a greater point deduction. Deduct one point for each stopping sight distance beyond the initial distance, or fraction thereof. For example, on a paved road with a design speed of 50 mph, safe stopping sight distance = 350 feet. If this cannot be achieved for a distance of 350 feet, count as one occurrence. If this unsafe condition occurs for between 350 and 700 feet (continuously), count as two (2) occurrences. For between 700 and 1150 feet, count as three (3).

4. Traffic Controls. Traffic controls meeting regulations in the 'Manual on Uniform Traffic Control Devices (MUTCD)' installed in accordance with applicable warrants, or adequate vision at uncontrolled intersections. Deductions from the full rating could be based on the loss of two points for each occurrence of:

- inadequate pavement markings

- less than adequate warning sign distances
- inadequate vision at uncontrolled intersections
- consistency of sign placement.

5. Horizontal Alignment. Horizontal alignment can pose two hazards. One is safe (or unsafe) stopping sight distance (covered under SSD) and the other with a comfortable driving speed below the design speed for that particular road. Assuming that drivers expect to slow somewhat on a curve, reduction of speed up to 5 mph (on paved roads) and 10 mph (on unpaved roads) might be expected, but more could be considered as unexpected. Therefore, deduct one point for each additional 5 mph reduction required to negotiate the curve. For example, consider a horizontal curve on a road designed for a maximum speed of 50 mph. Slowing to 45 mph would not be considered unsafe, but slowing to 40 mph would cause of deduction of one (1) point, - to 35 mph, a two (2) point deduction.

6. Passing Sight Distance. The minimum sight distance required to pass another vehicle safely and comfortably. Restrictions to passing are caused by roadway geometrics and opposing traffic. Evaluation is based on restrictions caused by roadway geometrics. The rating is based on the total restricted distance (in miles) compared to the total length of the section. Maximum score = 5 points, when over 90 percent of the rated road segment is considered to have safe passing sight distance, based on

the design speed. Lower ratings apply when less of the rated road segment has safe passing sight distance. Assigned point scores also vary according to design standard. See page 4 of the Guide for Preparation of Worksheets for complete details.

7. Shoulder Width. Shoulder width is measured from the edge of the pavement to the point where the shoulder line intersects the foreslope. Applicable to paved roads only. Maximum score = 5.

Excellent 5. Shoulder width meets or exceeds design standard.

Good 4. Shoulder width is less than design standard. Range of 6-8 feet (for 8 foot standard), 4-5 feet (for 6 foot standard), 2-3 feet (for 3 foot standard).

Fair 3. Less than design standard. Range of 4-6 feet (for 8 foot standard), 3-4 feet (for 6 foot standard), or 1-2 feet (for 3 foot standard). Tolerable.

Poor 0. Less than 4 feet (8 foot standard), or 3 feet (6 foot standard) or less than 1 foot (3 foot standard). Not tolerable.

SERVICE

1. Pavement Width (Roadbed Width) - used to reflect inadequate traveled way widths as determined by a comparison with the appropriate design standard. Though also related to safety, it has been included only under the category of Service. Maximum score = 9.

Excellent 9. Width of pavement or traveled way meets or exceeds the width specified in the appropriate design standard.

Good 6-7. Width of pavement or width of traveled way is not more than two feet (.6 m) less than the design standard.

Fair 5. A 'tolerable' width. Width of pavement or traveled way is two feet (.6 m) to four feet (1.2 m) less than the design standard.

Poor 1-4. Not tolerable. Needs to be wider. Width falls short of design standard by at least four feet (1.2 m).

2. Ride Quality - an evaluation of surface quality -- waviness, irregular surface, corrugations, and/channeling. Maximum score = 6.

Excellent 6. Smooth riding at design speed or above.

Good 4-5. Minor roughness of surface causes little discomfort in riding. Occasional irregularities, corrugations, or channeling causes the driver to slow down (below design speed) for short distances.

Fair 3. Roughness of surface causes some noticeable discomfort in riding. Occasional pavement cracking and failures require extensive patching. 'Wash-board' on granular surfaced road requires frequent grading. Tolerable.

Poor 0-2. Heavy cracking, deep failures, obvious instability. Very unsatisfactory riding surface.

3. Snow Problems - an evaluation based on the ability of roadside ditches and accessible portions of the right-of-way (R-O-W) to accommodate the quantity of snow that may have to be removed from the roadway and shoulders. Maximum score = 5.

Excellent 5. No significant drifting problems. Roadbed above the surrounding area, ditches deep and wide for storage.

Good 4. Occasional locations where drifting is a problem. Ditches still wide and deep enough to accommodate most of the snow.

Fair 3. Tolerable. Frequent locations where drifting is a problem, but not extremely long drifting areas or places where very deep drifts occur. Some problems on ditch width or depth. Roadbed elevation occasionally inadequate. Ditch may need some extensive maintenance to clear silt or vegetation.

Poor 0-2. Drifting and/or snow removal a recurring problem of significance. R-O-W width inadequate to allow for ditches to be wide or deep enough, or extensive grading needed to raise the roadbed and/or improve ditches.

6.6 TESTING THE MODEL

The next step in the development of the rating system was the preparation of a set of rating forms and a set of instructions to to aid in their use. The scaling factors discussed earlier were used as a basis for the forms, adjusted for variations in design standards.

A combination of functional class and ADT was used as a basis for selection of the appropriate design standard for the road to be evaluated. Directions for this selection have been provided in the GUIDE FOR PREPARATION OF WORKSHEETS. A sample copy of each of the worksheets and the Guide are provided in Appendix C.

A trial run of the use of the rating forms was made by completion of an actual rating of several secondary road segments in a Central Iowa county (totalling slightly more than 25 miles), using the forms and the Guide. An evaluation was made of their ease of use and applicability to the rating and minor revisions made. The samples in Appendix C reflect any changes made as a result of the test.

To a limited degree, the trial provided an opportunity to test the model as well. The rated road segments were chosen to be reasonably representative of the range of road surface types, functional classes, and the variations in ADT that is encountered in secondary road systems. The test was to determine whether the model, using the proposed calibration system, provided a meaningful differentiation in rating scores for the rated road segments.

The trail run proved to be adequate to evaluate the forms and the Guide, and several revisions were made reflecting the experience from the trial run. Two significant revisions were made to the system as a result of the trial run. One was to add the criterion 'Surface Type' to trunk and trunk collector road evaluatins - whenever the road was unpaved, and the second was to keep the scale for 'Snow Problems' identical for both systems. The end result is a set of evaluation forms which could be identical for all secondary roads. Table 13 shown below represents the final proposed model, modified only for road surface (paved or unpaved).

The trial run also revealed some potential problems that could occur in the use of the system. These problems are discussed briefly below, together with the suggested solutions.

1. It would be difficult to complete the Field Worksheet with only one person. It would seem that a two member team is needed - with one member being someone who is very familiar with the maintenance history of the rated road segments.

TABLE 13

Sufficiency Rating System Model, Secondary Roads

RATING CATEGORY	ITEM RATED	MAX. POINTS
Condition and Maintenance Experience 35 points	Foundation	9
	Wearing Surface	9
	Drainage	8
	Maintenance Economy	9
Safety 40 points	Accident Rate	6
	Hazards	9
	Stopping Sight Distance	8
	Passing Sight Distance	5
	Traffic Control	6
	Horizontal Alignment	6
Service 25 points	Pavement (roadbed) Width	9
	Ride Quality	5
	Snow Problems	6
	Surface Type or	5
	Shoulder Width	(5)

2. Accident data could prove to be a problem, depending on the completeness of local records. However, fairly complete records are available from the Iowa DOT, in form of the Accident Locator Analysis System (ALAS).
3. Stopping sight distance may be a difficult criterion to evaluate on roads without adequate records. However, an experience evaluator can pinpoint potential trouble locations from a field analysis fairly quickly. Once this is done, records from previous evaluations can be reused until the road is regraded.
4. Passing sight distance poses a similar problem. The solution is the same as for stopping sight distance.

5. To a lesser extent, horizontal alignment causes a similar problem. However, this will not occur often, and can be solved by field observations as well.

The extent of these problems will vary, depending on the completeness of local records. They may prove to be troublesome the first time the road system is evaluated, but subsequent iterations can reuse most of the data.

The trial run was not extensive enough to determine whether the model provides meaningful differentiation in rating scores. A much larger and varied sample is needed. Relative scores did seem to show a degree of contrast, but the trial run used too small a sample to be significant. A major portion of a whole county - or perhaps several counties - should be a good test of the model. Since the model is empirical, it could then be compared to the priority list of projects reached by normal procedures.

Chapter VII

SUMMARY AND CONCLUSIONS

The objective of this study was to produce a sufficiency rating system which could be used to evaluate the adequacy of secondary roads in Iowa. The system to be developed should be reasonably easy to use, yet yield results which are compatible with current processes used in priority programming.

Models currently being used for primary roads are empirical in nature, in that they are numerical ratings which relate well to 'experience based' adequacy ratings. It follows that the experience of local engineering practitioners should figure heavily in determining the form of the proposed model. To that end, a questionnaire was developed which could be used to survey local engineering practitioners - mostly county engineers. A statistical analysis of the responses provided the basis for the formation of the model proposed in this report.

The model that is proposed uses the same format used by the Arizona Highway Department for the first sufficiency rating system, developed in 1946. This format was adopted because it is well known, widely accepted, and comparatively easy to use. It also is considered to yield reasonable results, that are reproducible.

Rating criteria selection (and their relative weights) was based on the responses to the questionnaire. Scaling factors were based on the relative weights suggested by the responses and the model used by the Iowa DOT for primary roads. Maximum scores were established, using a set of design standards adopted for the model. Failure to meet the 'standard' represented a 'deficiency', the amount of deficiency dependent on how close the rated road segment came to meeting the standard. The concept of 'tolerability' figured heavily in forming the scales used with the criteria. The concept of tolerability, discussed in detail in the report, is predicated on the supposition that there exists (for each rating criterion) a 'tolerable' standard which is less desirable than the 'ideal', but still considered safe (or at least acceptable). A comparative level was selected for the 'tolerable' value (based on currently used models) and scales were graduated.

The worksheets and Guide in Appendix C were developed to aid users of the system in applying the model to roads in their jurisdiction. Revisions to the forms were made, using the experience gained in a trial run of the model. Some of the revisions made as a result the trial run produced a more uniform model for all functional classes of roads to be evaluated. Variations in the resultant ratings are based on whether the rated road segment is paved or unpaved and on the variability in design standards, based on functional class and ADT.

The trial run failed to test the model adequately - to determine its validity. The sample of roads in the trial run was too small, considering the wide range of roads that need to be rated (using functional class and ADT). The research contract does not provide for a trial run of adequate size to fully test the model. Yet, further research to test and refine the model would be desirable.

The comparative results produced by the trial run do suggest that the model is usable and should prove to be compatible with other processes used to form priority lists for project programming.

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Appendix A

COUNTY ENGINEER'S QUESTIONNAIRE

ROAD SUFFICIENCY RATING CRITERIA QUESTIONNAIRE

Your opinions are solicited regarding the choice of suitable rating elements for use with a proposed sufficiency rating system for secondary roads. There are a set of common rating elements usually used as part of sufficiency rating systems in the United States. It would seem that not all of the elements used for primary roads are useful for use in evaluating secondary roads. This survey is being conducted to select the appropriate rating elements as part of the development of a sufficiency rating system for secondary roads for a contract with the Iowa Highway Research Board.

Secondary roads have been divided into two groups -- trunk - trunk collector roads and area service roads. Two identical lists of rating elements have been prepared, one for each functional class group. The rating elements have been segregated into three categories. The categories are CONDITION, SAFETY, and SERVICE.

The categories have from six (6) to nine (9) rating elements used for the actual rating by various state and/or local highway agencies using sufficiency rating systems for priority planning. A few rating elements appear in more than one category. Some of the overlap is intentional, using the rationale that the rating element is an important factor in both categories, while in some instances, it is a matter of disagreement as to where the rating element belongs.

CATEGORY RANK
For the rating elements in each category, please indicate your perception of the appropriate rank for each element -- within each category. Do this for each category separately, with one (1) being the most important. An example is shown in Table 1 shown below. A short description of the rating elements is enclosed with this mailing.

TABLE 1

Example -Ranked Rating Elements

CONDITION	RANK-BY CATEGORY	OVERALL RANK	WEIGHTED RANK
Foundation	2	5	80
Wearing surface	4	11	60
Shoulder	6	16	50
Drainage	5	12	57
Remaining life	3	7	74
Maintenance economy	1	2	92

OVERALL RANK
Next, determine your perception of the appropriate rank for all 23 elements, ignoring category. Rank one (1) to 23.

WEIGHTED RANK
Using this ranking as an aid, weight the 23 elements, using 100 for the most important rating element and lesser weights for less important elements. Duplicate weights may be used. Table 2 lists all the rating elements for trunk and trunk collector roads. A blank is included for insertion of additional rating elements.

TABLE 2

Rating Element Weights-Trunk & Trunk Collector Roads

	RANK-BY CATEGORY	OVERALL RANK	WEIGHTED RANK
CONDITION			
Foundation	_____	_____	_____
Wearing surface	_____	_____	_____
Shoulder	_____	_____	_____
Drainage	_____	_____	_____
Remaining life	_____	_____	_____
Maintenance economy	_____	_____	_____
____________________	_____	_____	_____
SAFETY			
Pavement width (surface)	_____	_____	_____
Shoulder width	_____	_____	_____
Right-of-way width	_____	_____	_____
Stopping sight distance	_____	_____	_____
Passing sight distance	_____	_____	_____
Hazards (safety)	_____	_____	_____
Alignment consistency	_____	_____	_____
Traffic control	_____	_____	_____
Accident rate	_____	_____	_____
____________________	_____	_____	_____
SERVICE			
Alignment (horizontal)	_____	_____	_____
Alignment (vertical)	_____	_____	_____
Pavement width (surface)	_____	_____	_____
Improvement continuity	_____	_____	_____
Ride quality	_____	_____	_____
Surface type	_____	_____	_____
Shoulder width	_____	_____	_____
Snow problems	_____	_____	_____
____________________	_____	_____	_____

AREA SERVICE ROADS

Please repeat the process for area service roads. Since most are built to different design standards and most carry lighter traffic volumes, it is quite possible that you may rank and weight differently. Again, for this part, begin by ranking the 23 elements, followed by the weighting. As before, weight the most important as 100, with lesser ranked elements receiving a weighted rank below 100. Table 3 has been provided for this purpose.

TABLE 3

Rating Element Weights - Area Service Roads

CONDITION	RANK-BY CATEGORY	OVERALL RANK	WEIGHTED RANK
Foundation	____	____	____
Wearing surface	____	____	____
Shoulder	____	____	____
Drainage	____	____	____
Remaining life	____	____	____
Maintenance economy	____	____	____
____________	____	____	____
SAFETY			
Pavement width (surface)	____	____	____
Shoulder width	____	____	____
Right-of-way width	____	____	____
Stopping sight distance	____	____	____
Passing sight distance	____	____	____
Hazards (safety)	____	____	____
Alignment consistency	____	____	____
Traffic control	____	____	____
Accident rate	____	____	____
____________	____	____	____
SERVICE			
Alignment (horizontal)	____	____	____
Alignment (vertical)	____	____	____
Pavement width (surface)	____	____	____
Passing opportunity	____	____	____
Improvement continuity	____	____	____
Ride quality	____	____	____
Surface type	____	____	____
Shoulder width	____	____	____
Snow problems	____	____	____
____________	____	____	____

CATEGORY RANKINGS

The last question pertains to the relative importance of the three rating categories. Please rank the three categories and indicate your perception of their comparative importance, using the following procedure:

1. Rank the three categories, using one (1) to indicate the most important.

2. Assign the score of ten (10) to the most important category.

3. Indicate your perception of the relative importance of the other two categories by scores ranging from nine (9) down to as low as one (1), and indicate the values in the blanks provided.

Table 4 below shows an example ranking and weighting.

TABLE 4

Example Category Weighting

CATEGORY	RANK	WEIGHTED RANK
Condition	1	10
Safety	2	8
Service	3	5

The example shown has assumed a fictional ranking of CONDITION (most important) to SERVICE (least important). Since CONDITION was considered to be most important, its weighted rank was ten (10). In the fictional response, SAFETY was considered to be 0.8X as important as CONDITION (for trunk and trunk collector secondary roads) and SERVICE deemed to be 0.5X as important as SAFETY.

TRUNK AND TRUNK COLLECTOR ROADS

Please indicate your perception of the relative importance of the three categories in evaluating trunk and trunk collector roads for sufficiency ratings. Table 5 below lists the categories.

TABLE 5

Category Weight - Trunk and Trunk Collector Roads

CATEGORY	RANK	WEIGHTED RANK
Condition	____	______
Safety	____	______
Service	____	______

AREA SERVICE ROADS

Please repeat the process for area service roads. Table 6 lists the categories.

TABLE 6

Category Weights - Area Service Roads

CATEGORY	RANK	WEIGHTED RANK
Condition	____	______
Safety	____	______
Service	____	______

Thank you for your time and effort. Your opinions will be analyzed, along with those expressed by peers. The goal will be to obtain a list of rating elements considered to be the most meaningful and useful for evaluating secondary roads for priority planning plus the most appropriate weights for each. If you have any questions, please call Clete Mercier at Iowa State University, telephone 515-294-8387.

DESCRIPTION OF RATING ELEMENTS

A brief description has been prepared of the rating elements listed in the accompanying questionnaire to assist you in its completion. They are listed below, in the same order as they appear on the questionnaire.

CONDITION

Foundation: An appraisal based on degree of plasticity and the number of foundation failures observed per unit length of road.

Wearing surface: An evaluation of the various types (and frequency of occurrence) of physical defects observed per unit length of road.

Shoulder: An evaluation of the physical defects - deviation from the ideal - of the surface of the shoulders.

Drainage: An analysis of the occurrence of ponding, ditch erosion, silting, and scouring plus adequacy and condition of the culverts.

Remaining life: A rating based on the expected remaining life of the wearing surface.

Maintenance economy: An appraisal of maintenance requirements, based on historical knowledge.

SAFETY

Pavement width (surface): An evaluation using a comparison of existing pavement width with a design standard.

Shoulder width: Same as pavement width, except using the design standard for shoulders.

Right-of-way width: An appraisal of the adequacy of the right-of-way width to accommodate the desirable roadway cross sections.

Stopping sight distance: An analysis of road alignment which enumerates the occurrences of less than desirable stopping sight distance, based on design speed.

Passing sight distance: An analysis of the frequency of occurrence of passing vision being restricted by alignment, based on design speed.

Hazards (safety): A rating based on a safety study tally of less than desirable horizontal clearances from roadside obstacles plus sharp horizontal curves.

Alignment consistency: Numerical rating as a function of the number of inconsistencies in horizontal alignment per unit length of road, recognizing area terrain characteristics.

Traffic control: An analysis of traffic controls - how closely they meet MUTCD regulations, in terms of color, symbols, and proper sign distances. Also, do they convey sufficient information to the driver? Are they clearly visible and well maintained?
Accident rate: An assessment of the road segment's relative safety, based on the the number of fatal, personal injury, and property damage accidents, using accident records.

SERVICE
Alignment (horizontal): Frequency of occurrence of horizontal curves which cannot be safely negotiated at design speed.
Alignment (vertical): An analysis of deficiencies in vertical alignment, such as gradient exceeding design standards, or at railroads or drainage structures.
Pavement width (surface): A service rating based on the relationship between width and average daily traffic volume.
Improvement continuity: A rating which stresses the continuity (or discontinuity) of the rated segment compared to total route of which it is a part.
Ride quality: A rating element which is an evaluation of surface quality -- waviness, irregular surface evaluation, corrugations, and/or channeling.
Surface type: Is the surface type adequate for the type and volume of traffic using the road segment?
Shoulder width: For the average daily traffic on the evaluated road segment, does the width and condition of the shoulder meet design standards for adequate capacity and refuge for emergency stops?
Snow problems: An evaluation based on the ability of roadside ditches and accessible portions of the right-of-way to accommodate the quantity of snow that may have to be removed from the roadway and shoulders.

Appendix B

STATE QUESTIONNAIRE

State Questionnaire State ______________________

Name, title, telephone # of contact person

1. Does your state have a numerical evaluation system, a sufficiency rating or similar, used to prioritize secondary road projects for planning and/or budgetting purposes? Y N
2. If yes, by state or counties (circle one).
3. If state gathers data:
   a) Is there a written copy of the procedure? Y N
   b) Is it possible to get a copy? Y N (if yes, arrange for it)
   c) How are the results used?

   d) Does it vary from that used on primary roads? Y N
   e) If yes, how? (Try to gather details.)

   f) What do you use for data sources?

4. If local jurisdiction uses rating system, who do I contact to get information?

   a) Does state see the results? Y N
   b) If so, how is it used by the state?

   c) Does state do any disbursement of funds to local jurisdiction? Y N
   d) If so, describe briefly.

   e) Are the ratings used to prioritize any financial or other aid from state to local? Y N
   f) If so, how?

5. Are you aware of any attempt to evaluate surface condition of non-paved roads? (If so, try to get details.)

6. Who has responsibility for secondary roads in your state?

7. Do you know how the rating items and their weights were determined? If so, how?

8. What design standards are used for road design in your state? (If not a national standard, try to get a copy.)

Appendix C

SAMPLE EVALUATION FORMS AND GUIDE FOR PREPARATION

GUIDE FOR PREPARATION OF WORKSHEETS
Sufficiency Rating System for Secondary Roads

This is a set of instructions for completion of a set of worksheets. Completion of the worksheets will provide sufficient data for the assignment of a sufficiency rating to a designated segment of the county road system.

OFFICE WORKSHEET

Complete Part I from the field worksheet or office records. Combine road segments as appropriate to provide for logical continuity. List the I.D. numbers for each road segment from the Secondary Road Engineer's Listing.

Complete Part II from the Secondary Road County Engineer's Listing.

The Iowa DOT Alternate Design Guide (copy provided below) will be used as the basis for completion of Part III. Begin by determining the appropriate design class. Use ADT and the functional classification as a guide. Considering the type of terrain, determine the design standard and record the standard number. Then complete the ratings, using the information from Parts I and II and the guidelines provided in this document.

DESIGN GUIDES
RURAL PRIMARY AND SECONDARY HIGHWAYS
1982-2001 NEEDS STUDY

	Arterial Connector/Trunk/Trunk Collector									Area Service								
Highway Group	3			4			5			6			7			8		
ADT (Design Year)	Over 1,500			400-1,500			Under 400			Over 100			26-100			0-25		
Design Standard #	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Terrain[1]	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Design Speed	55	55	50	55	55	50	55	55	50	55	50	50	50	45	40	50	45	40
Max. Degree Curve	7	7	8	7	7	9	7	7	9	7	9	9	9	12	14	9	12	14
Max. Grade (%)	6	6	7	6	6	7	6	6	7	6	6	8	6	8	10	6	8	10
Stopping Sight	425	425	350	425	425	350	425	425	350	425	350	350	350	325	275	350	325	275
Lane Width[2]	12	12	12	12	12	12	11	11	11	11	11	11	11	11	11	11	11	11
Shoulder Width (Rt.)[3]	8	8	8	6	6	6	6	6	6	3	3	3	3	3	3	0	0	0
(Lft.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Median Width[4]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Surface Type[5]	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	4	4	4
Pavement Sec.[6]	1	1	1	1	1	1	3	3	3	3	3	3	0	0	0	0	0	0
Shoulder Type[7]	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4
Access Control[8]	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

1 - Terrain, 1=Flat, 2=Rolling, 3=Hilly.
2 - Actual number of lanes is computed based on the 1965 Highway Capacity Manual methods.
3 - Left shoulder applies only to divided highways. Left shoulder equals right shoulder width on two-lane highways.
4 - Median applied only when number of lanes required equals or exceeds four and divided highway justified.
5 - 1=Asphalt or portland cement concrete, 2=Surface treatment, 3=Gravel, 4=Earth.
6 - 0=No pavement, 1=Asphaltic or portland cement concrete, 2=Cold mix or road mix, 3=Seal coat, 4=Dust treatment.
7 - 1=Paved, 2=Stabilized, 3=Earth, 4=No shoulder.
8 - 1=Full control, 2=Partial control, 3=No control or local zoning.

Pavement (roadbed) Width Rating

For paved roads, use 2X the lane width for the design standard. If unpaved, use 2X (sum of lane width standard + shoulder width standard). Use the roadway width (for non-paved roads) for roadbed width. Use the table provided below to rate the road segment.

TABLE 1

Pavement (roadbed) Width Ratings

Design Width (ft)	Actual	Rating Score
Paved		
24	=>24	9
24	23-24	7
24	22-23	6
24	20-22	5
24	18-20	4
24	<18	1-3
22	=>22	9
22	21-22	7
22	20-21	6
22	18-20	5
22	<18	1-4
Unpaved		
34	=>34	9
34	33-34	7
34	32-33	6
34	30-32	5
34	28-30	4
34	26-28	3
34	<26	0
30	=>30	9
30	29-30	7
30	28-29	6
30	26-28	5
30	24-26	4
30	<24	0
28	=>28	9
28	27-28	7
28	26-27	6
28	24-26	5
28	<24	1-4
22	=>22	9
22	21-22	7
22	20-21	6
22	18-20	5
22	<18	1-4

Shoulder Width Rating

Use Table 2 to select the ratings for the Shoulder Width criterion. Record only if the road is paved.

TABLE 2

Shoulder Width Ratings

Design Width (ft)	Actual	Rating Score
8	=>8	5
8	6-8	4
8	4-6	3
8	<4	0
6	=>6	5
6	4-5	4
6	3	3
6	<3	0
3	=>3	5
3	2	4
3	1	3
3	0	0

Surface Type Rating

Relate design standard to surface type (as noted in Iowa DOT records). To relate surface type code to design standard, refer to Table 3 provided below.

TABLE 3

Surface Type Codes

CODE	DESCRIPTION
7001, 7011	P. C. Concrete
6202, 6901, 6902, 6903	Asphaltic Concrete
3210, 4221, 5223	Surface Treatment
2010, 2015	Gravel (granular)
0010, 1014	Earth

Rate the road segment (non-paved roads) as shown below.

Design Standard	Actual	Rating Score
Paved	Paved	5
Stabilized	Gravel or better	5
Stabilized	Earth	3

Passing Sight Distance Rating

Relate passing sight distance (at design speed) to alignment. Compute % of rated segment available by:

- -determining total length/segment with restricted passing, and
- -computing the percent available, via the equation shown below.

% Available = 100[Segment length-restricted length(sum)]/Length

Determine rating score by selecting from Table 4 below, using the appropriate design standard and computed % Segment Available. (See reprint of design standards, page 1.)

TABLE 4

Safe Passing Sight Distance Score

Design Std.	7	8,10,13,16	9,11,12,14,15,17	18,20,21,23,24
91-100	5	5	5	5
81-90	4	5	5	5
71-80	4	4	4	5
61-70	3	4	4	4
51-60	3	3	3	4
41-50	2	3	3	3
31-40	1	2	2	3
21-30	0	1	1	2
0-20	0	0	0	0

Horizontal Alignment (from Safety Evaluation)

Make no point deduction for any curve whose safe operating speed => Design Speed - 5 mph. Therefore, analysis is to be done only for curves with safe operating speed at 10 mph or less than design speed.

Example: Road segment with Design Speed = 50 mph. Compute point deductions for curves with maximum safe operating speed <= 40 mph.

The table below assumes that the appropriate superelevation exists on each curve (not to exceed 0.08 foot per foot). For curves without appropriate superelevation, determine the maximum safe operating speed by driving through the curve.

Maximum Degree of Curve	Design Speed
11.5	40
16.0	35
23.0	30
33.0	25
50.0	20

Complete the Office Worksheet by recording ratings from the Safety Evaluation Worksheet and the Field Worksheet.

FIELD WORKSHEET

Complete Part I. Road identification numbers are to be taken from the Secondary Road County Engineer's Listing. Group according to width data.

Complete the ratings for Part II. Use the Field Data Collection Guide from the next page of these instructions. Make a copy and attach to your clipboard.

Make notes on Hazards and Traffic Control Problems for the Safety Evaluation.

SAFETY EVALUATION WORKSHEET

This worksheet should be completed, using office records and notes from the Field Worksheet.

Part I is identical to Part I of the Field Worksheet.

TABLE 5

FIELD DATA COLLECTION GUIDE

NOTE: Use in judging the average condition throughout the road segment.

Rating Criteria	General Descriptions Excellent	Good	Fair	Poor
Foundation	No base failure. Foreslopes in excellent condition.	Occasional base failure, fully correctable by spot repairs. No need for extensive rework.	Frequent base failure, requiring heavy maintenance. Causes reduction in speeds below design speed. Candidate for reconstruction. Tolerable.	Severe base failure over all. Extreme 'wash-board' condition. Speeds reduced significantly. Needs rebuild.
Wearing Surface	Satisfactory. Smooth surface. Routine grading for granular surface. No surface failure.	Occasional spots of surface failure, correctable by normal maint. Resurfacing not absolutely necessary.	Frequent spots of surface failure, correctable by heavy maintenance. Rough surfaces cause reduction in speed. Tolerable.	Severe surface failure over all/segment. Resurfacing or reconstruction necessary. Substantial speed reduct.
Drainage	Satisfactory. No silting, scouring, significant erosion or ponding. Culverts are adequate, in good condition.	Heavy rains cause occasional ponding - some silting or scouring of culverts, requiring maintenance. Some problems with slope of crown.	Substantial ponding during light rain. Traffic problems due to ponding, rough or softened surface or fnd. Excessive costs of maintenance of road and/or drainage. Costly corrections or improvements needed. Tolerable.	Excessive ponding, poor drainage. Problems not correctable through maintenance.
Maintenance Economy	No expendituress except routine. Pavement patch rarely needed. Occasional need for add'n of gravel, but not lge. amounts. Earth road regularly needs blading, but no real problem.	Some expenses, not excessive. Some annual patching needed. Resurf/pvmt. desirable, not necessary. More gravel desired, not really necessary. Spot re-grading or extra dragging required.	Large expenditures of money, material. Much patching and crack filling. More gravel needed continuously, or annually. Road candidate for resurface/rebuild. Special attention needed on many locations. Tolerable.	Lge. expenses needed to keep serviceable. Great amt. of patching, more gravel needed regularly. Many spots need much regrading. Needs rebuilding.

Ride Quality	Smooth riding at design speed or above.	Minor roughness of surface causes little discomfort in riding. Occasional irregularities, corrugations, or channelling causes driver to slow to below design speed for short distances.	Noticeable discomfort in riding due to surface roughness. Occasional pvmt. cracking & failures require extensive patching. 'Wash-board' on gravel surface road requires frequent grading. Tolerable.	Heavy cracking, deep failures, obvious instability. Unsatisfactory riding surface.
Snow Problems	No significant drifting problems. Roadbed above surrounding area, ditches deep and wide for storage.	Occasional locations where drifting is a problem. Ditches still wide and deep enough to accommodate most of the snow.	Frequent locations where drifting a problem, but no extremely long drifting areas or places where very deep drifts occur. Some problems on ditch width or depth. Roadbed elevation occasionally inadequate. Ditch may need some extensive maintenance to clear silt or vegetation. Tolerable.	Drifting and/or snow removal a recurring problem of significance. R-O-W width inadequate to allow for ditches to be wide or deep enough, or extensive grading needed to raise the roadbed and/or improve ditches.

FIELD WORKSHEET - Sufficiency Rating System

County__________ Length ______miles Odometer-begin_______ end______

Local I.D. ____Std.___

Road I.D. Nos. _______ _______ _______ _______ _______ _______

Functional Class (circle) Trunk Trunk Collector Area Service

Record average condition over the rated road segment for each of the following rating criteria by circling the proper point score.

CRITERION	RATING SCORES Excellent		Good		Fair	Poor			
Foundation	9	8	7	6	5	4	3	2	1
Wearing Surface	9	8	7	6	5	4	3	2	1
Drainage	8	7	6	5	4	3	2	1	
Maintenance Economy	9	8	7	6	5	4	3	2	1

Subtotal - Condition and Maintenance Experience ____

Other field rated (or verified) scores.

Ride Quality	6	5	4	3	2	1
Snow Problems	5		4	3	2	1

Total (Worksheet) ____

Notes on other field observations

Hazards — Odometer Reading

- Narrow drainage structure _____ _____ _____
- R. R. X-ing @ grade w/o signals _____ _____ _____
- Poor Structure Approach (specify) _____ _____ _____
- Other Fixed Structure Encroachment _____ _____ _____

Traffic Control Problems

- Poor pavement markings (readability) _____ _____ _____
- Warning sign distance _____ _____ _____
- Vision @uncontrolled intersection _____ _____ _____
- Consistency/sign placement _____ _____ _____
- Other ______________________ _____ _____ _____

Other Notes:

SAFETY EVALUATION WORKSHEET - Sufficiency Rating System

County__________ Length ______miles Odometer - begin_______ end______

Local I.D. ____Std.___

Road I.D. Nos. _______ _______ _______ _______ _______ _______

Functional Class (circle) Trunk Trunk Collector Area Service

Accidents (use data from past five years):
- Property damage (Y,N). If yes, how many? ___X 1 point =____
- Personal injury (Y,N). If yes, how many? ___X 3 points=____
- Fatality (Y,N). If yes, how many? ___X 5 points=____

Total Accident Points ____

Hazards (see field worksheet and County Engineer's Listing)
- Structure (bridge or culv) restricts rdy. width (<20')__X 2=__
- Poor structure approach alignment __X 2=__
- R. R. X-ing @ grade without automatic signals __X 2=__
- Other fixed structure extending onto roadbed __X 2=__
  (10' from edge/pavement or onto roadbed)
- Abrupt or severe grade changes __X 2=__
- Combination of above conditions __X 2=__
- Other conditions (describe)________________________ __X 2=__

Total Hazard Points ____

Stopping Sight Distance Design Std.=___ SSSD=____@ Design Speed
- Single occurrences ____ X 1 point/occurrence = ____
- Multiple occurrences two ____ X 2 points/occurrence = ____
  - three ____ X 3 points/occurrence = ____
  - four ____ X 4 points/occurrence = ____

Total SSD Points ____

Traffic Controls (see field worksheet) - record occurrences/segment
- Poor pavement markings (readability) ____ X 2 = ____
- Warning sign distance ____ X 2 = ____
- Vision @ uncontrolled intersection (non-crop) ____ X 2 = ____
- Consistency of sign placement ____ X 2 = ____
- Other ____________________________ ____ X 2 = ____

Total Traffic Control Points _____

Horizontal Alignment [Road design speed = ____mph]
Compute point deductions based on the number of curves on the rated road segment with design speeds @ least 10 mph less than the road design speed.
- ___ curves @ 10 mph less than design speed X 1 = ___
- ___ curves @ 15 mph less than design speed X 2 = ___
- ___ curves @ 20 mph less than design speed X 3 = ___

Total Horizontal Alignment points ____

SAFETY EVALUATION TOTAL (total scores as noted below)

[Accident + Hazards + SSD + Traffic Controls + Horizontal Alignment]
Length (miles)

[____ + ____ + ____ + ____ + ____]/L = _____ points

OFFICE WORKSHEET - Sufficiency Rating System

County__________ Length ______miles Odometer-begin_______ end______

Local I.D. ____Std.___

Road I.D. Nos. _______ _______ _______ _______ _______ _______

Functional Class (circle) Trunk Trunk Collector Area Service

BASIC DATA - Iowa DOT Records

Surface Type ____ Width/surface____' Width/rdy____' ADT____Yr___

Number/R.R. X-ings____ Number/Structures______

OFFICE RATING

Record the Design Standard (use functional class, ADT)_____
Compare rated road segment to design standards and score.

Pavement (roadbed) width: Design Std.___' Actual___' Rating___

Shoulder width (paved): Design Std.___' Actual___' Rating____

Surface type (non-paved): Design Std.____ Actual____ Rating____

Passing sight distance: Design Std.____ Actual____ Rating____

WORKSHEET TOTAL (include only three ratings) _______

COMPOSITE RATING

The composite rating of the road segment is equal to the sum of individual ratings from three (3) sheets. These are the:

Field Worksheet,
Safety Evaluation Worksheet, and
Office Worksheet (this sheet).

List the scores from each sheet below and record the composite score in the space provided.

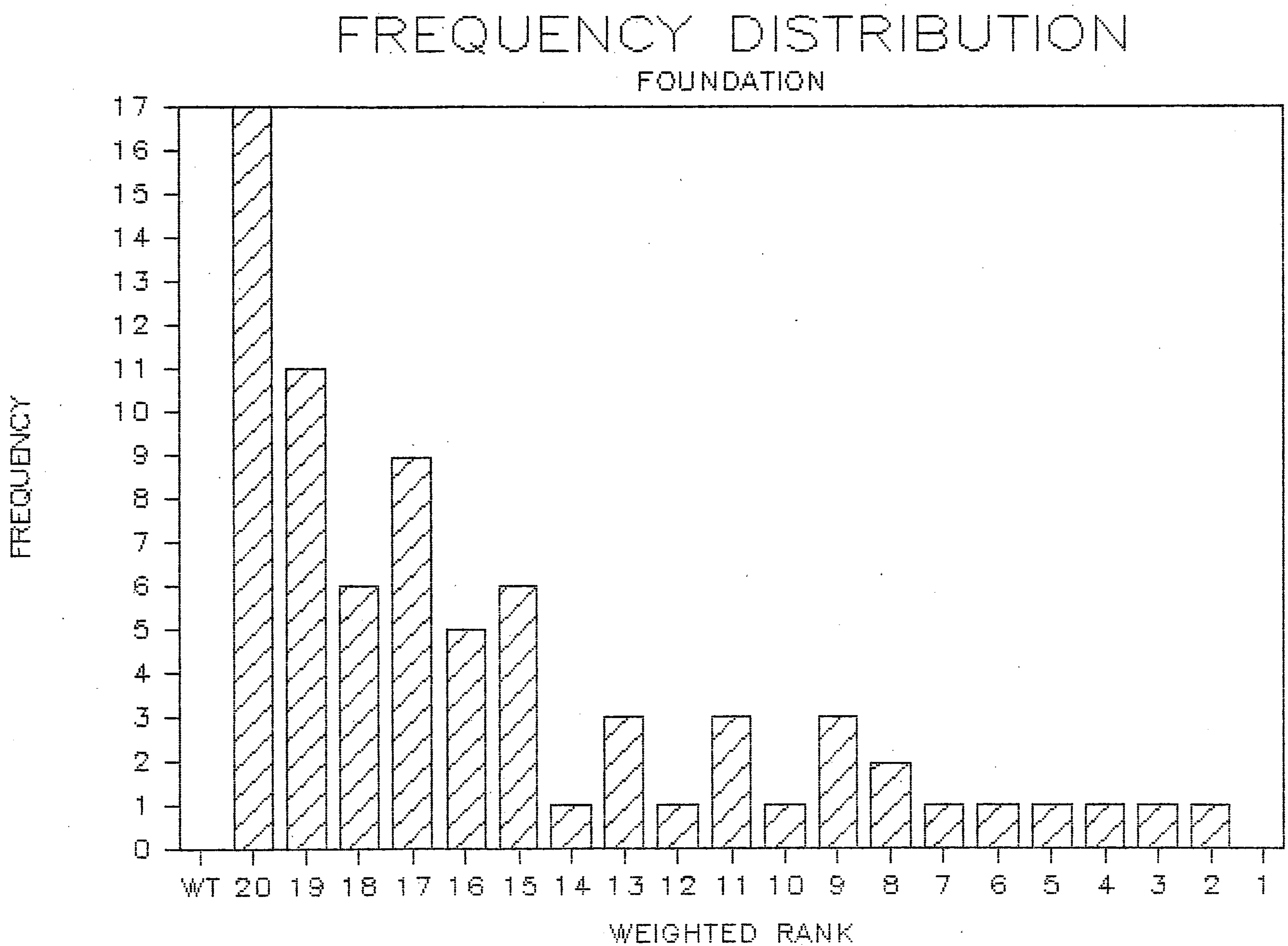
Field Worksheet____ + Safety Evaluation____ + Office Worksheet___

COMPOSITE SCORE _____

Notes on rating (include any remarks on critical needs):

Appendix D

FREQUENCIES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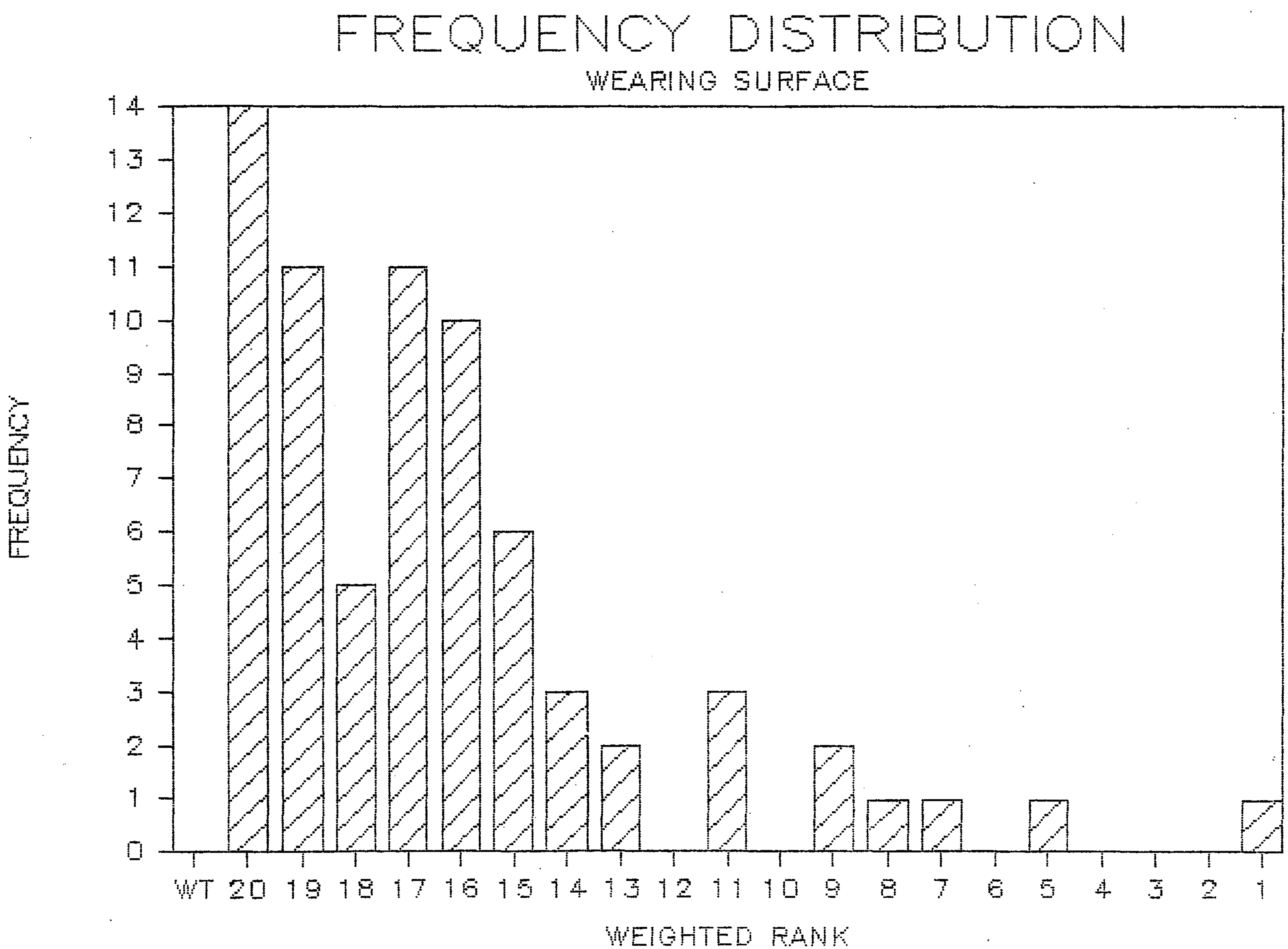

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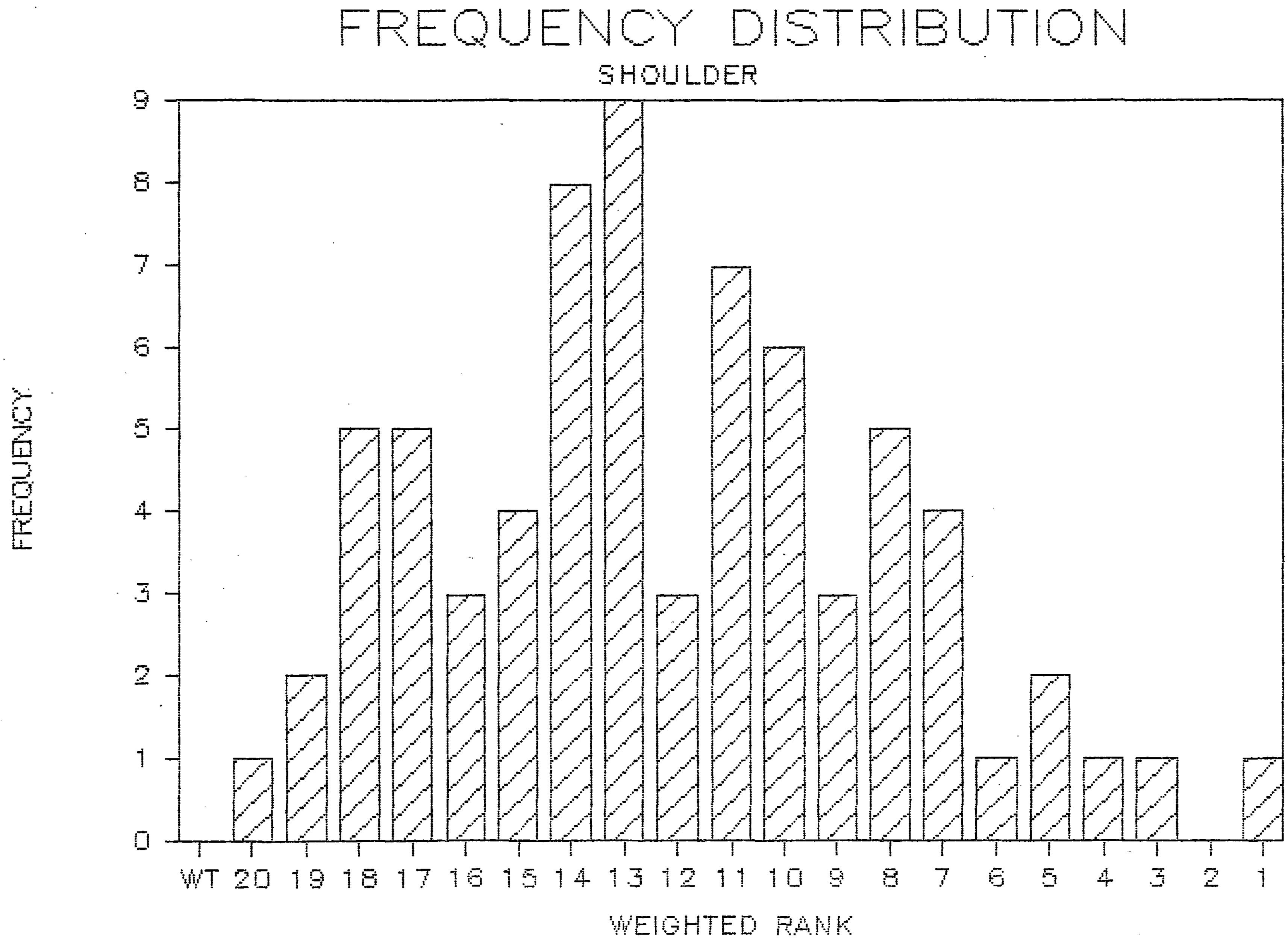

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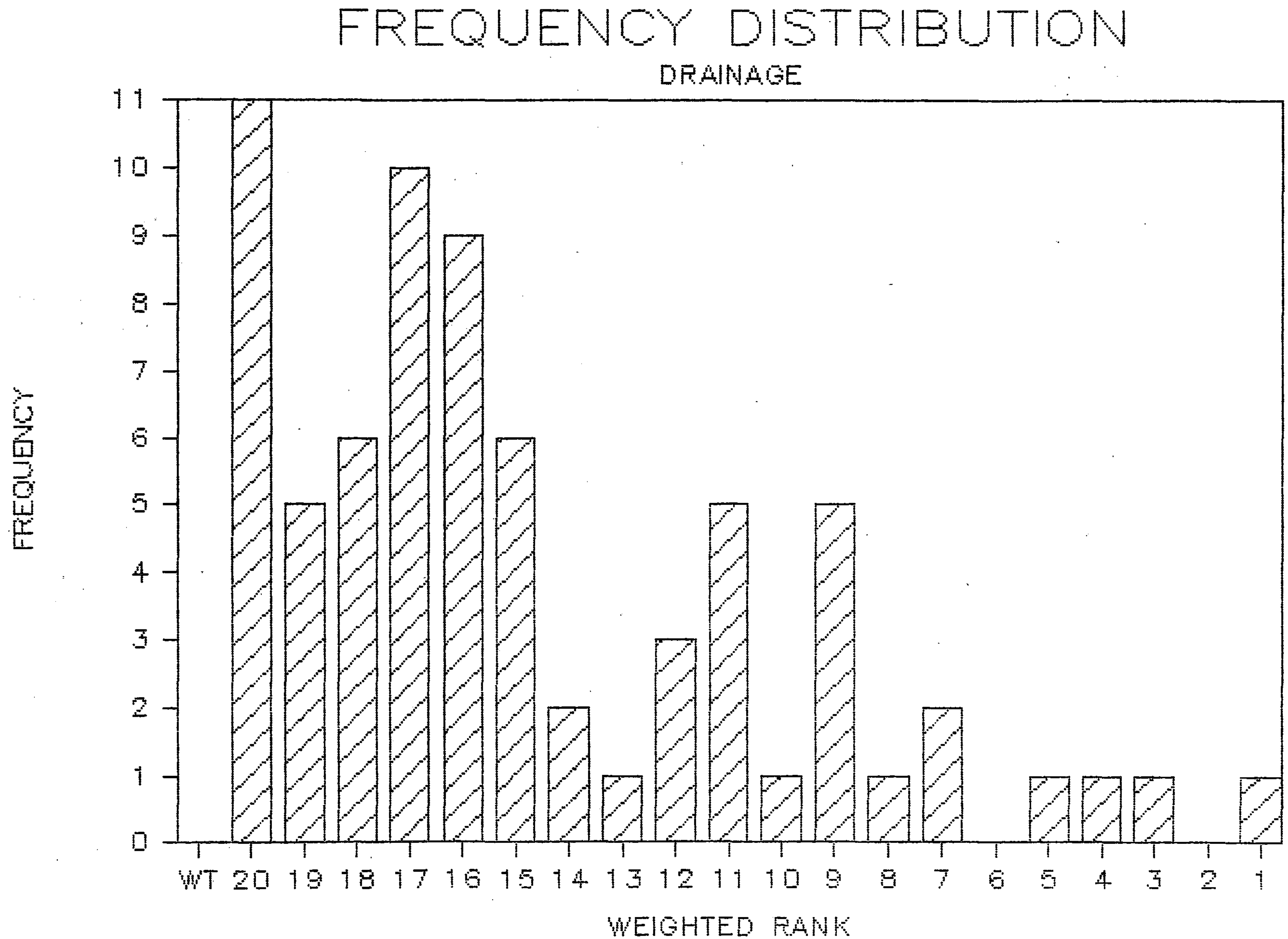

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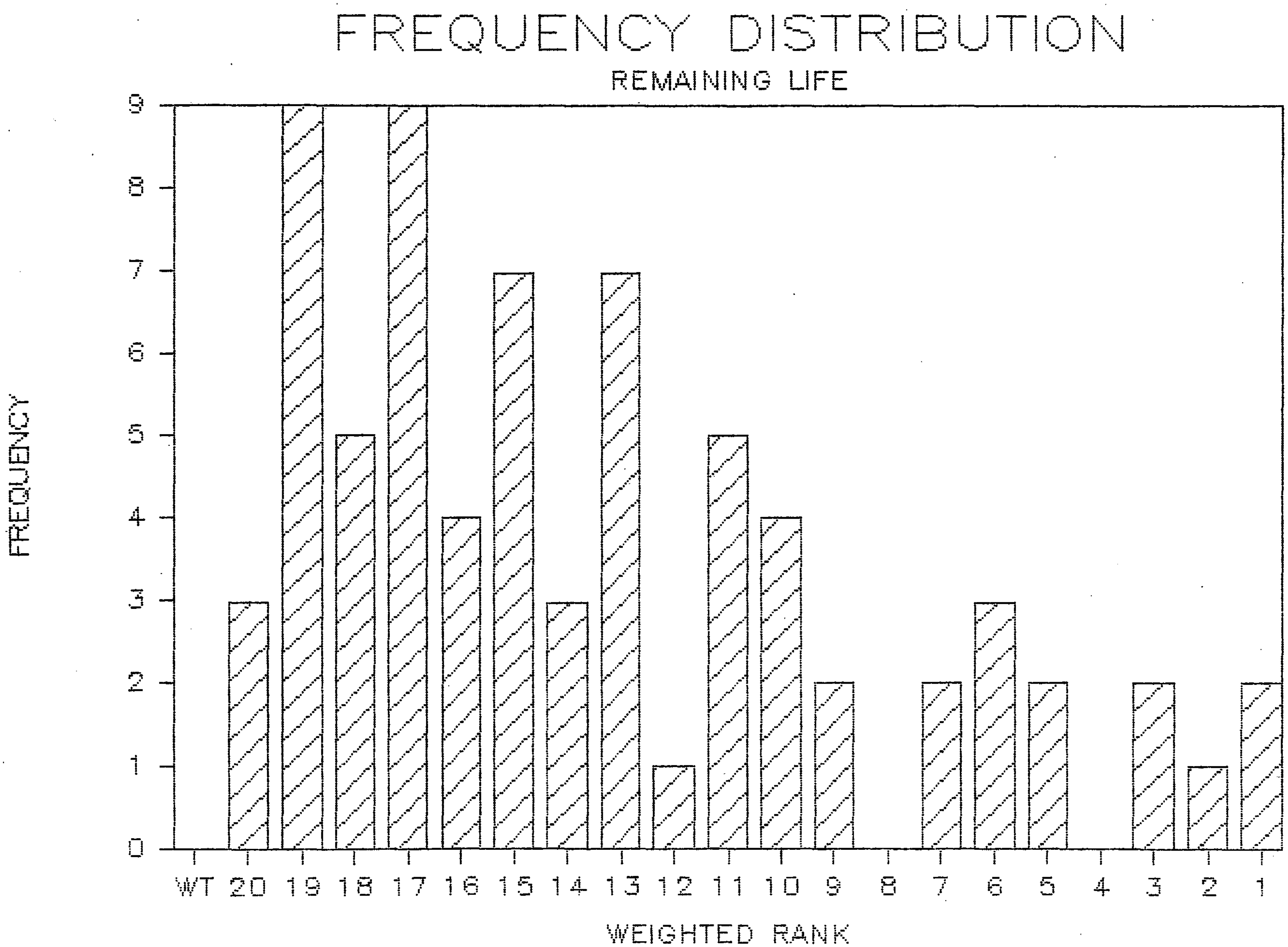

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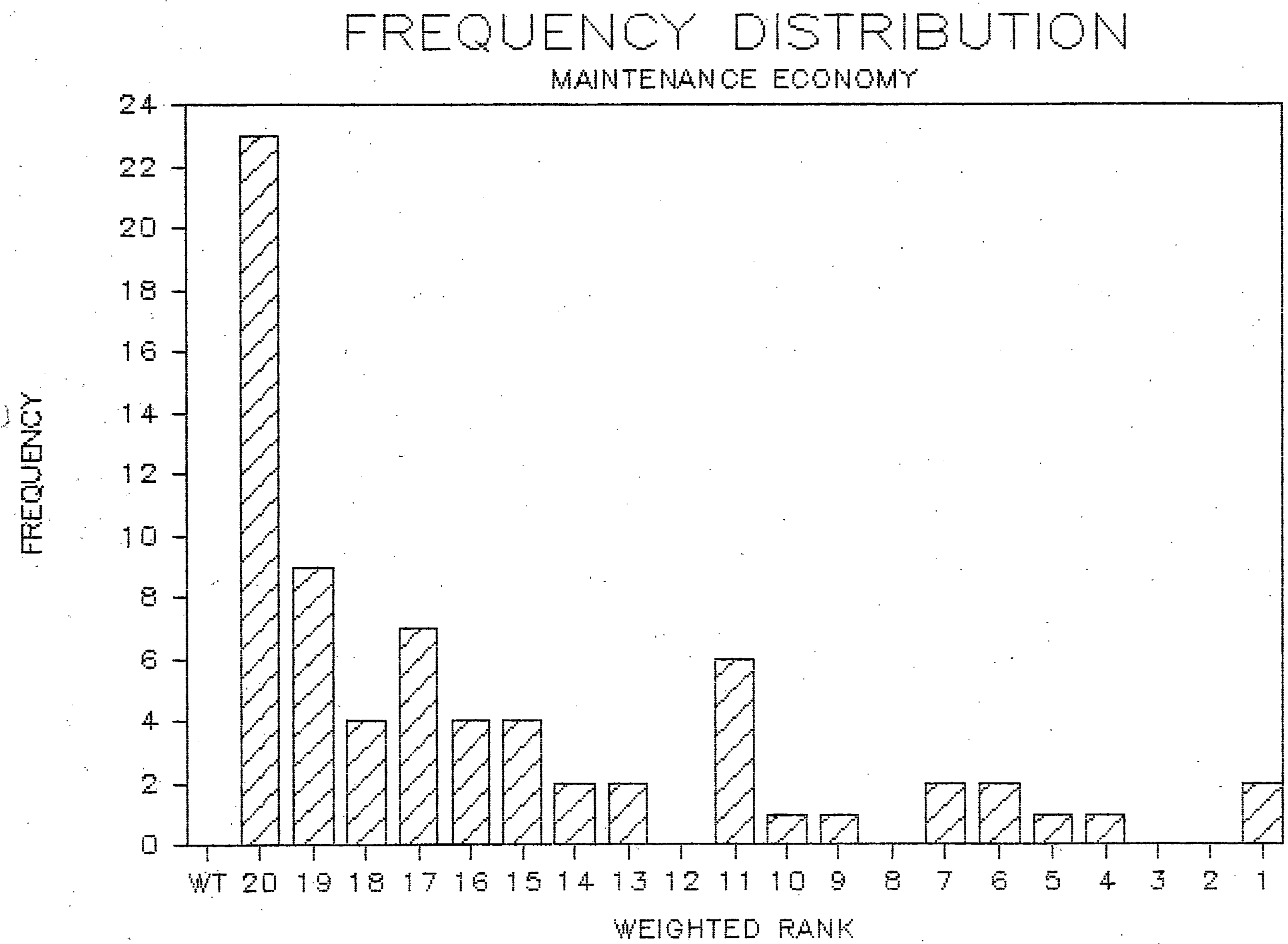
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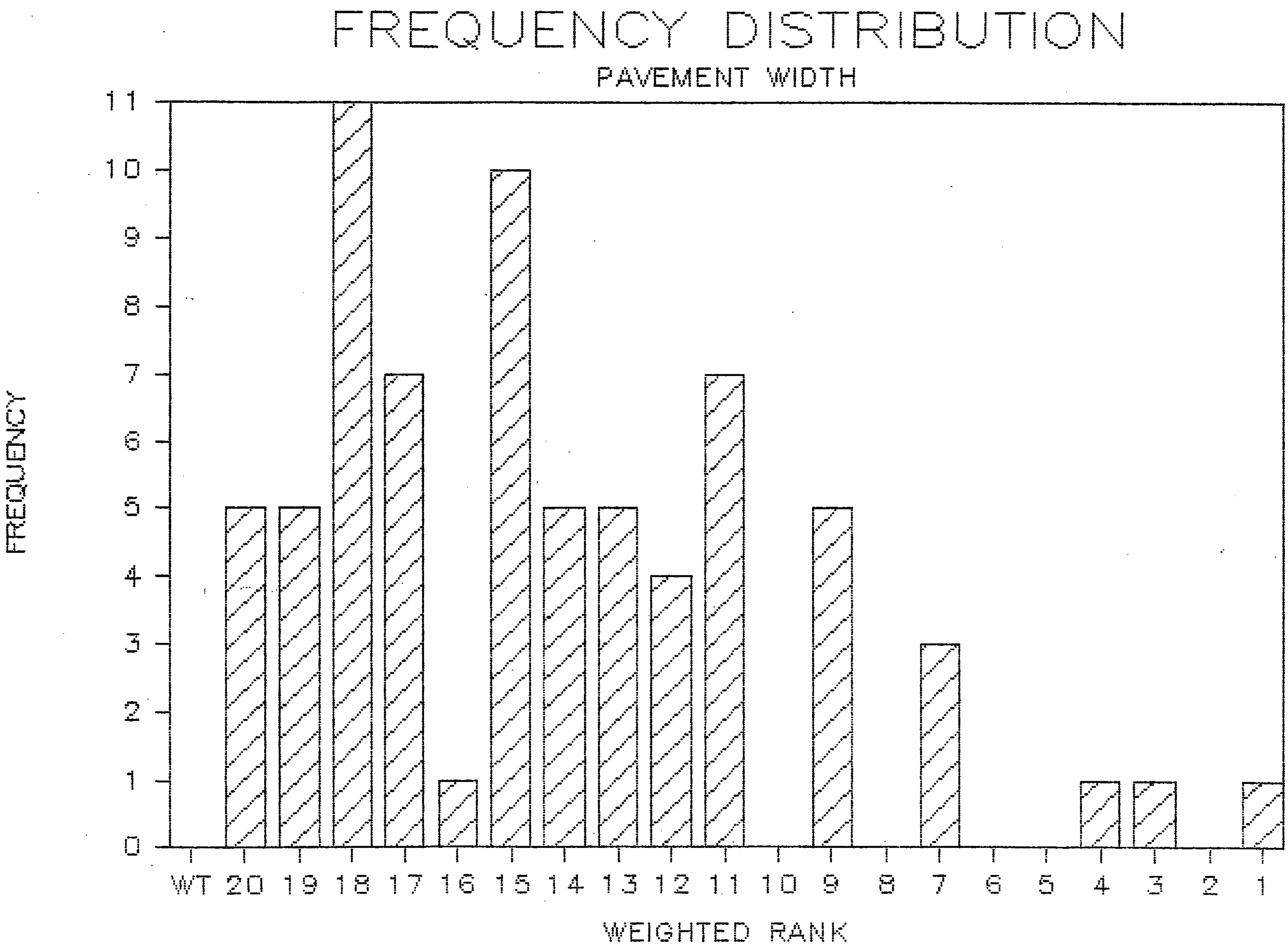
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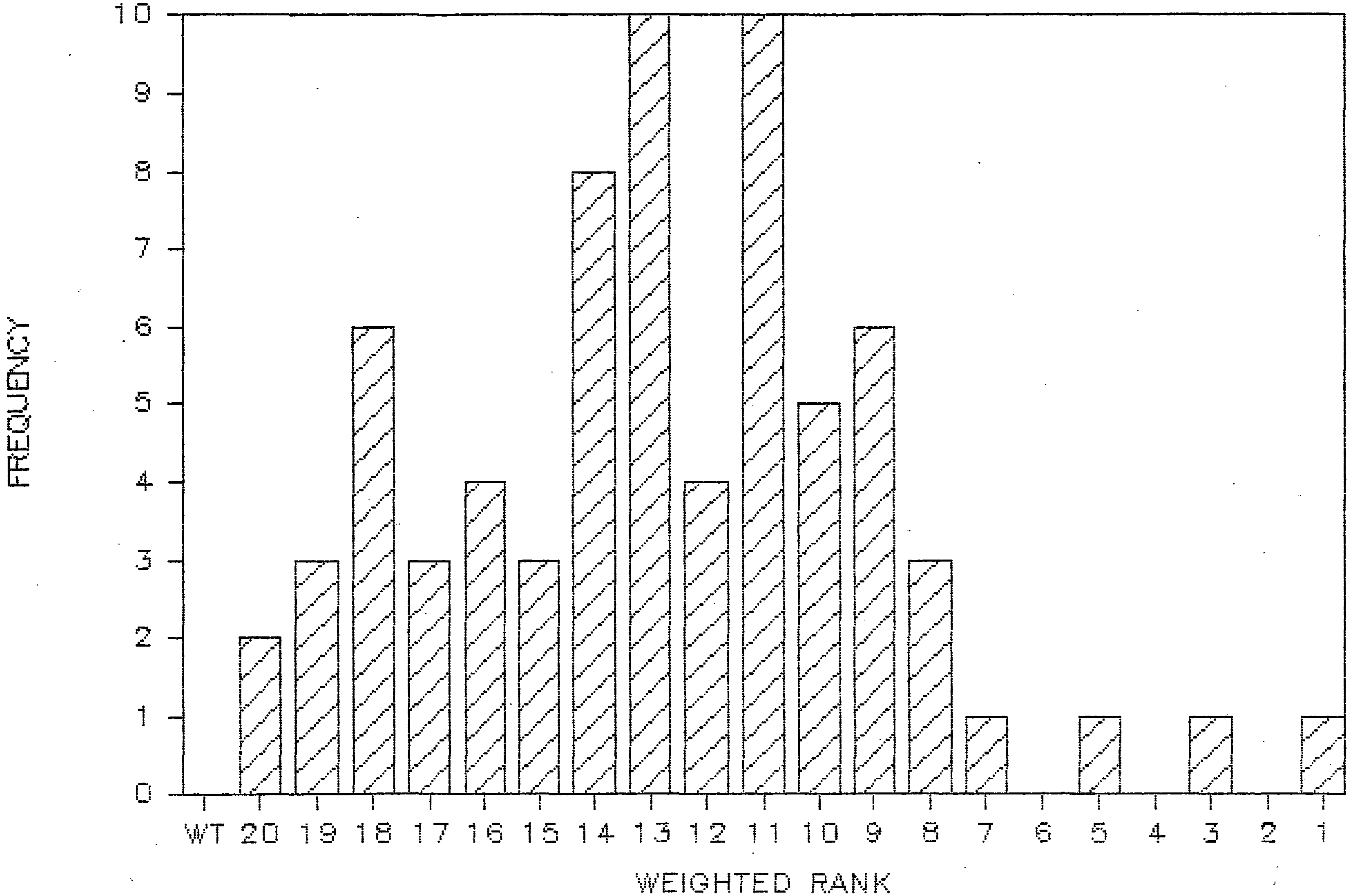

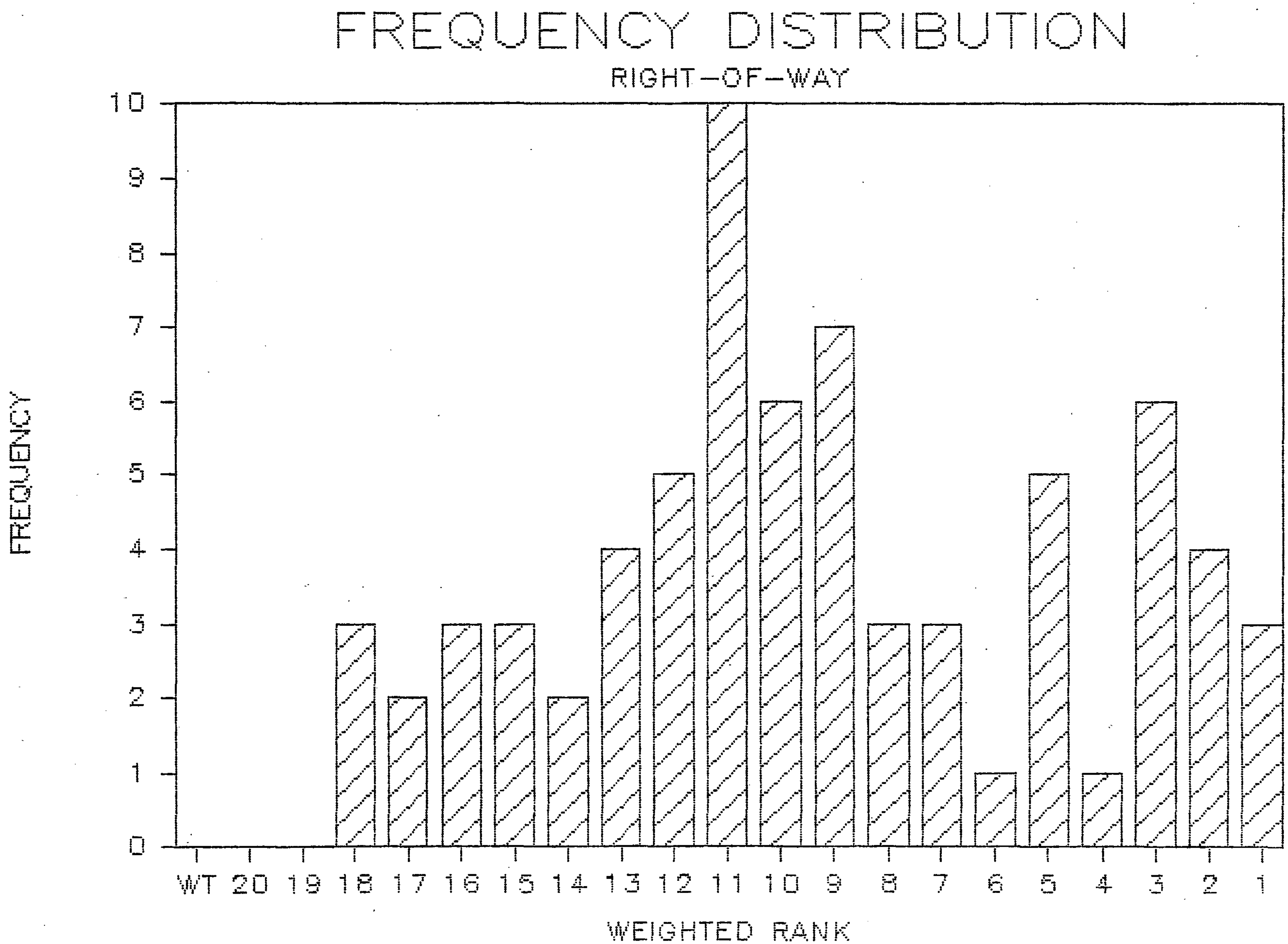
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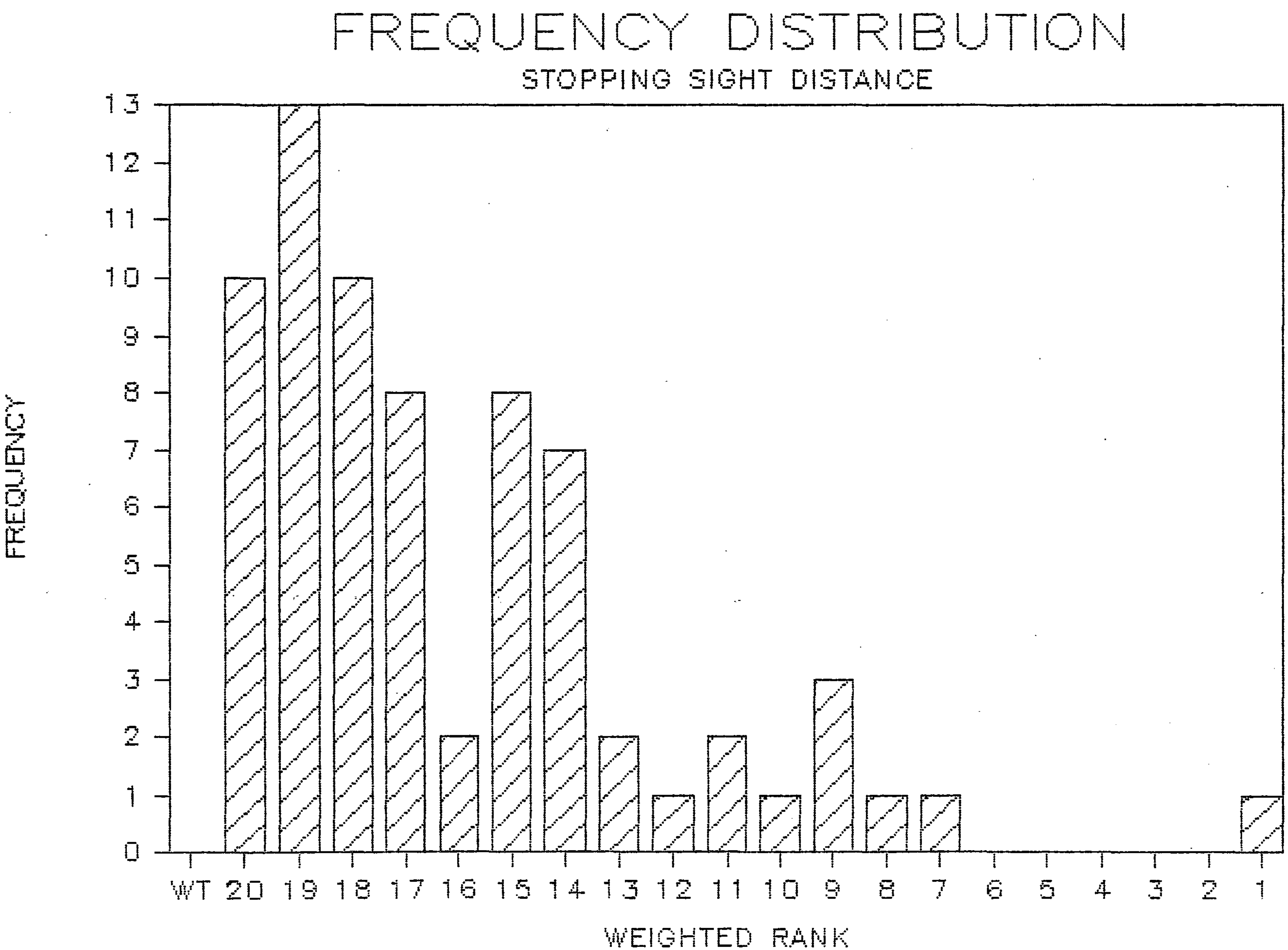
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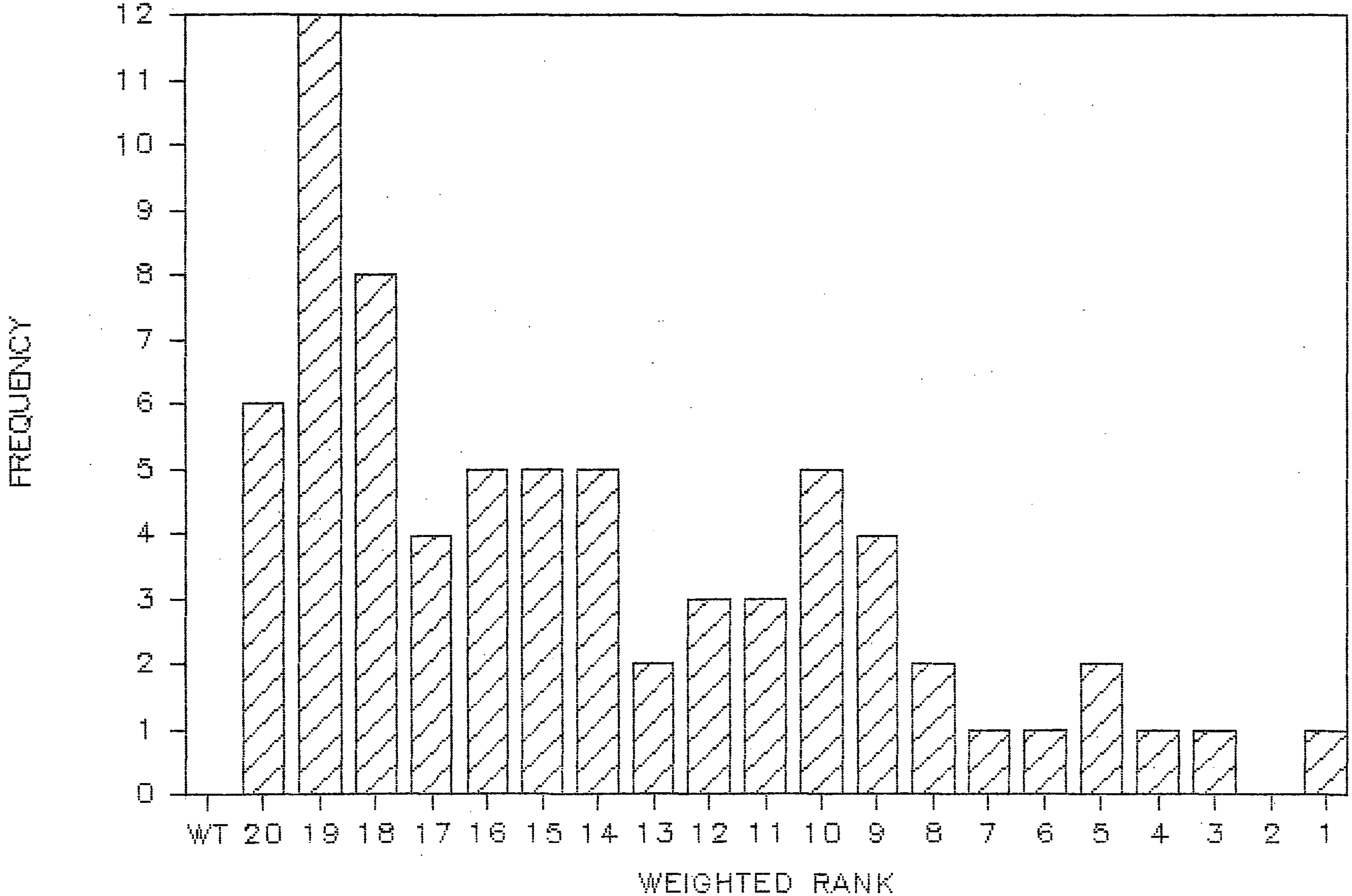

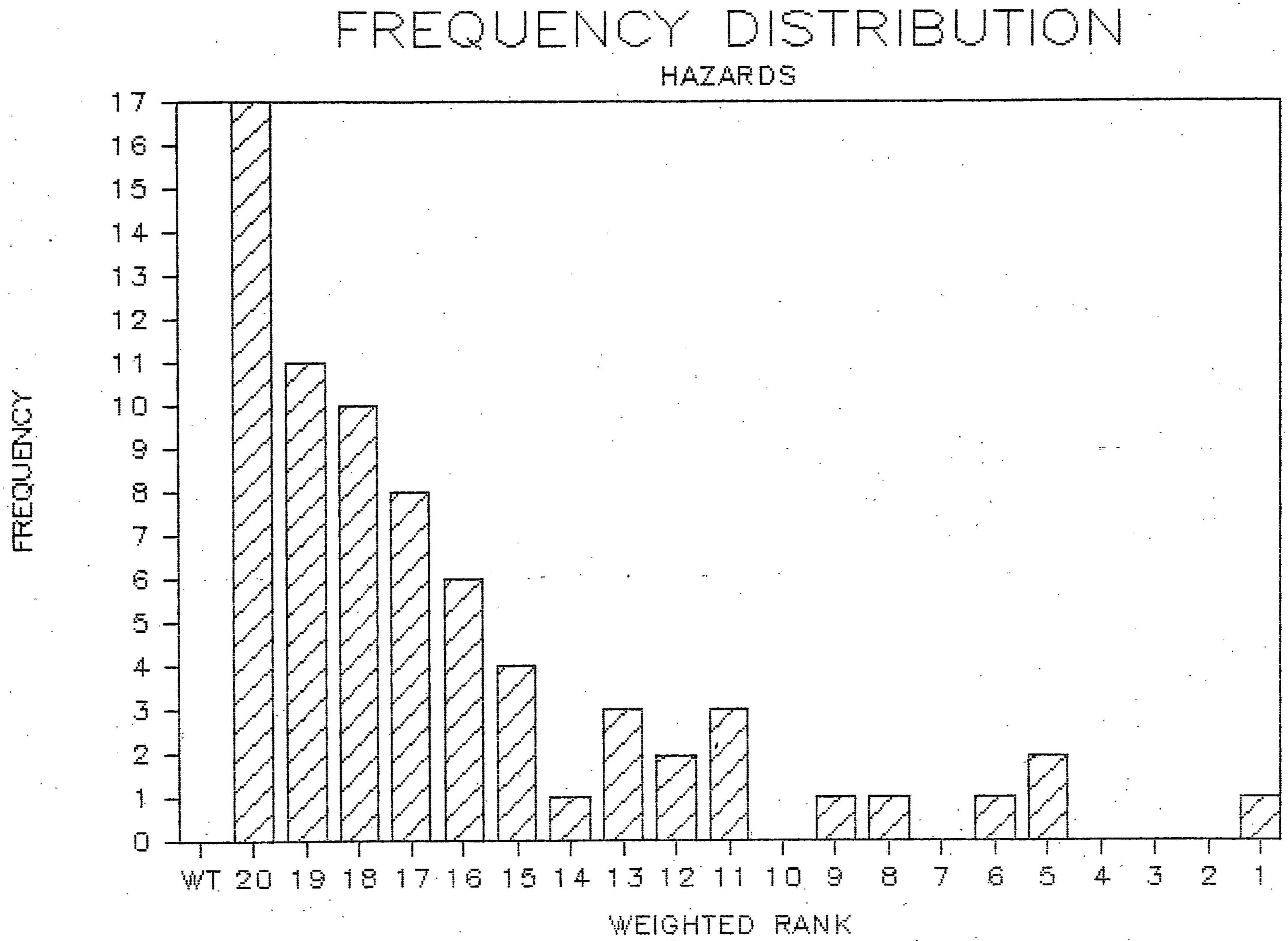

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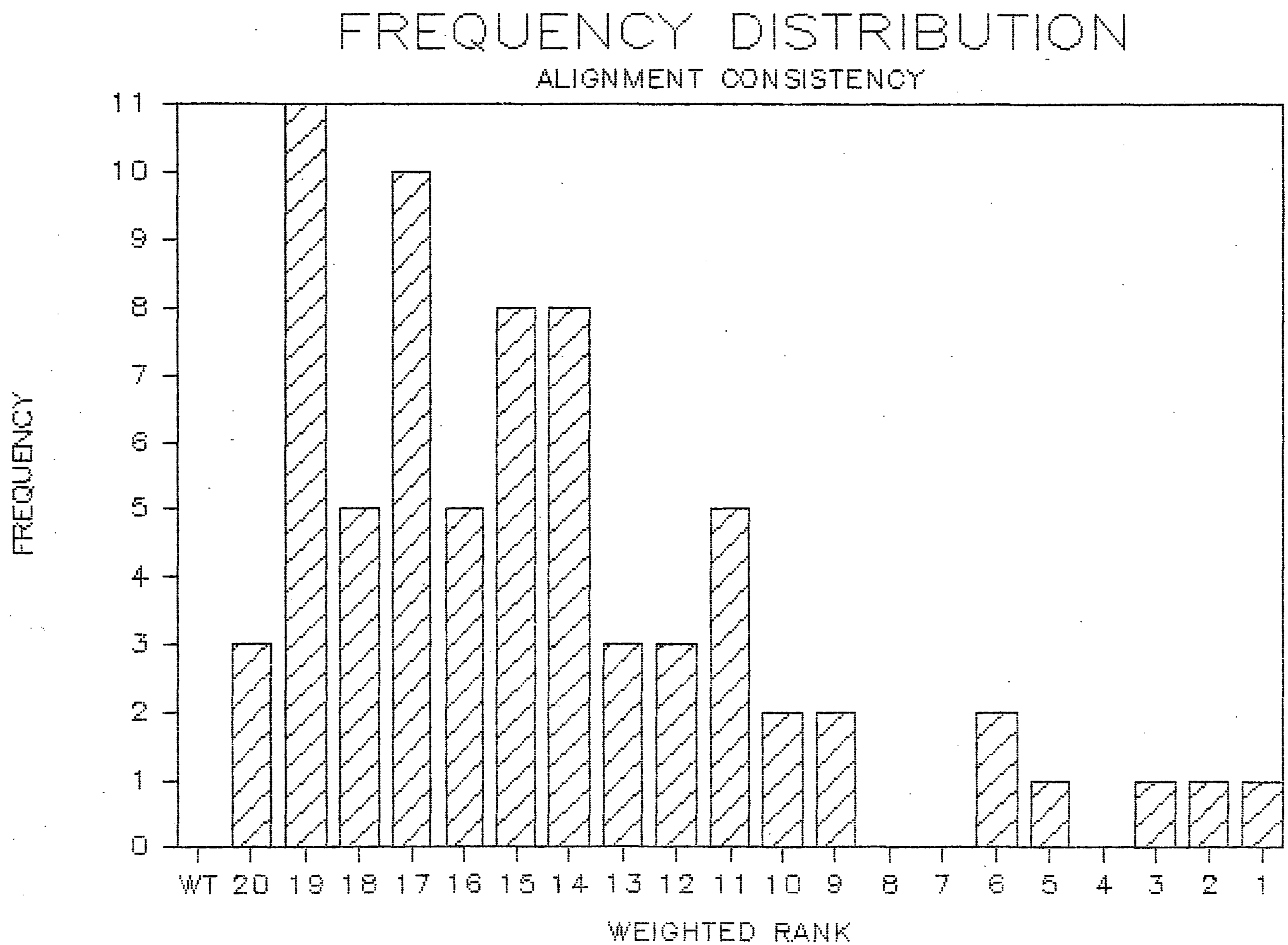
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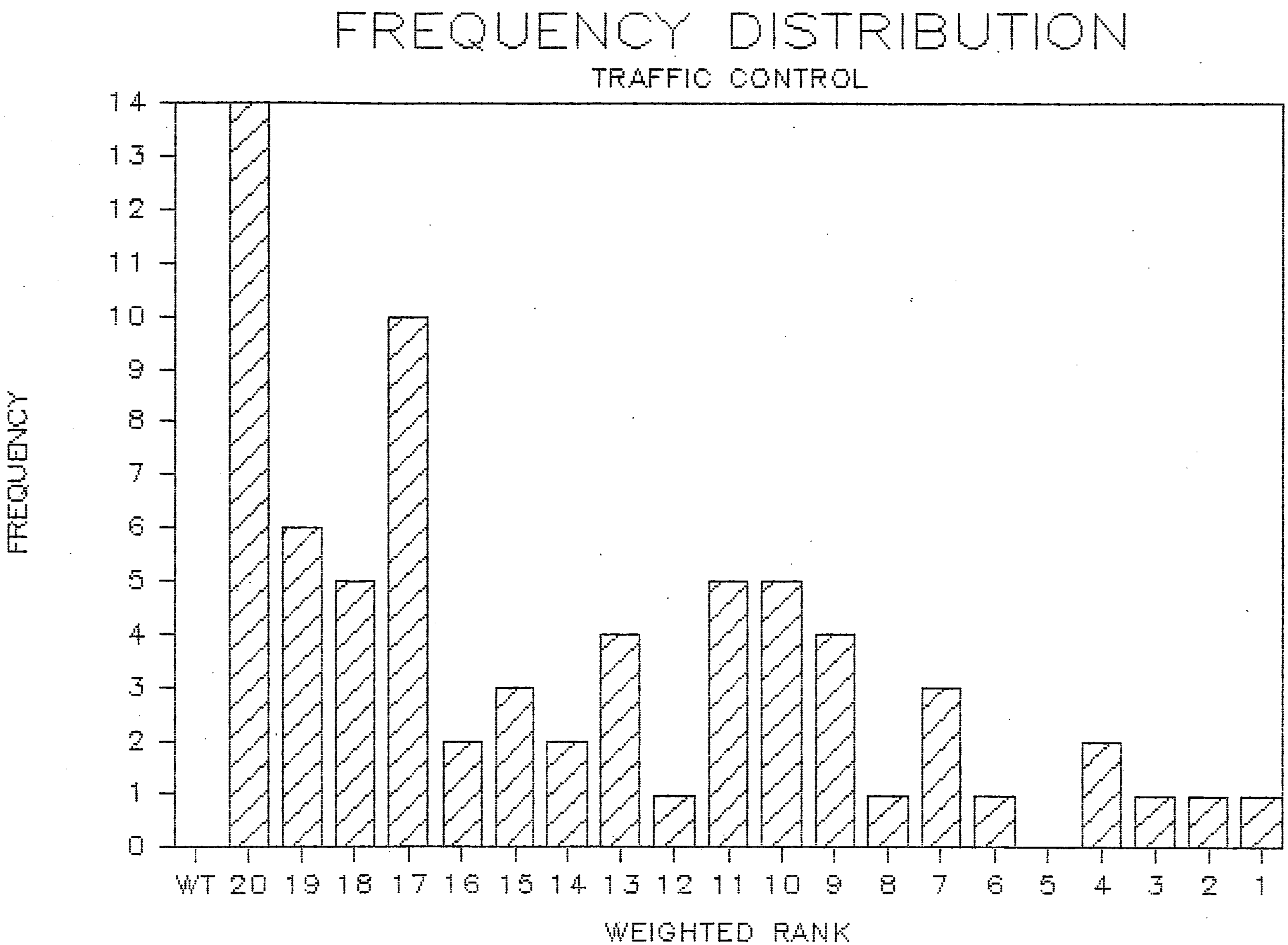
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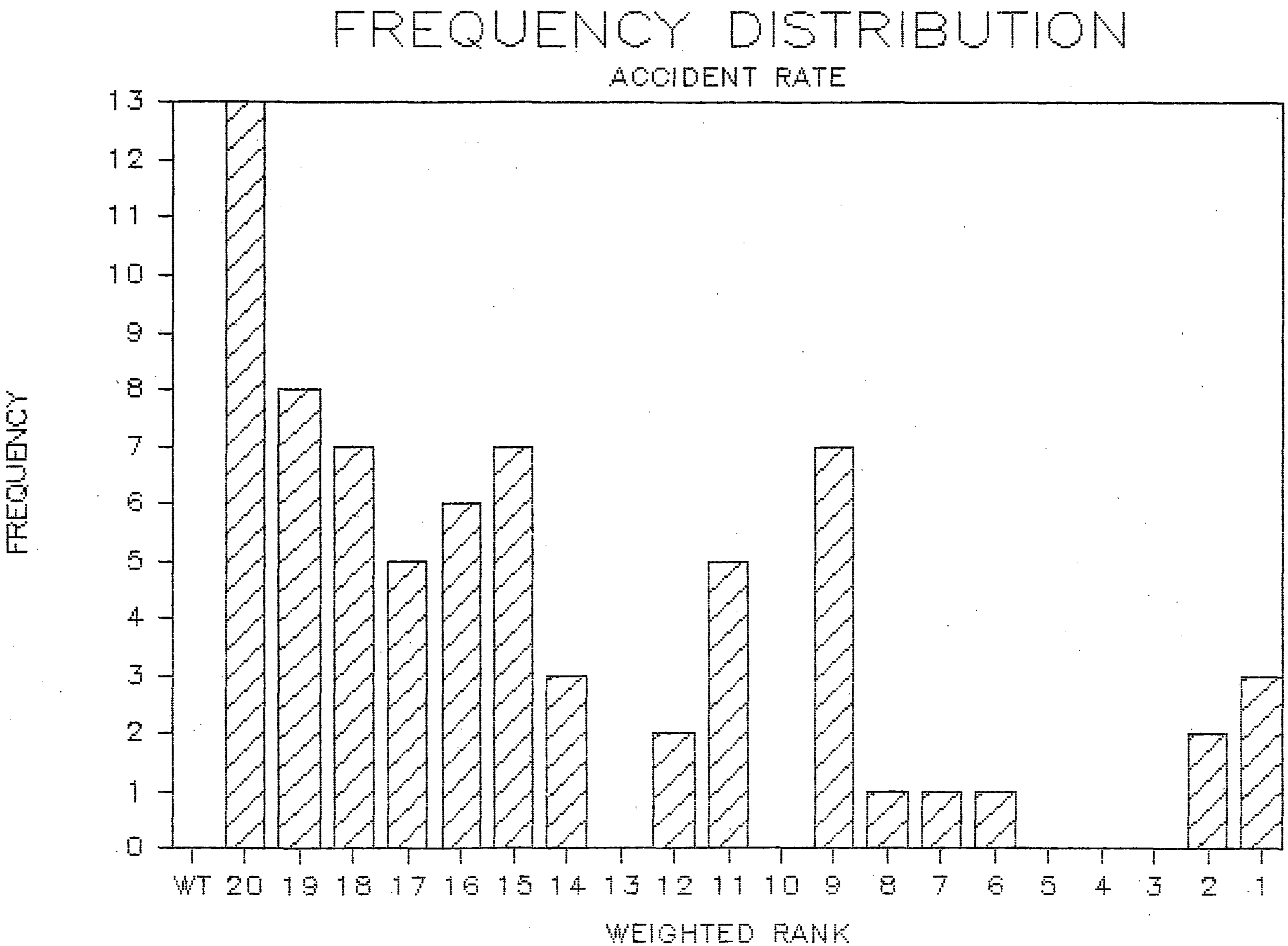

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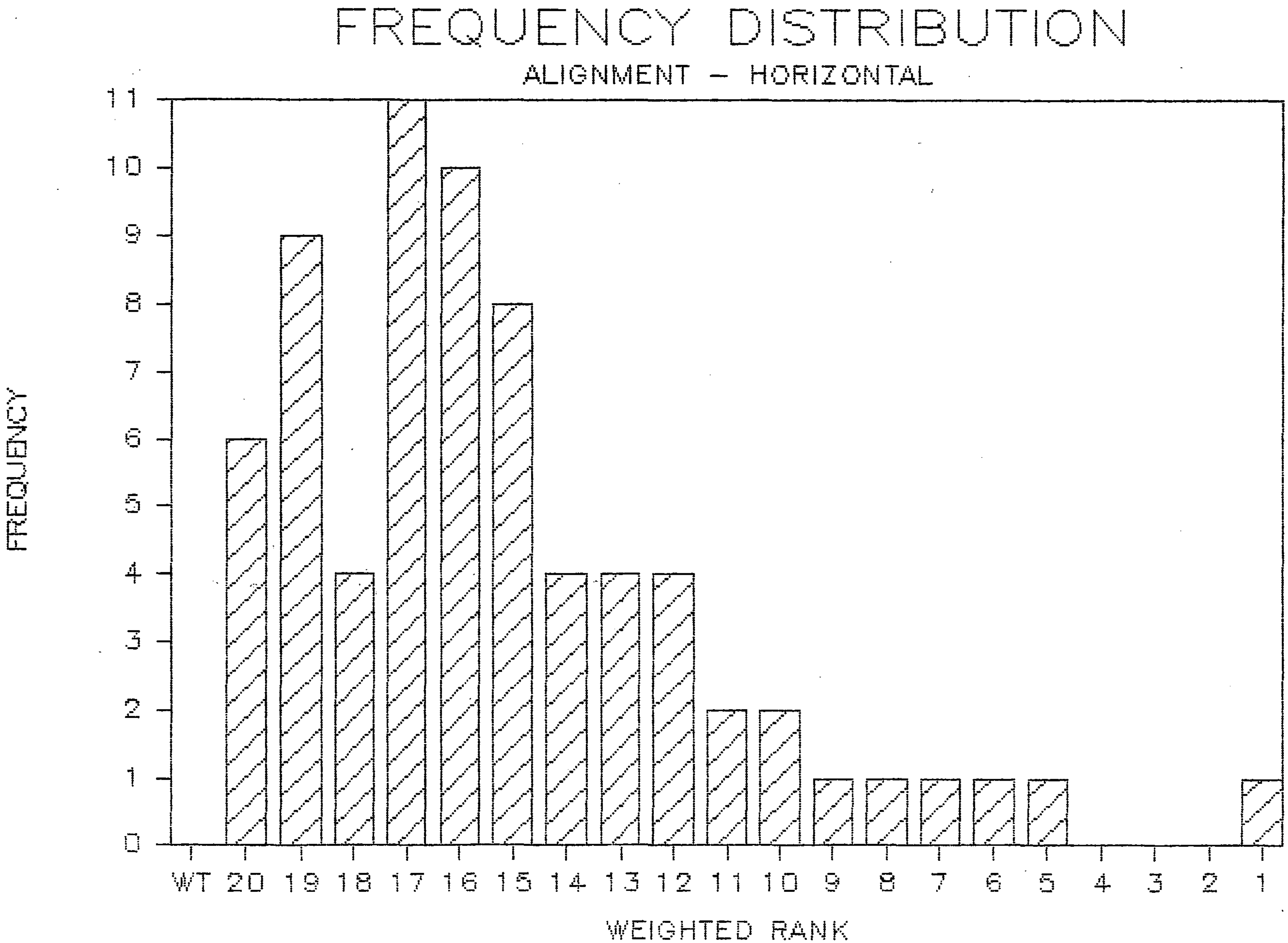
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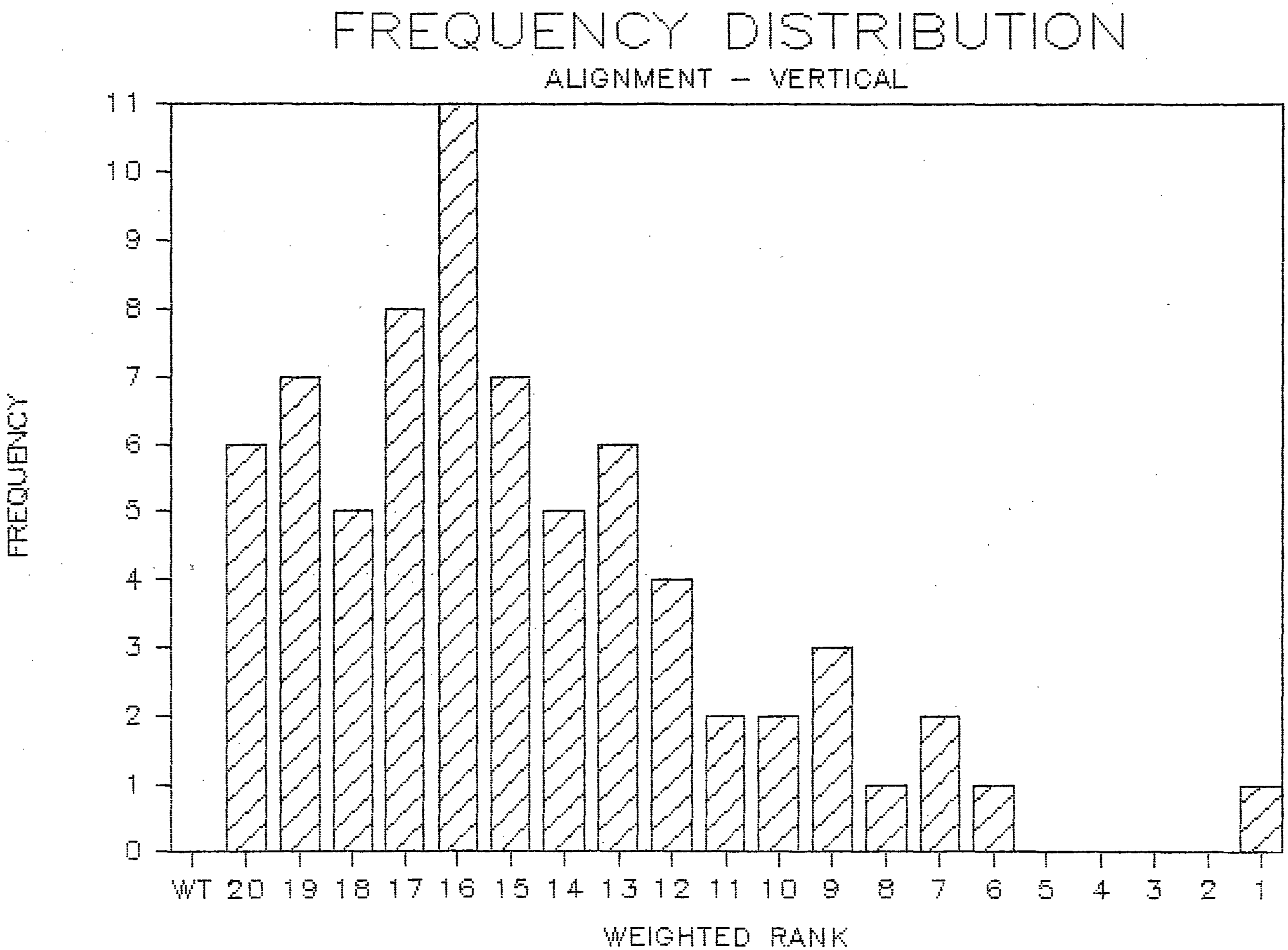

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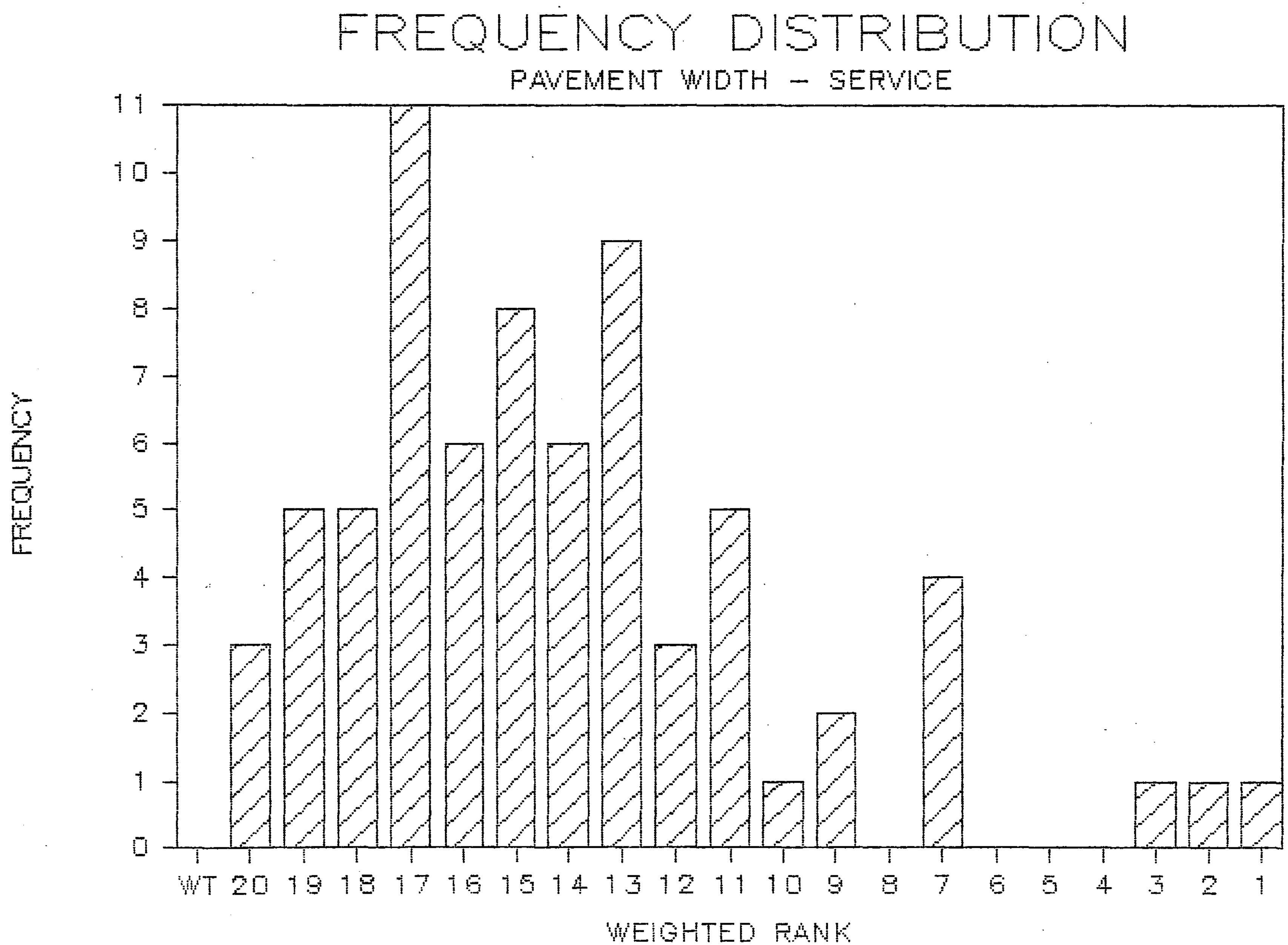

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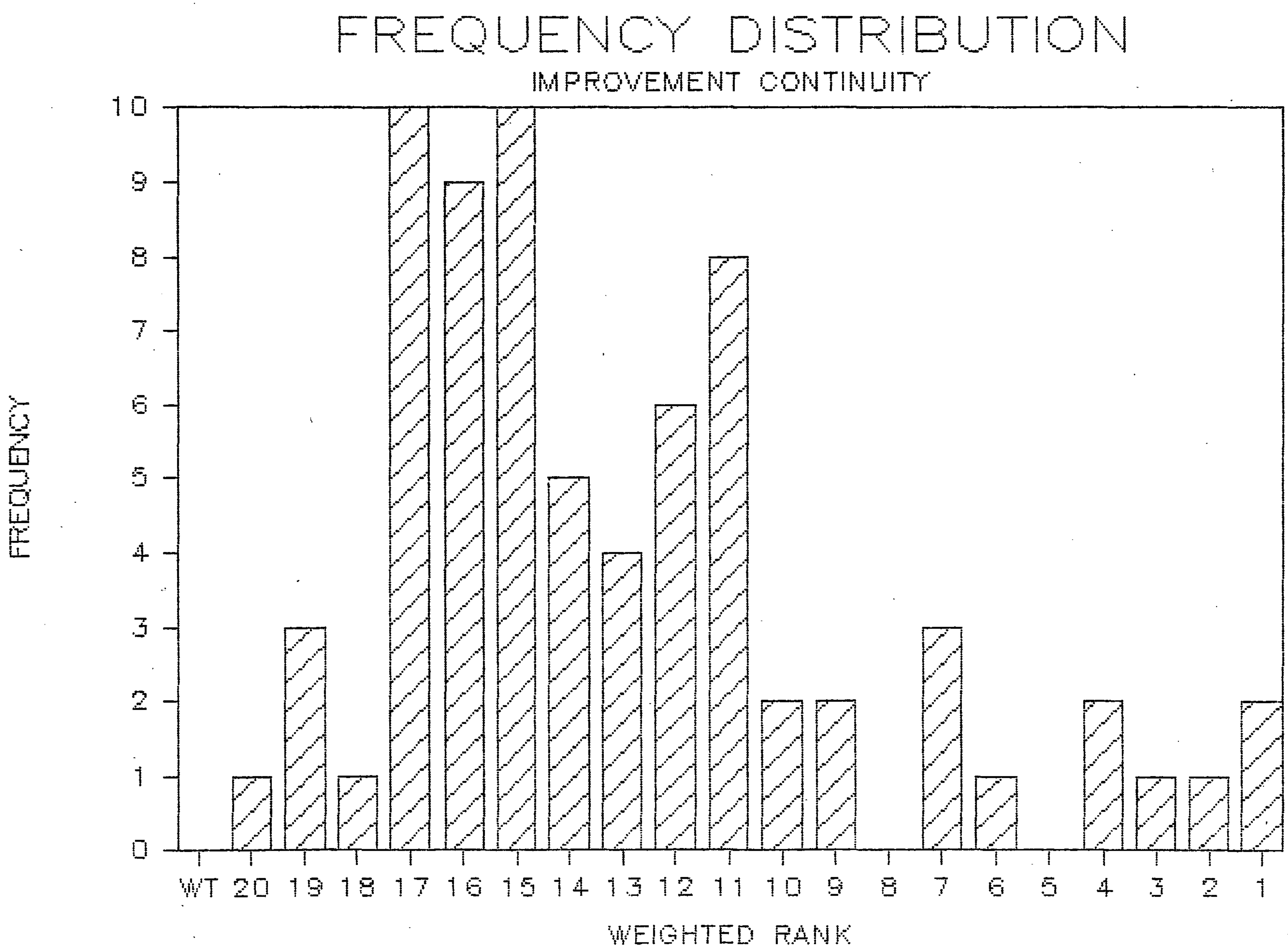

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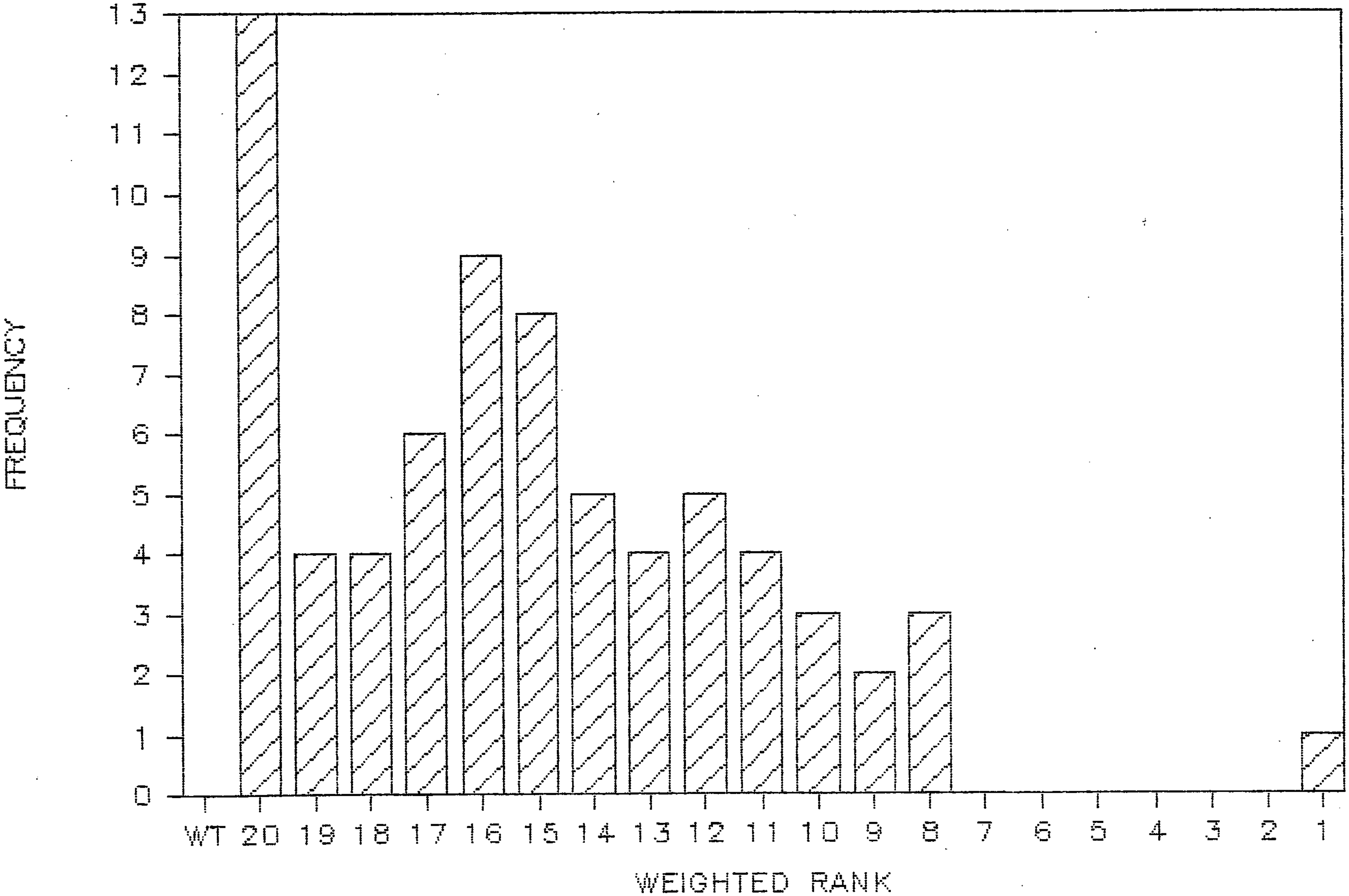

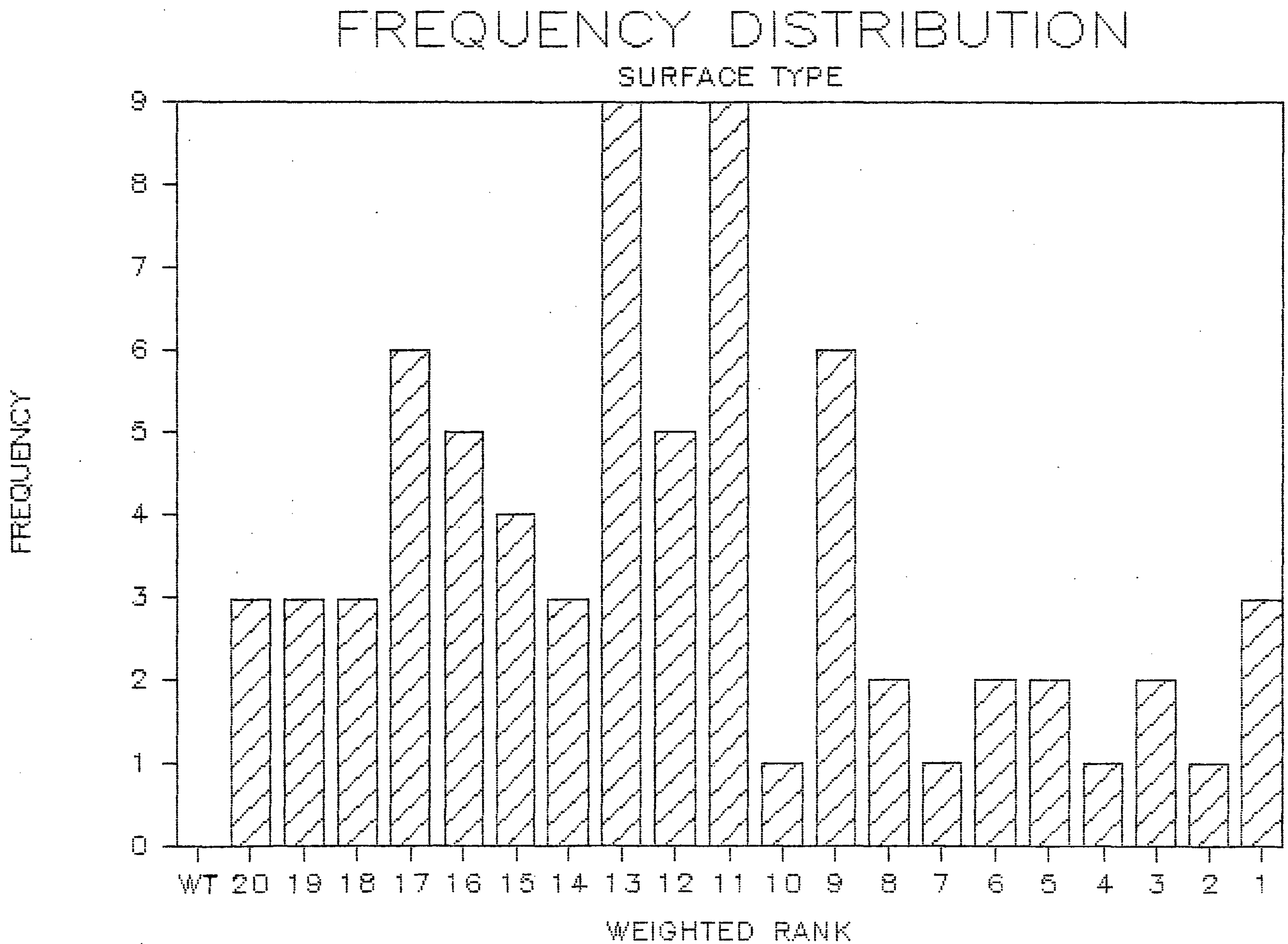
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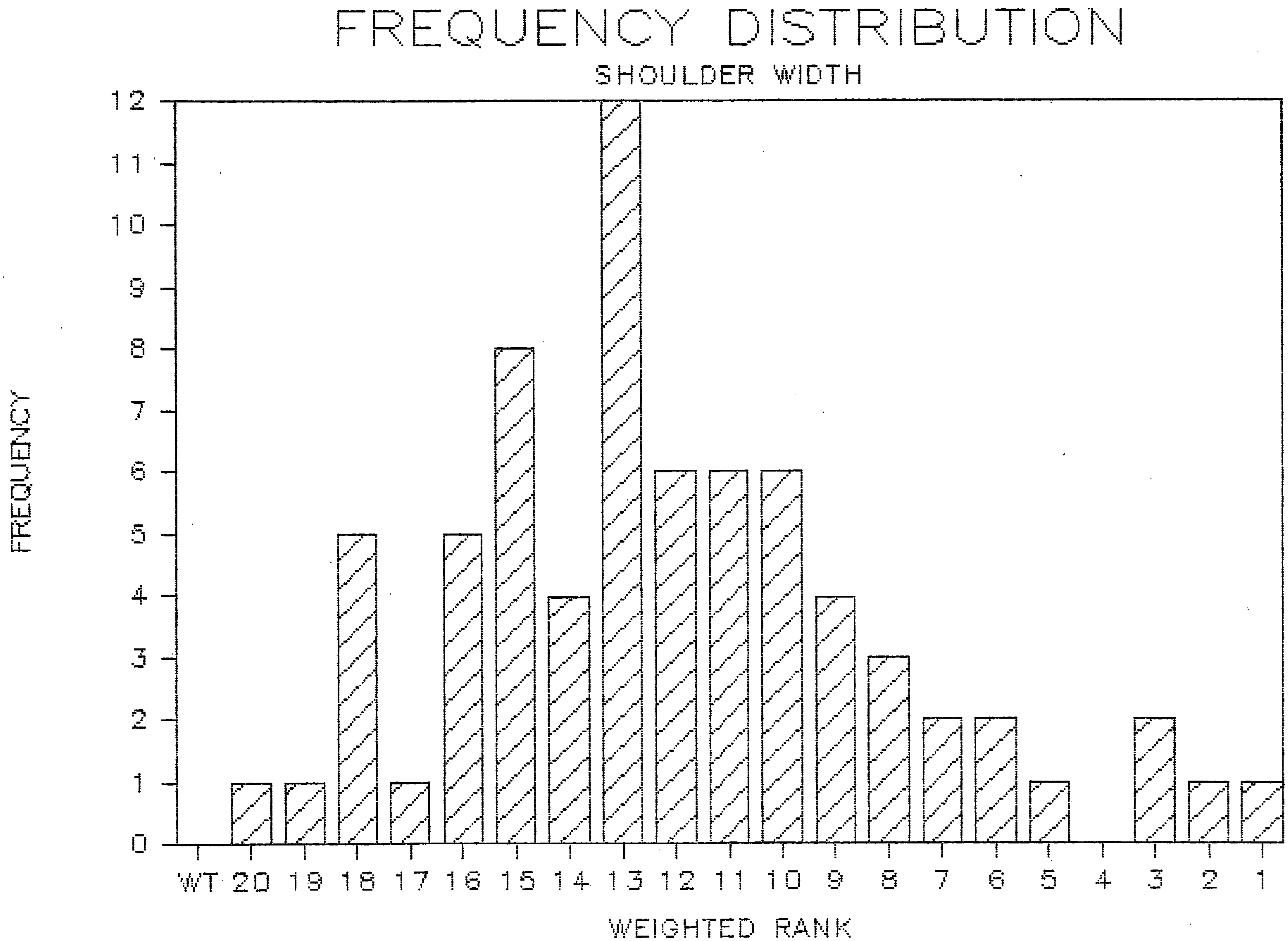

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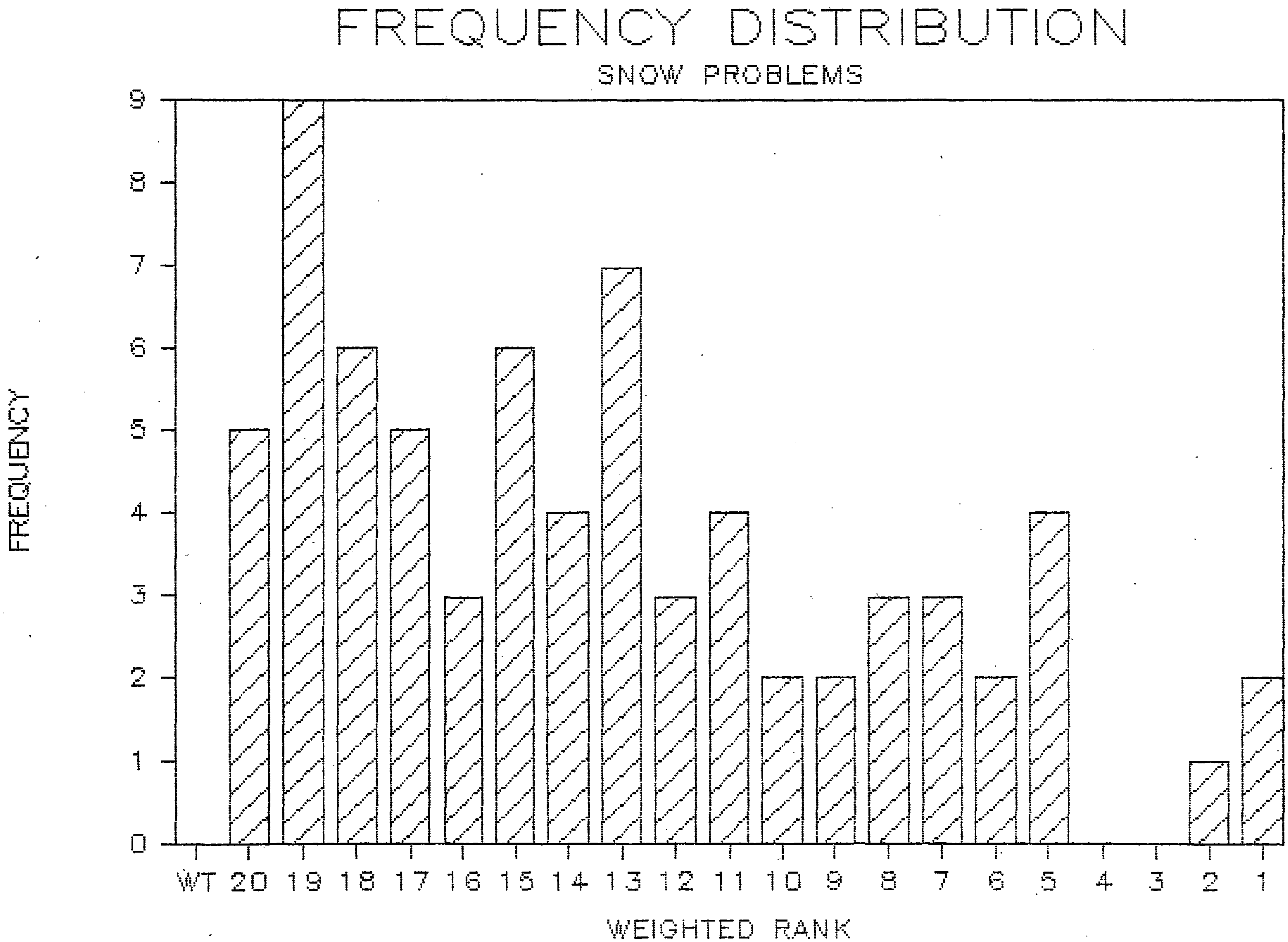

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WEIGHTED RANK

Appendix E

DESIGN STANDARDS

Del Norte County Rural Highway Design Standards

Average Daily Traffic	under 25			25 to 100			100 to 400		
Surface Type	graveled, graded and drained			gravel or crushed stone			bit. surface treatment		
Terrain	flat	roll.	mtn.	flat	roll.	mtn.	flat	roll.	mtn.
Design Speed	35	30	25	45	35	25	55	45	35
Curvature, Max. Deg.	18	25	36	11	18	36	7	11	18
Gradient, Max. %	6	12	15	5	7	12	5	7	9
Stopping Sight Dist.	240	200	165	315	240	165	415	315	240
Surface Width	20	20	(a)	20	20	20	22	22	22
Shoulder Width	2	2	(a)	4	3	2	5	4	3
R/W Width	50	50	50	50	50	50	60	60	60

Average Daily Traffic	400 to 1,000			1,000 to 2,000			2,000 and up		
Surface Type	mix bit., 1½-in. minimum			mixed bit., 2-in. minimum			plant-mix bit., 3-in. minimum		
Terrain	flat	roll.	mtn.	flat	roll.	mtn.	flat	roll.	mtn.
Design Speed	60	50	40	60	50	40	60	60	50
Curvature, Max. Deg.	6	9	14	6	9	14	6	6	9
Gradient, Max. %	5	6	7	5	6	7	4	5	6
Stopping Sight Dist.	475	350	275	475	350	275	475	475	350
Surface Width	24	24	24	24	24	24	24	24	24
Shoulder Width	6	6	4	8	8	6	8	8	6
R/W Width	60	60	60	60	80	100	80	80	100

(a) Graded width of 14 ft. and turnouts.

Design Standards for Five Traffic Groups

Design Feature	Terrain	*50*	*50 to 100*	*100 to 400*	*400 to 1000*	*1000 to 4000*
			Average Daily Traffic			
DESIGN STANDARDS FOR ROADS						
Right of Way Width		40	50	60	80	80
Roadbed Width (feet)	Flat	24	28	30	34	40
	Rolling	24	26	28	30	38
	Mountainous	24	24	26	28	34
Surface Width (feet)		16	20	22	24	24
Radii (feet)	Flat	400	400	650	800	1000
	Rolling	250	250	450	525	750
	Mountainous	100	100	250	325	525
Grade (percent)	Flat	7	6	6	5	3
	Rolling	12	8	8	7	5
	Mountainous	15	12	10	9	6
Stopping Sight Distance (feet)	Flat	275	350	375	400	550
	Rolling	250	275	300	325	425
	Mountainous	125	200	225	250	300
Design Speed (mph)	Flat	40	45	50	55	65
	Rolling	30	35	40	45	55
	Mountainous	20	25	30	35	45
DESIGN STANDARDS FOR BRIDGES						
Width (feet)		18	24	26	26	28
Design Loading		H-10	H-12½	H-15	H-20	H-20

Pavement Section Standards

Average Daily Traffic	*Section*
1000 - 4000	40-ft. compacted subgrade; 6-in. by 31-ft. Class C CTB or equivalent rock base; 2½-in. by 24-ft. PMS; 2½-in. by 3-ft. PMS tapered shoulders.
400 - 1000	34-ft. compacted subgrade; 4-in. Class C CTB base; 2-in. by 24-ft. RMS; 2-ft. BST shoulders.
100 - 400	30-ft. compacted subgrade; stabilized base where required; 2-in. by 20-ft. BST.
50 - 100	28-ft. compacted subgrade; 2-in. by 20 ft. BST.
Less than 50	24-ft. compacted subgrade; 2-in. by 16-ft. BST.

County Engineer's Association of California

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

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

IOWA STATE HIGHWAY COMMISSION

FARM-TO-MARKET ROAD DESIGN STANDARDS,[1] JANUARY 1, 1960

Design Control	Annual Average Daily Traffic					
	Under 100[2]		100 - 400		400 - 1,000	
	Min. Stand.	Recom. Stand.	Min. Stand.	Recom. Stand.	Min. Stand.	Recom. Stand.
Design speed (mph):						
Flat topography	40	50	50	55	50	60
Rolling topography	30	40	40	45	40	50
Mountainous topography	20	30	30	35	30	40
Sharpest curve (deg):						
Flat topography	14	9	9	7	9	6
Rolling topography	25	14	14	11	14	9
Mountainous topography	25	25	25	18	25	14
Maximum gradient (%):						
Flat topography	8	5	7	5	7	5
Rolling topography	12	7	8	7	8	6
Mountainous topography	15	10	10	9	10	7
Non-passing sight distance (ft):						
Flat topography[3]	350	350	350	415	350	475
Rolling topography[3]	275	275	275	315	275	350
Mountainous topography[3]	200	200	200	240	200	275
Dimensions of road (ft):						
Width of roadbed	22	28	24	34	30	36
Width of roadway surfacing	20	20	—	—	—	—
Width of pavement, A. C. conc.[4]	22	22	22	24	22	24
Width of pavement, P. C. conc.[4]	20	20	20	22	22	24
Roadway top, shoulder-to-shoulder[5]	22	28	22	30	28[6]	32
Thickness of pavement (in.)						
P. C. conc. pavement	6	6	6	6	6	8
Flexible base pavement[7]	8	8	8	8	8	8
Depth of ditch (ft):	3	3	3	3	3	3
Width of ditch bottom (ft):	6	6	6	6	6	6
Slope of foreslopes:						
In cuts:						
Not steeper than	2:1	2:1	2:1	2:1	2:1	2:1
Not flatter than	3:1	3:	3:1	3:1	3:1	3:1
In fills, over 5 ft (not steeper than):						
Traffic less than 100 vpd	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1
Traffic more than 100 vpd	2:1	2:1	2:1	2:1	2:1	2:1
Slope of backslopes						
In cuts	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1	1.5:1
Width of right-of-way (ft)	66	80	66	80-120	66	80-120

[1] Bridge design data omitted.
[2] When pavements are anticipated to be constructed on roads having less than 100 vpd, use the standards for traffic 100-400 except that the roadbed width shall be not less than 28 ft.
[3] In no case shall the passing sight distance be less than 250 ft.
[4] Bridge width minimum of 24 ft or 4 ft more than approach pavement width.
[5] When pavement is constructed in stages, widths will be increased so that when pavement is completed the finished shoulder-to-shoulder width will comply to these standards.
[6] For traffic volumes exceeding 750 vpd, minimum 4-ft shoulders will be required each side of the finished pavement; shoulders shall be let at the same time as the paving project.
[7] General note.---Grading or base projects let prior to Jan. 1, 1960, and meeting the requirements of the ISHC, Feb. 1, 1954, Farm-to-Market Standards, will be considered for a higher type surfacing improvement without full compliance with these standards.

KENTUCKY DEPARTMENT OF HIGHWAYS
BASIC GEOMETRIC DESIGN CRITERIA

THESE BASIC GEOMETRIC DESIGN CRITERIA ARE BASED ON THE LEVEL OF SERVICE CONCEPT. THE DESIRED LEVEL OF SERVICE RECOMMENDED BY THE DEPARTMENT WILL BE USED WITH THE APPROPRIATE ATTACHED TABLES IN SELECTION OF DESIGN CRITERIA ANY DEVIATION FROM THESE CRITERIA MUST BE APPROVED BY THE CENTRAL OFFICE.

HIGHWAY CLASS	6	5	4	3	2	1
TRAFFIC VOLUME ①	CURRENT A.D.T. 0 - 100	CURRENT A.D.T. 100 - 250	CURRENT A.D.T. UNDER 400 ②	CURRENT A.D.T. 400 - 749	D.H.V. 200 - 910 (A.D.T. 1500-7000) ③	D.H.V. 650 - UP (A.D.T. 5000-UP) ③
DESIGN SPEED (M.P.H.)	DESIGN SPEED WILL BE CONTROLLED BY THE HORIZONTAL & VERTICAL ALIGNMENTS		30 40 50 60	40 50 60 70	40 50 60 70	40 50 60 70
PAVEMENT WIDTH ④ 30 MPH / 40 MPH / 50 MPH / 60 MPH / 70 MPH	16'	18'	20' 20' 20' 22' –	– 22' 22' 22' 24'	– 24' 24' 24' 24'	24' PAVEMENT INITIAL 2-LANES WITH 4-LANES ULTIMATE OR 4 OR MORE LANES INITIAL DEPENDING ON D.H.V.
MINIMUM SHOULDER WIDTH	2'	3'	4'	6'	12'	SPECIAL DESIGN
MINIMUM ROADBED WIDTH 30 MPH / 40 MPH / 50 MPH / 60 MPH / 70 MPH	20'	24'	28' 28' 28' 30' –	– 34' 34' 34' 36'	– 48' 48' 48' 48'	SPECIAL DESIGN
DITCH WIDTH & SLOPE	3' @ 3 : 1	3' @ 3 : 1	6' @ 4 : 1	8' @ 4 : 1	8' @ 4 : 1 40 M.P.H. 18' @ 6 : 1 50-70 M.P.H.	8' @ 4 : 1 40 M.P.H. 18' @ 6 : 1 50-70 M.P.H.
EARTH CUT SLOPE RATIO UNDER 4' / OVER 4'	1 : 1 1 : 1	1 : 1 1 : 1	4 : 1 2 : 1	4 : 1 2 : 1	4 : 1 2 : 1	4 : 1 2 : 1
FILL SLOPE RATIO ⑤ UNDER 10' / 10' TO 20' / OVER 20'	1½ : 1 1½ : 1 1½ : 1	2 : 1 2 : 1 2 : 1	4 : 1 2 : 1 2 : 1	4 : 1 2 : 1 2 : 1	6 : 1 & 4 : 1 2 : 1 OR 4 : 1 2 : 1	6 : 1 & 4 : 1 2 : 1 OR 4 : 1 2 : 1
RIGHT OF WAY	The necessary width needed for construction and proper maintenance of entire roadway section.					
MAXIMUM CURVATURE (IN DEGREES) (Based on Superelevation rate of 0.10) 30 MPH / 40 MPH / 50 MPH / 60 MPH / 70 MPH	56	36	25.0 13.5 8.5 5.5 –	– 13.5 8.5 5.5 4.0	– 13.5 8.5 5.5 4.0	– 13.5 8.5 5.5 4.0
MAXIMUM GRADE ⑥ (IN PERCENT) TERRAIN: LEVEL / ROLLING / MOUNTAIN	14	12	M.P.H. 30 40 50 60 6 5 4 3 7 6 5 4 9 8 7 6	M.P.H. 40 50 60 70 5 4 3 3 6 5 4 4 8 7 6 –	M.P.H. 40 50 60 70 5 4 3 3 6 5 4 4 8 7 6 –	M.P.H. 40 50 60 70 5 4 3 3 6 5 4 4 8 7 6 –
MINIMUM STOPPING SIGHT DISTANCE ⑦ 30 MPH / 40 MPH / 50 MPH / 60 MPH / 70 MPH			200' 275' 350' 475' –	– 275' 350' 475' 600'	– 275' 350' 475' 600'	– 275' 350' 475' 600'
MINIMUM PASSING SIGHT DISTANCE ⑧ 30 MPH / 40 MPH / 50 MPH / 60 MPH / 70 MPH			1100' 1500' 1800' 2100' –	– 1500' 1800' 2100' 2500'	– 1500' 1800' 2100' 2500'	IF 2-LANES INITIAL THEN SAME AS CLASS 2. IF 4-LANES INITIAL THEN NOT NECESSARY
MAXIMUM DISTANCE			2.5 MILES	2.0 MILES	1.0 MILES	1.0 MILE IF 2-LANE

FARM TO MARKET DESIGN GUIDES

ACCEPTABLE VALUES FOR NEW OR RECONSTRUCTED RURAL SECONDARY ROADS

THESE FARM TO MARKET DESIGN GUIDES ARE PRESENTED FOR THE DESIGN OF ROADS ON THE TRUNK AND TRUNK COLLECTOR SYSTEMS, COUNTIES MAY ALSO USE THESE FOR ROADS ON THE AREA SERVICE SYSTEM EACH DESIGN ELEMENT OF EACH PROJECT SHOULD BE MEASURED AGAINST THE HIGHEST STANDARD PRACTICABLE AND ECONOMICALLY JUSTIFIED. VALUES BELOW THOSE SHOWN ON THIS TABLE WILL BE CONSIDERED ON A PROJECT BY PROJECT BASIS, PROVIDED THAT EACH EXCEPTION IS JUSTIFIED TO THE DISTRICT ENGINEER. IN NO CASE SHALL THE DESIGN CRITERIA BE LESS THAN THOSE SET OUT IN THE "GEOMETRIC DESIGN GUIDES FOR LOCAL ROADS AND STREETS, PART 1-RURAL, AASHTO", CURRENT EDITION.

DESIGN ELEMENTS		FUNCTIONAL CLASSIFICATION														
VALUES SHOWN ARE SUGGESTED GUIDES ONLY. EACH PROJECT IMPROVEMENT MUST BE ANALYZED ON ITS OWN MERITS AND FEATURES.		TRUNK OR TRUNK COLLECTOR (OR AREA SERVICE)														
		PAVED ROADWAY									NON-PAVED ROADWAY					
ADT-Design Year (In 20 yrs) -Current Yr. (After Completion)	(1)	2000 to 1000 Over 750			1000 to 400 750 to 250			400 to 100 250 to 50			400 to 100 250 to 50			Less than 100 Less than 50		
Terrain	(2)	FLAT	ROLLING	HILLY	FLAT	ROLLING	HILLY	FLAT	ROLLING	HILLY	FLAT	ROLLING	HILLY	FLAT	ROLLING	HILLY
Design Speed	MPH	60	55	50	55	50	45	50	45	40	50	45	40	45	40	35
Stopping Sight Distance	ft	475	425	350	425	350	325	350	325	275	350	325	275	325	275	238
Maximum Curvature (3)	Degrees	5	6	7	6	7	9	7	9	12	7	9	12	9	12	17
Maximum Gradient (4)	%	5	6	7	6	6	8	6	7	9	6	7	9	6	8	10
Pavement Width	ft	24	24	24	22	22	22	22	22	22	NA	NA	NA	NA	NA	NA
Surfacing Width-Granular	ft	NA	NA	NA	NA	NA	NA	NA	NA	NA	20	20	20	20	20	20
Shoulder Width	ft	8	8	8	6	6	6	4	4	4	4	4	4	3	3	3
Roadway Top Width	ft	40	40	40	34	34	34	30	30	30	28	28	28	26	26	26
Bridge Width-New (5)	ft	40	40	40	30	30	30	30	30	30	24	24	24	24	24	24
Design Loading		HS-20	HS-20	HS-20	*H-20	*H-20	*H-20	H-20	H-20	H-20	H-15	H-15	H-15	H-15	H-15	H-15
Foreslope		4:1	4:1	4:1	3:1	3:1	3:1	3:1	3:1	3:1	2:1	2:1	2:1	2:1	2:1	2:1
Normal Minimum Ditch		5x10	5x10	5x10	3x6	3x6	3x6	3x6	3x6	3x6	3x6	3x6	3x6	3x6	3x6	3x6
Special Ditch at Construction		2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4	2x4
Bridge Width-Existing	ft	24	24	24	24	24	24	24	24	24	20	20	20	20	20	20
Acceptable Loading		H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15	H-15
Clearance to Obstructions From edge of Surfacing	ft	30	30	30	16	16	16	14	14	14	10	10	10	10	10	10

IN CASE OF CONFLICT BETWEEN DESIGN YEAR ADT AND CURRENT YEAR ADT, USE THE HIGHER VALUES

GENERAL NOTES:

1. Over 2,000 ADT (Design Year), Use Arterial Connector Values
2. Use "Hilly Terrain" designation only upon concurrence by the District Engineer
3. Horizontal Curves shall have a minimum length of 500 feet
4. Maximum Gradient may be steepened by 1% for short distances
5. If over 100 ft long, may be pavement width plus 6 feet
6. *Over 400 ADT (Current Year), Use HS-20 Loading

LATEST REVISION DATE: February 1979