DOCUMENT RESUME

ED 063 423 UD 012 407

AUTHOR Pugh, George E.; Krasnakevich, John
TITLE School Desegregation With Minimum Busing: A Report to the Assistant Secretary for Planning and Evaluation, U.S. Department of Health, Education, and Welfare.
INSTITUTION Concord Research Corp., Burlington, Mass.; Lambda Corp., Arlington, Va.
SPONS AGENCY Department of Health, Education, and Welfare, Washington, D.C.
REPORT NO HEW-OS-71-140
PUB DATE 10 Dec 71
NOTE 63p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *Bus Transportation; Educational Policy; *Integration Methods; Integration Plans; *Integration Studies; Neighborhood Schools; Policy Formation; School Demography; School Districts; *School Integration; School Size; Student Characteristics; *Student Placement; Student Transportation

ABSTRACT

This analysis is designed to provide Health, Education and Welfare and local school officials with a more objective and uniform assessment of desegregation problems in specific districts in the United States. To carry out the study, Lambda Corporation designed and implemented an analysis procedure for systematically assigning students to schools. The analysis system was designed so that it could produce a wide range of different school assignments, ranging from simple neighborhood attendance zones to plans that provide extensive desegregation in a large metropolitan area. The system allows wide latitude in the specification of ground-rules and goals for an assignment. Once these are specified, the system can provide a systematic assignment that is as efficient as possible in terms of the specified objectives and constraints. Basically three types of publicly available data were required for the study: (1) information on the location and racial composition of the school-age population in each area; (2) information on the location and capacity of the schools in each school district; and, (3) information on the transportation networks in each area, to calculate travel times to assigned schools. (Author/JM)

SCHOOL DESEGREGATION WITH MINIMUM BUSING

A Report to
the Assistant Secretary for Planning and Evaluation
U.S. Department of Health, Education, and Welfare

December 10, 1971

The work on which this publication is based was performed pursuant to contract HEW-OS-71-140 with the Department of Health. Education. and Welfare.

LAMBDA CORPORATION
1501 Wilson Boulevard • Arlington, Virginia 22209 • (703) 528-8200

CONTENTS

ACKNOWLEDGMENT

This study was carried out jointly by Lambda Corporation and Concord Research Corporation. The participants in the study were:

Project Leader

George E. Pugh, Lambda (703) 528-8200

Associate Project Leader

John Krasnakevich, Concord (617) 272-8040

Lambda Corporation	Concord Research Corporation	
Earl Crisler	Alexandra Adrian	Nancy Khybery
Hugh Everett, III	Edward Bayliss	Carmela Krasnakevich
Sharon A. Folan	Lance Benson	Robert Lecours
Robert Goodrich	Grenville Bingham	Barbara Lyons
Cheryl Herrin	Howard Bloom*	Norman Meltz
Neil Killalea	Kevin Coffey	Susan Richardson*
Donald Reisler	Roy Cummings	David Sheehan*
	Harriet Feingold	Carol Standring
	Nancy Fontneau*	Sharon Stinehelfer*
	Edward Goldberg	Sandra Sutherland

Concord Research Corporation was responsible for the very large data collection and preparation effort, which included:

- identification of data sources
- conversion of source data to a standard format
- preparation of latitude/longitude coordinates for schools, census population data, and the road networks
- adjustment of census data on school-age populations to correct for those attending private and parochial schools
- adjustment of census data on minorities to include Spanish-surnamed Americans.

Lambda Corporation was responsible for the analysis and the data processing involved in the analysis effort, which included:

- planning and coordinating the project
- design and programming of the school assignment and network analysis systems

*Summer employees

- integration of all analysis and reporting components into an efficient data processing production system
- development of the desegregation criterion used in the analysis
- interpretation and evaluation of the analysis results.

The study would not have been possible without the cooperation of many local transportation planning agencies that provided data on local transportation networks. A list of the agencies and individuals who contributed to that effort is included in the Annex at the end of this report.

The project wishes to acknowledge the very effective guidance and leadership provided by Constantine Menges, the H.E.W. Project Officer, together with the support and assistance provided by Alan Ginsburg and Linda McCorkle under his leadership. The present report is, however, the responsibility of Lambda Corporation, and not of the Department of Health, Education, and Welfare or its staff.

SCHOOL DESEGREGATION
WITH MINIMUM BUSING

INTRODUCTION

In addition to its many responsibilities in the area of public education, the Department of Health, Education, and Welfare has responsibility for administering Federal funds authorized to assist school districts engaged in school desegregation. To provide a more objective basis for dealing with this responsibility the need was recognized for more quantitative information on the demographic problems of school desegregation in large urban areas. On June 4, 1971 an analysis program was initiated, under the sponsorship of the Assistant Secretary for Planning and Evaluation. This report deals with work completed under the initial contract (HEW-OS-71-140) of that program. Work is continuing (under contract HEW-OS-71-185), providing for a more careful and detailed treatment than was possible within the six months available for the first effort. Under the initial program, preliminary, as yet unvalidated analysis results were produced for a survey of 29 urban areas, and a more detailed sensitivity analysis was carried out for two of these.

A separate report is in preparation which will present the detailed results for each district studied. Table I lists the 29 urban areas, representing a cross-section of demographic and geographical situations that were included in the initial analysis.

TABLE I

Atlanta, Georgia	Newport News, Virginia
Birmingham, Alabama	Oakland, California
Cleveland, Ohio	Oklahoma City, Oklahoma
Colorado Springs, Colorado	Omaha, Nebraska
Dade County, Florida	Pasadena, California
Dayton, Ohio	Pomona, California
Denver, Colorado	Pontiac, Michigan
Detroit, Michigan	Prince George's County, Maryland
El Paso, Texas	San Antonio, Texas
Ferndale, Michigan	San Francisco, California
Fort Wayne, Indiana	St. Louis, Missouri
Hartford, Connecticut	Toledo, Ohio
Indianapolis, Indiana	Tucson, Arizona
Kansas City, Missouri	Wichita, Kansas
Mobile, Alabama	

SUMMARY

The analysis shows that the existing residential isolation of urban minority groups is not quite as serious a barrier to school desegregation as has usually been assumed. Even in the largest cities analyzed, almost complete elimination of segregation in the schools seems possible without exceeding practical limits for student travel time or economically reasonable limits on the number of students bused. The analysis also shows that in most school districts very substantial decreases in racial isolation can be accomplished without transporting any students who could otherwise walk to school.

The analysis system developed for this study is designed primarily to provide an overview of the available school desegregation alternatives, when specific local geographic and demographic factors are taken into consideration. The method uses data that is publicly available, and can provide illustrative results without the expense of the detailed analysis that would be required to implement a specific plan.

The technique has been used to examine the range of alternatives that are available, and to assess these alternatives in terms of the amount of desegregation achieved and the amount of transportation required. Some specific alternatives that can be examined include:

- Assignment of students to neighborhood schools without regard to race so as to minimize walking distance and transportation required.
- Assignment of students to neighborhood schools so as to minimize transportation required, but with the objective of contributing to school desegregation.

- Assignment of students to schools in order to produce the most desegregation possible with only a minimal increase in required transportation above the minimum required to get all students to school. (In most cases this type of assignment will require less transportation than is currently being used.)

- Assignment of students to schools so as to achieve an efficient balance between desegregation levels achieved and transportation requirements for moderate increases in transportation requirements.

- Assignment of students to provide extensive desegregation with minimum transportation requirements.

A review of such a series of alternatives may assist local officials in gaining a better understanding of the trade-offs involved. It may also help them in identifying instances of possible bias in existing school assignments. For example, the analysis system can be used to select racially unbiased neighborhood attendance zones. If these unbiased neighborhood attendance zones show much less racial isolation than the existing school assignments, then there is a strong possibility of racial bias in the existing attendance zones.

The flexibility of the system in adapting to a variety of goals and constraints makes it potentially useful in assisting local communities in the development of actual school desegregation plans. During some of the sensitivity analyses, relatively detailed prototype alternatives were developed for one of the illustrative areas. Although these prototype alternatives required more effort than the survey type analyses, they were still very economical compared to fully developed plans. Such prototypes produced in support of local school officials might provide a useful basis for the development of efficient practical plans.

Prototype plans can be produced that will explicitly take into account local preferences with regard to alternative racial compositions of schools, as well as local preferences with regard to the relative importance of limiting travel time, travel distance, and numbers of students transported. For any such definition of objectives the system can outline an efficient school desegregation plan. Because there are almost always certain detailed local considerations that are not easily incorporated in an overview analysis, a review and adjustment of such a plan is, of course, necessary.

Typically the analysis shows that very substantial reductions in racial isolation are possible without transporting any students who could otherwise walk to school. The key to realizing such reductions in racial isolation lies in the definition of local attendance zones, and in the effective use of existing levels of busing. The improvements that can be made without additional busing are typically largest for high school and junior high school students because of the higher percentage of these students that usually must be transported to school.

Because the school assignment plans used in the study are optimized to avoid unnecessary busing, they provide useful insight into how desegregation plans can be developed that require a minimum of additional busing. When reassigning students to provide greater racial desegregation, first consideration should be given to the reassignment of students who are normally bused to school, since their reassignment will not increase the number of students bused. Often the increase in busing time that is required to carry such students to other schools is trivial compared to the time that is routinely spent in just the neighborhood pickup of the students. Of course, in many central city areas the population density is high and schools are close together so that almost all students (especially in the elementary grades) can walk to school. Nevertheless, even in this situation, if more desegregation is desired, it may be possible to limit requirements for additional busing by exchanging with suburban students who are normally bused to school in any event, rather than with those who can walk to school.

The results obtained so far in some of the sensitivity analyses suggest that requirements for additional busing, even to provide almost complete desegregation, can be as little as one third to one fourth of the amount estimated by conventional rule-of-thumb techniques.

ANALYSIS APPROACH

The issue of school desegregation involves so many complex geographic and demographic issues that it has often been difficult to obtain an objective assessment of the facts in any specific situation. For example, "Is the current assignment of students to schools within an area an unbiased natural assignment, reflecting the actual racial composition of the area, or is it somehow biased toward segregation?"; or "Can the racial isolation in a school district be appreciably lessened without resorting to 'massive busing' of the students?" Within any individual school district the answers to questions such as this should be matters of fact, not of opinion. This analysis is designed to provide HEW and local school officials with a more objective and uniform assessment of desegregation problems in specific districts in the United States.

To carry out the study, Lambda Corporation designed and implemented an analysis procedure for systematically assigning students to schools. The analysis system was designed so that it could produce a wide range of different school assignments, ranging from simple neighborhood attendance zones to plans that provide extensive desegregation in a large metropolitan area. The system allows wide latitude in the specification of ground-rules and goals for an assignment. Once these are specified, the system can provide a systematic assignment that is as efficient as possible in terms of the specified objectives and constraints.

The resulting school assignments have the advantage that they are uniformly objective and free of hidden prejudice. A school official, of course, can express program preferences when he specifies goals for the assignment, but any such preferences must be explicit; they are not introduced as hidden biases in the way the assignments are implemented. The degree of racial desegregation achieved in these systematic assignments of students to schools provides a bench-mark against which existing or proposed school desegregation plans can be measured.

The assignments produced are also uniformly efficient (within limitations imposed by the accuracy and level of detail of the input data). For example, when an assignment is requested which minimizes the amount of busing, an assignment is produced which objectively minimizes the amount of busing required. If an assignment is requested which maximizes desegregation (subject to explicitly specified constraints), then a plan is produced which is optimum in terms of the specified constraints. The method can also produce plans in which the user can specify a balance between the amount of busing and the level of desegregation achieved. Through the use of this technique, preliminary and as yet unvalidated desegregation profiles have been produced for each of 29 metropolitan school districts which provide an estimate of the level of desegregation that can be achieved as a function of the amount of busing.

Obviously, such analysis deals with only a limited part of the school desegregation problem. It cannot deal with issues such as the fundamental desirability of school desegregation, or the extent to which busing is justified to reduce the level of racial isolation in a school system. It cannot answer questions about the effect of racial composition on the quality of education. It deals only with the quantitative demographic and geographic limitations which affect the achievement of racial desegregation in major school districts. The purpose of the analysis is to provide a more quantitative and objective understanding of the extent and magnitude of this problem. While this is an important consideration in the development of national policy on school desegregation, it is, of course, only one part of the overall problem.

DATA COLLECTION AND PREPARATION

The collecting and processing of the data required for the study was a major effort. Basically three types of publicly available data were required:

1. Information on the location and racial composition of the school-age population in each area
2. Information on the location and capacity of the schools in each school district
3. Information on the transportation networks in each area, to calculate travel times to assigned schools.

To use this information, a common geographic coordinate system for all of the data was essential. This massive effort of collecting and processing the data, to place it all in a standard computer readable format with standardized geographic coordinates, was carried out by Concord Research Corporation of Burlington, Massachusetts, under a subcontract.

A. The Population Data

The "First Count" data from the 1970 Census was used to provide the basic school population data. This data provides information on the age and racial composition of the population in each "block group." A "block group" is an area used by the Bureau of the Census in its First-Count data tabulations. The size of a block group is typically selected so that the population of the block group is approximately 800 people. Thus, a typical census block group has about 160 children of school age. The block group is usually composed of about 4 to 10 city blocks.

To obtain an estimate of the school-age population in each block group actually attending public schools, a correction was made to compensate for attendance at nearby private or parochial schools. The correction was based on data, provided by the Office of Education, which specifies the number of students attending private and parochial schools, together with data on the racial composition of students in parochial schools as provided by the National Catholic Educational Association.

The approximate latitude and longitude for the school population were obtained from files provided by the Office of Civil Defense which define the latitude and longitude of the population centroid for each census block group. These coordinate files were merged into the census data to provide the coordinate system required for the analysis.

B. The School Data

To estimate the capacity of the schools, school enrollment figures were used that were provided by the U. S. Office of Education. Enrollment rather than capacity data was used because of inconsistencies in the definition of "capacity." School addresses were used to determine the location of each school on the census map. The specific "block group" in which the school was located was then identified, and the coordinates for that block group centroid were used to approximate the school location.

C. The Transportation Networks

To qualify for federal assistance under the Federal Highway Aid Act of 1962, metropolitan areas were required to develop a transportation planning activity. As a result of this act, all the major metropolitan areas have established regional transportation planning councils. The Federal Bureau of Roads developed a "battery" of computer programs for transportation analysis which have been widely used by these agencies in the analysis of future transportation requirements. Through the cooperation of the regional councils, it was possible to obtain a relatively detailed and authoritative road network for each metropolitan area, including both distances and travel speed on all major roads within the area. In each case the regional planning council was asked to supply an available version of their road network which they felt would provide the best estimate of rush hour travel speeds for the 1970 time period. In some cases, the road network was accompanied by coordinate information which could be automatically converted to a latitude/longitude form. In other cases, it was necessary to derive the coordinates from maps to define the location of the intersections within the road network. In each case the resulting road network and coordinate system was carefully checked to assure that it correctly reproduced travel time estimates used by the local planning council.

THE SCHOOL ASSIGNMENT PROBLEM

Figure 1 shows in miniature the basic school assignment problem, as it is addressed in the analysis. The figure depicts a portion of a metropolitan road network. The small cross-hatched area corresponds to a typical "block group", which is the population unit used in the census data. The figure shows three schools to which students from this block group might be assigned. If the objective is to assign students to minimize busing, then students from the block group shown would be assigned to school 2 (assuming that is possible within the enrollment capacity of that school). If the school is within walking distance (typically a 3/4 mile radius from the center of the census block group), students assigned to the school will be assumed to walk to school. If, however, we are interested in an assignment designed to reduce racial isolation, it may be necessary to assign the students to a more distant school (for example, School 1, or School 3). For example, if School 2 is in a racial minority area, and has a predominantly minority school population, it may be preferable to assign the minority students to other schools where there would be less racial isolation.

Travel time to the more distant schools is estimated in the program by calculating the shortest travel time over the road network to the school in question. Since the road network does not intersect the center of the block group, an additional increment of travel time (based on a slow travel speed, typically about 15 miles per hour) is estimated from the center of the block group to a nearby intersection in the road network. Similarly, another increment of travel time is added to get from an intersection on the road network to the destination schools.

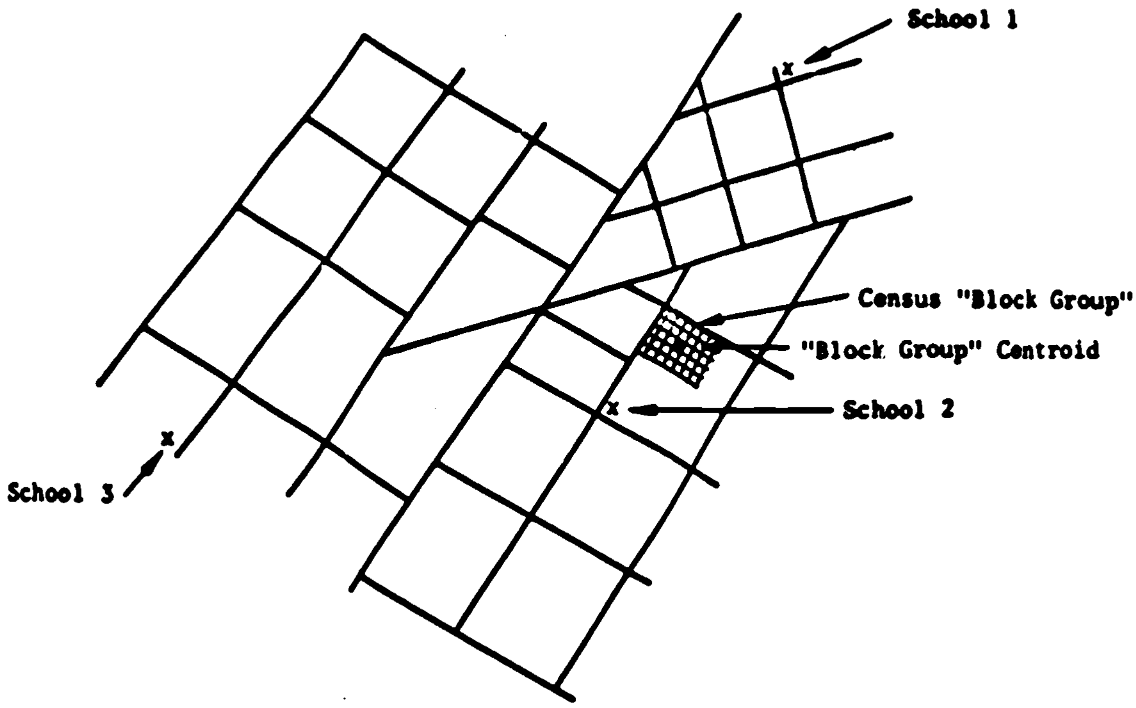

Figure 1. The School Assignment Problem

The assignment process is carried out in the computer in the following way. The block groups are processed one at a time. If there are several groups of students in the block group that must be considered separately (for example, elementary students, junior high school students, senior high school students, and perhaps minority and majority students for each of the grade levels), then each such distinct sub-group is considered one at a time.

To process the sub-group, we ask whether the overall quality (or value) of the assignment can be improved by reassigning any students in the sub-group to a different school. If an improved assignment alternative is available, the students are reassigned, and the next group is considered. The process is repeated several times through all "block groups" until it is not possible to make a significant improvement by reassigning any students. The "value" of the assignment is measured in terms of the specified assignment goals. Typically, the value is measured in terms of the level of school desegregation achieved minus a penalty for any increase in the number of students bused or any increase in travel time or walking distance. Obviously, to explicitly define the goals of the assignment it is necessary to specify how the level of desegregation is to be measured.

A CRITERION FOR MEASURING LEVELS OF DESEGREGATION

To measure the degree of desegregation achieved in a school system we need a criterion, or measure of merit. Such a measure is needed to assess or compare the quality of alternative school assignments from the point of view of the level of desegregation achieved. Because the present study is concerned with the assignment of students to schools rather than to classrooms within a school, the measure of desegregation used for the study is designed to reflect the racial composition of the schools, not of classrooms within the school. Obviously, the classrooms cannot be desegregated if the schools themselves are segregated. On the other hand, it is possible to maintain segregated classrooms within schools with a mixed racial composition. However, that is a separate problem which is not the concern of the present analysis.

The measure of desegregation used in the present study can be most easily understood if we look at the school assignment problem in relation to a single minority child. If the child is in a school where almost all his schoolmates are also minority children, the assignment has placed him in a segregated environment. The child's school environment will appear more desegregated if he can be assigned to a school with a larger percentage of non-minority schoolmates. We therefore define a "contribution" of each minority child to the desegregation measure, which is proportional to the percentage of non-minority students he finds in the school to which he is assigned. Figure 2 displays this contribution as a function of the racial composition of the school to which the minority child

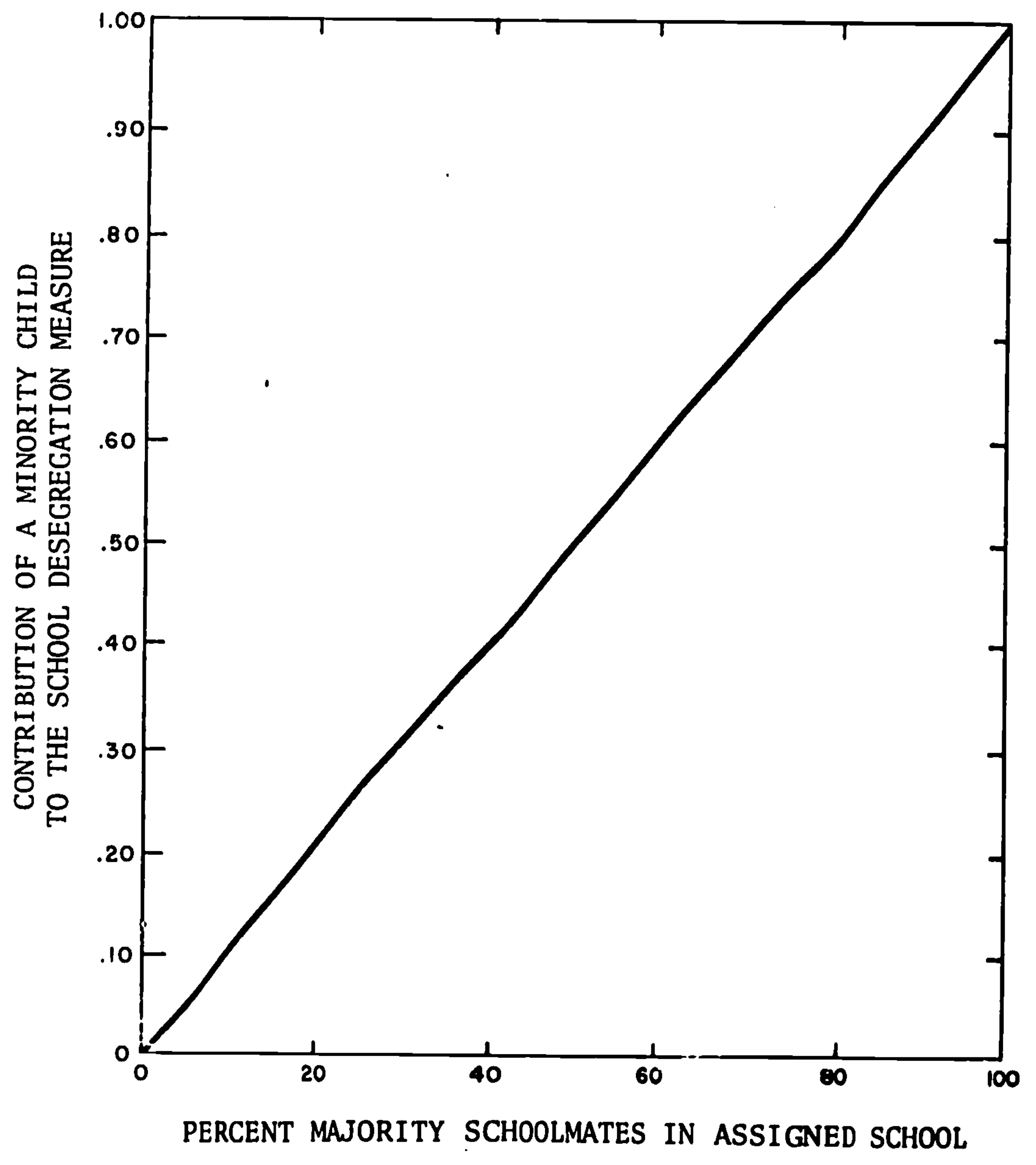

Figure 2. Showing How the Contribution of an Individual Minority Child to the Overall School Desegregation Measure Depends on the Racial Composition of his Assigned School

is assigned. The overall measure of the desegregation level for any school system is defined to be equal to the average of these individual "contributions" for all minority students in the system.

Using this basic concept, the desegregation level can be computed for an entire school system, or for any part of the school system. In the present study the desegregation level is reported separately for elementary schools, junior high schools, and senior high schools in each metropolitan area. In addition, a desegregation level over the entire school system is reported, in which all minority students are included regardless of grade level.

Figure 3 illustrates how this measure would operate in a school system which includes ten elementary schools of identical size. The initial school assignment, shown at the top of the page, illustrates a completely segregated assignment in which all minority students are in schools 1 and 6. Since none of the minority students have any non-minority schoolmates the desegregation level for this school assignment is zero.

Option Number 1 illustrates a reassignment option which provides the maximum feasible desegregation. The option provides a racial composition for every school that is identical with the racial composition in the entire system. In this assignment all the minority students are enrolled in schools with 80% non-minority students, and each minority student makes a "contribution" of .8 to the desegregation measure. The average of these contributions over all minority students gives an overall measure of desegregation for the system of .8, which is the best that is possible in a school system with an overall racial composition of 80%. If the overall racial composition in the district were 60%, the highest possible value of the desegregation measure would be only 60%. It is sometimes useful to express the level of desegregation in terms of an index that does not depend on the overall racial composition. The "desegregation index" (D.I.) is defined as the "desegregation measure" (D.M.) divided by the overall percentage

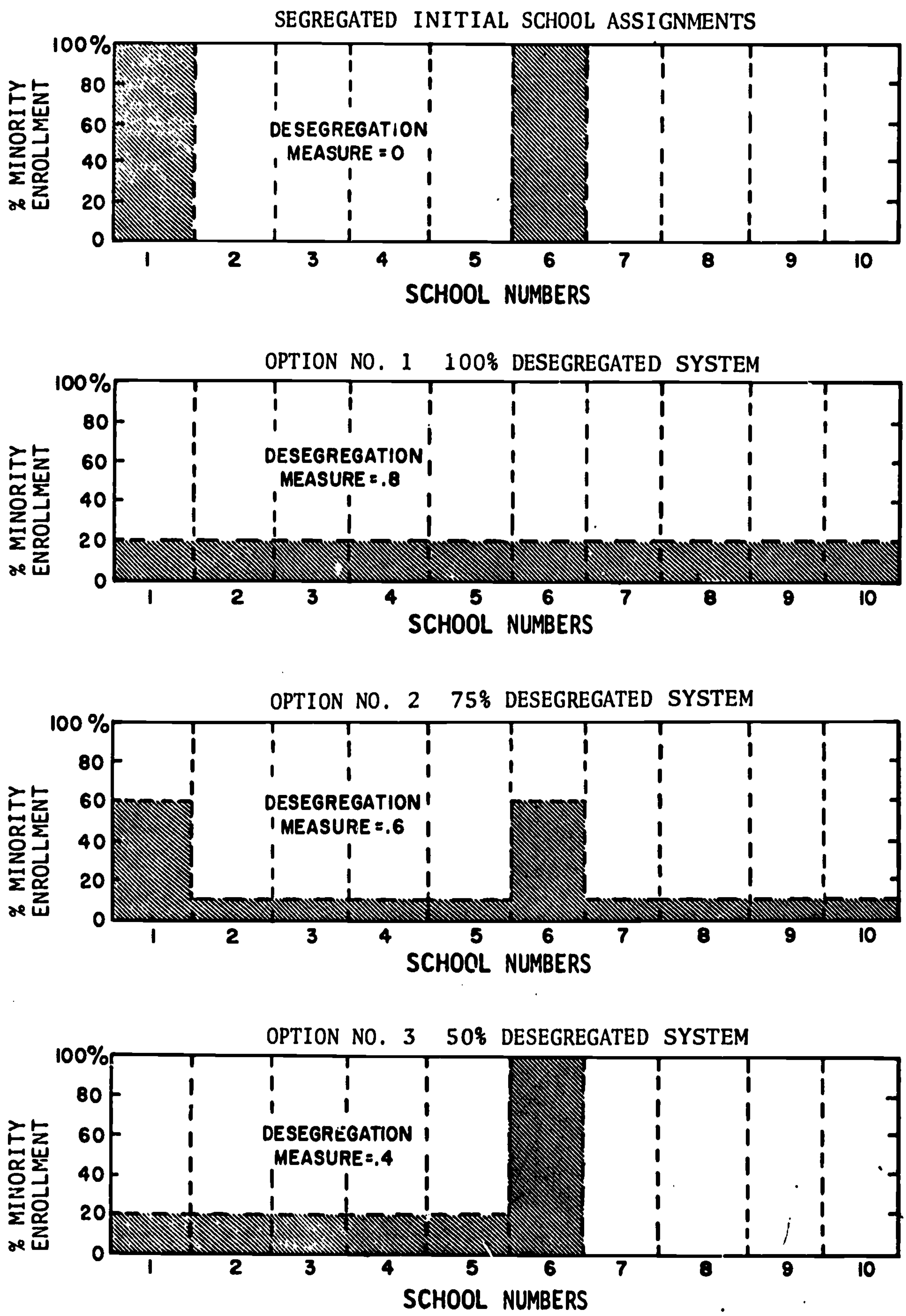

Figure 3. Desegregation Measure Illustrated for 10 Schools of Equal Capacity in a District with 20% Minority Students

of non-minority students in the school system.* In this study we use both the desegregation index (D.I.) and the desegregation measure (D.M.). The measure is a more useful guide when we wish to compare desegregation alternatives that interchange students between school districts with different racial compositions. The index is more useful as an absolute measure of desegregation compared to what is possible within a single school district.

Option 2 in Figure 3 illustrates a more limited desegregation plan for the school system. This plan requires the reassignment of only half as many students as Option 1, and provides a racial composition for each school that is midway between that found in the initial assignment and that provided by Option 1. It provides more than 50% as much desegregation, however, because it eliminates the extremes in racial isolation. Sixty percent of the minority students remain in schools 1 and 6 and make a "contribution" of .4 to the desegregation measure. Forty percent are moved to other schools and make a "contribution" of .9 to the measure. The average "contribution" is

$$(.6 \times .4) + (.4 \times .9) = .6$$

giving a desegregation measure of 60%. This is 75% of the best (.8) that is possible, so the desegregation index is 75%.

Option 3 at the bottom of Figure 3 involves the same number of reassignments as Option 2, but it does not eliminate the extremes in racial isolation and it produces only 50% of the maximum desegregation. In Option 3, half the school

*Although the derivation is different, the "Desegregation Index" defined in this way is mathematically identical to the Desegregation Index developed by Dr. Ira Cissin, Professor at George Washington University, for use by HEW.

system (schools 1 to 5) is totally desegregated; the other half remains totally segregated. The minority students in the desegregated schools contribute .8 each, but the other half of the minority students in segregated school 6 contribute nothing. The average contribution, of course, is exactly .4, giving a D.M. of 40% and a D.I. of 50%, as one would expect for a half-segregated school system.

Figure 4 illustrates how such measures can be used to compare alternative school assignments within a school district.

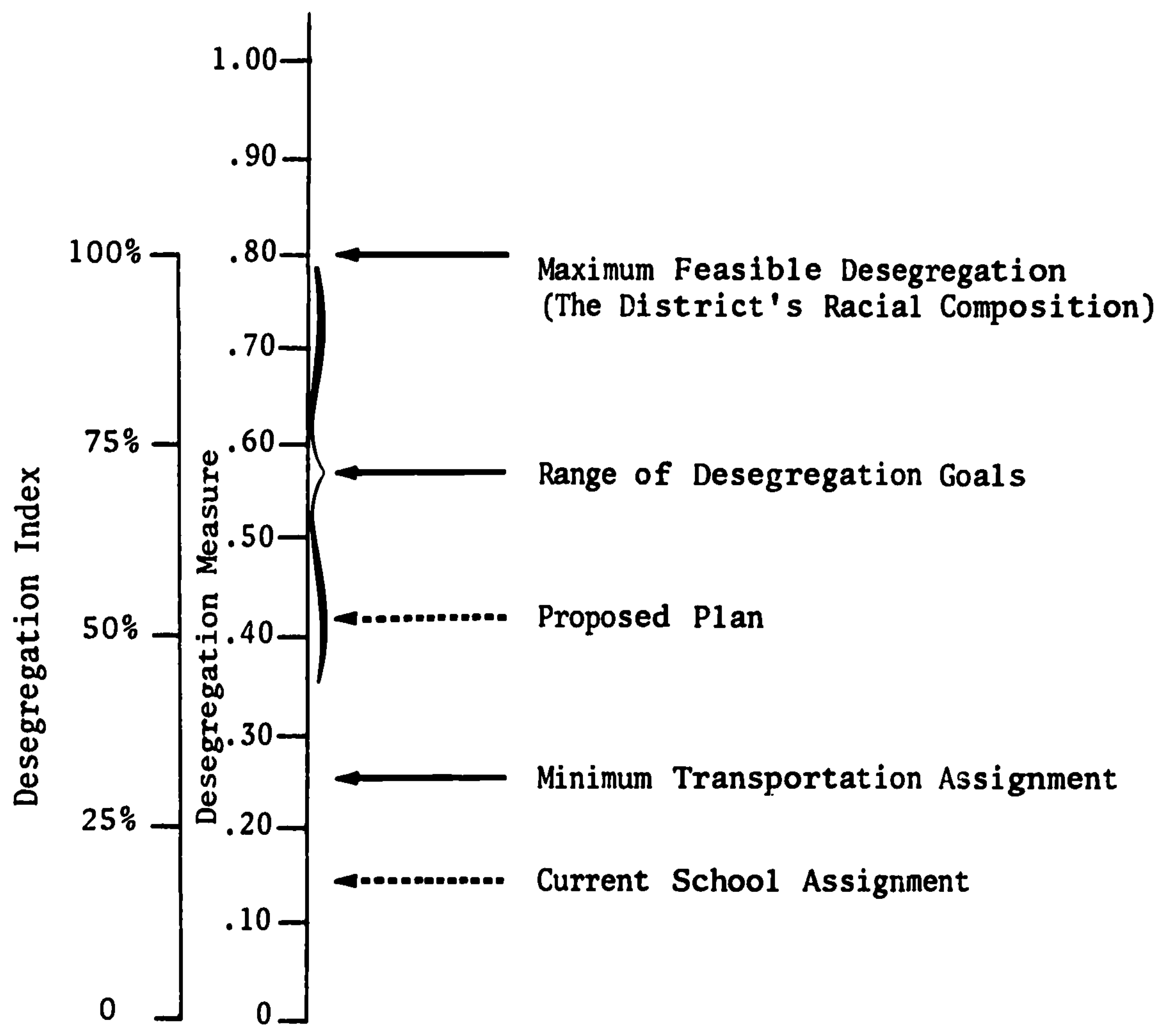

Figure 4. Illustration of Results for School District "X"

For example, we might consider an assignment of students to schools that minimizes the amount of busing required and that simply assigns students, regardless of race, to the nearest school with the required capacity -- what is sometimes referred to as the neighborhood school concept. Associated with that assignment there is a specific value of the measure of merit that can be calculated. This is illustrated in the example at 25% for the "Minimum Transportation Calculation." If the current school assignment shows a lower level of desegregation (as it does in this example) one can presume that the current school assignment involves more segregation than can be justified on the basis of minimum student transportation.

Conversely, if the current school assignment lies appreciably above this level, it is reasonable to presume that effort is already being made in the school system to achieve a degree of school desegregation.

If a plan is proposed for school desegregation which will result in an improvement in the level of desegregation, it may be interesting to compare the performance of that plan with the performance of one or other "Desegregation Goal" options which produce efficient desegregation at various reasonable busing levels. The performance of a "Proposed Plan" relative to such a theoretically feasible standard can provide an objective measure of the efficiency of the proposed plan.

DEFINITION OF "AMOUNT OF BUSING"

Thus far the phrase "amount of busing" has been discussed in relatively abstract terms, and of course a concrete definition is required in order to carry out a quantitative analysis. Many alternative definitions are possible. One might wish to minimize simply the total number of students who are transported. Alternatively, one might wish to minimize the time the students spend riding the bus. The definition originally specified for this study by H.E.W. was to minimize the number of students who ride the bus, with the limitation that busing transit time from the center of the population block group to the assigned school was not to exceed 35 minutes. In the survey of metropolitan areas, the calculations were carried out using this definition, and the results therefore display the maximum level of desegregation achievable as a function of a number of students bused in the 35-minute limit.

The analysis system itself, however, is capable of minimizing either the number of students bused or the time spent riding the bus or a combination of them. For two districts, a sensitivity analysis was carried out to compare the standard definition above with a definition in which an additional "penalty" is introduced for the length of time a student has to travel. For both districts studied, the results of the standard and of the additional sensitivity analysis were comparable. The comparisons indicate that the results are not seriously distorted by the simpler definition used in the basic study.

The analysis has not explicitly considered the possibility of using transportation modes other than special school buses. In many areas rapid transit systems or existing public transportation systems provide a practical and sometimes much preferable alternative. The assignment plans developed in the analysis are intended to reflect the best achievable assignments using only school buses. Where other preferable methods of transportation are available more efficient plans may be possible.

ILLUSTRATIVE ANALYSIS RESULTS

This section presents an illustrative, relatively complete analysis for one typical urban area.

Normally, of course, the level of desegregation that can be achieved tends to increase as busing is made available for an increased number of students. Usually, some percentage of the students live beyond walking distance and have to be bused to get to school -- regardless of any desegregation objectives. Figure 5 illustrates the type of curve that can usually be expected. As the figure shows, the desegregation that can be achieved typically reaches a point of diminishing returns where additional busing adds little or nothing to the level of desegregation that can be achieved.

Figure 6 illustrates the results of an actual calculation for a medium-size urban area (population approximately 1 million). The figure shows the achievable levels of desegregation of the elementary schools, plotted against the percentage of students bused. As expected we find that just to get all students to school, some must always be bused. In this example, this minimum busing level (shown with the heavy vertical line) amounts to about 22% of the elementary student body. Without increasing the number of students bused above this theoretical minimum, there is considerable flexibility in the amount of desegregation which can be achieved. The minimum level of busing can be used to contribute to desegregation, or alternatively it can be used to limit desegregation in the school system. There is, however, a natural neighborhood school assignment which minimizes the number of students bused and also minimizes the average busing time and

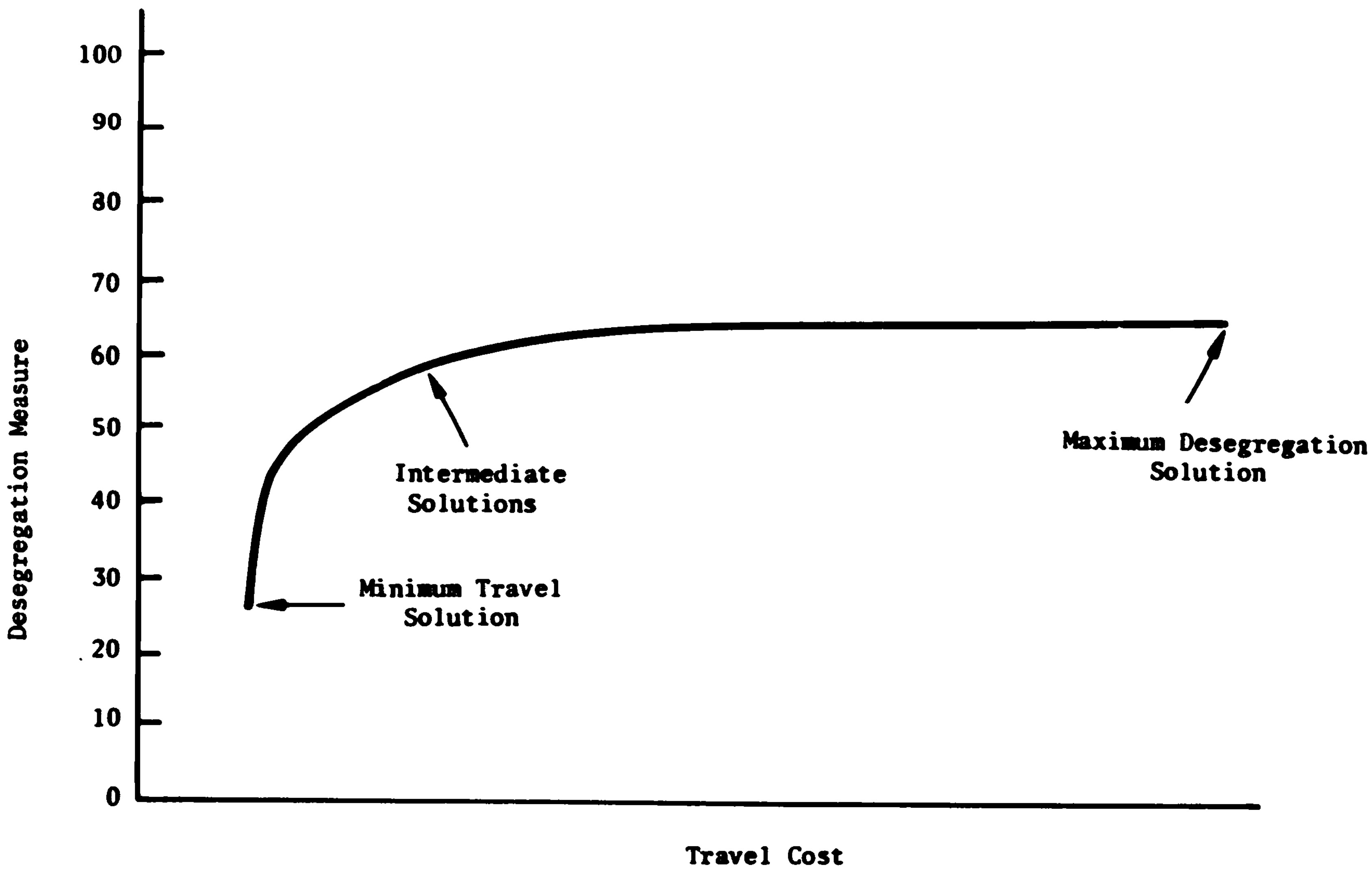

Figure 5. Illustrative Trade-off Alternatives for School District "X"

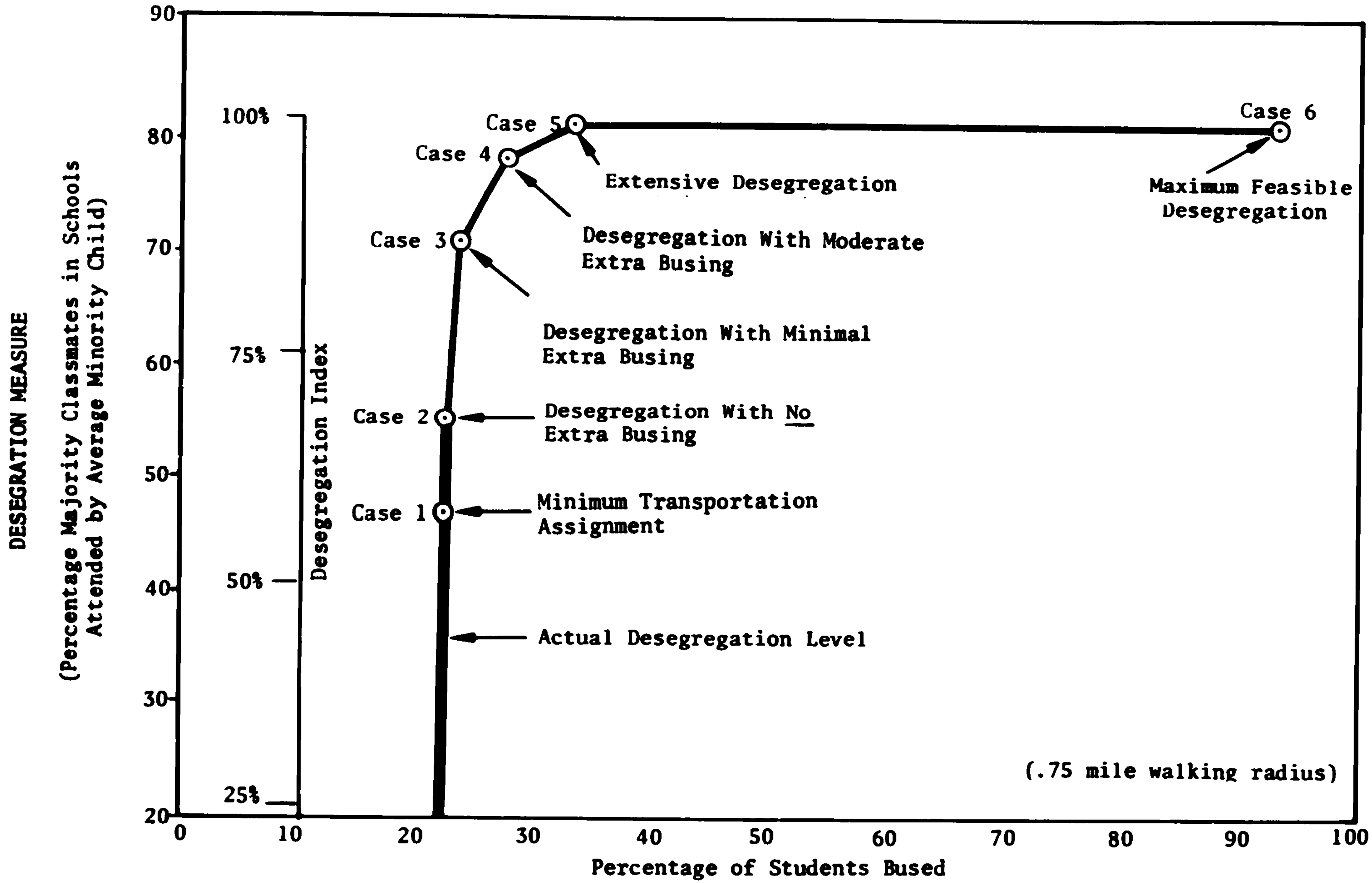

Figure 6 . Typical Analysis Results, Six Cases for Elementary Grades

walking distance. This point is noted by an arrow labeled "Minimum Transportation Assignment." The point just above it indicates the maximum desegregation achievable without any increase in the number of students bused (above the theoretical minimum).

With increasing percentages of students bused, the achievable level of desegregation increases rapidly. At about 33% of the students bused, the achievable desegregation level is almost as high as with unlimited busing. The level (of about 80%) is essentially identical with the racial balance in the system -- thus it represents an almost completely homogeneous school system. With additional busing above 33% only trivial improvement in the level of desegregation is possible.

Of course, the minimum feasible number of students bused depends on how far we are willing to have students walk. The curve shown was calculated for a three-quarter mile walking radius. If the permissible walking radius were increased, it would be possible to obtain an assignment with an even smaller percentage of students riding the bus.

At this point it is desirable to discuss in greater detail the meaning of the points on the curve of Figure 6, labeled case 1 through case 6. We note that the actual or existing desegregation level in this school district is appreciably below that achieved by the minimum transportation assignment, case 1, otherwise called the pure neighborhood assignment. Case 2 corresponds to an assignment in which there is <u>no</u> increase in the actual number of students bused, but the available transportation is used to maximize desegregation. Cases 3, 4, and 5 correspond to progressively higher levels of desegregation with limited additional busing. At case 5 the percentage of students bused is increased from about 22% to 33% and the racial composition of the school system is almost homogeneous. As a matter of academic interest, Case 6 represents placing no limit at all on the number of students bused, to obtain the maximum feasible level of desegregation, it produces a slightly more homogeneous racial composition than case 5 but it entails a ridiculous increase in the number of students bused.

Figure 7 shows how the results differ from junior high and high school compared with the elementary grade levels. The most striking thing about this comparison is the very large difference in the minimum percentage of students bused as we move from the elementary schools through the junior and senior high schools. This reflects the fact that the high schools typically are relatively large, and few in number, and draw students from a relatively wide neighborhood. As a consequence, many more high school students live more than 3/4 of a mile from the nearest high school. The overall percentage of minority students enrolled in the secondary schools is slightly less than in the elementary grades, thus the maximum achievable desegregation measure is higher in the upper grade levels. In each case the desegregation index reaches almost exactly 100%.

Another striking thing about the chart is that, in each case, the actual desegregation level is appreciably below what is obtained with the minimum transportation assignment. On the other hand, as would be expected, there is more desegregation in the high schools because they draw from a wider diversity of neighborhoods. Because so large a fraction of high school students already must ride the bus, very little additional busing is required to achieve a racial composition in the high schools which is very nearly homogeneous.

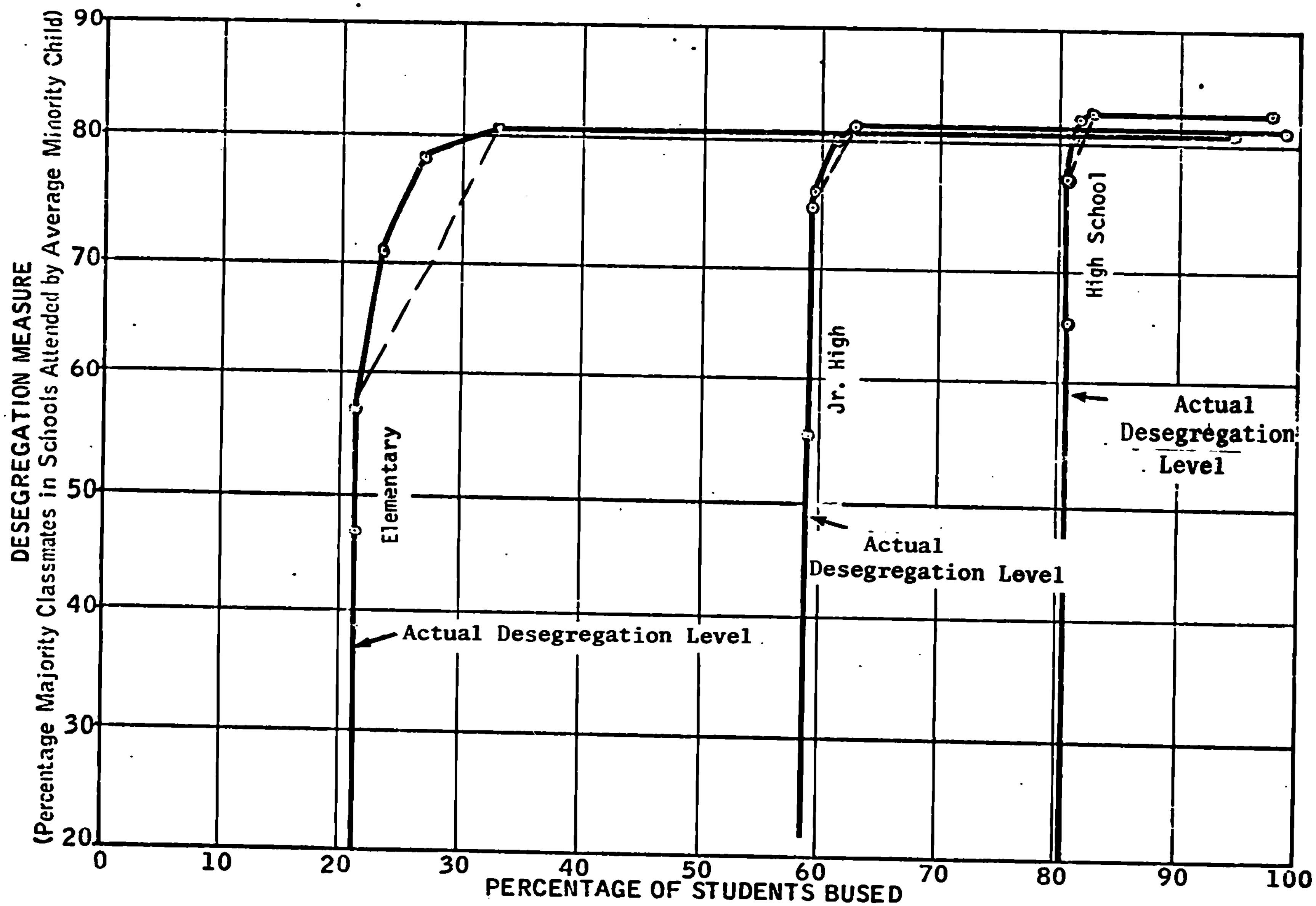

Figure 7. Typical Analysis Results Comparing Grade Levels

Not all of these cases have been calculated for all areas studied. To limit computation costs, the survey analysis has been limited to cases 2, 5, and 6 for most urban areas. This is usually sufficient to define the curve with the exception of the gap between cases 2 and 5.

The dotted lines in Figure 7 show how the survey curves will look when cases 3 and 4 are omitted.

In addition to the cases shown in Figure 7, an additional case has been calculated for many of the survey cities. For this additional case, identified as the Metropolitan Area Case, the area of analysis has been extended beyond the boundaries of the central school district to include other contiguous urbanized areas. The purpose of this calculation, of course, is to determine the extent to which school desegregation can be improved by a metropolitan area desegregation plan. This case is of particular interest in cities where the minority residential area covers most of the central school district, so that effective desegregation might require the inclusion of suburban areas.

SENSITIVITY TO ASSUMPTIONS

The basic calculations for the analysis survey deal only with a very simple theoretical question: "How much desegregation can be achieved for a given percentage of students transported to school?" (assuming a maximum of 35 minutes allowable busing transit time, and about a 3/4 mile walking radius). The student assignments used in the survey analysis are optimum in terms of these specific assumptions.

The time and resources available for the survey analysis were not sufficient to permit a detailed analysis of the sensitivity of the results for each city to the specific assumptions. For example, how would results be changed if the assignment plans were modified to include some of the more detailed considerations that should be incorporated in actual school desegregation plans. To provide an estimate of the sensitivity of results to such changes in assumptions a sensitivity analysis was done for two illustrative areas. This section reviews the results of the sensitivity analysis for one of those areas.

When we consider the very large increase in the level of desegregation that is achievable with very limited levels of additional busing, it is natural to ask if something important has been omitted in the analysis. One possibility, of course, is that we have asked too simple a question. Specifically the analysis shows only the maximum level of desegregation achievable with a given percentage of students transported, when the maximum busing transit time is limited to 35 minutes. It is possible that, while the assignment has relatively few children riding the bus, it may have those few riding the bus for unnecessarily long distances that are often close to the 35-minute limit.

To explore the sensitivity of results to some of these other considerations, calculations were carried out to evaluate achievable desegregation, with a given percentage of students bused, when other plausible restrictions are imposed on the types of busing plans that we will accept. Figure 8 shows the results of such a calculation. For comparison the results of the calculations displayed in Figure 6 have been left on the chart, and the new calculation is shown with dashed lines.

The "constrained" assignment shown in Figure 8 differs from the "standard" assignment in two important respects. First, whereas the "standard" assignment permitted minority and majority students from the same neighborhood to be independently assigned to different schools (if this would improve desegregation), the "constrained" assignment requires that both minority and majority students from the same "block group" be given identical school assignments. This allows all children from the same neighborhood to attend the same school, and precludes the possibility that separate buses might be required in the same neighborhood, to bus white students toward the central city and black students toward the suburbs.

Second, whereas in the "standard" assignment the travel time was limited only by a 35-minute travel limitation, in the "constrained" assignment it was re-required that the travel time for all students be kept as low as possible, without seriously degrading the amount of desegregation.

The very small difference between the two sets of curves shows clearly that the analysis results in the survey are not seriously distorted by the simplifying assumptions.

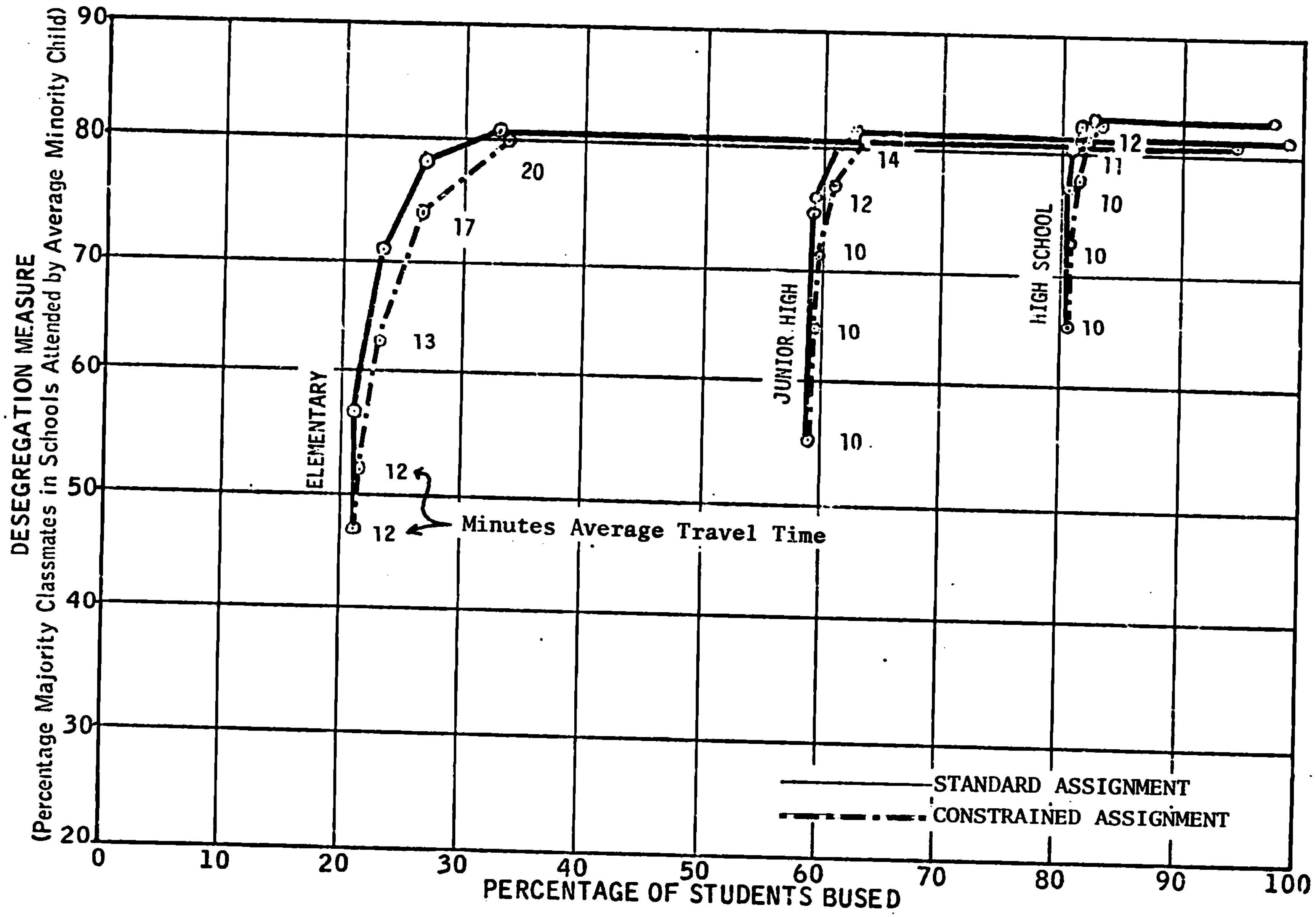

Figure 8. Analysis Results -- "Realistic" Assignment

The results of the calculations can provide useful additional information about the nature of efficient desegregation plans. Some of these results will be reviewed briefly in the following paragraphs.

The numbers to the right of each of the "constrained" assignment curves in Figure 8 represent the average travel time in minutes from the center of the "block group" to school, for those students bused under the school assignment shown. For the elementary students the average travel time increases gradually, from 12 minutes when no effort is made to achieve desegregation, up to an average travel time of 20 minutes when the point of diminishing returns is reached. In the case of high schools, the change in average travel time is much less. The total change is from an average of 10 minutes to an average of 12 minutes travel time. Presumably because of the large percentage of high school students already riding the bus, any increase in travel time required to achieve desegregation objectives has a much smaller effect on the averages.

To provide an intuitive impression of the levels of desegregation implied in Figure 8, Table II shows the actual racial composition of a small group of elementary schools (the names are obviously fictitious) for each of the six "constrained" assignments. The actual current racial composition of each school is shown in the column labeled "case 0." A comparison of the racial compositions for case 1, the minimum transportation or neighborhood school assignment, with actual current assignments is quite interesting. In most cases the current racial composition of the schools reflects rather accurately its surrounding neighborhood, and the columns are very similar. However, two schools stand out where this is

TABLE II

ILLUSTRATIVE SCHOOL COMPOSITION DATA
ELEMENTARY SCHOOLS
CENTRAL CITY

	PERCENT MINORITY ENROLLMENT						
SCHOOL NAME	CASE 0	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6
ALPHA EL SCH	6	17	13	11	12	17	19
BETA EL SCH	0	2	2	4	10	16	19
GAMMA EL SCH	2	1	0	4	10	17	19
DELTA EL SCH	0	3	3	4	9	14	18
EPSILON EL SCH	15	0	0	0	0	21	19
ZETA EL SCH	2	20	15	16	20	20	18
ETA EL SCH	0	0	0	0	6	15	18
THETA EL SCH	2	0	0	0	2	15	19
IOTA EL SCH	0	0	0	5	10	16	19
KAPPA EL SCH	63	4	15	16	20	21	19
LAMBDA EL SCH	16	29	30	33	25	20	18
MU EL SCH	1	1	1	3	12	23	19
NU EL SCH	1	18	12	23	21	21	19
XI EL SCH	7	5	11	23	22	19	19
OMICRON EL SCH	2	93	48	35	27	21	18
PI EL SCH	10	4	5	8	14	19	19
RHO EL SCH	0	1	1	0	14	17	18
SIGMA EL SCH	1	1	1	7	13	17	20
TAU EL SCH	97	98	96	65	38	23	19
UPSILON EL SCH	84	99	90	76	44	23	19
PHI EL SCH	1	4	4	5	12	22	18
CHI EL SCH	3	4	4	4	11	15	21
PSI EL SCH	13	6	6	6	10	15	19
OMEGA EL SCH	17	9	12	20	20	17	18

not the case. Kappa Elementary School is evidently being maintained as a predominately minority school in an area where the existing racial mix is predominately non-minority. Omicron Elementary School is evidently being maintained with very few minority students despite the fact that its immediate neighborhood is predominately minority.

As we progress from case 1 to case 6 we move toward more fully desegregated school assignments and the racial composition of the schools becomes much more uniform.

We can gain a much better understanding of the nature of the busing plans if we look separately at busing required of the minority and majority students. Figure 9 shows this type of a breakdown for the elementary grades. The striking thing about this display is that almost the entire increase in the level of desegregation (in this example, up to 74% in the desegregation measure) can be achieved without any appreciable increase in the number of majority students riding the bus. On the other hand, there is a substantial increase in the percentage of minority students that must be bused to school to achieve the same level of school desegregation. In the minimum transportation or neighborhood school assignment (the bottom of the curves), the percentage of minority students riding the bus is appreciably less than for the majority students (18 versus 22 percent). This is because the minority students typically live in more crowded urban areas where the distance to schools is less than in the suburban areas. On the other hand, as we impose a requirement for more school desegregation, the percentage of the minority students that must ride the bus increases faster than it does for the majority students. This reflects two separate effects:

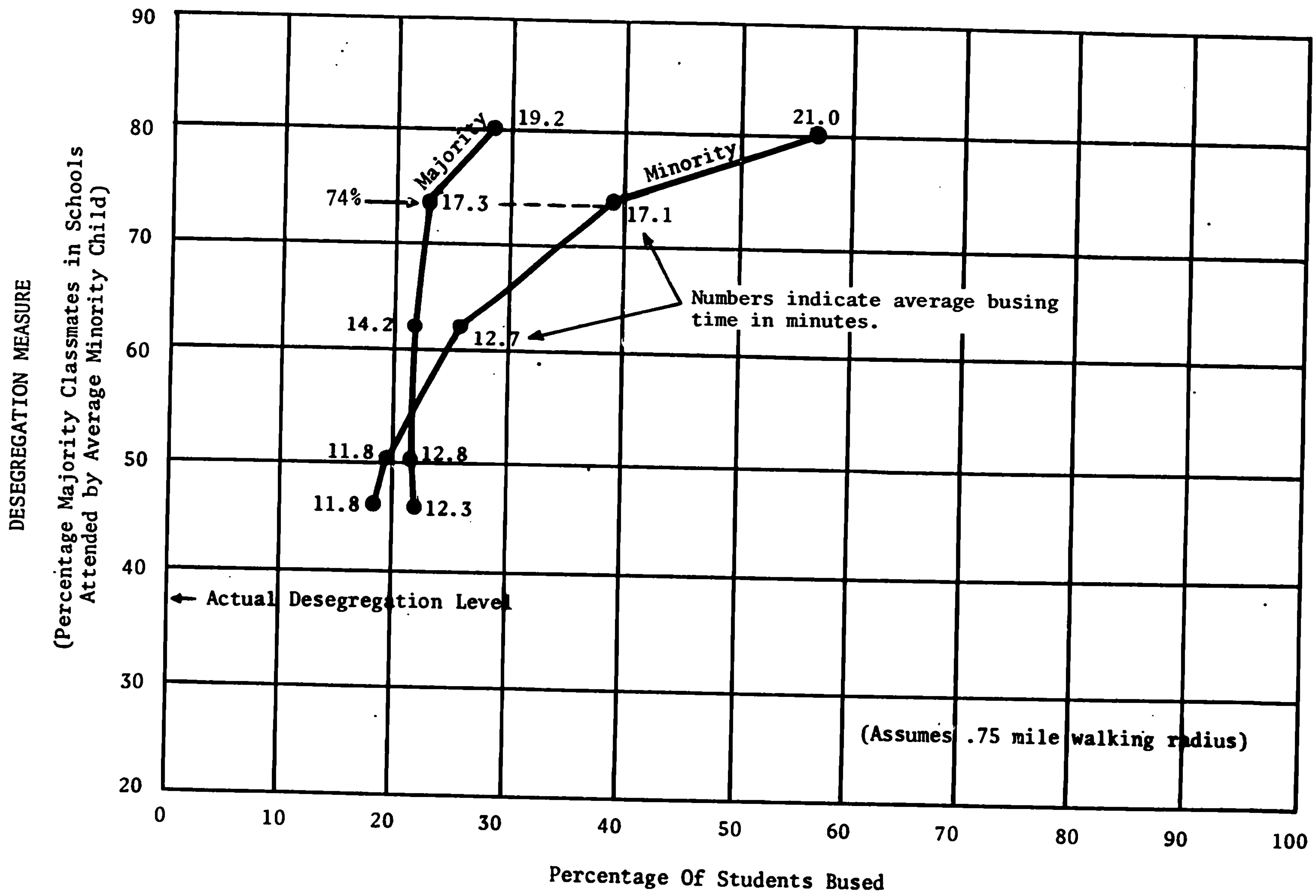

Figure 9. Transportation of Majority and Minority Students -- Elementary Grades

First, to the extent that desegregation involves an exchange of equal numbers of majority and minority students between the central city and suburbs, the percentage of minority students involved must be higher, because the population of minority students is less. This effect alone is sufficient to account for the difference in the rate of increase of majority versus minority busing at the top of the curves (between 74 and 80 percent on the vertical axis).

However, the fact that there is almost no increase in majority busing below the 74% level arises because of a second effect. In the case of the majority students, a large number are already bused to school. Simply by redirecting these buses it is possible to meet the demand for non-minority students in the central city area without additional busing. On the other hand, to bring the racial composition of the central city schools down to a level close to the school system without exceeding the capacity of the schools, it is essential to bus a large fraction of the minority students out of the central area. Since almost all of the minority students in this area are within walking range of the school, additional busing is required.

This result is interesting from a policy point of view because it shows why practical desegregation plans in cities with modest minority populations will almost always place a greater busing burden on the minority students. The cause arises from the geography and demography of the problem, and does not necessarily reflect any unfairness in the way the plans are developed.

On the other hand, if we look beyond the issue of simply the number of students bused, it is apparent from Figure 9 that the average busing time required to achieve the various levels of desegregation increases for both majority and minority students at approximately the same rate.

Figures 10 and 11 show the same type of results for junior and senior high school levels, respectively. Qualitatively the results for the three grade levels show exactly the trends one would expect. Since a higher percentage of students in the upper grade levels already ride the bus, less additional busing is required for desegregation.

The next few figures contain some displays that provide a more concrete visualization of the effect of the school reassignments on the racial composition of the schools. The information is again displayed from the perspective of the minority students in the school system. The figures show the distribution of minority enrollment in the schools displayed in terms of the racial composition of the schools attended. (The results shown are based on the "constrained" as opposed to the "standard" assignments of the previous charts.)

The top chart on Figure 12a displays the existing distribution for the elementary schools. The chart indicates that approximately 35% of the minority students attend schools that have less than 10% majority students. The remainder of the minority students are more or less uniformly spread through schools of all racial compositions. Overall the average minority student encounters approximately

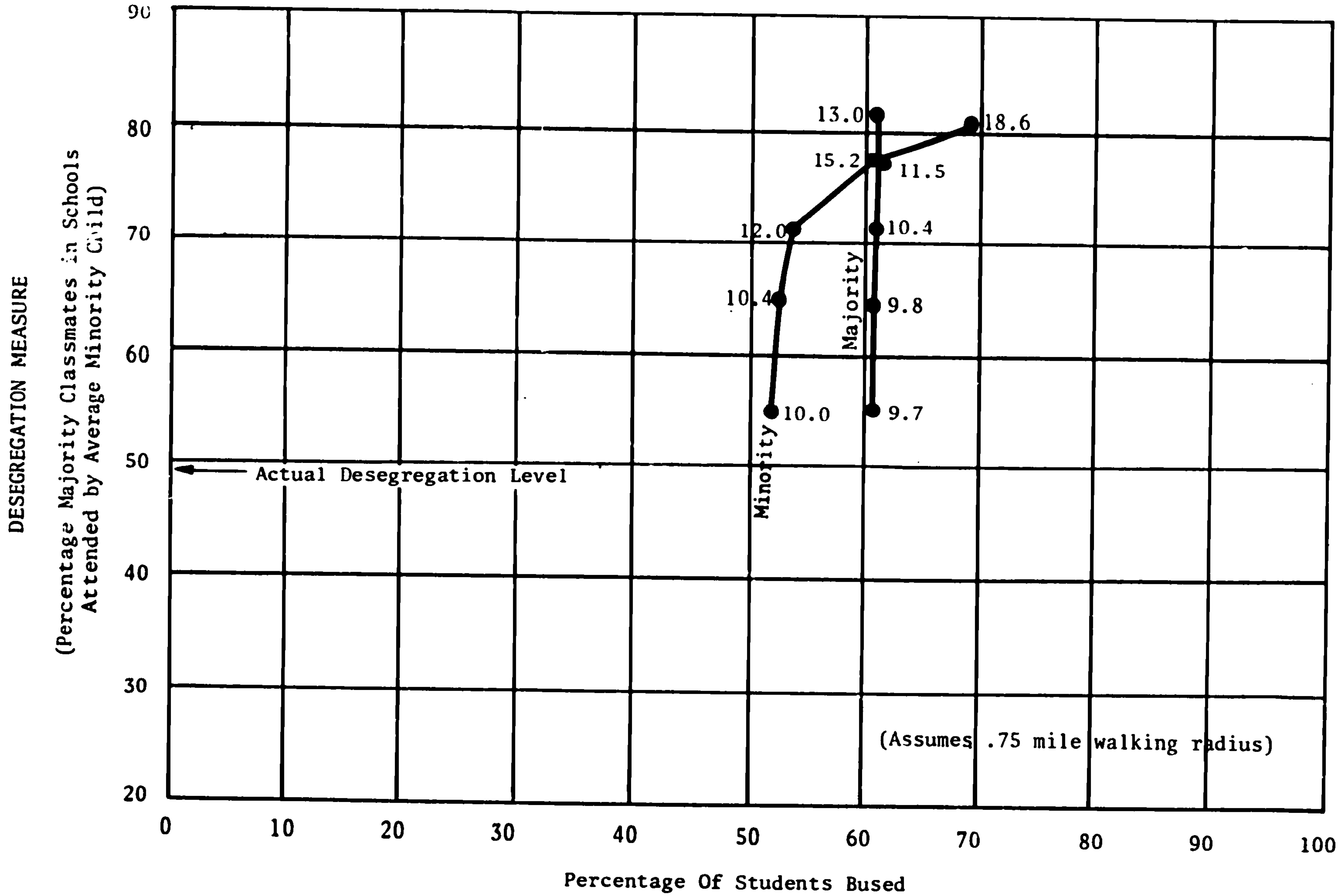

Figure 10. Transportation of Majority and Minority Students -- Junior High School

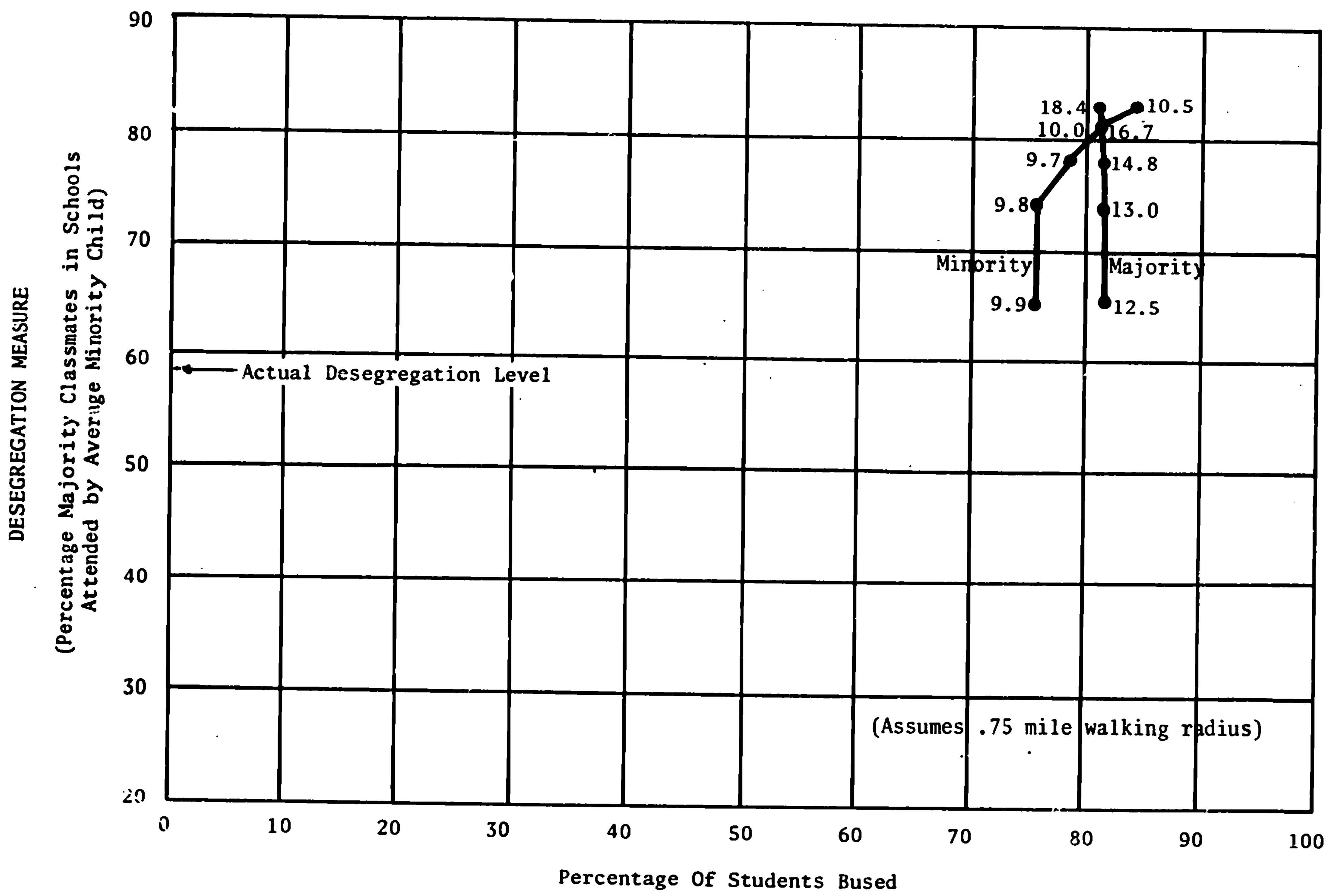

Figure 11. Transportation of Majority and Minority Students -- High School

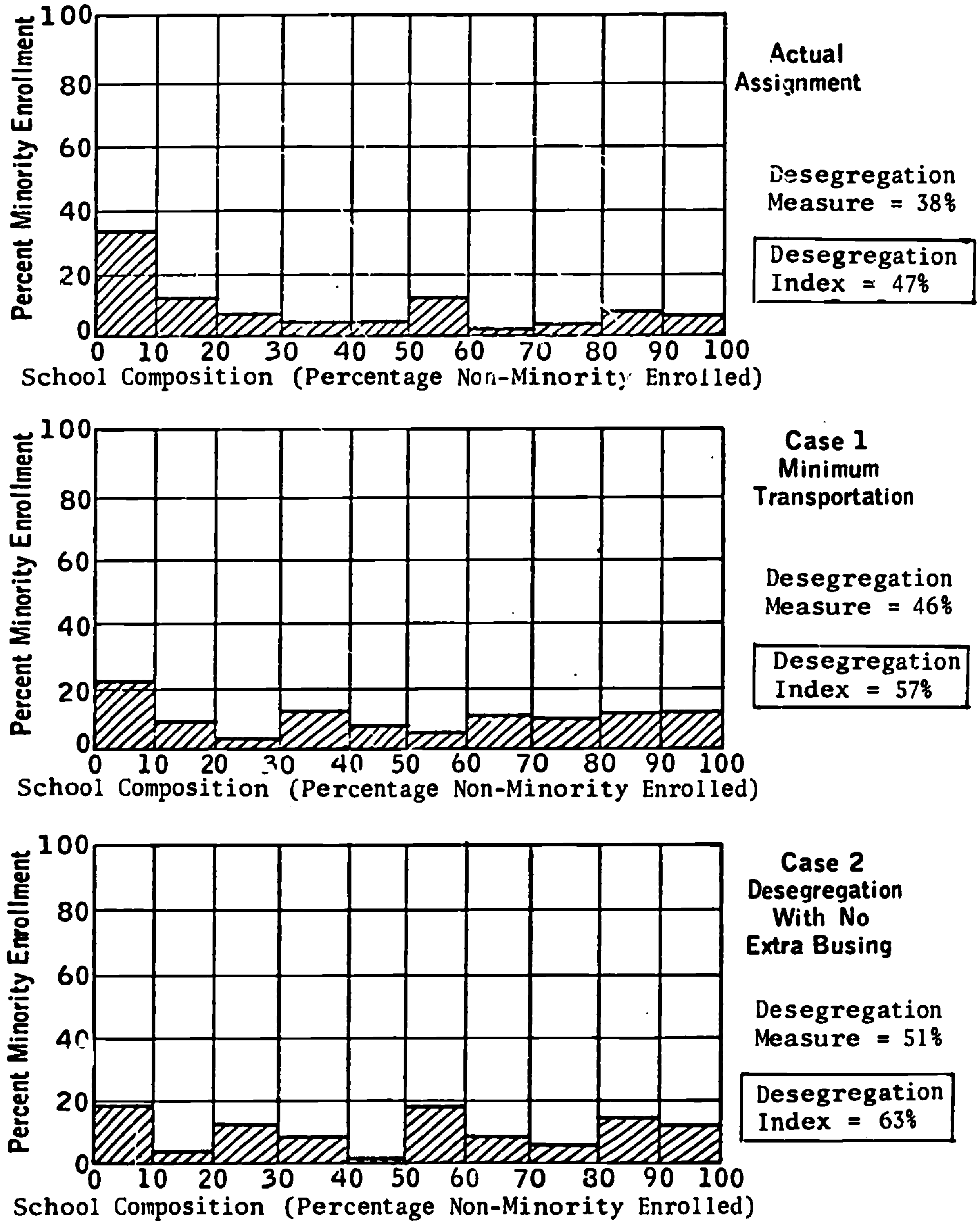

Figure 12a. Minority Enrollment By Racial Composition of Schools Attended -- Elementary Schools, Cases 1 and 2

38% majority schoolmates, corresponding to a desegregation measure of 38%. This is 47% of the best that is possible giving a desegregation index of 47%.

The racial distribution can be compared with the racial distribution resulting from case 1, the minimum transportation or ideal neighborhood school assignment. It is apparent that the idealized neighborhood school assignment provides somewhat better desegregation. Only about 23% of the minority students are in schools that are less than 10% non-minority. This improvement in racial composition is reflected in the fact that the average percentage of majority schoolmates is about 46%.

The bottom chart shows the best desegregation that can be accomplished without extra busing. In this case the desegregation measure increases slightly to about 51%, but this is not a very dramatic improvement.

Figure 12b shows what happens to the racial composition as we provide extra busing and move through Cases 3, 4, and 5. Notice how the racial composition moves gradually toward a less heterogeneous composition as the level of busing is increased. In case 3, with only 1.5 percent extra busing, schools with less than 20% non-minority students have been eliminated from the school system. With 5% extra busing, schools with less than 50% non-minority students have been eliminated. Finally with about 12.5 percent extra busing, the racial composition of all schools lies between 70 and 90 percent majority.

Figure 13a compares the actual assignment for high schools with the hypothetical assignment resulting from our Cases 1 and 2. Again the racial composition for the minimum transportation case is slightly better than (but

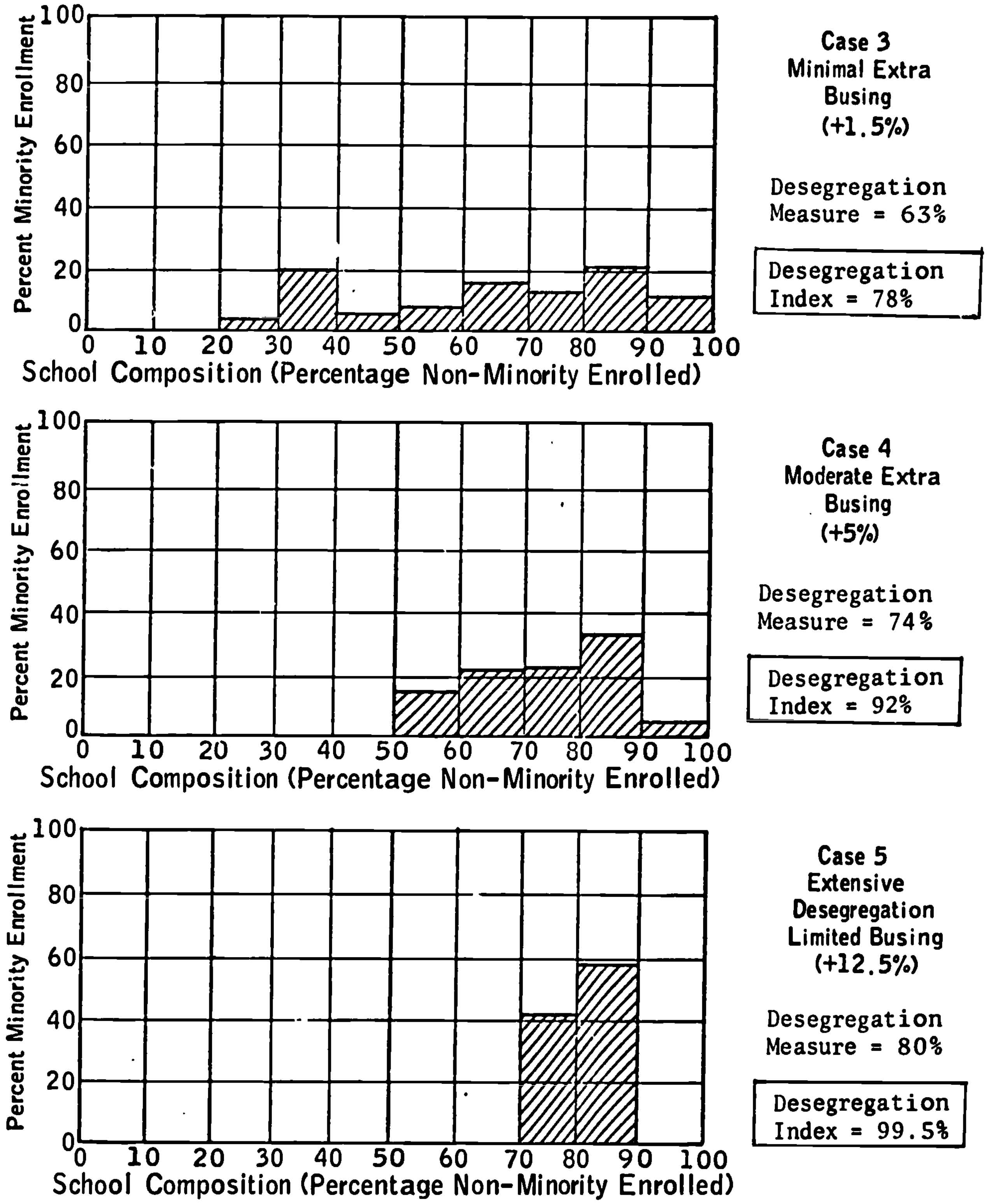

Figure 12b. Minority Enrollment By Racial Composition of Schools Attended -- Elementary Schools, Cases 3, 4, and 5

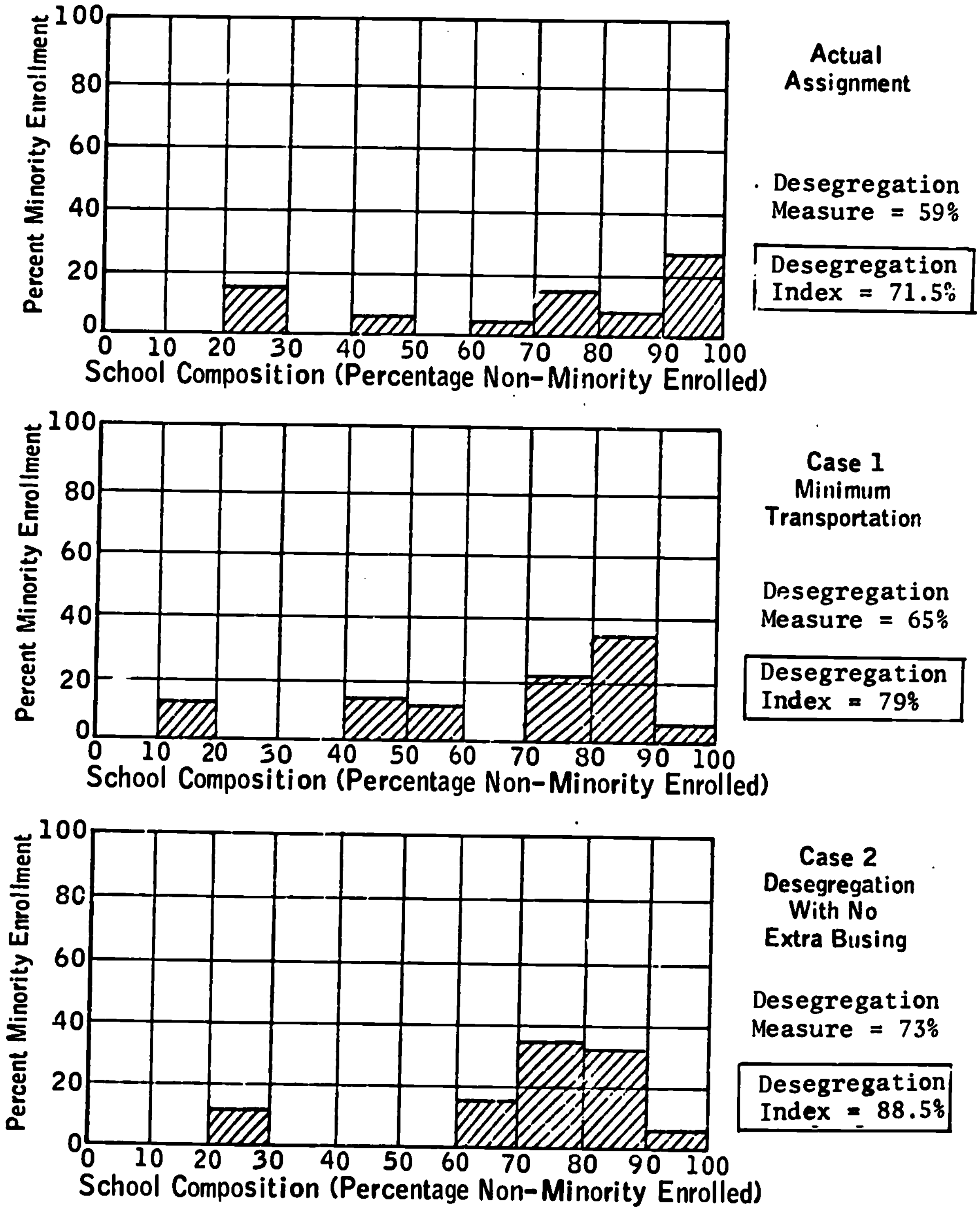

Figure 13a. Minority Enrollment By Racial Composition of Schools Attended -- High Schools, Cases 1 and 2

comparable to) what exists in the actual assignment. However, case 2 shows that with no additional busing a very appreciable reduction in racial isolation can be obtained.

Figure 13b shows the effects of a little additional busing in the case of the high school students. Only a limited amount of additional busing is required even to achieve an almost uniform racial composition in the high schools -- case 5 is achieved with only about 2% increase in the number of high school students riding the bus.

As we observed earlier, the minimum feasible percentage of students riding the bus depends in a rather sensitive way on the specific criterion used for the walking radius. In the previous calculations we assumed a 3/4 mile walking radius. To test sensitivity, the calculation was repeated for the elementary grades using a 1/2 mile walking radius, and the results are shown in Figure 14. With the reduced walking radius, the percentage of students bused increased from approximately 22 to approximately 35 percent.

In making a comparison of the calculated number of students bused relative to actual practice, it is important to recognize that a child's walking route to school is usually not straight, so that the average walking distance is somewhat greater than the straight-line distance to the school. As a general rule of thumb, the average walking distance is about 25% greater than the straight-line distance; or conversely, the straight-line distance is only about 80% of the actual walking distance. With few exceptions, the standard policy on transportation of

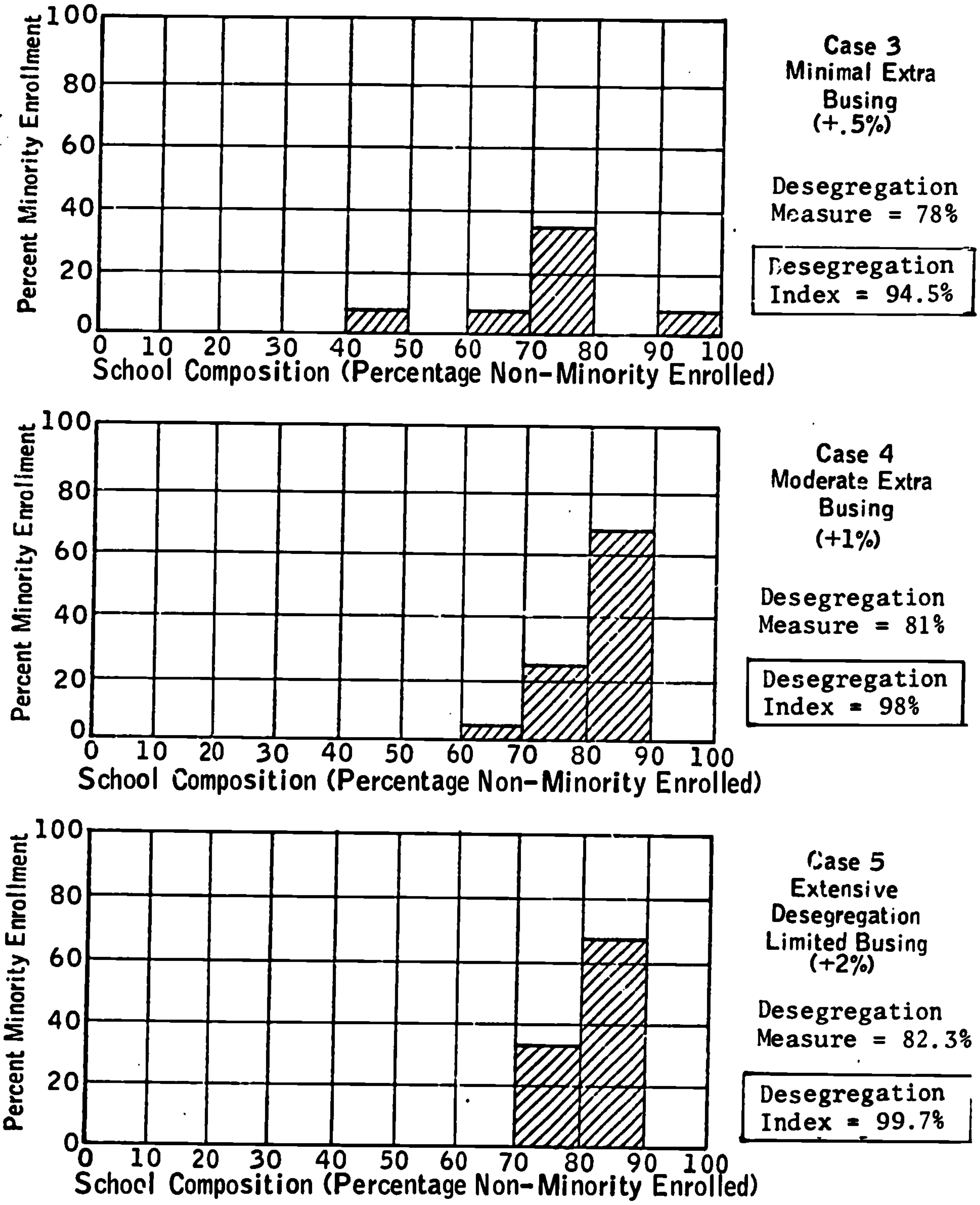

Figure 13b. Minority Enrollment By Racial Composition of Schools Attended -- High Schools, Cases 3, 4, and 5

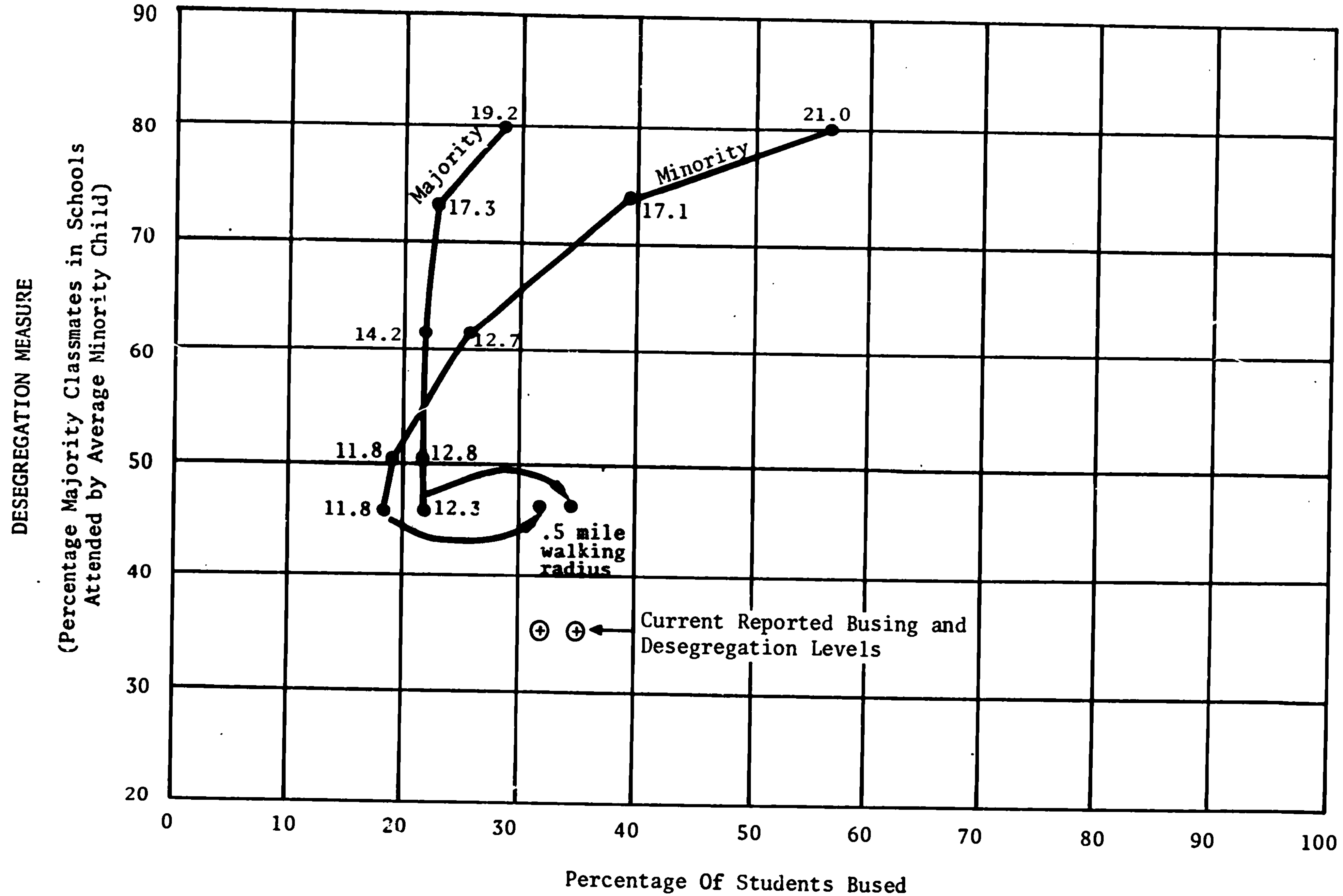

Figure 14. Sensitivity of Results to Walking Distance -- Elementary Grades

elementary students in the city is to provide transportation if and only if the actual walking distance to an assigned school exceeds 1.0 miles. This should be approximately equivalent to a .8 mile walking radius. The fact that the existing busing level closely matches the .5 calculation and is substantially greater than is calculated for the standard .75 mile radius, strongly suggests that the existing school assignment and busing program is inefficient in its use of transportation. Thus it is likely that an efficient school assignment policy could provide substantially improved desegregation with a lower level of busing than is currently used.

Figures 15 and 16 show a similar sensitivity analysis for the junior and senior high schools. The official limit on walking distance at these grades is about 1.5 miles, which according to the rule of thumb should be about equivalent to a 1.2 mile radius. Figure 15 shows that the existing level of busing is very close to what is predicted by the standard .75 mile walking radius, and is substantially higher than would be predicted by a 1.0 mile radius. Thus there is again evidence of substantial inefficiency in the present assignment.

Figure 16 shows that the predicted number of students bused for the senior high students using the 1.2 mile rule of thumb equivalent radius is very close to the present reported busing levels. This suggests that there may be relatively little transportation inefficiency in the high school assignment plan. Of course, it is also possible that many high school students utilize private rather than the publicly-supplied transportation.

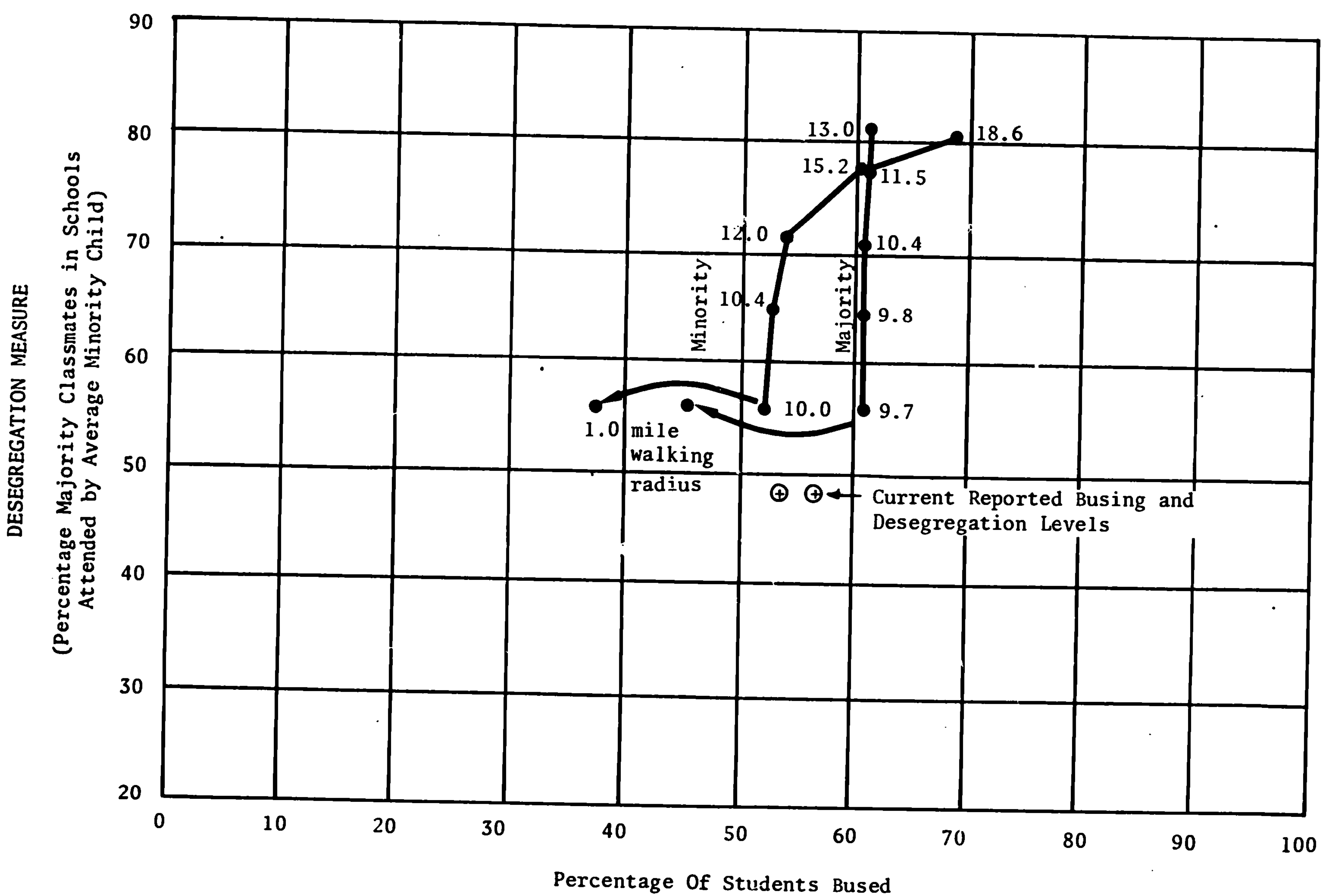

Figure 15. Sensitivity of Results to Walking Distance--Junior High School

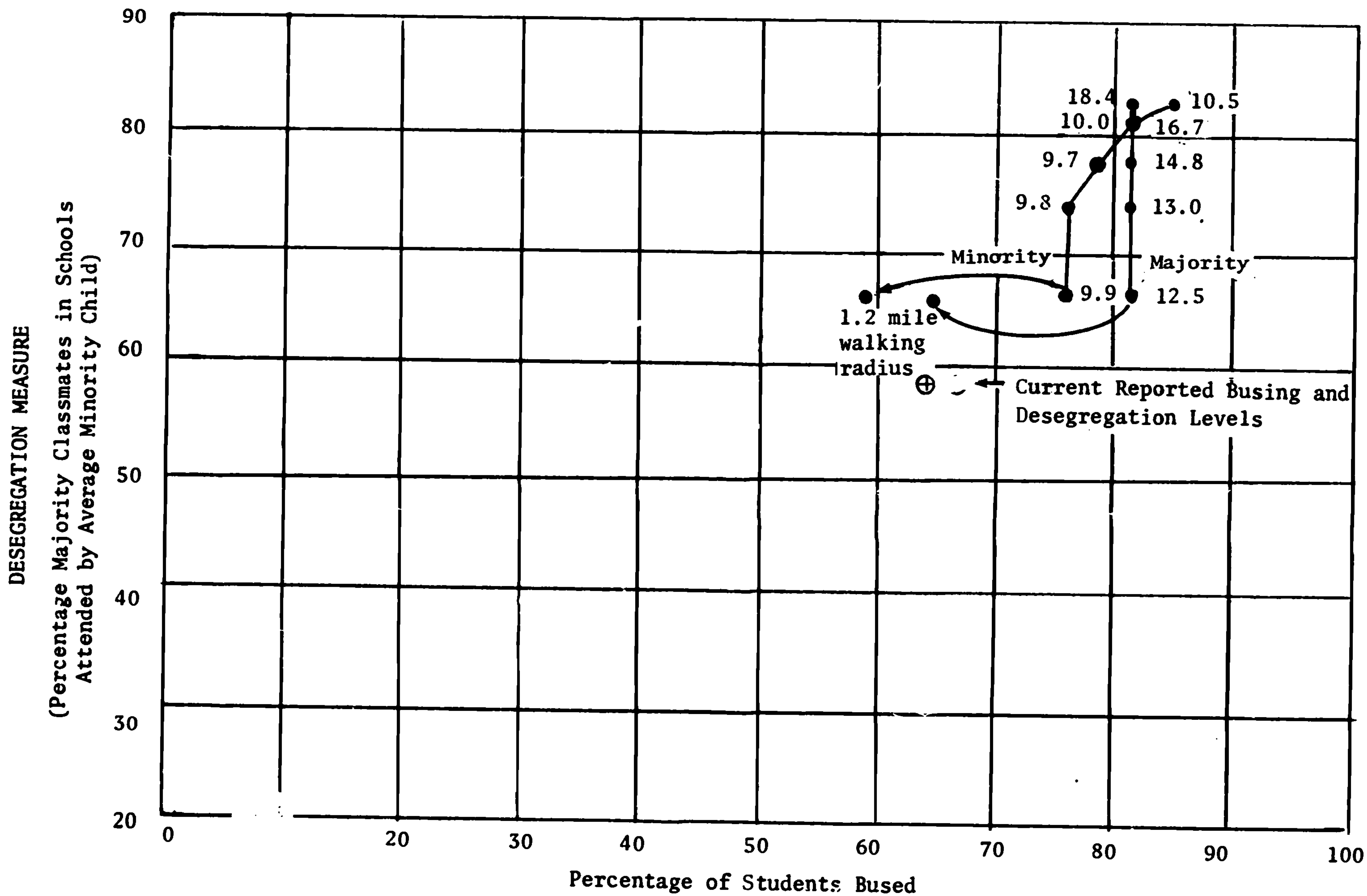

Figure 16. Sensitivity of Results to Walking Distance--High Schools

The extreme sensitivity of the estimated transportation requirements to assumptions concerning allowable walking distance was not recognized until the survey calculations were well under way. The survey calculations were carried out for all cities using a standard .75 mile walking radius. As a consequence, the absolute levels of transportation obtained in the calculations can be misleading for any city where the policy is very different from a one mile criterion. While a walking distance limit near one mile is quite common in much of the Northeast part of the country, many cities, particularly in other parts of the country, use longer distances such as two and sometimes even four miles. Obviously for such areas the initial survey calculations will greatly overestimate the amount of transportation required. The results may nevertheless be interesting as an indication of the desegregation alternatives that would be available if a walking limit of one mile were generally applied.

An additional problem has been encountered in relating the calculated transportation requirements to the reported student transportation in specific areas. In many areas, the school system makes extensive use of standard public transit systems. The use of such transportation may be subsidized by the school system, and may greatly decrease the requirement for the use of special-purpose school buses. Unfortunately such student transportation is often not included in the reported data. Consequently, the officially reported transportation may be substantially less than is actually used, and thus may be hard to reconcile with the calculated results.

An effort was made to reconcile the differences in six cities where large discrepancies were found between reported and calculated transportation requirements. In each case, it was possible to resolve the problem when the actual local practices were fully understood.

ANNEX

Information Sources for Transportation Data

INFORMATION SOURCES FOR TRANSPORTATION DATA*

St. Louis, Missouri: Missouri State Highway Commission, Jefferson City, Missouri, August Steiner, Engineering Planning Division.

East-West Gateway Coordinating Council, St. Louis, Missouri, John J. Murphy, Transportation Planner.

Detroit, Michigan: Southeast Michigan Council of Governments, Detroit, Michigan, Robert L. Smith, Jr., Transportation Engineer, Planning Division.

San Antonio, Texas: State Highway Department of Texas, Austin, Texas, Joseph E. Wright, Director, Planning Survey Division.

Richmond, Virginia: Commonwealth of Virginia, Department of Highways, Richmond, Virginia, Oscar K. Mabry, Assistant Transportation Planning Engineer.

Atlanta, Georgia: State Highway Department of Georgia, Atlanta, Georgia, Leland S. Veal, State Highway Planning Engineer, and Jere Burruss, Division of Highway Planning.

Philadelphia, Pennsylvania: Delaware Valley/Regional Planning Commission, Philadelphia, Pennsylvania, Richard E. Hubbell, Director, Transportation and Utility Planning.

El Paso, Texas: Texas Highway Department, Austin, Texas, Joseph E. Wright, Director, Planning Survey Division.

Cleveland, Ohio: Northeast Ohio Areawide Coordinating Agency, Cleveland, Ohio, Robert Brown, Executive Director, and James Allison.

Birmingham, Alabama: State of Alabama, Highway Department, Montgomery, Alabama, John L. Skinner, Jr., Chief, Bureau of Urban Planning.

Hartford, Connecticut: State of Connecticut, Department of Transportation, Hartford, Connecticut, Mr. I. Resnikoff, Transportation Director of Planning, and George McLean.

San Francisco, California: Metropolitan Transportation Commission, Berkeley, California, Paul C. Watt, Executive Director.

*Includes cities not yet studied.

Dayton, Ohio: State of Ohio, Department of Highways, Columbus, Ohio, F. J. Murray, Engineer Bureau of Planning Survey and Charles Groves.

Indianapolis, Indiana: City of Indianapolis, Department of Metropolitan Development Division of Planning and Zoning, Indianapolis, Indiana, Derdon Yang, Senior Planner.

Indianapolis Department of Transportation, James Cox.

Denver, Colorado: The State Department of Highways, Division of Highways, State of Colorado, Denver, Colorado, T. C. Reseigh, Planning and Research Engineer.

Tucson, Arizona: General Electric Company, Bethesda, Maryland, Adelbert J. Beesley, Project Analyst, Civil Engineering Projects.

Tucson Area Transportation Planning Agency, Tucson, Arizona, William G. Ealy, Manager.

Toledo, Ohio: State of Ohio Department of Highways, Columbus, Ohio, F. J. Murray, Engineer Bureau of Planning Survey, and Charles Grives.

Oklahoma, City, Oklahoma: State of Oklahoma Department of Highways, Oklahoma City, Oklahoma, Edward Kephart, Engineer III.

Omaha, Nebraska: State of Nebraska, Department of Roads, Lincoln, Nebraska, Derald S. Kohles, Transportation Planning Engineer.

Fort Wayne, Indiana: Barton-Aschman Associates, Inc., Chicago, Illinois, C. Gordon Herrington, P.E.

Ferndale City, Michigan: Southeast Michigan Council of Governments, Detroit, Michigan, Robert L. Smith Jr., Transportation Engineer, Planning Division.

Wichita, Kansas: State Highway Commission, Topeka, Kansas, E. D. Landman, Urban Transportation Planning Engineer.

Colorado Springs, Colorado: The State Department of Highways, State of Colorado, Denver, Colorado, T. C. Reseigh, Planning and Research Engineer and Greg Henk, Planning and Research Division.

Charleston, West Virginia: West Virginia Department of Highways, East Charleston, West Virginia, P. O. Bailey, Jr., Director

State Road Commission of West Virginia, Charleston, West Virginia, Jack Pascoli, Division of Urban Planning.

Pontiac, Michigan: Southeast Michigan Council og Governments, Detroit, Michigan, Robert L. Smith, Jr., Transportation Engineer Planning Division.

Pomona, California: State of California, Business and Transportation Agency, Department of Public Works, Division of Highways, District 7, Los Angeles, John W. Shaver, Assistant District Engineer and D. L. Wieman, Urban Planner.

Kansas City, Missouri: Metropolitan Planning Commission, Kansas City Region, Kansas City, Missouri, Stuart Eurman, Director.

Mobile, Alabama: Bureau of Urban Planning, State Highway Building, Montgomery, Alabama, John L. Skinner, Jr., Chief.

Miami, Florida: State of Florida Department of Transportation, Tallahassee, Florida, John H. DeWinkler, Supervisor, Plans Analysis.

Newport News, Virginia: Department of Highways, Richmond, Virginia, Oscar Mabry.

Jacksonville, Florida: State of Florida Department of Transportation, Tallahassee, Florida, John H. DeWinkler, Supervisor, Plans Analysis

Fort Lauderdale, Florida: State of Florida Department of Transportation, Tallahassee, Florida, John H. DeWinkler, Supervisor, Plans Analysis.

Oakland, California: Metropolitan Transportation Commission, Berkeley, California, Paul C. Watt, Executive Director.

East St. Louis, Ill.: Missouri State Highway Commission, Jefferson City, Missouri, August Steiner, Division Engineer Planning.

East-West Gateway Coordinating Council, 720 Olive Street, Suite 2110, St. Louis, Missouri, John J. Murphy, Transportation Planner.

Washington, D. C.: Metropolitan Washington Council of Governments, Washington, D. C., Albert A. Grant, P. E., Director, Department of Transportation Planning.