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ABSTRACT

A set of techniques is presented to assist administrators in forecasting the need for primary and secondary school facilities and in critically evaluating proposals to satisfy that need. Four basic components allow the analysis required to project future conditions and test alternative proposals. (1) The enrollment component forecasts the number and geographic location of students by grade for each year over a long-range planning period. (2) The facility component translates projected students into the number of teaching stations and/or square feet necessary to house them. (3) The fiscal component forecasts bonding capacity, tax revenue from different levels of government, and expected operating and capital costs. (4) The geographic component assists the user in considering locational questions, how best to draw attendance boundaries, and where to build or close a facility. Two additional chapters present considerations for (1) organizing a major planning project and (2) selecting alternative plans, assembling data, and periodically rerunning the system. Techniques described in this first of three documents are designed for districts with easy access to a computer. (Author/MLF)

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School Facility Planning System

USER'S HANDBOOK COMPUTER VERSION

prepared by

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Preface

The School Facility Planning System has been developed to assist public school administrators in their planning for educational space. The System has been made possible by a grant from the National Science Foundation to a consortium of institutions in St. Louis, Missouri. To date the System has had relatively limited test experience. All users who identify deficiencies in the procedures or documentation are encouraged to notify the Executive Director of the Council of Educational Facility Planners, 29 West Woodruff Avenue, Columbus, Ohio, 43210; and/or the Director of Planning, St. Louis County Government Center, Clayton, Missouri, 63105.

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Executive Summary

Most school administrators appreciate the problem of long-range facility planning. Recent fluctuations in school enrollments, facility standards, and financial resources have emphasized the need for a structured and systematic approach to educational planning. The School Facility Planning System presents a set of techniques for persons confronted with elementary and secondary public school planning decisions.

Purpose. The School Facility Planning System is designed to assist administrators in forecasting the need for primary and secondary school facilities and in critically evaluating proposals to satisfy that need. Two versions are offered; one is designed for the district with easy access to a computer, the second requires only a desk calculator. When used by school personnel with a knowledge of local conditions, the System should provide a rational environment in which to consider the closing or construction of school buildings.

Components. Four basic components have been developed that allow the analysis required to project future conditions and test alternative proposals.

1. Enrollment Component. This component assists the user in forecasting the "demand" for public school education. The number and geographic location of students by grade may be forecast for each year over a long-range planning period.

2. Facility Component. This component translates projected students into the number of teaching stations and/or square feet necessary to house them. Calculations are designed to reflect the district's unique standards and policies regarding school operations. A comparison of existing and planned space with projected needs establishes the anticipated excess or shortage of space.

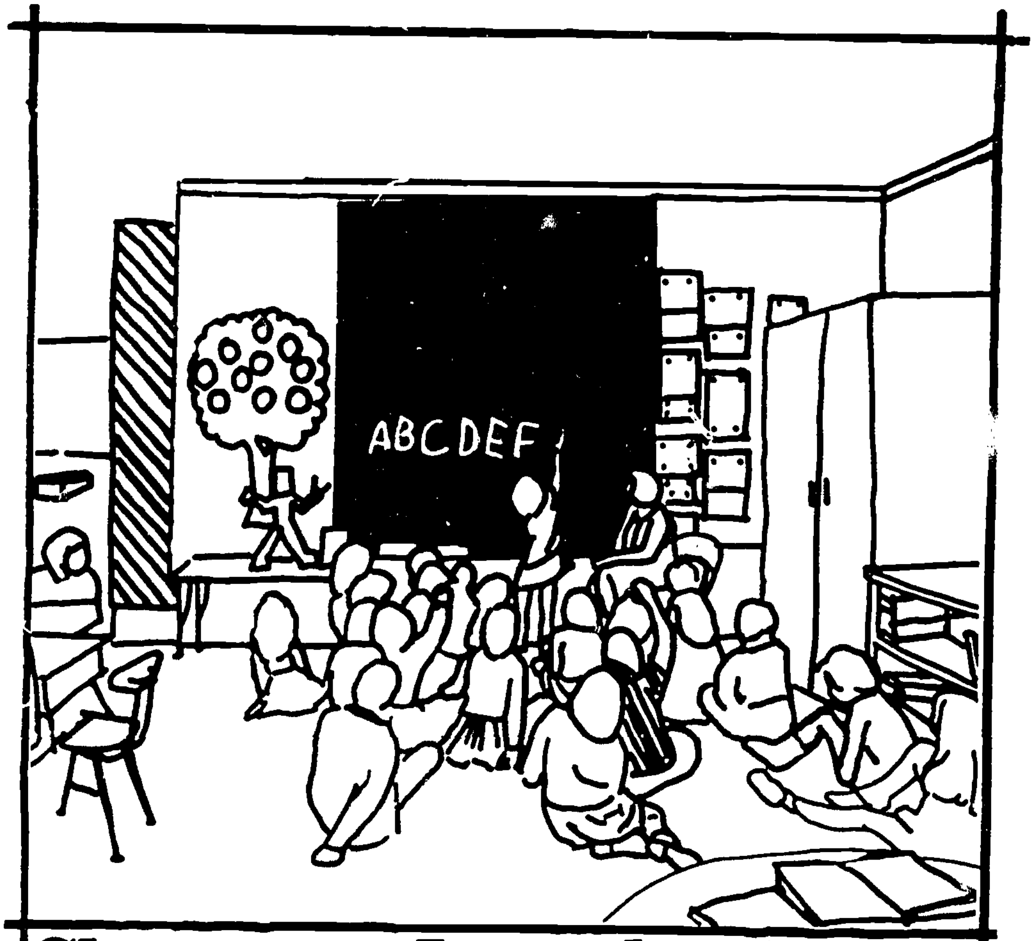
3. Fiscal Component. This component helps the user in forecasting bonding

capacity, tax revenue from different levels of government, and expected operating and capital costs. The fiscal implications of alternative facility plans may be examined and compared.

4. Geographic Component. This component assists the user in considering locational questions, how best to draw attendance boundaries, and where to build or close a facility. The transportation "costs" associated with alternative plans are calculated in light of the projected enrollment for different sub-areas of the district.

Two additional chapters are provided for those administrators desiring further insight into the facility planning process. Considerations are presented for organizing a major planning project (Chapter 7), and for selecting alternative plans, assembling data, and periodically re-running the system (Chapter 8).

Capability. The School Facility Planning System will not automatically improve the quality of long-range capital planning decisions. As with most planning tools, the utility of the product will be highly dependent upon the assumptions that enter into each calculation. The System must be used by individuals with an understanding of local demographic and economic conditions and of acceptable school board policies. However, when such individuals can be assembled, the System should enable a more rigorous and comprehensive planning process than has been previously possible.



Chapter 1: Introduction

The American public spends billions of dollars annually for the construction and modernization of public school facilities. In recent years, the form of these capital expenditures has begun to change as school closings have become as prevalent as openings and school remodeling has competed with new school construction. Many districts that until recently were growing in both population and assessed valuation have leveled off. Others that stabilized in the late 1960's are in the midst of a significant enrollment decline. Alternative approaches to local public education continue to be explored with emphasis on new curricula, instruction techniques, and forms of school organization. All of these factors have direct implications for school facilities. Thus, capital planning and budgeting for school systems in the years ahead will continue to be characterized by uncertainty.

1.1 The School Facility Planning System

The School Facility Planning System (SFPS) is a method for helping school administrators work in an environment of uncertainty. Developed under a National Science Foundation grant, this system represents the effort of a research consortium, consisting of a local planning agency, a computer-oriented consulting firm, the departments of urban studies and education at a university, and an architectural firm.*

The System has been reviewed by a 19-member review committee that included school administrators, representatives of related professional organizations, and several academic and private consultants. It has also been evaluated by a number of local school systems, primarily in the St. Louis, Missouri, area.

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The following document explains the procedures for using the computer-based version of the School Facility Planning System. Interested readers are referred also to the manual version (SFPS Volume 1) and to the final comprehensive report (SFPS Volume 3). The latter document contains a detailed description of:

Project Organization. The process by which the project was organized and carried out, including a review of the research phases, the resources used, and the individuals and agencies interviewed.

State of the Art. An overview of public school planning as practiced today, based on a review of current literature and questionnaires received from state departments of education and local education administrators.

System Components. A detailed review of the specific techniques selected for inclusion in the system.

Systems Utilization. A review of different ways of using the system, with emphasis on interpreting the results.

1.2 Systems Capability

A successful capital improvement plan depends on an accurate appraisal of several supply and demand factors. The number and location of required school facilities will depend ultimately on the number of expected students and the quality of education considered appropriate for them. These projected requirements must then be evaluated in light of the existing facilities and the ability to pay for the development and operation of new facilities. The likelihood of unacceptable deterioration of existing facilities, of growth in the tax base, and of the passage of bond issues or tax rate increases must all be considered.

Given the diversity of necessary considerations, it is understandable that long-range capital improvement plans have traditionally been difficult to prepare. Such plans have often failed as a result of forecasts based on crude techniques and unwarranted assumptions. For example, extrapolations of prior enrollments or assessed valuation growth rates often have failed to recognize the saturation limits within a community. In other situations the problem has resulted from unique events, such as the location of a highway or the loss of a major government contract, events which could not have been foreseen.

The ideal school planning system would monitor all migration into and out of the district, and all changes in the district's tax base. Based on this information, it would yield highly accurate long-range forecasts of district needs and resources. For most school systems such forecasts are not possible. What is possible is a systematic set of procedures for forecasting future conditions and evaluating the impact of specific proposals in light of those conditions. This is what the School Facility Planning System attempts to provide.

The ultimate decision to close or build a school will usually depend on the school district's approach to risk, and particularly its perception of the dangers of over-estimating or under-estimating projected trends. In a situation where nothing can be absolutely certain as to the number of future students, the standards which will apply to their education, or expected revenues and expenses, the school board must evaluate the cost of making a poor capital planning decision versus making a decision to postpone constructing or closing a facility. These costs will vary with the situation. In a growing district the decision to build a school sooner than necessary (i.e., based on a higher than realistic enrollment forecast) may prove wise if the facility ultimately would be necessary. Such a decision would minimize crowding and would save funds that might otherwise be lost to inflation if the district had waited on its decision. However, if after the decision to build, the enrollment trends actually peaked, stabilized, or declined, an unneeded school would have been constructed.

Similarly, in a district with declining enrollment, the costs of a bad estimate must be considered. The decision to sell an unnecessary school may prove wise if enrollments continue to decline. On the other hand, should future enrollment levels stabilize and begin to climb again, a much wiser decision would have been to lease or moth-ball the unnecessary school until it was required again.

The School Facility Planning System cannot determine the school administrator's or school board's position on such unquantifiable issues. Such positions must be adopted subjectively.

The System can, however, provide an administrator with a range of likely future conditions based on selected assumptions. It also provides a mechanism for evaluating policies designed to address such conditions.

1.3 System Components

The School Facility Planning System is a series of distinct components, each requiring certain information inputs and producing certain information outputs. Some of the components are further broken into specific system modules. Figure 1-1 presents the interaction of these components. Once a project is identified, most users will develop enrollment projections, followed by facility, fiscal, and geographic analysis. However, the System has been designed so that a component may be skipped which is of no interest, or for which information has been acquired from an independent source. In addition the user has the ability to re-analyze any component, using a new set of assumed input variables. Each component contains a general description of its purpose and design, followed by a set of specific procedures. Examples of input cards needed to run each component are presented in the respective chapters. Specific formats and instructions are contained in the appendices.

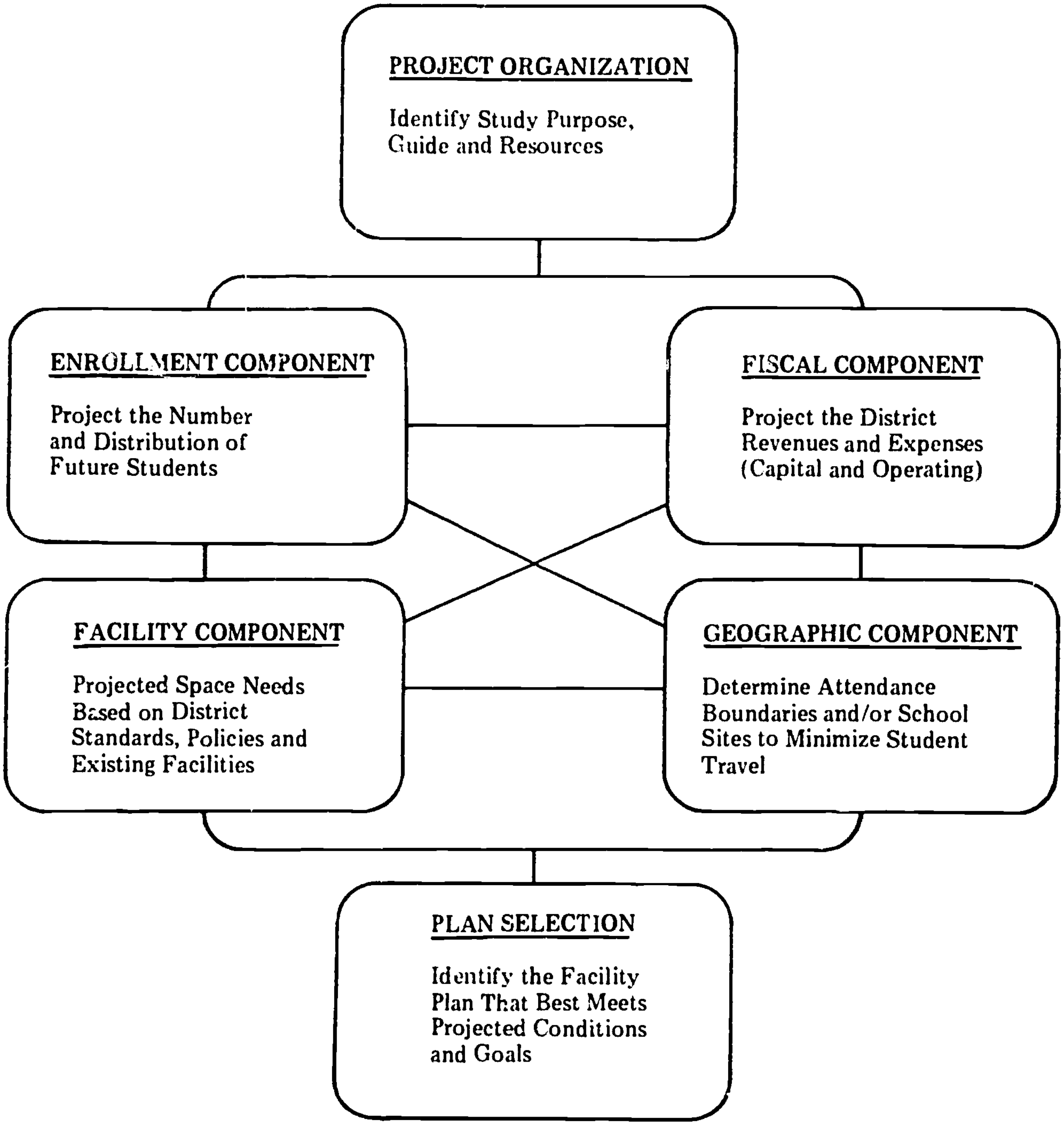


FIGURE 1—1 SCHOOL FACILITY PLANNING SYSTEM

1.3.1 Project Organization

Prior to the initiation of any analysis, the school system must conduct some basic organizational activity. Depending upon the scope of the project, this will usually include the assembly of a study team, review of the overall district situation, and some initial decisions as to the version of the School Facility Planning System that will be used (i.e., manual or computer-based). The level of detailed analysis to be conducted must be determined, as must the available data sources which might be used. These and other organizational considerations will be familiar to many school planners. Those individuals wishing to review the many steps that enter into the planning process are encouraged to read Chapter 7, “Project Organization,” before initiating the study.

1.3.2 Enrollment Analysis

The first analytical component projects future public school enrollments. These projections will vary with the number of families expected to live in the community and their characteristics in terms of family size, income, religion, and other social and economic factors.

As described in Chapter 3, the School Facility Planning System recommends that several forecasting techniques be considered. The traditional cohort survival or grade progression technique is suggested for those districts needing specific forecasts for grades over a short-or medium-range time span. An extrapolation technique may also be appropriate for extending time series data on a linear or non-linear basis. For longer range forecasts in an area where reliable independent population projections already exist, the ratio method may be applicable. The ratio method can also serve as a quick check on the enrollment totals produced by some other technique.

Communities characterized by rapid expansion or reduction of their housing stock may want to consider the dwelling unit method. This approach requires forecasts of future numbers of dwellings and future students per dwelling. It, as well as the other techniques, may be supported by a district-wide census or enumeration.

In addition to the district-wide projections, sub-area forecasts may be desired by certain school districts. Chapter 3 provides a method of projecting “regional” enrollments and then allocating those totals to “small areas” within each region. This geographic dimension will enable the attendance boundary adjustment and site selection procedures that are described in Chapter 6. Techniques for projecting racial composition and adjusting projections for unique events within a district also are presented.

1.3.3 Facility Analysis

The next step is to determine the ability of the school system, given its existing and expected school plant, to house the projected students. The Facility Component is used to translate projected students into the actual space required to serve them. This needed space can be measured in square feet, teaching spaces, or both. When compared to the district’s existing space, an indication is given of the projected shortage or excess of facilities. Chapter 4 describes the formula which yields the specific space requirements and provides the instructions necessary to carry out the calculations. The user is presented with the option of examining facility needs on a district-wide basis, a school-by-school basis, or, where necessary, a subject-by-subject basis. While the input data varies, the basic formula remains the same in all situations.

School capacity varies significantly, depending upon the district’s standards and policies. The Facility Component encourages the district to examine the impact of changes in the desired utilization rate, sessions policy, students per teaching space, and grade organization. Temporary adjustments in one or more of these variables may eliminate the need to construct or close a building. Chapter 8, “Planning Considerations,” reviews many of the alternatives that a school system may want to examine in its efforts to reduce the gap between expected space needs and actual capacity.

1.3.4 Financial Analysis

Any tentative building program must be evaluated in light of its fiscal impact. Thus Chapter 5, “The Fiscal Component,” provides the ability to forecast expected revenues and expected expenditures in light of any school facility configuration. The component allows the district to examine the following elements:

<u>Capital Resources.</u> The user is provided with the ability to calculate current and future bonding capacity in light of projected changes in assessed valuation and possible new bond issue efforts.

Future Revenues. The user is provided with the ability to forecast revenues from different levels of government that will be available for both operating and capital requirements.

Future Expenditures. The user is provided with the ability to project the future costs associated with any building program and to evaluate those costs in light of expected revenue.

Long-range fiscal analysis is especially difficult because of the impact resulting from national and state, as well as local conditions. Future assessed valuation will fluctuate with residential, industrial and commercial building rates and prices, and local reassessment policies. Revenue will vary with local tax base trends and tax rate decisions, state allocation formulas, and national legislative programs. Expenditures will reflect national inflation and interest rate conditions, as well as local construction costs, teacher contracts, and other specific situations. Throughout the Fiscal Component the user is encouraged to consider alternative assumptions regarding probable revenues and costs.

1.3.5 Geographic Analysis

The final component addresses the question of location. Previous analysis has considered the need for more or fewer schools and the district's ability to pay, but not the important questions as to where a school should be opened or closed and who should attend that school. Chapter 6 will assist the districts in considering two important locational issues:

Site Selection. The user is provided with a technique for determining the general location of school sites within a district that would minimize transportation costs in light of long-range enrollment projections.

Attendance Boundaries. The user is provided with a technique for designating the attendance boundaries of existing schools so as to minimize transportation costs and improve racial balance.

Geographic analysis can be extremely complicated, given the diversity of special considerations that must be taken into account. In addition to the projected location of students, examination must be made of the path of a railroad, major street artery, or limited access highway; historical attendance areas; bussing policy; and local political attitudes. The computer-based version of the School Facility Planning System provides several programs for allocating students to schools in light of distance, capacity, racial balance and other constraints.

Collectively the four components present a versatile set of techniques that can be applied to many kinds of school planning problems. Experienced administrators with a clear idea as to the scope and focus of a problem to be analyzed should examine those chapters describing the relative components. Users with less clearly defined planning problems should review all chapters, starting with Chapters 7 and 8 and skipping over the procedures sections of each component. All potential users are encouraged to consider ways of dealing with "uncertainty" as outlined below.

1.4 Projections Under "Uncertainty"

By itself the School Facility Planning System will not provide all the necessary answers. While it can be supported by quantitative techniques, school planning is essentially more an art than a science. The problem of obtaining additional school space or finding use for excess space would be difficult enough if the school administrator's perception of future conditions were completely accurate. As this is not the case. the planning process is more complicated.

Every forecast generated in the following components will be based on certain assumptions and will be subject to statistical forecasting errors. Future enrollments will deviate from the projected levels as birth rate and migration patterns vary. School system standards and policies may also change as educational philosophies and goals evolve. Existing facility conditions will change because of age, vandalism, and other unforeseen events. Costs and revenues will fluctuate with national and local economic conditions and voter attitudes.

The success of the planning effort will depend largely on the quality of the assumptions on which the projections are based. These, in turn, must rest upon the judgement and intuition of the individuals on the school planning team. Their combined perception of subjective probabilities is critical to the formulation of a relevant plan.

The analysis of a problem under conditions of uncertainty requires that a distinct set of procedures be followed: the options available for gathering information must be listed; the possible events that could occur must be considered; the probability that any particular event will occur must be evaluated; and preferences for alternative courses of action must be stated. It is important that the decision maker seek a course of action consistent with his personal judgements and preferences and that he consciously monitor the consistency of his subjective inputs and their implications for action.

1.4.1 Confidence Intervals

Anyone making the statement that a single forecast of population, fiscal resources, or any other variable will be 100 percent accurate either believes he has an audience of fools or is fooling himself. Very few forecasts have been "right on the money." Placing an upper and lower limit on forecasts represents a traditional technique for gaining more confidence in the projections which are derived. Confidence intervals can be determined objectively by using established statistical procedures, or subjectively by making reasonable assumptions.

Statistical procedures exist for calculating the probability that the mean of a population will fall within a certain interval based on the statistical variation and the relative size of a sample of that population. For example, given the heights of 100 of the 400 sixth grade children within a hypothetical school district, one could calculate a confidence interval or band based on the variance in height of the 100 sixth graders and the size of the sample population relative to the total population. This interval might be calculated so that there would be a ninety-five percent chance (or some alternative, depending on the desired confidence level) that the average height of all 400 sixth graders would fall within that confidence band.

At first glance these statistical procedures might seem useful to school facility planners in their calculation of enrollment or fiscal projections. However, since confidence intervals must be based on the variance in historical data, one would, in effect, be assuming that the variance in future data would be the same as it has been. If, as in the above example, the variance in the data was known. it could be said with 100 percent certainty that the confidence band would offer a ninety-five percent chance that the mean of the total population would fall within the band. But when, as in the case of projections, the variance in the data is not known, the above statement no longer applies. No longer could a planner be certain that a given confidence band would offer the desired confidence level. Even though the historical data might suggest that a projection would fall within, for example, plus or minus thirty students of the actual number ninety-five percent of the time, in reality the impact of future conditions might insure that this range was only an eighty percent confidence interval. Stated another way, for any given projection there might be only a fifty percent chance that plus or minus thirty students in fact constitute a ninety-five percent confidence band.

In situations that require forecasting, subjectively determined upper and lower limits offer more useful guidelines with which to work. Several precautions must be taken into consideration when determining these upper and lower limits. In most cases the upper limit should not be determined by assigning maximum values to all the variables involved in the forecast. This would result in a grossly exaggerated limit because of the fact that there is very little chance that all the variables incorporated in the forecast would reach their maximum values in the same time period. A more realistic approach would involve assuming maximum feasible values for each variable, one at a time. The resulting forecasts would be recorded to determine which variable had the most influence on the forecast. After making a subjective assertion as to those variables most likely to obtain their maximum values, an upper limit could be derived, using maximum values for the variables identified as most volatile and influential. The same procedure could be followed to determine a lower limit, beginning with minimum feasible values for each variable.

Regardless of whether a confidence interval is determined statistically or subjectively, it should be noted that the forecast certainty will vary inversely with time. Therefore, a confidence band must expand over time to maintain any given confidence level. This infers that a point in time exists beyond which the certainty of a forecast, including its confidence band, is so diminished as to render it worthless for planning purposes. A second factor must also be considered in the process of making projections, the length of the planning period.

1.4.2 Planning Period

If there were no uncertainty associated with enrollment and fiscal forecasts, the planning period would usually extend to the normal life of a school building. A facility that could be used for forty years would be designed and located in light of forty-year forecasts. However, because forecasting error increases, often exponentially, with time, such a long-range time frame will rarely make sense. The question is how far into the future a forecast should be made before it is considered useless.

Since the life of most school facilities will exceed the time beyond which a forecast will have totally lost its reliability, the planning period will usually be shorter than the life of a building. In situations involving new construction it might be advantageous to match the planning period with the bond or loan retirement period so that the projected utility of the building would extend for at least as long as the time for which the building was being paid. In some cases this also may be an unattainable goal since a normal debt retirement period of twenty years may often exceed the period for which an enrollment forecast is reliable. One constraint that should be observed in establishing the minimum length of a planning period is the capital construction time. A planning period should extend at least as far into the future as the time necessary for fund raising, land acquisition, and construction of the facility. Otherwise, a building could become obsolete before it was ever occupied.

The determination of an outer limit to the length of the planning period requires subjective considerations regarding forecasting error. Assume that an enrollment forecast of plus or minus thirty students from the actual total enrollment was believed acceptable for a hypothetical school district. Further assume that a decision was made not to use forecasts extending beyond that point in time where there was less than a 50-50 chance of maintaining the above confidence interval. Based on characteristics particular to an individual school district, considerations could be made to determine how far into the future the certainty of a given confidence interval would be maintained.

This approach defines "uncertainty" as the probability of exceeding predefined confidence intervals for a given projection. If, for example, the hypothetical school district had experienced steady enrollment growth and there were no indications that this trend would vary significantly. the school planner might judge that forecasting error would increase by only two percent per year. Beginning with the current year, where "uncertainty" is zero, the "uncertainty" factor could be compounded two percent a year until fifty percent "uncertainty" was reached, thus delimiting the planning horizon. For the first year in the planning period there would be only two percent "uncertainty" that the enrollment projection would not fall within thirty students of the actual enrollment. In the second year of the planning period, using the formula $(1+u)^n-1$, where u is the percent change in "uncertainty" per year, and n is the year of the planning period "uncertainty" would equal $(1.02)^2-1$, or 4.04 percent. This progression would continue until year twenty when "uncertainty" would reach 48.6 percent. The planning period based on a two percent change in "uncertainty" per year would be twenty years. If conditions in the school district were such that a five percent increase in "uncertainty" per year appeared more likely, the planning period would be cut almost in half, as shown in Figure 1-2.

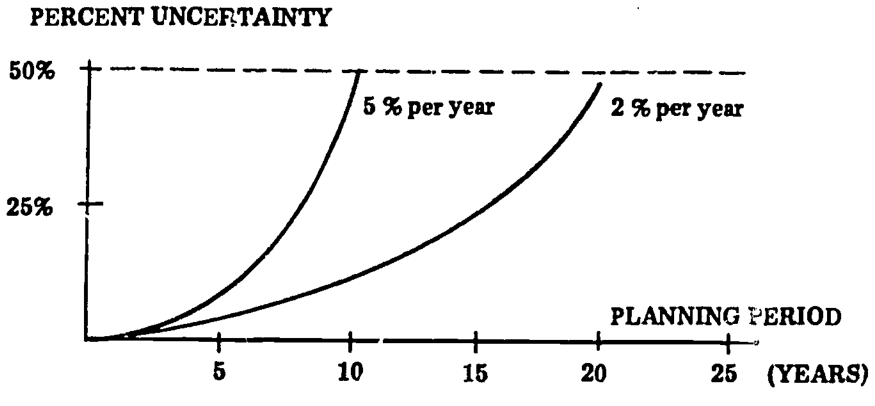


FIGURE 1—2 ALTERNATIVE PLANNING HORIZONS

In addition to the deterioration in forecasting confidence, a second factor may be important in establishing the planning period. Many users will want to consider the cost of making a mistake. Even in situations that are unstable to the degree that no confidence is warranted in the forecasts beyond a few years, it may be desirable to examine the consequences of a decision if certain projections did materialize.

This approach is based on the premise that while it is often not possible to make long-term projections with any certainty, the ease or difficulty of dealing with alternative "scenarios" can be examined. If the cost of being unprepared for a particular set of enrollment or fiscal conditions was great, the district might want to retain options for dealing with this eventualitiy. despite the probability of its occurrence being small. Users concerned with the consequences of possible enrollment or fiscal conditions may want to extend the planning period beyond that point for which there is reasonable certainty regarding specific projections. In most cases a minimum ten-year planning period is recommended.

1.4.3 Decision Focus

Once the length of the planning period has been established, the school planner must focus attention on when during the planning period facility changes should take place. Relevant subjects for consideration are the direct relationship between forecast error and time, economies of scale, interest rates, and building cost inflation.

Since one can be more confident in the accuracy of short-range as opposed to long-range forecasts, it follows that planning facility changes to meet immediate demand will be safer than building far ahead of projected demand. If the years of the planning period were ranked according to an "uncertainty" schedule such as those developed above, attention would focus on the earlier years in the planning period. For example, a fifteen-year enrollment forecast for a hypothetical school district might dictate the need for a 2,000 student capacity facility at a particular location by the twelfth year of the planning period. Construction of the facility early in the planning period, far ahead of demand, could offer the best facility mix over the entire period if the enrollment projections proved to be accurate. But the uncertainty schedule for this district might indicate the enrollment projections during the last years of the period to be so indefinite that it was deemed unwise to build the entire facility. Instead, a smaller facility might be approved in a different location designed to serve the demand forecasts for the first five years of the period.

Economies of scale. The relative accuracy of short-range forecasts is only one of the factors which must be considered in the timing of facility decisions. Economies of scale constitute a second factor; however, in the school planning context, this concept cannot be assigned its traditional meaning. Normally, economies of scale measure different levels of output corresponding to facilities of different size. Unfortunately there is no easy way to measure educational output. One can judge, but not measure, whether the size of a facility has any bearing on the quality of education offered. For purposes of school facility planning, economies of scale can only be measured in terms of operating and building costs for facilities of different size. Given this qualification some users may choose to estimate potential savings due to economies of scale in the following manner:

1. Collect construction cost data on various large and small facilities within the district or metropolitan area. To the extent possible these should be characterized by a similar level of amenities.
2. Correct the construction cost figure of each facility for inflation using the following formula:

$$\frac{X}{CCI_B} = \frac{CC_D}{CCI_D}$$

where:
X = construction cost corrected for inflation,
CCI_B = local construction cost index in the base year (usually 100),
CCI_D = local construction cost index for the period in which the facility was built, and
CC_D = actual dollar amount of the construction costs.

3. Divide each inflation corrected construction cost by the floor space for the associated building. This will result in a dollars-per-square-foot figure for each facility. Comparison of these figures should indicate which schools, large or small, have historically been more economical to build in the area.
4. Another economy of scale consideration involves operating costs, including custodial and administrative overhead. Personnel and maintenance costs must be allocated to each school according to staffing patterns. Then divide the operating expenses of each school in the district by the corresponding number of square feet of floor space for each school and

compare the figures. This may reveal any economies of scale in the operating expenses for facilities of various size.

The above information will provide a second guideline for the timing of facility changes. Consider the previous example, where a long-range forecast dictates the need for "x" amount of additional space. The additional space could be built in stages with the construction of several small facilities to hedge against the possibility of a downturn in the demand for space. Or one large facility could be constructed which would have the required additional space for the entire period. If the economies of scale associated with the large building outweigh the uncertainty of the long-range forecast, then the larger facility should be built in advance of projected demand.

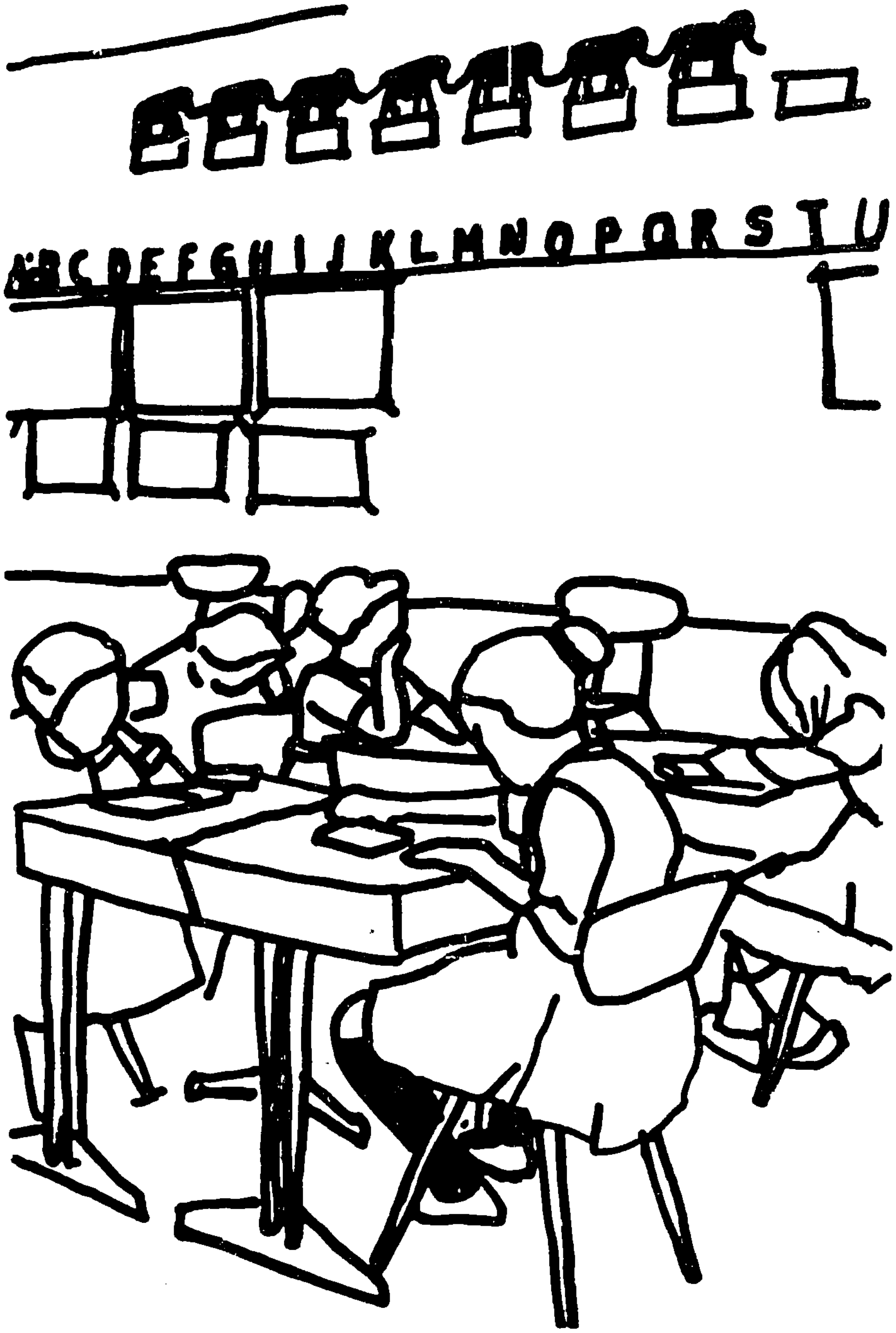
Interest Rates. Interest rates, or the cost of money, is a third factor that should relate to the staging of planned facility changes. Bonded indebtedness has traditionally been the common source of revenue for financing school facility construction and modernization. Interest rates on municipal bonds may vary as much as one percent within a year. Additional rate variation may occur depending on the type of bond, size of the issue, and bond rating of the issuing authority. The probable direction of long-term interest rates and the district's bond rating will have to be analyzed. If it is suspected that interest rates will increase (and/or the bond rating fall), there will be pressure to build sooner rather than later. Alternatively if there is a chance that the bond rating may increase in the future (and/or interest rates may fall), then there may be an incentive to postpone construction. A combined increase or decrease in interest rates and bonding rating could offset each other, thus offering no guidance in deciding when to build.

Inflation. The effect of building cost inflation must be considered in conjunction with interest rates and the district's bond rating. The basic question is whether the impact of inflation on a school district's expected revenues will be comparable to the impact on construction costs. Several possibilities exist. Costs and revenues could increase or decrease at the same rate, resulting in no incentive to build at one point in time over another. Costs could rise at a slower rate than revenue, in which case postponement of construction would be favored, or vice versa.

Differences in the cost of money and construction must also be considered. An evaluation will be especially difficult when material and labor costs are expected to rise in conjunction with falling interest rates. An attempt should be made to estimate when, and if, rising material and labor costs will offset potential savings due to declining interest rates.

1.4.4 Summary

Subjective assertions are necessary in every category of school planning. A major element in the success of any planning effort will be the knowledge and understanding that each planner has of a particular school district. Confidence intervals can assist in the forecasting effort and should play a role in determining the length of the planning period. Once the planning period has been identified and the projections made, judgements regarding uncertainty, economies of scale, interest rates, and inflation must all be considered jointly in the timing of facility changes.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Chapter 2: Systems Considerations

The use of a computer to carry out the analysis required in the School Facility Planning System introduces a unique set of considerations. The following chapter is designed to identify the opportunities and concerns associated with a computer-based system, to provide a general description of the programs that have been developed to support the System, and to suggest possible approaches towards the use of the System. In addition four technical appendices have been prepared. Appendix A provides a detailed explanation of the required input cards and the printouts produced by the four components. Appendix B summarizes selected hardware and software characteristics associated with each of the processing packages. Appendix C summarizes the derivation of selected mathematical routines and the statistical terms that are used. Appendix D describes an optional statistical analysis package that may be useful. Appendix F presents an optional mapping package.

2.1 General Considerations

Most planning activity requires the conscious or unconscious use of a "model" of some real world situation. A mathematical model is an abstract representation of an actual social, economic, or physical system that describes the relationship between appropriate variables in quantitative terms. Any variables may be used for which quantifiable data can be assembled, and which will contribute to a better explanation of the situation being described. Some variables are required as input information to the model. Others are calculated by it. Most of the models used in the School Facility Planning System describe the impact that could be expected if a variety of potential conditions occurred, including those both within and beyond a school district's control. In addition, the System's Geographic Component contains an optimizing model which determines the "best" attendance boundaries for a projected distribution of students and schools.

The use of a computer adds a dimension to most models which makes them particularly valuable tools for addressing complex planning problems. By providing speed and versatility a computer-based system allows for greater interaction between the planner and the model than would otherwise be possible. Properly constructed, such systems have several features which are of utmost importance.

Structure. Structure is intrinsic to the nature of computers. Calculations are performed on data that is entered according to prescribed formats. As a result, a computer-based model invokes a discipline which requires the introduction of order to a potentially confusing assemblage of variables. The insight which results from building a model (and/or understanding its structure) may be equally as valuable as the analysis of the model's output.

Speed. The computer allows the analysis of a greater volume of data, a greater variety of variables, and more complex relationships than could readily be accomplished manually. With its ability to apply mathematical routines against substantial amounts of information, the planner or analyst is freed to spend more time thinking, and less time doing clerical steps.

Flexibility. The fact that assumed input values can be easily changed, combined with the computer's speed, makes possible a third, and perhaps most important feature, that of man-machine interaction. Using a computer-based model, the planner can engage in a feed-back cycle in which knowledge gained in using the model can be re-entered into the system to obtain further insight. Models can be used to examine the probable impact of alternative courses of action and/or assumed conditions. Then, selected variables and relationships can be refined to more accurately reflect reality based on the previous interactive experience.

In summary, if the computer-based model is constructed properly, it will aid the planning process in important ways. It will introduce a systematic approach to understanding and analyzing a problem, and it will reveal the implications and consequences of the many facts and assumptions which are fed into it. The adoption of a computer-based system, however, should not be undertaken casually. Because extensive attention to detail is required, compiling the system and properly preparing the input data can demand considerable time. Running the system may be expensive, especially where access to an "in-house" computer is not possible. Finally, the mystique that too often accompanies computerized analysis can lead to the unthinking acceptance of unreasonable assumptions. Any potential user considering the computer version of the School Facility Planning System should be conscious of these potential "costs," as well as the significant attractions.

The probability of using the System on a repeated basis may be a critical consideration in deciding between the computer-based and manual versions. For maximum benefit a potential user should make a long-term commitment to the use of the computer version in the district. It should be regarded as an important element in the planning and budgeting process. If possible, an annual cycle should be initiated in which historical information is updated, the previous year's forecast checked against actual events, and any variation analyzed and explained. Where the analysis indicates that additional variables must be considered, they should be added to the model. If the analysis indicates that initial assumptions regarding projection methods were inappropriate, revisions should be made. When repeated each year, this process should refine the model so that it produces valuable insight into the merits of hypothetical plans.

2.2 System Overview

Each school district will have different informational needs and different amounts and types of available historical data. With these variations in mind, a set of programs has been designed that attempts to provide a maximum amount of analytical flexibility in the System without requiring that the user become a computer programmer. These programs have been assembled in several general packages for the analysis and projection of data. They provide a structure within which a specific problem can be analyzed and specific solutions evaluated.

The first package supports the Enrollment, Facility, and Fiscal Components. The second supports the Geographic Component, and the third is a general purpose multiple regression package which may be useful in both the enrollment and fiscal forecasting. All are written in Fortran and may be run on a medium-sized computer. The purpose and characteristics of each package are described below.

2.2.1 Basic Support System

The Enrollment, Facility, and Fiscal Components make use of a generalized family of programs which maintain a data base, perform analytical routines, and generate reports in a standard, but flexible format.

The data base consists of a matrix as shown in Figure 2-1 that has up to 105 columns representing 105 consecutive time periods, and up to 1000 rows, each row representing a variable to be projected. Each of the rows (variables) is named and numbered by the user. A basic set of variables has been defined and numbered for the Enrollment, Facility, and Fiscal Components as a part of this study. The user may change these names and numbers if necessary to suit the particular needs of the district.

	Period 1	Period 2	Period 3	Period 4	Period 5	Period 105
Variable 1						
Variable 2						
Variable 3						
Variable 4						
Variable 5						
Variable 6						
Variable 1000						

FIGURE 2—1 BASIC SUPPORT SYSTEM MATRIX

The user may designate a method for processing each of the variables. Available methods range from simply entering a set of values to the use of curve fitting and multiple regression techniques. Four basic projection methods are provided as an integral part of the system.

a. Fitting to a standard curve.
b. Regression analysis.
c. Arithmetic calculations.
d. Direct input by the user.

With the basic package a user names a variable and assigns it to a specific row; enters historical data for that variable if needed; and designates the mathematical operation that is to be used to process the information. Projection methods have been designated for each of the variables defined in the study. Most can be used as currently suggested. Others will have to be changed by the user to fit conditions that exist in the district.

The data that is entered is analyzed and projected and summary calculations are printed. The user can control the print-out organization if desired. Report headings, the variables to be printed, the time periods to be printed, and the sequence and groupings of the report can all be adjusted. Again, a report format has been designated as part of this study. The user may revise it to serve the specific school district's needs.

The procedures outlined in the Enrollment, Facility, and Fiscal Components are concerned primarily with the preparation of data as input to the computer. To facilitate this process, sample input forms are presented which contain much of the necessary information, including row numbers, variable names, and the designation of projection methods.

Enrollment Component. The package permits the projection of students within the school district at several levels. The total district enrollment and/or enrollment by grade may be projected. Projections for sub-geographic regions within the district and the allocation of such forecasts to even smaller areas, for purposes of geographic analysis, is also possible.

Five forecasting techniques may be undertaken using the package:

a. Cohort survival
b. Time trend projections

c. Ratio method
d. Dwelling unit multiplier
e. Multiple regression

Some of these techniques require that certain calculations be made "off-line" and then entered directly into the System. The sample program structure referenced in Chapter 3 is designed to be run concurrently with the Facility and Fiscal Components. However, some districts may want to analyze their enrollment situation at such a detailed level that the Enrollment Component may have to be run by itself.

Facility Component. The basic support system is used in the Facility Component to translate projected enrollment for a given school, or the district as a whole, into required teaching space. The Component requires the collection of selected standards and policies unique to each district, such as the desired utilization rate, sessions policy, students per teaching space and grade organization. Also an inventory of adequate existing and expected teaching spaces must be taken. This should be prepared for each separate space type, such as regular classrooms, large rooms or science laboratories, for which specific analysis will be conducted.

The program converts a projection of future students (as obtained from the Enrollment Component or independently) into, first a forecast of students by subject area, and then a forecast of the actual rooms or teaching spaces necessary to house those students. The required space is then compared with the actual and expected amount of space in the district to reveal an anticipated shortage or excess of space for each year during the planning period. In addition to space requirements, the program also calculates the required teachers for each subject area.

The sample program structure referenced in Chapter 4 allows a user to define up to six different subject areas for elementary school and up to twenty different subject areas for both junior and senior high school. The space requirements for these latter subject areas can then be combined into six basic space or room types.

Fiscal Component. The same program package is also used to conduct the Financial Component. Fiscal analysis in school capital planning requires three somewhat separate activities—an examination of debt financing opportunities, probable school district revenues, and probable school district expenditures. Thus, the Component has been divided into three sub-systems or modules.

The Bonding Capacity Module calculates the district's forecasted net bonding capacity for each year throughout the planning period. First, gross bonding capacity is projected as a function of the district's total assessed valuation. Then the district's principal payments on outstanding and proposed bonds are subtracted from gross bonding capacity to arrive at forecasted net bonding capacity. If a planned bond issue exceeds the district's bonding capacity, the net bonding capacity will have negative values, thereby indicating that the proposed issue must be modified.

The Revenue Module is used to forecast the district's revenues for the long-range planning period. Since the financing of school districts changes frequently in regard to the sources of revenue, long-range forecasts should be re-run on an annual basis, with the specific formulas modified to reflect local and state legislation. The program is organized so that local, state, and federal forecasts can be made along the lines of the United States Office of Education (USOE) Code of Accounts for local school districts.

The Expenditure Module forecasts the district's expenditures up to the long-range planning horizon. Again the USOE recommended Code of Accounts forms the basis for the expenditure categories. This Module yields a total projection of costs, which, when compared against future revenues, presents an expected cash flow for the school district.

2.2.2 Geographic Analysis Support System

The Geographic package consists of two linear programs which are presented to assist in designating attendance boundaries, and testing the travel implications of alternative sites for proposed school closings or construction.

As with all linear programs, these programs are designed to optimize an objective function subject to certain constraints. The first program is entitled Bound. It minimizes the total travel distance (or time, or cost) of students to schools, subject to the constraint that no school is assigned a number of students greater than its specified capacity. The second program, R Bound, is designed specifically for districts that are attempting to resolve a school integration issue. It establishes boundaries which minimize total travel distance subject to a maximum permissable variance in the racial composition of each school in the district.

Both these programs require enrollment projections on a small area basis throughout the district, as determined in the Enrollment Component. Each makes use of a previously written subroutine entitled Simplex to find the optimal allocation of students to each school. Linear programs may consume a considerable amount of computer time, depending on the way in which they are formulated. School districts without ready access to "free" computer time may want to consider solving their geographic analysis problems by using a service bureau's proprietary software.

2.2.3 Statistical Analysis System

The regression analysis capability in the basic support system should satisfy most user requirements. In some instances, however, more statistical versatility may be desired. The statistical analysis system is presented as an open-ended multiple regression technique with which users may formulate their own forecasting model. This program permits a variety of statistical options, including artificial orthogonalization of the independent variable vectors to eliminate multicollinearity, distributed lags, and an autoregressive least square routine. Its use is completely optional. Because the amount of data actually processed is small, the program requires no disc or tape operations, and has minimal core storage requirements.

2.3 User-System Interaction

The School Facility Planning System should be regarded as a set of adjustable tools which can be used in analyzing capital requirements and preparing an appropriate course of action. Components may be used together as a complete set or individually. Each of the components can actually be tailored to fit specific district needs. Because the System has been purposely designed on a modular basis, there are a number of ways in which to conduct the analysis. The following approach should prove useful to many districts; others will want to modify the sequence. Review of Chapter Seven indicates that initial thought must be given to the definition of the problem to be examined, and the team that can be assembled for the study. As a result of this organizational activity. decisions can be made as to which version of the System to use, which components will apply, the planning period and the level of analysis, district-wide or on a school-by-school basis.

Once there is initial understanding of the entire System, most users of the computer version will want to proceed with a specific case for each of the components they have selected. Completing the sample cards and running the sample data will lead to an appreciation for many of the specific procedures required. At this preliminary stage less thought should be given to the validity of input values, than to the basic relationships between variables and the mechanics of running the System.

After a first pass has been completed for all relevant components, attention should be concentrated on molding the System to a particular school situation. The user of the Enrollment Component will want to evaluate which of the five projection techniques are appropriate in light of the district characteristics, the length of the necessary forecast, and the available data. A series of passes may be run, followed by adjustments and re-runs, until an acceptable forecast is obtained. Districts are encouraged to make alternate forecasts based on various demographic assumptions. For example, "high," "most likely," and "low" forecasts might be calculated and retained.

After one or more "reasonable" enrollment forecasts have been calculated, most users will want to examine the space implications of these projections using the Facility Component. The current school standards and facility inventory should be entered initially. Where no formally adopted standards exist within the school district, as, for example. regarding the desired classroom utilization rate, the actual policy should be determined and entered.

The user will quickly observe that a projected space deficit or excess can be reduced by either "non-structural" or "structural" means. A projected shortage of facilities may be eliminated by a higher number of students per room, a staggered sessions policy or some other policy changes; or the shortage may be reduced through new construction or modernization. Similarly a projection of excess space may be reduced by "non-structural" means, such as a lower utilization rate or student classroom size, or by the actual disposition of buildings. The process of identifying and testing the implications of these many alternatives will require the entry of "assumed" values for a hypothetical new policy or building and a rerun of the System.

When satisfied that one or more facility plans are reasonable, users will want to explore the fiscal aspects. If it appears that debt financing may be necessary, analysis can be made to see if the required bonding capacity is available. If not, the feasibility of a scaled down, or postponed plan may have to be considered by returning to the Facility Component. Analysis of expected revenues and expenditures will provide evidence of the projected fiscal situation in light of the facility plan. Where the anticipated cash flow is projected to be insufficient to offset expected costs, the possibility of a smaller capital plan, better long-term financing terms, smaller operating costs, or larger revenues might be evaluated. Thus, the fiscal impact of a reduced plan, revised terms for proposed bond issues, a modified tax rate or smaller salary increases could all be analyzed with successive runs of the System.

Either before or after the fiscal analysis, the user may want to examine the geographic implications of a proposed plan. If the district is interested in devising attendance boundaries that will minimize transportation costs, either, or both, programs in the Geographic package may be run. In most cases this will necessitate rerunning the Enrollment Component so that the proper small area student forecasts are prepared. If the user desires to evaluate the transportation implications of additional or fewer school sites, the program Bound may be run with both current and projected enrollment data.

2.4 Projection Techniques

One of the most difficult requirements will be that of selecting a reasonable forecasting technique. This decision cannot be made lightly, for an approach that is valid in one community may be completely unrealistic in another. The most important forecasts in the System are those upon which subsequent calculations and analyses are based. In general, these will include:

Future student enrollment
Future dwelling units
Future assessed valuation
Future building costs
Future average salary costs

The School Facility Planning System allows a user to select from a variety of techniques for making these projections. Arithmetic calculations can be made from previously calculated data, or independent forecasts can be input directly. Time series extrapolations and regression analysis can also be performed. These latter techniques are summarized below. Additional detail is contained in Appendices C and D.

1. <u>Straight Line Regression</u>. This projection method assumes that the rate of absolute change will remain constant over the planning period. If past trends exhibit a straight line growth or decline and this pattern is expected to continue, this may be the most appropriate projection method. A graph of the historical values should resemble the solid lines as shown in Figures 2-2 and 2-3, for this method to be applicable.

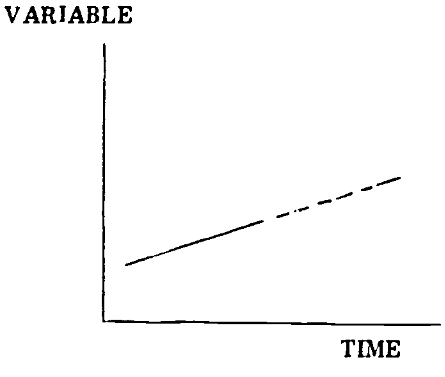


FIGURE 2—2 LINEAR GROWTH

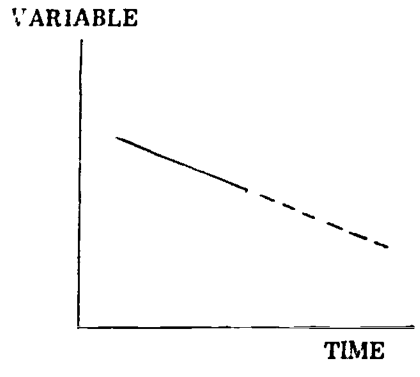


FIGURE 2—3 LINEAR DECLINE

2. Exponential Curve. The exponential curve may be applicable when there has been a constant percentage change in the rate of growth or decline of the variable in the past, and this trend is expected to continue over the planning period. A graph of the historical data should have the general shape of the solid lines shown in Figures 2-4 and 2-5.

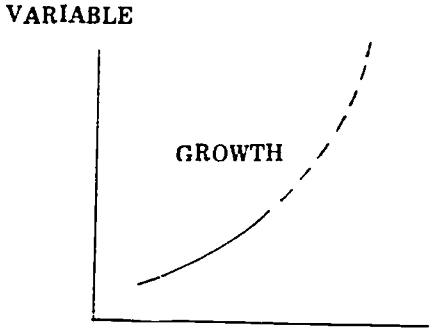


FIGURE 2—4
EXPONENTIAL GROWTH CURVE

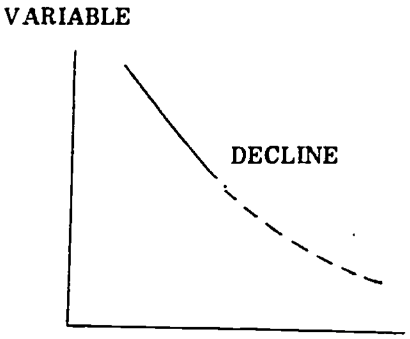


FIGURE 2—5
EXPONENTIAL DECLINE CURVE

3. Modified Exponential Curve. The modified exponential curve is similar to the exponential curve in concept and shape. This curve, however, will eventually reach a maximum limit. This type of curve may be appropriate for projection purposes if a graph of the historical data resembles the solid lines in Figures 2-6 and 2-7.

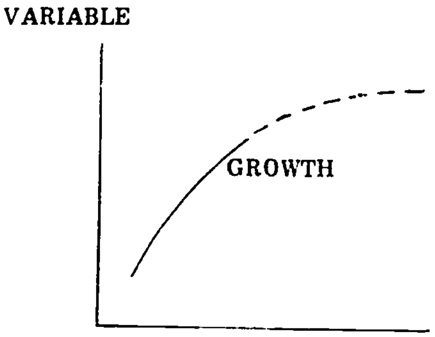


FIGURE 2—6
MODIFIED EXPONENTIAL CURVE

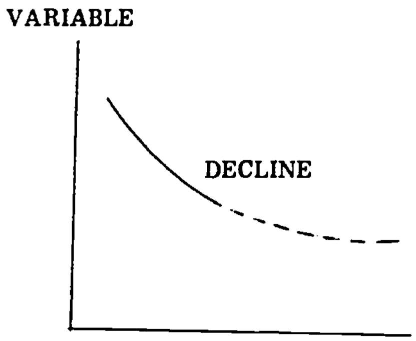


FIGURE 2—7
MODIFIED EXPONENTIAL CURVE

4. Modified Exponential Curve with Asymptote. This curve has the same general shape and formulation as the modified exponential curve. It may be appropriate when the user wishes to specify a maximum or minimum value that the variable can approach but not exceed.

5. Logistics Curve. The logistics curve usually assumes an S shape. It is based on the premise that there is an upper limit to the variable being projected and that the rate of change in the variable will decrease in direct proportion to that upper bound. This means that as the maximum value is approached, the rate of growth decreases, giving rise to an S-shaped curve. If this curve is chosen for projection purposes, a graph of the historical data should have a shape similar to the solid line in Figure 2-8 and Figure 2-9.

6. Logistics Curve with Asymptote. This curve has the same general shape and formulation as the logistics curve. It should be used when the user wishes to specify a maximum value or asymptote that the variable can approach but not exceed.

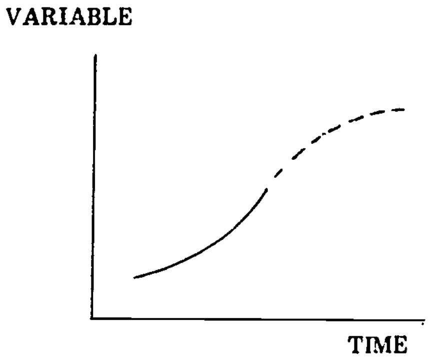


FIGURE 2–8 LOGISTICS GROWTH CURVE

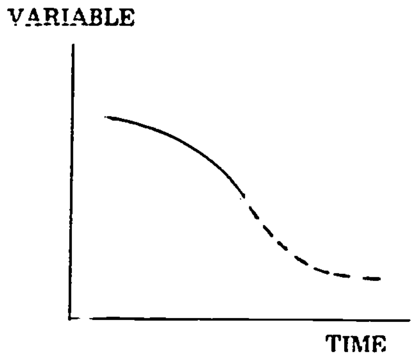


FIGURE 2–9 LOGISTICS DECLINE CURVE

7. Gompertz Curve. The Gompertz curve is a special case of the general logistics curve. The rate of growth for this curve declines by a constant percentage each time period; whereas the change in the regular logistics curve is in direct proportion to the limit. Data which resembles the solid line in Figure 2-10 and 2-11 may be appropriate for projection using a Gompertz curve.

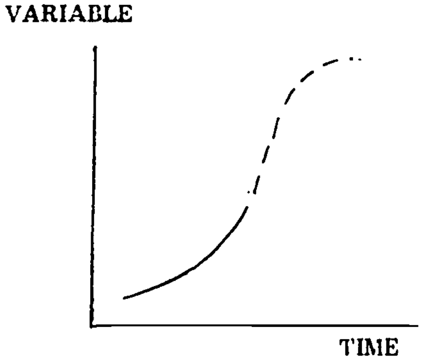


FIGURE 2–10 GOMPERTZ GROWTH CURVE

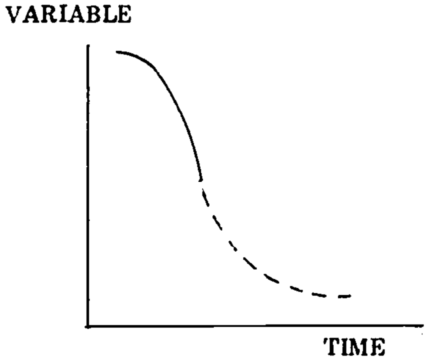


FIGURE 2–11 GOMPERTZ DECLINE CURVE

8. Gompertz Curve with Asymptote. This curve has the same general shape and formulation as the Gompertz curve. It should be used when the user wishes to specify a maximum value that the variable can approach but not exceed.

9. Multiple Regression. The multiple regression projection technique allows the user to forecast a variable based on the forecast of one or more independent variables. In this manner the user takes into account the projected and actual changes which have occurred in those variables affecting the variable being projected. A multiple regression attempts to fit a relationship of the form $Y = A_0 + A_1 X_1 + A_2 X_2 + \ldots. + A_n X_n$ to the user specified data where Y is the dependent variable being projected, X_n is the independent variable, and A_n is the relationship between Y and X_n as calculated in the program. If the user has a number of variables which are believed to affect the variable in question, this technique may be used to take explicit account of each one. The basic support system allows both linear and exponential regression with up to six independent variables. The statistical analysis system (Appendix D) permits additional forecasting rigor for users with some statistical experience.

The most critical element in selecting a forecasting technique is the user's judgement and intuition as to what is likely to happen. The initial eight curves described above provide no explanation as to why a variable will change in a certain direction. They simply indicate the variable's future course if it were to continue with the rate and direction suggested by the historical information. Thus, if there is reason to believe that past trends will not be reflected in the future, a time series curve will be inappropriate for forecasting purposes. A multiple regression technique may provide more explanation as to the behavior of a given variable. However, even when there is a strong statistical relationship between several variables, there may not be a cause-and-effect relationship. To be used effectively, the multiple regression equation must rest on a theoretically sound relationship between the independent and dependent variables. Its use will also depend on the availability of reliable forecasts for the independent variables.

Chapter 3: Enrollment Component

The objective of this component is to assist in the forecasting of future public school enrollments. Procedures are provided for the development of forecasts for total school system enrollment levels, enrollments in each grade, the geographic distribution of enrollments, and the racial composition of future public school students.

3.1 Overview

The general approach emphasized throughout the chapter is based on the assumption that no statistical forecasting technique is adequate unless tempered by professional judgement and experience that recognize the unique characteristics of an individual school district. Projections generated by the techniques in this chapter should not, therefore, be accepted without reservation or modification. These forecasts should be viewed as an initial baseline from which to deviate when conditions are not sufficiently explained by the assumptions inherent in the procedures used.

Section 3.2 includes four distinct techniques which may be used for forecasting total school system enrollment levels. The basic rationale of each technique is described briefly and the associated data requirements are outlined in this section.

The cohort survival technique is presented first. This method is generally used as a short-range forecasting tool (i.e., one-to-five years). It is based on the calculation of a series of survival rates, each of which indicates the fraction of students in one grade in a given year who 'survive' to the next grade in the next year. The survival rates will thus encompass all of the individual factors influencing enrollments, such as migration and retention rates. Enrollments in the initial grade are estimated independently on the basis of past birth data. This technique may be particularly appropriate for school districts where the principal source of uncertainty as to future enrollment levels can be attributed to changes in the birth rate or the age distribution of the population, and where other factors such as migration rates are expected to remain stable or continue to change at the same rate as they have in the past.

The second technique is entitled time trend projections. This method also lumps the effect of individual phenomena together and simply extrapolates the specified enrollment trend. An advantage of this technique is that the user is allowed considerable freedom in the selection of an appropriate trend curve. Therefore, the projections are not entirely constrained to an exact replication of past trends, but reflect the user's perception of the most likely pattern of future enrollments.

The ratio method is presented next. Forecasts derived using this technique are based upon currently available projections of trends for some larger region of which the local school district is a part. In general larger regional forecasts are more reliable than forecasts for a small geographic area. Thus, if the relationship between the larger area and the local school system is reasonably stable, this technique may be useful in deriving longer range forecasts.

The dwelling unit multiplier technique is the fourth method presented for projecting total school system enrollments. This technique involves the generation of separate forecasts of future dwelling unit growth (by type of dwelling) and of the yield of public school enrollments applicable to these dwellings. This method may be especially appropriate in growing school districts where a major portion of the enrollment growth is expected to stem from future residential developments.

The user is encouraged to examine these techniques carefully to determine those which may be appropriate in each school system. It is further suggested that several techniques be utilized. Comparisons of several forecasts, derived independently using different techniques, may provide valuable insight into future enrollment patterns. If these forecasts are quite similar, the associated uncertainty may be of less significance. If they are very dissimilar, it may be possible to locate the source of the discrepancy and thus avoid the possibility of relying on forecasts which are based upon an invalid set of assumptions.

Of the four enrollment forecasting techniques presented in Section 3.2, only the cohort survival technique specifically derives estimates of enrollments by grade. Section 3.3 thus contains a method whereby an estimate of enrollments in each grade may be generated. A modified formulation of the cohort survival technique is used to allocate the total enrollments which have been previously forecast to various individual grade levels.

Section 3.4 is concerned with the geographic distribution of future enrollments. Two levels of geographic detail are considered. In the first part of this section, projection techniques for relatively large regions within the school system are considered. These regions are defined as the largest areas within a district about which generalizations can be made concerning past and expected future densities and growth patterns. Each region thus defined will consist of relatively homogeneous neighborhoods. The suggested forecasting approach for these regions is simply to reiterate the most appropriate of the total enrollment forecasting techniques, using input data which pertains only to that region. The second part of Section 3.4 involves the allocation of total regional enrollments (or system-wide enrollments if no regional breakdown has been undertaken) to a number of smaller areas contained in the region. The enrollment in each of these smaller areas is initially forecast, using a modified dwelling unit multiplier technique. These area forecasts are then adjusted to conform to the forecast for the region, as it is assumed that these regional forecasts are more reliable than forecasts derived for the smaller areas.

The racial composition of future enrollments is examined in Section 3.5. The approach suggested in this section involves a reiteration of any of the previous techniques, substituting wherever appropriate non-white enrollment data for total enrollment information.

The last section of this chapter, Section 3.6, briefly looks at the uncertainty associated with enrollment forecasting. An attempt is made to measure the extent of this uncertainty by presenting a procedure for calculating confidence intervals for the initial forecasts. This procedure involves the reiteration of previously described procedures, using reasonable expectations of the likely high and low values which various inputs might take in each year of the planning period.

None of the techniques included in this chapter can adequately handle all of the multitude of possible contingencies. Adjustments should be made to the basic forecasts wherever it is possible to anticipate and quantify any future conditions which might cause the actual enrollment level to deviate from the forecast value. This adjustment process is discussed in the second part of Section 3.6.

The forecasting techniques have been illustrated, using the basic support system described in Chapter 2. Input cards containing sample information have been keypunched and included with the program deck. Examples of typical data preparation forms have also been included for selected rows throughout the procedures sections.

Some users may find it possible to carry out the necessary analysis simply by substituting data for their district in the rows that have been prepared. In most situations, however, differences in the planning period, the desired projection technique, the district organization, or the district size will necessitate modifying the rows themselves. Notice that if more than 300 rows are used in the Enrollment Component, it may not be possible to implement the Enrollment, Facility and Fiscal components together as part of one system's run. This is because of the 1,000 row maximum that characterizes the basic support system.

Prior to the execution of the procedures contained in the balance of this chapter, an appropriate planning horizon must be chosen. The length of the planning period may be influenced by the specific forecasting technique chosen. However, as stressed in the first chapter, many additional factors should be considered.

Capital planning and budgeting is essentially a long-range activity. The user is therefore encouraged to consider a planning period of at least ten years for enrollment forecasting purposes. While the degree of uncertainty will increase rapidly as forecasts are extended farther into the future, some measurement of long-range demands should be attempted. The time period presented in the current version of the System assumes nine years of historical information (1965-1973), the current year equal to 1974, and seventeen years in the planning period (1975-1991). As such three '1' cards are necessary when historical and projected data are input to the System for a given row.

3.2 Total Enrollment Forecasts

Four techniques are presented below for projecting the total number of students within a school district: cohort survival, time series analysis, the ratio method, and the dwelling unit method.

3.2.1 The Cohort Survival Technique

The cohort survival (or grade progression) technique is the most commonly used enrollment forecasting method. The data requirements are not extensive, but yield a projection of enrollment by grade.

3.2.1.1 General Design

This forecasting technique involves the calculation of a series of 'survival rates' which reflect the proportion of students in a given grade and year who progress or 'survive' to the next higher grade in the next school year. These rates are calculated using the equation below:

$$SR_{i,j+1} = E_{i+1,j+1} \; / \; E_{i,j}$$

where SR represents the survival rate from grades i to i+1, and $E_{i,j}$ the enrollment in grade i in school year j. For example, suppose that there were 300 students enrolled in the fourth grade, in the 1973-74 school year, and that there were 285 students enrolled in the fifth grade in the 1974-75 school year. The cohort survival rate in this case would equal 0.95 (i.e., 285/300). Survival rates are calculated similarly for several previous years. The average of these past survival rates is then applied to current enrollment data to obtain estimates of future enrollment levels. For example, suppose that the average survival rate for students progressing from grade four to grade five was calculated from historical enrollment figures and found to equal 0.97. If there were 300 students enrolled in the fourth grade in the current school year, then ninety-seven percent (97% or 0.97) of these students would be expected to 'survive' to the fifth grade in the next school year. The estimated enrollment in the fifth grade for the next school year would thus be 291 (i.e., 0.97 x 300 = 291). Average survival rates for each pair of consecutive grades may be similarly computed and applied to current enrollments to derive forecasts for each grade. These average survival rates may be further applied to subsequent years over the planning horizon so that enrollment forecasts may be generated as far into the future as desired.

All the factors which may influence the progression of students from one grade to the next are lumped together and measured simultaneously by the cohort survival rate. These factors include migration patterns, drop-out, retention and death rates, as well as public versus private school preferences. For this reason, the survival rates may be either greater or less than one depending on the net effect of all such factors. The use of the cohort survival technique does not facilitate an examination of any of these factors individually. The use of the average of previous survival rates in the generation of forecasts implicitly assumes that historical trends in these factors will continue relatively unchanged.

Where this assumption is thought to be appropriate, the cohort survival technique should provide reasonably valid enrollment projections. However, in school systems where these factors are expected to deviate from patterns exhibited in the past, the use of this technique may result in serious forecasting errors. The user in this case should rely upon the cohort survival method only for that period of time over which such factors are expected to remain stable or continue to change at rates similar to those exhibited in the past. For this reason the cohort survival method is frequently used in generating short-range forecasts, from one to five years.

Cohort survival rates cannot estimate the initial grade enrollment for kindergarten or first grade. This task must be accomplished independently. The technique used here to forecast enrollments in the initial grade involves an examination of the historical relationship between the initial grade enrollment and the number of births which occurred five years previously. A six-year lag would be appropriate where kindergarten is not offered. Births occurring within the school district boundaries, or county-wide (or municipal) birth data, may be used. A 'birth survival' rate will be used to reflect the relationship between the two variables. This rate is computed as follows:

$$BSR = E_{I,t} \; / \; B_{t-a}$$

where BSR represents the 'birth-survival' rate, $E_{I,t}$ represents the enrollment in the initial grade in year t, and B_{t-a} represents the number of births in year t-a, a being the average age of student enrolled in the initial grade. The average of birth-survival rates for several previous years may be applied to subsequent birth data to provide an estimate of future initial grade enrollments.

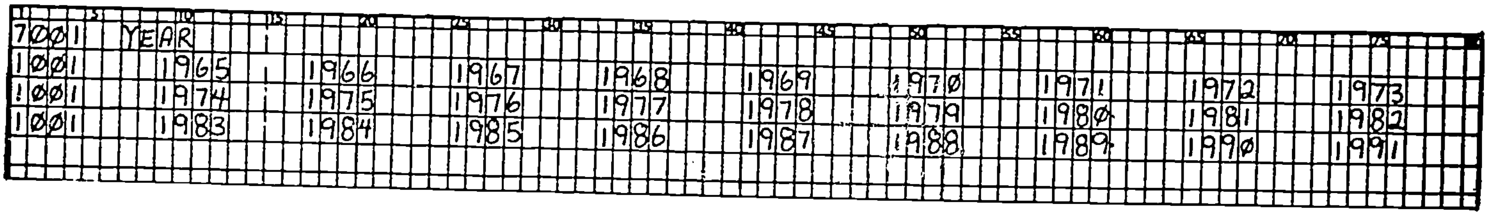
The relationship between initial grade enrollments and births occurring within the school system's boundaries should represent a more reliable predictive measure than would the relationship between initial grade enrollments and county births if, of course, these two jurisdictions are not contiguous. However, in cases where school system boundaries are not contiguous with those of a county or municipality, birth information may be unavailable or quite difficult to obtain In addition, where county birth projections are likely to be available through some public agency, e.g., the county department of planning, school system projections may not be as readily available or so reliable. If school system births are available and forecasts of future births for this jurisdiction have been generated and are accessible, they should be used in the calculation of 'birth-survival' rates. If school system birth data is available but forecasts of these births are not, this measure may still be appropriate where the planning horizon of the user does not exhaust the historical birth data. The choice of the precise measure of births to be used in the calculation of birth-survival rates is left to the discretion of the user.

3.2.1.2 COHORT SURVIVAL PROCEDURES

The procedures necessary for a cohort survival projection are outlined below with references to each variable currently used in the computer-based version of the School Facility Planning System. Each variable requires a unique row assigned by a '7' card; most also require that historical and/or projected data be entered using a '1' card, and that a mathematical or statistical operation be performed on the data using a '6' card. Specifications for completing these input cards are contained in Appendix A.

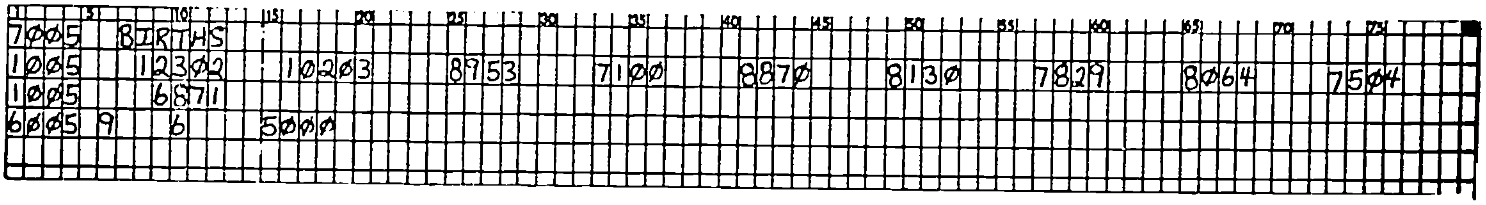
As currently defined, thirty-one variables are needed to obtain a projection of school district enrollment, using the cohort survival technique. The steps for preparing the input cards necessary to obtain this projection are discussed below on a row-by-row basis.

Row 001: Year. Each year of the historical and planning period is entered on Row 001. In the example this period has been selected to cover the years 1965 through 1991. Entries in all subsequent '1' cards used throughout the System must correspond to these years.



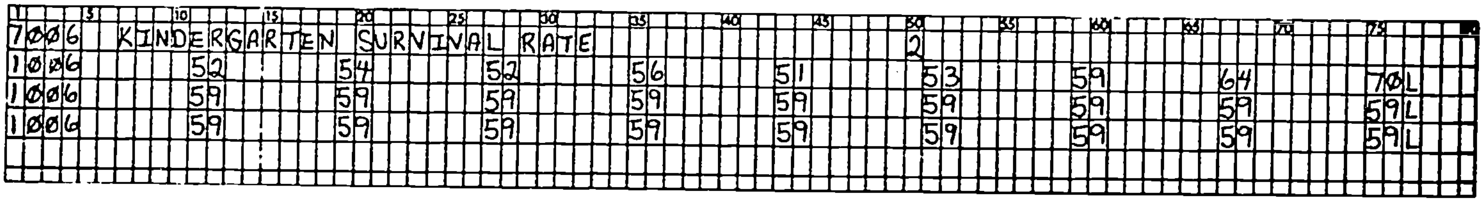
```
7001   YEAR
1001     1965    1966    1967    1968    1969    1970    1971    1972    1973
1001     1974    1975    1976    1977    1978    1979    1980    1981    1982
1001     1983    1984    1985    1986    1987    1988    1989    1990    1991
```

Row 005: Births. A '7' card is used to name the row. Historical and projected births for the smallest jurisdiction containing the school district are entered on '1' cards. If projected births are not available, they can be projected by using a '6' card to specify the desired projection method. In the example a logistics curve was chosen with a minimum of 5,000 births specified.



```
7005   BIRTHS
1005    12302   10203    8953    7100    8870    8130    7829    8064    7504
1005     6871
6005 9   6    5000
```

Row 006: Kindergarten Survival Rate. The values of the survival rate should be calculated manually and entered for every year of the historical period. These rates are obtained, using the formula presented in Section 3.2.1.1. Additional instructions for determining the ratios are available in the manual version of the S.F.P.S. User's Handbook. If the historic survival rates indicate a trend, they could be extrapolated, using one of the time series projection techniques described in Chapter 2. If no clear trend can be seen in the historical data, these values could be averaged and entered on the '1' cards for each year of the planning period. In the example, the current survival rate has been used for each year up to the planning horizon.



```
7006   KINDERGARTEN SURVIVAL RATE                2
1006       52      54      52      56      51      53      59      64      70L
1006       59      59      59      59      59      59      59      59      59L
1006       59      59      59      59      59      59      59      59      59L
```

Row 007: First Grade Survival Rate. See Row 006 Instructions.

Row 008: Second Grade Survival Rate. See Row 006 Instructions.

Row 009: Third Grade Survival Rate. See Row 006 Instructions.

Row 010: Fourth Grade Survival Rate. See Row 006 Instructions.

Row 011: Fifth Grade Survival Rate. See Row 006 Instructions.

Row 012: Sixth Grade Survival Rate. See Row 006 Instructions.

Row 013: Seventh Grade Survival Rate. See Row 006 Instructions.

Row 014: Eighth Grade Survival Rate. See Row 006 Instructions.

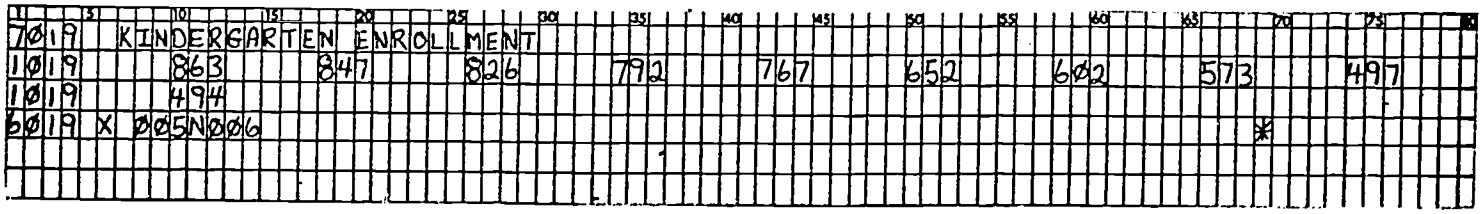
Row 015: Ninth Grade Survival Rate. See Row 006 Instructions.

Row 016: Tenth Grade Survival Rate. See Row 006 Instructions.

Row 017: Eleventh Grade Survival Rate. See Row 006 Instructions.

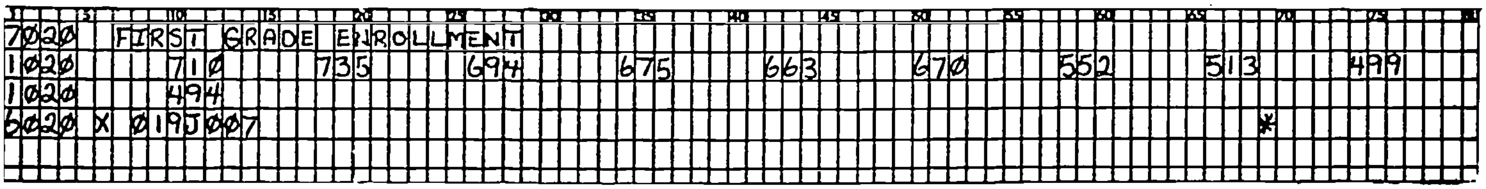
Row 018: Twelfth Grade Survival Rate. See Row 006 Instructions.

Row 019: Kindergarten Enrollments. This row is used to enter the historical kindergarten enrollments and to calculate future kindergarten enrollments. The historical data, including the current year, is entered on '1' cards. Future enrollments are obtained by specifying on a '6' card that births (Row 005) are to be lagged five (5) years and multiplied by the kindergarten survival rate (Row 006).



```
7019  KINDERGARTEN ENROLLMENT
1019     863     847     826     792     767     652     602     573     497
1019     494
6019 X 005N006                                                      *
```

Row 020: First Grade Enrollments. This row is used to enter the historical first grade enrollments and to project future first grade enrollments. Historical enrollments are entered on '1' cards. Future enrollments are obtained by specifying on a '6' card that kindergarten enrollments (Row 019) lagged one (1) year are multiplied by the first grade survival rate (Row 007).



```
7020  FIRST GRADE ENROLLMENT
1020     710     735     694     675     663     670     552     513     499
1020     494
6020 X 019J007                                                      *
```

Row 021: Second Grade Enrollments. See Row 020 Instructions.

Row 022: Third Grade Enrollments. See Row 020 Instructions.

Row 023: Fourth Grade Enrollments. See Row 020 Instructions.

Row 024: Fifth Grade Enrollments. See Row 020 Instructions.

Row 025: Sixth Grade Enrollments. See Row 020 Instructions.

Row 026: Seventh Grade Enrollments. See Row 020 Instructions.

Row 027: Eighth Grade Enrollments. See Row 020 Instructions.

Row 028: Ninth Grade Enrollments. See Row 020 Instructions.

Row 029: Tenth Grade Enrollments. See Row 020 Instructions.

Row 030: Eleventh Grade Enrollments. See Row 020 Instructions.

Row 031: Twelfth Grade Enrollments. See Row 020 Instructions.

Row 032: Total Elementary Enrollment. This row records the sum of the enrollments in all grades categorized as elementary grades. A '6' card is used to sum these rows. In the example Rows 019 through 025 are added together because the sample district has a K-6 grade organization.

```
7032  TOTAL ELEMENTARY ENROLLMENT
6032 X 019 020 021 022 023 024 025                                   ++++++
```

Row 033: Total Junior High Enrollment. This row is the sum of the enrollments in all grades assigned to the middle or junior high school. A '6' card is used to sum these rows. In the example Rows 026, 027 and 028 are summed because the seventh, eighth, and ninth grades are part of the junior high school organization.

```
7033  TOTAL JR HIGH ENROLLMENT
6033 X 026 027 028                                                   ++
```

Row 034: Total Senior High Enrollment. This row is the sum of the enrollments in all grades categorized as senior high grades. A '6' card is used to sum these rows. In the example they include the tenth, eleventh, and twelfth grades.

```
7034  TOTAL SR HIGH ENROLLMENT
6034 X 029 030 031                                                   ++
```

Row 035: Total Enrollment—Cohort Survival. This is the sum of all elementary, junior high, and senior high enrollments. A '6' card is used to sum these rows.

```
7035 TOTAL ENROLLMENT-COHORT SURVIVAL
6035 X 032 033 034                                                   ++
```

3.2.2 Time Trend Projections

A frequently used method of projecting total enrollment is simply to extrapolate the past trend. This is done by statistically estimating the curve which appears to best fit the historical observations. Used in conjunction with sound professional judgement regarding future enrollment trends, this technique could represent a useful forecasting tool if the data appears to follow a distinct trend.

3.2.2.1 General Design

This technique requires that the user specify the general shape of the curve which is most likely to reflect the expected enrollment trend over the chosen planning period. The selection of a particular type of curve is more important in obtaining an accurate enrollment forecast than the statistical estimation of that curve. For this reason careful consideration should be given to all potentially important factors prior to making this selection. These factors would include expected birth rates, migration retentions, dropouts, deaths, public versus private school preferences, and future housing patterns. Although not explicitly considered, expectations regarding all these factors will influence future patterns of enrollment growth or decline and should be subjectively examined before specifying a particular curve type.

The types of curves available in the basic support system are discussed in Chapter 2. Each of the curves represents a different set of assumptions about the likely pattern of future enrollment growth or decline. The user should select the most appropriate of these curves, but is encouraged to use several different curves in order to examine and evaluate their relative impact on the subsequent enrollment forecasts. Prior to the selection of a particular curve, the user should carefully graph the historical enrollment data. This procedure will assist in the selection process by allowing a visual comparison of previous enrollment patterns with any potential future trend.

Linear Change. The use of a straight line curve implies that the absolute rate of growth or decline will continue over the entire planning period. This may be a valid assumption, particularly where this rate of change is gradual, the curve does not slope steeply upward or downward, or where the planning horizon is relatively short. However, it should be kept in mind that in a school district with fixed geographic boundaries, enrollments are unlikely to increase or decrease without bounds. It is more likely that, in the case of growth, there is some reasonable upper limit beyond which the school district's enrollment will not pass. This limitation stems from the fact that there is a limit on the amount of land within the school district's boundaries which is available or suitable for residential development. A similar limit to the ultimate level of decline would be expected to exist. The straight line curve will usually be appropriate only in cases where the expected growth over the chosen planning horizon does not approach the upper limit of such growth, or where the expected decline does not approach the expected lower limit.

Exponential Change. The use of the exponential curve implies that the same rate of growth or decline will continue over the entire planning period. As with the linear curve this assumption may be valid if the historical data does not slope steeply upward or downward and, more importantly, if the planning horizon is relatively short. Since this curve is based on a projection of the rate of change, the increases or decreases in enrollment will be exponential in magnitude. This type of curve might be appropriate to use in a rapidly developing school district with a great amount of vacant land if development was expected to accelerate.

Logistics Change. A logistics or Gompertz curve is commonly used by demographers in forecasting population growth trends. It is based on the assumption that there is some upper limit to the ultimate level of population. A similar upper limit is likely to apply to school enrollments as well. The pattern of growth exhibited by these curves is one in which the school system progresses through a period of rapid growth, but as the enrollment level approaches the upper limit to growth, the rate of growth begins to diminish and eventually becomes negligible.

Even where the historical enrollment trend may not appear to follow a logistic growth pattern, a logistics or Gompertz curve may still be applicable. Suppose, for example, that the historical enrollment data follows a pattern such as that shown in Figure 3-1. This growth pattern cannot continue unabated over any appreciable period of time. If it did, enrollments would reach unreasonably high levels. As the upper limit to enrollment is approached, the growth rate will begin to slow down, even though the absolute growth may occur beyond the chosen planning horizon. In this situation, the S shape of the logistics curve may not be evidenced, but it is nonetheless implied for some time period beyond the planning horizon selected for examination. A similar situation may occur where the historical enrollment data follows a pattern such as that shown in Figure 3-2. In this case, the rate of growth has already begun to diminish so that the period of very rapid growth is not in evidence. Again the logistics or Gompertz curve may be used to estimate this growth trend. The lower portion of the S curve will be implied even though it has not been exhibited by the available historical data.

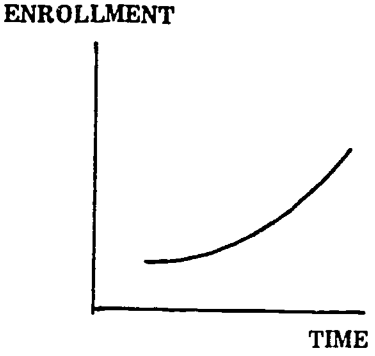


FIGURE 3—1 INCREASING RATE OF GROWTH

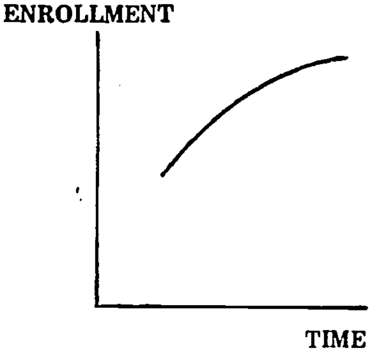


FIGURE 3—2 DECREASING RATE OF GROWTH

If a nonlinear growth trend is thought to be the most reflective of historical and expected future enrollment levels, an upper limit to enrollment should usually be specified. This upper limit should be estimated in light of the amount of undeveloped, but developable, land remaining within the school district boundaries, the likely impact of future birth and death rates, the expected age distribution of the population, and so on. Because of the uncertainties involved in the specification of such an upper limit, the user is encouraged to repeat the procedures, specifying various values for this limit in order to examine the impact of changing the assumptions about the future characteristics of the school system.

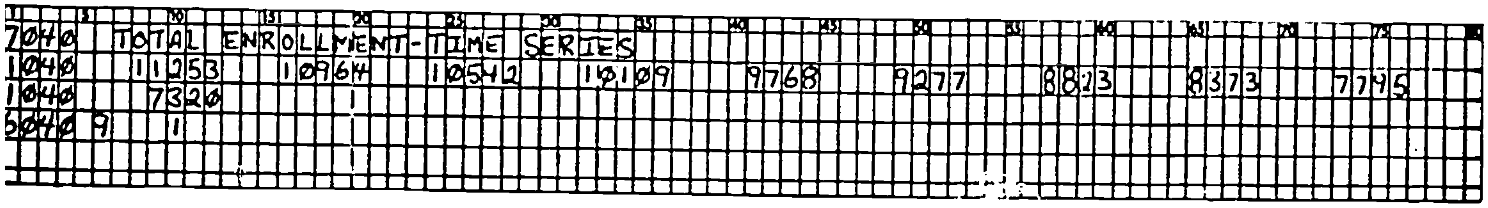
The pattern exhibited by a logistics or Gompertz curve may also be valid in enrollment decline situations. Again, because the decline pattern will not be expected to continue indefinitely, a minimum enrollment limit is often specified.

Once a specific type of curve has been chosen, the historical total enrollment data is used to estimate statistically the exact configuration of this curve. The curve which has been thus fitted to historical observations is then used to derive future enrollment estimates. The only data required is historical total enrollment figures and, depending on the type of curve chosen, an estimate of the ultimate maximum or minimum level of total enrollment. Specification of these maximum or minimum values requires careful judgement on the part of the user.

3.2.2.2 TIME TREND PROCEDURES

Only one variable, total enrollments, is needed for the time trend projection. An example of the input cards necessary for this projection is given below. The historical data should reflect the trend which is to be projected. This is especially true in a decline situation. Only those enrollment values which actually show a decline from the previous year should be entered as historical data. If enrollment information is unavailable for any historical year, estimates should be made for that year which reflect the trend being projected. If data is used which contains zeroes or exhibits an alternating growth and decline pattern from year to year, the projected values will be influenced by this information, and may not accurately reflect the actual enrollment trend.

Row 040: Total Enrollment—Time Series Projection. The historical total enrollment figures are entered on '1' cards. The '6' card is used to designate a specific curve type. In the example a linear decline curve has been chosen. As reviewed in Chapter 2, other curves could have been selected by changing the entry in Column 10 of the '6' card.



```
7040   TOTAL ENROLLMENT-TIME SERIES
1040     11253   10964   10542   10109    9768    9277    8823    8373    7795
1040      7320
6040 9   1
```

3.2.3 The Ratio Technique

The ratio technique is a method for projecting local school district enrollments based upon projections of the population or enrollment for some larger geographic area. This larger area may consist of the county, Standard Metropolitan Statistical Area (SMSA), or even the state which contains the local school district and for which there are reliable population or enrollment forecasts available. This technique assumes that the relationship between school system enrollments and the population or enrollment of the larger area will remain constant, or that it will continue to change at the same rate as it has in the past. If this assumption appears to be acceptable, then the ratio technique may represent a useful forecasting tool.

3.2.3.1 General Design

The first step in the ratio method is the selection of an appropriate larger geographic area and a suitable measure of trends within this larger area. If both historical data and acceptable enrollment forecasts are available for the larger area, they should be used. Reliable population projections are acceptable measures and are more likely to be available. The principal criterion for the selection of the larger area is the availability and reliability of projections. In general the smallest area containing the school district for which reliable projections are available should be used.

The next step in the ratio method is the calculation of the historical ratio between the local school system enrollment and the population or enrollment in the larger area. The ratio is computed as follows:

$$R_t = L_t \ / \ A_t$$

where R_t is the ratio in year t, L_t is the enrollment level in the school district in year t, and A_t is the population or enrollment of the larger area in year t. If no trend is discernible in the calculated historical values, the average of these past ratios can be used for the forecast value. If an increasing or decreasing trend is indicated by the historical ratios, it could be projected using that projection technique listed in Chapter 2 which most closely approximates the trend. Only those observed ratios which reflect the trend to be forecast should be used in a time trend projection. If a ratio for a historical year cannot be calculated or does not reflect the current trend, an estimate of the ratio which does follow the trend should be derived and input by the user.

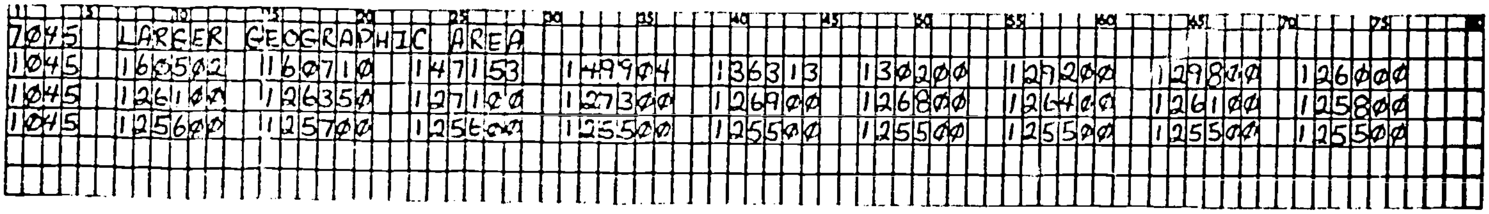
The final step in the ratio method is to multiply the projected ratios times the projections of the larger area population or enrollment to derive the enrollment for the school district in each year of the planning period.

3.2.3.2 RATIO TECHNIQUE PROCEDURES

The procedures necessary for a ratio technique projection are outlined below with references to each variable currently used in the computer-based system. Each variable requires a unique row (assigned by a '7' card); historical or independently derived data can be entered for a variable (using a '1' card); and mathematical or statistical operations can be performed on the data (using a '6' card). Directions for completing these input cards are contained in Appendix A.

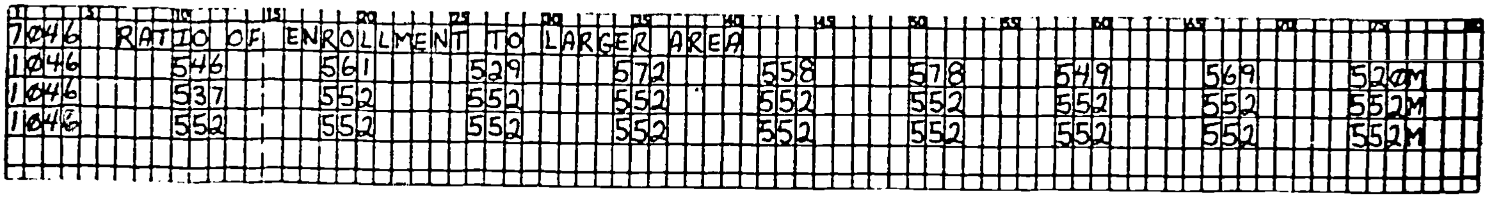
As currently defined, only three variables are needed to develop a projection of school district enrollment using the ratio technique. The steps for preparing the input cards necessary to obtain this projection are discussed below on a row-by-row basis.

Row 045: Projection of Larger Geographic Area. The historical and projected population or enrollment values for the larger geographic area are entered using '1' cards. Local planning agencies or utilities should be contacted to obtain this information.



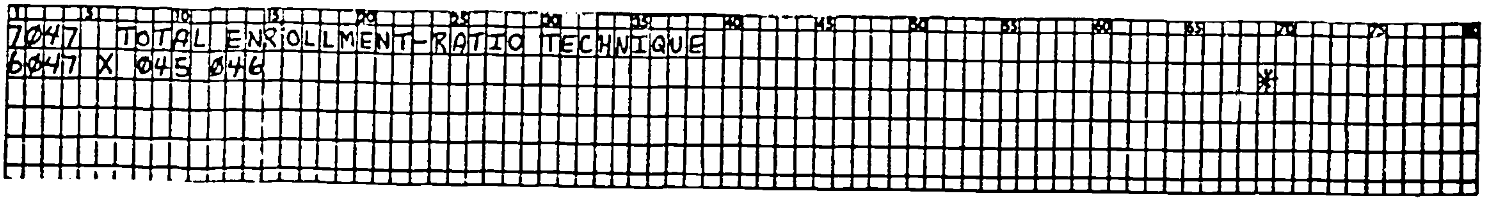
```
7045 LARGER GEOGRAPHIC AREA
1045 165502 160710 147153 149904 136313 130200 127200 129870 126000
1045 126100 126350 127100 127300 126900 126800 126400 126100 125800
1045 125600 125700 125600 125500 125500 125500 125500 125500 125500
```

Row 046: Ratio of Enrollment to Larger Geographic Area. The historical ratios between the enrollment in the school district and the larger geographic area are entered on '1' cards. If a trend is exhibited by the calculated ratios, a '6' card can be used to calculate future ratios. The descriptions of the time series extrapolation techniques in Chapter 2 should be reviewed before a decision is made as to the appropriate projection method. If no clear trend is evident from the historical data, the ratios should be averaged. This average is entered for the planning years, using '1' cards.



```
7046 RATIO OF ENROLLMENT TO LARGER AREA
1046    546    561    529    572    558    578    549    569    520M
1046    537    552    552    552    552    552    552    552    552M
1046    552    552    552    552    552    552    552    552    552M
```

Row 047: Total Enrollment—Ratio Technique. Total future enrollment in a school district as calculated by the ratio technique is obtained by specifying on a '6' card that the projection of the larger geographic area (Row 045) is to be multiplied by the ratio of enrollment to the larger geographic area (Row 046).



```
7047 TOTAL ENROLLMENT-RATIO TECHNIQUE
6047 X 045 046                                                 *
```

3.2.4 Dwelling Unit Multiplier Technique

The dwelling unit multiplier technique may represent a useful alternative to the three previous forecasting techniques. It should be particularly applicable to rapidly growing school systems where a large portion of the increase in enrollment has been and is expected to be attributable to residential development. This technique requires more extensive data than do the other techniques and thus may not be feasible for some districts. The items for which historical data is required are the number of dwelling units by type of unit, and the yield factor applicable to these dwelling units, i.e., the average number of public school children in each dwelling unit, by dwelling unit type if possible.

3.2.4.1 General Design

The technique may be applied to all dwellings grouped together, regardless of type, or for each specific category of dwelling units within the district. As fine a breakdown as possible should be used, with the deciding factor being the availability of data. In general, separate analysis of single and multiple family dwellings will be desirable, because the yield of public school children typically varies substantially between these two types.

Three basic procedures are involved in the estimation of future enrollment levels, using the dwelling unit multiplier technique. The first of these is the calculation and projection of historical yields for each type of dwelling unit to be examined. Where data is already available for these yield factors, it should be used to project future yields. If a trend is discernible in the historical values, any of the time trend projections discussed in Chapter 2 can be used. The one chosen should reflect the trend which is expected to continue throughout the planning period. If no trend exists in the historical yield factors, an average of these rates or the current rate can be used for the future planning years.

Where past values of these yield factors are not available, a sampling technique is recommended to estimate the rates. A random sample of the students enrolled in each historical year should be selected. In small school systems, all students might be included in the sample. The sample must include a sufficiently diversified and large percentage, at least ten percent, of the total enrollment to insure a valid representation of student residence by dwelling type in the district. The residence type of each student in the sample is then identified by examining the address based on general knowledge of the district or telephone and field surveys. After the residence type is determined, the number of students should be summed by residence type. To obtain the percentage of students in the sample in each residence type, divide the number of students in each residence type by the total number of students in the sample. This ratio is then multiplied by total school district enrollment to derive the total number of students in the district who lived in that type of residence for each historical year. This number is then divided by the total number of that residence type in the district for that year to obtain the student yield factor. These calculated yield factors must then be projected for each year of the planning period.

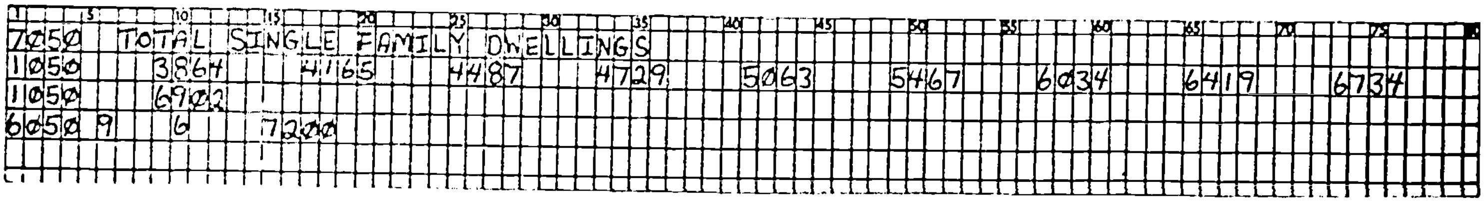
The next step is to calculate and project the number of dwelling units of each type for each year of the historical planning periods. Where the boundaries of the school system are not contiguous with those of governmental jurisdictions for which dwelling unit count data is available, the historical information may be difficult to obtain. The planning department of the county or municipality which contains the school district may be able to assist in obtaining the information. Though available only every ten years, census data may be a good starting point. The addition of housing permit data to this base figure should yield a reliable estimate of current dwelling units by type. In some communities adjustments will be necessary to account for the demolition of dwellings, and for those structures that were not built despite the issuance of a construction permit. Occupancy permits, utility company accounts, and aerial photography may provide alternative update sources. To project dwelling units, a logistics curve is recommended. If it appears that the community's growth or decline will reflect an 'S' curve, gradual initial growth (decline) followed by accelerated change, which in turn tapers off as it approaches an upper (lower) limit, the logistics curve should be used. If a reliable projection of dwelling units by type is available from an independent source, it could be used instead.

The final step in the dwelling unit multiplier technique is to derive future enrollments. This is done by multiplying the student yield factor times the projected dwelling units.

3.2.4.2 DWELLING UNIT MULTIPLIER PROCEDURES

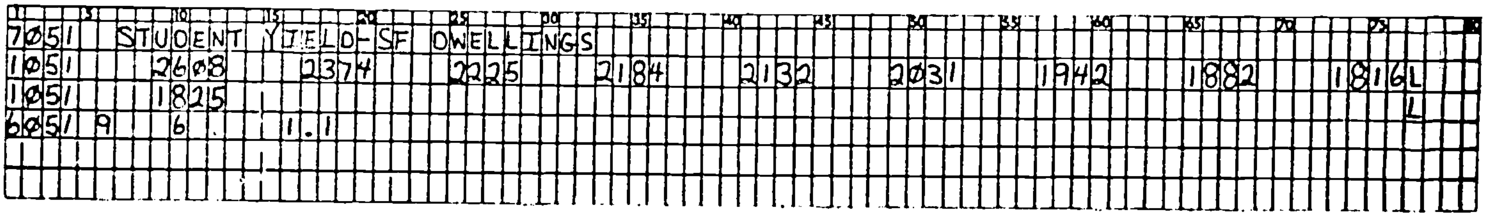
The procedures necessary for a dwelling unit multiplier projection are outlined below with references to each variable used in the current version of the System. As presently defined, seven variables are required to obtain enrollment based on projections of future single family and multiple family residences. If the user desires a finer breakdown of residence types, more variables will be needed; alternatively, if no residential breakdown by type is possible or desired, fewer variables will be necessary. It should also be noted that if either student yield factors or dwelling unit counts are to be projected, only that data which reflects the expected trend should be used. This is especially true in a decline situation. If data is unavailable for any historical year, estimates should be made for that year which follows the trend being projected. The preparation of input cards necessary to obtain the projection is discussed below on a row-by-row basis.

Row 050: Total Single Family Dwellings. Historical data on the number of single family dwelling units should be entered on '1' cards. If an independent projection of the number of units expected during the planning period is available, this data is also entered. If no projection is available and the trend exhibited by the historical data is expected to continue during the planning period, a '6' card is used to specify the projection technique. In the example, a logistics curve is requested with an upper asymptote of 7,200 units.



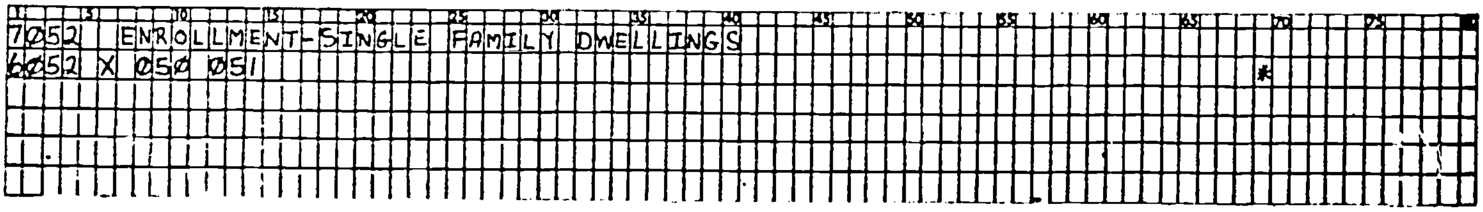
```
7050  TOTAL SINGLE FAMILY DWELLINGS
1050    3864    4165    4487    4729    5063    5467    6034    6419    6734
1050    6902
6050 9   6      7200
```

Row 051: Student Yield per Single Family Dwelling. The historical yield figures are entered on '1' cards. If a trend is observed and expected to continue during the planning period, a '6' card is used to specify the projection technique which best resembles this pattern. If no trend is discernible or the trend is not expected to continue, the average of the historical yields or the current yield, whichever is considered more likely. is entered for the planning years on '1' cards.



```
7051  STUDENT YIELD-SF DWELLINGS
1051    2608    2374    2225    2184    2132    2031    1942    1882    1816L
1051    1825
6051 9   6       1.1                                                        L
```

Row 052: Single Family Enrollment. Future single family enrollment is obtained by specifying on a '6' card that total single family dwellings (Row 050) be multiplied times the student yield per single family dwelling (Row 051).



```
7052  ENROLLMENT-SINGLE FAMILY DWELLINGS
6052 X 050 051
```

Row 053: Total Multiple Family Dwellings. This row is similar to Row 050. Replace single family dwellings with multiple family dwelling information.

Row 054: Student Yield per Multiple Family Dwelling. This row is similar to Row 051. Replace single family yields with multiple family yields.

Row 055: Multiple Family Enrollment. Future multiple family enrollment is obtained by specifying on a '6' card that total multiple family dwellings (Row 053) be multiplied times the student yield per multiple family dwelling (Row 054).

Row 056: Total Enrollment—Dwelling Unit Method. Total future enrollment for a school district as calculated by the dwelling unit method is obtained by specifying on a '6' card that single family enrollment (Row 052) be added to multiple family enrollment (Row 055).

```
7056  TOTAL ENROLLMENT-DWELLING UNIT METHOD
6056 X 052 055                                                      +
```

3.2.5 **Multiple Forecast Reconciliation**

Four separate techniques have been presented to estimate future total school district enrollment. None of these techniques has been proven clearly superior. It is more likely that each may be an appropriate method under different sets of conditions. Whenever it is unclear which of the techniques is the most valid for a particular school district, it is both legitimate and potentially enlightening to use two or more techniques. The resulting divergence of forecasts may, in fact, provide more insight into future enrollment trends than the specific forecast values themselves. If, for example, forecasts generated from the use of two different techniques were very similar, as illustrated in Figure 3-3, the user is more likely to have confidence in the forecast values. Each technique is based upon a slightly different set of assumptions. If both sets lead to the same conclusions regarding future enrollments, then each technique will tend to lend credence to the forecast produced by the other. If, on the other hand, forecasts derived from two techniques are quite dissimilar, as shown in Figure 3-4, then the user should be alert to the possibility that some invalid assumptions may have been made. In such situations, a detailed review of the calculations associated with each technique should be made in an attempt to trace the effect of various assumptions and perhaps identify the source of the discrepancy. Suppose, for example, that technique A in Figure 3-4 was the cohort survival technique, and technique B was a time trend projection technique employing a logistic growth curve. Technique B clearly shows a leveling off of the rate of growth in enrollments, while technique A demonstrates a constant rate of growth over the entire planning period. Two possible sources for this divergence are immediately apparent. Either the enrollment level is approaching a peak as residential development reaches a saturation point, and the cohort survival technique has not adequately accounted for this phenomenon, or the eventual maximum limit to enrollment growth has been underestimated in executing the logistic time trend projection. Re-evaluation of these possibilities may lead to useful insight into the sensitivity of enrollments to changes in these assumptions as well as the relative validity of the two sets of forecast values.

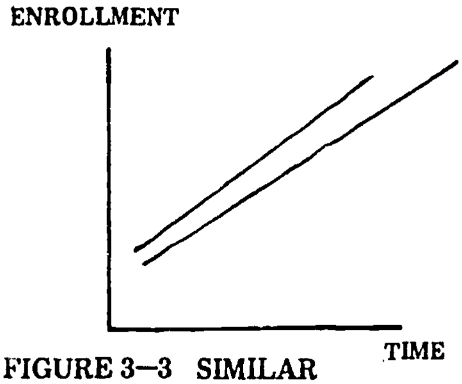


FIGURE 3—3 SIMILAR FORECAST RESULTS

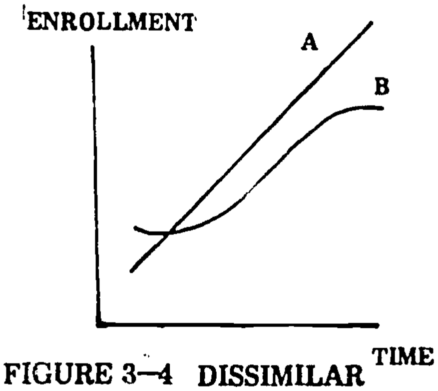


FIGURE 3—4 DISSIMILAR FORECAST RESULTS

In some cases where two or more techniques have been used and where the projections are reasonably similar, it may be desirable to produce one set of projections which summarizes the trend indicated by each of the techniques. When it is not possible to determine which of the forecasts is the most valid, an average of the forecast values might be used to serve as a crude synthesis of all the techniques used. Such an average forecast might be useful in reducing the confusion which could result from the presentation of two or more forecasts, and might conceivably represent the most valid forecast available. This averaging technique should be used only in cases where the forecasts derived from several techniques are quite similar and where there is no set of criteria upon which to evaluate the relative accuracy of the individual techniques.

In certain instances, the user may have more confidence in one technique for a certain number of years during the planning period, while placing more faith in the results of some other technique for the remainder. Suppose, for example, that the cohort survival technique appeared to be more valid to use in the short run, e.g., one to five years, whereas the ratio technique appeared to be more valid for longer range forecasts, e.g., six to ten years. Further suppose that projections generated by these two techniques resembled Lines A and B in Figure 3-5, respectively. If the cohort survival forecasts were used for the first five years of the planning horizon and the ratio method was used for the next five years, a large, discrete, and unaccountable decline would appear in enrollments in the sixth year as seen in Figure 3-6. A method is therefore needed whereby the two forecasts can be linked together.

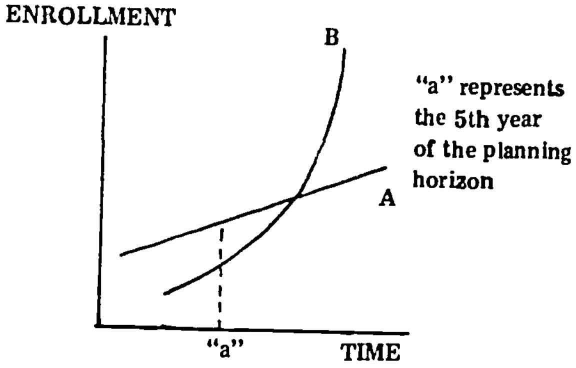


FIGURE 3—5 FORECASTS USING TWO TECHNIQUES

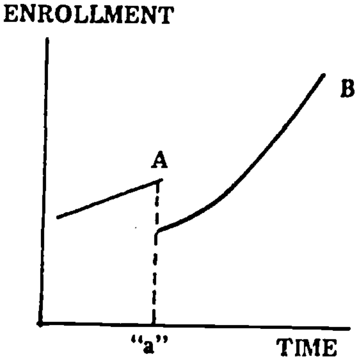


FIGURE 3—6 TWO UNRECONCILED FORECASTING TECHNIQUES

One method for reconciling two forecasts is as follows: First, the technique which is thought to be more valid for the short run should be used, beginning with the first year of the forecast period and continuing up to but not including the year in which some other technique is believed more appropriate. In the above example, the cohort survival technique would be used to derive the enrollment forecasts for the first five years of the planning horizon. Next the technique believed to be more valid for the remaining years of the planning period should be initiated, using the forecast enrollment values which were generated with the first technique as historical data. For example, all the forecast values shown on Line A in Figure 3-6 would be treated as historical observations and used in the ratio technique for forecasting the enrollments during the remaining years. The enrollment forecasts over the entire planning horizon might thus appear as in Figure 3-7.

There should be no difficulties whenever the desired technique for the longer range forecast is the time trend projection method since the only required input data is previous enrollments, which will have been forecast by some other technique over the short range. When the cohort survival technique is preferred for the longer range projection, some difficulties will be encountered since the other techniques do not provide the enrollment forecasts for each grade. This data is required to calculate the survival rates. It will not be possible, therefore, to easily link several techniques when the cohort survival technique is used for the longer range forecasts. This situation is unlikely, however, since the cohort survival technique is generally viewed as a short run forecasting tool.

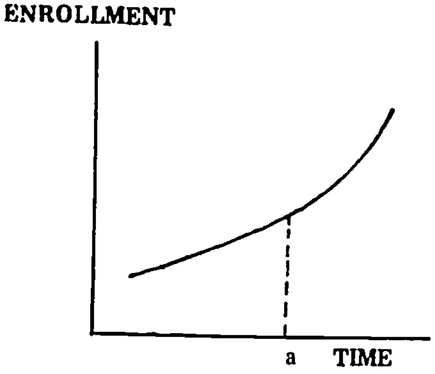


FIGURE 3—7 TWO RECONCILED FORECASTING TECHNIQUES

A different problem develops when the dwelling unit multiplier method is used for making the longer range projections. Two essential elements are forecast in the process of executing this technique, future dwelling units and yields. While the dwelling unit projection will be unaffected by the short run forecasts derived with the use of some other technique, the yields associated with the various dwelling types may be altered. As no acceptable method for directly modifying these yields is available, the linkage must be handled in a different manner.

The steps of this alternative procedure require first using the technique thought to be appropriate in the short run up to, but not including, the year in which the dwelling unit multiplier technique becomes more valid. Then forecasts are generated using the dwelling unit multiplier method for each year of the planning period.

Next, subtract the enrollment forecast derived by using the dwelling unit multiplier technique from the forecast derived by using the preferred short run technique for the last year in which the short run technique was used. The resulting value will act as an adjustment factor. Finally, beginning with the first year of the planning period for which the dwelling unit multiplier method is preferred, add the adjustment factor calculated in the previous step to the dwelling unit multiplier forecast in each of the remaining years of the planning horizon. The results of such an adjustment process might appear as Line A in Figure 3-8.

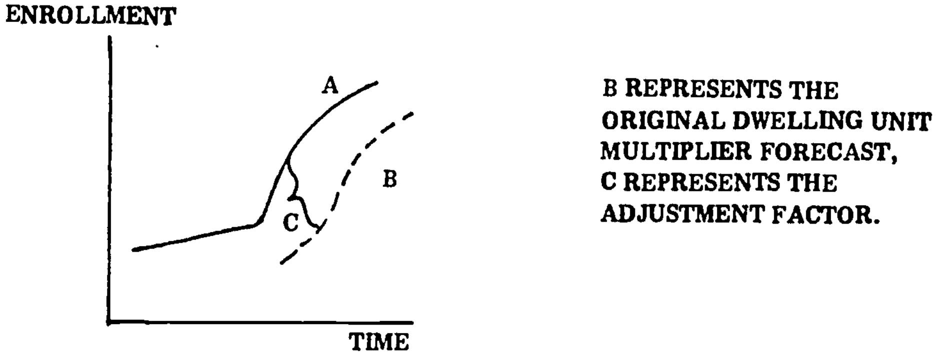


FIGURE 3—8 ADJUSTED DWELLING UNIT MULTIPLIER FORECAST

Determining the precise year of the planning period in which the results of one technique become more valid or reliable than another technique is, of course, arbitrary. The process of linking the two techniques may, however, be useful in avoiding confusion or concern which might arise from a discrete change in the forecasts from one year to the next, especially where the magnitude of the adjustment required is relatively small.

In the current version of the computer-based system no variables (rows) have been set aside for multiple forecast reconciliation. The procedures for this task will depend on the types of projection techniques which were used in the initial forecasts. The user can, therefore, reconcile the forecasts either manually or by specifying the necessary rows in the computer-based model.

3.3 Enrollment Forecasts by Grade

Several procedures were presented in Section 3.2 by which the total enrollment level for the school system could be projected. Total enrollment estimates provide useful information about the general magnitude of future facility needs. The specific nature of these needs will, however, vary according to the distribution of the total enrollment among the different grades included in the school district.. The objective of this section is to provide a methodology whereby enrollments may be determined for each grade level.

3.3.1 General Design

The recommended procedure is based on the assumption that the estimated total enrollment level for any particular year is a more accurate and valid estimate than an estimate for any particular grade in the same year. All the factors contributing to the uncertain nature of the total enrollment forecast will also be applicable to the forecasts for a particular grade. Additional factors might, however, affect the enrollment within each grade more than they affect total enrollment forecast. For example, the retention rate for all grades taken together may remain very stable, even though the retention rates for various grades may fluctuate significantly. Therefore, the initial estimates for each grade generated by the following technique are adjusted so that their total equals the total enrollment forecast previously derived.

The method for deriving initial enrollment forecasts for each grade is the cohort survival or grade progression technique. As described in Section 3.2.1, it is based upon the calculation of a series of 'survival' rates from historical data. A 'survival' rate indicates the fraction, either less than or greater than one, of students in a given grade and school year who 'survive' to the next grade in the next year. These estimated survival rates are then applied to current enrollments to generate estimates of the enrollment in subsequent years.

The estimates of enrollment for each grade are then adjusted according to the relative magnitude of the cohort survival total enrollment estimate and the estimate of total enrollment derived from some alternative procedure, the latter value acting as a control total. An adjustment factor is calculated for each year as follows:

$$a_t = E_t \;/\; S_t$$

where a_t is the adjustment factor for year t of the planning horizon, E_t is the total enrollment forecast serving as the control total, and S_t is the total enrollment forecast derived from the use of the cohort survival technique. The grade specific estimates generated using the cohort survival technique are then multiplied by this adjustment factor to derive the adjusted estimates.

This same method can be applied to the smaller geographic sub-regions or areas which are defined in Section 3.4. In this situation, the total enrollment forecast for the region or the area would act as the control total in adjusting the estimates for each grade. This would, of course, require historical data on enrollments in each grade level.

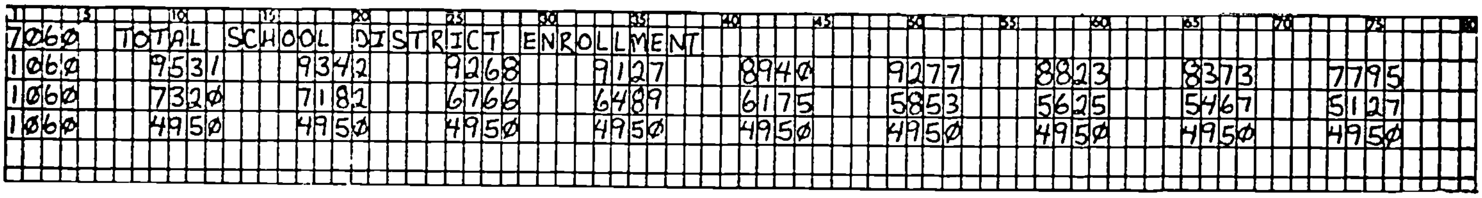
This method may similarly be applied to non-white enrollment forecasts, which are described in Section 3.5. Non-white enrollment estimates would be used as the control total in this case.

3.3.2 ENROLLMENT FORECASTS BY GRADE PROCEDURES

The procedures necessary for obtaining enrollment forecasts by grade from a total enrollment projection are outlined below with references to each variable currently used in the computer-based system.

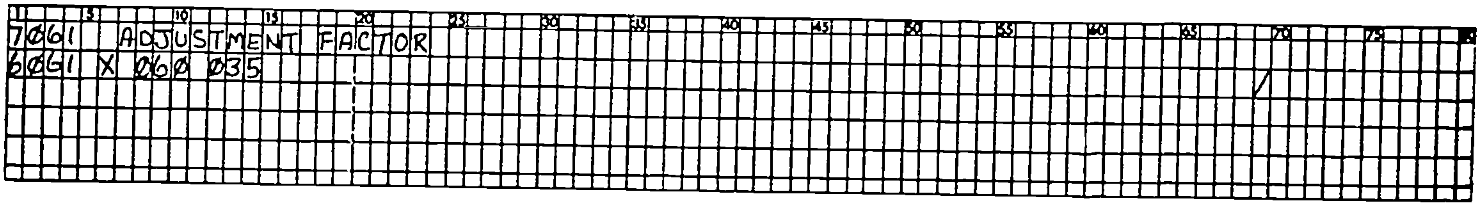
The first step in allocating the total enrollment to specific grades is to perform the cohort survival technique as described in Section 3.2.1.2 of this chapter. The cohort survival method should be carried out for each year of the planning period for which total enrollment forecasts are available. Upon completion of this procedure the user will have initial estimates of future grade enrollments for each year of the planning period. Input cards should then be prepared for the eighteen variables which follow. At the completion of these procedures the total school district enrollment will be allocated to grades.

Row 060: Total School District Enrollment. The historical and projected enrollments believed to be the most accurate for the district are entered on a '1' card.



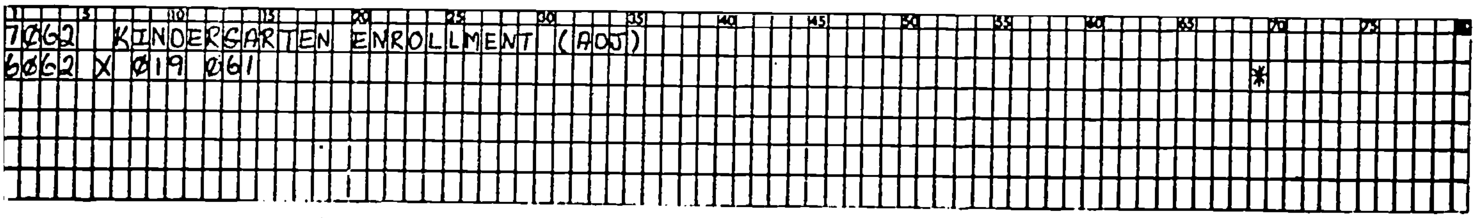
```
7060  TOTAL SCHOOL DISTRICT ENROLLMENT
1060    9531    9342    9268    9127    8940    9277    8823    8373    7795
1060    7320    7181    6766    6489    6175    5853    5625    5467    5127
1060    4950    4950    4950    4950    4950    4950    4950    4950    4950
```

Row 061: Adjustment Factor. The adjustment factor is obtained by dividing the total enrollment serving as the control total (Row 060) by the total enrollment cohort survival (Row 035).



```
7061  ADJUSTMENT FACTOR
6061 X 060 035                                                       /
```

Row 062: Kindergarten Enrollment Adjusted. The adjusted kindergarten enrollment is obtained by specifying on a '6' card that kindergarten enrollment (Row 019) be multiplied by the adjustment factor (Row 061).



```
7062  KINDERGARTEN ENROLLMENT (ADJ)
6062 X 019 061                                                       *
```

Row 063: First Grade Enrollment Adjusted. See Row 062 Instructions.

Row 064: Second Grade Enrollment Adjusted. See Row 062 Instructions.

Row 065: Third Grade Enrollment Adjusted. See Row 062 Instructions.

Row 066: Fourth Grade Enrollment Adjusted. See Row 062 Instructions.

Row 067: Fifth Grade Enrollment Adjusted. See Row 062 Instructions.

Row 068: Sixth Grade Enrollment Adjusted. See Row 062 Instructions.

Row 069: Seventh Grade Enrollment Adjusted. See Row 062 Instructions.

Row 070: Eighth Grade Enrollment Adjusted. See Row 062 Instructions.

Row 071: Ninth Grade Enrollment Adjusted. See Row 062 Instructions.

Row 072: Tenth Grade Enrollment Adjusted. See Row 062 Instructions.

Row 073: Eleventh Grade Enrollment Adjusted. See Row 062 Instructions.

Row 074: Twelfth Grade Enrollment Adjusted. See Row 062 Instructions.

Row 075: Elementary Enrollment Adjusted. To obtain the total adjusted elementary enrollment, a '6' card is used to sum the appropriate grades. In the example, grades kindergarten through six are added together.

```
7075  ELEMENTARY ENROLLMENT ADJUSTED
6075 X 062 063 064 065 066 067 068                                   ++++++
```

Row 076: Junior High Enrollment Adjusted. To obtain the total adjusted junior high enrollment, a '6' card is used to sum the appropriate grades. In the example, they include grades seven through nine.

```
7076  JR HIGH ENROLLMENT ADJUSTED
6076 X 069 070 071                                                   ++
```

Row 077: Senior High Enrollment Adjusted. To obtain the total adjusted senior high enrollment, a '6' card is again used to add the appropriate grades. In the example, they include grades ten, eleven, and twelve.

```
7077  SR HIGH ENROLLMENT ADJUSTED
6077 X 072 073 074                                                   ++
```

3.4 Geographic Distribution of Enrollment

The preceding sections have been concerned with the task of forecasting enrollments on a district-wide basis. A geographic distribution of future enrollments will be important for many school districts, especially where the location of schools to be closed or constructed is of interest. This section is provided to assist in projecting the geographic distribution of enrollments. The enrollments for sub-geographic areas within the boundaries of the school district are then reconciled with the forecasts made for the district as a whole.

Two levels of analysis are presented. A method for projecting enrollments for relatively large regions within the school system is described in Section 3.4.1. This geographic level of analysis may be particularly appropriate for school districts that encompass several distinct regions in terms of expected growth patterns, population densities, and other social or demographic characteristics. A second level of analysis is presented in Section 3.4.2 wherein the forecast enrollments for either the entire school system or for the larger regions are allocated to a number of smaller sub-geographic areas. The allocation process incorporated in this analysis is based primarily on the expected number of dwelling units in these small areas. The small area forecasts are used as input data to the Geographic Component (Chapter 6).

3.4.1 Regional Forecasts

Many school districts contain distinct regions characterized by different rates of enrollment growth or decline. A school district may consist of a densely populated, highly developed urban region and a more sparsely populated suburban region in which future growth is likely. In such situations, a forecast generated for the school district as a whole would cover up differences that could be revealed through a region-by-region analysis.

3.4.1.1 General Design

Sub-geographic area analysis may be especially important where one forecasting technique appears to be appropriate for one of the regions, but inappropriate for another. In this case the accuracy and validity of the enrollment forecast for the entire school system might be enhanced if forecasts were generated independently for each of the regions, using the forecasting technique best suited to the specific characteristics of each region. These regional forecasts could then be added together to derive a forecast enrollment level for the total school district. In other instances where a forecast generated for the school district as a whole appears to be more reliable than the sum of the regional forecasts, the regional enrollment forecasts should be adjusted to be consistent with the total system-wide projection.

The specific methodology suggested for the generation of regional forecasts consists simply of repeating the procedures outlined in Section 3.2, using data pertaining to a specific region rather than the district as a whole. Either of the two approaches identified above may be used in an analysis of regional forecasts, depending on the perceived extent of the differences between regions. Forecasts for each region may be generated, using the technique thought to be the most appropriate, and then added together to derive a forecast for the total school district. This method will probably be the most valid approach when the differences between regions are quite significant and easily distinguishable. Alternatively, regional forecasts may be generated and then adjusted so that their sum is equal to the forecast which has been previously made for the school district as a whole. This approach will probably be appropriate where the distinction between the regions is less clearly defined. The only significant difference between these approaches is one of emphasis. The procedures to be followed are identical, with the exception that the latter approach requires reconciliation of the regional forecasts with the system-wide forecast.

3.4.1.2 REGIONAL ANALYSIS PROCEDURES

The first and probably most important step in the regional analysis is the definition of several large geographic sections within the school system based on distinctive characteristics. Most school districts can usually be divided into two to four distinct regions. A more detailed breakdown will usually not be worthwhile.

The techniques presented in Section 3.2 should be reviewed to determine which seems most appropriate for each region. The specific procedures associated with the selected techniques should then be used to project regional enrollments.

3.4.2 Small Area Forecasts

If a more refined level of geographic detail is desired, the system-wide or regional enrollment forecasts may be allocated to a series of smaller geographic areas. The enrollments forecast for these small areas could provide valuable insight into future geographic patterns of enrollment growth or decline. In addition, these forecasts will provide necessary information for the Geographic Component presented in Chapter 6, in which the issues of attendance area boundaries and site selection for either school closings or construction are addressed.

3.4.2.1 General Design

The method for estimating future enrollments in small areas is similar to the dwelling unit multiplier method as described in Section 3.2.4 of this chapter. A modified dwelling unit multiplier approach, in which the yield factors for each type of dwelling remain constant over time, is applied to the expected number of units of this type in order to derive an initial enrollment forecast for the area. The initial forecast for each area is then adjusted so that the enrollment total for all areas is consistent with the enrollment level previously forecast for the school district as a whole or for the region which contains the smaller areas. Growth which is attributable to residential development in a particular area is thus explicitly considered. Changes in all other variables affecting enrollments, such as the age distribution of the population or birth rates, are assumed to occur uniformly in each area within the region, or the entire school district where no breakdown into homogeneous regions has been undertaken.

Allocating enrollment forecasts to small geographic areas involves seven separate tasks: the division of the school district or region into smaller geographic areas, the selection of an appropriate number of dwelling unit types for consideration, the calculation of current yield factors in each area for each dwelling type used, the generation of dwelling unit forecasts by type, the generation of an initial set of enrollment estimates for each area, the adjustment of these estimates, and the determination of grade specific enrollments.

The number of smaller areas or grids established in the school district is not constrained by the mechanics of the procedures. As forecasts for smaller and smaller geographic areas are made, however, the validity of the forecasts will decline rapidly. As few areas as possible should be defined, while still providing sufficiently detailed forecasts for use in the Geographic Component. Since the purpose of the Geographic Component is to allocate students to schools, the number of areas defined should be greater than the number of elementary schools. The exact number chosen will depend on the size of the district and the number of schools it contains. Thirty small areas will usually suffice. However, if the school district is especially large or the number of elementary schools is greater than ten, this suggested maximum may need to be exceeded to make the geographic analysis useful.

The shape of the defined areas or grids need not be uniform. The availability of data necessary for forecasting enrollments for each area is an important consideration in defining these areas. Boundaries which coincide with geographic divisions for which historical information is available, such as census blocks or enumeration districts, should be used whenever possible. Areas should be selected which encompass approximately equal population levels. While equal-sized areas are desirable, if necessity dictates the collapse of several areas into one, those with lesser densities should be chosen.

The selection of the types of dwelling units to be considered depends on the composition of each individual grid. Some grids may have only single family units while others are predominantly multiple family. In these cases, the enrollment forecast could be made using only one dwelling unit type. If the grid is composed of a mixture of single family and multiple family units, and the student yield factor for each is very different, then enrollment should be calculated for each dwelling unit type.

The next task in allocating enrollment forecasts to grids is the calculation of the current student yield factor. This value is obtained by dividing the number of students residing in a particular dwelling type by the number of units of that dwelling type in a grid. If these two values are unknown, they can be determined from surveys of the area, samples, aerial photos, and/or municipal or county files. (See Section 3.2.4.1 Dwelling Unit Multiplier Technique General Design for a detailed discussion on calculating student yield factors from a sample survey.) Some users may prefer to use the same yield factors for all grids within the region.

The fourth step in this process is the forecast of dwelling units by type for each grid. Dwelling unit forecasts for the entire school district and each region must be available. If these forecasts do not exist, a nonlinear growth curve with a specified maximum is recommended for use in their calculation. The allocation of dwelling units to grids should be made based on firsthand knowledge of the characteristics of each grid. In areas that are fully developed, few new dwellings should be assigned. Probable growth areas will be characterized by vacant land which is serviced by utilities, and by older areas where the number of units may be increased by renewal and rehabilitation activity. In the absence of other guidelines, the new units should be allocated to grids on the basis of the amount of developable land in each grid, and its proximity to developed areas.

The initial enrollment estimates for each grid may now be calculated. The current yield factor for a specific dwelling type is multiplied by the number of units of that dwelling type in each grid to obtain future enrollment levels from that dwelling type for each grid. The enrollments by dwelling type are then summed for each grid to obtain future initial enrollments by grid. These projections are based on the assumption that the student yield factor will remain constant. In actuality this factor will change because of shifts in the birth rate, age distribution, public and private school preferences, and a variety of other variables.

The calculation of an adjustment factor to account for this shift and the subsequent recalculation of grid enrollment forecasts constitute the sixth step in small area forecasting. The adjustment factor is obtained by summing the individual grid enrollments by region and dividing by the enrollment forecast for the region. This adjustment factor is then multiplied by the initial grid enrollments to obtain adjusted enrollment projections for each grid.

The final step in small area forecasting is the disaggregation of grid enrollments to specific grade combinations. This is done by calculating the percentage of students expected to be in various grade levels (e.g., elementary, junior high, senior high) at the regional or district level for each year in the future. These factors are then multiplied by the enrollment in each grid to obtain the grade level breakdown needed for the Geographic Component. The percentage of students in each grade grouping at the regional or district level can be obtained, if not already available, by using the technique explained in Section 3.3, Enrollment Forecasts by Grade.

3.4.2.2 SMALL AREA FORECAST PROCEDURES

The sample school district presented in the current version of the computer-based system consists of only one region and fifteen grids. The user is free to make projections for additional regions and grids by preparing the necessary additional rows.

The necessary steps for preparing the input cards to obtain small area forecasts are discussed below on a row-by-row basis.

Row 080: Region Enrollment. This row contains the historical and projected enrollments for a region containing fifteen grids.

080	REGION ENROLLMENT								
080	9531	9342	9268	9127	8940	9277	8823	8373	7795
080	7320	7182	6766	6489	6175	5853	5625	5467	5127
080	4950	4950	4950	4950	4950	4950	4950	4950	4950

Row 081: Grid 1—Single Family Dwellings. The historical and projected single family dwellings for Grid 1 are entered on '1' cards.

081	GRID 1 SINGLE FAMILY DWELLINGS								
081	100	120	120	120	140	140	140	150	150
081	154	284	315	418	425	440	450	450	450
081	450	450	450	450	450	450	450	450	450

Row 082: Grid 1–Student Yield SF Dwellings. The student yield is entered on '1' cards for both historical and projected enrollment.

```
7082 GRID 1-STUDENT YIELD-SF DWELLINGS
1082     143     143     143     143     143     143     143     143     143K
1082     143     143     143     143     143     143     143     143     143K
1082     143     143     143     143     143     143     143     143     143K
```

Row 083: Grid 1–Enrollment SF Dwellings. To obtain the enrollment from single family dwellings in Grid 1, a '6' card is used to multiply the single family dwellings in Grid 1 (Row 081) times the student yield from single family dwellings in Grid 1 (Row 082).

```
7083 GRID 1-ENROLLMENT SF DWELLINGS
6083 X 081 082
                                                                     *
```

Row 084: Grid 1–Multiple Family Dwellings. This row is similar to Row 081. Replace single family dwelling with multiple family dwelling data.

Row 085: Grid 1–Student Yield MF Dwellings. This row is similar to Row 082. Replace single family yield with multiple family yield data.

Row 086: Grid 1–Enrollment MF Dwellings. To obtain the enrollment from multiple family dwellings in Grid 1, a '6' card is used to multiply the multiple family dwellings in Grid 1 (Row 084) times the student yield from multiple family dwellings in Grid 1 (Row 085).

Row 087: Grid 1–Enrollment. To obtain total enrollment in Grid 1, a '6' card is used to add single family enrollment (Row 083) to multiple family enrollment (Row 086).

```
7087 GRID 1 ENROLLMENT
6087 X 083 086
                                                                     +
```

Row 088: Grid 2–Single Family Dwellings. See Row 081 Instructions.

Row 089: Grid 2–Student Yield SF Dwellings. See Row 082 Instructions.

Row 090: Grid 2–Enrollment SF Dwellings. See Row 083 Instructions.

Row 091: Grid 2–Multiple Family Dwellings. See Row 084 Instructions.

Row 092: Grid 2–Student Yield MF Dwellings. See Row 085 Instructions.

Row 093: Grid 2–Enrollment MF Dwellings. See Row 086 Instructions.

Row 094: Grid 2—Enrollment. See Row 087 Instructions.*

Row 179: Grid 15-Single Family Dwellings. See Row 081 Instructions.

Row 180: Grid 15—Student Yield SF Dwellings. See Row 082 Instructions.

Row 181: Grid 15—Enrollment SF Dwellings. See Row 083 Instructions.

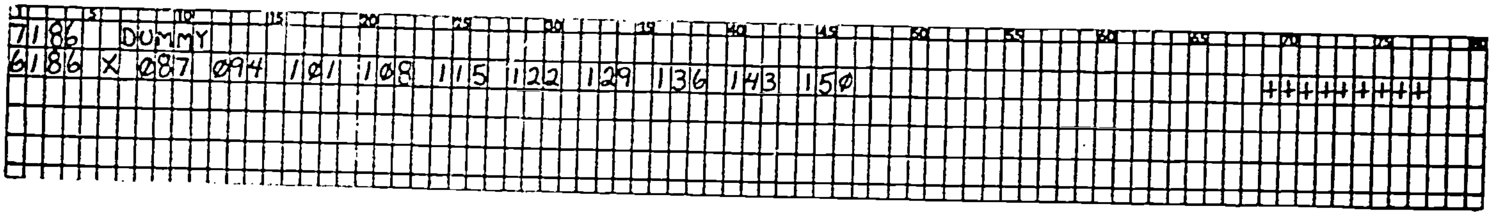
Row 182: Grid 15—Multiple Family Dwellings. See Row 084 Instructions.

Row 183: Grid 15-Student Yield MF Dwellings. See Row 085 Instructions.

Row 184: Grid 15—Enrollment MF Dwellings. See Row 086 Instructions.

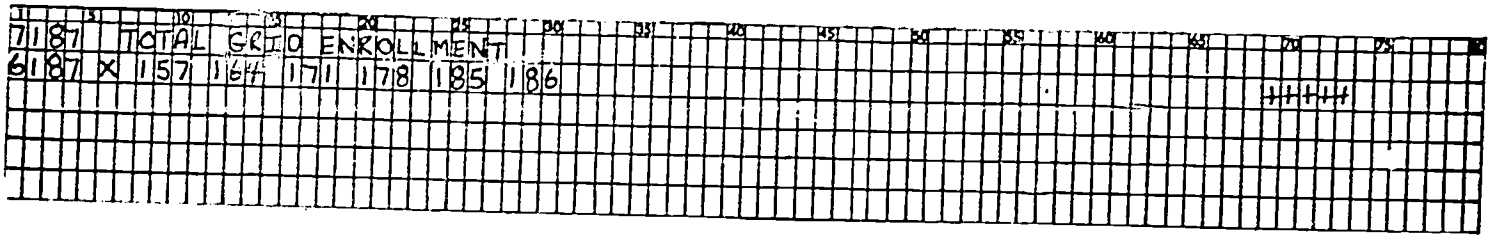
Row 185: Grid 15—Enrollment. See Row 087 Instructions.

Row 186: Dummy. This row is used to sum the enrollments of the first ten grids. It is necessary because the basic support system does not permit data from more than ten rows to be added together at one time.



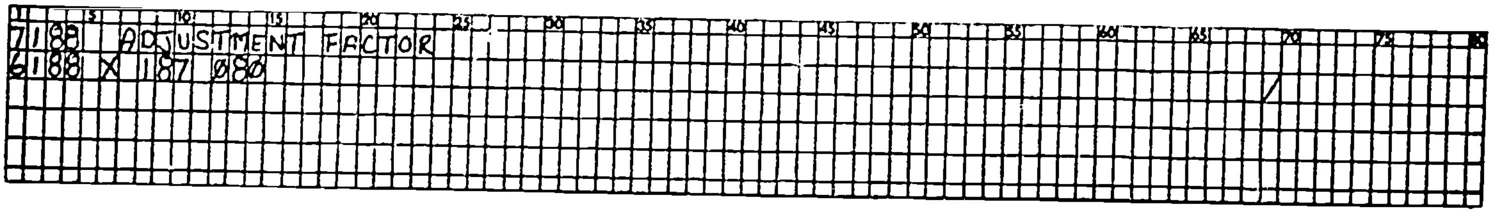
```
7186 DUMMY
6186 X 087 094 101 108 115 122 129 136 143 150                   +++++++++
```

Row 187: Total Grid Enrollment. This row is used to sum the enrollments in all fifteen grids. The first ten grids (Row 186) are added to the remaining five grid enrollments by means of a '6' card.



```
7187 TOTAL GRID ENROLLMENT
6187 X 157 164 171 178 185 186                                    +++++
```

Row 188: Adjustment Factor. To adjust the grid enrollments so they sum to the independently derived regional enrollment, an adjustment factor must be calculated. A '6' card is used to divide the total grid enrollment (Row 187) by the region enrollment (Row 080).

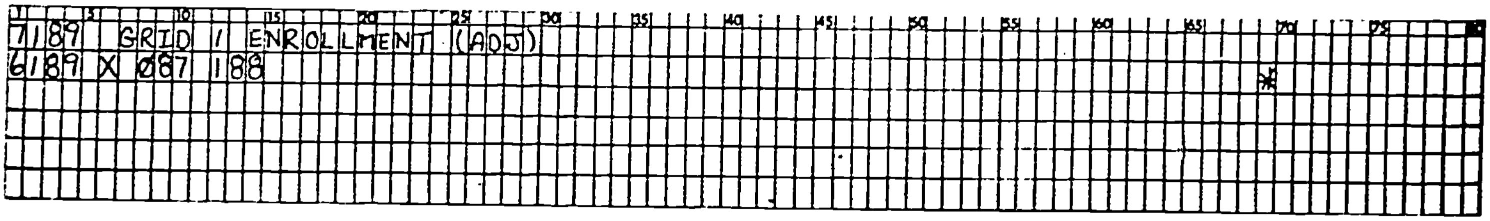


```
7188 ADJUSTMENT FACTOR
6188 X 187 080                                                    /
```

---

*Note; Not all rows are listed because of their similarity.

Row 189: Grid 1—Enrollment Adjusted. The calculated enrollment for Grid 1 (Row 087) is multiplied by the adjustment factor (Row 188).



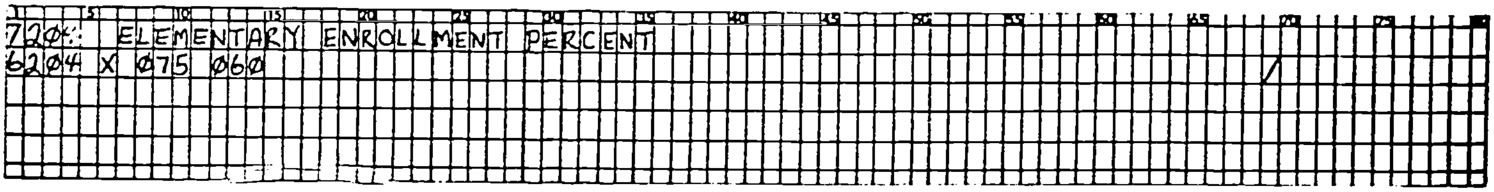
```
7189 GRID 1 ENROLLMENT (ADJ)
6189 X 087 188                                                       *
```

Row 190: Grid 2—Enrollment Adjusted. See Row 189 Instructions.*

Row 202: Grid 14—Enrollment Adjusted. See Row 189 Instructions.

Row 203: Grid 15—Enrollment Adjusted. See Row 189 Instructions.

Row 204: Elementary Enrollment Percent. This row is used to determine the percent of enrollment in the school district which will be in elementary schools. A '6' card is used to divide elementary enrollment (Row 075) by total school district enrollment (Row 060).

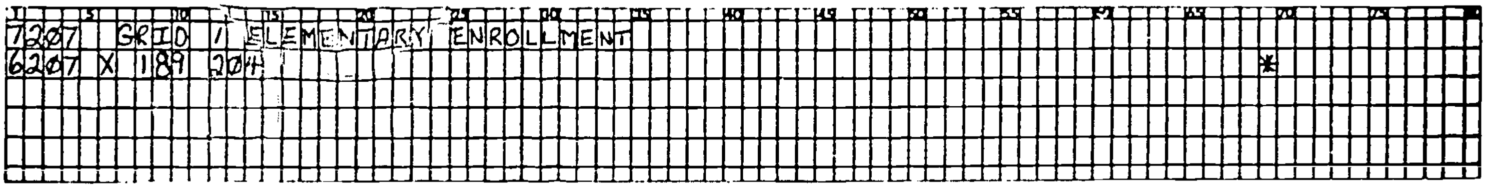


```
7204 ELEMENTARY ENROLLMENT PERCENT
6204 X 075 060                                                       /
```

Row 205: Junior High Enrollment Percent. See Row 204 Instructions.

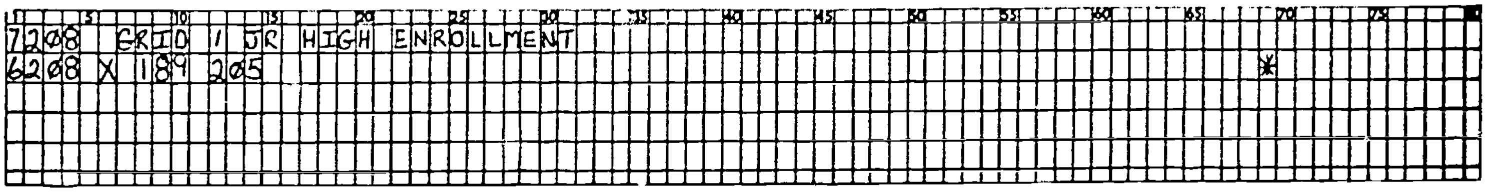
Row 206: Senior High Enrollment Percent. See Row 204 Instructions.

Row 207: Grid 1—Elementary Enrollment. This row is used to determine the enrollment in the elementary grades in Grid 1. The Grid 1 adjusted enrollment (Row 189) is multiplied by the elementary enrollment percent (Row 204).



```
7207 GRID 1 ELEMENTARY ENROLLMENT
6207 X 189 204                                                       *
```

Row 208: Grid 1—Junior High Enrollment. This row is used to determine the enrollment in the junior high grades in Grid 1. The Grid 1 adjusted enrollment (Row 189) is multiplied by the junior high enrollment percent (Row 205).



```
7208 GRID 1 JR HIGH ENROLLMENT
6208 X 189 205                                                       *
```

---

*Note: Not all rows are listed because of their similarity.

Row 209: Grid 1—Senior High Enrollment. This row is used to determine the enrollment in the senior high grades in Grid 1. The Grid 1 adjusted enrollment (Row 189) is multiplied by the senior high enrollment percent (Row 206).

```
7209  GRID 1 SR HIGH ENROLLMENT
6209 X 189 206                                                      *
```

Row 210: Grid 2—Elementary Enrollment. See Row 207 Instructions.

Row 211: Grid 2—Junior High Enrollment. See Row 208 Instructions.

Row 212: Grid 2—Senior High Enrollment. See Row 2 9 Instructions.*

Row 249: Grid 15—Elementary Enrollment. See Row 207 Instructions.

Row 250: Grid 15—Junior High Enrollment. See Row 208 Instructions.

Row 251: Grid 15—Senior High Enrollment. See Row 209 Instructions.

3.5 **Racial Composition** The expected racial composition of future enrollments may be of interest to many school systems in terms of educational needs and racial balance among schools. No unique technique has been designed to forecast non-white enrollments in this chapter. Rather, the suggested approach is to repeat previously described procedures, in each case replacing all data pertaining to enrollments with data for non-white enrollments only. The following brief discussion is intended to provide some guidance in the use of the various techniques.

3.5.1 **Cohort Survival Technique** The cohort survival technique may be used to forecast future non-white enrollment levels by substituting non-white enrollment by grade whenever enrollment data is needed in the procedures described in Section 3.2.1. If possible, birth data by race should be used in the derivation of initial grade enrollments.

In instances where the racial composition of enrollments is changing very rapidly, the cohort survival rates are apt to vary considerably from one (1.0).These rates may also exhibit a large degree of fluctuation over time as the racial composition changes. This possibility renders the cohort survival technique less appropriate since the method itself assumes stable rates of change. Extreme caution should be used when employing this method.

3.5.2 **Time Trend Projections** The procedures described in Section 3.2.2 for extrapolating past trends may be appropriate to use in projecting non-white enrollment levels. The only required data is historical non-white enrollment information Again, if a dramatic change has been occurring in racial composition, the use of this technique will involve a high degree of uncertainty, especially if a linear or straight line curve is used to represent future trends. A nonlinear pattern is more likely to yield acceptable results. In specifying the upper or lower limit for the non-white enrollment level, the user should examine the limit which was specified for total enrollments. An estimate of the percentage of this eventual total enrollment limit thought to be non-white could then be used to derive the limiting value to apply when forecasting non-white enrollments. It should be cautioned, however, that in some districts, while total enrollments may be decreasing, non-white enrollment may be on the rise. Extreme care should be exercised when selecting an appropriate curve.

---

*Note: Not all rows are listed because of their similarity.

3.5.3 Ratio Method

The ratio method may also be used to forecast non-white enrollments. The enrollment data used should pertain to non-white students only. A stronger relationship might exist between non-white enrollments in the local school system and the level of non-white population or enrollment for the county, SMSA, or state, than between local non-white enrollment and total population or enrollment for the larger area. If forecasts of non-white population or enrollments are available for the larger area, they should be used as the appropriate measure of future area-wide trends.

3.5.4 Dwelling Unit Multiplier Technique

When this technique is used to forecast non-white enrollments, non-white student yields should replace total enrollment yields. The dwelling unit inventory and subsequent forecasts of this variable would be similar to those used in the generation of forecasts of total enrollment levels.

If the racial composition in the school system has been changing rapidly, caution should be used in the extrapolation of yield factors for non-white enrollments. If these yields have increased or decreased significantly in the past, then an extrapolation of this trend may result in unrealistically high or low forecast values.

3.5.5 Enrollment Forecasts by Grade

Forecasts of non-white enrollments in each grade may be generated in exactly the same manner as that presented earlier. The enrollment data would, however, encompass only non-white students.

3.5.6 Geographic Distribution of Non-White Enrollments

Perhaps the most important planning aspect of future non-white enrollments is their geographic distribution. This may be estimated by following the procedures exactly as presented in Section 3.4 of this chapter, using non-white rather than total enrollment data. The region or area boundary definitions should be identical to those used in predicting the distribution of total enrollments. The total enrollment estimates for each region or area may be used as a check on the validity of similar estimates generated for non-white students.

In summary it is quite possible to use the procedures described in previous sections of this chapter to derive forecasts of non-white enrollments, thereby drawing inferences regarding the likely racial composition of students in the school system. Caution should be used because the variance in non-white enrollments may be greater than that of total enrollments, thus adding to the degree of uncertainty associated with these forecasts.

3.6 Uncertainty

In the preceding sections, techniques were presented for projecting total enrollment levels, enrollments in each grade, and the geographic distribution and racial composition of future public school students. Each of these projections will be characterized by uncertainty, the nature and extent of which will vary from one technique to the next, and from one school district to another. The objective of this section is to examine approaches for considering this uncertainty. The concept of confidence intervals introduced in Chapter 1 is further examined as a means of measuring the uncertainty associated with a particular enrollment forecast. Beyond this a set of factors is identified which might cause actual enrollment levels to diverge from forecast levels. Procedures for adjusting the forecast values in light of expectations regarding these specific factors are suggested as a means of reducing uncertainty.

3.6.1 The Measurement of Uncertainty

Confidence intervals or bands may be used to measure the uncertainty associated with a particular enrollment forecast. A confidence interval shows the range of values which might be expected to occur for a specified confidence level. Suppose, for example, that the confidence band illustrated in Figure 3-9, was estimated for a confidence level of 0.95. The user would be ninety-five percent certain that the enrollments in each year would fall within the range bracketed by the upper and lower limits shown as Lines A and B respectively.

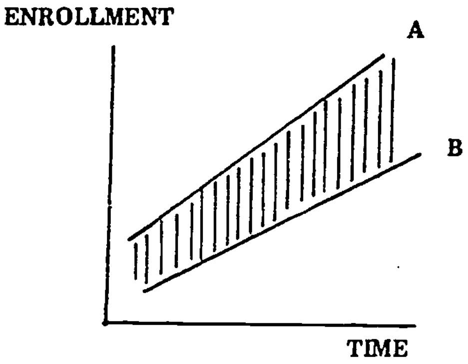
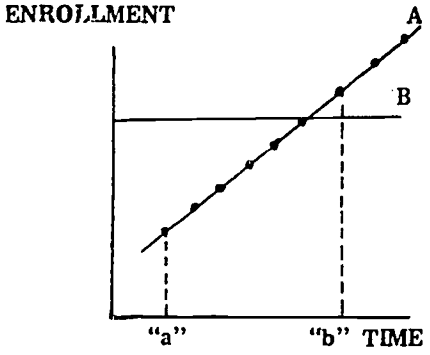


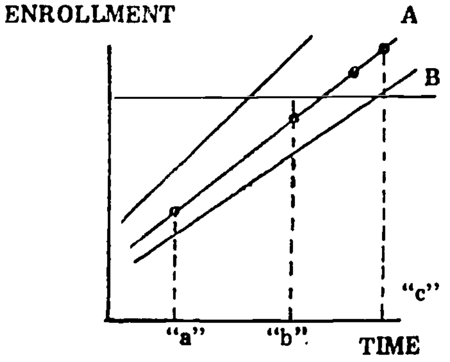
FIGURE 3—9 SAMPLE CONFIDENCE INTERVAL

Reliable estimates of such confidence intervals might be used to assist the user in the decision-making process. For example, suppose that the estimated enrollments in each year of the planning period appeared as Line A in Figure 3-10 and that the student capacity was represented by Line B. This figure indicates that enrollments would be expected to exceed capacity in the sixth year of the planning period. However, because of the uncertainty involved in the forecast, this shortage of space might well be encountered at an earlier or later date. A confidence interval may be estimated for this forecast, as illustrated in Figure 3-11. This interval would indicate that there was a possibility within a ninety-five percent confidence level that this shortage could occur as early as the fourth year of the planning period, and the user could be more than ninety-five percent sure that the shortage would exist by at least the ninth year of the planning period. The sixth year would still represent the most probable estimate of the shortage; however, the introduction of confidence intervals would provide added insight into the flexibility which might be desirable in the future facility plan and into the risks associated with various alternatives.



"a" REPRESENTS THE CURRENT YEAR, AND "b" THE 6th YEAR OF THE PLANNING HORIZON.

FIGURE 3—10 ENROLLMENT FORECAST AND SCHOOL CAPACITY



"a" REPRESENTS THE CURRENT YEAR, AND "b" AND "c" REPRESENTS THE 4th AND THE 9th YEAR OF THE PLANNING HORIZON RESPECTIVELY.

FIGURE 3—11 ENROLLMENT FORECAST WITH CONFIDENCE INTERVAL

As noted in Chapter 1, several distinct approaches could be used in estimating confidence intervals for enrollment forecasts. The statistical approach would involve estimating confidence intervals based on variation in the historical data used to derive the forecast itself. The calculations using this approach would, in most cases, be both complex and laborious, and the potential additional insight gained would probably not be sufficient to offset the additional required effort. A more fundamental objection stems from the fact that these confidence intervals would be based almost entirely on historical data and would not facilitate the incorporation of expected future conditions in the school system. For these reasons, specific procedures are not presented for the calculation of confidence intervals using this approach.

The alternative subjective approach that is recommended is based upon user-specified potential high and low values for certain inputs to the basic forecasting techniques already described. These procedures are repeated, using first the high estimates and then the low estimates. The resulting forecasts represent the likely upper and lower limits for future enrollment trends. While statistically less rigorous, this approach may have more intuitive appeal and is likely to make better use of first-hand knowledge concerning the unique characteristics of the school district.

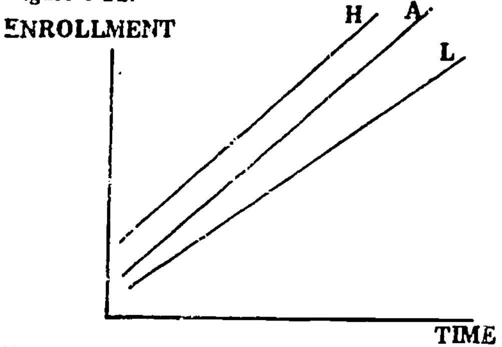
The most difficult aspect of this subjective approach is the specification of high and low values for the various inputs. For this reason several values for high and low specifications may be used to determine a series of confidence intervals. While the validity of the high and low estimates will be difficult to test, the assumptions upon which subsequent forecasts are based will be available for scrutiny. The impact on the confidence band resulting from changes to these high and low specifications will itself be of interest. If the impact of two different sets of likely high and low values can be shown to be very slight, for example, then the need for extensive debate concerning the precise specification of high and low values will have been eliminated.

The estimation of confidence intervals using the subjective approach for each of the enrollment forecasting techniques outlined in Section 3.2 is briefly described below.

3.6.1.1 Cohort Survival Technique

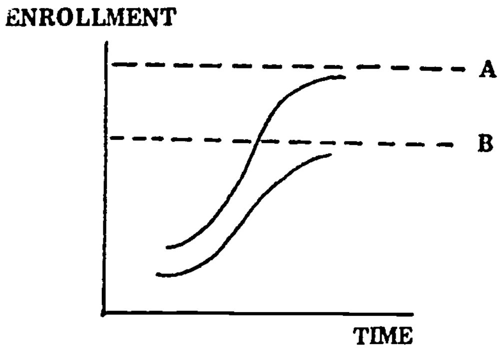
This technique involves the computation of a series of survival rates using past enrollment data. These past rates are averaged or extrapolated and applied to current enrollments to derive forecasts of future enrollment levels for each grade. The initial grade enrollment is estimated on the basis of births five or six years previously. The projected grade-survival rates and the projected birth-survival rates may, of course, over- or underestimate the actual rates which will prevail during the planning period. On the basis of variations in the previous values for these rates and the user's perception of future trends, a high and low value for each may be specified. For example, if the average survival rate for students progressing from the sixth to the seventh grade was equal to 1.05, the most probable forecast would be derived using this value. If the user believed that each of the survival rates could conceivably be ten percent higher or lower, the high and low survival rates would be specified as 1.155 (i.e., 1.05 x 1.10) and .945 (i.e., 1.05 x 0.90) respectively. These values would represent the user's best perception as to the reasonable maximum and minimum values which the survival rates could take. In other words, it would be thought quite unlikely that future values for this survival rate would be greater than 1.155 or less than 0.945.

The procedures of the cohort survival technique should be repeated twice, first using likely maximum survival rates and then likely minimum survival rates. The resulting two additional sets of forecasts will represent a confidence band for future enrollments as illustrated in Figure 3-12.



A REPRESENTS THE MOST PROBABLE ESTIMATE, AND H AND L THE LIKELY HIGH AND LOW ESTIMATES RESPECTIVELY.

FIGURE 3—12 CONFIDENCE INTERVALS--COHORT SURVIVAL

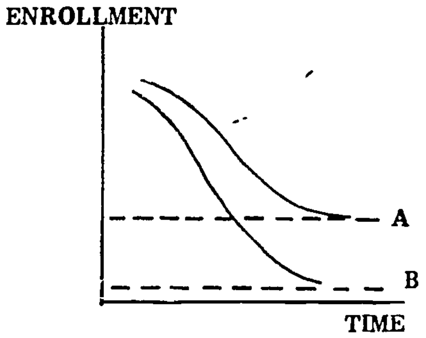


A AND B REPRESENT THE LIKELY HIGH AND LOW VALUES FOR THE MAXIMUM ENROLLMENT LEVEL.

FIGURE 3–13 CONFIDENCE INTERVALS–LOGISTICS GROWTH CURVE

3.6.1.2 Time Trend Projections

Confidence intervals for logistics and Gompertz curves may be derived by specifying high and low estimates of the eventual maximum or minimum enrollment level. This curve would then be estimated, using first the high and then the likely low values for this maximum. The resulting sets of forecasts would represent the limits for the confidence band for future enrollments. Typical confidence bands thus derived are illustrated in Figure 3-13 and Figure 3-14.



A AND B REPRESENT THE LIKELY HIGH AND LOW VALUES FOR THE MINIMUM ENROLLMENT LEVEL RESPECTIVELY.

FIGURE 3–14 CONFIDENCE INTERVALS–LOGISTICS DECLINE CURVE

These likely high and low values may be estimated by making different assumptions regarding future densities, zoning patterns, birth rates, and other factors influencing development. An analagous procedure is not available for linear or exponential curves.

3.6.1.3 Ratio Method

Confidence intervals may be derived for enrollment estimates using the ratio method by making assumptions about the potential high and low value for the larger area population or enrollment forecasts, and/or the ratio itself. High and low estimates for the larger area may already be available. If not, the user is encouraged to experiment with several sets of such values that seem reasonable. Initial high and low specifications for the ratio will be more difficult to determine since this ratio is not linked to any single measure of local or regional conditions. The procedures of the ratio method may be reiterated, using these high and low estimates for future large area forecasts and for the ratios. The resulting forecasts will represent the limits of the confidence band.

3.6.1.4 Dwelling Unit Multiplier Technique

Confidence intervals for enrollment estimates using the dwelling unit multiplier method may be generated by specifying high and low assumed values for the eventual maximum number of dwelling units as well as the projected student yields. The high and low estimates for the number of dwellings of each type may be obtained by considering the impact of alternative local economic conditions, and local government development policies. Likely maximum and minimum values for the yield factors may be estimated by using different assumptions about the future age distribution of the population and/or birth rates. The set of high estimates can be used to derive the upper boundary of the confidence band, and the set of low estimates used to generate the lower limit by reiterating the forecasting procedures.

The most difficult task in the estimation of confidence intervals using this approach will be specifying realistic and appropriate high and low values. All available previous data should be carefully examined. In addition assistance might be sought from sources such as a local or regional department of planning or bureau of vital statistics.

The validity of these confidence intervals will be dependent upon the quality of the high and low values used. The use of a subjective approach in determining these values presents an opportunity for the integration of sound professional judgement with explicit statistical forecasting procedures.

3.6.2 Forecast Adjustments

It may be possible to further reduce forecasting uncertainty by examining several contingent trends in factors not explicitly dealt with in the projection techniques. Each of the previously discussed enrollment forecasting techniques is based upon a specific set of assumptions. The procedures themselves merely translate past data into forecast values on the basis of these assumptions. Certain events which may not be accounted for in the mechanics of the forecasting technique will significantly impact future enrollment patterns. A list of such phenomena is presented below. This list should be carefully examined to determine which, if any, of the potential situations might be of importance in a particular school district. In those instances where the events have not been adequately incorporated into the technique used to derive the initial enrollment forecasts, an adjustment should be made. For example, suppose that a relatively large trailer court was expected to be developed at some point in the future. If no significant trailer court development activity had occurred in the past, then none of the forecasting techniques would be expected to pick up the discrete increase in enrollments which might result. The number of additional public school students attributable to this future complex should, therefore, be independently estimated. The previously developed enrollment forecast would then be adjusted by adding the estimated trailer court enrollments to it.

This adjustment process may be performed at any level of detail as long as it is possible to identify the additional students by geographic location, age, race, or any combination thereof.

It should be emphasized that enrollment adjustments for a particular phenomenon or unique event should be made only if it was clearly not considered by the previously used forecasting technique. Careful thought must be given to precisely which phenomena have and have not been addressed. If the user believes that the future trend in one or more of the factors considered in the original forecasting technique will significantly differ from the historical trend, an adjustment to the initial forecast may be appropriate. For example, suppose that the trend in public versus private school preferences among families residing within the district resembled the curve shown in Figure 3-15.

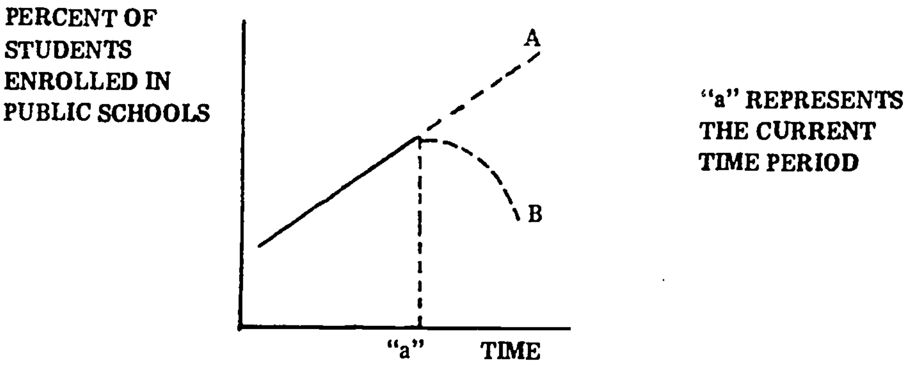


FIGURE 3—15 ADJUSTMENTS DUE TO CHANGE IN TRENDS

If this trend was expected to continue as illustrated by dotted Line A, then explicit consideration need not be given to this factor as its effect on public school enrollments would be implicitly incorporated into each of the forecasting techniques. If, on the other hand, this trend was expected to shift dramatically so that the pattern resembled dotted Line B, an adjustment would be necessary. Thus, whenever an abrupt change in the trend of any factor influencing public school enrollments is expected, the magnitude of this change should be evaluated and an adjustment to the basic forecast considered.

A second type of potential change that might not be incorporated into the forecasting techniques would be a unique, discrete alteration in some factor influencing public school enrollments. For example, suppose that the past trend exhibited in public versus private school preferences appeared as in Figure 3-16. Again, if the trend was expected to continue relatively unaltered, as shown by dotted Line A, no adjustment would be necessary. If, however, the user, possibly through personal contact with local private school officials, expected a major discrete change in this preference, then the future pattern might appear as Line B. This phenomenon could occur as the result of the closing of one or more private or parochial schools. An adjustment to the public school enrollment forecasts would then be called for in each year of the planning period, beginning with the year in which the discrete change was expected.

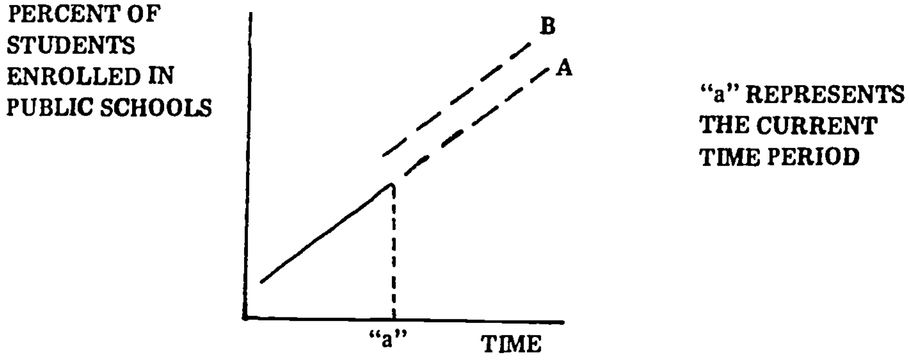


FIGURE 3–16 ADJUSTMENTS DUE TO UNIQUE EVENTS

The following list briefly describes some of the changes which may warrant forecast adjustments. Additional considerations are presented in Chapter 8.

Public versus private school preferences. A change in private school demand may be brought about by a shift in the religious composition of the population or may result from a change in the availability of nearby private or parochial schools. A review of private school trends should focus on the entire region, as private and parochial school trends in surrounding school districts may impact the local public school system enrollments. Particular attention should be devoted to the possibility of major private school closings or openings.

Residential development. An adjustment might be appropriate if a very large subdivision or apartment complex was scheduled for construction or demolition at some point over the planning period. Similarly a significant change in the number of families residing in trailers or mobile homes could also rapidly alter future public school enrollments. In all cases these proposed complexes should represent a distinct departure from existing trends. Where the proposed development appeared to be a continuation of existing patterns, it might already be accounted for in the basic forecasting technique.

Birth trends. The abrupt alteration of birth rates which occurred in the 1960's significantly affected enrollments in many school districts. Birth rate forecasts should be reviewed at the national, state, or local level to examine recent and expected local birth trends.

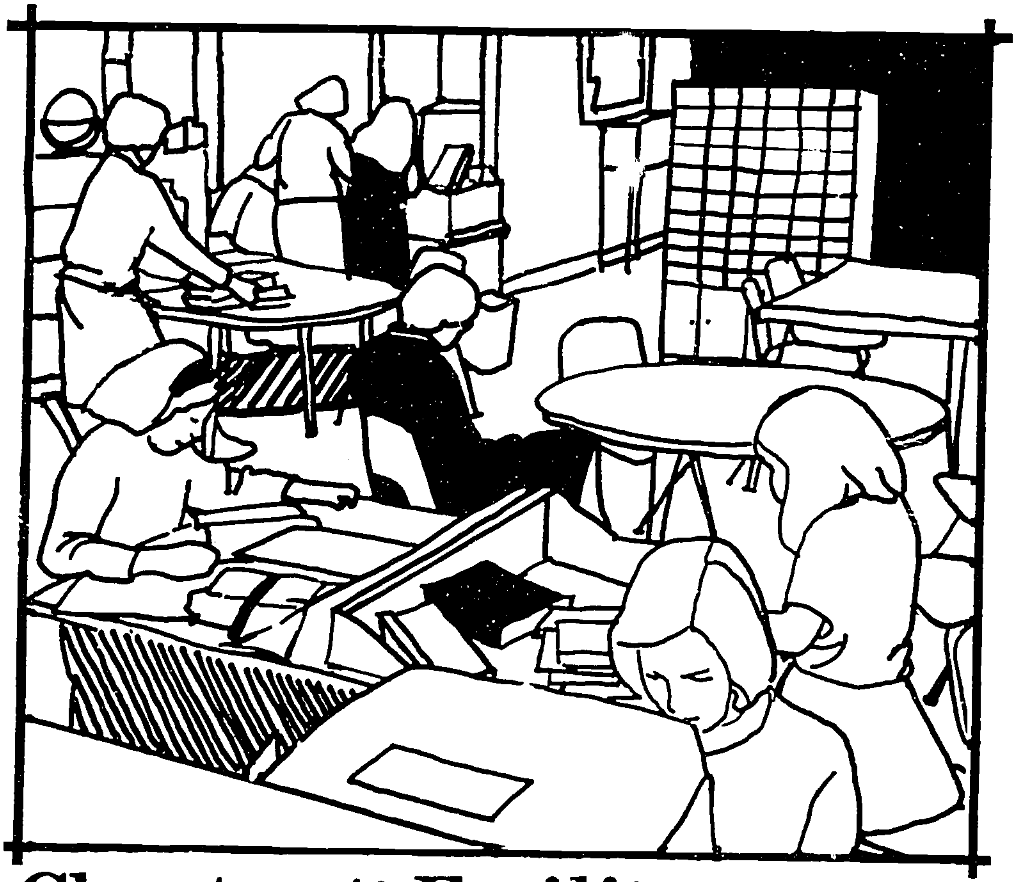
Migration trends. Fundamental causes of inter- and intra-regional migration should be reviewed in an effort to detect the possibility of a distinct shift in migration trends. An abrupt change in the regional economy could influence migration into or out of the metropolitan area. A major road, utility extention, or commercial development could influence migration from one school district to another within a metropolitan area. Indications regarding the likelihood of a disruption in historical migration patterns may necessitate an enrollment adjustment.

Age distribution. The age distribution of families residing within the boundaries of the local public school system will significantly affect enrollment levels. In many neighborhoods, families tend to remain at the same residence after their children have gone through the school system. As these families reach retirement age, they are more likely to leave the district, vacating homes which may be reoccupied by younger families with school age children. In cases such as new suburban communities where a large number of persons moved into the district during the same time period, many are also likely to move at roughly the same time. A dramatic and rapid change in the average age of the school district's population and hence enrollments could occur. Where this 'cycling' effect is expected, an adjustment of future enrollment estimates may be necessary. A careful examination of any available data reflecting the age of residents within the school system will assist in identifying the potential for such rapid neighborhood turn-over and the likely magnitude of its consequences.

Annexation/Mergers. The annexation of additional land by the school system will, of course, affect future enrollment. Since this one-time event would not be included in any historical data, its potential effect on enrollments must be independently estimated and added to the basic forecasts which have been derived. Also, when several school systems are combined into one, enrollment forecasts for each of the school systems would need to be calculated separately, and then added together.

Institutional changes. A major change in the disposition of a military base or other federal installation may occur very suddenly, often with significant impact on the surrounding community. The closing or opening of a major industrial plant, university, or other large scale employment center would have a similar effect. Knowledge of this kind of major community impact will necessitate adjusting the enrollment forecasts.

The above list is not inclusive, but is intended to suggest the types of phenomena which should be considered, and if relevant, adjusted for in the enrollment forecasts. Where it is believed probable that a major shift in trends or a unique event has not been accounted for by the forecasting technique, the user should attempt to estimate the magnitude of shifts and adjust the initial forecast accordingly. If used with discretion, this adjustment should increase the validity of the enrollment forecasts. Blind adherence to a set of forecast values simply because they have been statistically derived should be avoided. An initial forecast developed with any of the above techniques should be viewed as a base line from which to deviate when warranted by the user's judgement and knowledge of the school district. The accuracy and validity of the enrollment forecasting techniques will, in the final analysis, depend largely on the skill and diligence with which they are applied.



Chapter 4: Facility Component

The objective of this component is to examine the impact of expected enrollment levels on future facility needs. These expected facility requirements are then compared to the school district's existing facilities in order to identify any potential future shortage or surplus of educational space.

4.1 Overview

The Facility Component establishes the link between future enrollment forecasts and the development of capital planning strategies. Enrollment forecasts have been generated by the previous component or have been derived independently. The procedures in this component will assist in the translation of enrollment forecasts into estimates of the number of teaching stations or the amount of square footage necessary to accommodate these expected enrollments. Comparison of the projected space requirements with existing or planned school buildings will indicate the dimensions of the planning problem. With this information alternative strategies may be formulated for resolving any serious excess or deficit space situations. The Fiscal Component described in the next chapter translates the needs and strategies into financial terms. Once planning strategies are identified, they may be "tested" by entering the district's proposed standards, policies, and/or structural modifications into the appropriate parts of the System and examining the facility, fiscal, and geographic implications.

The estimated number of teaching stations or the amount of square footage implied by a given enrollment projection is highly dependent upon the educational programs and policies unique to each school district. This uniqueness is incorporated into the Facility Component by allowing the user to specify values for all critical standards and policies which impact future facility demand.

Considerable flexibility is permitted throughout the component. The procedures may be executed on a district-wide basis, an individual school basis, or on a subject area or educational space type basis, depending on the needs of the user.

The user is encouraged to repeat the component procedures in order to examine the impact of modified standards and policies. The use of several enrollment forecasts will also enable greater understanding regarding the extent to which future facility needs are sensitive to alternative community trends.

The balance of this chapter briefly outlines the technique used in the translation of enrollment forecasts into facility needs and examines the assumptions underlying this technique. This is followed by step-by-step procedures for preparing the necessary input forms for entry into the System.

4.2 General Design

The technique employed in this component translates expected student enrollments into required teaching stations or rooms. The room requirement is then compared to the number of available rooms to determine the expected shortage or surplus of educational space. This shortage or surplus may then be translated into square footage. The System can be redefined so that all measurements of space are made directly in square feet, rather than teaching stations. This approach is presented in Appendix E.

Analysis is made for separate subject areas which may be defined by the user as broadly or as narrowly as desired. For example, all courses may be grouped into one subject area, or each course may be designated a subject area and examined separately. In general, all courses that have the same type of space requirements (e.g., regular rooms, large rooms, laboratories, etc.) may be grouped into one subject area. The technique used to translate expected student enrollments into the needed number of teaching stations is summarized by the following mathematical formula:

$$TS = \frac{N \times W}{A \times P \times U}$$

The variables used in this expression are defined as follows:

TS — the number of teaching stations required to house the expected student enrollment in a subject area
N — the total subject area enrollment
W — the average number of periods per course in this subject area each student attends in a typical week
A — the average number of pupils per class
P — the number of periods per week that school is in session
U — the desired maximum utilization factor (i.e., the average percent of educational space which is occupied at any given time in a typical school day)

This formula represents a modification of techniques developed by Professors Marion Conrad and Basil Castaldi. Users will note that it is also a slight modification of the formulation presented in the manual version of the School Facility Planning System. The number of students enrolled in a specific study area (N) times the average number of periods the courses in this subject area meet per week (W) is the numerator of the equation. It is the number of student periods per week. To convert this factor into the required number of teaching stations, N x W is divided by A x P x U. Dividing the student periods by the average class size (A) reduces student periods per week to the number of class periods per week required to accommodate the expected subject area enrollment. Dividing the number of class periods per week by the periods per week (P) that school is in session estimates the number of rooms or teaching stations necessary to house these classes. This estimate of required rooms is based on the assumption that class scheduling can be arranged so that all educational space is occupied in each period throughout the week. In practice such scheduling is not always possible or desirable. A utilization factor (U) is incorporated into the equation to maintain a level of flexibility. Theoretically, this rate may range from zero to one. Depending on the grade level organization or the unique features of a particular school, the utilization factor will probably vary from .80 to .95. Dividing the estimate of required rooms by a utilization factor of less than one increases the number of rooms needed, thereby enabling space flexibility within the school system. The equation can be illustrated with an example as follows:

$$TS = \frac{N \times W}{AxPxU}$$

$N \times W$ = student periods per week in a given subject area

$1500 \times 4.5 = 6750$

$$\frac{N \times W}{A} = \text{class periods per week}$$

$$\frac{6750}{25} = 270$$

$$\frac{N \times W}{A \times P} = \text{estimated teaching stations per week}$$

$$\frac{270}{30} = 9$$

$$\frac{N \times W}{AxPxU} = \text{number of required teaching stations}$$

$$\frac{9}{.95} = \text{9.5 or 10 (rounded)}$$

A change in the values of any of the variables in the equation will significantly impact the resulting number of required teaching stations. Each change will affect the district's educational program since each variable is based on a district policy or standard. The user is encouraged to experiment with alternative values but should keep in mind the impact that such changes may have on the educational program.

The available teaching stations that are considered adequate must then be subtracted from the required number of teaching stations. The magnitude and direction of this difference will aid the district in analyzing its ability to accommodate expected future enrollments while maintaining acceptable standards and policies. The shortage or excess of the number of teaching stations may be multiplied by a square footage average supplied by the user. This option is available for those districts who desire an estimate of the total area in surplus or deficit.

The equation is structured so that need may be calculated on a number of different levels of detail. The level of analysis should be varied according to the needs and resources of the school district. Space requirements can be calculated on the basis of the entire school district; for all elementary, junior high, and senior high grades; or for each school within the district. The use of the estimates should, of course, be kept in mind in selecting the focus of analysis. Since the Component is intended to identify the nature and magnitude of future facility needs, the level of analysis and the selection of subject areas should generally be confined to those which reflect actual physical differences in educational space requirements. Six potential subject areas have been established in the elementary school section of the Facility Component. Twenty such areas have been set up in the junior high and in the senior high sections of the Component. These subject areas are optional. As many or as few subject areas may be used as needed.

Some districts may want to calculate the required number of teachers necessary to serve the projected enrollment. This is especially important if this figure is to be used in forecasting future district operating expenses in the Fiscal Component. The approach taken in the computer version of the School Facility Planning System is to divide the number of class periods per week needed to accommodate the expected enrollment by the average number of periods a teacher is available to teach in a week. Required teachers are calculated for each level of analysis studied in the Facility Component. The need of each level or subject area is then summed to obtain a district total.

4.3 FACILITY COMPONENT PROCEDURES

The procedures necessary to determine the space requirements for one or more subject areas are outlined below with references to each variable currently in the computer-based System.

The user will recall from Appendix A that each variable requires a unique row, assigned by a '7' card; that historical or independently derived data may be entered for a variable, using a '1' card; and that mathematical or statistical operations can be performed on that data, using a '6' card. The specifications for completing these input cards are contained in Appendix A as are the additional cards necessary to modify the System's report format and projection time period. Familiarity with these latter cards may not be necessary for those users satisfied with the current version of the System.

Before initiating the basic data collection and input card preparation, some preliminary decisions must be made regarding the time frame, focus, and measures of capacity to be used in the procedures.

1. Planning Period. The first of these considerations is the selection of an appropriate time horizon. Capital planning is essentially a long-range activity. However, any analysis of future conditions will become increasingly uncertain as later years are examined. Those school districts that have conducted the Enrollment Component will have already evaluated the trade-offs between the need for an adequately long planning period and the increasing level of uncertainty. Those that have not yet established a time horizon must attempt to arrive at some reasonable balance between these two conflicting considerations. The current procedures allow projections up to and including 1991. Any users desiring a longer or shorter time frame may want to modify the 'X' card, as described in Appendix A.

2. School and Subject Focus. A second, closely related issue is that of the appropriate level of detail at which to conduct the analysis. The longer the planning horizon is extended, the less reliable will be the detailed analysis. Individual course enrollments are likely to vary considerably in response to long-term social, legal, and economic trends. Therefore, in very long-range planning situations, many districts will want to focus on district-wide requirements. Where a shorter time frame is used, individual school and course enrollment forecasts may be more useful. Experimentation with different levels of analysis is encouraged.

   The computer-based version may be conducted on a district-wide or individual school basis. As currently organized, up to six different subject areas may be identified for elementary school analysis, and twenty different subject areas for middle-junior and senior high school.

3. Measure of Space. A third consideration is that of the appropriate definitions for teaching stations and square footage. The district should use those definitions with which it is most familiar. The current

computer-based version is oriented to those districts willing to define space in terms of different kinds of rooms or teaching stations, and then translate the required teaching stations into square footage, based on an average room or teaching station size. Those users desiring to calculate need strictly in terms of square feet per pupil will have to modify the program as listed in Appendix E. In all cases the definitions should be written and agreed upon by all members involved in the study.

4. Elementary School Space Analysis. As currently defined, forty-six potential variables have been identified for purposes of analyzing the need for elementary school space. The steps for preparing the input cards necessary to conduct the analysis are reviewed below on a row-by-row basis.

Row 001: Year. This row identifies the years for which historical data is to be entered and the years for which data will be projected. When, as in the current version of the System, the Facility and Enrollment Components are used together, this row will have already been prepared. It should be remembered that all data entered for subsequent rows should correspond by columns to the years in this row. If historical data is not available for a given year, zeroes should be entered in the appropriate columns.

Row 300: Elementary Enrollment. The historical and projected enrollment for the school or district being analyzed is entered in this row. This data is obtained from the Enrollment Component or an independent projection. These figures will be used to determine subject area loadings for future years. The '7' card labels the row and the '1' cards are used to input the data. In situations where the Enrollment and Facility Component are being run together, this row could be eliminated. In the example, the '6' card for Row 301 would then refer to Row 032 or 075, whichever was considered the best forecast.

```
7300      ELEMENTARY ENROLLMENT
1300      3687      3767      4243      4577      4802      4902      5192      5306      5322
1300      5441      5616      5686      5721      5784      5768      5833      5683      5511
1300      5388      5315      5278      5203      5121      5036      4968      4900      4846
```

Row 301: Elementary Subject Enrollment. Historical data for total subject enrollments is entered for all the subject areas under consideration. This row is optional, as are the equivalent rows for junior high school (Row 394) and senior high school (Row 541). Its purpose is to help ensure that subject-area forecasts are not distorted by the total enrollment forecasts, especially if a substantial percentage of the students are, in effect, part-time students because of work-study or similar programs. If the variable is not used, subject area enrollment projections should be made directly as a function of total enrollment forecasts.

Note that the total subject area enrollments will be larger than the school enrollment by a factor roughly equivalent to the number of periods each day. Thus, if all 800 students in a junior high school attended classes six periods per day, the total subject area enrollment would be 4,800. The method specified in the example is a simple linear regression against elementary enrollment. The description of the '6' card in Appendix A should be reviewed for other possible projection methods.

```
7301      ELEMENTARY SUBJECT ENROLLMENT
1301     16045     19845     21215     22885     24610     24510     25960     26530     26610
1301     27205
6301 3    300
```

Row 302: Subject Area-1 Enrollment. Up to six distinct subject area categories can be analyzed on the elementary level. A subject area can consist of any combination of courses providing that similar space requirements and student per class standards apply. For example, if Course A had 400 students, Course B had 300 students, and Course C had 50 students, and all were lumped into Subject Area-1, then the current Subject Area-1 enrollment would be 750. In the elementary school situation many users may be satisfied to group all courses together, in which case Subject Area-1 will be the same as the previous row. However, if it is desired that music and art, for example, be separated from other school activity because of their different space requirements, more than one subject area category will be necessary.

The future subject area enrollments must be projected. In the example, simple regression on Elementary Subject Enrollment is suggested. Other users may want to make the projection as a ratio of elementary subject enrollment based on historical patterns and knowledge or judgement regarding future subject area participation. Alternative approaches for projecting subject area enrollment are discussed in Appendix E.

```
7302  SUBJECT AREA 1 ENROLLMENT
1302     9345    10536    10547    11326    11843    12464    12958    13743    14671
1302    15016
6302 3 301
```

Row 303: Subject Area-2 Enrollment. See Row 302 Instructions.

Row 304: Subject Area-3 Enrollment. See Row 302 Instructions.

Row 305: Subject Area-4 Enrollment. See Row 302 Instructions.

Row 306: Subject Area-5 Enrollment. See Row 302 Instructions.

Row 307: Subject Area-6 Enrollment. See Row 302 Instructions.

Row 308: Sum of Rows 302-307. This row is necessary only if the elementary subject enrollment has been broken into a number of subject areas. Historical data will be the same as that in Row 301. In the example only four of the six possible subject areas have been used.

```
7308  SUM OF ROWS 302-307
6308 X 302 303 304 305                                         +++
```

Row 310: Subject Area-1 Enrollment (ADJ). Since each subject area enrollment is projected independently, the sum of the enrollments may not equal the total projected subject enrollment. The adjustment necessary to achieve this equality is made by dividing the subject area enrollment by the sum of the subject area enrollments. The product is then multiplied times the elementary subject enrollment.

```
7310  SUBJECT AREA-1 ENROLLMENT (ADJ)
6310 X 302 308 301                                             /*
```

Row 311: Subject Area-2 Enrollment (ADJ). See Row 310 Instructions.

Row 312: Subject Area-3 Enrollment (ADJ). See Row 310 Instructions.

Row 313: Subject Area-4 Enrollment (ADJ). See Row 310 Instructions.

Row 314: Subject Area-5 Enrollment (ADJ). See Row 310 Instructions.

Row 315: Subject Area-6 Enrollment (ADJ). See Row 310 Instructions.

Row 320: Subject Area-1 Class Periods per Week. This variable is calculated by multiplying the adjusted subject area enrollment times a factor supplied by the user. This factor is the average number of periods per course per week, in the subject area, divided by the average class size, or $\frac{W}{A}$. See Section 4.2 for a more detailed discussion of these variables. This quotient should be carried to at least three decimal places.

This factor will change whenever an alternative average class size or average number of periods per course per week is considered. For example, if the average number of periods per course per week is five for a subject area entitled academic, and the average class size is twenty-five, then the factor will be 5 ÷ 25 = .200. If the user wanted to consider the impact of reducing the class size to twenty, the factor would be changed to 5 ÷ 20 = .250. If the introduction of new electives meeting only two or three times per week caused the average number of course periods each week in the subject area to drop, the factor might be changed to 4.5 ÷ 25 = .180.

```
7320  SUBJECT AREA-1 CLASS PERIODS PER WK
6320 X 310 *   333L
```

Row 321: Subject Area-1 Required Rooms. This variable is calculated by dividing class periods per week by a factor supplied by the user. This factor is equal to the number of periods per week school is in session times the utilization factor, or P x U. See Section 4.2 for a more detailed discussion of these variables.

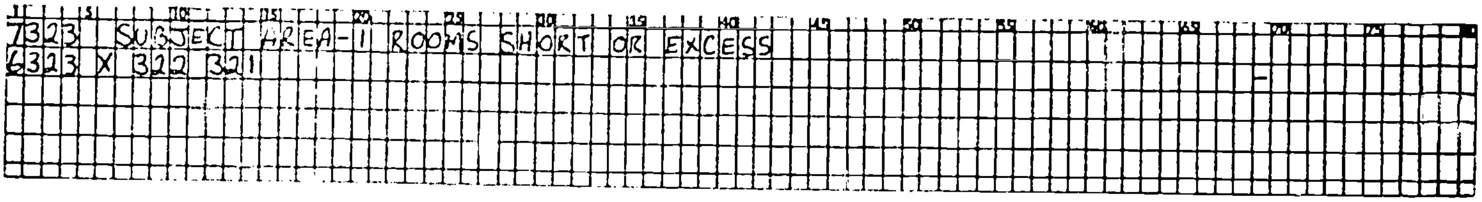
This factor will change whenever an alternative number of periods per day or days per week is considered, and when an alternative utilization rate is considered. For example, if the district meets thirty periods per week (five days times six periods per day) and a .9 utilization rate is desired, the factor will be 30 x .9 = 27. If the user wanted to experiment with seven periods per day and a utilization rate of .85, then the new factor would be 35 x .85 = 29.75. If all students in a given subject area were in a work-study program and hence not available during the last two periods of a six period day, then the new factor might be 20 x .85 = 17.

```
7321  SUBJECT AREA-1 REGUIRED ROOMS
6321 X 320 /     27
```

Row 322: Subject Area-1 Available Rooms. Historical data on the number of adequate rooms available for the subject area should be entered for all historical years. If data is unavailable for any year, a zero should be entered into that field. The expected number of available rooms should be entered for every year of the planning period. Thus, if new space is being constructed or existing space is being closed, the number of available rooms for the subject area should be modified to reflect these changes in the appropriate years.

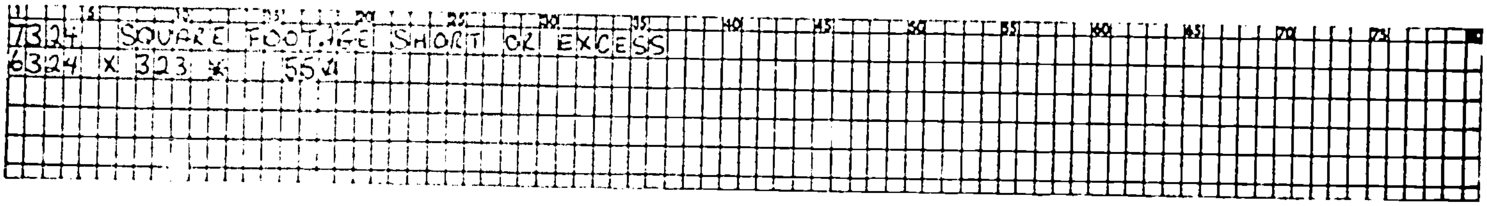
```
7322  SUBJECT AREA-1 AVAILABLE ROOMS
1322     116     124     155     163     177     193     211     211     231
1322     231     231     231     231     231     231     231     231     231
1322     231     231     231     231     231     231     231     231     231
```

Row 323: Subject Area-1 Rooms Short or Excess. This variable is obtained by subtracting the required number of rooms from the available rooms for the subject area.



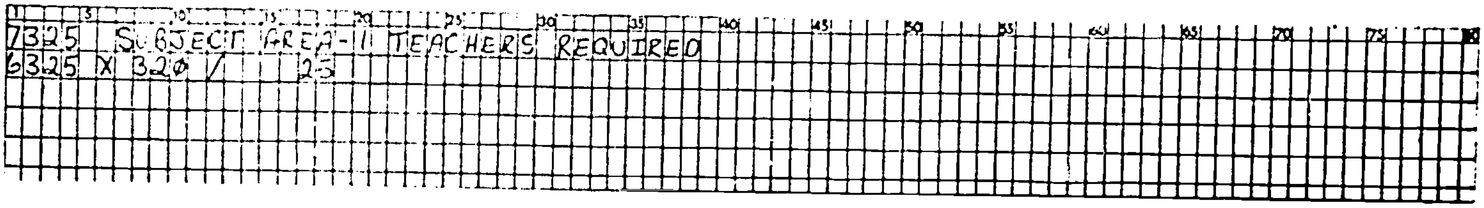
```
7323 SUBJECT AREA-1 ROOMS SHORT OR EXCESS
6323 X 322 321
```

Row 324: Square Footage Short or Excess. This variable is obtained by multiplying the number of rooms short or excess in the subject area by a standard room size for this subject area. In the example the standard room size is 550 square feet. This figure must be estimated by the user for each of the subject areas under study.



```
7324 SQUARE FOOTAGE SHORT OR EXCESS
6324 X 323 *  550
```

Row 325: Subject Area-1 Teachers Required. The number of teachers required for the subject area is calculated by dividing the projected class periods per week by the number of periods per week a teacher is available to teach. In the example teachers must teach five out of every six periods per day, or twenty five periods per week.



```
7325 SUBJECT AREA-1 TEACHERS REQUIRED
6325 X 320 /    25
```

Row 326: Subject Area-2 Class Periods per Week. See Row 320 Instructions.

Row 327: Subject Area-2 Required Rooms. See Row 321 Instructions.

Row 328: Subject Area-Available Rooms. See Row 322 Instructions.

Row 329: Subject Area-2 Rooms Short or Excess. See Row 323 Instructions.

Row 330: Square Footage Short or Excess. See Row 324 Instructions.

Row 331: Subject Area-2 Teachers Required. See Row 325 Instructions.

Row 332: Subject Area-3 Class Periods per Week. See Row 320 Instructions.

Row 333: Subject Area-3 Required Rooms. See Row 321 Instructions.

Row 334: Subject Area-3 Available Rooms. See Row 322 Instructions.

Row 335: Subject Area-3 Rooms Short or Excess. See Row 323 Instructions.

Row 336: Square Footage Short or Excess. See Row 324 Instructions.

Row 337: Subject Area-3 Teachers Required. See Row 325 Instructions.

Row 338: Subject Area-4 Class Periods per Week. See Row 320 Instructions.

Row 339: Subject Area-4 Required Rooms. See Row 321 Instructions.

Row 340: Subject Area-4 Available Rooms. See Row 322 Instructions.

Row 341: Subject Area-4 Rooms Short or Excess. See Row 323 Instructions.

Row 342: Square Footage Short or Excess. See Row 324 Instructions.

Row 343: Subject Area-4 Teachers Required. See Row 325 Instructions.

Row 344: Subject Area-5 Class Periods per Week. See Row 320 Instructions.

Row 345: Subject Area-5 Required Rooms. See Row 321 Instructions.

Row 346: Subject Area-5 Available Rooms. See Row 322 Instructions.

Row 347: Subject Area-5 Rooms Short or Excess. See Row 323 Instructions.

Row 348: Square Footage Short or Excess. See Row 324 Instructions.

Row 349: Subject Area-5 Teachers Required. See Row 325 Instructions.

Row 350: Subject Area-6 Class Periods per Week. See Row 320 Instructions.

Row 351: Subject Area-6 Required Rooms. See Row 321 Instructions.

Row 352: Subject Area-6 Available Rooms. See Row 322 Instructions.

Row 353: Subject Area-6 Rooms Short or Excess. See Row 323 Instructions.

Row 354: Square Footage Short or Excess. See Row 324 Instructions.

Row 355: Subject Area-6 Teachers Required. See Row 325 Instructions.

If no subject area breakdowns are being considered, then the rows allocated to Subject Area-1 should be utilized to project the total elementary enrollment needs. Row 301 will replace Row 310; the other row numbers and factors will stay the same. If more than one subject area is analyzed, the following rows will be used to aggregate all the subject area needs to obtain the total elementary requirements.

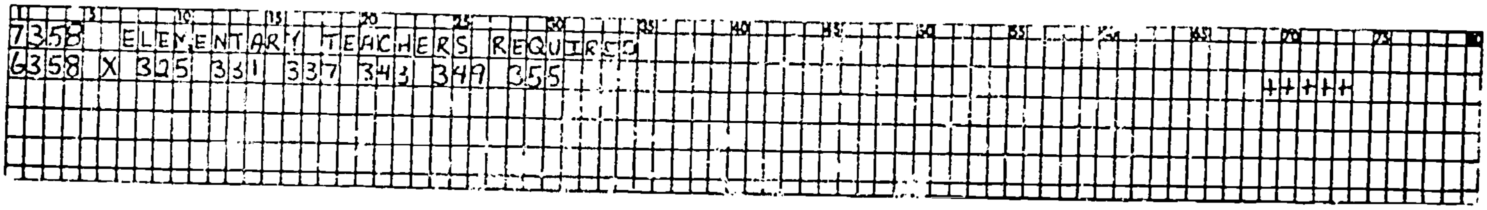
Row 356: Elementary Rooms Short or Excess. This is the sum of elementary rooms short or excess for all subject areas used—the sum of Rows 323, 329, 335, 341, 347 and 353.

```
7356  ELEMENTARY ROOMS SHORT OR EXCESS
6356 X 323 329 335 341 347 353
                                                                    +++++
```

Row 357: Total Square Footage Short or Excess. This is the sum of the square footage shortage or surplus for all subject areas used—the sum of Rows 324, 330, 336, 342, 348, and 354.

```
7357  TOTAL SQUARE FOOTAGE SHORT OR EXCESS
6357 X 324 330 336 342 348 354
                                                                    +++++
```

Row 358: Elementary Teachers Required. This is the sum of elementary teachers required for all subject areas—the sum of Rows 325, 331, 337, 343, 349, and 355.



```
7358 ELEMENTARY TEACHERS REQUIRED
6358 X 325 331 337 343 349 355
                                                                    +++++
```

5. Junior High School Space Analysis. Rows 370-519 are used to calculate junior high or middle school facility needs. Most of the rows are handled in a manner similar to rows in the elementary section. For each row in this section, the instructions associated with the similar row in the elementary section are referenced.

Row 370: Enrollment—Junior High. See Row 300 Instructions.

Row 371: Total Subject Enrollment. See Row 301 Instructions.

Row 372: Subject Area-1 Enrollments. See Row 302 Instructions.

Row 373: Subject Area-2 Enrollments. See Row 302 Instructions.

Row 374: Subject Area-3 Enrollments. See Row 302 Instructions.

Row 375: Subject Area-4 Enrollments. See Row 302 Instructions.

Row 376: Subject Area-5 Enrollments. See Row 302 Instructions.

Row 377: Subject Area-6 Enrollments. See Row 302 Instructions.

Row 378: Subject Area-7 Enrollments. See Row 302 Instructions.

Row 379: Subject Area-8 Enrollments. See Row 302 Instructions.

Row 380: Subject Area-9 Enrollments. See Row 302 Instructions.

Row 381: Subject Area-10 Enrollments. See Row 302 Instructions.

Row 382: Subject Area-11 Enrollments. See Row 302 Instructions.

Row 383: Subject Area-12 Enrollments. See Row 302 Instructions.

Row 384: Subject Area-13 Enrollments. See Row 302 Instructions.

Row 385: Subject Area-14 Enrollments. See Row 302 Instructions.

Row 386: Subject Area-15 Enrollments. See Row 302 Instructions.

Row 387: Subject Area-16 Enrollments. See Row 302 Instructions.

Row 388: Subject Area-17 Enrollments. See Row 302 Instructions.

Row 389: Subject Area-18 Enrollments. See Row 302 Instructions.

Row 390: Subject Area-19 Enrollments. See Row 302 Instructions.

Row 391: Subject Area-20 Enrollments. See Row 302 Instructions.

Row 392: Dummy. Since the '6' card can process only ten rows of data, when a calculation involves more than ten rows, a dummy variable must be used. If more than ten but less than twenty rows are involved, only one dummy row is needed. However, when more than nineteen but less than twenty-eight rows are involved, two dummy rows are needed. Dummy variables are needed at this point to aggregate the subject area enrollments.

```
7392   DUMMY
6392 X 372 373 374 375 376 377 378 379 380 381
                                                                     ++++++++++
```

Row 393: Dummy. See Row 392 Instructions.

Row 394: Total Junior High Subject Enrollment. This is the sum of all subject area enrollments. This row is necessary only when the total enrollment has been broken into subject areas. Data for historical years will be the same as that in Row 371.

```
7394   TOTAL JR HIGH SUBJECT ENROLLMENT PROJ
6394 X 392 393
                                                                     +
```

The subject area projections are adjusted so that they will sum to the total subject area enrollment projection (Row 394) using the previously described technique.

Row 395: Subject Area-1 Enrollment (ADJ). See Row 310 Instructions.

Row 396: Subject Area-2 Enrollment (ADJ). See Row 310 Instructions.

Row 397: Subject Area-3 Enrollment (ADJ). See Row 310 Instructions.

Row 398: Subject Area-4 Enrollment (ADJ). See Row 310 Instructions.

Row 399: Subject Area-5 Enrollment (ADJ). See Row 310 Instructions.

Row 400: Subject Area-6 Enrollment (ADJ). See Row 310 Instructions.

Row 401: Subject Area-7 Enrollment (ADJ). See Row 310 Instructions.

Row 402: Subject Area-8 Enrollment (ADJ). See Row 310 Instructions.

Row 403: Subject Area-9 Enrollment (ADJ). See Row 310 Instructions.

Row 404: Subject Area-10 Enrollment (ADJ). See Row 310 Instructions.

Row 405: Subject Area-11 Enrollment (ADJ). See Row 310 Instructions.

Row 406: Subject Area-12 Enrollment (ADJ). See Row 310 Instructions.

Row 407: Subject Area-13 Enrollment (ADJ). See Row 310 Instructions.

Row 408: Subject Area-14 Enrollment (ADJ). See Row 310 Instructions.

Row 409: Subject Area-15 Enrollment (ADJ). See Row 310 Instructions.

Row 410: Subject Area-16 Enrollment (ADJ). See Row 310 Instructions.

Row 411: Subject Area-17 Enrollment (ADJ). See Row 310 Instructions.

Row 412: Subject Area-18 Enrollment (ADJ). See Row 310 Instructions.

Row 413: Subject Area-19 Enrollment (ADJ). See Row 310 Instructions.

Row 414: Subject Area-20 Enrollment (ADJ). See Row 310 Instructions.

The subject area enrollment projections are translated into their associated room and teacher requirements using the previously described techniques.

Row 415: Subject Area-1 Class Periods per Week. See Row 320 Instructions.

Row 416: Subject Area-1 Teachers Required. See Row 325 Instructions.

Row 417: Subject Area-1 Rooms Required. See Row 321 Instructions.

Row 418: Subject Area-2 Class Periods per Week. See Row 320 Instructions.

Row 419: Subject Area-2 Teachers Required. See Row 325 Instructions.

Row 420: Subject Area-2 Rooms Required. See Row 321 Instructions.

Row 421: Subject Area-3 Class Periods per Week. See Row 320 Instructions.

Row 422: Subject Area-3 Teachers Required. See Row 325 Instructions.

Row 423: Subject Area-3 Rooms Required. See Row 321 Instructions.

Row 424: Subject Area-4 Class Periods per Week. See Row 320 Instructions.

Row 425: Subject Area-4 Teachers Required. See Row 325 Instructions.

Row 426: ,Subject Area-4 Rooms Required. See Row 321 Instructions.

Row 427: Subject Area-5 Class Periods per Week. See Row 320 Instructions.

Row 428: Subject Area-5 Teachers Required. See Row 325 Instructions.

Row 429: Subject Area-5 Rooms Required. See Row 321 Instructions.

Row 430: Subject Area-6 Class Periods per Week. See Row 320 Instructions.

Row 431: Subject Area-6 Teachers Required. See Row 325 Instructions.

Row 432: Subject Area-6 Rooms Required. See Row 321 Instructions.

Row 433: Subject Area-7 Class Periods per Week. See Row 320 Instructions.

Row 434: Subject Area-7 Teachers Required. See Row 325 Instructions.

Row 435: Subject Area-7 Rooms Required. See Row 321 Instructions.

Row 436: Subject Area-8 Class Periods per Week. See Row 320 Instructions.

Row 437: Subject Area-8 Teachers Required. See Row 325 Instructions.

Row 438: Subject Area-8 Rooms Required. See Row 321 Instructions.

Row 439: Subject Area-9 Class Periods per Week. See Row 320 Instructions.

Row 440: Subject Area-9 Teachers Required. See Row 325 Instructions.

Row 441: Subject Area-9 Rooms Required. See Row 321 Instructions.

Row 442: Subject Area-10 Class Periods per Week. See Row 320 Instructions.

Row 443: Subject Area-10 Teachers Required. See Row 325 Instructions.

Row 444: Subject Area-10 Rooms Required. See Row 321 Instructions.

Row 445: Subject Area-11 Class Periods per Week. See Row 320 Instructions.

Row 446: Subject Area-11 Teachers Required. See Row 325 Instructions.

Row 447: Subject Area-11 Rooms Required. See Row 321 Instructions.

Row 448: ,Subject Area-12 Class Periods per Week. See Row 320 Instructions.

Row 449: Subject Area-12 Teachers Required. See Row 325 Instructions.

Row 450: Subject Area-12 Rooms Required. See Row 321 Instructions.

Row 451: Subject Area-13 Class Periods per Week. See Row 320 Instructions.

Row 452: Subject Area-13 Teachers Required. See Row 325 Instructions.

Row 453: Subject Area-13 Rooms Required. See Row 321 Instructions.

Row 454: Subject Area-14 Cla [illegible] per Week. See Row 320 Instructions.

Row 455: Subject Area-14 Teachers Required. See Row 325 Instructions.

Row 456: Subject Area-14 Rooms Required. See Row 321 Instructions.

Row 457: Subject Area-15 Class Periods per Week. See Row 320 Instructions.

Row 458: Subject Area-15 Teachers Required. See Row 325 Instructions.

Row 459: Subject Area-15 Rooms Required. See Row 321 Instructions.

Row 460: Subject Area-16 Class Periods per Week. See Row 320 Instructions.

Row 461: Subject Area-16 Teachers Required. See Row 325 Instructions.

Row 462: Subject Area-16 Rooms Required. See Row 321 Instructions.

Row 463: Subject Area-17 Class Periods per Week. See Row 320 Instructions.

Row 464:, Subject Area-17 Teachers Required. See Row 325 Instructions.

Row 465: Subject Area-17 Rooms Required. See Row 321 Instructions.

Row 466: Subject Area-18 Class Periods per Week. See Row 320 Instructions.

Row 467: Subject Area-18 Teachers Required. See Row 325 Instructions.

Row 468: Subject Area-18 Rooms Required. See Row 321 Instructions.

Row 469: Subject Area-19 Class Periods per Week. See Row 320 Instructions.

Row 470: Subject Area-19 Teachers Required. See Row 325 Instructions.

Row 471: Subject Area-19 Rooms Required. See Row 321 Instructions.

Row 472: Subject Area-20 Class Periods per Week. See Row 320 Instructions.

Row 473: Subject Area-20 Teachers Required. See Row 325 Instructions.

Row 474: Subject Area-20 Rooms Required. See Row 321 Instructions.

Row 475: Dummy—Teachers. As described previously, several dummy rows are necessary in order to add twenty variables together, using the basic support system. This row is used to sum the required teachers for the first ten subject areas.

Row 476: Dummy. See Row 475 Instructions.

Row 477: Total Junior High Teachers. The sum of all teachers required in the junior high school. In the example the sum is obtained by adding Rows 475 and 476 using a '6' card.

```
7477  TOTAL JR HIGH TEACHERS
6477 X 475 476                                                      +
```

The System now permits the aggregation of various subject areas into specific space categories. If the subject area delineations have been made according to required space types, this aggregation may not be necessary. The following six space categories may be renamed; the number of categories could be easily expanded or contracted.

Row 478: Regular Rooms Required (Junior High). The number of regular classrooms required by subject area will be summed to obtain the total number of regular classrooms required in the junior high. In the example it is assumed that the first nine subject areas require regular classrooms.

```
7478  REGULAR ROOMS REQUIRED JR HIGH
6478 X 417 420 423 426 429 432 435 438 441                          ++++++++
```

Row 479: Regular Junior High Rooms Available. Historical data on the number of regular rooms available for the junior high should be entered for all historical years. If the data is not available for any year(s), a zero should be entered in that field. The number of available regular classrooms should be entered for the current year and every year of the planning period. However, if a new school is being constructed or an existing school is being modified or closed, the number of regular classrooms should be modified to reflect this change in all years concerned. The impact of different facility plans may be tested by adding or subtracting rooms on this row.

```
7479  REGULAR ROOMS AVAILABLE JR HIGH
1479      25      25      29      32      32      40      40      45      45
1479      45      45      45      45      45      45      45      45      45
1479      45      45      45      45      45      45      45      45      45
```

Row 480: Regular Rooms Short or Excess. This is the difference between Row 478 and Row 479. If all regular room requirements are associated with Subject Area-1 courses, then Row 417 would be subtracted from Row 479.

```
7480  REGULAR ROOMS SHORT OR EXCESS
6480 X 479 478
```

Row 481: Square Footage Short or Excess. This row is used to convert the shortage or excess of rooms into square footage. The number of regular rooms calculated in Row 480 is multiplied by a standard room size in square feet. In the example, the standard room size is 550 square feet.

```
7481  SQUARE FOOTAGE SHORT OR EXCESS
6481 X 480 *   550
```

Row 482: Large Rooms Required (Junior High). See Row 478 Instructions.

Row 483: Large Rooms Available. See Row 479 Instructions.

Row 484: Large Rooms Short or Excess. See Row 480 Instructions.

Row 485: Square Footage Short or Excess. See Row 481 Instructions.

Row 486: Science Labs Required (Junior High). See Row 478 Instructions.

Row 487: Science Labs Available. See Row 479 Instructions.

Row 488: Science Labs Short or Excess. See Row 480 Instructions.

Row 489: Square Footage Short or Excess. See Row 481 Instructions.

Row 490: Voc. Ed. Rooms Required (Junior High). See Row 478 Instructions.

Row 491: Voc. Ed. Rooms Available. See Row 479 Instructions.

Row 492: Voc. Ed. Rooms Short or Excess. See Row 480 Instructions.

Row 493: Square Footage Short or Excess. See Row 481 Instructions.

Row 494: Type 5 Rooms Required (Junior High). See Row 478 Instructions. This row is available for the user to specify a different room type than already noted.

Row 495: Type 5 Rooms Available. See Row 479 Instructions.

Row 496: Type 5 Rooms Short or Excess. See Row 480 Instructions.

Row 497: Square Footage Short or Excess. See Row 481 Instructions.

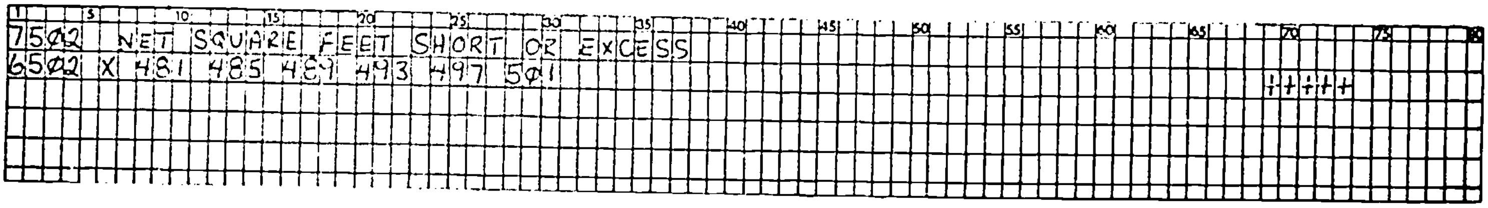
Row 498: Type 6 Rooms Required (Junior High). See Row 478 and 494 Instructions.

Row 499: Type 6 Rooms Available. See Row 479 Instructions.

Row 500: Type 6 Rooms Short or Excess. See Row 480 Instructions.

Row 501: Square Footage Short or Excess. See Row 481 Instructions.

Row 502: Net Square Feet Short or Excess. This is the sum of square feet short or excess for the junior high school. To obtain the sum, add Rows 481, 485, 489, 493, 497, and 501. If a row was not calculated, it will not be included in the summation.



```
7502 NET SQUARE FEET SHORT OR EXCESS
6502 X 481 485 489 493 497 501                                   ++++
```

6. Senior High School Space Analysis. Rows 520-653 are currently used to analyze senior high school space. The rows are handled similarly to those in the elementary and junior high space analysis. Reference is made to the appropriate row instructions in the elementary and junior high section. Because the variables correspond directly to those in the junior high section, some of the row descriptions have been purposely skipped.

Row 520: Enrollment. See Row 300 Instructions.

Row 521: Total Subject Area Enrollments. See Row 301 Instructions.

Row 522: Subject Area-1 Enrollment. See Row 302 Instructions.

Row 541: Subject Area-20 Enrollment. See Row 302 Instructions.

Row 542: Dummy. See Row 392 Instructions.

Row 543: Dummy. See Row 392 Instructions.

Row 544: Total Senior High Subject Enrollment. See Row 394 Instructions.

Row 545: Subject Area-1 Enrollment (ADJ). See Row 310 Instructions.

Row 564: Subject Area-20 Enrollment (ADJ). See Row 310 Instructions.

Row 565: Subject Area-1 Class Periods per Week. See Row 320 Instructions.

Row 566: Subject Area-1 Teachers Required. See Row 325 Instructions.

Row 567: Subject Area-1 Rooms Required. See Row 321 Instructions.*

---

*Note that the class periods per week, teachers required, and rooms required rows associated with Subject Area-2 through 19 (Rows 568-621) have not been listed because of similarity with the instructions that are presented.

Row 622: Subject Area-20 Class Periods per Week. See Row 320 Instructions.

Row 623: Subject Area-20 Teachers Required. See Row 325 Instructions.

Row 624: Subject Area-20 Rooms Required. See Row 321 Instructions.

Row 625: Dummy. See Row 475 Instructions.

Row 626: Dummy. See Row 475 Instructions.

Row 627: Total Senior High Teachers. See Row 477 Instructions.

Row 628: Regular Rooms Required. See Row 478 Instructions.

Row 629: Regular Rooms Available. See Row 479 Instructions.

Row 630: Regular Rooms Short or Excess. See Row 480 Instructions.

Row 631: Square Footage Short or Excess. See Row 481 Instructions.

Row 632: Large Rooms Required. See Row 478 Instructions.

Row 633: Large Rooms Available. See Row 479 Instructions.

Row 634: Large Rooms Short or Excess. See Row 480 Instructions.

Row 635: Square Footage Short or Excess. See Row 481 Instructions.

Row 636: Science Labs Required. See Row 478 Instructions.

Row 637: Science Labs Available. See Row 479 Instructions.

Row 638: Science Labs Short or Excess. See Row 480 Instructions.

Row 639: Square Footage Short or Excess. See Row 481 Instructions.

Row 640: Voc. Ed. Rooms Required. See Row 478 Instructions.

Row 641: Voc. Ed. Rooms Available. See Row 479 Instructions.

Row 642: Voc. Ed. Rooms Short or Excess. See Row 480 Instructions.

Row 643: Square Footage Short or Excess. See Row 481 Instructions.

Row 644: Type 5 Rooms Required. See Row 478 and 494 Instructions.

Row 645: Type 5 Rooms Available. See Row 479 Instructions.

Row 646: Type 5 Rooms Short or Excess. See Row 480 Instructions.

Row 647: Square Footage Short or Excess. See Row 481 Instructions.

Row 648: Type 6 Rooms Required. See Rows 478 and 494 Instructions.

Row 649: Type 6 Rooms Available. See Rows 479 Instructions.

Row 650: Type 6 Rooms Short or Excess. See Row 480 Instructions.

Row 651: Square Footage Short or Excess. See Row 481 Instructions.

Row 652: Net Square Feet Short or Excess. See Row 502 Instructions.

Row 653: Total Number of Teachers Employed. This is the sum of elementary, junior high, and senior high teachers.

```
7653  TOTAL NUMBER OF TEACHERS EMPLOYED
6653 X 358 477 627                                                   H+
```

4.4 Analysis

The completion of the procedures described in the preceding section will yield an initial measure of the nature and magnitude of the school system's future facility needs. These needs will vary in response to some factors, such as enrollment or state imposed standards, that are largely beyond the control of the local school district. Other factors, such as a utilization rate, will be directly susceptible to local district manipulation. It is important that the procedures be repeated to examine the impact of a change in local conditions, standards, and policies. It is equally important that alternative capital plans be tested using the procedures.

4.4.1 Selecting Standards and Policies

The district's standards and policies should be considered in light of the district's ability to meet the educational needs of the community. Thus some possibilities, such as "double sessions," may automatically be beyond consideration as a potential solution to a space problem because of their perceived educational shortcomings.

If the user is relatively unfamiliar with certain variables found in the procedures, the initial entries may be determined by calculating current values from existing historical data. For example, the current utilization rate or space per student may be calculated and used. In subsequent calculations, revisions to these standards and policies should be explored which might prove feasible for the district. These revisions must take into account many factors. Professional teachers' organizations may exert significant influence over policy decisions concerning the number of students per teaching station and the work load of each teacher. National educational trends should be examined regarding educational space standards and programs that might be appropriate to the district.

Alternative standards and policies may be used to alleviate temporary shortages of space. By relaxing standards, such as the students per teaching station, number of sessions per week, or the utilization rate, the need for new space may be radically diminished. Alternatively, an excess of space may be reduced by lowering the number of students per station, decreasing the number of sessions per week, or the utilization rate.

4.4.2 Definitions

Each row and variable included in this component has been briefly defined. If these definitions are inadequate for the district's needs, the user can modify them as long as the modifications do not alter the basic logic of the technique. All definitions should be agreed to prior to the start of the project and used consistently throughout.

The selection of the measure of future facility need is left to the user. The teaching stations or rooms required is the most familiar measure, but will not always be superior to the use of a square footage measure. Square footage may be defined in terms of gross square footage or net square footage (i.e., gross square footage less hallways, storage, and other non-teaching space) with no difficulty if the definition is used consistently. When considering renovation, a school district may want to use a gross square footage measure because of the potential convertibility of "non-instructional" areas into teaching stations.

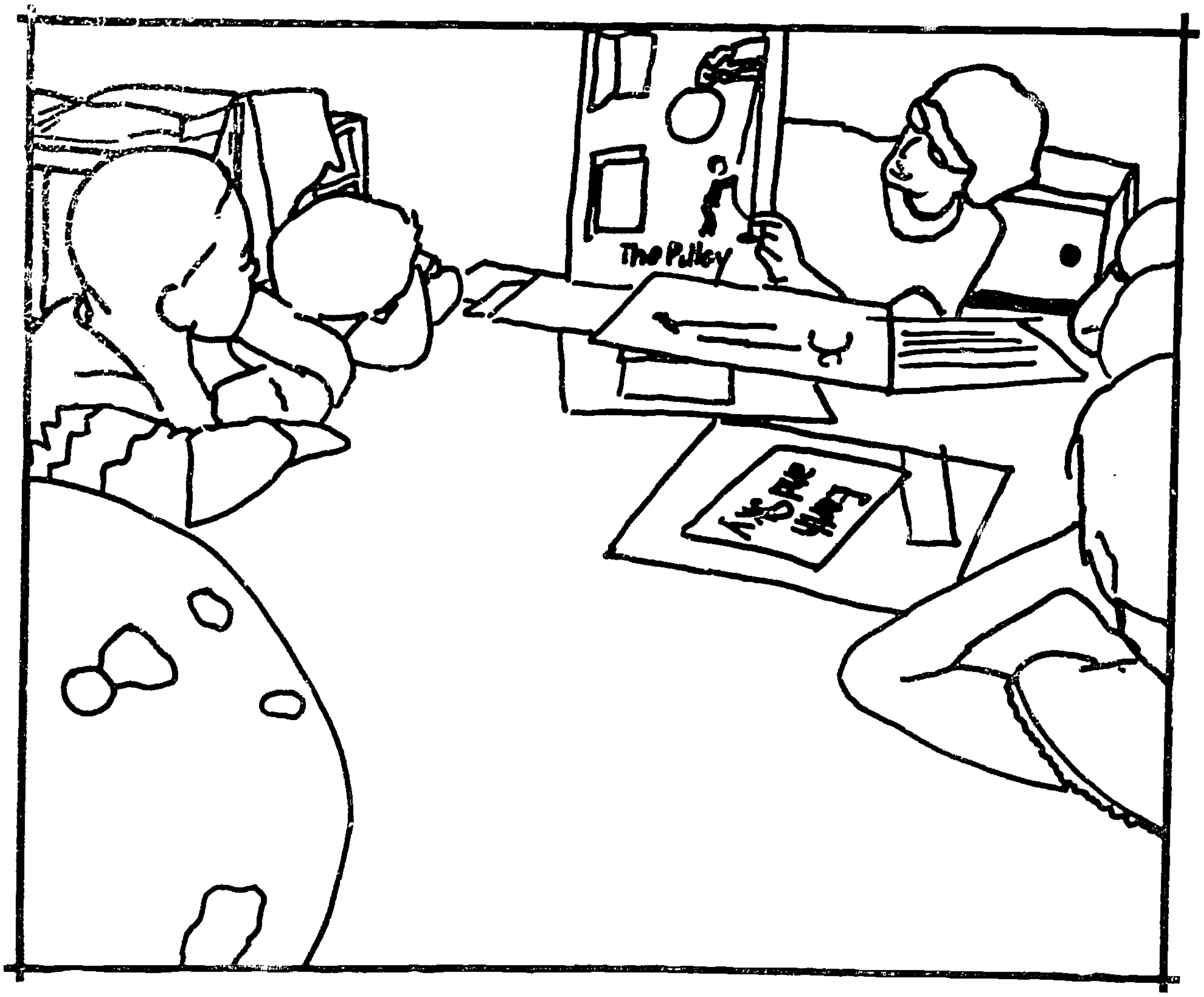
4.4.3 Capital Planning

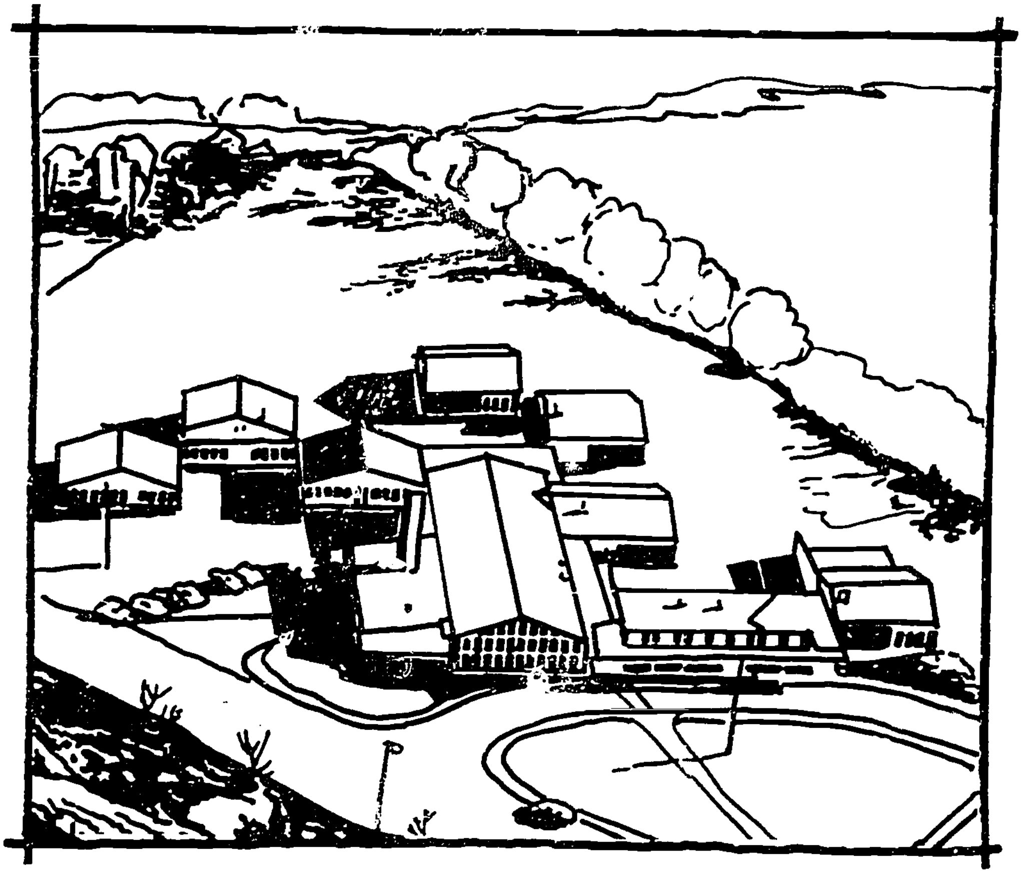
The measures of facility needs provide much of the basic information with which specific capital planning strategies can be formulated. The school system is encouraged to consider a variety of possible solutions and then to examine their facility impact. This will involve changing values in the appropriate rows for the proposed year in which they would take effect, and rerunning the System.

Specific plans will, of course, vary with the nature and magnitude of the problem. A problem that is concentrated in a few grades or a few geographic sections of the district may be resolved by changing the grade organization, reassigning specific classes to different schools, or revising the attendance boundaries. Other problems will pervade all grades throughout the entire district.

In a declining enrollment situation, the impact of allowing fewer children per teaching space or more square feet per child might be explored. Similarly the effect of devoting a greater amount of space to non-teaching or community uses could be tested by changing the utilization rate. The impact of disposing of certain facilities could be examined by adjusting the existing teaching stations or square feet for the correct years.

In a growth situation the same kinds of possibilities would be considered but in the opposite direction. The space implications of more children per teaching space and less space per child, of higher utilization rates, of a new sessions policy and finally of new facilities could all be evaluated. While further plan formulation considerations are presented in Chapter 8, the essential process of designing alternatives cannot be reduced to a check list. Ultimately, the user must develop these based on judgement, experience, and knowledge of the district.


The Pulley
Emily



Chapter 5: Fiscal Component

The objective of this component is to examine the demand for a school district's educational services in terms of their financial implications. Revenues, expenditures, and bonding capacity are projected throughout the planning period and the district's cash flow is calculated. Once this information is available, a fiscal plan can be developed by comparing expected revenues against the expenditure forecasts associated with alternative facility proposals.

5.1 Overview

The Fiscal Component is divided into three modules: the Bonding Capacity Module, the Revenue Forecasting Module, and the Expenditure Forecasting Module. The Bonding Capacity Module projects gross bonding capacity as a function of the district's projected assessed valuation. Net bonding capacity is then calculated by subtracting scheduled payments on the principal of both outstanding and proposed bond issues. The Revenue Module forecasts school district income over the planning period. Local, intermediate, state, and federal revenues are projected. The Expenditure Module projects expenditures that will be incurred by the district throughout the planning period. Operating, capital, and bond retirement expenditures are projected and summed to arrive at an estimate of total disbursements. The capital expenditures section of this module translates planned facility and land committments, generated as part of the previous component, into their fiscal implications. At the conclusion of the Fiscal Component, the user will have forecast capital outlays, expenditures, revenues, and bonding capacity in light of the demand for educational services projected by the previous components.

5.2 General Design

The techniques employed in this component allow the projection of future revenues and expenditures on the basis of past fiscal patterns, as a function of other variables, or in response to the user's independent judgement. Regardless of the approach selected, forecasts of both revenues and expenditures must take economic conditions and legal restrictions into account. While this component does not attempt to address all possible situations, it does possess the flexibility that will allow school planners to consider unique conditions which may characterize their district. This flexibility requires the user to make decisions as to how certain variables are to be projected. Past trends will aid school planners in making these decisions. However, ultimately the user's knowledge of the community and how it is affected by economic factors will determine the predictive accuracy of the results generated by the model.

In the Revenue Forecasting Module and the Expenditure Forecasting Module, the user is given the choice of itemizing and projecting revenue source and expenditure categories individually or applying a shortened forecast method. The shortened method allows the user to project total district expenditures or total district revenue by regressing one or more major itemized variables against historical totals. This technique will save the user several steps over the itemized approach and may provide a satisfactory level of analysis.

The procedures necessary for completing the shortened forecast method and other alternative forecasting techniques are listed in Appendix E. Notations are made at appropriate points in the text when an alternative technique, presented in the Appendix, might be substituted for those in the main text. In general, the procedures in the main text are recommended initially until the user is familiar with the System.

The user is encouraged to repeat the component procedures in order to examine the impact of alternative expenditure programs, revenue forecasts, and bond issue sales. In the case of a forecasted negative cash flow, reiteration will be necessary to determine where expenditures might be cut or revenues increased. Successive runs of the System will also be useful in analyzing the impact of one fiscal plan against another. With the change of only a few variables, the fiscal implications can be explored of closing or opening a school, seeking new taxing authority, improving the tax base, and many other policy options. Finally, repeated runs of the System can alert the district to the effect of possible conditions over which it has no control. The impact of alternative inflation rates, local economic conditions, and demographic patterns can be examined, thereby emphasizing the uncertainty associated with school planning.

5.3 FISCAL ANALYSIS PROCEDURES

The procedures necessary to forecast the district's bonding capacity, revenues, and expenditures are outlined below. Review of Appendix A is suggested before continuing in order to understand the row format and the completion of cards within each row, as necessitated by the basic support system.

The Fiscal Component may be run with or without the other components that make up the computer version of the School Facility Planning System. If it is run without the other components, then certain data items may have to be manually calculated and entered where necessary. In addition, the cards that define the historical and planning period (Row 001) will have to be prepared. The use of '7' and '1' cards to name the row and enter the years has been described in Chapter 3. Remember that the respective fields in all the '1' cards that are used throughout the component will refer to the years identified in Row 001.

5.3.1 Bonding Capacity Module

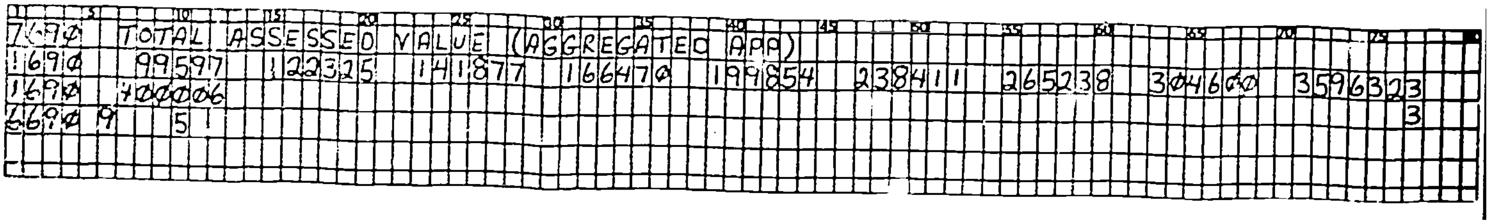
The objective of the Bonding Capacity Module is to forecast the district's bonding capacity for each year of the planning period. Since gross bonding capacity is usually determined as a function of community assessed valuation, it is necessary to project assessed valuation first.

Two methods are presented for projecting the district's assessed valuation. The method outlined below and in the example extrapolates historical values by means of a user selected growth curve. A second approach is listed in Appendix E, whereby assessed valuation is projected as a function of both community growth or decline and inflation.

Regardless of the method selected, the user must give consideration to the rate of growth or decline that the community is experiencing. This will aid in the selection of a curve by which assessed valuation is to be projected. Curves that are provided by the basic support system are reviewed in Chapter 2 and again in greater detail, in Appendices A and C.

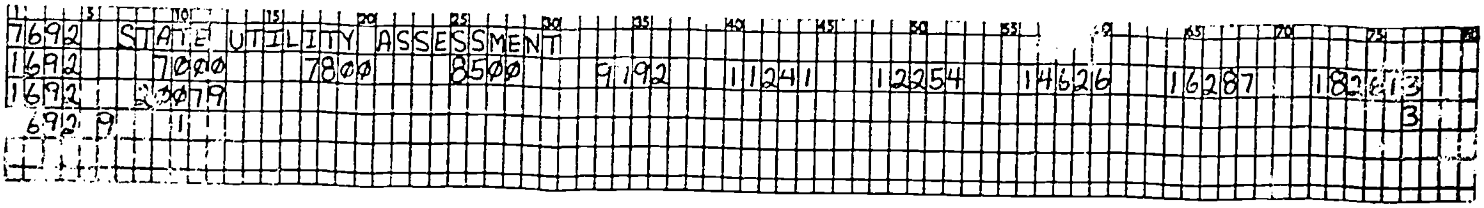
Projecting assessed valuation by means of extrapolation can be conducted with aggregated or disaggregated data. Aggregated data combines the assessed valuation for all district real property into one figure. Disaggregated data breaks the total assessed valuation into separate figures for commercial, industrial, residential and, if necessary, other categories of property. The disaggregated approach allows different growth curves to be selected for projecting each subtotal. This may be advantageous if one sector of the community is growing faster than another. An example of the disaggregated approach is described in Appendix E. A projection using aggregated data is presented below.

Row 690: Total Assessed Value (Aggregated Approach). Historical total assessed valuation is entered into the corresponding year-positions on the '1' cards. The '6' card in this example indicates that the historical total assessed valuation data is to be projected using a logistics growth curve. (The nine in Column 6 requests a time series projection and the five in Column 10 indicates that it should be a logistics curve without a user specified ceiling.) The three in Column 77 of the '1' cards indicates that the historical data is entered in thousands of dollars.



```
7690  TOTAL ASSESSED VALUE (AGGREGATED APP)
1690    99597  122325  141877  166470  199854  238411  265238  304600  3596323
1690  400006
6690 9   5                                                                   3
```

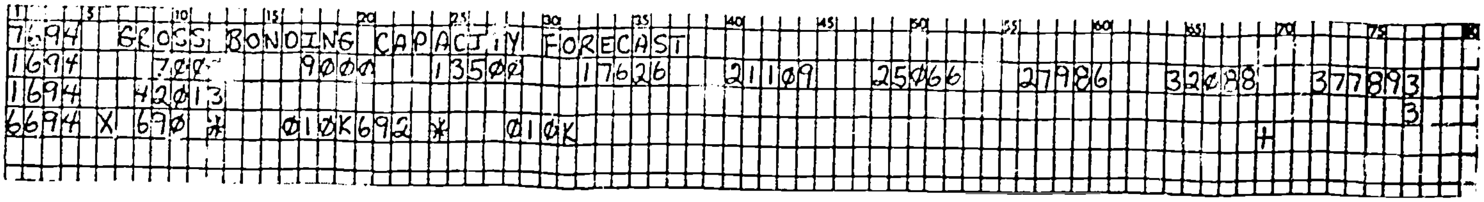
Row 692: State Utility Assessment. In some districts the state may conduct separate assessments on utilities. If this is the case, and the valuation of utility owned property enters into the calculation of bonding capacity, then these utility assessments must be projected and added to total assessments. The following example illustrates a linear projection of utility assessments:



```
7692  STATE UTILITY ASSESSMENT
1692     7000    7800    8500    9192   11241   12254   14626   16287   182613
1692   20079
 692 9   1                                                                   3
```

The particular formula that is used to calculate gross bonding capacity from assessed valuation varies from state to state. Thus, it may be necessary for the user to develop a formula that applies in the district's state. A typical formula is presented in the example. If the state formula is not known, or if it is considered too difficult to build into the System, gross bonding capacity may be calculated as a regression against historical and projected assessed valuation.

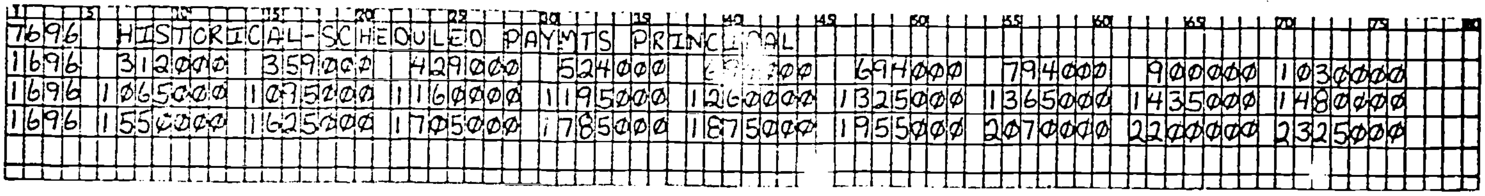
Row 694. Gross Bonding Capacity Forecast. In the example, gross bonding capacity is calculated as a percentage of total assessed valuation (Row 690) and the state utility assessment (Row 692). The '6' card multiplies Row 690 times ten percent (010K = .10) and multiplies Row 692 times ten percent it then adds the two results together to derive gross bonding capacity.



```
7694  GROSS BONDING CAPACITY FORECAST
1694     7000    9000   13500   17626   21109   25066   27986   32088   377893
1694   42013
6694 X 690 *  010K692 *  010K                                                3
                                                                   +
```

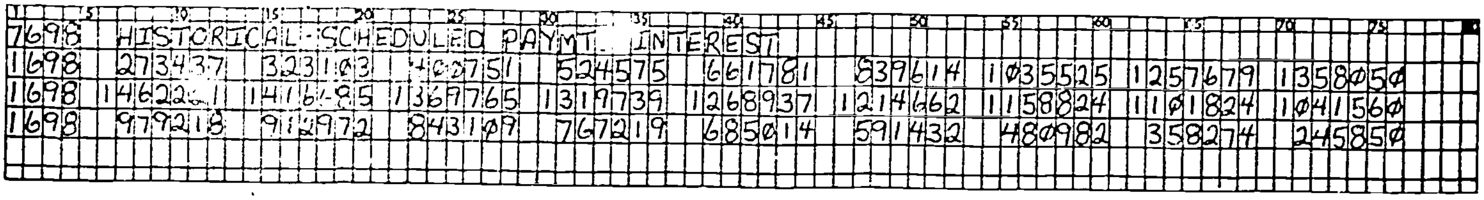
In order to determine an intermediate bonding capacity, the outstanding balance on bonds already issued must be subtracted from the gross bonding capacity. The user enters the current balance and the payment schedule for bonds already issued. The future bond balance is calculated and subtracted from the future gross bonding capacity to arrive at an intermediate bonding capacity for each year of the planning period. This figure is called intermediate because it does not consider any future bond issues which would affect gross bonding capacity. Rows 696, 698 and 700 pertain to the established payment schedules on bonds that are already outstanding. If there are no outstanding bonds, skip to Row 706.

Row 696: Historical and Scheduled Payments on Principal. The historical and scheduled principal payments on outstanding bonds are entered in Row 696. If a bond is to be issued in the current year, its payments should be entered here as a scheduled payment and not as a proposed bond issue in later rows.



```
7696  HISTORICAL-SCHEDULED PAYMTS PRINCIPAL
1696    312000  359000  429000  524000 [illegible]  694000  794000  900000 1030000
1696   1065000 1095000 1160000 1195000 1260000 1325000 1365000 1435000 1480000
1696   1550000 1625000 1705000 1785000 1875000 1955000 2070000 2200000 2325000
```

Row 698: Historical and Scheduled Payments on Interest. The historical and scheduled interest payments on outstanding bonds are entered in Row 698. If a bond is to be issued in the current year, its payments are to be entered here as a scheduled payment and not as a proposed bond issue in later rows.



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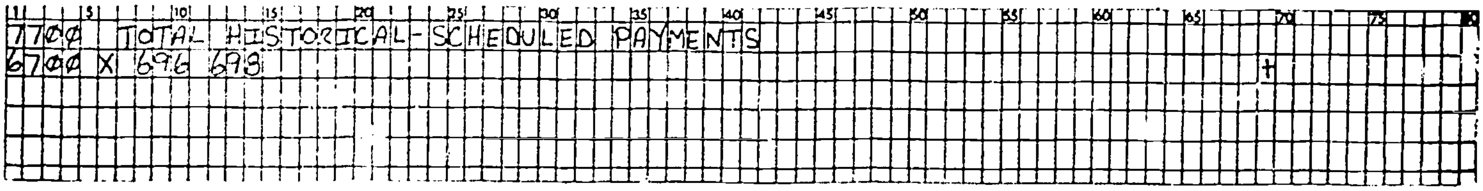
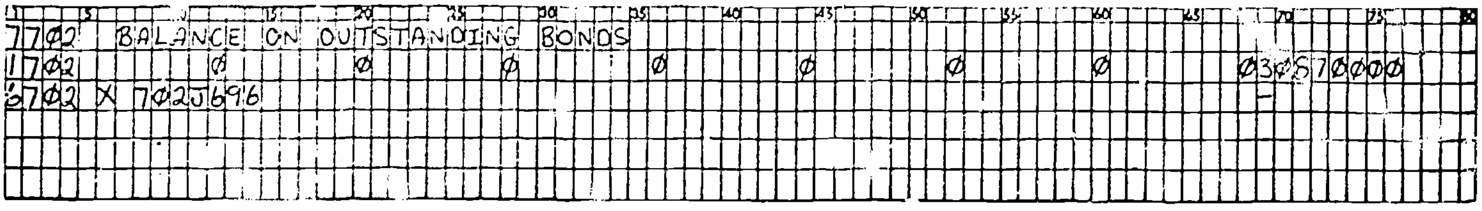
7698  HISTORICAL-SCHEDULED PAYMT. INTEREST
1698    273437  323103  402751  524575  661781  839614 1035525 1257679 1358050
1698   1462211 1416485 1367765 1317739 1268937 1214662 1158824 1101824 1041560
1698    979218  912972  843109  767219  685014  591432  480982  358274  245850
```

Row 700: Total Scheduled Payments. Total scheduled payments on existing bonds are calculated by adding Row 696 and Row 698.



```
7700  TOTAL HISTORICAL-SCHEDULED PAYMENTS
6700 X 696 698                                                       +
```

Row 702: Balance on Outstanding Bonds. The outstanding bond balance can usually be found on the user's summary schedule of bond payments. These balances should be totaled and entered into the appropriate time periods. If these balances are not available, they can be manually calculated from the bond amount and the payments on principal. A third alternative is to let the program compute the bond balance for each forecast year in the planning period. The example below indicates an outstanding bond balance of $30,870,000 for the end of 1973. The program will calculate the balance for 1974 by subtracting the principal payment (Row 696) for 1974 ($1,065,000) from the previous year's balance. The J in Column 11 of the '6' card indicates that the principal should be subtracted from the balance lagged one year.



```
7702  BALANCE ON OUTSTANDING BONDS
1702        0       0       0       0       0       0       0       030870000
6702 X 702J696                                                       -
```

Row 704: Current Net Bonding Capacity. The net bonding capacity is calculated by subtracting the balance on outstanding bonds (Row 702) from the gross bonding capacity (Row 694). This is an intermediate bonding capacity because proposed issues have not yet been considered.

```
7704  CURRENT NET BONDING CAPACITY
6704 X 694 702
```

Row 706: Proposed Bond Issues. At this point, the user should enter any bonds that might be issued in the future into Row 706. The amount of the bond is entered in the year for which it is planned to be issued. The example indicates a $12,000,000 bond issue planned for 1977 and a $14,000,000 bond issue for 1980. If no bond issues are proposed, skip to Row 714

```
7706  PROPOSED BOND ISSUES
1706           0       0       0       0       0       0       0       0       0
1706           0       0       012000000       0       0       014000000       0
1706           0       0       0       0       0       0       0       0       0
```

Row 708: Proposed Payments on Principal. The proposed payments on principal of future bond issues are entered into Row 708. If more than one bond issue is planned, the payments on principal for the second bond issue are added to the payments of the first bond issue and entered as one figure for the appropriate years. In the example the $12,000,000 issue will be retired with twelve payments of $1,000,000 each, starting in 1978. The $14,000,000 issue will be retired with an annual payment of $1,200,000, starting in 1981.

```
7708  PROPOSED PAYMENTS ON PRINCIPAL
1708           0       0       0       0       0       0       0       0       0
1708           0       0       0       0 1000000 1000000 1000000 2200000 2200000
1708 2200000 2200000 2200000 2200000 2200000 2200000 2200000 1200000 1200000
```

Row 710: Balance on Proposed Bond Issues. Row 710 calculates the balance for proposed bond issues. The amounts of proposed bond issues entered in Row 706 are added to the existing balance for proposed bonds (always zero), from which the proposed payments on principal (Row 708) are subtracted. All historical years and the current year for Row 710 must be zeros.

```
7710  BALANCE ON PROPOCED BOND ISSUES
1710           0       0       0       0       0       0       0       0       0
1710           0
6710 X 710 706 708
                                                                     +-
```

Row 712: Proposed Payments on Interest. The proposed interest payments on future bond issues are entered on Row 712. If more than one bond issue is planned, the payments on interest of the second bond issue are added to the payment of the first bond issue and entered as one figure for the appropriate years. An alternative approach would involve using a '6' card to multiply the balance in Row 710 times a tentative interest rate, thereby projecting interest payments.

```
7712  PROPOSED PAYMENTS ON INTEREST
1712       0       0       0       0       0       0       0       0       0
1712       0       0       0       0  600000  550000  500000 1150000 1090000
1712  980000  870000  760000  650000  540000  430000  320000  250000  200000
```

Row 714: Total Indebtedness. Total indebtedness is calculated in Row 714 by adding the outstanding bond balance (Row 702) and the balance on proposed bond issues (Row 710).

```
7714  TOTAL INDEBTEDNESS
6714 X 702 710                                                       +
```

Row 716: Total Payments on Proposed Bonds. The total payments on proposed bonds are calculated by adding the proposed principal payments (Row 708) and the proposed interest payments (Row 712).

```
7716  TOTAL PAYMENTS ON PROPOSED BONDS
6716 X 708 712                                                       +
```

Row 718: Total Bond Payments - All Bonds. The total payments on all bonds are calculated by adding the total scheduled payments on outstanding bonds (Row 700) and the total payments on proposed bonds (Row 716).

```
7718  TOTAL BOND PAYMENTS-ALL BONDS
6718 X 700 716
```

Row 720: Forecasted Net Bonding Capacity. Row 720 calculates the net bonding capacity by subtracting the unpaid balance on all outstanding and proposed bonds (Row 714) from the gross bonding capacity (Row 694). If the projected net bonding capacity is negative [illegible] year, the district has exceeded its bonding capacity.

```
7720  FORECASTED NET BONDING CAPACITY
6720 X 694 714                                                       -
```

5.3.2 Revenue Forecasting Module

The objective of the Revenue Forecasting Module is to project revenues that can be expected by the school district throughout the planning period. Funds are projected from local, intermediate, state, and federal revenue sources. If additional sources of revenue are available to a district which are not covered here, the user should project these revenues, using the most applicable techniques, and include them in the computations where appropriate.

Some of the information estimated in the Enrollment Component and the Facility Component is used as input to the Revenue Module. Therefore, it is anticipated that these components will be executed either manually or on the computer before the Fiscal Component is run. If the preceding components are not being run with the Fiscal Component, the data that is required by the Revenue Module must be entered manually.

In general, the accounting structure as outlined in <u>Financial Accounting — Classifications and Standard Terminology for Local and State School Systems,</u> United States Office of Education, 1973, is utilized as the basis for the revenue and expenditure analysis. Since many school districts base their accounting systems on this structure, its use should facilitate the transfer of data back and forth between the accounting system and the Revenue and Expenditure Forecasting Modules. Users are encouraged to redesignate rows within these two modules so that they relate directly to the revenue sources and expenditure accounts within the district.

A projection of the district's assessed valuation is the prime basis for the determination of local revenues. If the Bonding Capacity Module has been executed, assessed valuation is available in Row 690. If not, the user must go back and execute the steps associated with Row 690, insuring that the information is calculated prior to that row containing the tax rate. The other alternative is to manually project assessed valuation and enter the figures, using '1' cards, into a row prior to the tax rate information. In the example it is assumed that assessed valuation has already been projected in Row 690.

Row 732: Tax Rate. Row 732 contains the historical and projected property tax rate. This is input by the user and should reflect any changes which might occur. For instance, if a district has a current tax rate of $5.40 per hundred assessed valuation, ten cents of which is associated with a particular bond issue which will be paid out in two years, then the tax rate should decrease by ten cents in the third year. Similarly, any incremental tax levy that the district hopes to achieve should be included. For instance, if a bond issue is proposed which will require a tax levy increase of twenty cents for the term of the bond, that increase is shown in this row. Notice in the example that the current tax rate of $5.62 is carried out to the end of the planning period by adding zeros with a '6' card. Alternatively, an estimated rate could be directly entered for each year with '1' cards.

```
7732  TAX RATE
1732    0369    0435    0435    0495    0557    0557    0557    0562    0562K
6732 X 732J+     0
```

Row 734: Ad Valorem Taxes. Ad valorem tax revenue is calculated by multiplying assessed valuation (Row 690) times the tax rate in Row 732. The '6' card divides the assessed valuation (Row 690) by one hundred (100) and multiplies the result by the tax rate (Row 732) times one (1).

```
7734  AD VALOREM TAXES
6734 X 690 /00010  732 *C00001
```

Row 736: Ad Valorem Tax Receipts. The actual property tax collected may be significantly less than the amount levied. Row 736 is used to calculate expected receipts. The user enters historical property tax receipts. In the example, the program regresses the collection data against gross property taxes levied and projects the expected tax receipts as a function of the projected gross taxes. Alternatively, a simple percentage of the values in Row 734 could be calculated, using a '6' card. This row is necessary only in districts where it is likely that the actual income from property tax receipts will be substantially less than one hundred percent of expected income.

```
7736  AD VALOREM TAX RECEIPTS
1736 3630893 5217030 6046248 82292711107078613146641147318211673232719242175
6736 3 734
```

Rows 738 through 840 itemize and project additional common sources of local, intermediate, state, and federal revenue for a typical school district. These revenues are then summed in Row 850 to arrive at a total revenue forecast for the district. Because of time or convenience, some users may not want to project individually each source of revenue. In this case, the user may project total revenue as a function of one or more revenue sources which appear to be historically correlated with total revenue. This shortened method is described in Appendix E; the itemized method is presented below. Regardless of the method chosen, Row 850 must contain the district's projected total revenue.

Row 738: Sales Tax. In some areas, revenue from a sales tax imposed upon the sale and consumption of local goods and services may accrue to the district. This revenue could be forecast as a regression against commercial construction, employees, or some other independent forecast . In the example a linear extrapolation is made. The historical revenues from this source are entered by the user, with the years to be projected left blank. The user is encouraged to graph the historical data and consider alternate projection techniques based on past trends and expected activity.

```
7738   SALES TAX
1738     64000    71500    83000    97000   113000   120000   131000   142000   147000
1738   156000
6738 9     1
```

Row 740: Income Tax. Income taxes are defined as taxes on net income. These taxes can be levied on individuals, corporations, or unincorporated businesses, where the income is taxed separately from individual income. In the example, historical data is entered pertaining to district revenue from income tax sources, and the program executes a least squares fit and linear projection.

```
7740   INCOME TAX
1740     15000    20000    30000    40000    50000    60000    70000    80000    90000
1740   100000
6740 9     1
```

Row 742: Other Local Taxes. These would include all other local taxes, such as licenses and/or permits that provide revenue directly to the district. Again, in the example, the program performs a linear extrapolation.

```
7742  OTHER LOCAL TAXES
1742    1000    2000    3000    4000    5000    6000    7000    8000    9000
1742   10000
6742 9    1
```

Row 744: Revenue from Local Government Other Than the School District. This would include revenue from the appropriations of another local governmental unit. In this situation the district is not the final authority, within legal limits, in determining the amount of money to be received. The money is raised by municipal or county taxes and is not necessarily earmarked for school purposes. In the example, the projection is made by a least square fit and linear extrapolation of historical data.

```
7744  LOCAL GOV. REN. OTHER THAN DISTRICT
1744    1500    2000    2500    3000    3500    4000    4500    5000    5500
6744 9    1
```

Row 746: Tuition. This would include any money received from pupils, their parents, welfare agencies, or other districts for education provided in the user's district. In the example, the projection is performed with a least squares fit and linear projection. An alternative approach would involve multiplying a projection of pupils expected to pay tuition times a projection of the student tuition.

```
7746  TUITION
1746    1200    1300    1400    1600    1500    1800    2500    2700    3000
1746    3300
6746 9    1
```

Row 748: Transportation Fees. This would include money received for transporting pupils to and from school and related school activities. In the example, projection is made by a simple regression of historical transportation fees against historical enrollment, assuming a linear relationship. If the Enrollment Component has been executed, historical and projected enrollments can be referenced in the appropriate row. If the Enrollment Component has not been executed, historical and projected enrollments must be prepared and inserted in a prior row. An alternative approach would be to project transportation fees manually and enter the projected values in Row 748, using '1' cards.

```
7748  TRANSPORTATION FEES
1748    1800    2700    3600    3900    4600    5100   11000   13000   17500
6748 3 676
```

Row 750: Earnings on Investments. This would include Interest received on temporary or permanent investments in United States Treasury bills, notes, bonds, savings accounts, time certificates of deposit, mortgages, or other interest bearing obligations; dividends received on stocks; and capital gains realized from the sale of bonds or stocks. Earnings from these sources are best calculated manually and input by the user. In the example, the earnings for 1974 ($530,000) have been assumed to hold constant for all future years during the planning period.

```
7750  EARNINGS ON INVESTMENTS
1750   113000  169000  195000  189000  295000  350000  244000  205000  722000
1750  530000
6750 X 7505+      0
```

Row 752: Food Services. This would include money received for dispensing food to pupils, teachers, and administrators. In the example, the projection is made by a simple linear regression between historical food service revenues and enrollment. Alternatively, the forecast could be made by multiplying an estimated dollar amount per student times projected enrollment.

```
7752  FOOD SERVICES
1752  311000  390000  449000  596000  694000  703000  718000  840000  895000
6752 3 676
```

Row 754: Pupil Activities. This would include money received from school sponsored activities such as dances and football games, bookstore sales, memberships in pupil organizations, etc. In keeping with the previous row, the forecast in the example is by a simple linear regression between historical revenue data and enrollment.

```
7754  PUPIL ACTIVITIES
1754    82000  123000  141000  204000  257000  278000  346000  264000  424000
6754 3 676
```

Row 756: Other Local Revenues. Other revenues from local sources, such as rentals of school property, contributions and donations, sale and loss of fixed assets, and revenue for services provided to other districts, might be included here. In the example, the current amount is conservatively estimated to continue for each year of the planning period.

```
7756  OTHER LOCAL REVENUES
756     53000   62000   83000  117000  125000  196000  172000  233000  252000
756   200000
756 X 7565+      0
```

Rows 758, 760: Total Local Revenues. The amount of revenue expected from all local sources is calculated by adding the rows containing local revenue projections. In the example, a dummy row is required because more than ten categories of information are added together.

```
7758 DUMMY TOTAL LOCAL REVENUE
6758 X 736 738 740 742 744 746 748 750 752 754
                                                                     +++++++++
7760 TOTAL LOCAL REVENUE
6760 X 758 756
                                                                     +
```

5.3.2.1 Intermediate Sources of Revenue

The categories of revenue associated with intermediate, state, and federal levels of government are very similar to those outlined above. It is unlikely that a district would receive revenue from all of these sources. Most districts will receive the majority of their aid from state and local sources, with little or no revenue from an intermediate or federal source. This being the case, not all possible rows are presented in this section or the state and federal revenue sections. Instead, an explanation of each revenue source is given, followed by an example for an actual school district.

There are two general cases in which a school system may receive revenue from intermediate sources. The first is the situation in which the district is not a legal taxing entity and, therefore, derives its local support from the general revenue of the city or county. In this case, the city or county's general revenue will have to be forecast and the school district's share computed.

In the second case, the school system is a legal taxing entity but receives some of its revenue from the intermediate source either because of local legislation or because the district has delegated the tax collection function. In this situation, the collection/distribution function may be strictly a pass-through activity, or the intermediate source may exercise some discretion in the allocation of collected funds. If either case exists, the user must obtain a forecast of intermediate revenues for each year of the planning period.

Row 778: Intermediate Source Revenue. In the example, the school district receives revenue from only one intermediate source. Historical revenue from this source is entered in Row 778. It is projected by means of a regression against Row 692, the state utility assessment within the district.

```
7778 INTERMEDIATE SOURCE REVENUE
1778  161515    235863    287793    412087    562201    629246    753546    874492  1087608
6778 3 692
```

Row 780: Total Intermediate Source Revenue. All the intermediate revenue sources are totaled in Row 780. Since there is only one intermediate revenue source in the example, zeros are added to the data in Row 778 to arrive at a total in Row 780.

```
7780 TOTAL INTERMEDIATE SOURCE REVENUE
6780 X 778 +     0
```

5.3.2.2 State Revenue

Most state aid to education falls into one of four major categories: unrestricted grants-in-aid, restricted grants-in-aid, revenue in lieu of taxes, and revenues for or on behalf of the school system.

Unrestricted Grants-In-Aid. Unrestricted grants-in-aid are the primary source of revenue from state government. This category of assistance constitutes a substantial portion of most school systems' revenues. Approximately thirty-one percent of total school revenues came from unrestricted grants-in-aid provided by state governments in 1971-72. These unrestricted grants-in-aid are made by using one or more of five basic techniques for distributing funds. These techniques have been defined by the National Education Finance Project as follows: Flat Grants, Strayer-Haig-Mort, Percentage Equalization, Guaranteed Valuation on Tax Yield, and Complete State and Federal Support. Within each of these techniques there are so many variations that it is impractical to create a precise formula that would explicitly include all the variables. Moreover, a large amount of uncertainty characterizes the typical state legislature's activities in regard to state aid. In view of this complexity, the method for projecting unrestricted state grants-in-aid should be varied with each state. The example presents a simplified approach for those users unable to incorporate their particular legislative guidelines.

The average allocation per pupil is calculated for the past five or ten years and projected on the basis of the past trend. Then the projected ratio is multiplied times the projected enrollment to arrive at an estimate of projected revenue from state grants-in-aid. This method for projecting financial support does not, of course, account for the uncertainty associated with state legislation. The user is cautioned to view these projections with only the amount of certainty placed in the activities of the state legislature. If during the planning period the formula for distributing unrestricted grants-in-aid changes,the figures should be recalculated.

Restricted Grants-In-Aid. Restricted grants-in-aid at the state level include several categories of special purpose programs which include, but are not limited to:

Special or Exceptional Education Grants
Vocational Education Grants
Transportation Grants
School Housing Grants
Textbook, Library, Equipment, and Supply Grants
Driver Education Grants
School Lunch Grants

Individual school districts may or may not qualify for these programs, depending upon the special legislation; and when they do qualify, they may or may not apply for the funds. Revenues in this category must therefore be forecast by the user, based upon knowledge of the various grant programs and knowledge of the district's desires to participate in them.

Revenue in Lieu of Taxes. Revenue in lieu of taxes is revenues obtained from the state to compensate a school district for state owned property within the district on which Ad Valorem taxes are not paid. Revenues of this nature will vary with the amount and value of property owned or controlled by the state, the local tax rate, and the generosity of the legislature.

Revenues for or on Behalf of the School System. Revenues for or on behalf of the school system include any funds collected by the state on behalf of the system and "passed through" without redistribution. Payments to a pension fund or contribution of equipment or supplies would fall in this category.

Users should project state revenue in terms of the four categories outlined above. In the example, the school district projects its historical unrestricted grants-in-aid from the state, and five separate revenue sources under the restricted category.

In projecting the unrestricted grants-in-aid amount, the historical average state allocation per pupil has been calculated and entered in Row 806. These historical allocations have been graphed and a linear curve selected for future average values. The historical state unrestricted grants-in-aid received by the district are entered in Row 808. Future amounts are projected by multiplying the projected average allotment per pupil times the projected enrollment.

```
7806   AVERAGE STATE ALLOCATION PER PUPIL
1806    10025   13551   15638   17997   20778   23164   25822   28116   31075K
6806 9    1
```

```
7808  STATE GRANTS-IN-AID (UNRESTRICTED)
1808  861478 1214930 2361664 3034812 3851692 4142366 5604087 6162204 6497455
6808 X 806 676
                                                                     *
```

In the example, the district receives restricted grants-in-aid for transportation, exceptional pupils, text books, a vocational program, and food services. Transportation, exceptional pupil, textbook, and vocational aid have all been projected as a regression against projected enrollment. The last category, food services, is projected as a function of the local revenue received from the food service program by multiplying Row 752 times a constant factor (.0168) determined by the state. Total revenue expected from the state is calculated in Row 820 by adding Rows 808, 810, 812, 814, 816, and 818.

```
7810  TRANSPORTATION GRANT
1810  154217  197712  234983  259655  309070  416132  473498  469945  512123
6810 3 676
7812  EXCEPTIONAL PUPIL GRANT
1812    9364   10734   11627   13315   14475   15585   48500   50000   56500
6812 3 676
7814  TEXTBOOK GRANT
1814   79882   83135  110322  136958  172880  191630  224972  257254  296081
6814 3 676
7816  VOCATIONAL GRANT
1816    3800    4350    4875    5045    5134   17502   11169   19415   33785
6816 3 676
7818  FOOD SERVICE GRANT
1818       0       0       0       0       0       0       0       0   15139
6818 X 752 * 0168M
7820  TOTAL STATE SOURCE REVENUE
6820 X 808 810 812 814 816 818                                     +++++
```

5.3.2.3 Federal Revenue

At the federal level, the basic revenue categories are the same as at the state level. However, unrestricted grants-in-aid from the federal government are not a significant source of revenue, and the distinction between restricted and unrestricted grants-in-aid is mainly for accounting purposes. In most districts the revenue from federal sources represents such a small percentage of total school system revenues that there will usually be no need for a detailed breakdown. In those districts where the amount of federal aid is extremely small or variable, the user may want to estimate an overall amount and place it in the appropriate columns of Row 830. Those districts that choose to project federal revenue on a somewhat more rigorous basis can apply the same procedures used in projecting state grants-in-aid.

Revenue from the federal government is projected as a gross figure in the example, rather than being divided into separate categories. The historical average allocation of federal aid per pupil has been calculated and entered in Row 828. These historical allotments have been projected, using a linear curve.

```
7828  AVERAGE FEDERAL ALLOTMENT PER PUPIL
1828     875    1187    1430    1617    1950    2219    2413    2673   2967K
6828 9   1
```

The historical total federal revenues are entered in Row 830. These historical figures are projected by multiplying the projected average allotment per pupil times the projected enrollment.

```
7830  TOTAL FEDERAL SOURCE RENENUE
1830  74288 133775  201993 250488  217647  359683  587686  675679  623167
6830 X 828 676
                                                                *
```

Row 840: Non-Revenue Income. Income generated or to be generated from the sale of bonds is entered in Row 840. The historical income derived from the sale of bonds is entered as well as the income to be derived from future bond issues. Refer to Row 706 for the amount of future bond issues.

```
7840  NONREVENUE INCOME (BOND ISSUE SALES)
1840 1175978 2512237 3398717 3052411 2706306 4009003 5812504 3308258 2409401
1843 3000000      0      012000000      0      0      014000000      0
1840      0      0      0      0      0      0      0      0      0
```

Row 850: Total Revenue - All Sources. The total revenue from local intermediate, state, and federal sources and from the sale of bonds is calculated in Row 850 by adding Row 760, 780, 820, 830 and 840.

```
7850  TOTAL REVENUE FROM ALL SOURCES
2850 X 760 780 820 830 840                                    ++++
```

5.3.3 Expenditure Forecasting Module

The objective of the Expenditure Forecasting Module is to project expenditures that can be expected by the school district throughout the planning period. The forecasted expenditures are then compared to forecasted revenues to determine the district's cash flow.

Outputs from the Enrollment and Facility Components and the Capital Resources and Revenue Modules are required as input to the Expenditure Module. Therefore, it is assumed that considerable analysis will have been completed either manually or on the computer before the Expenditure Module is executed. If the preceding analysis has been executed manually, the data required by this module must be entered, using '1' cards.

This module can forecast expenditures by individual schools and accumulate district totals, or it can be used to forecast district totals directly. The example presented below forecasts total district-wide expenditures. The procedures have been set up to coincide with the Recommended Code of Account for Expenditures, established by the United States Office of Education. The following general categories are included: salaries and benefits, purchased services, supplies and materials, capital outlays, reduction of principal and interest, school housing authority obligations, dues and fees, and insurance and judgements. These categories and their associated sub-categories are defined in detail in Handbook II (Revised) of the State Educational Research and Reports Series, published by the United States Office of Education. Users are encouraged to redefine the categories, where necessary, so that they fit the district's code of accounts.*

*Referenced on following page.

For many categories, the school administrator can forecast expenditures by relating historical expenditure patterns to historical enrollment. This regression approach is recommended for projecting salaries, benefits, purchased services, and supplies and materials. Capital outlays will have to be projected separately, although a regression against historical enrollment may be appropriate for forecasting equipment, vehicle, and library book expenditures. These categories represent a condensed set of variables for analysis. If a more precise breakdown is desired, sub-classifications of these categories may be projected using the same general techniques.

For clarity and ease of calculation, the Expenditure Forecasting Module has been subdivided into three sections: operating expenditures, capital expenditures, and bond retirement expenditures. Totals are summed for each section and for the module as a whole.

---

*Expenditures are classified several ways in the United States Office of Education handbook. The classifications (referred to as dimensions) include:

A — Fund
B — Object
C — Function
D — Operational Unit
E — Program
F — Source of Funds
G — Fiscal Year
H — Instructional Organization
I — Job Classification Activity
J — Term
K — Special Cost Center

A school district may select whatever dimensions it believes desirable and adopt a chart of accounts accordingly by redefining rows. Some districts may want to prepare several versions of the Component, each in terms of a different dimension. The example is built around the B dimension — Object and the G dimension — Fiscal Year; the latter dimension is automatically included in the forecast nature of the System.

5.3.3.1 Operating Expenditures

The first item of expense to be forecast is teacher salaries which constitutes approximately eighty-five percent of the operating budget of most school districts. The projection method recommended here is that of relating teacher salaries to per capita income as projected by the United States Department of Commerce - Office of Business and Economic Research Statistics (OBERS). During the past decade, teacher salaries have risen more rapidly than per capita income. If this trend does not continue, a simple regression, as illustrated here, may overestimate future salaries. Local economic conditions and the national rate of inflation will, of course, impact the forecast. The user, therefore, should monitor the ratio between teacher salaries and the OBERS projection and change the projection curve accordingly in future runs.

An independent projection of per capita income may not be readily available to some users. If this is the case, Appendix E presents several alternatives for projecting teachers' salaries (Row 868) directly.

Row 864: OBERS Per Capita Income Projection. The user enters the current OBERS projection in the input lines of Row 864. All historical and forecasted years are filled.

```
7864  OBERS PER CAPITA INCOME PROJECTION
1864      3320    3450    3575    3675    3765    3776    3828    3980    4125
1864      4250    4380    4500    4700    4800    4950    5100    5250    5375
1864      5500    5640    5800    5950    6100    6200    6375    6500    6650
```

Row 866: Average Teacher Salaries. Historical data regarding the mean teacher salary should be entered in Row 866. Future average salaries are projected by a regression against the independent projection of per capita income. Some users may want to consider an exponential, rather than linear, regression.

```
7866  AVERAGE TEACHER SALARIES (MEAN)
1866      9187    7200    7618    8410    8800    9430   10400   11420   11860
6866 3 864
```

Row 868: Teacher Salaries (Expenditures). Historical data regarding total teacher salary expenditures should be entered in Row 868. The expenditures for future teacher salaries are projected by multiplying average teacher salary (Row 866) times the projected number of teachers. The user is reminded that the number of teachers projected in the Facility Component is the minimum number required to satisfy the user's input standards. (The standards here are the average number of classroom hours per week a teacher is available to teach and the number of classroom hours per week for each subject area.) The actual or expected number of teachers may be greater than the required number. Thus, the user may want to increase the projected number of teachers for each forecast year. This should be done after running the Facility Component and before executing the Fiscal Component. The other alternative is to project and enter the number of teachers manually.

```
7868  TEACHER SALARIES (EXPENDITURES)
1868 2442766 3035181 4108002 5600472 6846811 8057494 95068571104781912103316
6868 X 866 677                                                      *
```

Row 870: Total District Salary Expenditure. The historical data on total district salary expenditure is entered in Row 870. Total district salaries are considered to be a function of total teacher salaries and are projected by means of a regression against total teacher salaries (Row 868).

```
7870  TOTAL DISTRICT SALARY EXPENDITURE
1870 3372218 4154489 5918160 7990060 980285711476441131734731551226216940975
6870 3 868
```

Row 872: Benefits. The historical expenditures for employee benefits are entered into Row 872. They will consist of health, pension, and any other personnel related overhead costs. Employee benefits are projected by a simple regression against total district salaries.

```
7872  EMPLOYEE BENEFITS
1872   172427  211076  340153  612927  739709  940442 1042689 1206341 1331228
6872 3 870
```

In the example, Rows 874, 876 and 878 itemize and project additional district operating expenditures. The user may desire to project total operating expenditures as a function of total district salaries (Row 870) and employee benefits (Row 872). This approach may be advantageous if there are a large number of additional operating expenditure categories. Appendix E illustrates the alternative procedures.

Row 874: Purchased Supplies and Services. Historical data on purchased supplies and services is entered in Row 874. The user may want to project these expenditures separately. In the example, they have been combined and projected together by a regression against projected enrollment and projected teachers.

```
7874  PURCHASED SUPPLIES AND SERVICES
1874 1018422 1465774 1645027 2333200 2754000 3189000 4022000 4386000 5087000
6874 3 677 676
```

Row 876: Dues and Fees. School district historical due and fee expenditures are entered in Row 876. Here, dues and fees are projected by a regression against the projected number of teachers. In many cases, the expenditure for dues and fees will be so small that a manual projection may suffice.

```
7876  DUES AND FEES
1876      800     950    1040    1190    1314    1141     866     511    5779
6876 3 677
```

Row 878: Other Operating Expenditures. Historical miscellaneous operating expenditures are entered in Row 878 and a projection technique is selected. The forecasting procedure selected in the example is a regression against projected enrollment.

```
7878  OTHER OPERATING EXPENDITURES
1878   10435   11648   13476   15694   17302   19519   21987   23799   26173
6878 3 676
```

Row 880: Total Operating Expenditures. Total operating expenditures are calculated by summing Rows 870, 872, 874, 876, and 878.

```
7880  TOTAL OPERATING EXPENDITURES
6880 X 870 872 874 876 878                                          ++++
```

5.3.3.2 Capital Expenditures

After completion of the Facility Component, the user will have determined the district's need for additional facilities to house projected demand for educational services. Because of the impact of inflation on the construction industry, current costs cannot be used for estimating expenditures in future time periods. Future construction costs can be estimated by projecting a building cost index. This index is then used to forecast construction cost on a per square foot basis. The district's proposed new facilities (in square feet) are multiplied times the projected per square foot construction cost to arrive at estimated future construction expenditures.

Row 894: Building Cost Index. The easiest way to account for inflation is to obtain an independent cost index which has already been prepared. One such index is included in the Dodge Manual for Building Construction Pricing and Scheduling. The user must copy the figures into the appropriate year columns of Row 894, using '1' cards. For those users desiring to project the building cost index themselves, different methods are presented in Appendix E.

```
7894  BUILDING COST INDEX
1894     259     273     293     304     325     344     375     402     436
1894     467     489     504     515     523     530     537     544     551
1894     558     565     572     579     586     593     600     607     615
```

Row 896: Construction Cost per Square Foot. The current construction cost per square foot is entered into the current year position of Row 896. The example shows a current cost of $32 for 1974. This information is input by dividing 3200 by one hundred, which is initiated by a K in Column 77. The K must appear on both '1' cards. The procedure card uses the following formula to forecast building cost:

$$\frac{\text{Cost per Sq. Ft. (lagged one year)}}{\text{Building Cost Index (lagged one year)}} \times \text{Building Cost Index}$$

```
7896  CONSTRUCTION COST PER SQUARE FOOT
1896       0       3       0       0       0       0       0       0       0K
1896    3200                                                                K
6896 X 896J894J894                                                   /*
```

The first year, 1975 in the example, is projected by dividing the cost per square foot in the previous year by the building cost index, also lagged one year. This result is then multiplied by the building cost index of the year to be forecasted. The school building cost per square foot for 1975 would be calculated as follows:

$$\text{1975 School Construction Cost} = \frac{32}{467} \times 489$$

$$= .0685224 \times 489$$

$$= \$33.51 \text{ per square foot}$$

Row 898: Planned New Facilities. After running the Facility Component, the user will have projected the amount of classroom space needed in the future. If new facilities are to be built, the proposed square footage of these structures is entered into Row 898. The example indicates that 84,000 square feet of teaching space is planned to be added in 1976 and 146,000 square feet in 1980. Here, the '6' card is used to continue the last entered value (0) to the end of the planning period.

```
7898  PLANNED NEW FACILITIES
1898         0      0      0      0      0      0      0      0
1898         0      0  84000      0      0      0 146000      0      0
6898 X 898J+      0
```

Row 900: New Facility Capital Expenditures. The historical capital expenditures for buildings are entered in Row 900. If any capital expenditures for buildings are to be or have been made in the current year, this amount is entered into the current year position. Forecast years are left blank. The expenditure for planned new facilities is calculated by multiplying the square footage of the planned facilities (Row 898) times the cost per square foot for school buildings (Row 896) for each year in the planning period.

```
7900  NEW FACILITY CAPITAL EXPENDITURE
1900  9684007 1257058 4287124 4349835 2555433 5322931 8377321 5434234 4382624
6900 X 898 896
                                                                 *
```

Row 912: Land-Capital Expenditures. The historical expenditures for land are entered in Row 912. If the district plans to purchase land in the future, these planned expenditures are entered in the appropriate forecast years. The example illustrates planned expenditures of $150,000 in 1976 and $250,000 in 1980.

```
7912  LAND CAPITAL EXPENDITURE
1912   192676  336523  474964  247362  193505  623825  354663  237698  229373
1912         0      0 150000      0      0      0 250000      0
6912 X 912J+      0
```

Row 914: Equipment-Capital Expenditures. The capital expenditures for equipment are entered in Row 914. In the example, these expenditures are projected by a regression against projected enrollment.

```
7914  EQUIPMENT CAPITAL EXPENDITURE
1914    183762  268843  276741  549494  444996  810213 1069062  531321  643483
6914 3 676
```

Row 916: Vehicles - Capital Expenditures. Expenditures for vehicles are entered in Row 916. In the example, vehicle expenditures have been projected off line, since vehicle purchases are usually not made every year. Projected expenditures are entered for the appropriate years using '1' cards.

```
7916  VEHICLE CAPITAL EXPENDITURE
1916     66317  101395       0   67500  139620       0       0  418618       0
1916         0       0   85000       0       0   87000       0       0   89000
1916         0       0   94200       0       0   97000       0       0  100000
```

Row 918: Other Capital Expenditures. Miscellaneous capital expenditures are entered into Row 918 and a projection technique selected. A linear regression against time has been selected here to forecast other capital expenditures.

```
7918  OTHER CAPITAL EXPENDITURES
1918     12000   16500   17000   19000   22000   24000   25000   27000   28500
6918 9   1
```

Row 920: Total Capital Expenditures. The total capital expenditures are calculated by adding building (Row 900), land (Row 912), equipment (Row 914), vehicles (Row 916), and other capital expenditures (Row 918).

```
7920  TOTAL CAPITA EXPENDITURES
6920 X 900 912 914 916 918                                          ++++
```

Row 926: Total Payments on Principal. Total payments on principal are projected by adding historical and scheduled payments (Row 696) to the forecasted payments on planned bond issues (Row 708).

```
7926  TOTAL PAYMENTS ON PRINCIPAL
6926 X 696 708                                                      +
```

Row 928: Total Payments on Interest. Total payments on interest are projected by adding historical and scheduled interest payments (Row 698) to the projected interest payments on planned bond issues (Row 712).

```
7928  TOTAL PAYMENTS ON INTEREST
6928 X 698 712                                                       +
```

Row 930: Total Debt Service Expenditures. Total debt service is calculated by adding total payments on principal (Row 926) and total payments on interest (Row 928).

```
7930  TOTAL DEBT SERVICE EXPENDITURES
6930 X 926 928                                                       +
```

Row 940: Total Disbursements. All expenditures are totaled in Row 940. This will include the district's projected outlays for operating expenses (Row 880), capital expenses (Row 920) and debt service expenditures (Row 930) for each year of the planning period.

```
7940  TOTAL DISBURSEMENTS
6940 X 930 920 880                                                   ++
```

Row 945: Cash Flow. The projected cash flow is determined by subtracting the district's total disbursements (Row 940) from its total revenues (Row 850) for each year of the planning period.

```
7945  CASH FLOW
6945 X 850 940                                                       -
```

Row 950: Balance. The district's balance for each historical year and the current year is entered in Row 950. Forecast years are left blank. The balance is projected by adding the cash flow (Row 945) to the previous year's balance. In the example, the balance is $2,656,000 in the current year. A negative cash flow in any year will draw down on the balance. A positive cash flow will add to the balance.

```
7950  BALANCE
1950 1150000 1000000 1900000 1654000 1700000 1800000 1800000 1900000 2210000
1950 2656000
6950 X 950 945                                                       +
```

5.4 Fiscal Analysis

Completion of the procedures outlined in Section 5.3 will result in an initial forecast of the district's total revenues, expenditures, and resulting cash flow. Whether the initial cash flow is positive or negative, the user is encouraged to repeat the component procedures in order to examine the impact of various alternative plans and policies. Even if the cash flow remains positive throughout the planning period, substantial savings may be realized by implementing an alternative plan of school closings, openings, debt retirement, or other variables which affect the district's fiscal situation. These alternative plans should be examined by rerunning the System.

If the reiterated cash flow is positive throughout the planning period and there are no planned bond issues, the only further analysis necessary is the possibility of a tax reduction. If the cash flow is positive and a bond issue is planned, then the projected bond payments can be met.

Capital expenditures may be paid out of current revenue or they may be paid through a bond issue. If an initial run results in a negative cash flow because capital expenditures were paid out of current revenue, possible bond issues should be considered in subsequent system iterations. If a bond issue is not required, these expenditures are to be entered as capital expenses in the Expenditure Module.

If the cash flow is negative during any of the years of the planning period, changes in either expenditures or revenues must be made. For example, a tax increase, a decrease in services, or a change in standards such as class size might be considered. Most of these changes will have an impact on the entire fiscal plan rather than only the one area changed. Moreover, these changes will, of course, affect other aspects of the educational program.

Much of the fiscal analysis associated with alternative proposals to close or construct specific buildings must be done manually Each proposal's marginal impact on revenues and costs will have to be determined "off-line" and then entered in the appropriate rows for separate runs of the System. The closing of a school may result in reduced operating costs because of lower utility, maintenance, insurance, and administrative overhead. These savings may be partially offset by increased school bussing requirements, demolition, or higher security costs. School district income might also be affected if the building and site are leased or sold.

The construction of a new building will have an equally diverse impact on operating, as well as capital, costs. New requirements must be established for changing light bulbs, maintaining parking lots, purchasing library books, and the hundreds of other necessary supply and service activities. More difficult will be the determination of additional staff necessary to meet custodial and administrative requirements. The difference in operating costs due to utility, transportation, and other factors may be important in deciding between building a new structure versus adding to an existing one.

Chapter 6: Geographic Component

The projected geographic distribution of children within a school district will have a significant impact on the designation of attendance area boundaries and on the selection of sites for school construction or closing. The Geographic Component presents two techniques to assist in making locational decisions. Each assumes that the geographic distribution of future enrollments has been previously estimated. The topics considered are boundary area analysis and site selection.

6.1 Overview

The Boundary Analysis Module uses detailed estimates of the school age population in small geographic subdivisions of the district to develop boundaries for the attendance areas of each of the district's schools. The boundaries are selected in such a way as to minimize the total distance traveled by students to and from their assigned schools. The basic program is entitled BOUND. It makes use of a previously written sub-routine to perform linear programming analysis. Special attention is directed to the issue of school integration with a second program that includes racial constraints. These constraints specify the maximum and minimum percent minority enrollment proposed for each school in the district. The constraints are established using the district-wide minority percentage, plus or minus a permissible variation from that percentage. The program that conducts this analysis is entitled RBOUND.

The second topic to be considered in this chapter is addressed by the Site Selection Module. Locational decisions involve a variety of subjective determinations, assessment of the effects of variability in the data; and numerous local considerations, such as land availability and transportation policy. Systematic procedures are outlined for developing and evaluating alternative sites in the long-range planning of school facilities. These procedures presuppose familiarity with much of the preceding analysis. The method of population projection is important, especially the potential variance in these projections. Projected space requirements, construction costs, and available resources must all have been previously reviewed. Finally the module makes use of the BOUND program in order to determine the student transporation "costs" associated with various options.

6.2 Boundary Analysis Module

Often school attendance boundaries are the result of tradition, neighborhood pride, and many other non-quantifiable factors. Each of these factors is important and should not be overlooked when applying the methods discussed below. The analytical techniques can assist in the determination of general attendance zones. They can not replace the administrator's task of preparing actual boundary lines in light of all planning and political factors. Several initial considerations are appropriate.

The first question to be resolved is the identification of criteria for designating attendance area boundaries. One of the strongest arguments for the neighborhood school concept is that it allows pupils to attend the school nearest their home. Thus one could determine whether a set of boundaries is "good" by totaling the distance traveled by each student to school each day. These service area boundaries could then be redrawn and the total distance traveled recalculated. If this second total was less than the first, one could reasonably argue that the second set of school attendance area boundaries was more desirable than the first. The Boundary Analysis Module is based on the assumption that total commuting distance is the major element in measuring the desirability of a set of boundaries.

At this point it is worthwhile noting that the concept of distance can be defined in various ways other than physical distance. An alternative would be that of monetary cost. If the cost of transporting each student to school could be estimated, similar calculations would indicate whether a second set of boundaries would be better than the first. Inherent in this definition is the difficult problem of consistently assigning one cost to a student who walks and another to a student who is bussed.

A third definition of distance is that of travel time. This concept accounts for the fact that though two students may live the same physical distance from school, one may take a route that has more traffic or obstructions. The use of travel time partially alleviates the problem of relating the cost of a student walking to the cost of one who is bussed.

A final concept that may deserve consideration in certain situations is that of preference. If each student or family was asked to rank preferences among the schools in the district (a low score being most desired), then the criterion could be to draw the boundaries in such a way that the total rating of the assigned schools was as small as possible. This approach might be useful in implementing an open enrollment policy. Under such a policy each school in the district would be open to all students as a matter of choice. Throughout the remainder of this section the term distance will refer to any of the concepts of distance or cost discussed above.

Having determined that a better set of boundaries is one which reduces the total distance between children and schools, the next question is what is the "best" set of boundaries? The word "best" as used here is a technical abstraction. It is defined only in terms of the selected distance criterion.

Each attendance zone must meet certain conditions. No set of boundaries may require a school to operate at a level above its capacity. Moreover, the attendance zones must cover the entire district. These two conditions will be referred to as constraints. The mathematical problem may now be stated precisely as follows: Assign students to schools in such a way that the following conditions are met:

1) Each school's enrollment does not exceed its capacity;
2) Each student is assigned to a school;
3) The total of the distances commuted daily by all students is a minimum.

Numbers 1 and 2 are called constraints, and Number 3 is called the objective.

Though the problem has now been stated precisely, it cannot be solved practically. In any reasonably sized district, the number of students would be so large that the problem would exceed available data collection and analysis resources. Therefore the problem must be approximated to reduce the amount of data required.

6.2.1 General Design of BOUND

A good approximation is to assume that students who live in the same geographic sub-area all live the same distance from a given school. Suppose that the entire district has been divided into compact geographic sub-areas or grids. Uniformity in the configuration of these grids greatly increases the ease of implementation as well as the accuracy of the model. The population center of each grid is called its centroid.

The problem of allocating students to schools is applicable to linear programming. This is an established technique for determining the optimal allocation of selected resources to meet a particular objective. As applied in this component the linear program produces a solution which will minimize the total distance traveled, however measured, by all students to their assigned schools.

The Boundary Analysis Module consists of a main program named BOUND and a sub-routine named SIMPLX.* It is the function of BOUND to read in data describing selected characteristics of the school district and to print the optimal solution to the transportation problem. Between these two functions BOUND calls SIMPLX which actually solves the problem. The manual version of the School Facility Planning System solves the same problem, using an approach known as the distribution or stepping-stone method. The problem will now be stated in mathematical symbols for those readers that are interested. Others may proceed directly to the procedures section.

Suppose a school district contains n schools and that it has been divided into m small areas or grids. Let p_i, $i=1,2,\ldots,m$, denote the anticipated school-age population of each of the m grids. Let c_j , $j=1,2,\ldots,n$, denote the capacity of each of the n schools. Let d_{ij} , $i=1,2,\ldots,m$, $j=1,2,\ldots,n$, denote the distance from the centroid of the ith grid to the jth school. Each of the values of p_i , c_j and d_{ij} must be estimated by the user.

These concepts are illustrated graphically in Figure 6-1 for a hypothetical district consisting of three schools and ten grids.

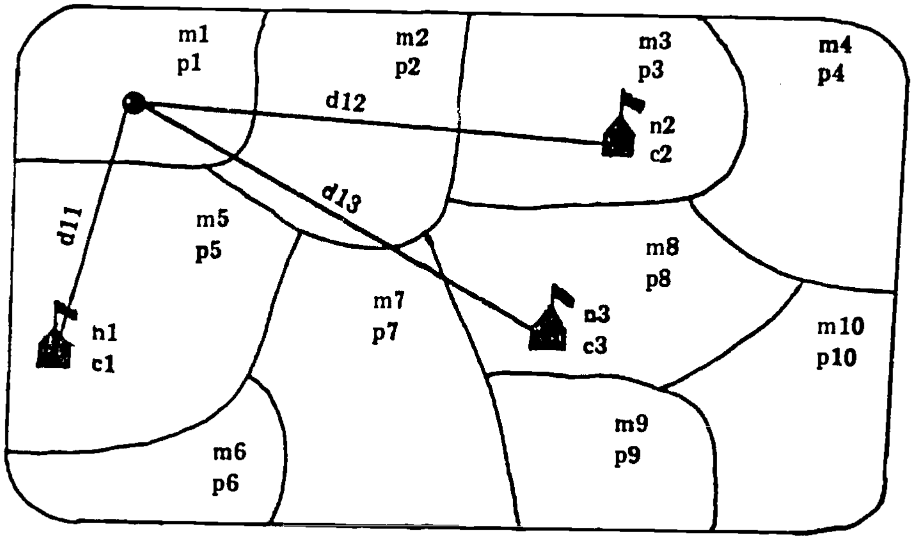


FIGURE 6—1 SCHOOL LOCATION AND GRID STRUCTURE FOR SAMPLE DISTRICT

Let x_{ij} , $i=1,2,\ldots,m$, $j=1,2,\ldots,n$ denote the number of students from grid i to be sent to school j. The values of x_{ij} are unknown. However, certain conditions on the x_{ij} are known.

(1) For any school j, the number of students attending may not exceed its capacity. Symbolically: $\sum_i x_{ij} \leq c_j$, for $j=1,2,\ldots,n$.

(2) For any grid i, the number of students sent from grid i, to all of the schools is equal to the population of that grid.

Symbolically: $\sum_j x_{ij} = p_i$ for $i=1,2,\ldots,m$.

(3) Since the product $d_{ij} \cdot x_{ij}$ is the total distance commuted by students from grid i to school j, $\sum_i \sum_j d_{ij} \cdot x_{ij}$ is the total distance commuted by students in the district. This sum is to be minimized.

In mathematical shorthand the problem is:

Find x_{ij}, $i=1,2\ldots,m$, $j=1,2,\ldots,n$ which

$$\begin{array}{llcll}
\text{minimizes} & \sum_i \sum_j d_{ij} & \cdot & x_{ij} & \\
\text{subject to} & \sum_i x_{ij} & \leq & c_j & \text{for } j=1,2,\ldots,n. \\
 & \sum_j x_{ij} & = & p_i & \text{for } i=1,2,\ldots,m. \\
 & x_{ij} & \geq & 0 & j=1,2,\ldots,n.
\end{array}$$

Such a problem is solvable (x_{ij} values can be found) using linear programming. As long as the total capacity of the schools ($\sum_j c_j$) is larger than the school-age population of the district ($\sum_i p_i$) a solution is known to exist.

6.2.2 General Design of RBOUND

Many school districts have recently been faced with the issue of racial desegregation. A conscious desegregation policy often requires that the percentage of minority students assigned to any school in the district be reflective of that minority's percentage of the population in the district as a whole. This translates generally into a goal that the percent minority in any school fall in the range of a certain number, plus or minus a permissible variance. As an example, a district with a thirty-one percent minority population might be required to insure that its minority enrollment in all schools was within ten percent of that figure. Thus every school would have a minority population between twenty-one percent (31 minus 10) and forty-one percent (31 plus 10).

The program BOUND, described in the previous section, has been modified to include racial constraints in a program called RBOUND. Like BOUND, RBOUND provides data to the sub-routine SIMPLX and prints the results that are obtained. The desegregation approach can also be stated in more mathematical language for those interested readers. Others may proceed to the procedures section.

Let the symbol B stand for the percent minority in the entire district (31% in the example above) and let the symbol V stand for the permitted variation between schools (10% in the example above). The percent minority in any school must fall between the limits B-V and B+V. In the previous discussion it was noted that the number of students in school j is $\sum_i x_{ij}$. If this number is multiplied by B-V, the number obtained, (B-V) $\sum_i x_{ij}$, is the minimum number of minority students permissible in school j. In similar fashion, (B+V)) $\sum_i x_{ij}$ is the largest number of minority students allowed in school j. This extension of the model must allow all of the previous constraints and in addition must insure that the number of minority students in each school falls between the limits above.

The number of minority students in each grid must be estimated. That number divided by the number of students in each grid provides the percent minority in each grid. The percent minority in grid i is denoted b_i. To calculate the number of minority students in school j, recall that x_{ij} is the number of students from grid i who are to be sent to school j. If they are sent in proportion to race, $b_i x_{ij}$ will be the number of minority students sent to school i from grid j. Summing over i, $\sum_i b_i x_{ij}$ is the number of minority students assigned to school j.

When the desired minimum and maximum minority student limits are applied, it is seen that for each school two inequalities must be satisfied:

$$\sum_i b_i x_{ij} \geqslant (B-V) \sum_i x_{ij} \text{ and } \sum_i b_i x_{ij} \leqslant (B+V) \sum_i x_{ij}$$

6.2.3 Boundary Analysis Procedures

The assignment of students to schools using BOUND or RBOUND requires three general tasks: The collection and/or estimation of data, the preparation of input cards, and the actual designation of attendance zone boundaries.

1. Data Collection. Three kinds of information must be assembled:

Enrollment. Projected student enrollment must be collected by small areas or grids, and by grade organization throughout the district. Techniques for making projections by area and grid organization are described in Chapter 3, Enrollment Component. It should be noted that the model minimizes transportation distance for a particular year. Therefore, when attendance areas are being established to last for more than a year or when a site is being selected, repeating the procedures for different years may be appropriate to account for the anticipated change in projected enrollments.

School Capacity. The ability of each school within a grade organization to accomodate students must be determined. This will have been calculated in Chapter 4, Facility Component. Capacity is measured in terms of potential students that could be housed, given the physical school space and the district's space standards.

Distance. The distance from the approximate center of population of each area to each school must be measured in either time, miles, or travel expense. The user should decide which measure of distance is most suitable. For example, a school district which covers a large geographic area and contains one or more highways might show large distances between various residential locations and schools within the district, but, because of the highways, might be characterized by travel times well within acceptable limits. Such a district should consider measuring in travel time as opposed to physical distance. If the user chooses to calculate distance in mileage, the measurement should be done using a street map to determine the mileage over the most direct street route as opposed to straight line distances from each grid to each school.

Minority Data. If racial balance is to be one of the criteria in designating attendance areas, two additional types of information must be determined: An estimate of minority population per grid, and the upper and lower minority percent limits to be allowed by school.

To illustrate these procedures the following example of an elementary school system is presented. The district has been divided into ten grids (n=10). It has five schools (m=5). The distances from each grid to each school have been calculated as shown in Figure 6-2.

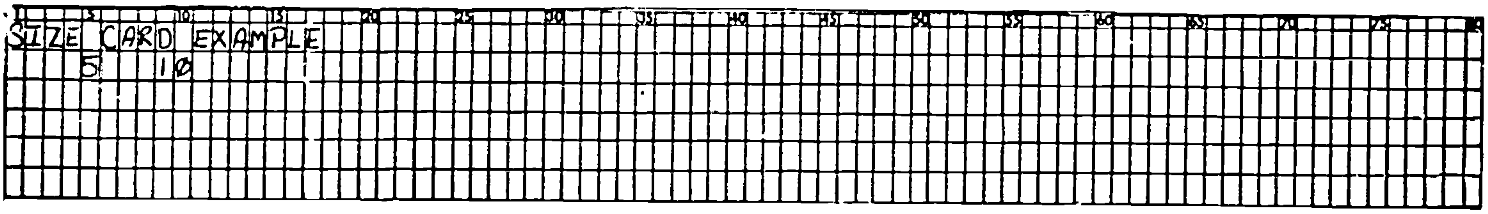
The elementary students have been projected by grid and placed in the far right column. The capacity of each school has been determined and placed in the bottom row.

FIGURE 6–2 SAMPLE DISTANCE MATRIX

Grids	Schools 1	2	3	4	5	Projected Enrollment by Grid
1	4	5	3	2	1	100
2	2	3	4	4	5	200
3	3	2	1	2	3	300
4	4	5	1	2	3	200
5	4	5	5	1	1	300
6	2	3	4	5	2	200
7	1	3	4	5	3	150
8	2	1	2	3	4	250
9	5	1	2	3	4	200
10	5	5	1	1	2	300
Enrollment Capacity by School	400	500	500	300	600	2200 2300

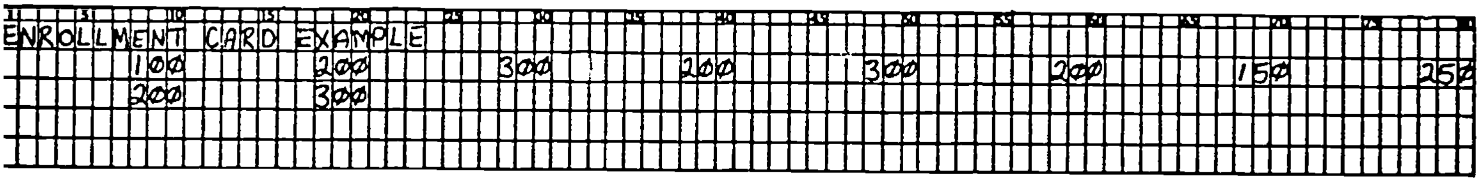
2. Input Card Preparation. This data must be converted to punch cards according to the formatting rules that are provided in Appendix A. BOUND requires four types of input cards as illustrated below. The actual number of cards required will vary with the scope of the problem. The example presented above would require eleven cards.

   Size Card. The first card records the number of schools in the grade organization that is being analyzed, (Columns 4-5), and the number of areas or grids for which enrollment will be estimated (Columns 8-10).



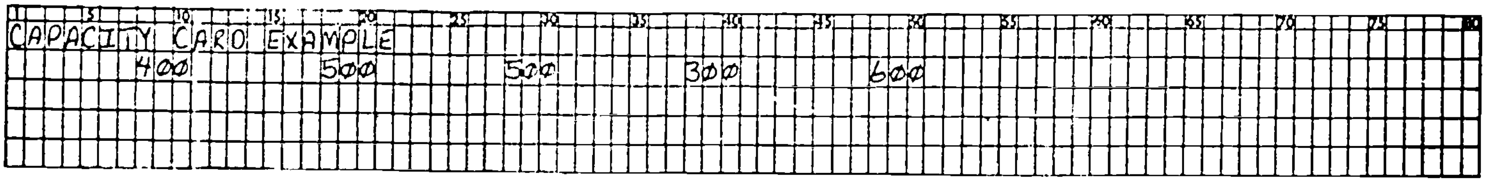
SIZE CARD EXAMPLE
5 10

   Enrollment Card. The next card type records the enrollment per grid. As many as eight entries are permitted per card. Thus, two enrollment cards would be necessary to enter the student population associated with the example.



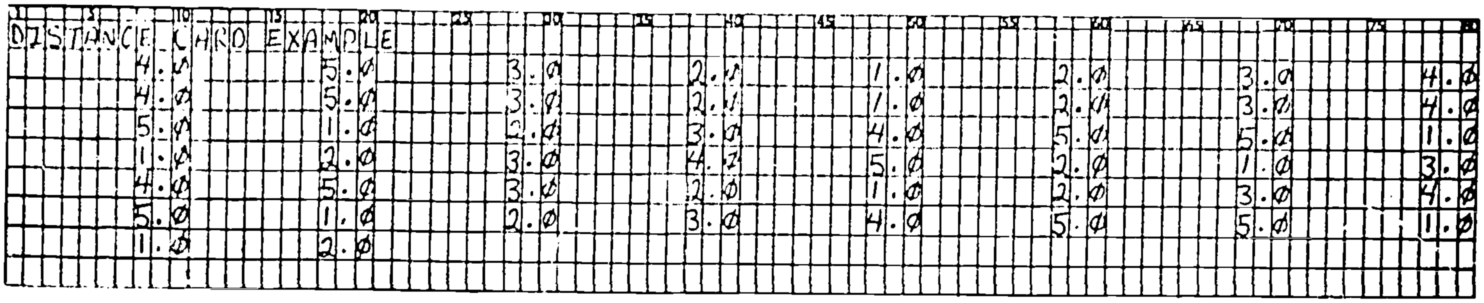
ENROLLMENT CARD EXAMPLE
100 200 300 200 300 200 150 250
200 300

Capacity Card. The school capacities are also punched with up to eight entries per card. As there are five schools in the example, only one card would be needed.



```
CAPACITY CARD EXAMPLE
       400       500       500       300       600
```

Distance Card. The final input required is the distance from every grid to every school. As there are five schools and ten grids in the present example, fifty distances must be entered. The distances to all schools from Grid 1 are listed first, followed by the distances to all schools from Grid 2, etc. Again eight entries are made per card. In the example, six full cards and one partially punched card would be necessary.



```
DISTANCE CARD EXAMPLE
       4.0       5.0       3.0       2.0       1.0       2.0       3.0       4.0
       4.0       5.0       3.0       2.0       1.0       2.0       3.0       4.0
       5.0       1.0       2.0       3.0       4.0       5.0       5.0       1.0
       1.0       2.0       3.0       4.0       5.0       2.0       1.0       3.0
       4.0       5.0       3.0       2.0       1.0       2.0       3.0       4.0
       5.0       1.0       2.0       3.0       4.0       5.0       5.0       1.0
       1.0       2.0
```

In order to run RBOUND, additional data must be determined and entered. Following the previous example, the minority population must be estimated for each of the grids. Suppose that these populations were estimated as reflected in the second row of Figure 6-3. The third row contains the previously determined student population data by grid. The fourth row is developed by dividing the second row by the third row. These fourth row percentages are input to RBOUND.

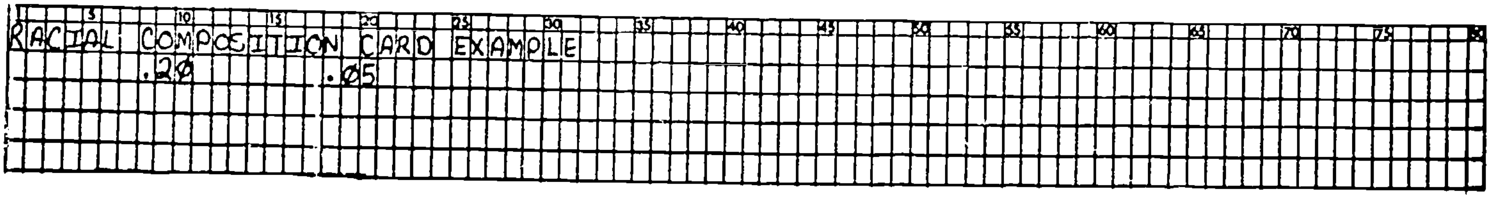
FIGURE 6—3 ESTIMATED MINORITY POPULATION

1. Grid	1	2	3	4	5	6	7	8	9	10
2. Minority Population	5	40	30	50	15	20	45	125	80	30
3. Total Population	100	200	300	200	300	200	150	250	200	300
4. Percent Minority	.05	.20	.10	.25	.05	.10	.30	.50	.40	.10

It is evident from the figure that the total minority population of the district is 440 while the total population is 2200. Thus the minority percentage of the district as a whole is twenty percent (B=.20). Assume in the example that the school board has established a policy that each school contain a minority enrollment between fifteen percent and twenty-five percent (V=.05).

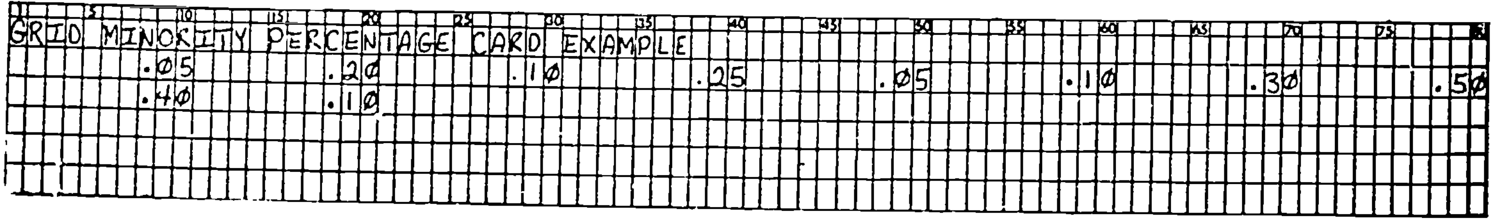
Input to RBOUND for this example would consist of the eleven cards already prepared for BOUND, followed by three more cards:

Racial Composition Card. The minority student population as a percentage of total student population is entered first (Columns 8-10), followed by the percentage that any one school is allowed to vary from this figure (Columns 18-20). Both entries must be in decimal form.



```
RACIAL COMPOSITION CARD EXAMPLE
       .20       .05
```

Grid Minority Percentage Card. The minority fractions per grid are punched, with the decimal point, in groups of eight per card. Two cards are required to enter data for the ten grids in this example.



```
GRID MINORITY PERCENTAGE CARD EXAMPLE
       .05       .20       .10       .25       .05       .10       .30       .50
       .40       .10
```

Some consideration of problem size must be made prior to running the programs. The amount of storage required by BOUND and RBOUND will vary with the size of the problem to be solved. In certain instances it will be necessary to vary the dimensions of the problem to permit the solution of larger problems. The exact amount of storage required is a function of both m, the number of schools, and n, the number of grids, as specified in Appendix B.

3. Boundary Identification. The printout will indicate which students should be assigned to which schools in order to minimize the total distance traveled. In most cases all the students in a given grid will be assigned to one school. However, in some instances the grid enrollment must be divided among schools. This division should be made judgmentally so that the appropriate proportion of students within the grid is assigned to the correct schools, while at the same time selecting natural or reasonable boundaries. One approach is to assume an equal yield of students per dwelling, and then to allocate residential blocks to schools using a land use map or aerial photograph. If more detailed information is available concerning the distribution of students within the grid, it should, of course, be used.

The final task is to adjust the attendance boundaries so that natural division lines are respected. Thus highways, railroad tracks, creeks, and other man-made or natural features should be selected that are located as close as possible to the grid boundaries. This process will depend on the knowledge and judgement of the user rather than on any mechanical procedures. It will be simplified if the areas or grids were initially defined using natural, instead of arbitrary, boundaries.

6.3 Site Selection Module

A basic assumption of the Boundary Analysis Module is that the number and location of schools operating in the district are known. However, the question of which schools should be opened or premitted to remain open is often a more fundamental question. This locational issue is critical to school facility planning. It must be answered prior to determining the boundaries of attendance zones. The objective of the Site Selection Module is to provide some guidance in decisions of this nature. It should be noted that the topic of site selection has only recently been examined by individuals skilled in operations research and management science. Typical of the recent literature on this topic is the study performed by Fred L. Hall for the SIMU School Project.*

The School Facility Planning Project sets aside sophisticated programming techniques in favor of a more heuristic application of the methods developed in the preceeding sections. This approach consists of developing a number of school construction and/or closing options, and then evaluating the cost of each strategy, using the methods discussed elsewhere in this report. Student transportation cost is, of course, only one of many factors to be considered in the site selection process. Others have been identified in Chapter 8.

6.3.1 School Closing Procedures

In situations where projected enrollment decline will permit the closing of one or more schools, a variety of concerns must be addressed. The functional obsolescence, operating expenses, proximity to other schools, potential alternative uses, and neighborhood concerns must all be examined. However, where consideration of these factors fails to produce a single best school closing site, the total transportation distance required of all students, given each school closing alternative, may be worth reviewing.

The procedures are the same as those described in Section 6.2. Simply eliminate one of the potential school closing sites from the original distance matrix (See Figure 6-2), and make the necessary changes on the input cards. Run the program and note the minimum feasible total distance traveled by students to the existing schools. Then beginning with the original distance matrix, remove an alternative potential closing site and follow the procedures for determining the optimal distribution of students given that configuration of remaining schools. Record the total distance traveled.

Comparison of the total distances traveled under each alternative school closing will reveal which school should be closed in order to minimize the distance traveled by students. This "best" alternative should then be weighed against other evaluation criteria before the final site is selected.

To be conducted properly the analysis should be run for that year in the planning period that is designated as the decision focus. The proposed closing/construction site that minimizes student travel distance for next year, may be far from an optimal solution five or ten years into the future. This potential disparity will necessitate a decision regarding the appropriate year in the planning period for which to design. Review of Chapter 1, Section 1.4, will assist in selecting this time frame. Alternatively, runs can be made for all facility plan options and for all years of the planning period. Then the cost of transportation could be summed for all years, thereby determining the total transportation cost associated with each option over the planning period. In terms of transportation criteria alone, that school should be closed which BOUND indicates would be least utilized under an optimal assignment of students.

6.3.2 School Construction Procedures

In cases demanding the construction of new facilities, a similar approach will apply. A finite number of potential school sites will usually be available. If none of these sites is an obvious choice on the basis of the school and construction requirements, travel distance considerations may be appropriate.

The same procedures will determine which new site will minimize combined distance traveled by students to school. Choose any new site and add it to the original distance matrix along with the distances from each grid to that site. Assign the maximum feasible enrollment capacity to the new school as determined by construction costs, site size, availability of funds, and other factors. Modify the input cards and run the program.

If the optimal solution assigns a number of students to the new site substantially less than the school's maximum capacity, then the capacity of the new site could be reduced with no change in the optimal solution Calculate the total distance traveled under the enrollment distribution. Repeat this procedure with a second new site and record the new total distance traveled. Once this has been done for all potential new sites, they may be ranked according to total distances traveled by students. The resulting transportation cost estimates can be used, along with enrollment capacity requirements determined for each new site, in determining the most appropriate location.

Some users may be able to devise an approach whereby the total transportation cost associated with each plan option is added to the total operating and construction cost. In the absence of other considerations, that plan with the smallest total cost will then be selected as the best course of action. This process will require weighing the relative importance of personnel versus capital costs, a task that will demand concensus on the part of all those involved in the district's planning.

6.4 Analysis

From the mathematical standpoint, both BOUND and RBOUND are guaranteed to develop eventually the optimal solution for the data presented. The validity of that solution, however, depends on more than the proper functioning of the program. Various sources of possible error exist in the formulation of the problem.

6.4.1 Sources of Error

For the sake of simplicity, students must be projected in terms of geographic subdivisions of the district as a whole. The method of drawing these small areas or grids is important if potential error is to be limited. The effect of the grid or cluster approach is to assume that all students in the grid live approximately the same distance from a given school. Clearly when a grid is drawn in such a way that it is long and narrow, this assumption will not be reasonable. For this reason, grids should be made as compact and small as possible, within the constraints of data collection and computer size.

A second source of potential error arises in the method of designating grid-school distances. The rule to follow is to assign the distance from the center of population in the grid, not from the geographic center of the grid. Special care should be taken for grids that include portions of sparsely populated areas, such as parks and business districts.

Still another source of error may derive from the technique used to assign distance. As previously noted, a measurement of straight line or "crow-flight" distance on the map may be misleading. Instead, the most likely travel route should be considered, with allowance made for time delays such as would occur in congested areas or slow zones. Some users will want to attempt calculating the transportation costs of maintaining and operating a fleet of buses, and the "good will" cost of requiring students to walk substantial distances to their assigned schools.

Finally, the dangers of basing plans on uncertain population forecasts must be recognized. Even when projections can be made on a district-wide basis with tolerable accuracy, attempts to disaggregate these forecasts to small areas or grids may be extremely unreliable. Such uncertainty should discourage assigning too much weight to planning strategies that are based on very long-range projections of student geographic distribution.

No attempt has been made to assess the quantitative effects associated with each of the above sources of error. In the final analysis, however, the school administrator's assessment of the realism of the results generated should prevail over numerical accuracy. Users are encouraged to experiment with various concepts of distance and cost to arrive at a realistic estimate of total cost in the district.

6.4.2 Data Considerations

Beyond the basic definition of grid boundaries and distance tables, the school district administrator may wish to introduce additional local constraints that prevail in the district. A number of "tricks" in formulating the input data will make this possible. However, such variations as outlined below should be conducted with caution. Because the input data will be fictitious, the final estimate of total cost will be wrong, and hence subject to misinterpretation.

<u>Barriers.</u> Every school district is characterized by certain routes between students and schools that are either undesirable or impossible to travel. A trip that requires students to cross several railroad tracks or busy arterial streets, or to pass though an industrial or commercial zone will typically be discouraged by school board policy. Other paths between students and schools may be relatively short in straight line distance, but because of barriers

like a river or limited access highway may require considerably longer travel distances.

Impediments of this sort can be easily incorporated into the distance matrix. The user must remember simply to reflect the probable travel distance (or time or cost) between every grid and school, rather than the straight line distance. If, for any reason, it is decided that no students should be assigned from a given grid to a given school, this can be assured by designating an arbitrarily high distance for that square in the matrix. A statement to the effect that there are ninety-nine miles between a particular grid and school will effectively preclude any possible interaction between that grid and school.

Walking to School. Some districts may want to consider a policy whereby all children within a defined distance of a school are assigned to that school. This will be particularly appropriate where a district requires all students living within one mile of a school to walk, thereby reducing school bussing costs. This policy may not always be possible if, at the same time, the board does not desire to expand the capacity of a school and/or wants to minimize total student travel distance. However, the policy can be explicitly considered in formulating the distance matrix.

The specific policy must be geographically displayed on a map containing schools and grid boundaries. The simplest approach is to draw circles around each school whose radius is equal to the required walking distance. Each circle would have to be modified to account for any barriers of the type described above. All students falling inside a circle are then assigned to that school. In some instances the complete grid will be assigned. More often only a section of the grid will be affected, in which cases a proportionate estimate of grid enrollment will have to be made.

The total capacity of each school should then be reduced by the number of students assigned to that school. Similarly, where necessary, each grid must be reduced by the students designated to walk to a school. A revised distance matrix can then be prepared that reflects the remaining unused school capacity and unassigned students in each area. In situations where the complete school capacity is consumed by walking students, and/or the complete grid enrollment is assigned, each must be dropped from the new matrix. Once the input cards are prepared, the program can be run to determine the optimal allocation of non-walking students.

Equalizing Capacity. Occasionally the minimum travel distance solution will result in an allocation plan that badly underutilizes a given school. This will be especially true in situations where the district as a whole has considerable excess capacity or the population has shifted away from certain sections of the city. The school board may understandably identify some percentage of capacity below which no school is allowed to fall. The policy might be alternatively stated so that the range between the most utilized and the least utilized school never exceeded a certain amount.

The effect of this policy is to include an additional constraint to the allocation problem. The constraint can be considered by altering the existing capacity of schools in the distance matrix, and recalculating the minimum travel distance solution. Thus, if the optimal solution achieved using actual school capacities revealed one or more schools to be severely under utilized while others were at or near capacity, an adjustment might be in order.

The difference between total capacity for all schools and total enrollments is the total excess capacity in the district. In situations where the possibility of school closings is to be considered, the site selection procedures should be used. If an equal distribution of excess capacity among all schools is desired, new fictitious capacities will have to be determined. The capacity of each school should be reduced by applying the percent of district-wide capacity attributable to that school against the total excess capacity. For example, Elementary School A with cmpacity for 400 students might constitute eight percent of the total elementary school capacity. If on a district-wide basis 1,200 seats of the 5,000 total capacity were considered excess, then the new capacity for school A would be designated as 304 students, or eight percent of 1,200 (96) subtracted from 400. School B with an actual capacity of 250 students would be recalculated to have a capacity of 190 students.

Execution of BOUND or RBOUND using the new school capacity figures will yield an optimal distribution of students within the guidelines that excess capacity be equally distributed among all schools.

Some problem constraints may be complicated to the extent that no modification of the input data will be sufficient to resolve the situation. Consider, for example, a policy that all minority students in a particualr grid be sent to a particular school, while all other students be assigned to the schools that would minimize total transportation distance. In this case, the constraint would require modifying the program RBOUND, rather than simply manipulating the input data.

6.4.3 Computer Size and Time

The final observation in this section concerns program size and time. The program BOUND was executed using the data of the example on the IBM 370 model 145 computer with 52K bytes of storage. It required less than fifteen seconds of execution time. But the speed of execution for this rather simple problem is misleading. For a medium-sized school district consisting of seven schools and thirty-eight grids, 100K bytes of memory were required and the program ran fifteen minutes to completion.

If the user has a larger problem and finds the time and storage excessive, there are several alternatives. One would involve running the problem at a data processing service bureau where the proprietary software is likely to include the most recent and efficient linear programming techniques. A second approach would be to program the "stepping stone" method discussed in the manual version of the User's Handbook. This method is much more efficient in both required memory and speed of execution but it is adaptable only to the problem solved by BOUND, and not to the more general problem. It could not be used to assign students to schools in districts where racial constraints were considered important.

Notes:

* SIMPLX is the name assigned to a program presented by Claude McMillan and Richard Gonzalez in Systems Analysis: A Computer Approach to Decision Models, Richard D. Irwin, Homewood,Illiniois, 1968. It executes the SIMPLEX algorithm as developed by Dr. George Dantzig in 1952.

* See Fred L. Hall, "A Preliminary Evaluation of an Optimizing Technique for Use in Selecting New School Locations" in Educational Facilities Planning in Chicago, Ashraf S. Mansi, Editor, Project SIMU School: Chicago Component, Chicago Public Schools, Chicago, Illinois, 1974. Hall has developed a model for determining locations for new schools by using the technique of integer programming. In terms of the previously discussed boundary area analysis techniques, Mr. Hall generalizes the model to introduce for each potential school a variable whose value will be either one or zero (it cannot be a fractional value). The value of this variable indicates whether a school is to be opened or not. The model is designed to optimize total travel time over the district. Though limited in approach, the model is an ambitious beginning toward a mathematically precise solution of the optimization problem.

Chapter 7: Project Organization

A school district should recognize the purpose and capabilities of the School Facility Planning System before deciding to use it. The System is designed to assist in the general analysis and formulation of a long-range school facility plan. This involves what the Council of Educational Facility Planner's Guide calls "the educational facilities survey" and "Master Plan." The System does not address that detailed planning which must precede the construction or remodeling of a specific building. Thus, any school district that has already made basic decisions as to desired school closings or school construction, and is now concerned with the implementation of such projects will have little use for this System.

The fundamental steps involved in any major long-range planning effort are reflected in Figure 7-1. The analytical components have been designed to assist school districts in the situation analysis and alternative plan preparation stages. Chapter 7 focuses on the preparatory activity that should precede actual use of the School Facility Planning System whenever a large scale project is desired.

7.1 Project Initiation

The idea to initiate development of a general school facilities plan may be derived from many sources. It may reflect recognition of a need on the part of a school superintendent, members of the school board, state officials, or citizens within the community.

It may often result from an immediate problem, such as a crowded school or a situation involving racial imbalance. No matter what the source of the idea, the successful project will be possible only if it is endorsed and supported by both the superintendent and the school board.

.2 Project Organization

The success of the project will depend directly on the people assigned to it, and the initial considerations given to its purpose. These factors are examined below:

7.2.1 Project Leader Designation

Once the project is initiated, the superintendent must provide overall guidance and remain informed as to the project status. Responsibility for the day-to-day operational control should usually be delegated to a high-level staff assistant, such as an assistant superintendent, or, in some of the larger districts, the chief school planner. In most cases the project leader should be a generalist, able to communicate with a variety of specialized individuals. Direct access to the superintendent is essential.

7.2.2 Study Guide Preparation

Working together, the project leader and the school superintendent must give initial thought to the kind of study that will be conducted—its breadth, depth, and overall emphasis. At a minimum, this initial preparation should include:

Statement of the Problem. A written description, in not more than two or three pages, of the problem. This might include identification of general concern for many aspects, or specific concern for erratic enrollment trends, an uncertain fiscal situation or some similar issue.

Review of Resources. Consideration must be given to the available talent, funding, and data. Potential individuals on the school staff, in professional planning agencies, and in the community at large should be considered in terms of their skill and available time. The available funding will, of course, determine the amount of data collection activity, data processing services, and professional consulting advice feasible. Conducting an overview of available data may require three or four days of local trips and telephone calls. The survey should include the extent to which school district information is already in machine readable form, or in such shape that it could easily be converted. It should reveal any previous studies which have been conducted and may still be partially relevant, and it should identify potentially useful analysis and projections as prepared by the local planning department, utility companies, Chambers of Commerce, and other community institutions.

Review Community Situation. The community served by the school district will possess a variety of educational concerns. While many of these will have little bearing on the facility planning process, nevertheless the study must be sensitive to these concerns and the way in which they might be affected by the study results. If the study focus involves questions of racial balance, potential bond issues, and/or potential school closings, careful attention must be directed to the establishment of policies for releasing information to the public. The community review should also identify potential leaders to participate in the study, either in a technical or general review capacity

The above considerations should all be made in light of the analysis that will be possible using the School Facility Planning System, and/or some similar techniques.* The severity of the problem, the available resources, and the overall community situation will, in large part, prescribe the type of analysis that is feasible and desirable.

A preliminary Study Guide should be developed that reflects these considerations. Consisting of not more than five or six pages, this report should provide preliminary suggestions as to the planning process which is believed appropriate. The report should contain initial recommendations regarding the following:

Manual or Computer-Based Version. A tentative recommendation regarding the use of the manual or computer-based version should be stated. This should be supported with a brief analysis of the probable effort required to implement each version. Attention should be directed to the possible additional benefits to be realized from the computer-based version in terms of accuracy, time saved and easy examination of alternative policies versus likely additional costs.

The Planning Horizon A tentative recommendation should be made as to the time period for which forecasts will be appropriate. Some districts may be satisfied with a five-year

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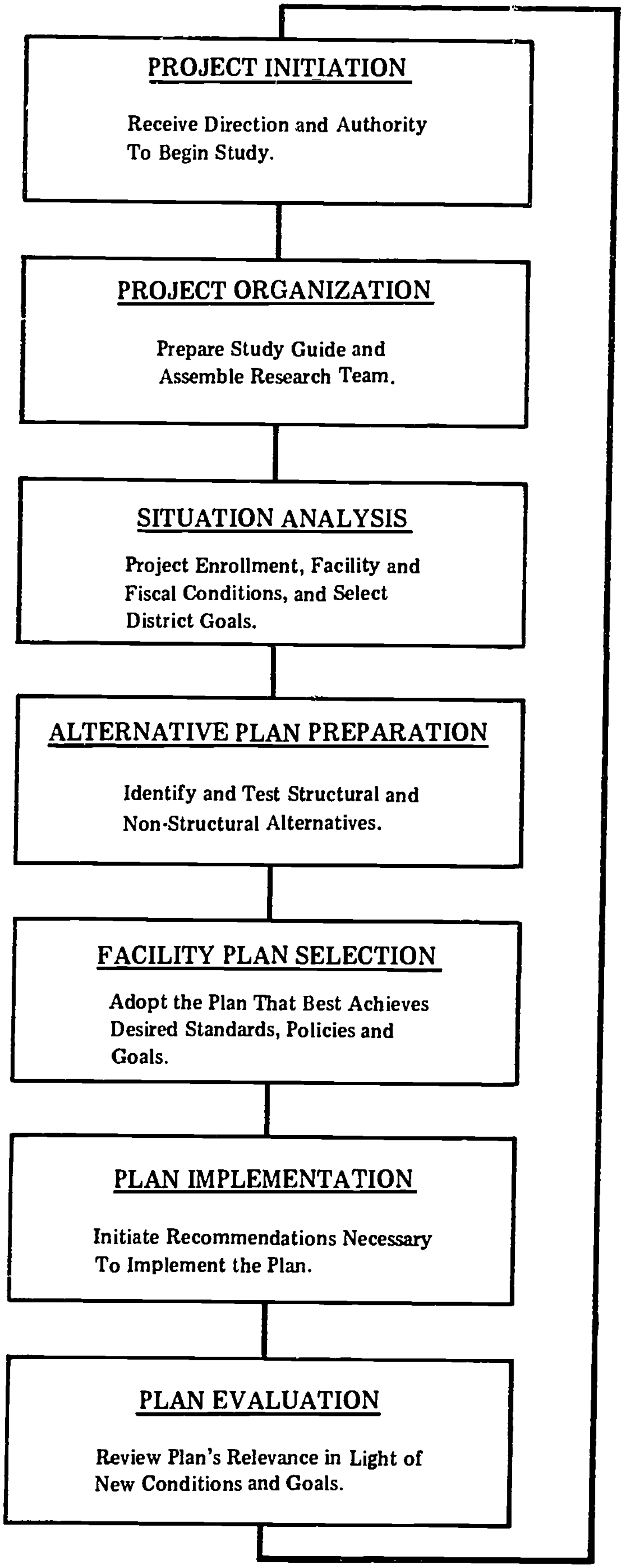
*Administrators possessing the resources for a major facilities study may want to consider using products developed under the SIMU School Project. Particular attention is directed to the ENSIM 1 and 2 programs developed in Santa Clara, California, and the EDPLAN projection programs developed in Dallas, Texas.

FIGURE 7–1 SCHOOL FACILITY PLANNING PROCESS



forecast, whereas others will want to analyze expected trends for a fifteen or twenty-year period. Considerations outlined in Chapter 1 as to the confidence placed in forecasts, and the costs of making forecasting mistakes must be reviewed.

System Components. Because the School Facility Planning System's components are modular, they may be implemented on an individual or collective basis. Those districts which do not perceive a problem in a given area, or which already have projections derived from independent analysis, may choose not to consider a given component.

Level of Analysis. Every component within the School Facility Planning System permits different levels of analysis. Enrollment projections can be made on a general district-wide basis, or for specific sub-areas by grade and racial composition. Similarly, the facility and financial analysis can be conducted at very general or specific levels. The study plan should attempt to identify that level of analysis considered appropriate.

It must be emphasized that any recommendations presented in the Study Guide should be made on a very preliminary basis, with the idea that they can be revised after the full study team has been selected and had a chance to conduct further research.

7.2.3 Assemble Research Team

Having given some initial thought to the focus and detail of the facility study, the superintendent will select and structure the study team.

Team Personnel. The size and composition of the research team will vary, depending upon the scope of the problems to be studied. Small districts that do not envision an in-depth study may be satisfied with only one or two participants. Larger districts undertaking a major comprehensive plan may desire a team of six or more individuals.

The degree to which each individual is involved will vary with the stage of the project. For example, individuals with demographic skills will probably expend most of their efforts before those individuals conducting the financial analysis. Nevertheless, it is best to identify all team members at the beginning of the project and to meet periodically on a group basis.

On most large studies, a professional community planner-architect is recommended. Such an individual should be capable of providing an independent perspective of probable long-range community development trends. In some school districts, this kind of individual may be available from the State Department of Education. In other districts, the services of a local public or private planning firm may be desirable.

Under the direction of the project leader, the research team's first assignment should be the examination and revision of the preliminary Study Guide.

Responsibilities. Research responsibilities should be assigned with careful attention to individual capabilities and the magnitude of the project. Responsibility must be assigned for each of the components that will be used.

1. Enrollment Forecast. To the extent possible this should be assigned to an individual with quantitative or statistical skills. He or she may be assisted by one or more individuals with some experience in long-range planning and the ability to consider alternative assumptions.
2. Existing Facility Inventory. If a detailed inventory is desired, a professional architect and engineer should be retained. This will be necessary if extensive consideration of the future adequacy of each building is to be made. Districts undertaking a less detailed inventory may assign a maintenance supervisor or other administrative staff member to the task.
3. Standards and Policies. This task should be undertaken by an individual familiar with the overall educational philosophy and curriculum plans in the district. Some school districts may want to establish a separate committee to develop or revise a district-wide organization plan which will yield this information.
4. Financial Analysis. Typically this will be conducted by the school business officer, perhaps assisted by a bond attorney or some other individual with financial experience.
5. Public Relations. Responsibility should be assigned to one individual for coordinating the release of information to the public. Poorly interpreted information or its untimely release can be damaging to a research effort; therefore this activity must be

closely controlled. Prudent communications planning can also result in building a sense of community awareness and support for the facility plan.

6. Data Collection. Some research projects may be of such magnitude that a separate team is needed for data collection.

Schedule. The school superintendent and board should establish a research schedule. A typical schedule may vary anywhere from four to twelve months in duration. The schedule should include anticipated completion dates of intermediate research phases and recommended release dates for selected research findings. In addition to these recommended deadlines, the schedule should provide for a routine meeting of the study group at least every three or four weeks.

Advisory Committee. In many districts, it will be advisable to supplement the research activities of the study team with a citizen's advisory committee. Depending upon the desires of the school superintendent and the board, such a committee can serve several purposes. Potential contributions include providing general project direction, establishing contacts with various community agencies, and formally endorsing the final school facilities plan. Some districts may engage the advisory committee in research activities; other districts will prefer that its role be limited to reviewing plans after they have been prepared by the staff.

The composition, responsibilities, and schedule of both the study team and any advisory committees must be incorporated into the revised Study Guide. This set of recommendations should then provide sufficient information to guide all research activities during subsequent months. The document need not be formal, but it should be reviewed and endorsed by both the superintendent and the school board. As such, it should clearly state the nature of the end-product which the board can expect. In some cases, this product will consist of the one plan which the study team considers best suited to accommodate future trends in the district. Other boards may prefer a series of alternative plans from which they can select.

There is no one best approach to the planning process. It must be tailored to the unique conditions that characterize a given school district. However, in most cases the successful school facilities plan will directly reflect the amount of thought and commitment devoted to the particular planning process by which it was developed.

Chapter 8: Planning Considerations

Previous chapters have outlined the mechanics of the School Facility Planning System and the considerations to be made in organizing a facility planning project. The purpose of this chapter is to assist the user in selected aspects of the planning process. The initial section suggests ideas to consider in the design or formulation of specific facility plans. The next section provides suggestions for conducting a background analysis and specifies data necessary to support the System. The final section outlines considerations to be made in re-running the System and revising the plan in subsequent years.

For some experienced administrators the chapter will be quite basic. Those concerned only with the specific system instructions, or those who have a distinct facility plan which they desire to test may wish to skim the material. On the other hand, those with less experience in facility planning or with no definite solution to their school situation in mind will probably find it helpful.

8.1 Plan Formulation

The steps that constitute the facility planning process have been reviewed in Chapter 7 "Project Organization." They include:

1. Project Initiation
2. Project Organization
3. Situation Analysis
4. Alternative Plan Preparation
5. Plan Selection
6. Plan Implementation
7. Plan Evaluation

The four major components that make up the School Facility Planning System have been developed to assist in analyzing a unique school district situation, and in the testing and evaluating that lead to the selection of a plan among several feasible alternatives. However, no component specifically addresses the procedures whereby alternative facility solutions are formulated. With few exceptions, this process cannot be reduced to a specific formula or series of discrete steps, but must depend on the judgement and intuition of the user.

8.1.1 Situation Analysis

Prior to discussing specific plan formulation considerations, it may be useful to review the nature of the facility planning problem. The school planner's assignment is not unlike that of many other public or private corporation planners. The first task is to project the demand for a product (in this case education), and then to translate that general demand into a set of specific requirements necessary to meet it.

The difference between required space and existing space (as estimated in the Facility Component) will represent a measure of the ability of the school district's existing facilities to accommodate expected future levels of demand. When the school capacity is anticipated to fall below projected demand, or when the projected demand is anticipated to fall far below existing capacity, a definitive facility plan will usually be required.

In most situations the school district will be presented with a substantial number of options. Some of these options imply significant investments or disinvestments in the school plant (e.g., the construction or abandonment of a school building). Other options may be termed "non-structural." Since the capacity of a school may be significantly altered by modifying district standards and policies, the actual building or closing of a facility should be only one of many choices to be considered.

8.1.2 Plan Design

When analysis of the local situation reveals that an unsatisfactory condition exists or is projected to exist, a series of potential solutions must be developed. No one approach is necessarily more correct than others in formulating these alternatives.

The challenge is to prepare a reasonable number of options that can be subjected to critical review by the staff, school board, and community. Typically, a range of alternatives should be sought that neither concentrates solely on the most expedient solutions nor focuses on too many "far out" alternatives which from a practical viewpoint could never succeed. The first approach may miss non-conventional, but potentially feasible solutions; the second approach will often be conducted at the cost of wasted time, false hopes, and increased frustration. Unfortunately, there is no way to generalize about the proper focus. Consideration of the twelve-month school year, a "school without walls," or a tax rate increase, for example, may be very legitimate options in some communities, while being completely unrealistic in others.

In general, those districts with the time to examine the trade-offs associated with a variety of different solutions will produce a better plan. At minimum, each solution should be evaluated in light of the following considerations:

— <u>Capacity</u>. The extent to which the solution is likely to accommodate projected enrollments while remaining within the school system's range of acceptable standards and policy criteria.

— <u>Existing Facilities</u>. The extent to which the solution makes the best possible use or reuse of the school system's existing physical plant.

— <u>Educational Philosophy</u>. The extent to which the solution meets the school board's and the community's goals, as reflected by the desired instructional program.

— <u>Financial Resources</u>. The extent to which the solution can be accomplished within operating and capital cost limits acceptable to the community.

— <u>Location</u>. The extent to which the solution meets the travel time. attendance area composition, and other geographic guidelines as desired by the local community and state or federal officials.

A list of the basic options to be considered in formulating alternative plans is outlined below. These options are presented for two different community situations, projected enrollment decline and projected enrollment growth.

8.1.2.1 Enrollment Decline-Surplus Space

School districts characterized by substantial surplus capacity should consider the following options:

- Revised allocation of students
- Improved educational facility standards
- Increased number of multi-purpose school facilities
- Increased number of community-oriented facilities within the school
- School closing

These alternatives can be examined individually or in combination with one another.

Revised Allocation of Students. A major concern of many school administrators confronted with surplus space is the geographic distribution of this space. The surplus space may be concentrated in different grade levels or may be limited to a certain geographic area within the school system. There may, in fact, be significant shortages of space in some areas even though the district has an overall excess of capacity. This is a relatively common phenomenon, especially in those school districts where residential development has occurred rapidly and unevenly. In these situations several options may be possible. Reassignment of certain classes from the crowded schools to the less crowded schools may be the simplest step. Selected high school classes, for example, might be required to meet in elementary school teaching spaces. Another approach would involve grade reorganization. In a district characterized by a surplus of elementary school space and a shortage of secondary space, reorganization from a K-6, 7-9, 10-12 system to a K-8, 9-12 system might be desirable. The impact of any hypothetical reorganization can, of course, be tested using the Facility Component.

If the problem is one of geographic distribution, with certain sections of the district having surplus space while other areas are over-crowded, then changing attendance boundaries may be desirable. Here the primary trade-off will be between less crowded facilities and potentially higher transportation costs as defined in terms of additional bussing requirements or student travel time. The Geographic Component should help the user consider the feasibility of new attendance boundaries and their accompanying cost implications.

Improved Educational Facility Standards. Surplus space within the school system may permit improvement of certain standards and policies. For example, a school system may be able to relax its current double or staggered sessions policy, or reduce the number of students per teaching space. In this situation it is important to examine the extent to which the excess space is evenly distributed for all types of space and to determine whether selected facility types are still in short supply. Thus, the opportunity may exist for the conversion of surplus educational space into needed laboratory or vocational educational facilities.

A decision to increase the amount of space per child will have implications for the school system's operating budget. In most cases a reduction of the number of children per teaching space implies a need for additional teachers. Janitorial, supply and other supporting services may also need to be expanded.

Increase the Number of Multi-Purpose School Rooms. Surplus space may allow a flexibility that was not previously possible. Teaching spaces may be used for study halls, student club rooms, special project rooms, and for various other student uses. Similarly, additional storage rooms, teachers' lounges, meeting rooms, and other spaces useful to the administration may become possible.

The advantages of this versatility must, of course, be evaluated in light of the ongoing overhead costs of these spaces as well as the cost of modernizing or rehabilitating them.

Increase the Number of Community-Oriented Facilities. School systems with considerable unused space may be in a position to serve the community in terms of more than just the education of children. Excess space may be appropriate for a variety of uses, such as senior citizen activities, day care centers, public interest group meetings, or even selected municipal functions such as libraries or health clinics.

Introducing this kind of mixed activity into an operating school raises questions about the effects on traffic, parking, and the educational environment. The use of surplus space for various community activities must not be allowed to interfere with the primary purpose — the education of students. Therefore, separate entrances, additional parking, and other such considerations must be carefully evaluated.

In situations where the community use of school facilities is possible, the issue of rent or fees must be considered. This will require an examination of the value of potential revenue if the going market price were to be charged versus the goodwill which might be obtained from a nominal rent or fee basis.

School Closing. When the surplus space within a school system reaches a certain level, the benefits associated with each of the above alternatives may be outweighed by the cost of maintaining one or more unnecessary schools. In such situations several difficult and interrelated questions must be addressed: How many schools to close; which schools to close; when to close them; and how to dispose of them?

How Many Schools to Close? The number of schools to be closed must be decided in light of many variables. These include:

—The amount of surplus space projected to exist and the user's confidence in that projection.

—The desired standards which are to apply to the remaining school space such as the maximum acceptable students per teaching space or square feet per student.

—The school's carrying costs in terms of both direct costs, such as insurance, maintenance, utilities, central administrative staff, and opportunity costs, such as potential sales revenue to the school system and the community benefits that could be realized if the school were converted to another use.

—The community concern associated with a school closing and the subsequent redrawing of attendance area boundaries.

Which Schools to Close? A related issue is the question of which schools to close. Each pertinent factor must be examined from the perspective of the school district and the overall community. Each existing school facility should be evaluated in terms of the following criteria:

—Structural conditions. What is the current condition of the building in terms of safety, usability, and amenities? What is the probability of significant problems, such as the need for a new furnace, major roof repairs, or other large scale maintenance costs?

—Structural flexibility. How readily could the building be modernized to serve alternative uses? Do the design and construction characteristics lend themselves to cost-effective rehabilitation?

— School operating costs. What are the current operating costs in terms of administrators, maintenance personnel, lighting and heating, and vandalism repair? Note that in deciding between closing two small schools versus one large school, the amount of space in question may be identical, but the associated operating costs may be quite different.

—School location. How will transportation times or distances and attendance area composition be affected by the school closing? Is the school in a neighborhood that is expected to have more, rather than fewer, children in future years?

—Site conditions: How much of an asset is the school site? What is its value as a recreation area, a neighborhood park, a community focal point? What potential does the site have for future school system needs?

—Immediate neighborhood concerns: How strongly do the neighboring citizens feel about the school? How would they react to alternative public or private uses?

—Land use flexibility: In light of zoning, access, surrounding activity, and available parking, how compatible would different uses be? Could the school be transformed to commercial or industrial use without causing major neighborhood disruption?

—Conversion potential: How easily could the school be converted to a new non-educational use given its facade, interior walls, and construction characteristics?

What demand for alternative uses exists in the area?

When to Close a School? The timing of any school closing is important. Consideration must be given to such factors as current and expected interest rates, rates of inflation, as well as the expected future characteristics of the immediately surrounding area.

Disposition. A fourth interrelated issue concerns the method selected for the disposition of a school. The school system must decide whether to sell, grant a long-term lease, or simply "mothball" an unnecessary school. This decision will be determined partly by the confidence the district has in its enrollment projections, and partly by its willingness to assume risks.

Once a decision to sell or lease the facility has been made, another issue will be that of price. The district may elect to maximize its revenue by selling to the highest bidder; it may choose to sell at a reasonable price to a worthy buyer; or it may donate the facility at a nominal fee or free. The district's fiscal situation and its community relations will have an important bearing on this decision. State laws pertaining to school district operations may also provide guidelines. Ultimately, the decision will be based on the costs of keeping the facility. Unlike a commercial or industrial property, carrying costs will not include local taxes. However, even if the school is boarded up, thus eliminating most utility and administrative costs, there will still be insurance, security, and outside maintenance requirements. Moreover, the carrying costs must be considered from the perspective of the community as well as the school district. A vacated school building may constitute a fire hazard or a blighting influence in the neighborhood. Finally, the costs in opportunity of not transforming the land and structure into some other use must be examined.

8.1.2.2 Enrollment Growth-Space Shortage

In those communities that continue to be characterized by enrollment growth, a different problem exists. While the issue is that of obtaining more space rather than eliminating excess space, many of the same questions must be resolved. A check list of considerations similar to those necessary in an enrollment decline situation is offered.

Revised Student Allocation. The first step should be to examine all schools throughout the system. A capacity shortage in one geographic area of the district or at one grade level in the district may be resolved through the reassignment of selected classes to a different school, reorganization of the grade groupings, and/or the redefinition of attendance boundaries.

The first solution may be the easiest but often the least satisfactory. Assigning selected elementary classes to a secondary school, or vice versa, may cause an important loss of school identity. The decision to reorganize the grade organization may be controversial and expensive. Converting a given school building from elementary to secondary purposes will probably require some new facilities, equipment, and support personnel. A third solution is a change in attendance boundaries. Longer student travel times or distances may require additional busses and drivers, not to mention parental cooperation. Though none of these solutions may be desirable, each should be explored.

Relaxed Educational Facility Standards. As previously observed, a greater number of children can be placed in a given school building simply by relaxing the space standards or changing the sessions policy. Thus, a decision to allow more children per teaching space (or less square footage per child) or a more intensive session policy, such as a staggered or double session, or a twelve-month school year, might be considered. This option may have particular appeal in those districts characterized by a projected enrollment wave or bulge in selected grades, followed by subsequent enrollment declines.

In secondary school situations the problem may be partially relieved through the introduction of new instructional programs, such as work-study, "schools without walls," or some other activity that allows students to operate outside the building. Of course, these programs should be evaluated first on their instructional merit, and only then in terms of their space implications. In considering those implications, the user must be careful to examine whether the space requirements will be lowered throughout the school day, or only at certain times of the day. A work-study program that operates only during the afternoon may not represent a feasible solution.

Limit the Non-teaching Spaces Within the School. A third approach for accommodating increased enrollment would be an increase in the number of teaching stations and a decrease in the amount of space not used for actual teaching purposes. Thus, space previously used for study halls, meeting rooms, lounges, etc., by school personnel, and space used for non-student purposes would be reduced. Such activities would be required to locate elsewhere. This policy would, in effect, increase the school utilization rate, and hence the actual capacity of the school system.

Provide More Physical Space. If the above "non-structural" solutions appear inadequate, the provision of more physical space will become necessary. Again, several interrelated issues must be resolved: How much additional space, where, and what type?

How Much Additional Space? When a shortage of space exists, the question of how much capacity to provide must be addressed in a slightly different fashion than in the excess space situation. In the case of the potential school closings, one school is closed or two schools are closed, but rarely one and one-half schools. In most school growth situations a more continuous range of possibilities exists. Whether defined in terms of teaching spaces or square feet, a new school can be built in almost any size.

The amount of space necessary will depend upon the district's projected enrollment, desired standards and policies, current fiscal burden, and the degree to which the community is willing to shoulder any additional fiscal commitments.

Locating New Space. Where to locate new space will depend on the magnitude of the space problem and a variety of existing community conditions. At a minimum the following five options should be considered:

— Rehabilitation: In some situations the relatively simple process of school modernization will transform previously inadequate space into useful space. Rehabilitation is particularly recommended where a moderate rise in enrollment is anticipated on a temporary basis.

— Found Space: Existing vacant structures are proving to be useful, low-cost solutions. Store fronts, vacant office buildings, warehouses, supermarkets, or old train stations constitute just a fraction of the possible resources that may exist.

— Expansion of Existing School: The addition of several classrooms, a new wing, or new special facilities may be a solution. In this context mobile classrooms may be appropriate. The advantages of expanding an existing school are several: the availability of land, the availability of basic facilities such as office space, parking, or a gymnasium, and the availability of administrative staff. These advantages will, of course, have to be evaluated in light of the probable impact on the school site (especially recreation facilities and adjacent land uses) and the total school size. If the existing school is not well situated considering the geographic distribution of projected enrollments, the impact on transportation costs should be examined.

— New School on an Existing School Site: A variation to expanding existing schools is the building of a second school on the same site. This may provide the advantage of having a unique school on existing school land, with easy access to facilities in the adjacent school. This solution will require a relatively large site and may be more costly than expanding existing facilities. It may also suffer from the same locational shortcomings described before.

— New School on a Separate Site: Traditionally, the most common method of alleviating a severe shortage of space has been the construction of a new school on a separate site. Because of the ability to select a site that meets the needs of the new school, this approach may have more flexibility than others. However, the basic questions remain to be answered: how large a school, in what location, and when.

Construction Type. The construction and the level of amenities will also have to be considered. Materials, landscaping, air conditioning, carpeting, and the many other decisions that go into a new building will depend principally on the school board's philosophy of education and financial situation. These decisions should also be influenced by the confidence surrounding the enrollment and fiscal projections. Where the school board is committed to the construction of traditional school buildings, characterized by rigid design and high quality materials, decisions should be based on forecasts with a great degree of associated certainty. On the other hand, where the school board and community are prepared to build flexible facilities that could be easily transformed to another use or demolished without great cost, less certainty in the enrollment and fiscal projections may be necessary.

In communities that are characterized by great uncertainty as to future conditions, mobile classrooms may provide a solution. While not always a panacea, as they have occasionally been promoted, mobile units can provide a flexible and relatively inexpensive supplement to existing facilities. Of course, potential building code restrictions, visual disharmony, limited internal versatility, maintenance problems, and other potential shortcomings may offset the advantages of this approach.

All of the above analysis will have to be made with an awareness that the projected conditions necessitating a change in facilities may not occur. Some users will want to account for this uncertainty by developing brackets or an envelope to surround their enrollment and fiscal projections. Using the approach outlined in Chapter 1, they will then consider the impact of the "worst" case, evidenced by high enrollments, high costs, and low revenues. Similarly the impact of the "most likely" and the "best" situations will have to be examined. Caution must be exercised. The use of high and low estimates may be very misleading if the brackets are built around a projection or curve that is fundamentally inaccurate.

Closing or building one or more schools is a challenging assignment. If a set of alternative plans is developed in a rigorous fashion, then hard to measure and evaluate trade-offs between social, educational, economic, and political values will be necessary. With few exceptions, no optimal solutions can be identified. Instead, based on intuition and judgement, the user must strive to identify several reasonable alternatives which can be critically evaluated, using the Facility Planning components.

8.2 Data Considerations

Users of the School Facility Planning System will have two categories of concern with regard to data. First, the specific data input requirements necessary to implement the system components must be considered. Determination will have to be made as to whether the data items or reliable substitutes are available within the district, and as to how they might be collected. Second, a more general understanding of community trends may be desired by school planners. This would include a general community profile or description against which specific projections could be made, and specific plans drawn up. The following sections present a checklist of information relevant to school planning. Techniques for collecting, analyzing, and displaying the data are also suggested.

8.2.1 Required School Facility Planning System Information

Each of the procedural sections in the four components indicates specific data requirements. These items are summarized below, with brief indications as to their importance and probable sources.

— Students by Grade: A tabulation of the public school students for the current and past years provides basic trend information. Display of this data using a line or bar graph will heighten the visual impact of specific enrollment trends, and assist in selecting projection techniques. All the forecasting methods require total student enrollment for past years. The cohort survival technique requires specific grade data. Geographic analysis requires enrollment information by different regions and areas within the district.

— Vital Statistics: The number of births in a community will influence educational requirements for many years. This data is mandatory in the cohort survival technique. Vital statistics are usually recorded at the municipal or county level. Where the school system boundaries do not coincide with the city or county boundaries, adjustments will be necessary. These adjustments might be accomplished either manually or by machine by using the ratio between the school district and the recording level of government or by the actual allocation of births to the school district.

— Housing Type and Size: The kinds of dwellings in a community will affect the number of children. A profile of dwellings by type is required in the dwelling unit multiplier technique which rests on the premise that single-family homes attract different kinds of families than multi-family units. The number of dwellings by type may be determined from the United States Census. This figure can be adjusted monthly by using the Census Bureau's housing permit and housing start figures or using local building department records. Where the school district does not have the same boundaries as the local government, data adjustment problems will have to be resolved. Many medium and small school systems will be able to measure the number of single family dwellings from aerial photographs. Some municipal records may reveal the average number of bedrooms per dwelling type in different sections of the school system.

— Housing Yield: The projected number of children per residential type is also required by the dwelling unit multiplier approach. The type, value, and age of dwellings will all influence the yield of public school children. Demographic, social, and economic factors will also have an important bearing. As discussed in the Enrollment Component the yield of children per dwelling may be determined empirically by using either a door-to-door or telephone survey in randomly selected neighborhoods. An approximation of this yield may also be determined from a sample of student records within the school district.

— Vacant Land: An estimation of the number of future dwellings, and hence children, can be facilitated by examining the available vacant land in each of the community's zoning categories. This will indicate the possible number of dwellings that could be constructed in each residential category. The probability of rezoning to higher residential densities must also be examined. This information is important in establishing upper growth limits for use in the non-linear time trend projections of dwellings or assessed valuation.

— Housing Built and Under Construction: Residential and tax base forecasts will also need trend data as to construction and demolition activity. In many suburban communities the amount of new housing expected in the future can often be estimated by reviewing recent subdivision plans and outstanding building permits. These records will also indicate the probable size and price of new housing.

— Parochial School Changes: The opening or closing of a private or parochial school may have a major impact on the public school system. The possibility of such an event must be examined when projecting future enrollments. If anticipated, a discrete shift upwards or downwards in the student forecast may be appropriate. The occurrence of such an event in the past must also be recognized to ensure that it has not caused the calculation of misleading enrollment trends.

— Major Growth Factors: The projection of student enrollments, dwellings or assessed valuation should reflect sensitivity to unique events that could severely alter historical development trends. Thus, a major highway project could induce substantial residential development or cause the demolition of a substantial number of dwellings. The implications of a major industrial contract, a building permit freeze, an energy crisis, and other unpredictable situations within the community must be recognized.

— Boundary Adjustments: Should a school district annexation or merger occur or if one has occurred in the recent past, special data may be required. Estimates of the students, dwellings, or tax base in the area prior to annexation may be necessary for continuity during the analysis period.

— Student Curricula: A projection of enrollments by subject area is important in determining space requirements by type of school space. This is particularly true in secondary school situations where different subject areas may have quite different room and/or special equipment implications. Historical subject area enrollment, other measures of student subject interest, and state requirements should all assist in determining the expected course enrollments necessary in the Facility Component.

— School Sessions Policy: The number of periods available for instruction each week is a necessary element in translating projected students into required space. Similarly, the possibility of a staggered session, double session, or twelve-month school year must be considered. Each of these policies will alter the need for physical space.

— Grade Organization Policy: A change in the grouping of grades into elementary, middle, and senior school categories may have a bearing on the calculation of required space. The board's willingness to alter the policy from the current grade organization should be considered.

— Facility Standards: Each school district must select its own standards in light of its unique characteristics and its educational philosophy. However, certain general rules may serve as points of departure for those school systems without specific standards in mind. Based on a survey of recent school planning materials, these are presented below. Where a range is indicated, the first number reflects typical existing values, whereas the second number reflects a desired standard for new construction.

Standard	Typical Values
Site Acreage	
Elementary	5-15 usable acres
Middle/Junior High	15-25 usable acres
High School	25-35 usable acres
Walking Distances	
Elementary	1/2 mile
Middle/Junior High	1 mile
High School	1 1/2 miles
Transportation Times	
Elementary	1/2-1 hr. twice a day
Middle/Junior High	1 hr. twice a day
High School	1 hr. twice a day
Student Capacity	
Elementary	250-650 students
Middle/Junior High	500-1,000 students
High School	700-1,500 students
Space Required	
Elementary	85-100 sq. ft./pupil (gross)
Self-contained	30-50 sq. ft./pupil
Flexible spaces	30-60 sq. ft./pupil
Open spaces	100-120 sq. ft./pupil
Gymnasium	40' x 60' — 80' x 120'
Middle/Junior High	95-110 sq. ft./pupil (gross)
Learning space	same as elementary
Special facilities	kitchen/typing/vocational
Gymnasium	75' x 90' — 100' x 100'
High School	100-130 sq. ft./pupil (gross)
Learning space	25-35 sq. ft./pupil
Flexible spaces	25-40 sq. ft./pupil
Open spaces	60-100 sq. ft./pupil
Gymnasium	100' x 110'
Swimming pool	75' x 45'
Special Facilities	
Pupils/Teaching Space	22-34 students
Administrative Space	Needs considered
Guidance Space	Needs considered
Conference Space	Needs considered
Instructional Materials Production Area	400 sq. ft. per elementary school 1200 sq. ft. per secondary school
Seminar Spaces	1/12 teachers, 350 sq. ft.
Teacher Office Space	1/2 teachers, 100 sq. ft.
Remedial Instruction Rooms	3/school, 200 sq. ft.

Library and Ancillary Space	1,000-2,700 sq. ft. per elementary school 2,000-5,000 sq. ft. per secondary school
Program Enrichment Areas	1/school, 1,200 sq. ft.
Small Project Areas	1/school, 350 sq. ft.
Carrels	15% of enrollment, 15 sq. ft.
Space for Programmed Instruction	1/school, 600 sq. ft.

The appropriate values for these standards will exhibit a tremendous degree of variation from one school system to another and will reflect the wide disparity of community needs, interests, goals, and resources. These values are presented merely to assist users in arriving at some initial figures. Perhaps the easiest way to specify standards during the planning process is to determine their present value within the district and then attempt to assess their adequacy.

— Existing Space: The Facility Component requires an inventory of available space, measured in teaching spaces or square feet. This should include space that is anticipated in the future as well as current space. The space type may be general (e.g., all classrooms) or specific (e.g., all large classrooms, all regular classrooms, etc.). The square feet may be measured in a gross category (e.g., all space in the building) or a net category (e.g., only space activity used for teaching).

— Facility Adequacy: Only usable or adequate space should be analyzed in the Facility Component. The level of school building adequacy can be measured from many perspectives. These include relatively objective measures, such as potential safety hazards and maintenance problems associated with the heating, wiring, ventilation, or waste disposal facilities. They may also include more subjective factors, such as the environmental impact on creativity concentration and other learning attributes. It is generally recognized that a comprehensive measure of school facility adequacy will require the combined skills of architects, engineers, educators, and administrators. The costs of upgrading or repairing inadequate space must be examined if that space is to be considered available for future use.

— Additional School System Policies: A variety of additional policies must be considered in light of their space implications:

— Student Drivers: What proportion of the students will want to or be allowed to drive their own vehicles to school? How much parking will be required?
— Sports: What sports will be offered? Will tennis courts, a football field, a swimming pool, or an ice hockey rink be necessary or desirable? Should parking, access, and seating capacity be designed to accommodate spectator volumes substantially in excess of the student body?
— Food: Will a hot lunch be offerd? If so, will it be catered or prepared on the premises? What proportion of the student body should be able to eat at a given time?
— Amenities: Are carpeting, air conditioning, a media center, a theater, etc., considered necessary or desirable?
— Special Use Location: Will special activities, such as machine shop training, automobile mechanics, and other activities, be taught at each school or at a central facility?
— Community Use: Will the school be built so that it can readily serve adult education, senior citizens, and other community wide functions?

Many of these considerations will be important in establishing a desired utilization rate for each proposed school. If it is desired that there be substantial flexibility in teaching space so that unused classrooms are often available for meeting rooms, study hall, lounges, or storage, a low utilization rate (e.g., seventy-five or eighty percent) may be appropriate. Alternatively, if these needs have been considered separately and less flexibility is deemed important, a high utilization rate (e.g., ninety-five percent) may suffice.

— Site Characteristics: Existing and potential school building sites must be examined in terms of their positive and negative characteristics. Is the size sufficient for a school, including possible expansions? Does the topography lend itself to proper drainage, recreational opportunities, and easy construction? Are there wooded areas, vistas, or any other attributes that should be used to advantage? Is the site compatible with the existing and probable adjacent land uses? These questions, as well as the site's impact on student travel distance, must be resolved during the site selection procedures in the Geographic Component.

— Construction Costs: All potential rehabilitation or new construction projects must be evaluated in light of the probable construction costs per square foot. These will vary widely from region to region based on the availability of building materials and the characteristics of the labor market. In most cases local architects/contractors will provide the best source for current and projected figures. A technique for projecting construction costs is presented in the Fiscal Component. An approach for examining possible variation in construction costs due to economy of scale factors is presented in the Handbook Introduction.

— Tax Base: In most cases the local tax base will directly impact the school system's capital, as well as operating, budget. Assessed valuation of real and personal property must be analyzed to determine probable bonding capacity and expected local tax revenue. Local income and sales taxes may also be important, depending on the tax structure.

— Revenue: Historical revenues supporting the school district must be examined as to the amount and trend per source. In some instances the potential uses of these monies will be restricted to certain expenditure categories. The difference between taxes levied and actually collected should be analyzed. Also the past and possible changes in state allocation formulas should be studied. Federal support will be an important element in some districts.

— Expenditures: Historic expenditures by the district must be analyzed on a total cost and unit cost basis. Unique local conditions such as union demands and purchasing regulations must be considered as unit costs are projected. Educational policy regarding the desired number of teachers, administrators, support personnel, and supplies must also be examined in order to forecast total probable expenditures.

— School Capacity: The total existing space times the desired number of students per teaching station (or divided by the desired square feet per student) indicates the capacity of a school, or the number of students that can be accommodated. If a utilization rate is used by the district, it should be expressed in decimal form (i.e., less than one) and multiplied by the initial capacity to obtain an "effective" capacity Individual school capacity information is necessary to implement the Geographic Component.

— School Distance: The average distance from all students living within small geographic areas or grids in the district to each school is necessary to implement the Geographic Component. This information should be calculated for the center of student population within each grid and may be estimated by using a land use map, street map, or aerial photography. Distance can be expressed in terms of travel miles, travel time, or travel cost.

8.2.2 General School Planning Information

In addition to those items required to implement the various system components, further information may be desired. In some cases this additional data will contribute to better estimates of the previously described variables. In other cases the information will be useful in gaining a general understanding of the community; how it is changing over time, and how it compares to adjacent communities, the state, and the nation. Familiarity with the broad social and economic trends that influence school district conditions should lead to the formulation and adoption of a better plan.

— Total Population: The total population constitutes a basic measure of a community. This information is available every ten years from the United States Census at the county, municipal, census tract, and block level. Specific tabulations for school systems can be obtained from the National Center for Educational Statistics. Local planning offices and universities may have this information as well as inter-census year estimates.

— Age Composition: An understanding of the age distribution of the population is important. Population "pyramids" are often used to designate this distribution. Females of childbearing age, school-age children, and pre-school children are, of course, the most important cohorts. Age profiles by sub-geographic areas within a school system may be helpful in identifying those neighborhoods likely to increase or decrease their percentage of students.

— Minority Group Composition: The number and location of racial minorities are important to the school system. Racial or ethnic shifts may portend changes in birth rates and may necessitate revisions in attendance area boundaries. Minority population data may be determined from the decennial or local school district census, or inferred from local health department records. Techniques for projecting the racial composition of students are described in the Enrollment Component.

— Demographic Characteristics: A variety of information regarding income, education, occupation, head of household, and other socio-economic characteristics is available on a sample basis from the United States Census. Often it can be supplemented by a local survey. Analysis of these factors may provide indications as to the kind of people who live in and are moving into a community. With caution, some inferences may be drawn as to the likelihood of future families sending their children to private schools and/or supporting public education. Religious data is not available from the United States Census. Community trends that might influence the proportion of children attending parochial schools must be determined from local data.

— Housing Value: The price of dwellings will directly affect the school district. Communities characterized by more costly housing will typically be chosen by older, wealthier families with older children. Less expensive subdivisions will tend to accommodate younger families with younger children. Housing value also affects the tax base. In communities where reappraisal occurs on a routine basis, rising residential property values will contribute to a higher tax base. They may also indirectly promote housing turnover as retired families are pressured to seek communities with lower taxes.

— Housing Age: In many communities the age of housing may be directly correlated with the number of children. Large subdivisions characterized by similar dwellings typically attract similar families. Over time, the demographic mix of the subdivisions broadens as dwellings change hands. However, during the early years (the first ten to fifteen), a subdivision may be characterized by a very narrow age distribution of families and children. Knowledge of housing value and age factors should contribute to a better understanding of probable migration trends.

— Student Drop-Outs: Historical information concerning drop-out rates, retention rates and intra-district transfers between schools should be examined if readily available. Major shifts in these rates may imply demographic and migratory trends useful in selecting an enrollment projection technique, or may modify an existing forecast. The cumulative or net effect of these shifts will be reflected in the historical cohort survival rates.

— Student Commuters: Some school districts accept students from outside the school district upon payment of extra tuition fees, or as part of a voluntary program. In certain school systems, the number of non-resident commuters may be large enough to have significant facility space implications. These students may constitute a good revenue source to the school district. They may also be viewed as a first area in which cutbacks may be made when space shortages are expected.

— Private School Enrollment: Historical enrollment levels will often be desirable for private/parochial schools in the district's vicinity. Because these schools will usually not adhere to public school district boundaries, information should be collected for private and parochial schools in a considerably larger service area. Some private school systems may have records that allow identification of the public school system in which the students reside. Gross private school enrollment statistics are also available on a census tract, municipality, or county basis in the decennial census reports. The trend information may be useful in selecting a forecasting technique and evaluating the forecast results.

— General Plan: The comprehensive, master, or general plan in a community may provide valuable insights into the future housing supply. Especially where there is no zoning or a record of continuing rezoning, this document may be the best predictor of the community's residential holding capacity. Where available, this information should be examined in conjunction with the inventory of vacant land within the district.

— Critical Development Factors: In those communities where growth management and land use controls have become an issue, additional considerations may be necessary. State land use regulations and state and regional plans may restrict local community activity in flood plain. wetland, mountainous, and other "critical" areas. Environmental concerns may also result in moratoria, air pollution restrictions, and other growth regulating limitations.

— Regional Housing Market: In addition to factors influencing the supply of residential land, consideration must be given to the demand for housing. The probability of new housing being built and sold will be directly affected by population and economic trends within the region. The local realtors association, chamber of commerce, and regional planning agency may provide insight. Probable shifts in the school district's proportion of the regional market must be considered.

— Employment: Population growth within a region is usually correlated with the region's economic health. Employment trends constitute the most common measure of economic conditions. Unlike housing, the distribution of employment centers within a school system is not usually a critical factor, except to the extent that it generates automobile traffic. Employment centers located within a school district may be major sources of real property tax, sales tax, manufacturing tax, or other kinds of income. Employment trends within the region will have an important, though hard to measure, impact on migration patterns. Employment information may be gathered from United States Census reports, County Business Patterns reports, the State Division of Employment Security, and local business development groups.

— Industrial-Commercial Land: A second measure of local economic conditions is the amount of industrial and commercial acreage that is developed annually. Local planning, real estate, and utility firms should have this information available on a regional basis. Recalculations for the school system will typically be necessary. The land absorption rates will indicate how fast the economy of the community is changing, the probable impact on assessed valuations, and the extent to which the community's general plan remains relevant.

— Additional Economic Indicators: A variety of additional statistics will usually be available at the metropolitan, county, or municipal levels. Retail sales information is often available from those jurisdictions collecting sales taxes. Bank assets and related financial data may be obtained from the federal reserve bank and the state banking regulatory commission. Business licenses, inventory assessments, bankruptcies, and tax delinquencies may be available locally. Collectively, these trends will suggest the direction of the local economy.

— Voter Attitude: The power of the voters to control school finances will vary widely depending on state enabling legislation. The record of recent tax levy and bond issue attempts and the reasons for their success or failure should be studied early and carefully in the planning process. Old newspapers, the Board of Elections Office, and local governmental officials may provide valuable insight.

— Tax Effort: The effective tax in the school system should be compared to that of surrounding communities. Differences in assessed valuation should be accounted for. An attempt should be made to understand why the school district spends more or less per pupil than surrounding districts. This may indicate the desirability of adjusting the state allocation formula or raising local taxes.

— Institutional Cooperation: Review should be made of cooperative efforts between the school system and other local institutions. These might include the sharing of municipal workers, such as nurses, social workers, and police, and the sharing of transit authority busses. Relations between the local press and the school system should be examined.

—Citizen Concerns: Major community issues surrounding local education should be identified. Review of past school board minutes and of previous school board election campaigns should provide insight. An understanding of community aspirations should enable the creation of a more relevant and acceptable school plan.

8.3 Systems Maintenance

Like many planning activities, school facility planning is most successful when it is undertaken as a continual process. Those school systems that prepare and adopt a long-range master plan and then do nothing to monitor and revise that plan may encounter difficulties. Particularly in an environment characterized by a high degree of uncertainty. every long-range plan should be re-examined periodically so that new information, assumptions, and standards are explicitly considered. In fact, in those situations where the School Facility Planning System has not revealed an obvious need for a new facility or facility closing, it may make sense to postpone final adoption of a plan until new enrollment, cost, and/or revenue information become available. At a minimum, each school system should devote several days each year to a re-examination of the plan in light of new information.

8.3.1 Preliminary Review

When a decision is made to re-examine a plan, the first step will be to compare previously projected data with actual new information. After the difference and hence the short-comings of the projection have been identified, an effort must be made to understand the sources of this forecasting error. In certain cases, these differences may result from a major unforeseen event. Thus a new shopping center or residential complex, of which the user was unaware at the time of the first plan, may explain higher enrollment levels or a higher tax base than was previously expected. In other cases, the difference will result not so much from a unique event, but from an inadequate set of initial assumptions. The actual grade survival rates, growth in dwelling units, and tax base should be examined with this in mind.

8.3.2 New Projections

Based upon the preliminary examination. a set of new assumptions should be made for each of the System's components. Specific shifts in actual enrollment or housing permits and general shifts in zoning or economic activity should provide the basis for revising the Enrollment Component analysis. New school board members, new issues, and changes in existing facility conditions should provide the basis for a re-examination of the Facility Component. New cost and revenue trend information should provide the basis for a re-examination of the Fiscal Component. A new road or a shift in student residential patterns may justify review of the attendance boundaries by the use of the Geographic Component.

Once a new set of independent projections has been generated, the relevance of the existing facility plan can be tested. In many cases, the difference between the new and old projections will not justify a major revision. In other cases, new alternatives and a new plan may be justified. Even where the main elements of the plan are still appropriate, some minor adjustments in terms of timing may be necessary. For example, the new projection might continue to support the need for a new high school, but indicate that a faster or slower construction schedule was desirable.

8.3.3 Record-Keeping

Those school districts interested in using the System on a recurring basis should consider modifications to their record-keeping procedures which would facilitate the System's use. These modifications need not take the form of a major project. In some cases, a simple written or telephone request to certain government agencies may be sufficient. In other situations, a more detailed study may be appropriate.

The specific record-keeping changes will vary with each school system. For example, in communities where school system boundaries are coterminous with the municipal government boundaries, vital statistical information may not be a significant problem. In areas where the boundaries are divergent, efforts might be initiated to record births by school system on an ongoing basis. This could involve providing a list of school system addresses to the local government's vital statistics department with the request that it summarize births for the school system, or a copy of all births in the municipal jurisdiction might be obtained by one of the school system's clerks.

With only minor record-keeping modifications, a more complete picture of migration trends may be possible. The school system's personnel office may be willing to keep a summary sheet of selected data for new students entering and leaving the system. Information recorded would include the grade, the date of the move, the location from which or to which the student was moving, and the reason for the move.

Some communities monitor the number of pre-school children by age and public/private school intent. If the school system is small enough, a continuing review of real estate listings and housing ads will indicate housing turnover and new families that are moving into the area. These families can be provided with an information packet, through Welcome Wagon or some similar organization with a form to be returned to the school district. This activity may be unreasonably time-consuming for a large school system, but, where possible, it will give a profile of pre-school children, as well as initiate interest in the school system.

GLOSSARY

The following terms are used frequently throughout the School Facility Planning System documentation. In some cases the meaning may differ slightly from that commonly used by educational administrators.

Adequate Space — All existing facility space considered adequate for teaching purposes, and requiring no financial investment other than routine maintenance costs. In the Facility Component, adequate space is compared with required space to determine the expected space deficit or surplus.

Assessed Valuation — The real property tax base against which a tax rate is applied to yield local property tax revenue. Assessed valuation varies with the level and quality of urban development and local assessing policy. Techniques whereby it may be forecast are described in the Fiscal Component.

Asymptote — The upper (or lower) limit of a community, whether measured in terms of population, dwellings or assessed valuation. Some of the projection techniques used in the Enrollment and Fiscal Components allow the user to establish this upper (or lower) limit.

Attendance Area — A geographic area within a school district from which all public school children attend the same school. The Geographic Component is designed to help draw up attendance area boundaries.

Alternative School — A "non-school" approach oriented to students that are not interested in a traditional high school format (e.g., Philadelphia's Parkway Program or Chicago's Metro High School). This may be an important consideration in calculating "effective enrollment" in the Facility Component.

Bonding Capacity — The maximum bonded indebtedness permitted of a school district under state law. This may be calculated on a gross basis, usually as a percent of total assessed valuation, or on a net basis after existing outstanding indebtedness is considered.

Capacity — The number of students that can be accommodated in a school given its physical size and design, and the policies and standards endorsed by the school board.

Cohort Survival — A technique for projecting student enrollment by calculating the "survivors" from one grade to the next. Also known as the "Grade Succession" or "Grade Aging" technique.

Component — A major sub-system within the School Facility Planning System. The four analytical components are designed to be used independently or together, depending upon the needs of the user.

Confidence Interval — A range of values within which a projected variable such as enrollment or assessed valuation will fall a large percentage of the time. Also known as a confidence band, limit or envelop, this concept is very important in making long-range forecasts.

Course Enrollment — The average number of courses taken daily by individual students in a particular subject area multiplied times the number of students in the school or district. As described in the Facility Component, this variable is used to calculate "effective enrollment."

Demand — An expressed need or request for a commodity. A major objective of the School Facility Planning System is to help school districts forecast the future demand for public education and derive the facility implications.

Dwelling Unit Multiplier — A technique for projecting student enrollment based on a projection of residential dwellings and expected yield of school children per dwelling. Appropriate in rapidly growing districts.

Economy of Scale — A measure of the unit cost savings for land, labor, and materials that may be achieved by building a larger rather than smaller facility. The concept must be used carefully because the contribution to educational quality of any two school facilities will rarely be the same, and hence comparing their costs may be misleading.

Effective Enrollment — The number of students expected to be physically in attendance at a specific point in time during a typical school week. The desired teaching station or square foot standard applied against effective enrollment in the Facility Component yields a measure of required space.

Extended School Day/Year — A program for increasing the capacity of a school facility by reducing the number of children attending school at any specific time. The impact of staggered or double sessions, or a 12 month school year can all be "tested" using the Facility Component.

Facility — Any school space or building used to serve students. The user of the Facility Component may consider the need for any kind of space measured in terms of teaching spaces or square feet.

Found Space — Building space "discovered" within an existing school or "non-school" building (e.g., warehouse, industrial plant) for teaching purposes. An important consideration in formulating alternative facility plans.

Gompertz Curve — A special type of logistics curve in which the rate of change is decreasing exponentially. This function appears as an "S" curve, and has the form $P_{t+n} = \log K + (\log a) (\log/r^{n})$. It may be used in the computer-based version of the Enrollment and Fiscal Components.

Grade Organization — The manner in which a school system assigns its grades to elementary and secondary schools (e.g., 4-4-4, 6-2-4, 6-3-3, etc.).

Grid — The smallest geographic area for which dwellings and students are forecast in the System. Also known as "areas," grids may have irregular or rectangular boundaries. Data must be assembled by grid to support the Geographic Component.

Home-Base School — A school system in which the building is the "Home-Base" only for students' activities. High schools with work study programs or a "School Without Walls" are Home-Base schools with the potential for an enlarged student capacity.

Joint Occupancy — A method for sharing the cost of a facility between a public school district and some other organization (e.g., a city government) by sharing the space. An option to be considered in drawing up a fiscal plan and facility plan.

Linear Program — A mathematical technique which allows the value of a linear function to be minimized or maximized, subject to certain constraints. Linear programming is used in the Geographic Component to assign students to schools so that transportation costs are minimized.

Logistics Curve — An "S" shaped curve resulting from an exponential function of the form $P_{t+n} = K/1 + c^{a+bn}$ Techniques using this function are found in the Enrollment and Fiscal Components.

Module — A discrete set of tasks in the computer version of the System. Typically a component can be categorized in terms of several modules.

Open Campus — An increasingly popular concept that permits high school students to move freely inside and outside of school when not scheduled for a course. Adoption of an open campus policy will have implications for required teaching spaces, libraries, lounges, and other school space.

Periods Per Course — The average number of periods per course each student attends in a typical school week. This factor is used to help determine effective enrollment for a given subject area in the Facility Component.

Periods Per Day — The number of periods each day during which classes are held. As reviewed in the Facility Component, this factor will contribute to the calculation of effective enrollment.

Planning Period — The future time period over which forecasts will be made, and for which facility size and location decisions will be made. The planning horizon is the farthest year into the future for which facility planning will be conducted.

Policy — A course of action adopted by the school district which directly or indirectly impacts facility planning (e.g., staggered sessions, grade organizations, etc.).

Projection — A statement of conditions expected to exist in the future based on a set of explicit assumptions. The terms "projection" and "forecast" are used interchangeably throughout the documentation.

Ratio Method — A technique for projecting enrollment whereby students are estimated as a function of a projected ratio multiplied times an independently derived projection for a larger jurisdiction (e.g., county, state, or national).

Region — A geographical homogeneous sub-area of a school district for which independent projections are made. The typical district can be divided into two to four "regions" which in turn can be broken into as many as 30 "grids."

Regression Analysis — A statistical measurement of the form and strength of relationships between variables. Linear and exponential regression techniques may be used in the Enrollment and Fiscal Components for projection purposes.

Resource Center — A particular facility such as a library, art or vocational building which may attract students from more than one separate school. A consideration in developing a facility plan.

School District — A government entity engaged in the operation of public schools. The term is used synonymously with "school system," "local educational authority (LEA)," and "the user" throughout the documentation.

School Size — The desired maximum capacity or number of students per school type (e.g., elementary schools—400 children, high schools—1500 children, etc.). This standard may have an important bearing on a facility plan.

Square Feet — One of the measures of school capacity that may be used in the Facility Component. Gross or net square feet per student may be used. See Teaching Station.

Standard — A measure or criterion that directly or indirectly impacts facility planning (e.g., desired square feet per pupil, desired pupils per teaching station, etc.) as adopted by the school district.

Subject Area — Any course or combination of courses for which the effective enrollment is to be calculated in the Facility Component. In general, a particular subject area should be defined in light of similar space type requirements (e.g., regular classrooms, large classrooms, etc.).

Survey — The traditional approach whereby administrators inventory and evaluate school buildings, curriculum, and instructional techniques. The School Facility Planning System does not replace the need for comprehensive school surveys.

Teaching Station — Any classroom or learning space as defined by a school district, and used in measuring capacity in the Facility Component. See Square Feet.

Transportation Costs — A measure of the distance, time or money associated with transportation. The Geographic Component assists in the design of attendance boundaries, or the evaluation of school sites by indicating the configuration which will best reduce transporation costs.

Utilization Rate — The average percent of educational space which is occupied at any time during a typical school day. This factor is used to permit increased flexibility in determining space requirements in the Facility Component.

Uncertainty — A condition that characterizes all planning activity. especially where long-range forecasts or projections are involved. The School Facility Planning System has been designed to assist administrators in explicitly considering the reality of uncertainty.

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The following books, reports and articles constitute a small fraction of the literature relevant to educational facility planning. The material is organized in terms of six categories:

- A. General School Planning
- B. Capital Planning, Budgeting and Quantitative Methods
- C. Enrollment Analysis
- D. Facility Analysis
- E. Fiscal Analysis
- F. Geographic Analysis

With few exceptions the bibliography does not include general planning references, articles in "popular" educational journals, foreign literature or specific school plans. Educational Resource Information Center numbers (ERIC) and Dissertation numbers have been included where available.

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APPENDICES

APPENDIX A
DATA PREPARATION AND SYSTEMS OUTPUT

Chapter 2 has provided an introduction to the various program packages that are used throughout the computer version of the School Facility Planning System. The purpose of this appendix is to provide a more detailed explanation of the kinds of information necessary to run the basic support system and the geographic analysis support system. The function and format of each input card are described. The System's analytical and report generation options and typical printout displays are also presented. Reference to this appendix will be necessary to prepare data for entry to the System and to interpret the results. The sequence for submitting cards and typical job control language statements are contained in Appendix B.

1. Basic Support System.

The program package used to support the enrollment, facility and fiscal analysis makes use of eight separate data cards. The first three of these cards are used together to specify data and relationships within the model, and, as such, will be most important to the user. The latter cards are important primarily for modifying the format of reports generated by the System. The cards are described generally in Sections 1.1 and 1.2. Specific card layouts are provided in Sections 1.3 and 1.4. Sample printouts are presented in Section 1.5. The name and purpose of each card are as follows:

Name	Purpose
'7' card	Assigns a row number to a row name.
'1' card	Contains data observations provided by the user.
'6' card	Identifies the calculations to be performed on information in each row.
'R' card	Signifies that a report should be printed covering a specified time period.
'G' card	Signifies that a graph should be printed for selected data items.
'8' card	Provides the header information for reports.
'9' card	Specifies the data groups to appear on a report.
'X' card	Signifies the number of periods for which data will be printed, and the fact that there are no more input cards for a given run.

1.1 Basic Input Cards. The basic system that supports the Enrollment, Facility and Fiscal Components consists of a series of "rows" of information, each containing data which is provided by the user or calculated by the System. The '7', '1' and '6' cards define these rows and the operations associated with each. The program then executes the necessary computations sequentially in order of increasing row numbers.

As reflected in Figure A-1, the '7', '1' and '6' cards are typically used together. The first column of each 80 column card indicates the card type. The next three columns indicate the row number that is referenced for each set of these three kinds of cards. The three cards function as follows:

FIGURE A–1 FIELD NAMES '7', '1' AND '6' CARDS

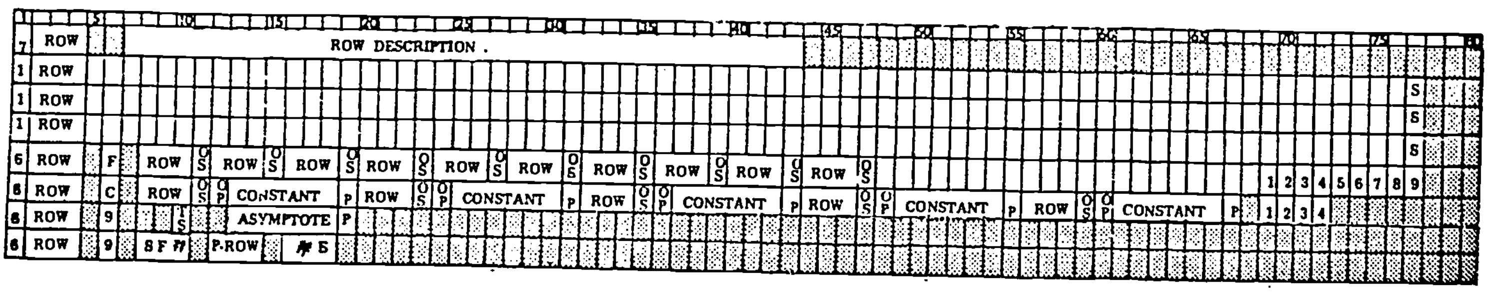
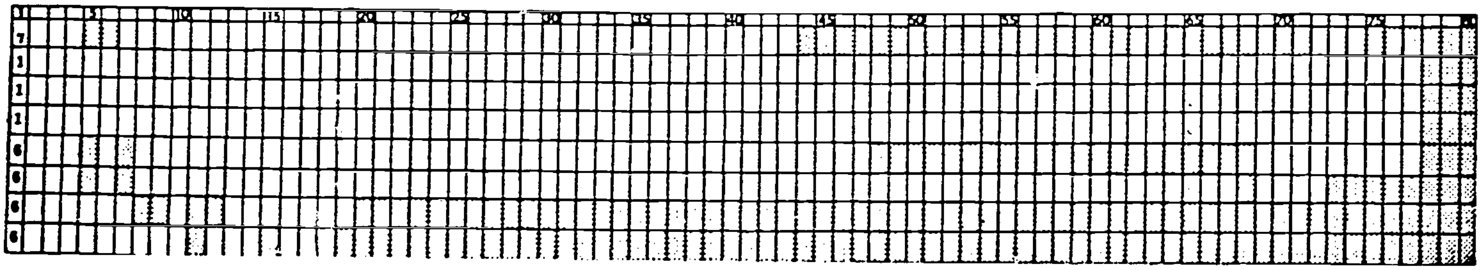


FIGURE A—2 PERMITTED FIELDS FOR '7', '1', AND '6' CARDS



The '7' card assigns a row or variable name to a row number. The '1' card is then used to record data observations associated with that variable for distinct time periods. Each card can accept up to nine data entries; as many as twelve cards can be used to define the 105 permitted time periods. In the current System three '1' cards are recommended for each variable, identifying twenty-seven time periods. The first nine are reserved for historical data, and the next eighteen for the current and projected years.

The '6' card initiates one or more mathematical operations on the data that has been entered into a given row. The card may take four different formats, depending upon the specific techniques to be performed. These can include arithmetic calculations, multiple regression, eight different time series projection methods, or a user supplied special function.

Only one '6' card is permitted per row. It will initiate the appropriate operation, starting with that time period for which no data (i.e., blanks) have been entered on the '1' card. Thus a user that enters both historical and projected data on the '1' cards for all time periods, will not receive any projections generated by the System.

Users that are satisfied with the currently defined System will have only to fill in their own '1' card data and submit '7' and '6' cards as they appear in the Enrollment, Facility and Fiscal Components procedures. Those that want to change the name of a variable or the type of operation may do so by modifying a '7' card or '6' card respectively. Users that want to add variables may fill out new '7', '1' and '6' cards. Caution must be taken to see that a unique row number is used, and that it is in the proper logical sequence with regard to all other rows.

Throughout the preparation of the cards, care must be taken to ensure that no entries are placed in the wrong fields. To assist in this effort, it is recommended that the user darken out certain columns on the coding sheets prior to entering information (see Figure A-2). Typical error messages are listed in Appendix B. Caution must also be directed so that all data applicable to a given year or time period is entered in the same field wherever '1' cards are provided for multiple rows. Thus, if the first field is assigned the time period 1966, for example, then the first field of the first '1' card for all subsequent rows must refer to 1966 data.

1.2 Report Generation Cards. The remaining five cards are used primarily to structure the reports produced by the Enrollment, Facility and Fiscal Components analysis. As noted above, those users satisfied with the standard report formats present in the current version of the System need not develop a thorough understanding of their use. These individuals may submit duplicate report generation cards to obtain the same report format.

Header and Data Group Information Cards. The '8' and '9' cards are used together to structure report formats. Each report requires the use of at least three cards; two '8' cards which define the heading to be used for a report, and a '9' card which identifies the rows that constitute the data group to appear in that report. Additional '9' cards may be used where more than 15 rows are desired to be printed in the report.

The header cards ('8') and data group cards ('9') will be interspersed. Thus the header and data group numbers must be sequential. For example, if the two '8' cards associated with a report have header numbers of 080, and the '9' card has a data group number of 081, then the next report must have a header number of 082 or greater. Note, that if a second '9' card was required for the first report, it would have a consecutive data group number of 082.

The '8' card has two formats so that a report header of up to 120 characters may be defined. However, a pair of '8' cards is required even if there is no text on the second card. The card has options that permit skipping to the top of a new page before a header is printed, and skipping lines after the header and before the data groups.

The '9' card has an option which permits skipping of spaces after each row. A generalized format for completing '8' and '9' cards is presented in Figure A-3. Permitted fields for placing information on these cards are presented in Figure A-4.

FIGURE A—3 FIELD NAMES FOR '8' AND '9' CARDS

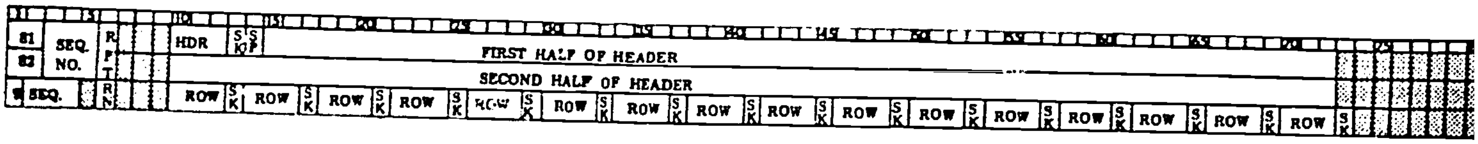
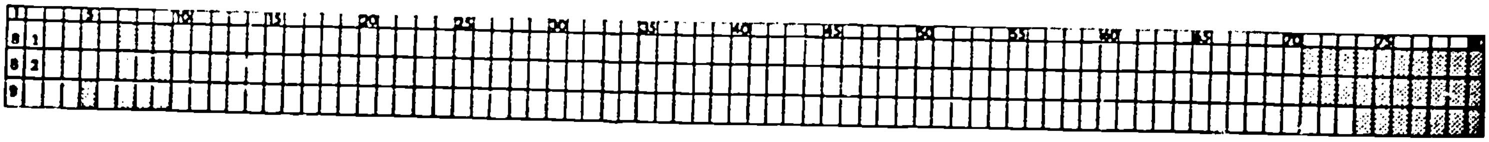


FIGURE A—4 PERMITTED FIELDS FOR '8' AND '9' CARDS



Request Information Card. The 'R' card is submitted whenever a report is to be printed during a run of the System. It identifies the report number, the first period in the basic matrix, and the first period that shows on the left hand column of the report. In the current version of the System where three groups of nine years are printed (e.g., 1965-1973, 1974-1982, and 1983-1991), three 'R' cards must be submitted. The dates on these cards would be 1965-1965, 1965-1974, and 1965-1983 respectively.

Graph Information Card. The 'G' card initiates the generation of graphical printed output. A linear or logarithmic scale may be used, and as many as four different data items may be printed on any graph. The user is cautioned to interpret these graphs carefully. In some instances data which has different values (by an order of magnitude) appears to have the same value because of the characteristics of the graphics subroutine.

The graphics subroutine locates the first observation in a range of ten to one hundred, or a multiple thereof. Each succeeding observation is located on this scale until the total range of the graph is exceeded. The scale of the graph changes for succeeding observations by a factor of ten, shifting the placement of the observation values back to the left. If this series of observations again exceeded the total range of the graph, the scale would change by another factor of ten, shifting all subsequent observations to the left.

For example, if the first observation had a value of 8,674, the program would locate it between 1,000 and 10,000, making the total range of the graph 100-15,000. Succeeding historical or projected values could easily be placed on this scale until they exceeded 15,000. However, a value of 18,267 would be printed as if it were 1,826. The user would have to realize that the scale of the graph had changed, and that the total range of the graph was now 1,000-150,000. Use of the logarithmic scale reduces the frequency of this situation.

Execute Information Card. The 'X' card is the last card in the input deck. Information on this card indicates the range of periods for which data will be projected. The card also provides an option so that the computations provided by the program are printed in addition to the input, report and graph printouts. In most circumstances, this option will probably be appropriate.

The generalized format and input forms for completing the 'R', 'G' and 'X' cards are reflected in Figures A-5 and A-6 respectively.

FIGURE A—5 FIELD NAMES FOR 'G', 'R' AND 'X' CARDS

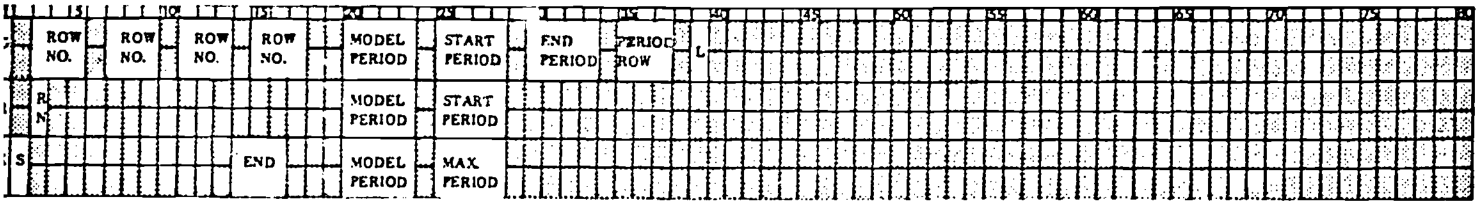
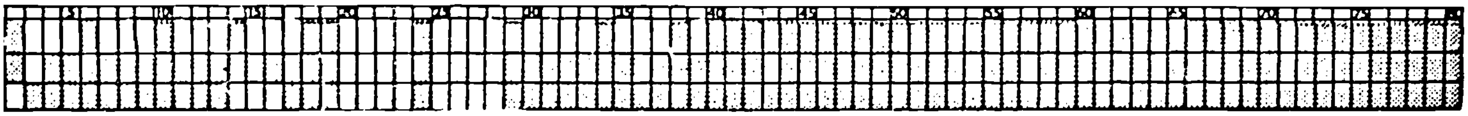


FIGURE A—6 PERMITTED FIELDS FOR 'G', 'R' AND 'X' CARDS



1.3 Input Card Formats. Each of the specific card layouts is presented below. Multiple formats are possible for the '6' and '8' cards, depending upon the circumstances.

The '7' Format

Col. 1	The digit 7.
Col. 2 - 4	The row number associated with this description.
Col. 5 - 6	Not Used.
Col. 7 - 43	The description of this row.

Col. 44 - 49	Not used.
Col. 50	The location of the decimal point as it is to appear in the report. Allowable entries are blank, 0, 1, 2, 3, ..., 9. Blank will cause the output to be printed without any decimal point. 0 will have the output printed with a decimal point appearing in the right-most position. 1, 2, ..., 9, will, respectively, have the output printed with 1, 2, ..., 9 digits on the right side of the decimal point.
Col. 51 - 80	Not used.

The '1' Format

Col. 1	The digit 1.
Col. 2 - 4	The row number corresponding to the '7' card format.
Col. 5 - 12	The value for the first time period of the basic matrix for the row specified in Columns 2-4.
Col. 13 - 76	The values for time periods two to nine of the basic matrix. If there are more than nine periods to be entered, continue on a new '1' card. Repeat the entries in Columns 1-4.
Col. 77	Code for the location of the decimal point for the entries in Columns 5-76. Used for scaling purposes. a) 0 or blank - numbers entered are whole numbers and are not to be scaled further. b) 1, 2, 3, ..., 9 - numbers entered are to be multiplied by 10, 100, 1,000, ..., 1,000,000,000, respectively. c) J, K, L, ..., R - numbers are to be divided by 10, 100, 1,000, ..., 1,000,000,000, respectively.
Col. 78 - 80	Not used.

The '6' Format

The first seven columns are always the same. The remaining fields will vary, depending upon the forecasting technique selected.

Col. 1	The digit 6.
Col. 2 - 4	Row number to be calculated or projected.
Col. 5	Not used.
Col. 6	Forecast code. Four options are permitted: 3 - Simple or multiple linear regression. Up to six rows containing the independent variables may be designated. Each row can be offset in time, if desired. 4 - Exponential regression. Least squares determination of Y=A*xp(B*X).

	9 - Time series projection or special subroutine.
	X - Arithmetic calculation, using rows previously projected.
Col. 7	Not used.

Alternative Format-1. (Used with a 3, 4 or X in Column 6.)

Col. 8 - 10	First row number of the rows used in calculation.
Col. 11	Lead or lag of time period. If entry is 0 or blank, the data entries used for the calculation will correspond to the same time period as that in the row being calculated. Entries of 1, 2, 3, ..., 9 will use a leading entry of 1, 2, 3, ..., 9 time periods. Entries of J, K, L...R will use a lagging entry of 1, 2, 3...,9 time periods.
Col. 12 - 47	Similar functions to Columns 8-11 for other rows used in the calculation.
Col. 48 - 68	Not used.
Col. 69 - 77	Entries of +, —, / or * are allowed. These are used only for an X in Column 6, and represent arithmetic operations between the ten rows indicated in Columns 8-47.
Col. 78 - 80	Not used.

Alternative Format-2. (Used with an X entry in Column 6.)

Col. 8 - 10	Same as Columns 8-10 of the Alternative 1 Format.
Col. 11	Same as Column 11 of the Alternative 1 Format.
Col. 12	Entries of +, —, *, / are allowed. These are modifying operations on the row in Columns 8-10 by the constant term in Columns 13-18.
Col. 13 - 18	Constant modifier of the entries in the row in Columns 8-10.
Col. 19	Decimal point locator for constant in Columns 8-10. Entries of 1, 2, 3, ..., 9 shifts decimal to right. J, K, L, ..., R indicates a shift to the left.
Col. 20 - 67	Similar functions to Columns 8-19 for other rows involved in the calculation.
Col. 68	Not used.
Col. 69 - 72	Entries of +, —, /, * are allowed. These are used only with an entry of X in Column 6 and represent arithmetic operations between the five rows given in Columns 11-67.
Col. 73 - 80	Not used.

Alternative Format-3. (Used with a 9 entry in Column 6 for time series projections.)

Col. 8 - 9	Not used.
Col. 10	The number 1,2,3,4,5,6,7 or 8 depending on the desired time series extension technique. Further discussion of these methods is presented in Appendix C.

1. Straight Line. Least squares fit of $Y=A+BT$. Values are projected from resulting formula.

2. Exponential Curve. Least squares fit of $Y=A \times EXP(BT)$. Values are projected from resulting formula.

3. Modified Exponential Curve. Least squares fit of $Y=A+B \times EXP(CT)$. C is determined by fitting first differences. A and B are determined by linear least squares. Values are projected from resulting formulae.

4. Modified Exponential Curve with Asymptote. Least squares fit of $Y=A+B \times EXP(CT)$. A is entered by the user in Columns 13-18. Exponential curve is then fit after transformation and values are projected from resulting formulae.

5. Logistics Curve. Least squares fit of $1/Y=A+B \times EXP(CT)$. The calculation is similar to code 3 following the transformation of Y. Values are projected from resulting formulae.

6. Logistics Curve with Asymptote. Least squares fit of $1/Y=A+B \times EXP(CT)$. 1/A is given by the user in Columns 13-18. Exponential is then fit after transformation.

7. Gompertz Curve. Least squares fit of $LOG\ Y=A+B \times EXP(CT)$. Same as 5 except for LOG transformation.

8. Gompertz Curve with Asymptote. Same as 6 except for LOG transformation.

Col. 11 - 12	Not used.
Col. 13 - 18	The values of the asymptotes when needed (codes 4, 6, 8).
Col. 19	Decimal point location for asymptote (Columns 13-18). Entries of 1, 2, 3, ..., or 9 shifts the decimal point to the right. J, K L, ..., R indicates a shift to the left
Col. 20 - 80	Not used.

Alternative Format-4. (Used with a 9 entry in Column 6 for special user defined functions. See Section 1.4.)

Col. 8 - 10	The number used to designate the special function. Subroutines 1-8 are already designated in the program. Numbers 9-999 are available for user supplied subroutines.
Col. 11	Not used.
Col. 12 - 14	The row number of the parameter row which contains or references information necessary to carry out the function.
Col. 15	Not used.
Col. 16 - 18	The number of entries in the parameter row which refer to rows used in the special function. The first 'n' entries in the parameter row identify the 'n' rows that are used in the function.
Col. 19 - 80	Not used.

The '8' Format

It is necessary that all '8' cards appear in pairs. The first nine columns are the same for both cards. The remaining columns vary, depending on the card.

Col. 1	The digit 8.
Col. 2	The digits 1 or 2 signifying whether it is the first or second card.
Col. 3 - 5	This is the header number. Remember that the headers and data groups are interspersed. The header numbers must be sequential with the data group numbers.
Col. 6	Report number.
Col. 7 - 9	Not used.

First Card Format

Col. 10 - 12	The characters HDR.
Col. 13	Allowable characters are blank or 1. Designation of a 1 causes a skip to the top of a new page before the header is printed.
Col. 14	Space character. Designation of a 1, 2, or 3 causes the spacing of one, two or three lines after the header is printed.
Col. 15 - 71	First part of the header as supplied by the user.
Col. 72 - 80	Not used.

Second Card Format

Col. 10 - 71	Second half of the header.
Col. 72 - 80	Not used.

The '9' Format

Col. 1	The digit 9.
Col. 2 - 4	The data group number for the report.
Col. 5	Not used.
Col. 6	The report number.
Col. 7 - 9	Not used.
Col. 10 - 12	The first row appearing in the data group.
Col. 13	Allowable entries are blank, 1, 2, ..., 9. They indicate that zero, one, ..., nine line spaces are to be effected after the printing of this line of the report.
Col. 14 - 73	Same as Columns 10-13 for the remaining rows in the data group.
Col. 74 - 80	Not used.

The 'R' Format

Col. 1	The character R.
Col. 2	Not used.
Col. 3	The report number.
Col. 4 - 19	Not used.
Col. 20 - 23	The number of the first time period in the basic matrix.
Col. 24	Not used.
Col. 25 - 28	The number of the first time period appearing in the left-hand column of the report. This will change if the historical and planning period exceeds nine years, and, hence, more than one '1' card is used.
Col. 29 - 80	Not used.

The 'G' Format

Col. 1	The character G.
Col. 2	Not used.
Col. 3 - 5	The row number of a row requested for graphic display.
Col. 6	Not used.
Col. 7 - 17	Similar to Columns 3-6 for the remaining three rows requested on the graph.
Col. 20 - 23	The number of the first time period in the basic matrix.
Col. 24	Not used.
Col. 25 - 28	The period number at which output should begin.
Col. 29	Not used.
Col. 30 - 33	The period number at which output should terminate.
Col. 35 - 37	The row number of the row in the basic matrix which contains the time period numbers. The values of this row will be printed along the abscissa of the graph. This is optional.
Col. 38	Not used.
Col. 39	The scale designation. A blank in this column will plot the graph, using a linear ordinate scale. A 1 will initiate a logarithmic scale.
Col. 40 - 80	Not used.

The 'X' Format

Col. 1	The character X.

Col. 2	Printout option. If 1, a row-by-row summary of the computation is printed. If blank, no summary is printed. This is in addition to any reports requested with '8' and '9' cards.
Col. 3 - 13	Not used.
Col. 14 - 16	The characters END.
Col. 17 - 19	Not used.
Col. 20 - 23	The number of the first time period in the basic matrix.
Col. 24	Not used.
Col. 25 - 28	The maximum time period required for any report or graph.
Col. 29 - 80	Not used.

1.4 Special Function Subroutine. The user can branch to any special calculation or projection method, providing it is a Fortran program which is prepared in a special subroutine format. The subroutine is referenced, using two rows of the basic matrix - the row being calculated and the row used to pass parameters and row numbers necessary in the calculation.

The subroutine itself is entitled SPEC. It must have the following format:

```
SUBROUTINE SPEC (I,N,K,M)

DOUBLE PRECISION R(105)

Fortran coding supplied by user

RETURN

END
```

WHERE:

I= Disk File 3 record address of the row being calculated. This number is the row number given in Columns 2-4 of the '6' card.
N= Special routine number. This number is the user supplied number given in Columns 8-10 of the '6' card.
K= Disk File 3 record address of the parameter record. This number is the row number given in Columns 12-14 of the '6' card.
M= Number of row numbers appearing in the parameter record. The System converts these to relative addresses of file 3 prior to passing control to SPEC. This number appears in Columns 16-18 of the '6' card.

The parameter card used to enter row numbers and data used by the special function is a '1' card. The following format applies.

Col. 1	The digit 1.
Col. 2 - 4	The row number. This number cannot have been used elsewhere in the matrix.
Col. 5 - 12	The number of the first row containing information which is used in the special calculation. If no rows are used, the first parameter should be entered that is used in the formula.

Col. 13 - 20	The number of the second row used in the calculation. If data in only one row is used, the first parameter appearing in the formula. If no row numbers are used, the second parameter appearing in the formula.
Col. 21 - 76	Additional row numbers, if necessary, followed by all special function parameters in the sequence they appear in the formula.

Use of the special function subroutine can be illustrated by considering a situation in which a district wished to apply a particularly complicated state allocation formula. If the decision was made to program a separate routine (rather than build the formula into the basic support system, using arithmetic calculations, regression, or extrapolations), the '6' and '1' card might be prepared as follows. The example assumes that the special function would write results in row 115, entitled State Allocation. It would make use of previously calculated data including enrollment projections (row 65), assessed valuation projections (row 81), and some poverty index (row 94). It would also use two constants (i.e., 2.7 and .04), in that order in the equation.

The '6' Card:

```
6115    9    12    120    3
```

The '1' Card:

```
1120    065    081    094    2.7    .04
```

In this example the '6' card calls for special function subroutine number 12, as prepared by the user. It identifies the parameter row as 120, and notes that the first three entries will refer to rows of information necessary to the function, and already in the basic matrix. The last two entries on the '1' card contain the constants necessary in the function. The function itself would be submitted with the other subroutines discussed in Appendix B. It would be preceded by the cards SUBROUTINE SPEC (I,N,K,M) and DOUBLE PRECISION R(105) and followed by the cards RETURN and END.

1.5 Systems Output. The printout generated by the system will consist of a variety of distinct elements, depending upon the requests submitted by the user. These include:

A. Job control language
B. Clear disk utility
C. Input cards
D. Calculation summary
E. Reports
F. Graphs

Familiarity with the job control language and clear disk utility are not required to understand the systems output. A sample listing of Input cards is presented in Figure A-7, a sample Summary printout is presented in Figure A-8. Figures A-9 and A-10 illustrate typical Report and Graphic printouts respectively.

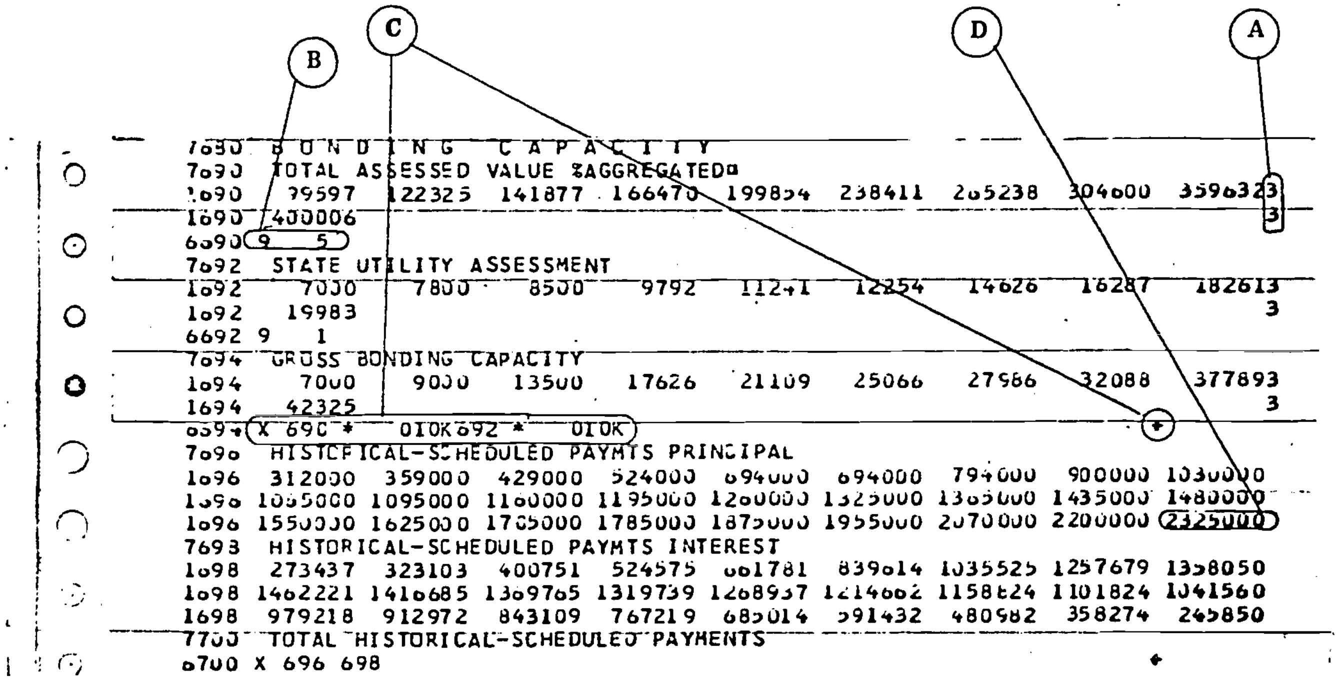
The first card printed immediately before the listing of input cards is the report heading. This same heading is preceded by the words STOP and printed after all the reports and graphs. The card currently contains the wording, School Facility Planning System. Any report heading may be substituted, providing it does not exceed forty positions.

2. Geographic Analysis Support System.

The program used to support the geographic analysis makes use of six separate data cards. These cards are used to designate the number of schools and grids, the population of each grid, the capacity of each school, the distance from each grid to each school, the percent minority in the district, and the percent minority in each grid. The first four card types are used in the program BOUND, the last two are needed in RBOUND. The cards are described generally in Section 2.1, with specific card layouts presented in Section 2.2. Sample printouts are included in Section 2.3.

FIGURE A–7 SAMPLE LISTING OF INPUT CARDS

The first portion of the printout is a listing of all input cards. These cards are listed in the order in which they were submitted. The example illustrates selected '7,' '1,' and '6' cards from the Fiscal Component.



```
7690  B O N D I N G   C A P A C I T Y
7690  TOTAL ASSESSED VALUE %AGGREGATED□
1690   99597  122325  141877  166470  199854  238411  265238  304600  3596323
1690  400006                                                                3
6690 9   5
7692  STATE UTILITY ASSESSMENT
1692    7030    7800    8500    9792   11241   12254   14626   16287   182613
1692   19983                                                                3
6692 9   1
7694  GROSS BONDING CAPACITY
1694    7000    9000   13500   17626   21109   25066   27986   32088   377893
1694   42325                                                                3
6694 X 690 *    010K692 *    010K                                     +
7696  HISTORICAL-SCHEDULED PAYMTS PRINCIPAL
1696  312000  359000  429000  524000  694000  694000  794000  900000 1030000
1696 1055000 1095000 1160000 1195000 1260000 1325000 1365000 1435000 1480000
1696 1550000 1625000 1705000 1785000 1875000 1955000 2070000 2200000 2325000
7693  HISTORICAL-SCHEDULED PAYMTS INTEREST
1698  273437  323103  400751  524575  661781  839614 1035525 1257679 1358050
1698 1462221 1416685 1369765 1319739 1268937 1214662 1158624 1101824 1041560
1698  979218  912972  843109  767219  685014  591432  480982  358274  245850
7700  TOTAL HISTORICAL-SCHEDULED PAYMENTS
6700 X 696 698                                                        +
```

Explanation:

Ⓐ Row 690 contains historical assessed valuation data. The 3 in Column 77 of the '1' cards indicates that the input values should be multiplied by 1000. Thus the entry in the eighth time period is $304,600,000.

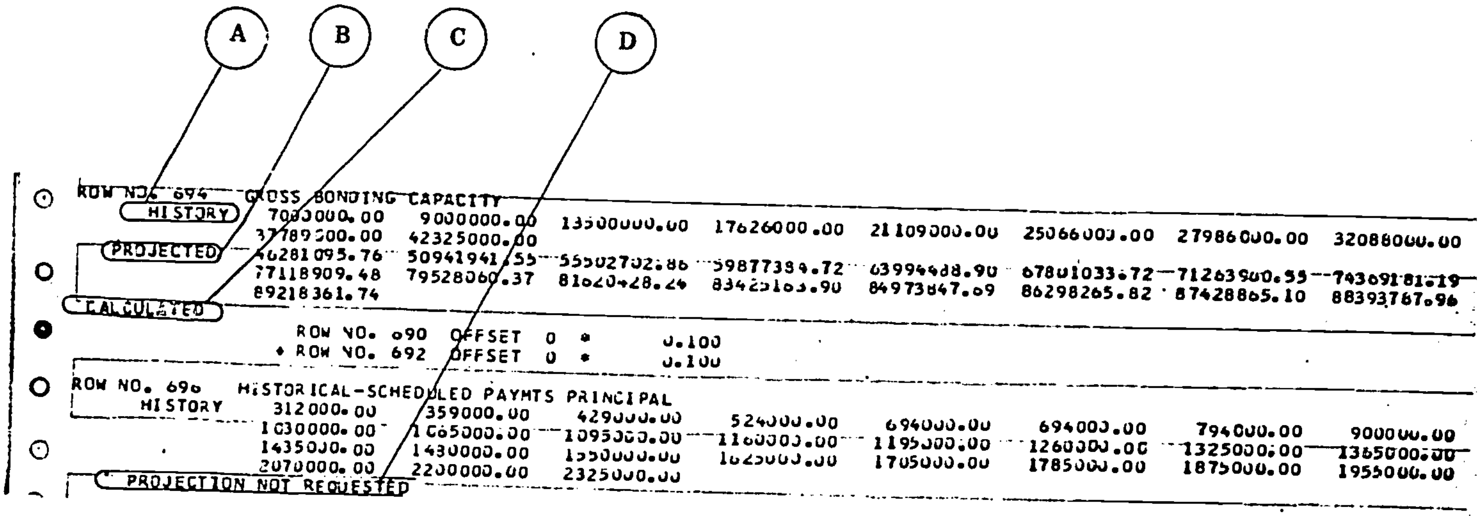
Ⓑ The '6' card for Row 690 indicates that a time series projection should be made (the 9 in Col. 6) using a logistics curve (the 5 in Col. 10).

Ⓒ Gross bonding capacity is projected by an arithmetic calculation (the x in Col. 6). Rows 690 (Cols. 8-10) and 692 (Cols. 20-22) are multiplied (the *s in Cols. 12 and 24) by ten percent (the 010K in Cols. 16-19 and Cols. 28-31). The two products are then added together by the + in Col. 69.

Ⓓ The scheduled payment of principal is $2,325,000 in the 27th time period. Because this projected data is provided by the user, no '6' card is required.

FIGURE A–8 SAMPLE SUMMARY PRINTOUT

The second part of the printout summarizes the processing that has occurred on each row. This summary is requested by entering a 1 in Column 2 of the 'x' card. The example presents a summary for two rows.



```
ROW NO. 694    GROSS BONDING CAPACITY
   HISTORY     7000000.00   9000000.00  13500000.00  17626000.00  21109000.00  25066000.00  27986000.00  32088000.00
              37789000.00  42325000.00
              46281095.76  50941941.55  55502702.86  59877384.72  63994488.90  67801033.72  71263900.55  74309181.19
              77118909.48  79528060.37  81620428.24  83425163.90  84973847.09  86298265.82  87428865.10  88393767.96
              89218361.74
                    ROW NO. 690   OFFSET  0  *      0.100
                  + ROW NO. 692   OFFSET  0  *      0.100
ROW NO. 696    HISTORICAL-SCHEDULED PAYMTS PRINCIPAL
      HISTORY   312000.00    359000.00    429000.00    524000.00    694000.00    694000.00    794000.00    900000.00
               1030000.00   1065000.00   1095000.00   1160000.00   1195000.00   1260000.00   1325000.00   1365000.00
               1435000.00   1430000.00   1550000.00   1625000.00   1705000.00   1785000.00   1875000.00   1955000.00
               2070000.00   2200000.00   2325000.00
```

Explanation:

- Ⓐ The history data was input for ten time periods on two '1' cards for Row 694.
- Ⓑ Projections have been made for seventeen future time periods.
- Ⓒ The projection technique is listed for each row requesting a projection.
- Ⓓ No projection was requested because no '6' card was submitted for this row. The '1' cards contained data for all time periods, thus a '6' card was not required.

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FIGURE A–9 SAMPLE REPORT PRINTOUT

The third portion of the printout is the report of all calculated information. As explained below, the report is formatted using '8' (header) cards and '9' (data group) cards. The example illustrates the middle nine years of the twenty-seven time periods for a part of the Fiscal Component.

```
                                     *****   FISCAL COMPONENT   *****

--------------------------------** BONDING CAPACITY FORECASTING MODULE  **---------------------------------

YEAR                                       1974      1975      1976      1977      1978      1979      1980      1981      1982

TOTAL ASSESSED VALUE %AGGREGATED%     400006000 442065854 487212358 531338017 573602881 613291968 649875461 683022772 712593022
STATE UTILITY ASSESSMENT               19983000  20725200  22207164  23689127  25171091  26653055  28135016  29616962  31098945
GROSS BONDING CAPACITY                 42325000  46281095  50941942  55502703  59877385  63954489  67801034  71263961  74369181

HISTORICAL-SCHEDULED PAYMTS PRINCIPAL   1065000   1095000   1160000   1175000   1260000   1325000   1365000   1435000   1480000
HISTORICAL-SCHEDULED PAYMTS INTEREST    1462221   1416685   1369765   1319739   1268937   1214662   1158824   1101824   1041560
TOTAL HISTORICAL-SCHEDULED PAYMENTS     2527221   2511685   2529765   2514739   2528937   2539662   2523824   2536824   2521560

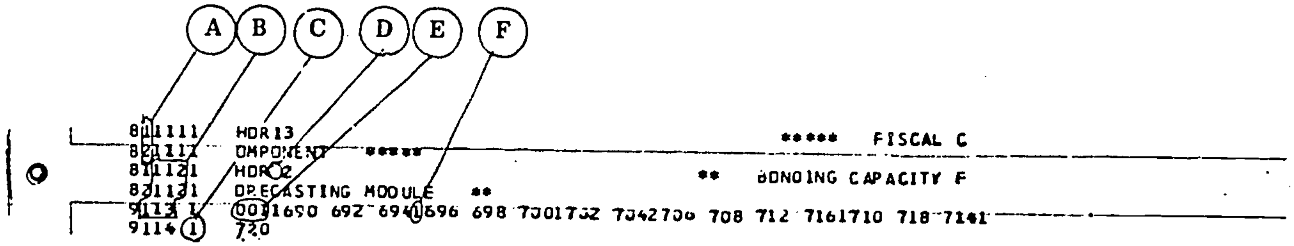
BALANCE ON OUTSTANDING BONDS           29805000  28710000  27550000  26335000  25095000  23770000  22405000  20970000  19490000
INTERMEDIATE BONDING CAPACITY          12520000  17571096  23391942  29147703  34782385  40224489  45396034  50293961  54879181

PROPOSED BOND ISSUES                          0         0         0  12000000         0         0         0  14000000         0
PROPOSED PAYMENTS ON PRINCIPAL                0         0         0         0   1000000   1000000   1000000   2200000   2200000
PROPOSED PAYMENTS ON INTEREST                 0         0         0         0    600000    550000    500000   1150000   1090000
TOTAL PAYMENTS ON PROPOSED BONDS              0         0         0         0   1600000   1550000   1500000   3350000   3290000

BALANCE ON PROPOSED BOND ISSUES               0         0         0  12000000  11000000  10000000   9000000  20600000  18600000
TOTAL BOND PAYMENTS - ALL BONDS         2527221   2511685   2529765   2514739   4128937   4089662   4023824   5866824   5811560
TOTAL INDEBTEDNESS                     29805000  28710000  27550000  38335000  36095000  33770000  31405000  41770000  38095000

FORECASTED NET BONDING CAPACITY        12520000  17571096  23391942  17147703  23782385  30224489  36396034  29493961  36279181
```

Explantion: This report was formatted using four '8' cards and two '9' cards. They appeared in the input card listing as follows:

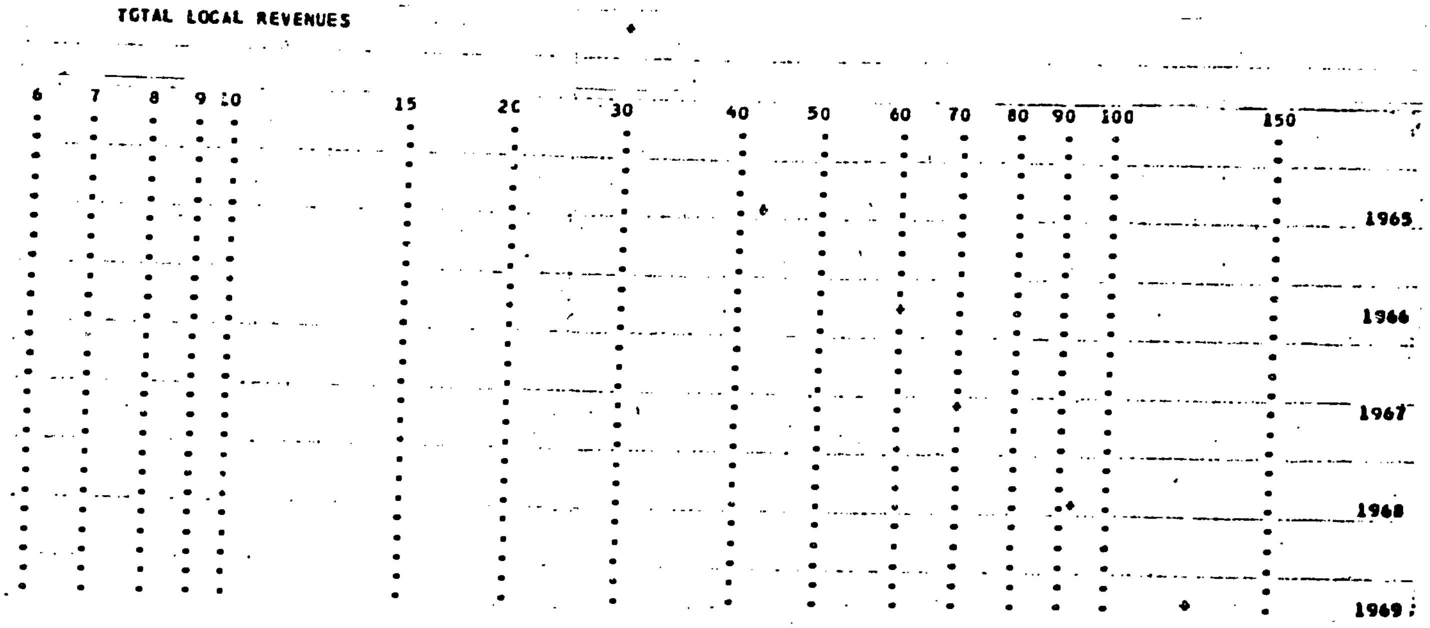


```
811111   HDR13                                          *****   FISCAL C
821111   OMPONENT    *****
811121   HDR 2                                    **    BONDING CAPACITY F
821121   ORECASTING MODULE    **
9113 1   0011690 692 6941696 698 7001732 7042706 708 712 7161710 718 7141
9114 1   720
```

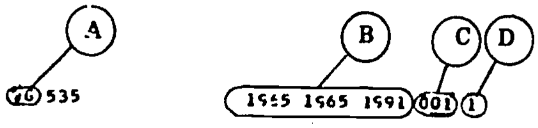
- Ⓐ Every '8' card must be submitted in pairs, with the 2 following the 1.
- Ⓑ Every '8' and '9' card must have header and data group numbers respectively that are sequential.
- Ⓒ This is Report Number 1.
- Ⓓ The blank in Column 13 directs the report to be printed on the same page rather than the top of a new page.
- Ⓔ This is the first row in the data group (the years of the time period in this example).
- Ⓕ A one in Column 13, 17, 21, 25, etc. directs a line to be skipped in the report (see blank line after "gross bonding capacity").

FIGURE A–10 SAMPLE GRAPHIC PRINTOUT

The final portion of the printout is a graph of selected data items. This optional display is requested with a 'G' card. The example presents one data item for the first five years of a planning period.



Explanation: The graph was initiated with a 'G' card which appeared in the input card listing as follows:



Ⓐ Row 535 information (Total Local Revenues) is displayed. Up to four data items per graph are permitted.

Ⓑ In this example, data is to be displayed for every time period.

Ⓒ This causes the years (Row 001) to be printed along the abscissa of the graph.

Ⓓ A one in Column 39 directs that the graph be printed on a logarithmic scale.

2.1 Basic Input Cards. The first user supplied card specifies the number of schools and the number of grids in the school district. The geographic analysis should be done by grade levels such as elementary, junior high, and senior high. The number of grids in the district is a function of the number of schools at that grade level and the total enrollment projected for that grade level. Reference should be made to Section 3.4 of the Enrollment Component for a more detailed discussion of the number of grids needed. The second card type necessary for BOUND is used to specify the student population of each grid. The number of cards needed is a function of the number of grids into which the district has been divided. Each card can accommodate eight population figures. If the school district has been divided into more than eight and less than seventeen grids, two cards are necessary. If more than sixteen and less than twenty-five grids are involved, three cards are required. The total number of cards needed is thus determined by the number of grids.

The third set of cards contains data describing the capacities of each school of that type in the district. This card is similar in format to the population card in that eight school capacities can be accommodated on one card. The number of cards needed is dependent on the number of schools.

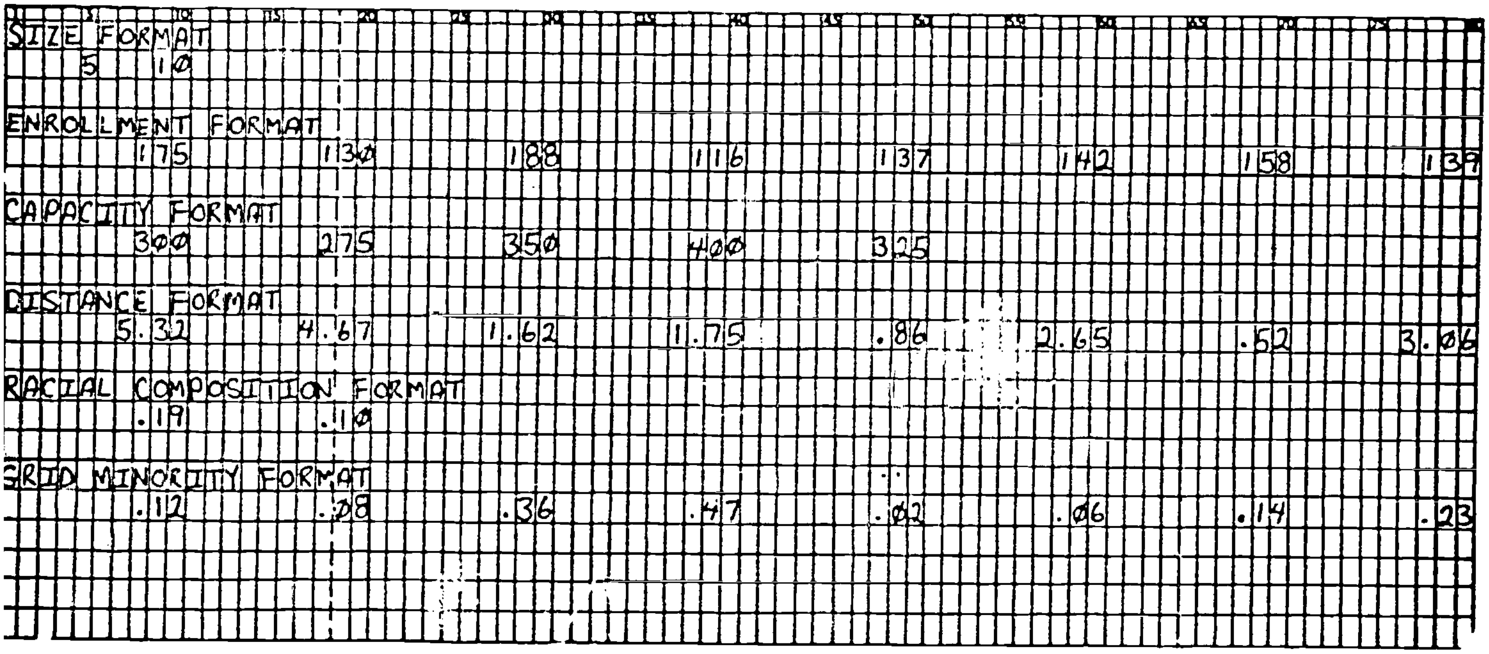
The final set of cards needed for the program BOUND represents the distance matrix. The number of cards needed is a function of the number of grids times the number of schools. The distance from each grid to each school is specified as a decimal. The format allows eight distances to be listed per card. The total number of cards needed is determined in the same manner as the population and capacity cards.

The first additional card needed in RBOUND specifies the total minority of the district as a decimal and states the variance allowed in this factor. This data is an additional constraint on the allocation of student population to schools.

The last set of cards needed to run RBOUND specifies the percent minority, expressed as a decimal, in each grid in the district. The number of cards needed equals the number of population cards used.

2.2 Input Card Formats. The following formats should be used to prepare the necessary input cards for the programs BOUND and RBOUND. An example of each card type is shown in Figure A-11.

FIGURE A–11 SAMPLE INPUT CARD FORMATS FOR BOUND AND RBOUND



```
SIZE FORMAT
    5   10

ENROLLMENT FORMAT
       175       130       188       116       137       142       158       139

CAPACITY FORMAT
       300       275       350       400       325

DISTANCE FORMAT
      5.32      4.67      1.62      1.75       .86      2.65       .52      3.06

RACIAL COMPOSITION FORMAT
       .19       .10

GRID MINORITY FORMAT
       .12       .28       .36       .47       .02       .06       .14       .23
```

The Size Format

Col. 1 - 5	The number of schools in the district, right justified.
Col. 6 - 10	The number of grids in the district, right justified
Col. 11 - 80	Not Used.

The Enrollment Format

Col. 1 - 10	The school population of the first grid, right justified.
Col. 11 - 80	The school population of grid two thru grid eight. If there are more than eight grids, continue on another card by repeating Column 1-80.

The Capacity Format

Col. 1 - 10	The capacity of the first school, right justified.
Col. 11 - 80	The capacity of school two thru school eight. If there are more than eight schools, continue on another card by repeating Columns 1-80.

The Distance Format

Col. 1 - 10	The distance from grid one to school one, right justified, with the decimal specified.
Col. 11 - 20	The distance from grid one to school two, right justified, with the decimal specified.
Col. 21 - 80	The distance from grid one to each school, right justified, with the decimal specified. When the distances have been listed from grid one, the same procedures are followed for grid two and so on until all grids have been exhausted. When the number of distances exceed eight (or a multiple of eight), a new card is started repeating Columns 1-80.

Racial Composition Format

Col. 1 - 10	The percent minority of the entire school district, right justified, expressed as a decimal.
Col. 11 - 20	The variance allowed in the percent minority of the district, right justified, expressed as a decimal.

Grid Minority Format

Col. 1 - 10	The percent minority of grid one, right justified, expressed as a decimal.
Col. 11 - 80	The percent minority of grid two thru grid eight, right justified, expressed as a decimal. If there are more than eight grids, continue on a second card, repeating Columns 1-80.

2.3 Systems Output. The printout generated by the System includes the data submitted on the input cards and a matrix of the optimal allocation of students to schools based on the distance matrix and the constraints specified by the user. Also included in the output is a listing of the number of iterations needed in each phase of SIMPLX to calculate the optimal solution.

The message concerning the number of iterations can be transferred to the console of the computer system utilizing the "spooling" technique of output. A sample listing of the message is in Figure A-12. The output format of the input cards is in Figure A-13. The optimal allocation matrix and the feasible maximum distance are shown in Figure A-14.

FIGURE A–12 NUMBER OF ITERATIONS OF SIMPLX

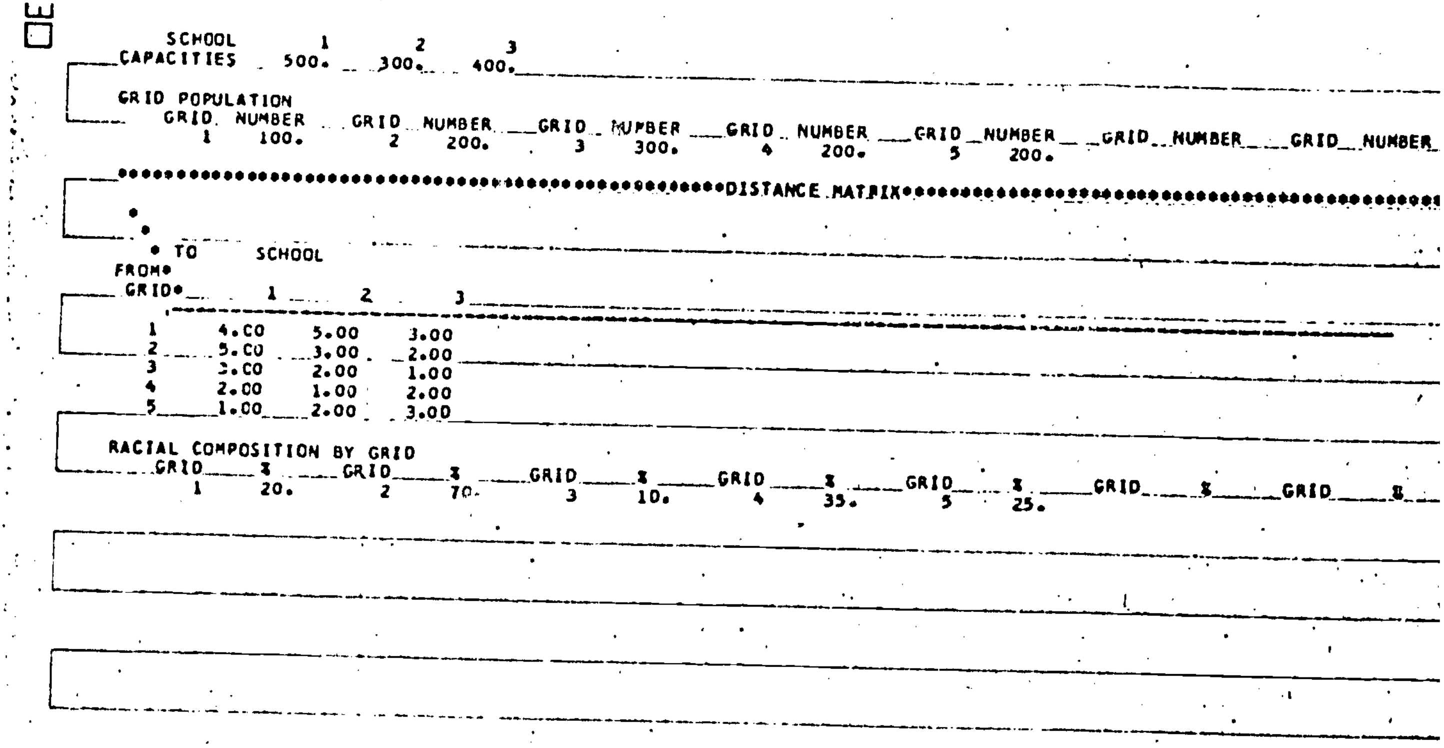
```
 AFTER      7 ITERATIONS  SIMPLEX CRITERION #    0.0
```

Phase 1 works toward a feasible solution of the distance matrix. A message is printed on every 50th iteration and on the iteration at which the feasible solution is achieved.

Phase 2 starts with the feasible solution produced by Phase 1 and works toward an optimal solution. The optimal solution is where the minimum feasible distance of the matrix is at its lowest. Phase 2 also prints a message on every 50th iteration and on the iteration at which the optimal solution is reached.

```
 AFTER     50 ITERATIONS  SIMPLEX CRITERION #    0.28610229E-05
 AFTER    100 ITERATIONS  SIMPLEX CRITERION #    0.46491623E-05
 AFTER    106 ITERATIONS  SIMPLEX CRITERION #    0.0
```

FIGURE A–13 OUTPUT FORMAT OF GEOGRAPHIC ANALYSIS INPUT CARDS



```
   SCHOOL        1      2      3
CAPACITIES     500.   300.   400.

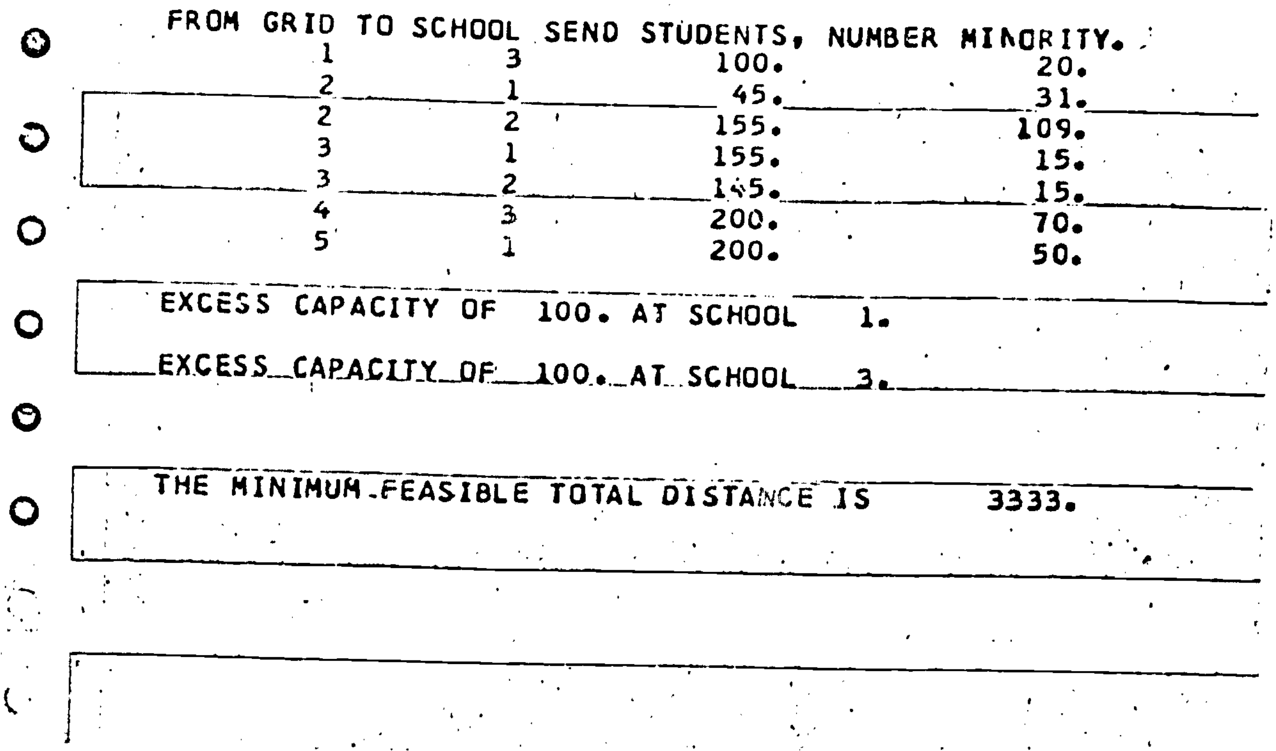
GRID POPULATION
      GRID  NUMBER    GRID  NUMBER    GRID  NUMBER    GRID  NUMBER    GRID  NUMBER    GRID  NUMBER    GRID  NUMBER
        1    100.       2    200.       3    300.       4    200.       5    200.

**********************************************DISTANCE MATRIX********************************************************
 *
  *
   * TO     SCHOOL
FROM*
 GRID*      1       2       3

   1      4.00    5.00    3.00
   2      5.00    3.00    2.00
   3      3.00    2.00    1.00
   4      2.00    1.00    2.00
   5      1.00    2.00    3.00

RACIAL COMPOSITION BY GRID
     GRID     %      GRID     %      GRID     %      GRID     %      GRID     %      GRID     %      GRID     %
       1     20.       2     70.       3     10.       4     35.       5     25.
```

FIGURE A–14 OPTIMAL ALLOCATION MATRIX



```
FROM GRID TO SCHOOL SEND STUDENTS, NUMBER MINORITY.
        1         3         100.         20.
        2         1          45.         31.
        2         2         155.        109.
        3         1         155.         15.
        3         2         145.         15.
        4         3         200.         70.
        5         1         200.         50.

EXCESS CAPACITY OF  100. AT SCHOOL   1.
EXCESS CAPACITY OF  100. AT SCHOOL   3.

THE MINIMUM FEASIBLE TOTAL DISTANCE IS      3333.
```

APPENDIX B
HARDWARE/SOFTWARE CONSIDERATIONS

Each of the program packages used in the School Facility Planning System is written in Fortran. Each has been tested on an IBM Model 370-145 operating under DOS/VS. Appendix B is designed to further document the technical aspects of these programs including the job control language, the core requirements, error messages and subroutines.

1. Basic Support System.

The computer programs that enable the analysis of the first three components require a total of 150 K bytes of core storage on an IBM 370. It is possible to overlay portions of programs and execute in a sixty-five K partition.

1.1 Disk Requirements. A disk drive is required. Five disk files are defined as working areas:

File	Description
1–File	Direct access file with 1000 records. This file holds all of the row descriptions as entered from the '7' cards.
2–File	Direct access file with 200 records. This file holds all of the information from the '8', '9', 'R', 'G' cards.
3–File	Direct access file with 1005 records. This file holds all of the information of the basic matrix.
4–File	Direct access files with 1000 records. This file holds all of the information from the '6' cards.
7–File	Direct access file with twenty records. This is a utility file used for passing information from the main calculation programs to the subroutine SUMRY.

The clear disk utility is required by DOS and is executed prior to program execution. No files are saved.

1.2 Data Submission to the Computing System. Once all forms have been keypunched, the resulting deck must be submitted in the proper sequence if the System is to operate properly. Figure B-1 illustrates the sequence by which the cards should be assembled.

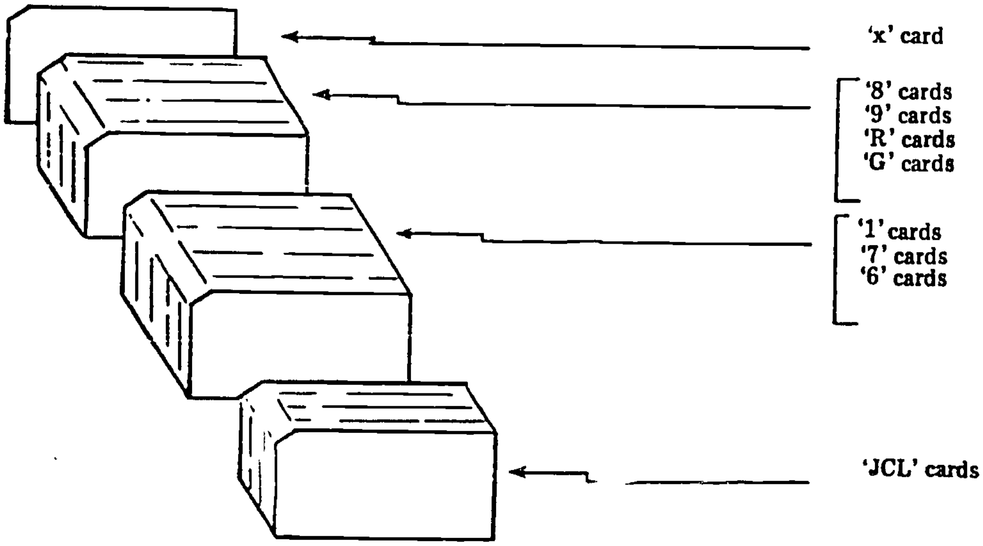


FIGURE B–1 CARD SEQUENCE

The Job Control Language (JCL) cards are the first set of cards and the 'X' card is the last. In general the basic input cards ('7', '1' and '6') should be kept separate from the report generation cards ('8', '9', 'R' and 'G'). However, the only formal restrictions are that:

1. '3' cards be submitted in pairs, with the '81' card ahead of the '82' card.
2. If more than one '1' card is submitted per row, the cards with the earliest time periods must be submitted first.

Sample job control listings are presented in Figures B-2 and B-3 for an IBM-DOS environment. The first figure illustrates the JCL used to catalog the programs. The second figure illustrates the execute JCL. The linkage editor map is presented in Figure B-4.

1.3 Error Messages. Error messages are printed in line on the output reports as they are encountered. They are of the form

```
ERROR     N     ROW     XXX
```

where N is the error number and XXX is the row number of the card in error, or the row being processed at the time the error is detected. After the error message is printed, the System continues if possible.

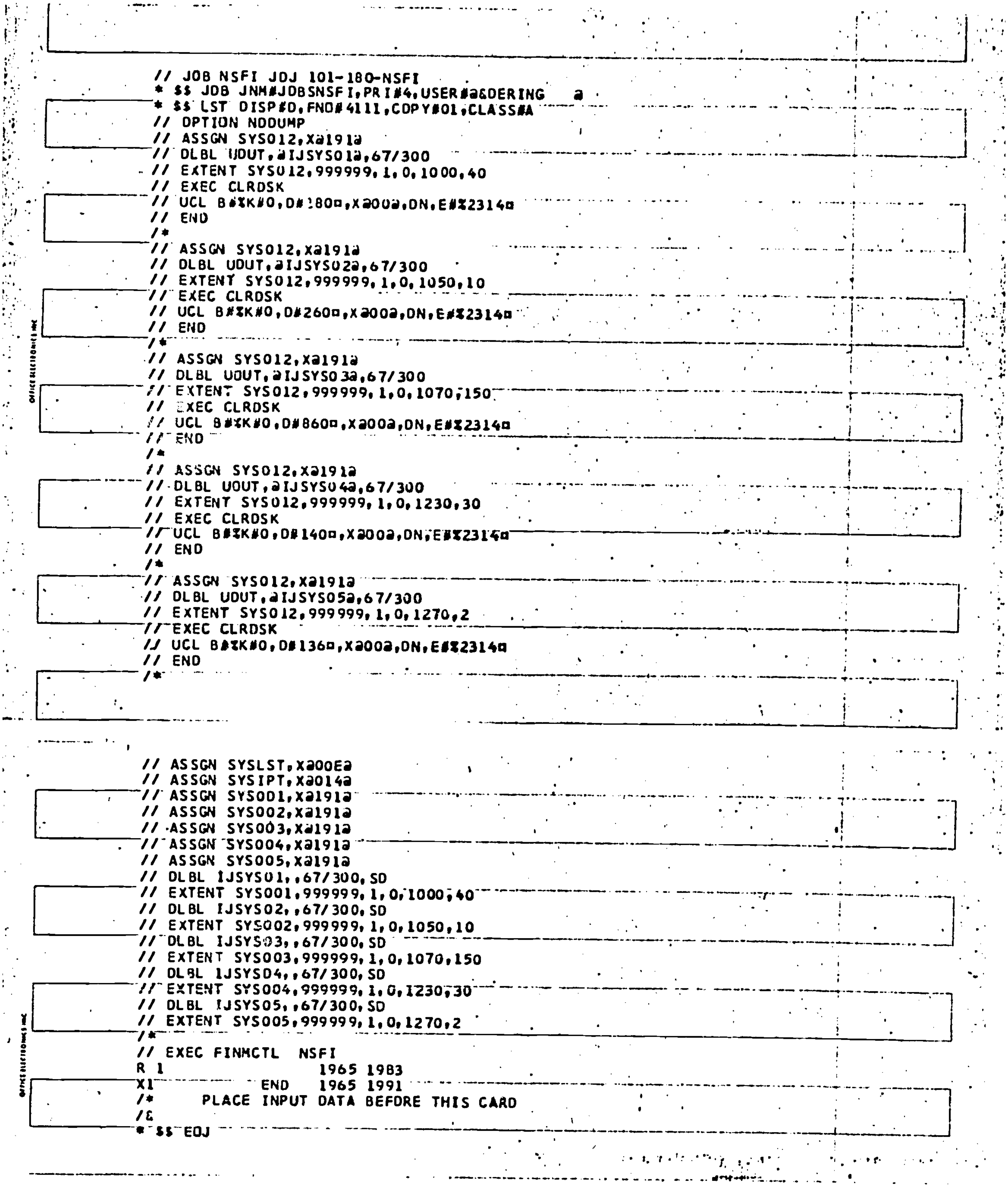
Error Number	Definition
3	End card was read but no history information has been entered into the System.
4	End card was read but no '6' cards were entered into the System.
5	End card was read but no '7' cards were entered into the System.
6	On the 'X' card the first time period and the maximum period are not consistent.
7	End card was read but no '9' cards were entered into the System.
8	Row for which a second degree projection was requested contained no history information.
9	Row requested in a calculation is not on file.
11	Same as 9.
12	Row requested for a report ('9' card) is not on file.
13	File is full. 1000 records exceeded.
14	Row requested in a regression is not on file.
15	Row description requested in a report is not on file
17	Input card has syntax error.

1.4 Basic Support System Subroutines. Thirty-three subroutines combine to provide the necessary support for the School Facility Planning System. As illustrated in Figure B-5, the System Flowchart, and B-6, the Subroutine Cross Reference Table, these subroutines are assembled in six phases, in addition to the root phase. A short description of each subroutine follows:

```
// JOB 0000 JDJ 991-999-9907
* $$ JOB JNM#JOBSNSFI,PRI#4,USER#@GOERING   @
* $$ LST DISP#D,FNO#4111,COPY#01,CLASS#T
// OPTION CATAL
 PHASE FINMCTL,ROOT,NOAUTO
 INCLUDE ILFGHTAB
 INCLUDE ILFDIOCS
 INCLUDE ILFFEXIT
 INCLUDE ILFFRXPI
 INCLUDE ILFIBCOM
 INCLUDE ILFADCON
 INCLUDE ILFFINT
 INCLUDE ILFFIOCS
 INCLUDE IJJCPD1
 INCLUDE ILFLEXP
 INCLUDE ILFLSQRT
 INCLUDE ILFLLOG
 INCLUDE ERROR
 INCLUDE PUT
 INCLUDE FILL
 INCLUDE PRINT
 INCLUDE MOVE
 INCLUDE FINM
 PHASE FINMONE,*
 INCLUDE FINMON
 PHASE FINMTWO,FINMONE,NOAUTO
 INCLUDE FINMTW
 PHASE FINM21,*
 INCLUDE BUILD
 PHASE FINM22,FINM21
 INCLUDE BAP
 INCLUDE CURF
 PHASE FINM23,FINM21
 INCLUDE MREG
 INCLUDE CORRE
 INCLUDE ORDER
 INCLUDE MINV
 INCLUDE MULTR
 INCLUDE DATA

 PHASE FINM24,FINM21
 INCLUDE SPEC1
 INCLUDE SPEC
 PHASE FINM25,FINM21
 INCLUDE SUMRY
 INCLUDE HISTP
 INCLUDE FOREP
 PHASE FINMTHRE,FINMONE
 INCLUDE FINMTH
 INCLUDE REPT
/*
// LBLTYP TAPE
// EXEC LNKEDT
/*
/&
* $$ EOJ
```

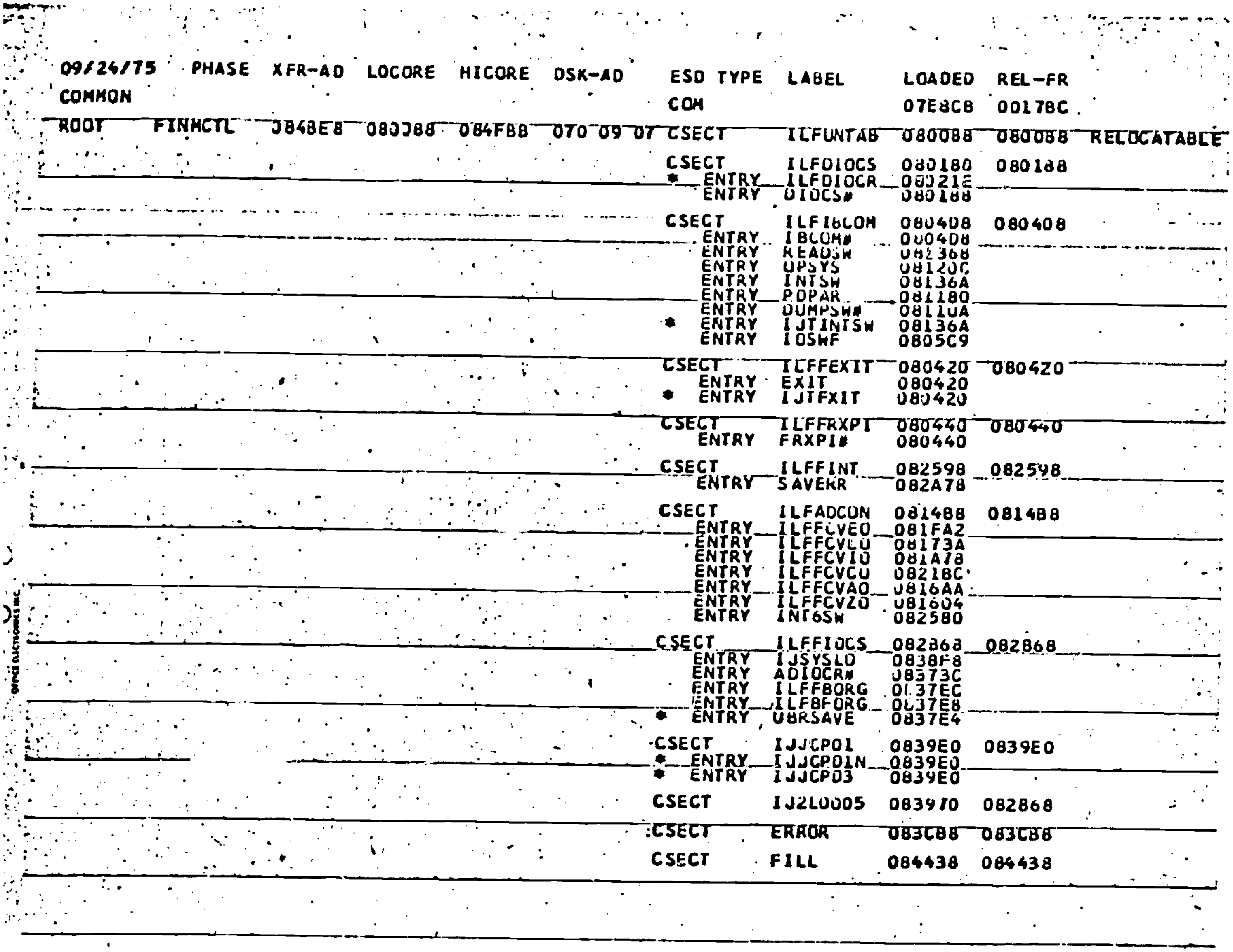
FIGURE B–2 JCL CATALOG



```
// JOB NSFI JDJ 101-180-NSFI
* $$ JDB JNM#JDBSNSFI,PRI#4,USER#a&DERING    a
* $$ LST DISP#D,FND#4111,CDPY#01,CLASS#A
// DPTION NDDUMP
// ASSGN SYS012,Xa191a
// DLBL UDUT,aIJSYS01a,67/300
// EXTENT SYS012,999999,1,0,1000,40
// EXEC CLRDSK
// UCL B#%K#0,D#180¤,Xa00a,DN,E#%2314¤
// END
/*
// ASSGN SYS012,Xa191a
// DLBL UDUT,aIJSYS02a,67/300
// EXTENT SYS012,999999,1,0,1050,10
// EXEC CLRDSK
// UCL B#%K#0,D#260¤,Xa00a,DN,E#%2314¤
// END
/*
// ASSGN SYS012,Xa191a
// DLBL UDUT,aIJSYS03a,67/300
// EXTENT SYS012,999999,1,0,1070,150
// EXEC CLRDSK
// UCL B#%K#0,D#860¤,Xa00a,DN,E#%2314¤
// END
/*
// ASSGN SYS012,Xa191a
// DLBL UOUT,aIJSYS04a,67/300
// EXTENT SYS012,999999,1,0,1230,30
// EXEC CLRDSK
// UCL B#%K#0,D#140¤,Xa00a,DN,E#%2314¤
// END
/*
// ASSGN SYS012,Xa191a
// DLBL UDUT,aIJSYS05a,67/300
// EXTENT SYS012,999999,1,0,1270,2
// EXEC CLRDSK
// UCL B#%K#0,D#136¤,Xa00a,DN,E#%2314¤
// END
/*

// ASSGN SYSLST,Xa00Ea
// ASSGN SYSIPT,Xa014a
// ASSGN SYS001,Xa191a
// ASSGN SYS002,Xa191a
// ASSGN SYS003,Xa191a
// ASSGN SYS004,Xa191a
// ASSGN SYS005,Xa191a
// DLBL IJSYS01,,67/300,SD
// EXTENT SYS001,999999,1,0,1000,40
// DLBL IJSYS02,,67/300,SD
// EXTENT SYS002,999999,1,0,1050,10
// DLBL IJSYS03,,67/300,SD
// EXTENT SYS003,999999,1,0,1070,150
// DLBL IJSYSD4,,67/300,SD
// EXTENT SYS004,999999,1,0,1230,30
// DLBL IJSYS05,,67/300,SD
// EXTENT SYS005,999999,1,0,1270,2
/*
// EXEC FINMCTL  NSFI
R 1                 1965 1983
X1          END     1965 1991
/*     PLACE INPUT DATA BEFORE THIS CARD
/&
* $$ EOJ
```

FIGURE B–3 JCL EXECUTE



```
09/24/75  PHASE  XFR-AD  LOCORE  HICORE  DSK-AD     ESD TYPE  LABEL      LOADED  REL-FR
COMMON                                              COM                  07E8C8  00178C
ROOT      FINMCTL 0848E8 080088  084FB8  070 09 07  CSECT     ILFUNTAB   080088  080088  RELOCATABLE

                                                    CSECT     ILFDIOCS   080180  080188
                                                  *    ENTRY  ILFDIOCR   08021E
                                                       ENTRY  DIOCS#     080188

                                                    CSECT     ILFIBCOM   080408  080408
                                                       ENTRY  IBCOM#     080408
                                                       ENTRY  READSW     082368
                                                       ENTRY  OPSYS      08120C
                                                       ENTRY  INTSW      08136A
                                                       ENTRY  POPAR      081180
                                                       ENTRY  DUMPSW#    08110A
                                                  *    ENTRY  IJTINTSW   08136A
                                                       ENTRY  IOSWF      0805C9

                                                    CSECT     ILFFEXIT   080420  080420
                                                       ENTRY  EXIT       080420
                                                  *    ENTRY  IJTFXIT    080420

                                                    CSECT     ILFFRXPI   080440  080440
                                                       ENTRY  FRXPI#     080440

                                                    CSECT     ILFFINT    082598  082598
                                                       ENTRY  SAVERR     082A78

                                                    CSECT     ILFADCON   081488  081488
                                                       ENTRY  ILFFCVEO   081FA2
                                                       ENTRY  ILFFCVLO   08173A
                                                       ENTRY  ILFFCVIO   081A78
                                                       ENTRY  ILFFCVCO   0821BC
                                                       ENTRY  ILFFCVAO   0816AA
                                                       ENTRY  ILFFCVZO   081604
                                                       ENTRY  INT6SW     082580

                                                    CSECT     ILFFIOCS   082868  082868
                                                       ENTRY  IJSYSLO    0838F8
                                                       ENTRY  ADIOCR#    08373C
                                                       ENTRY  ILFFBORG   0837EC
                                                       ENTRY  ILFBFORG   0837E8
                                                  *    ENTRY  UBRSAVE    0837E4

                                                    CSECT     IJJCP01    0839E0  0839E0
                                                  *    ENTRY  IJJCP01N   0839E0
                                                  *    ENTRY  IJJCP03    0839E0

                                                    CSECT     IJ2L0005   083970  082868

                                                    CSECT     ERROR      083CB8  083CB8

                                                    CSECT     FILL       084438  084438
```

FIGURE B—4 LINKAGE EDITOR MAP

```
09/24/75   PHASE  XFR-AD  LOCORE  HICORE  DSK-AD    ESD TYPE  LABEL     LOADED  REL-FR
                                                    CSECT     MOVE      084A10  084A10
                                                    CSECT     PUT       083F50  083F50
                                                    CSECT     PRINT     084508  084508
                                                    CSECT     FINM      084BE8  084BE8
         FINMONE  084FC0  084FC0  087C88  070 08 06 CSECT     FINMON    084FC0  084FC0  RELOCATABLE
                                                    CSECT     FINM1     085000  085000
                                                    CSECT     HIST      0861C0  0861C0
                                                    CSECT     GET       085050  085050
                                                    CSECT     MATR      0866F8  0866F8
                                                    CSECT     REPH      0871C8  0871C8
                                                    CSECT     ILFFDXPI  086658  086658
                                                       ENTRY  FDXPI#    086658
         FINMTWO  084FC0  084FC0  085583  070 0C 09 CSECT     FINMTW    084FC0  084FC0  RELOCATABLE
         FINM21   085588  085588  0860C7  070 0C 08 CSECT     BUILD     085588  085588  RELOCATABLE
         FINM22   085588  085588  0864D3  070 0D 04 CSECT     BAP       085588  085588  RELOCATABLE
                                                    CSECT     CURF      086280  086280
                                                    CSECT     ILFFDXPI  086438  086438
                                                    *  ENTRY  FDXPI#    086438
         FINM23   085588  085588  089447  070 0D 09 CSECT     MREG      085588  085588  RELOCATABLE
                                                    CSECT     CORRE     086AD0  086AD0
                                                    CSECT     ORDER     0876A0  0876A0
                                                    CSECT     MINV      087A00  087A00
                                                    CSECT     MULTR     088250  088250
                                                    CSECT     ILFLEXP   089100  089100
                                                       ENTRY  DEXP      089100
                                                    *  ENTRY  IJTLEXP   089100
                                                    CSECT     DATA      088850  088850
                                                    CSECT     ILFLSQRT  089068  089068
                                                       ENTRY  DSQRT     089068
                                                    *  ENTRY  IJTLSQT   089068
```

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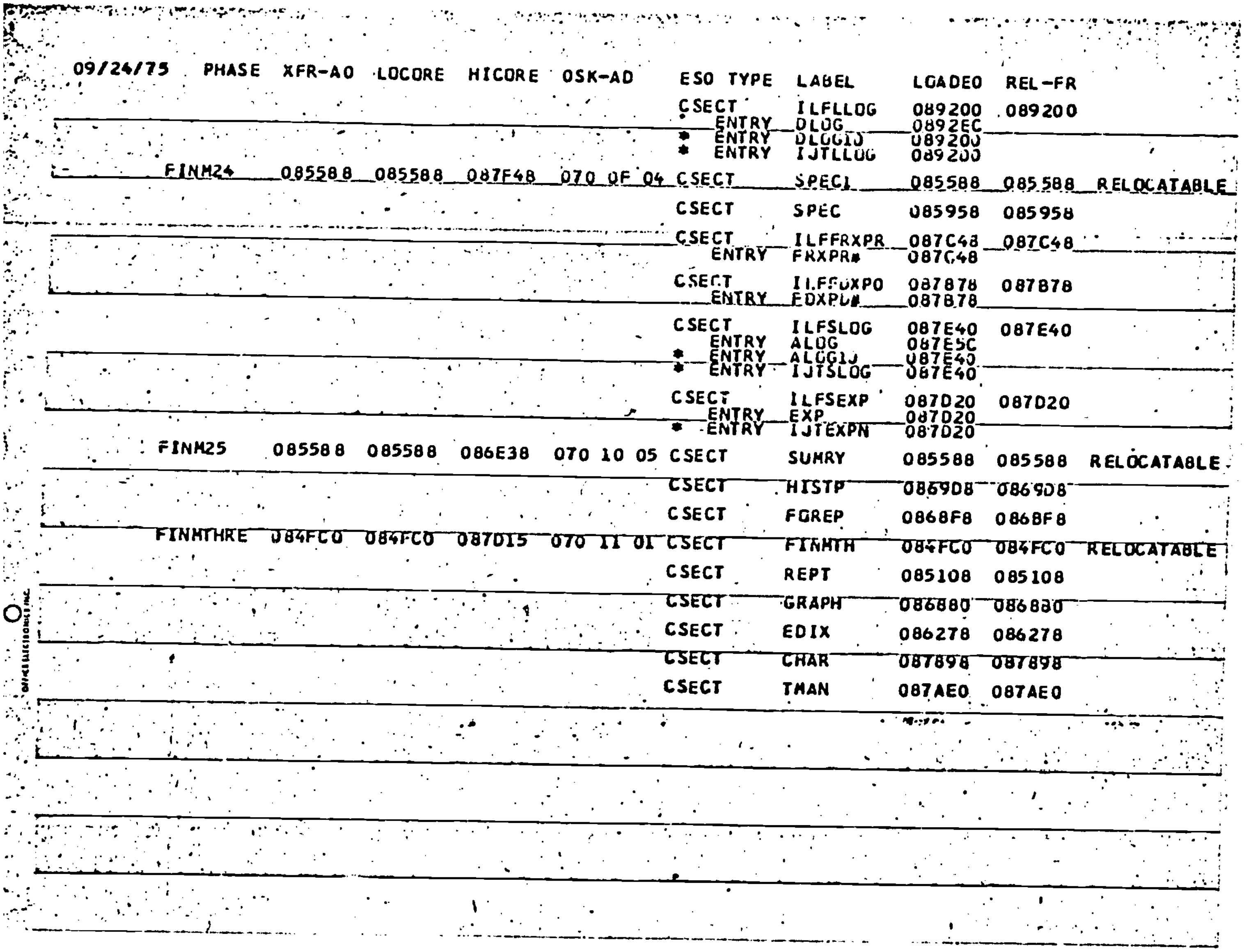
FIGURE B—4 LINKAGE EDITOR MAP (con't)



```
09/24/75  PHASE    XFR-AD  LOCORE  HICORE  DSK-AD     ESD TYPE  LABEL      LOADED  REL-FR
                                                      CSECT     ILFLLOG    089200  089200
                                                        ENTRY   DLOG       0892EC
                                                      *  ENTRY  DLOGIJ     089200
                                                      *  ENTRY  IJTLLOG    089200
          FINM24   085588  085588  087F48  070 0F 04  CSECT     SPEC1      085588  085588  RELOCATABLE
                                                      CSECT     SPEC       085958  085958
                                                      CSECT     ILFFRXPR   087C48  087C48
                                                        ENTRY   FRXPR#     087C48
                                                      CSECT     ILFFDXPD   087878  087878
                                                        ENTRY   FDXPD#     087878
                                                      CSECT     ILFSLOG    087E40  087E40
                                                        ENTRY   ALOG       087E5C
                                                      *  ENTRY  ALOGIJ     087E40
                                                      *  ENTRY  IJTSLOG    087E40
                                                      CSECT     ILFSEXP    087D20  087D20
                                                        ENTRY   EXP        087D20
                                                      *  ENTRY  IJTEXPN    087D20
          FINM25   085588  085588  086E38  070 10 05  CSECT     SUMRY      085588  085588  RELOCATABLE
                                                      CSECT     HISTP      0869D8  0869D8
                                                      CSECT     FGREP      0868F8  0868F8
          FINMTHRE 084FC0  084FC0  087D15  070 11 01  CSECT     FINMTH     084FC0  084FC0  RELOCATABLE
                                                      CSECT     REPT       085108  085108
                                                      CSECT     GRAPH      086880  086880
                                                      CSECT     EDIX       086278  086278
                                                      CSECT     CHAR       087898  087898
                                                      CSECT     TMAN       087AE0  087AE0
```

FIGURE B–4 LINKAGE EDITOR MAP (con't)

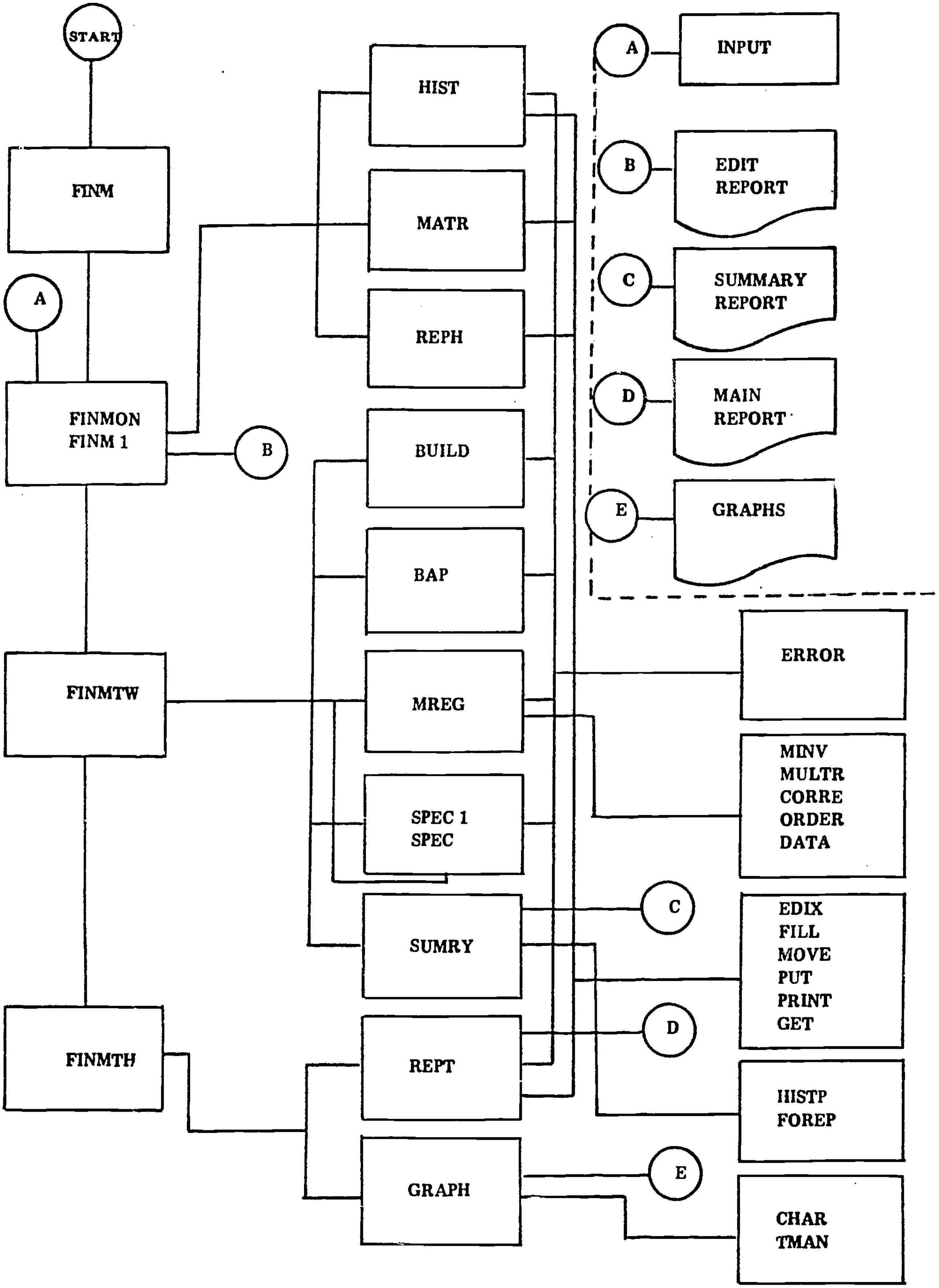


FIGURE B–5 SYSTEM FLOWCHART

Name	Description
FINM	Main program. Initializes 1-file and 3-file. Calls the overlaid phases FINMONE, FINMTWO AND FINMTHRE, with entries FINMON, FINMTW and FINMTH, respectively.
FINMON	Calls FINM1. Its purpose is simply an entry into phase FINMONE.
FINMTW	Entry into phase FINMTWO. Its purpose is to overlay three phases, FINM21, FINM22, FINM23, FINM24 and FINM25. These have entries BUILD, BAP, MREG, SPEC1 and SUMRY, respectively. These programs are the actual projection routines for the System.
FINMTH	Entry into phase FINMTHRE. Program calls REPT and GRAPH.
FINM1	This reads and l[illegible] all of the input cards. At statement 2 it branches 10 ways depending upon whether CC1 contains a blank, 1, 5, 6, 7, 8, 9, G, R or X. The cards with a blank in CC1 are ignored and the next card is read. The '1' cards call subroutine HIST to make entries in the 3-file. The '5' cards will modify entries previously made in the 3-file. The calculations are done between 103 and 104. The '6' cards cause a call to MATR to make entries in the 4-file. The '7' cards make entries in the 1-file. These calculations are made at statements 105 to 106. The '8', '9', 'R', 'G' cards cause a call to REPH to make entries in the 2-file. The 'X' card is processed at statement 110. Some entries are made in the COMMON variables to indicate the number of periods of projection required. After the 'X' card is processed, program returns control to FINMON which will relinquish control to FINM.
HIST	This program is called by FINM1. It makes an entry into the 3-file for a '1' card. If the row number on the card was previously entered, this program locates the record and adds the additional historical information. If it has not yet been entered, a new entry is initialized into the file.
MATR	This program is called by FINM1 to process the '6' cards and make the necessary entries into the 4-file. These entries will subsequently be used by other programs to actually make the projections.
REPH	Called by FINM1 to process '8', '9', 'R' and 'G' cards, and make the necessary entries in the 2-file. Subsequently this information will be used to print the main reports and the graphs.
BUILD	Called by FINMTW. This is the program which performs all of the arithmetic calculations.
BAP	Called by FINMTW. This program performs second-degree extrapolation. It should not be necessary in the School Facility Planning System.
MREG	Called by FINMTW. This program performs all multiple regressions. It is called by SPEC. The program uses the IBM Scientific Subroutines CORRE, ORDER, MINV and MULTR.

SPEC1 SPEC	SPEC1 is called by FINMTW. SPEC1 calls SPEC after performing some initialization tasks. These programs perform all of the time series projections. They do the least squares fitting of the linear, exponential, logistics and Gompertz curves.
SUMRY	Called by FINMTW following the calculation of each row. This program analyzes and prints the Summary Report.
MINV MULTR CORRE ORDER	These are IBM Scientific Subroutines.
CURF	Called by BAP. Not used in the System.
DATA	Called by CORRE. This is needed to provide the data in the correlation matrix for the multiple regressions.
HISTP	Called by SUMRY to print out the historical data for the row just calculated in the Summary Report.
FOREP	Called by SUMRY to print out the projected data for the row just calculated in the Summary Report.
REPT	Called by FINMTH. This is the main report generator. It interprets the '8' and '9' card data and prints out the reports requested. It calls routines EDIX, FILL, PUT, and PRINT to edit and print the output lines.
GRAPH	Called by FINMTH. This is the graph generating program for the graphical output.
EDIX FILL MOVE PUT PRINT GET	Small routines to assist in data input and output printing, editing and converting.
ERROR	Called by most programs to print error messages.
CHAR TMAN	Called by GRAPH to perform data scaling operations.

FIGURE B–6 SUBROUTINE CROSS REFERENCE TABLE

	NAME	SUBROUTINES CALLED	CALLED BY
1	FINM	2, 3, 4	—
2	FINMON	5	1
3	FINMTW	9, 10, 11, 12, 13, 26	1
4	FINMTH	23, 24	1
5	FINM 1	6, 7, 8, 26, 30, 31	2
6	HIST	26, 31	5
7	MATR	31	5
8	REPH	30, 31	5
9	BUILD	26	3
10	BAP	19, 26	3
11	MREG	15, 16, 17, 18, 26	3, 14
12	SUMRY	21, 22	3, 14
13	SPEC 1	14, 26	3
14	SPEC	11, 12	13
15	MINV	—	11
16	MULTR	—	11
17	CORRE	20	11
18	ORDER	—	11
19	CURF	—	10
20	DATA	—	17
21	HISTP	—	12
22	FOREP	—	12
23	REPT	25, 26, 27, 29, 30	4
24	GRAPH	32, 33	4
25	EDIX	27	23
26	ERROR	27, 28, 29, 30	3, 5, 6, 9, 10, 11, 13, 23
27	FILL	—	23, 25, 26

FIGURE B–6 SUBROUTINE CROSS REFERENCE TABLE (continued)

	NAME	SUBROUTINES CALLED	CALLED BY
28	MOVE	–	26
29	PUT	–	23, 26
30	PRINT		5, 8, 23, 26
31	GET		5, 6, 7, 8
32	CHAR	–	24
33	TMAN	–	24

2. <u>Geographic Analysis Support System.</u>

The BOUND and RBOUND programs that perform the allocation of students to schools require a variable amount of core storage area depending on the number of grids and schools involved in the problem. To implement these programs the DIMENSION statement at the beginning of each program may need to be modified. The DIMENSION statement has the following general format: DIMENSION IBV(r),D(c),A(r,c),X(c).

In BOUND the variables assume the following values

$r=m+n+1 \qquad c=mn+2m+n+1$

where m = number of grids and n = number of schools.

In RBOUND the variables assume the following values

$r=m+3n+1 \qquad c=mn+2m+3n+1$

where m = number of grids and n = number of schools.

The user should ensure that core storage of the amount r x c + 10 percent is available. The two cards immediately following the DIMENSION statement must also be changed to specify adequate core storage. The general format of the cards is NRD=r and NCD=c. The variables r and c assume the same values as specified in the DIMENSION statement of each program.

2.1 <u>Program Description</u>. The basic concept of the programs BOUND and RBOUND is to read the input data, construct a matrix, and determine the optimal solution utilizing the functions of linear programming. The subroutine used in these programs is SIMPLX. The first use of SIMPLX is to determine a feasible solution (Phase 1) and the second is to move from that feasible solution to an optimal solution (Phase 2). Phase control is provided by the formal parameter, IPHS=1 or 2.

The problem to be solved by BOUND is the following:

$$\begin{array}{lll} \text{minimize} & = \sum_i \sum_j d_{ij} x_{ij} & \\ \text{subject to} & \sum_j x_{ij} = p_i & \text{for } i = 1,2,\ldots,m \\ & \sum_i x_{ij} \leq c_j & \text{for } j = 1,2,\ldots,n \end{array}$$

The assumption is made that d_{ij} is non-negative for all i and j. The first m equality constraints can therefore be replaced with inequality constraints of the form $\sum_j x_{ij} \geq p_i$.

An examination of the structure of the matrix yields a more complete understanding of the operation of the program BOUND. An example of this matrix construction is given for a problem with five grids and three schools. Figure B-7 indicates the general form of the array. This array consists of zeros (0) and ones (1) except in two locations. The first is the rightmost column where the data is entered as shown. The other is the partial diagonal where negative ones (-1) have been entered. These values account for the artificial variables that are introduced in performing the Phase 1, SIMPLX algorithm. A detailed explanation of the role of artificial variables can be found in Hadley, Theory of Linear Programming, p. 118.

FIGURE B–7 BOUND MATRIX

$$\begin{array}{c|ccc|ccc|ccc|ccc|ccc|ccc|ccccc|ccccc|c}
 & \multicolumn{15}{c|}{mn} & \multicolumn{3}{c|}{n} & \multicolumn{5}{c|}{m} & \multicolumn{5}{c|}{m} & \\
\hline
m & 1 & 1 & 1 & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & -1 & {} & {} & {} & {} & 1 & {} & {} & {} & {} & P_1 \\
{} & {} & {} & {} & 1 & 1 & 1 & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & -1 & {} & {} & {} & {} & 1 & {} & {} & {} & P_2 \\
{} & {} & {} & {} & {} & {} & {} & 1 & 1 & 1 & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & -1 & {} & {} & {} & {} & 1 & {} & {} & P_3 \\
{} & {} & {} & {} & {} & {} & {} & {} & {} & {} & 1 & 1 & 1 & {} & {} & {} & {} & {} & {} & {} & {} & {} & -1 & {} & {} & {} & {} & 1 & {} & P_4 \\
{} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & 1 & 1 & 1 & {} & {} & {} & {} & {} & {} & {} & -1 & {} & {} & {} & {} & 1 & P_5 \\
\hline
n & 1 & {} & {} & 1 & {} & {} & 1 & {} & {} & 1 & {} & {} & 1 & {} & {} & 1 & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & C_1 \\
{} & {} & 1 & {} & {} & 1 & {} & {} & 1 & {} & {} & 1 & {} & {} & 1 & {} & {} & 1 & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & C_2 \\
{} & {} & {} & 1 & {} & {} & 1 & {} & {} & 1 & {} & {} & 1 & {} & {} & 1 & {} & {} & 1 & {} & {} & {} & {} & {} & {} & {} & {} & {} & {} & C_3
\end{array}$$

The two groups of rows correspond to the two classes of constraints in the basic problem. The first m rows correspond to the population constraints of the m grids. The last n rows correspond to the capacity constraints of the n schools. The ones in the first nm columns represent the coefficients of X_{ij} in the sums of the constraints. The remaining ones and negative ones in the array account for slack or artificial variables as needed. The total size of the array is m+n+1 rows plus mn+n+2m+1 columns. An extra row not shown in the figure is included for the cost function.

Once the array has been built, BOUND calls the subprogram SIMPLX with the parameter IPHS=1. A Phase 1 calculation is performed and the artificial variables are eliminated according to standard Phase 1 techniques. Upon return from Phase 1, SIMPLX is called immediately with IPHS=2. This time the cost function is minimized and the optimal solution is found. BOUND then prints out the non-zero variables of the matrix in a readable format.

Two additional sets of constraints are needed to solve the RBOUND problem. These constraints have the following general form:

$$\sum_i (B\text{-}V\text{-}b_i)\, x_{ij} \le 0 \qquad \text{and} \qquad \sum_i (b_i\text{-}B\text{-}V)\, x_{ij} \le 0 \qquad \text{for } j = 1,2,\ldots,n$$

$$\text{where } r_i = B\text{-}V\text{-}b_i \;;\; s_i = b_i\text{-}B\text{-}V$$

RBOUND is organized in the same way as BOUND except for the revised structure of the matrix. The additional constraints are added to the array as 2n rows. The slack variables for these sets of constraints are inserted as columns mn+n through mn+3n moving the remaining columns of the original array 2n positions to the right. These modifications to the original array are shown in Figure B-8.

The total size of the above array is m+3n+1 rows by mn+3n+2m+1 columns. An extra row not shown in the figure is included for the cost function.

Once the array has been constructed, the remaining operations of RBOUND are identical to those of BOUND.

2.2 Data Submission to the Computing System. Since the program was tested on an IBM 370/145 DOS/VS, the job control language below is for that configuration. In general the operation requires a compile, link edit and go. The sequence of the program submission and the JCL are presented in Figure B-9.

FIGURE B–8 RBOUND MATRIX

$$
\left.\begin{array}{c|ccc|ccc|ccc|ccc|ccc|ccc|cccccc|ccccc|ccccc|c}
 & \multicolumn{15}{c}{mn} & \multicolumn{3}{c}{n} & \multicolumn{6}{c}{2n} & \multicolumn{5}{c}{m} & \multicolumn{5}{c}{n} & \\ \hline
m & 1 & 1 & 1 & & & & & & & & & & & & & & & & & & & & & & -1 & & & & & 1 & & & & & P_1 \\
 & & & & 1 & 1 & 1 & & & & & & & & & & & & & & & & & & & & -1 & & & & & 1 & & & & P_2 \\
 & & & & & & & 1 & 1 & 1 & & & & & & & & & & & & & & & & & & -1 & & & & & 1 & & & P_3 \\
 & & & & & & & & & & 1 & 1 & 1 & & & & & & & & & & & & & & & & -1 & & & & & 1 & & P_4 \\
 & & & & & & & & & & & & & 1 & 1 & 1 & & & & & & & & & & & & & & -1 & & & & & 1 & P_5 \\ \hline
n & 1 & & & 1 & & & 1 & & & 1 & & & 1 & & & 1 & & & & & & & & & & & & & & & & & & & C_1 \\
 & & 1 & & & 1 & & & 1 & & & 1 & & & 1 & & & 1 & & & & & & & & & & & & & & & & & & C_2 \\
 & & & 1 & & & 1 & & & 1 & & & 1 & & & 1 & & & 1 & & & & & & & & & & & & & & & & & C_3 \\ \hline
2n & r_1 & & & r_2 & & & r_3 & & & r_4 & & & r_5 & & & & & & 1 & & & & & & & & & & & & & & & & 0 \\
 & & r_1 & & & r_2 & & & r_3 & & & r_4 & & & r_5 & & & & & & 1 & & & & & & & & & & & & & & & 0 \\
 & & & r_1 & & & r_2 & & & r_3 & & & r_4 & & & r_5 & & & & & & 1 & & & & & & & & & & & & & & 0 \\
 & s_1 & & & s_2 & & & s_3 & & & s_4 & & & s_5 & & & & & & & & & 1 & & & & & & & & & & & & & 0 \\
 & & s_1 & & & s_2 & & & s_3 & & & s_4 & & & s_5 & & & & & & & & & 1 & & & & & & & & & & & & 0 \\
 & & & s_1 & & & s_2 & & & s_3 & & & s_4 & & & s_5 & & & & & & & & & 1 & & & & & & & & & & & 0
\end{array}\right.
$$

```
// JOB (Standard Job Card)
* $$ JOB JNM=OBSNSFI,PRI=4,USER='NATL SCI FOUND'
* $$ LST DISP=D,FNO=4111,COPY=01,CLASS=A
// OPTION LINK
// EXEC FFORTRAN NSFI

   Include Program Source Deck Here

/*
// EXEC FFORTRAN NSFI

   Include Subroutine Source Deck Here

/*
// EXEC LNKEDT NSFI
// ASSIGN SYS002,X'014'
// ASSIGN SYS003,X'00E'
// EXEC

   Include Data Input Cards Here

/*
/&
* $$ EOJ
```

FIGURE B–9 JCL BOUND

APPENDIX C
MATHEMATICAL AND STATISTICAL ROUTINES

The School Facility Planning System recommends the use of various extrapolation and regression analysis techniques. The following Appendix is designed to further familiarize users with the logic of these techniques and the printout information that is provided. The Appendix refers only to the techniques that are incorporated in the basic support system package.

It is not possible to provide more than a summary of the techniques. Reference to standard statistical textbooks is encouraged to fully understand the fundamental procedures.

1. Time Series Projections.

Time series projections are used to extrapolate trends into the future which have been exhibited in the past. This is done by identifying the curve which best fits the historical and expected data. The selection of that curve is perhaps the most important and difficult aspect of long range forecasting.

Two distinct aspects of time series forecasting must be addressed if meaningful results are to be obtained. The first is the problem of determining the basic dynamics of the variables involved. The questions which must be answered are: Why do the variables behave as they do? What pressures cause them to change values as time goes by and what is the magnitude of these pressures? In the context of curve fitting these questions combine into: What is the mathematical form of the curve which is to be fit to the data?

The second part of the problem is that of determining the nature of the statistical deviation from the basic dynamic relationships. In the curve fitting context the question becomes: What is the distribution of the probabilities associated with the deviations of the variables from the curve being fit to the data?

Neither of these concerns are easily resolved because time series projections belong to that special case of curve fitting in which the projected values obviously lie outside the range of observed data points. All statistical techniques for fitting curves can be most easily validated inside the range of values under observation. But in long-range projections the values of the estimated variables within the range of the time variable, or even closely outside its range, are not of interest. Rather interest focuses on values so far outside the range of the observed time values that the statistical measures associated with the projected values will be largely meaningless. It therefore becomes essential that in selecting a curve for a long-range planning situation, most of the effort be directed toward determining the dynamics of the relationships. That is, most of the effort must be directed toward choosing the form of the curve to be fit.

Much of the literature on time series forecasting deals with the problems of short term extrapolations and ignores the difficult task of long term projection. The reasons are apparent. The dynamics of the relationships vary widely and must be handled on a case by case basis. Without some advanced knowledge of the ways in which the variables are controlled by the pressures upon them, it is meaningless to simply look at historical data for a view of the future.

As indicated in Chapter Two, the basic support system provides five different growth/decay curves for time series forecasting. Each of these has a derivation based on an assumption regarding the conditions which regulate the growth or decline of the variable being projected. The extent to which actual conditions agree with these assumptions will determine whether a given curve will provide useful forecasts of future values.

The five curves can be described in terms of the pressures which affect growth or decline within a community. Each curve is a special solution of the differential equation:

$$Y' = f(Y,t) + M(Y,t)$$

where:

$f(Y,t)$ = growth/decline factor
$M(Y,t)$ = migration factor
Y = total value or population being estimated
t = time.

This equation suggests that every community has a nuclear growth element, F(Y,t), and a migratory element, M(Y,t). Thus a population changes as a function of births/deaths of the existing population and migration. Similarly assessed valuation fluctuates in response to the value of existing land and structures and the addition, or deletion, of structures. Assumptions concerning the values f(Y,t) and M(Y,t) affect the different formula derivations from the differential equation.

1. Linear Curve. If $f(Y,t)=0$, and $M(Y,t)=A$ (the migration factor is a constant), then the differential equation takes the form:

$$Y' = A$$

The solution of this equation is:

$$Y = A + BT$$

2. Exponential Curve. If $f(Y,t)=B$ (the growth/decline factor is a constant) and $M(Y,t)=0$, then the differential equation takes the form:

$$Y' = BY$$

The solution of this equation is:

$$Y = AX^{BT}$$

3. Modified Exponential Curve. If $f(Y,t)=C$ (the growth/decline factor is a constant) and $M(Y,t)=A$ (migration factor is also a constant), then the differential equation takes the form:

$$Y' = CY + A$$

The solution of this equation is:

$$Y = A + BX^{CT}$$

4. Logistics Curve. If $f(Y,t)=\left(\frac{L-Y}{L}\right)$ (the growth/decline factor decreases in direct proportion to an upper bound) and $M(Y,t)=0$, then the differential equation takes the form:

$$Y' = \left(\frac{L-Y}{L}\right)Y$$

The solution of this equation after substituting $1-\frac{1}{A}$ is:

$$\frac{1}{Y} = A + BX^{CT}$$

5. Gompertz Curve. If $f(Y,t) = LX^{CT}$ for C-0 (the growth/decline factor decreases exponentially) and $M(Y,t)=0$, then the differential equation takes the form:

$$Y' = LX^{CT}Y$$

The solution of this equation after substituting $B=\frac{L}{C}$ is:

$$\operatorname{Log} Y = A + BX^{CT}$$

Figures C-1 through C-5 graphically depict these five curves. Figure C-6 depicts sample output data that is provided by the basic support system when one of the time series techniques is used.

2. Regression Analysis.

The basic support system allows the use of linear or exponential multiple regression. Chapter 2 has described the regression formula. A relatively simple version is presented using subroutines from the IBM SSP computer package.

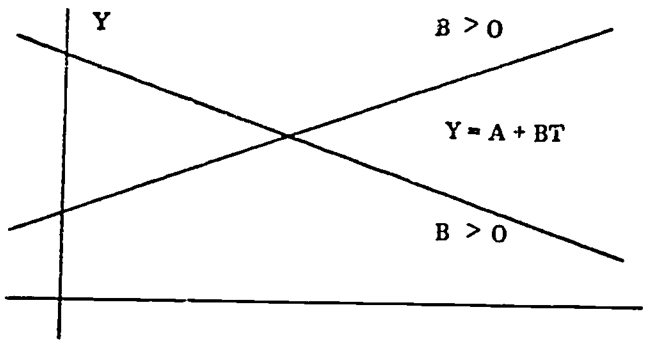


FIGURE C–1 LINEAR CURVES

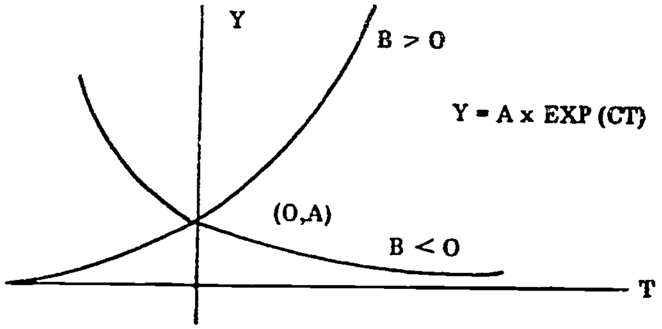


FIGURE C–2 EXPONENTIAL CURVES

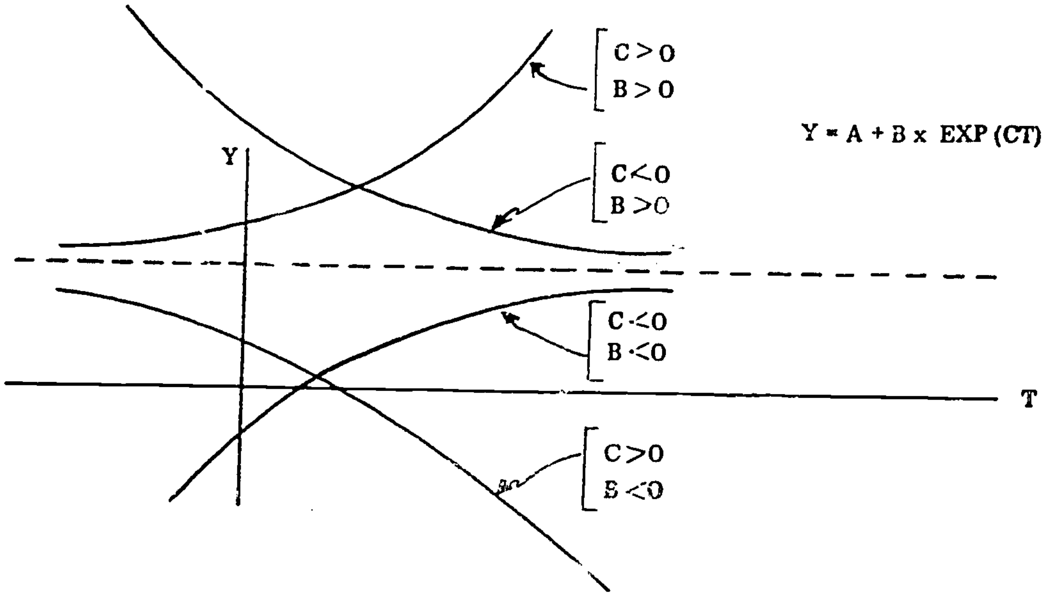


FIGURE C–3 MODIFIED EXPONENTIAL CURVES

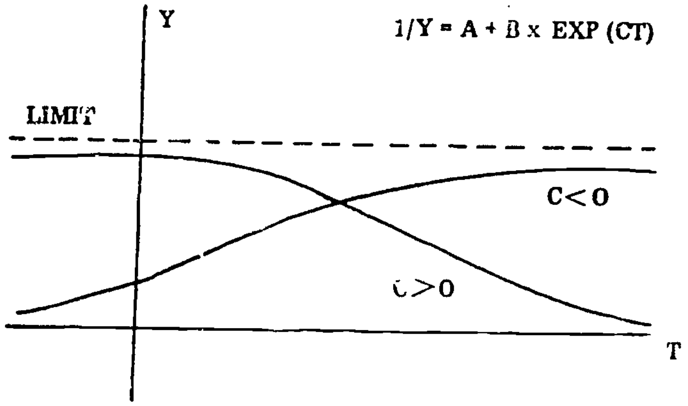


FIGURE C–4 LOGISTICS CURVE

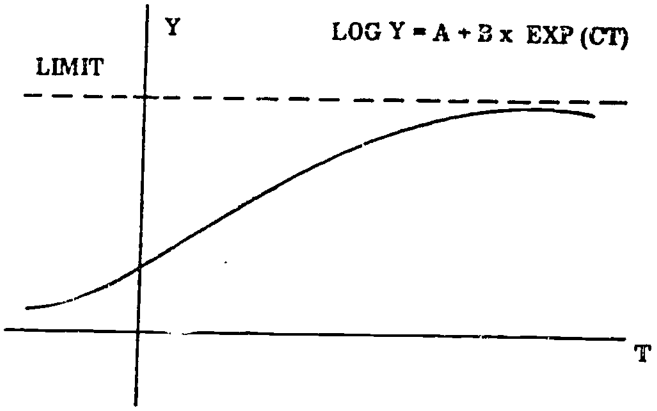


FIGURE C–5 GOMPERTZ CURVE

FIGURE C–6 SAMPLE OUTPUT—TIME SERIES TECHNIQUE

```
ROW NO.   1   YEAR
     HISTORY        1965.00      1966.00      1967.00      1968.00      1969.00      1970.00      1971.00      1972.00
                    1973.00      1974.00      1975.00      1976.00      1977.00      1978.00      1979.00      1980.00
                    1981.00      1982.00      1983.00      1984.00      1985.00      1986.00      1987.00      1988.00
                    1989.00      1990.00      1991.00
   PROJECTION NOT REQUESTED

ROW NO.   5   BIRTHS
     HISTORY       12302.00     10203.00      8953.00      8900.00      8670.00      8130.00      7829.00      7800.00
                    7504.00      6871.00
   PROJECTED        6772.25      6553.68      6354.09      6171.06      6002.77      5847.53      5703.94      5570.76
                    5446.96      5331.62      5223.94      5123.21      5028.81      4940.20      4856.59      4776.44
                    4704.47
 SPECIAL FUNCTION FORECAST

   LOGISTIC     1/ Y= A+B*EXP(C*T)

   B=       0.2495535D-03    LEAST SQ

   C=      -0.2688108D-01    LEAST SQ

   A=       0.3333333D-03    GIVEN

                  LEAST SQUARE DATA FOR B C
                         SS                      MS
   REGRESSION       0.5961390D-01            0.1106795D 03
   DEVIATION        0.4303938D-02            0.5386173D-03
ROW NO.   6   KINDERGARTEN SURVIVAL RATE
     HISTORY        0.0          0.0          0.0          0.0          0.05         0.05         0.06         0.05
                    0.07         0.05         0.06         0.06         0.06         0.06         0.06         0.06
                    0.06         0.06         0.06         0.06         0.06         0.06         0.06         0.06
                    0.06         0.06         0.06
   PROJECTION NOT REQUESTED
```

All variables included in the regression must be named by the user. The dependent variable is also named. Figure C-7 illustrates the summary printout provided for every regression that is used in the model. The regression coefficients as determined by the computer are printed. In addition, an analysis of variance table (ANOVA) is printed so that the goodness-of-fit can be verified.

Users will want to determine the goodness-of-fit for each regression. The R^2 or Coefficient of Determination can be calculated by dividing the sum of the squares attributable to regression by the same number plus the sum of the squares deviation from the regression. The R^2 value indicates the percentage of total variation in the dependent variable than can be explained by the independent variables, as opposed to random fluctuations or phenomena not accounted for in the regression.

The R^2 value may range from 0 to 1. The closer the value of R^2 is to 1, the greater the portion of total variation explained by the regression. If R^2 is near 0, the fit is effectively worthless. Additional terms that are contained in the regression analysis printout include the following:

Regression Coefficients: Coefficients determined by the program for each of the independent variables used in the regression. These are estimates which indicate the magnitude, and by their sign, direction of the relationships between each of the independent variables, and the dependent variable which is being projected. Other statistics presented in the table are used to indicate how well these coefficients meet various statistical criteria.

Standard Error Coefficient: A measure of the significance of the regression coefficient. The range of the regular regression coefficient is interpreted as B - S where B is the regression coefficient and S is the standard error. If S is much smaller in magnitude than B, then the sign of the regression coefficient may be interpreted with confidence. If S is nearly as large as B, then the coefficient should be used with care since there is a significant chance, at least 15 percent, that the true regression coefficient is of the opposite sign as the calculated value due to random errors in the data.

X/Y Correlation: The degree of correlation between the dependent variable and the independent variable.

T-Value: A measure of the significance of the regression coefficient representing more than mere chance. A statistical table should be consulted to determine the level of significance. The larger the absolute value of the T-statistic, the greater the degree of confidence that can be placed on the significance of each particular coefficient.

Mean: The mean value of the observations.

Standard Deviation: A measure of dispersion of the observations. The square root of the arithmetic mean of the differences between the actual values and the mean. $(S_y = \sqrt{1/n \quad \Sigma \; (Y-\bar{Y})^2})$

Constant Term: Intercept of the vertical or y-axis.

Multiple Correlation: The degree of correlation between the dependent variables and all independent variables in the equation.

Standard Error of the Estimate: This is the standard deviation of the residual. This term is the square root of the arithmetic mean of the squared deviations around the estimate. $(S_y = \sqrt{1/n \; \Sigma \; (Y-\hat{Y})^2})$. It measures the error involved in the regression. The smaller the value of the standard error, the better the regression has reproduced past history.

Degrees of Freedom: The number of unrestricted variables. This is typically calculated as the number of data observations minus the number of variables in the regression equation.

Sum of Squares (attributable to regression): The variation explained by the fitted regression. $\Sigma (\hat{Y}-\bar{Y}).^2$

Sum of Squares (deviation from regression): The variation left unexplained by the fitted regression. $\Sigma ((Y - \hat{Y}).^2$

Mean Squares: The sum of squares divided by the number of degrees of freedom.

F-Value: A measure of the significance of the regression representing more than mere chance. A statistical table should be consulted to determine the level of significance. It is similar to the T-statistic, but where each T-value is associated with a particular independent variable, the F-value applies to the entire regression. The larger the F-value the better the goodness of fit for the entire equation.

FIGURE C–7 SAMPLE OUTPUT—REGRESSION ANALYSIS

```
ROW NO. 874   PURCHASED SUPPLIES AND SERVICES
      HISTORY     1018422.00    1465774.00    1045027.00    2333000.00    2754000.00    3189000.00    4022000.00    4386000.00
                  5097000.00
   PROJECTED      4643305.41    4821869.35    4959645.01    5074222.24    5169507.14    5248748.14    5314646.66    5365449.31
                  5415024.33    5452925.59    5484475.06    5510657.34    5532456.03    5550584.30    5565650.16    5578197.58
                  5588623.96    5597294.77
 MULTIPLE REGRESSION WITH 2 INDEPENDENT VARIABLES
ROW NO. OFFSET     REGR COEFF     STD ERROR COEF    X/Y CORRELATION   T-VALUE          MEAN             STD DEV
   677     0    0.33630500D 03   0.16755240D 04   0.92316130D 00   0.20071630D 00   0.74633330D 03   0.30147660D 03
   676     0    0.28054920D 03   0.11261710D 03   0.96274220D 00   0.24911780D 01   0.15755220D 05   0.44853960D 04
    DEPENDENT VARIABLE                                                              0.28778030D 07   0.14073130D 07

    CONSTANT TERM              -0.17933080D 07
    MULTIPLE CORRELATION        0.96299540D 00
    STD ERROR OF EST            0.43797290D 06

          SOURCE OF VARIATION         DEGREES       SUM OF           MEAN            F VALUE
                                    OF FREEDOM     SQUARES          SQUARES
    ATTRIBUTABLE TO REGRESSION          2      0.14693320D 14   0.73466580D 13   0.38299690D 02
    DEVIATION FROM REGRESSION           5      0.11509220D 13   0.19182030D 12

ROW NO. 876   DUES AND FEES EXPENDITURE
     HISTORY          800.00        950.00       1040.00       1190.00       1314.00       1141.00        866.00        511.00
                     5799.00
   PROJECTED         2160.50       2226.06       2270.04       2318.70       2353.69       2382.78       2406.97       2427.09
                     2443.82       2457.74       2469.31       2478.93       2486.93       2493.59       2499.12       2503.73
                     2507.56       2510.74
 MULTIPLE REGRESSION WITH 1 INDEPENDENT VARIABLES
ROW NO. OFFSET     REGR COEFF     STD ERROR COEF    X/Y CORRELATION   T-VALUE          MEAN             STD DEV
   677     0    0.17333840D 01   0.19289980D 01   0.32159390D 00   0.39855920D 00   0.74633330D 03   0.30147660D 03
    DEPENDENT VARIABLE                                                              0.15123330D 04   0.16249530D 04

    CONSTANT TERM               0.21865100D 03
    MULTIPLE CORRELATION        0.32159390D 00
    STD ERROR OF EST            0.16448670D 04

          SOURCE OF VARIATION         DEGREES       SUM OF           MEAN            F VALUE
                                    OF FREEDOM     SQUARES          SQUARES
    ATTRIBUTABLE TO REGRESSION          1      0.21640780D 07   0.21640780D 07   0.80746900D 00
    DEVIATION FROM REGRESSION           7      0.18939110D 08   0.27055870D 07
```

APPENDIX D
STATISTICAL ANALYSIS SYSTEM

Multiple regression estimation analysis often represents a useful tool in evaluating the relative impact of various factors on a phenomenon of particular interest. Regression estimates may also be used to generate forecasts in cases where reliable forecasts for each of the independent variables are readily available or may be obtained with a reasonable expenditure of time and effort.

The objective of this appendix is to outline the function and operation of an optional computer program which may be used in the estimation of multiple regression equations. This program includes several procedures which are not incorporated in the Basic Support System described previously.[1]

This program is more limited than the Basic Support System in that only one regression equation can be estimated per run. It has not been exhaustively tested and evaluated. However, in some instances, the program may represent a tool capable of handling certain more complex and elaborate models than those which can be accommodated by the Basic Support package.

No specific regression model is built into the program described in this appendix. It is intended to represent a tool which is applicable to many areas of the school facility planning process. Those users familiar with statistical techniques may thus estimate models of their own construction. The additional procedures included in the program allow a greater degree of flexibility in the choice of such models.

The basic procedure in the program is the straightforward multiple regression technique. The additional routines which may be executed in conjunction with the basic technique are distributed lags, artificial orthogonalization, and autoregressive least squares. Each of these is briefly described in the first section of this appendix. The next section outlines the steps necessary for the implementation and operation of the program itself, including input card formats and interpretation of sample output. A final section identifies various critical locations within the program to facilitate potential modifications and to provide access to more extensive output.

1 General Design

The three techniques incorporated into the program for use in conjunction with the basic multiple regression estimation technique may be used one at a time, or in any combination. The general purpose of each technique is described below.

1. Distributed Lag. The dependent variable in a regression equation may be influenced not only by the current level of a particular independent variable, but by previous values of this variable as well. For example, suppose that the dependent variable in a particular regression model was the level of district wide enrollment, and that one of the independent variables was the number of new housing units of a particular type. A housing unit constructed in a given year should (on the average) exert some impact on the overall public school enrollment level. This housing unit should continue to affect enrollment levels in future years as well. However, the nature of this effect may change over time as the dwelling unit ages (along with its inhabitants). This relationship could be modeled by the following equation:

$$E_t = B_1D_{t\text{-}0} + B_2D_{t\text{-}1} + B_3D_{t\text{-}2} + \cdots\cdots + B_jD_{t\text{-}i}$$

where E_t represents the level of enrollment, in time t, $D_{t\text{-}i}$ the number of dwelling units constructed in the time period t-i, and B_j represents the coefficient to be estimated, i.e. the magnitude of the effect of new dwelling units in a given year on enrollments. For a given type of dwelling unit, the B coefficients could be plotted against the time period to which it applies, as in Figure D-1.

A plot of this nature might indicate a cycling effect wherein newer housing contributes more significantly to enrollment levels than older homes in which families continue to reside after their children are past school age. Dwelling units constructed in the current time period ($D_{t\text{-}0}$) as well as units constructed in previous years ($D_{t\text{-}i}$, i=1,2,...) could each be used as independent variables in an attempt to explain the variation in the current enrollment level. However, two major problems might be encountered in the estimation of such a model. One of these problems could stem from the likely collinearity among the independent variables ($D_{t\text{-}i}$). This collinearity could significantly distort the statistical estimation of coefficients for each variable

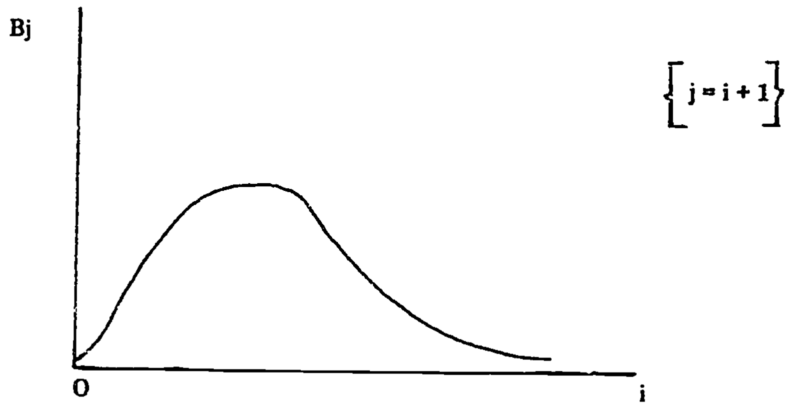


FIGURE D—1 SAMPLE B COEFFICIENTS—DISTRIBUTED LAG

and thus obfuscate potentially useful insight into the nature of any cycling phenomena associated with the relationship between new housing and enrollment in subsequent years.

The second possible difficulty with the straightforward inclusion of dwellings constructed for previous years as independent variables is that each such variable uses up a degree of freedom, and hence decreases the reliability of estimates made with restricted amounts of data.

Both of these potential problems may be partially compensated for by using a distributed lag technique. Such a technique involves the construction of a smaller number of intermediate variables from the original variable. Coefficients applicable to the intermediate variables are estimated, and these coefficients are then transformed into a set of coefficients applicable to the original variables. Collinearity is generally not a problem with these intermediate variables, and since there are fewer of them, fewer degrees of freedom are sacrificed. The distributed lag technique employed in this program is that developed by Almon[2] and involves the estimation of distributed lag weights by polynomial approximation (to a curve such as that shown in Figure D-1).

When an independent variable is to be converted into a distributed lag variable, two values must be specified by the user, the degree of the polynomial and the length of the lag. The selection of both of these values is somewhat arbitrary and a process of trial and error may represent an effective method of such a determination.

The degree of the polynomial affects the complexity of the restrictions to be placed on the lagged weights (as plotted against the lag period). For example, if a second degree polynomial is specified, then the weights will appear in the general configuration found in Figure D-2. As the degree of the polynomial increases, this configuration can become more complex.

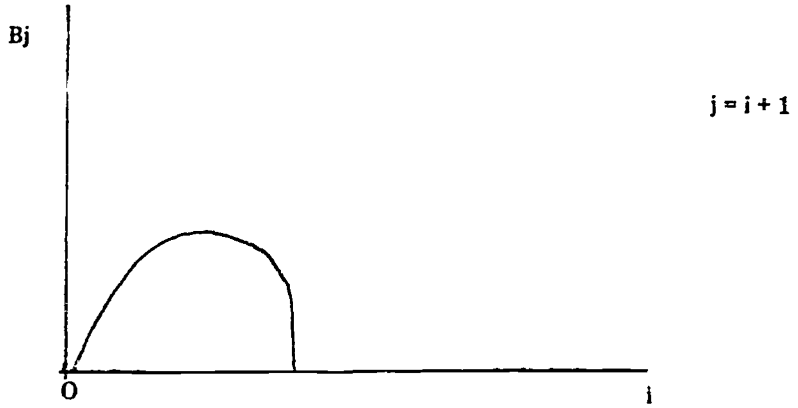


FIGURE D—2 SAMPLE B COEFFICIENTS—DISTRIBUTED LAG
(Second Degree Polynomial)

The number of intermediate variables is equal to the degree of the polynomial minus one. There is a trade-off, therefore, between conserving degrees of freedom by decreasing the degree of the polynomial, and allowing the approximating polynomial to approach more closely to the actual weights by increasing the degree of the polynomial. It is suggested that the user begin with a second or third degree polynomial and then reiterate the procedure using higher degree polynomials. By examining the significance of the resultant distributed lag weights (as measured by the associated t values for these weights as well as the overall R-squared value for the regression), the user can arrive at a subjective determination of an appropriate degree for the polynomial.

A determination of the length of the lag to be used may be less subjective than the decision as to the appropriate degree of the polynomial where the user has some idea as to the reasonable maximum time period over which the value of the independent variable in a given time period will continue to affect the dependent variable. A system of trial and error may also be used to determine the appropriate length of the lag by initially using the likely maximum lag length and subsequently changing the lag length so that only significant distributed lag weights are maintained (as measured by the associated t values).

2. Artificial Orthogonalization. A second procedure included in the program is the artificial orthogonalization of the independent variable vectors in the regression equation as an approach to the problem of multicollinearity. When two or more independent variables are closely related, the estimated regression coefficients may be distorted. In such a situation, it may be difficult or impossible to identify the impact of an individual independent variable.

The independent variable matrix can be artificially orthogonalized by computing the principal components of this matrix, and using the components themselves as regressors in the multiple regression estimation procedure. The resultant regression coefficients may then be transformed into coefficients applicable to the original set of independent variables. These transformed coefficients should more accurately reflect the relationships between the dependent variable and the independent variables.

As was the case with the distributed lag procedure, the user must specify two values, both of which are rather arbitrary in nature. In order to determine whether the artificial orthogonalization process is in fact called for, a decision must be reached as to the severity of the multicollinearity between the independent variables. One way of making such an evaluation is to examine the correlation matrix for the independent variables. A large correlation coefficient (i.e. a correlation coefficient approaching an absolute value of 1.0) indicates a degree of collinearity between the two variables. Some arbitrary value for the correlation coefficient must be selected as representing the degree of collinearity which warrants the use of the artificial orthogonalization procedure. It is suggested that the user specify a critical value of around 0.75 initially. This is, however, entirely arbitrary, and the user may choose some other value, or may try, sequentially, several critical values depending on the severity of the potential distortion arising from this collinearity.

The procedure incorporated into the program involves the transformation of the initial independent variables into another set of orthogonal variables. This transformation process is based on a weighting matrix, the columns of which consist of the eigen vectors which were calculated from the original independent variable matrix. These vectors are arranged in descending order according to the magnitude of the associated eigen values. In the process of converting the coefficients estimated using the orthogonalized variables into coefficients applicable to the original independent variables, the weighting matrix is again used. If this weighting matrix is used unaltered, the resulting coefficients are identical to those which would be estimated if the original independent variables were used in the multiple regression equation, and thus will contain any distortions arising from multicollinearity among the independent variables. By eliminating certain columns from the weighting matrix and replacing them with vectors containing all zeros, alternative sets of coefficients applicable to the original variables may be derived. The elimination of columns in the weighting matrix corresponds to the elimination of noise or nonsense variation in the independent variable matrix. The coefficients resulting from this procedure should more clearly demonstrate the nature of the relationships involved. Several criteria exist, however, for the determination of the appropriate vector(s) to eliminate from the weighting matrix. The criterion incorporated into the program is based on the deletion of the component(s) contributing the smallest amount of variance. This is done by specifying the percentage of variance in the initial independent variable matrix that the user wishes to retain in the component matrix. It is suggested that a very large percentage be used initially, for example 99%. This percentage can be reduced in subsequent iterations of the procedures. There is a trade-off associated with the specification of this value. As noise variance is eliminated (by eliminating columns in the weighting matrix) the resulting regression coefficients should more accurately reflect the fundamental relationship between the independent variables and the dependent variable. However, as components are eliminated, the overall fit of the regression equation will be diminished. The selection of an appropriate number of components to be deleted (and hence the percentage of variance in the original variable matrix to be retained) is thus an arbitrary one and will vary from one equation to the next. A subjective evaluation of various sets of coefficients derived from trial and error iterations is perhaps the most efficient method of evaluation for this trade-off.

For the exact procedure used in this program, see B.T. McCallum, "Artificial Orthogonalization in Regression Analysis," The Review of Economics and Statistics, Vol. LII, No. 1, February 1970, pp. 110-113.

3. Autoregressive Least Squares. Serial correlation among the errors is a problem frequently encountered in multiple regression estimation when time series data is used. This problem is of particular importance when the regression coefficients which have been derived are to be used in the generation of forecasts. Serial correlation occurs where the error term (defined as the actual value minus the estimated value) in a particular time period is correlated to the error term in the previous period. Thus, when an error is positive one year, for example, it is likely to be positive in the following year as well. Ideally, this error term should be randomly distributed.

Serial correlation may be identified by simultaneously plotting the estimated and actual values of the dependent variable (Y), as in Figure D-3.

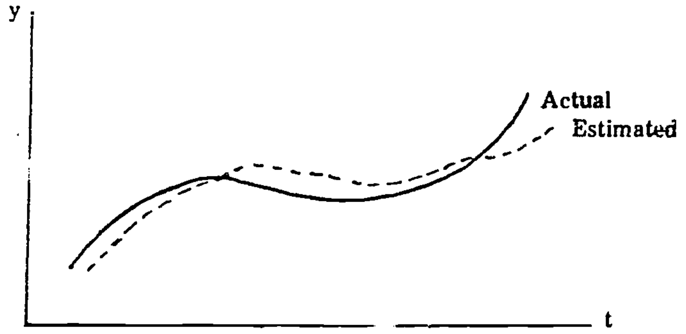


FIGURE D—3 IDENTIFICATION OF SERIAL CORRELATION

In this figure, serial correlation is obviously a problem since the estimated values tend to remain above or below the actual values over long consecutive time periods. A more rigorous method of determining the existence (or nonexistence) of serial correlation is to compute the Durbin-Watson statistic. Values for this statistic close to 2.00 indicate an absence of serial correlation. Values significantly greater or less than 2.00 indicate negative or positive serial correlation respectively. Tests are available to determine an acceptable range for the Durbin-Watson statistic. Such a determination is dependent upon both the number of independent variables as well as the number of observations used. The user should attempt to determine such an acceptable range of deviation from 2.00, as it must be specified as an input to the program if the autoregressive least squares procedure is to be instigated.

The autoregressive least squares procedure included in this program involves the reestimation of the regression using the error term, lagged one time period, which was derived during the initial estimation, as an additional regressor. To the extent that this lagged error term is related to the other independent variables, the remaining regression coefficients will be slightly modified upon this second regression run. When forecasts are to be made based upon the regression results, the coefficient associated with the error term regressor is simply ignored.

The autoregressive least squares estimating procedure used here is similar to (and the mathematical equivalent of) that found in J. Johnston, Econometric Methods, New York: McGraw-Hill, 1963, pp. 195-197. This procedure allows adjustment to be made to account for the autocorrelated error without the alteration of the constant term. One degree of freedom is lost, however.

Each of the procedures briefly described above may be used individually or in combination with one another. The input necessary to instigate these procedures is described in the next section of this appendix.

2. Operating Procedures

The program is completely self contained and independent of any other computer program. It requires no disks or tapes and the associated core requirements are reasonably small. This section is a guide to the input necessary to operate the program.

All input data is to be entered in card form. The dependent variable is read in first, using an F10.4 format, with one observation per card. Each independent variable is then similarly read (i.e., one observation per card using an F10.4 format). For each variable (dependent as well as independent) the first observation to be read in is the earliest observation, the last observation for each variable being the most recent.

The same number of observations need not be used for each variable. However, the last (most recent) observation for each variable must correspond to the same time period. It should be kept in mind that when lagged variables are created, or when a distributed lag is used for a particular variable, the actual number of observations used in the regression will be less than the original number. It should further be noted that the variable (dependent or independent) with the fewest observations after lags and distributed lags have been accounted for determines the actual number of observations used in the regression. The number of observations used in the regression is determined internally, the user must simply be aware of the potential loss of observational data (and hence degrees of freedom) from these several sources and thus use a sufficient number of observations to suit his or her particular needs.

The input data and the necessary control cards (which are described below) must be entered in the order which follows:

The Artificial Orthogonalization/Autoregressive Control Card Format

Col. 1	A zero is entered in this column, if the artificial orthogonalization procedure is not to be executed. A one is entered if the correlation matrix is to be examined for the potential existence of collinearity among the independent variables, and artificial orthogonalization is to be executed if collinearity appears to be present. A two is entered if artificial orthogonalization is to be executed regardless of the values in the correlation matrix of independent variables.
Col. 2 - 3	Zeros should be entered in Columns 2 and 3 if Column 1 contains a zero or a two.
	The maximum acceptable value for the coefficients in the correlation matrix of independent variables should be entered if Column 1 contains a one. Artificial orthogonalization will not be run if no correlation coefficients exceed this value.
Col. 4 - 5	Zeros should be entered in Columns 4 and 5 if Column 1 contains a zero or two.
	The desired percentage of variance in the original independent variable matrix to be retained in the component matrix should be entered in Columns 4 and 5 if Column 1 contains a one.
Col. 6	A one is entered in Column 6 if the autoregressive least squares procedures are to be executed if serial correlation exists in the error terms. A zero is entered if autoregressive procedures are not to be executed.
Col. 7 - 9	Zeros should be entered in Columns 7-9 if Column 6 contains a zero.

	The acceptable deviation from 2.00 for the Durbin-Watson Statistic should be entered in Columns 7-9 if Column 6 contains a one. This field is formatted as F3.2. If the Durbin-Watson Statistic falls within this range, the autoregressive least squares routine will not be executed.
Col. 10 - 80	Not used.

The Dependent Variable Control Format

Col. 1	Not used.
Col. 2	A one is entered in this column.
Col. 3 - 4	The number of observations of the dependent variable.
Col. 5 - 6	The length of the lag period for the dependent variable. If no lag is desired, zeros are entered.
Col. 7	Not used.
Col. 8	A one is entered if the dependent variable is to be transformed to natural logarithmic form. A zero is entered if no logarithmic transformations are to be made.
Col. 9 - 12	Zeros are entered in all columns.
Col. 13 - 14	Programmed user supplied variable transformations are coded in these columns. If no such transformations have been specified, zeros are entered in the columns.
Col. 15 - 80	Not used.

The Dependent Variable Format

Col. 1 - 10	The first observation of the dependent variable is entered right justified in a format of F10.4. A separate card is needed for each observation and these cards are entered into the System with the earliest time period first.
Col. 11 - 80	Not used.

Number of Independent Variables Control Format

Col. 1 - 2	The number of independent variables used, not to exceed ten.
Col. 3 - 80	Not used.

The Independent Variable Control Format

One of these cards must precede each group of observations of each independent variable.

Col. 1	Not used.
Col. 2	A one is entered in this column.

Col. 3 - 4	The number of observations for the specific independent variable.
Col. 5 - 6	The length of the lag period if the independent variable is to be lagged: otherwise a zero is entered.
Col. 7 - 8	A one is entered if the independent variable is to be transformed to natural logarithmic form. A zero is entered if no logarithmic transformations are to be made.
Col. 9 - 10	A value equal to one less than the degree of the polynomial to be used is entered if a distributed lag is to be estimated for the independent variable. Zeros are entered if no distributed lag is used.
Col. 11 - 12	Zeros are entered if zeros appear in Columns 9 and 10. The length of the lag period if a distributed lag was specified in Columns 9 and 10.
Col. 13 - 14	Programmed user supplied variable transformations are coded in these columns. If no such transformations have been specified, zeros are entered in the columns.
Col. 15 - 80	Not used.

The Independent Variable Format

This format is the same as the dependent variable format.

3. System Output

The basic output which is printed has been kept quite simple. If additional output is desired, refer to the next section of this appendix.

A sample of the basic printed output containing hypothetical data is presented in Figure D-4 at the end of this section. This simple output is briefly described below in the order in which it appears on the printout.

1. Dependent variable. The first item which is printed is simply the dependent variable vector. Each observation is numbered from 1 to n, where n is the total number of observations for this variable. In the example, therefore, observation number 24 is the most recent datum for the dependent variable.

2. Independent variables. Each of the independent variables is then printed, in the order in which they have been read in. These variables are also numbered, the last observation for each variable being the most recent.

3. Correlation matrix. This table presents the correlation matrix for the regressors. These regressors correspond to the independent variables which have been read in, after all modifications and transformations have been made.

   The number of regressors may not equal the number of independent variables initially input if the distributed lag procedure has been initiated. When a distributed lag is to be estimated for a variable, intermediate variables will be calculated and substituted for the original variable. The number of such intermediate variables is equal to the degree of the polynomial which has been specified minus one. Thus, in the sample output, if a distributed lag was to be estimated for original variable number four, and if this distributed lag was to employ a third degree polynomial, then two intermediate variables would be computed. These would appear as regressors (variables) four and five in the correlation matrix. Variable 6 in the correlation matrix would, therefore, correspond to the original variable number five.

4. Artificial orthogonalization procedure. If the artificial orthogonalization procedure has been initiated, a message will be printed to that effect.

5. Autoregressive least squares procedure. If the autoregressive least squares procedure has been executed, a message will similarly be printed.

6. Correlation matrix. If the autoregressive least squares procedure has been executed, the correlation matrix will be reprinted, this time including as the last regressor, the error term computed from the initial iteration of the regression procedures.

7. If the autoregressive least squares procedure has been used, a message will be printed indicating that the independent variable matrix, this time including as a regressor the lagged error term, has again been artificially orthogonalized.

8. Regression results. The regression results are printed next, including the regression coefficient, the standard error, and the t-value for each regressor, along with a constant term. The regression coefficients printed in this table correspond to the numbering of the variables initially read in. If a distributed lag has been estimated for one of the original variables, a message to that effect is printed in place of the regression coefficient. The last numbered variable will correspond to the lagged error term when the autoregressive least squares procedure has been run. Each of the coefficients in this table (including the constant term listed on the last line) is applicable to the transformed variables. For example, if a variable has been converted into natural logarithmic form, the corresponding regression coefficient is applicable to the natural logarithm of the independent variable, and not to the variable as it was originally read in.

9. Distributed lag weights. A table will be printed for each variable for which a distributed lag has been estimated. These weights are applicable to the corresponding independent variable (as transformed), lagged 0,1,2,...periods.

10. The R-Square value for the entire regression is printed after any and all of the distributed lag weights tables have been printed.

11. The Durbin-Watson statistic is similarly printed.

12. Finally, the actual and the estimated dependent variable values are printed for each time period along with the resulting error terms (i.e. the actual minus the estimated values).

4. Guide to Additional Printouts and Modifications

This final section is intended to facilitate those users wishing to have additional items printed or who may desire to modify or supplement the procedures contained in the program. As a general guide, Figure D-5 presents an overall view of the Statistical Analysis System's logic. Of a more detailed nature, the following list identifies the nature and the contents of certain constants, vectors, and matrices within the program. This list follows the order of statements found in the program listing given above. Each item is identified by a line number found in this program listing, and its dimensions are given if a particular item is to be printed or modified. The appropriate statement(s) should be entered immediately after the line number indicated.

Line Number	Statement	Definition
0023	X3 (I) I = 1,N1	Original dependent variable.
0042	X2 (K7 (2,J), J) J = 1, K4	Original matrix of independent variables.
0052	X2 (I, K4) I = 1, K3	Lagged error vector from 1st iteration when autoregressive least squares procedure is executed.
0062	K3	The number of observations used in the regression estimation.
0071	K8	The number of regressors used in the regression equation.
0104	X6 (I) I = 1, N5	x(i) vector for distributed lag artificial variable computation (see Almon, op.cit.)

Line Number	Statement	Definition
0122	X7 (I,J) I - 1, N5 J - 1, N4	Omatrix for distributed lag artificial variable computation (see Almon, op. cit.)
0128	X8 (I,J) I - N5, N2 J = 1, N4	Artificial variables for distributed lag estimation.
0136	X5 (I,J) I - 1, K3 J = 1, K8	Matrix of transformed regressors.
0144	X6 (I) I - 1, K3	Transformed dependent variable.
0150	X4 (J) J - 1, K8	Means of regressor variables.
0153	X5 (I,J) I = 1, K3 J = 1, K8	Regressor matrix minus means of regressors.
0158	X9 (J) J = 1, K8	Standard deviation of regressors.
0161	X5 (I,J) I = K3 J = K8	Standardized regressor matrix.
0165	X10	Mean of dependent variable.
0168	X6 (J) I = 1, K3	Dependent variable minus mean.
0172	X11	Standard deviation of dependent variable.
0174	X6 (J) I = 1, K3	Standardized dependent variable.
0188	X7 (I,J) I - 1, K8 J - 1, K8	Correlation matrix of regressors.
0251	EIVU (I) I - 1, K8	Eigen values.
	EIVR (I,J) I - 1, K8 J - 1, K8	Eigen vectors.
0263	R (I) J - 1, K8	Eigen values in descending order.
	X7 (I,J) I - 1, K8 J - 1, K8	Eigen vectors ordered according to ordering of corresponding eigen values.
0279	X8 (I,J) I - 1, K3 J - 1, K8	Regressor matrix; if artificial orthogonalization procedure has been performed, component matrix (called the X matrix below).

Line Number	Statement	Definition
0287	A (I,J) I = 1, K9 J = 1, K9	X' X
0306	A (I,J) I = 1, K9 J = 1, K9	$(X' X)^{-1}$
0312	X36 (I,J) I = 1, K9 J = 1, K3	$(X' X)^{-1} X'$
0317	B (I) I = 1, K9	Estimated regression coefficients.
0337	EIVU (I) I = 1, K8 EIVR (I,J) I = 1, K8 J = 1, K8	Eigen values in descending order. Eigen vectors ordered according to ordering of corresponding eigen values.
0347	R (I) I = 1, K8	K8 sets of estimated regression coefficients computed when artificial orthogonalization procedure has been performed.
0356	B (I) J = 1, K8	Regression coefficients (if artificial orthogonalization procedure has been performed, one of the sets selected from the above K8 sets).
0361	AINV (I) I = 1, K3	Estimated values for dependent variable.
0363	AINV (I) J = 1, K3	Error vector.
0371	X14	Durbin-Watson statistic.
0399	A1	Standard error of the regression.
0402	X7 (I,J) I = 1, K8 J = 1, K8	Covariance matrix if artificial orthogonalization procedure not performed.
0417	X7 (I,J) I = 1, K9 J = 1, K9	Covariance matrix if artificial orthogonalization procedure has been performed.
0419	AINV (I) I = 1, K9	Standard errors of regression coefficients.
0421	AINV (I) I = 1, K9	t-values for regression coefficients.
0428	B (J) J = 1, N1	Unstandardized regression coefficients.
0454	X6 (I) I = 1, N4	x(i) vector for distributed lag artificial variable computation (see Almon, op. cit.)

Line Number	Statement	Definition
0472	X8 (I,J) I = 1, N5 J = 1, N4	O matrix for distributed lag artificial variable computation (see Almon, op. cit.)
0481	X9 (I) I = 1, N3	Distributed lag weights.
0493	X4 (I) I = 1, N2	Variance of distributed lag weights.
0495	X4 (I) I = 1, N2	Standard error of distributed lag weights.
0497	X4 (I) I = 1, N3	t-values for distributed lag weights.
0534	X36 (I,1) I = 1, K4	Regression coefficients.
	X36 (I,2) I = 1, K4	Standard error of regression coefficients.
	X36 (I,3) I = 1, K4	t-values of regression coefficients.
0538	X36 (N1, 1)	Constant.
0562	X36 (I,1) I = 1, N2	Distributed lag weights.
	X36 (I,2) I = 1,N2	Standard error of distributed lag weights.
	X36 (J,3) I = 1,N2	t-values for distributed lag weights.
0632	A1	R-Square.
0642	A1	Durbin-Watson statistic.
0649	X4 (I) I = 1, K3	Actual dependent variable.
	R (I) I = 1, K3	Estimated dependent variable.
	X3 (I) I = 1, K3	Error term.

FIGURE D–4 SAMPLE OUTPUT FROM STATISTICAL ANALYSIS SYSTEM

```
                         DEPENDENT VARIABLE

                      1        5182.00000
                      2        5709.00000
                      3        6189.00000
                      4        6618.00000
                      5        7011.00000
                      6        7551.00000
                      7        8115.00000
                      8        8510.00000
                      9        8936.00000
                     10        8601.00000
                     11        8826.00000
                     12        8595.00000
                     13        9399.00000
                     14        9552.00000
                     15        9745.00000
                     16        9875.00000
                     17       10206.00000
                     18       10115.00000
                     19        9578.00000
                     20        9277.00000
                     21        9003.00000
                     22        8373.00000
                     23        7795.00000
                     24        7321.00000

                         INDEPENDENT VARIABLES*

                         VARIABLE NUMBER     1

                          1        381.00000
                          2        612.00000
                          3        773.00000
                          4        904.00000
                          5        954.00000
                          6       1195.00000
                          7       1372.00000
                          8       1490.00000
                          9       1605.00000
                         10       1735.00000
                         11       1816.00000
                         12       1871.00000
                         13       1916.00000
                         14       1940.00000
                         15       1969.00000
                         16       1976.00000
                         17       1988.00000
                         18       2019.00000
                         19       2020.00000
                         20       2021.00000
```

* 6 Independent Variables, Only 1 Illustrated

FIGURE D–4 SAMPLE OUTPUT FROM STATISTICAL ANALYSIS SYSTEM (continued)

```
          CORRELATION MATRIX

VARIABLE        1        2        3        4        5        6
   1         1.0000   0.9787  -0.6092  -0.3729   0.5830   0.9117
   2         0.9787   1.0000  -0.5971  -0.4031   0.5847   0.9184
   3        -0.6092  -0.5971   1.0000   0.7515  -0.1139  -0.8337
   4        -0.3729  -0.4031   0.7515   1.0000   0.0128  -0.5863
   5         0.5830   0.5847  -0.1139   0.0128   1.0000   0.3970
   6         0.9117   0.9184  -0.8337  -0.5863   0.3970   1.0000


             ARTIFICIAL ORTHOGONALIZATION PROCEDURE EXECUTED
             AUTOREGRESSIVE LEAST SQUARES PROCEDURE EXECUTED
```

```
          CORRELATION MATRIX

VARIABLE        1        2        3        4        5        6        7
   1         1.0000   0.9748  -0.6759  -0.3628   0.2525   0.9236   0.0511
   2         0.9748   1.0000  -0.6250  -0.3876   0.3298   0.9086  -0.1432
   3        -0.6759  -0.6250   1.0000   0.7454  -0.0110  -0.8582  -0.1209
   4        -0.3628  -0.3876   0.7454   1.0000   0.1636  -0.5821   0.2159
   5         0.2525   0.3298  -0.0110   0.1636   1.0000   0.1628  -0.4593
   6         0.9236   0.9086  -0.8582  -0.5821   0.1628   1.0000   0.0125
   7         0.0511  -0.1432  -0.1209   0.2159  -0.4593   0.0125   1.0000


             ARTIFICIAL ORTHOGONALIZATION PROCEDURE EXECUTED
```

FIGURE D–4 SAMPLE OUTPUT FROM STATISTICAL ANALYSIS SYSTEM (continued)

```
                              REGRESSION RESULTS

        VARIABLE        REGRESSION        STANDARD        T-VALUE
                        COEFFICIENT        ERROR
              1             0.0962          0.0152          6.3202
              2             0.0236          0.0041          5.7359
              3             0.3692          0.0984          3.7504
              4           DISTRIBUTED LAG WEIGHTS IN TABLE BELOW
              5            -0.0800          0.0995         -0.8037
              6             0.0588          0.0296          3.3360
         CCNSTANT           2.16358

                              DISTRIBUTED LAG WEIGHTS
                              VARIABLE NUMBER    4

        PERIODS        WEIGHT        STANDARD        T VALUE
        LAGGED                       ERROR

           0           0.0800        0.1493          0.5356

           1           0.1536        0.1555          0.5880

           2           0.2017        0.1050          1.9215

           3           0.2050        0.1032          1.9861

           4           0.1442        0.1083          1.3315

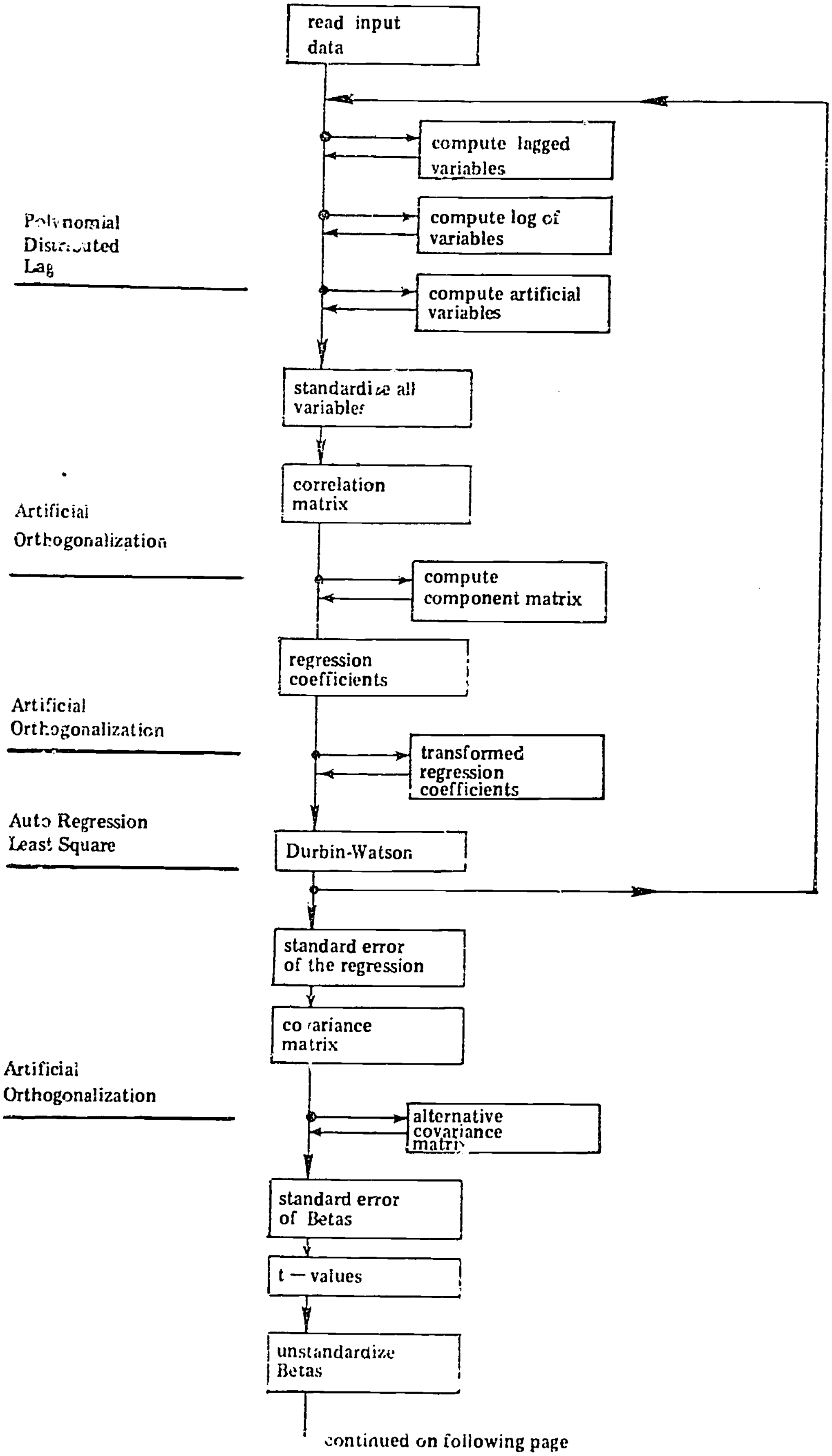
        R SQUARED #     0.924847

        DURBIN WATSON STATISTIC #     1.804724

        TIME            ACTUAL             ESTIMATED          ERROR
        PERIOD

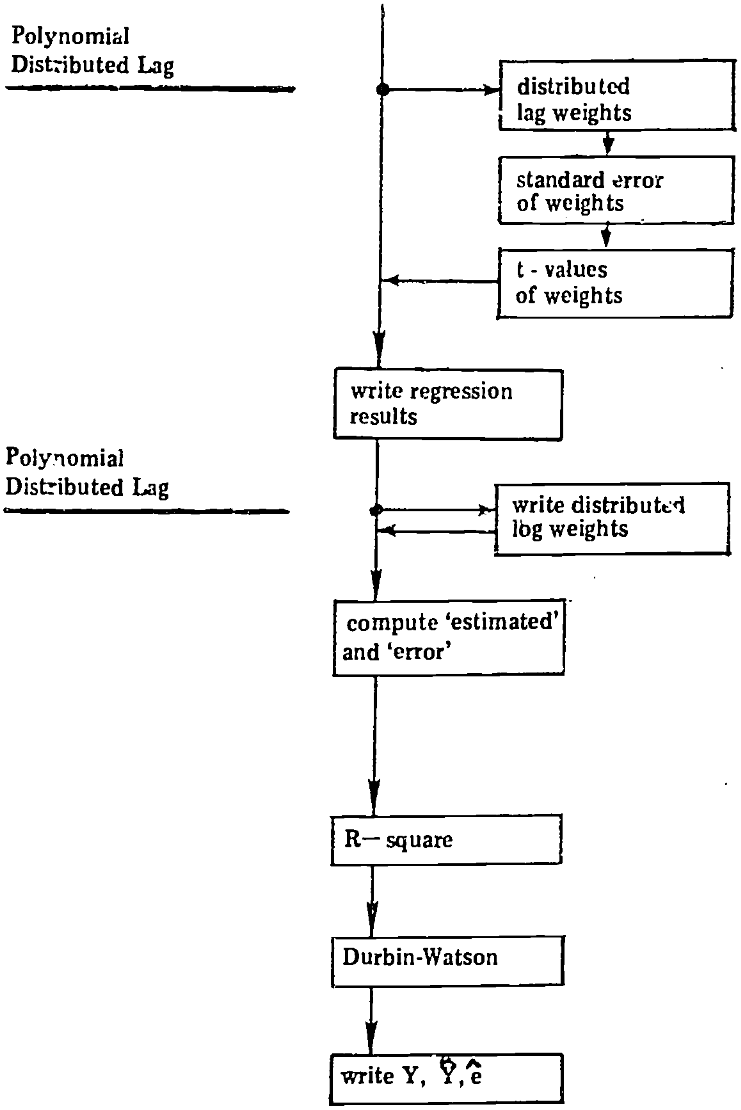
            1           8115.0000          7866.2139          248.7861
            2           8510.0000          8449.9749           60.0251
            3           8936.0000          8974.9264          -38.9264
            4           8601.0000          9119.6609         -518.6609
            5           8826.0000          8820.3004            5.6996
            6           8995.0000          9212.8370         -217.8370
            7           9399.0000          9302.8742           96.1258
            8           9552.0000          9685.1265         -133.1265
            9           9745.0000          9633.8158          111.1842
           10           9875.0000          9762.1398          112.8602
           11          10206.0000          9780.0965          425.9035
           12          10115.0000         10063.0655           51.9345
           13           9578.0000          9799.0394         -221.0394
           14           9277.0000          9166.8868          110.1132
           15           9003.0000          8917.2441           85.7559
           16           8373.0000          8421.1425          -48.1425
           17           7795.0000          7812.6690          -17.6690
           18           7321.0000          7392.9089          -71.9089
     END CF JOB
```

FIGURE D—5 STATISTICAL ANALYSIS SYSTEM



continued on following page

(figure D—5 continued)



APPENDIX E
ALTERNATIVE COMPONENT PROCEDURES

One of the prime characteristics of the School Facility Planning System is flexibility. The techniques used in each of the components may be modified by adding or deleting rows, and by changing the entries on the '1' and '6' cards. A few of the many alternative procedures are discussed below. Users are encouraged to add to this list.

1. Subject Area Enrollment Forecasts.

If the user wants to project subject area enrollments based on the trend in the average number of courses each student in the school takes in that subject area, the following rows could be substituted for each subject area used. A junior high situation is presented for illustrative purposes. It should be emphasized that this change would necessitate renumbering a series of additional rows.

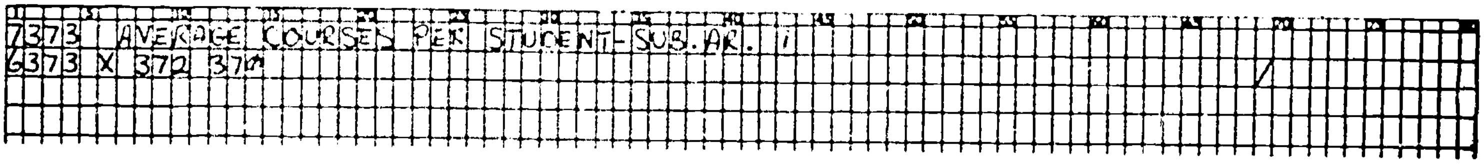
Row 370: Junior High Enrollment. Total enrollment in the junior high school grades.

Row 372: Average Courses in Subject Area-1 per Student. This value is calculated and input by the user, by dividing the subject area enrollment by the total enrollment in the school for the historical years. A '6' card can be used to calculate future ratios or the average of the historical years can be input using a '1' card.

Row 373: Subject Area-1 Enrollment. This row is calculated by multiplying projected junior high enrollment times the projected average courses in Subject Area-1 per student. Data for the historical years will be the same as that used to derive the historical ratios.

Similar entries would be repeated for each subject area used. No subsequent adjustments would need to be made to these projections since no independent projection of total subject area enrollment is made. The same steps could be substituted into the elementary and senior high sections of the Component. A different adjustment could be made by those users satisfied with the current procedures for projecting subject area enrollment, but curious about the resulting average number of courses per student in a given subject area. This adjustment would involve adding a row for each subject area, and dividing the subject area enrollment by the total enrollment.

In the junior high school situation, the average number of courses for the first subject area could be determined with the following cards:



```
7373  AVERAGE COURSES PER STUDENT-SUB.AR. 1
6373 X 372 370                                                  /
```

This would, of course, require that subsequent rows be renumbered. Also '8' and '9' cards would have to be added if the information was to be displayed in the report output.

2. Measuring Capacity in Square Feet.

If the user wants to project facility need directly in terms of square feet, rather than first in teaching stations which can be translated into square feet, certain modifications must be made. To make these changes the following substitutions should be considered:

Row 320: Subject Area-1 Student Spaces/Week. This variable is calculated by multiplying the adjusted subject area enrollment times a factor supplied by the user. This factor is the average number of classes in the subject area per week multiplied by the average square feet required per student or WxSF.

Row 321: Subject Area-1 Square Feet Required. This variable is calculated by dividing student spaces per week by a factor supplied by the user. This factor is equal to the number of periods per week the school is in session times the utilization factor or PxU.

Row 322: Subject Area-1 Square Feet Available. Historical data on the number of square feet available for the subject area should be entered for all historical years. If data is unavailable for any year, a zero should be entered in that field. The current amount of square feet should be entered for every year of the planning period. If a new school is being constructed or an existing school modified or closed, the amount of square feet should be adjusted to reflect these changes in all years concerned.

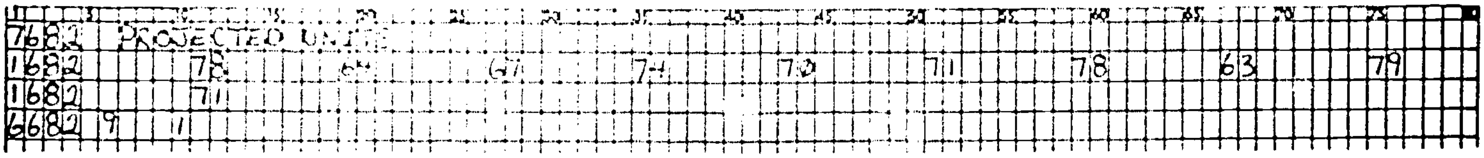
Row 323: Subject Area-1 Square Feet Short or Excess. This variable is obtained by subtracting the required square footage (Row 321) from available square feet (Row 322) for the subject area.

Row 324: Rooms Short or Excess. This variable is obtained, if desired, by dividing the square feet short or excess by the standard room size for the subject area.

The above steps must be repeated for every subject area used in the elementary school analysis. Measurement of facility need in square feet is also possible for the junior high and senior high analysis when similar changes are made to the pertinent rows.

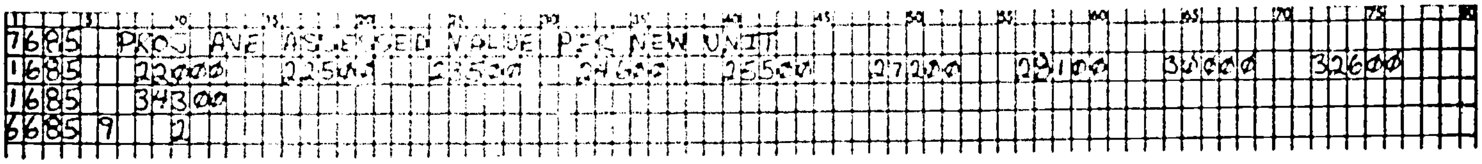
3. Assessed Valuation (Logical Unit Method).
An alternative approach for determining future assessed valuation is to project community growth in terms of structures, acres, square feet, or some other logical unit. The projected number of units is multiplied times the projected average assessed valuation per new unit. This figure is then added to the estimated assessed valuation of existing units to arrive at a projected total assessed valuation. Aggregated or disaggregated data may be used. For instance, all structures may be projected on an aggregated basis or structures may be projected by individual land use category such as residential, commercial/industrial, or any other logical breakdown for which data is available. The rows below illustrate an aggregated approach using the number of structures as the unit of analysis.

Row 682: Projected Units (structures). The historical number of new units (structures in this example) is entered in Row 682 for each appropriate year. The number of new units is projected with a user selected growth curve (linear extrapolation in this example).



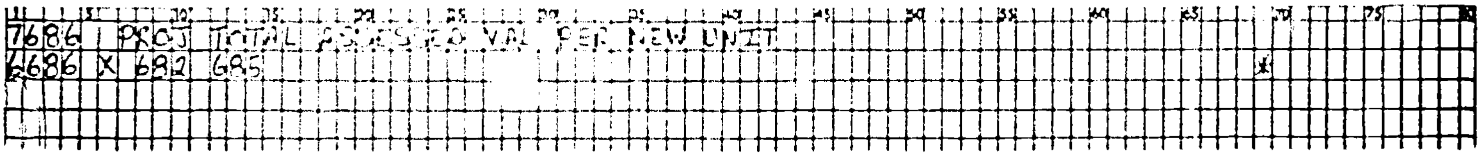
```
7682  PROJECTED UNITS
1682      78      64      67      74      70      71      78      63      79
1682      71
6682 9    1
```

Row 685: Projected Average Assessed Valuation per New Unit. The historical average assessed valuation for new units for each year is calculated manually and entered into Row 685 in the appropriate years. Projection is made with a growth curve that reflects the user's expectations regarding inflation. The curve selected here is exponential.



```
7685  PROJ AVE ASSESSED VALUE PER NEW UNIT
1685  22000   22500   23500   24600   25500   27200   29100   31000   32600
1685  34300
6685 9    2
```

Row 686 : Projected Total Assessed Valuation per New Units. The projected total assessed valuation for new structures is calculated by multiplying Row 682 times Row 685. Some users may be tempted to dispense with these rows and simply extrapolate historical total assessed valuations for new units in Row 686. This short cut will result in an unreasonable forecast, however, unless the growth curve is based on an understanding of the probable number and price of new units in the community.



```
7686  PROJ TOTAL ASSESSED VAL PER NEW UNIT
6686 X 682 685                                      1
```

Row 688 : Rate of Change in Assessed Valuation for Existing Structures. The annual rate of change in assessed valuation for existing structures is entered into Row 688. This is a user supplied variable based on knowledge of reappraisal policies in the district and on judgement regarding future inflation. If property is reappraised every time it is transferred, then there probably will be a small increase each year. If all property is reappraised every five years, then there will be a more sizeable increase every fifth year. It is recommended that the user manually enter the forecast ratio rather than select a projection technique. The example below illustrates a three percent increase in assessed valuation due to ongoing reappraisals at the time of property transactions, and a twelve percent increase due to a five year reappraisal program

7688	RATE OF CHANGE IN ASSESSED VALUATION								
1688	0112	0105	0103	0103	0103	0112	0103	0103	0103K
1688	0105	0112	[illegible]	0103	[illegible]	0103	0112	0103	0103K
1688	0103	0105	0112	0103	0103	0103	0103	0112	0103K

Row 690 : Projected Total Assessed Valuation. The historical total assessed valuation for all units is entered into Row 690. The procedure card multiplies the forecasted rate of change times the last historical total assessed valuation and adds in the assessed valuation for projected new structures to arrive at an estimate of assessed valuation for all structures.

7690	PROJECTED TOTAL ASSESSED VALUATION								
1690	910000	920000	930000	940000	950000	960000	970000	980000	9900002
1690	1000000								
6690	X 690525 [illegible]								2

Some users may want to expand further this approach so that the anticipated demolition of units, and hence loss of tax base, is accounted for as well as the development of new units.

4. Assessed Valuation (Disaggregated Approach).

Assessed valuation may be projected separately for different types of land use and then summed to arrive at total assessed valuation. If this approach is used, then historical data for each land use should be entered in Rows 679 to 689 inclusive. Each of these subtotal rows is to take the format of Row 690 illustrated in the text. Since each land use is projected individually, a total assessed valuation must be summed. This is calculated in Row 690.

7687	COMMERCIAL [illegible] ASSESSED VALUE								
1687	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	138410	155238	[illegible]	2216323
1687	[illegible]								3
6687	H 5								
7689	RESIDENTIAL ASSESSED VALUATION								
1689	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100000	110000	120000	1300003
1689	140000								3
6689	H 1								
7690	PROJECTED TOTAL ASSESSED VALUATION								
6690	X 687 689						+		

5. Short Method for Total Revenue Projection.

A simplified projection technique may be appropriate in situations where there is no need for revenue projections by source, and one or two revenue categories provide the majority of district funds. The user is cautioned not to include income derived from the sale of bonds in this abbreviated approach. Because of its fluctuating nature, income from the sale of bonds should be projected separately and then added to the results of the short method to arrive at total revenue. Either a regression or ratio approach can be used.

Alternative A. Total revenue may be forecast as a regression against ad valorem taxes and/or state unrestricted grants-in-aid. In the example, total district revenue is entered in Row 838 and projected as a function of real property tax receipts (Row 736). Row 850 adds the non-revenue income derived from the sale of bonds (Row 840) to arrive at a total revenue estimate for the district.

```
7838  SHORT METHOD REVENUE PROJ. ALTER. A
1838 5567356 7247121333044013441662175825272044886342371878926799177330971554
6838 3 736
7850  TOTAL REVENUE FROM ALL SOURCES
6850 X 838 840
```

Alternative B. A second shortened method of projecting total revenue is to calculate manually the historical ratio between total revenue and ad valorem taxes and then multiply this ratio times the projected tax receipts to arrive at projected subtotal revenue. The ratio used in the example is one and four tenths. In other words, total revenue has historically been one and four tenths times ad valorem tax receipts and this relationship is assumed to continue into the future. Row 850 adds income from the sale of bonds and the subtotal revenue to arrive at total revenue for the district. If desired, the ratio can be projected.

```
7838  SHORT METHOD REVENUE PROJ. ALTER. B
6838 X 736 * 0140K
7850  TOTAL REVENUE FROM ALL SOURCES
6850 X 838 840
```

The user is encouraged to experiment with other "short-cut" formulas for projecting total district revenue.

6. Teacher Salary Forecasts.
Several alternatives to the use of an independent per capita income projection can be used to forecast future outlays for district salaries.

Alternative A. Teacher salaries may be projected directly by assuming a constant inflation rate and applying it. The example below assumes that teacher salaries will increase at a constant rate of four percent per year. A variable rate could also be applied.

```
865  TEACHER SALARIES ALTERNATIVE A
868 2442766 3035181 4108002 5600472 6846811 8057494 9506857 11047819 12103316
868 X 865 * 0104K
```

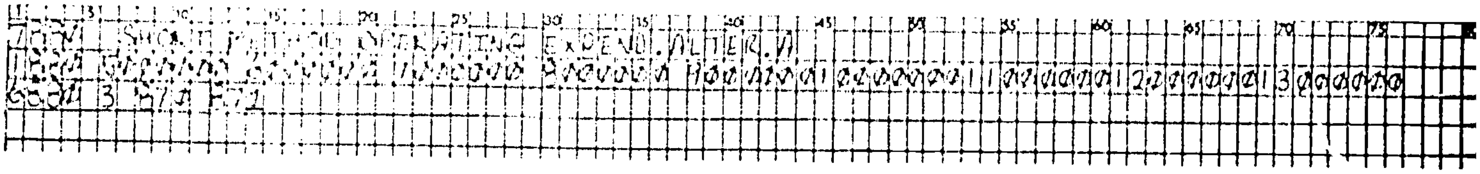
Alternative B. Teacher salaries may also be projected by choosing a growth curve and applying it against historical data. In this example, historical teacher salaries are projected, using an exponential curve.

```
868  TEACHER SALARIES ALTERNATIVE B
868 2442766 3035181 4108002 5600472 6846811 8057494 9506857 11047819 12103316
868 9   2
```

7. Short Method for Operating Expenditures Projection.

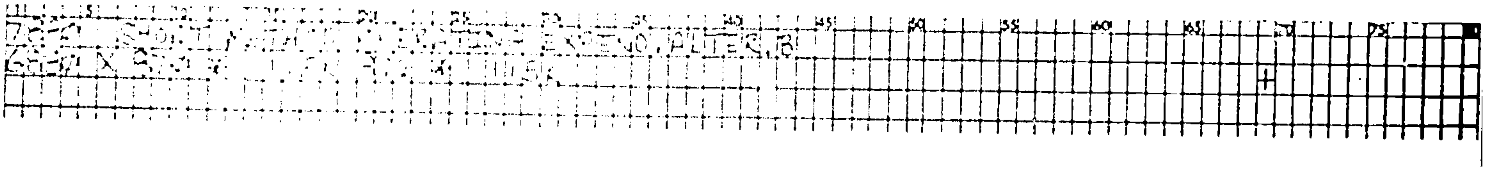
The same kind of abbreviated approach used to forecast revenues can be used in the calculation of district expenditures.

Alternative A. District salaries and benefits usually constitute the vast percentage of total district operating expenditures. This being the case, operating expenditures may be projected as a function of district salaries (Row 870) and district benefits (Row 872). The following example illustrates this multiple regression approach:



```
7004 SHORT METHOD OPERATING EXPEND. ALTER. A
[illegible] 1000000 0000000 1000000 2000000 3000000
6504 3 870 872
```

Alternative B. A second approach is to calculate manually the historical ratio between total salaries plus benefits and total operating expendigures. This ratio is then multiplied times forecasted district salaries plus benefits to arrive at projected operating expenditures.

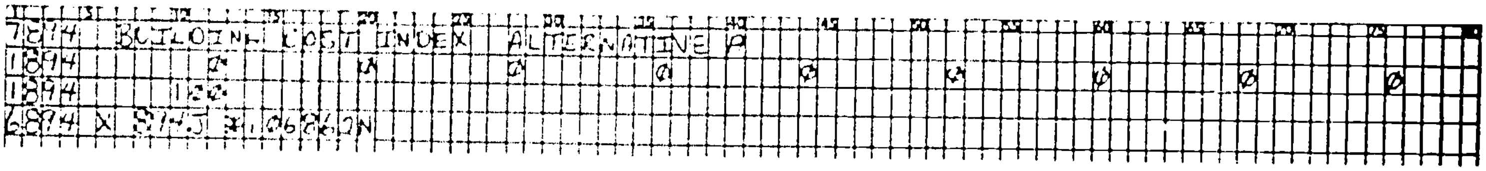


```
7504 SHORT METHOD OPERATING EXPEND. ALTER. B
6504 X 870 [illegible]
```

8. Building Cost Index Forecasts.

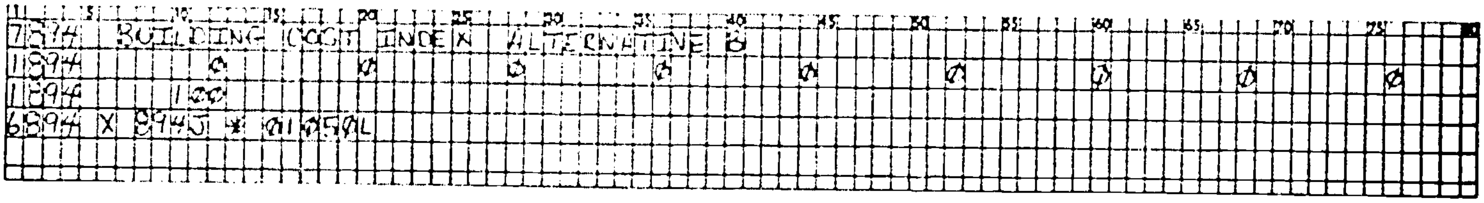
A variety of techniques can be used to forecast construction costs over the planning period if a reliable independent forecast is not available.

Alternative A. The mean historical rate of change in a local building cost index or other indicator of construction cost is manually calculated. This average rate of change is then carried into future years. The assumption is that the average historical rate of change will apply in the future. In the example below the average historical rate of change for the first six years of the Dodge Manual Building Cost Index has been calculated to be .06862. Since no historical data is needed for the projection of future indices, none are entered. Also, because in this case, any value may serve as an index, one hundred is entered in the current year. The procedure card lags one year from the blank in 1975 to the 1974 index of one hundred. The program multiplies one hundred times 1.06862 to calculate an index of 106.862 in 1975. The 1976 index is 114.19487 or 106.862 times 1.06862, and so forth to the end of the planning period.



```
7894 BUILDING COST INDEX ALTERNATIVE A
1894      0     0     0     0     0     0     0     0     0
1894    100
6894 X 8745 *1.06862N
```

Alternative B. In the second alternative the rate of change in the building cost index is assumed to reflect a constant inflation rate. The data requirements and procedures are similar to Alternative A. The example below illustrates an estimated future annual inflation rate of five percent in the local construction industry.



```
7594 BUILDING COST INDEX ALTERNATIVE B
1894      0     0     0     0     0     0     0     0     0
1894    100
6894 X 8945 * 01050L
```

Alternative C. The historical building cost index or any other indicator of construction cost can be projected, using any of the growth curves listed in Chapter 2. The example presents an exponential projection of the historical Dodge Manual Building Cost figures. This curve assumes that the inflation rate in the historical data will remain constant. A small problem for some users may be that the projection will not start with the exact data for the last historical year.

```
1   5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
7894  BUILDING COST INDEX  ALTERNATIVE C
1894     273     284     293     304     325     344     375     402     436
1894     467
6894 9   2
```

APPENDIX F
GRAPHIC DISPLAY PACKAGE

A Choropleth mapping program (C-Map) has been included in this version of the School Facility Planning System to provide the user with the ability to graphically represent the projections derived in the Enrollment Component. This program was developed by Dr. Morton W. Scripter of the Department of Geography, University of Idaho. The program produces a conformal map which represents areas in their true shape.

1. Program Description.

The program is written in Fortran, and requires approximately 32K bytes of core storage. A 'scan-line' principle is used so that only one print line of the map is in memory at a time. After the line is printed, that area of core storage is then available for the next print line. Any size map can be printed with the one restriction being computer run time. Single page maps have been produced in less than two minutes.

2. Input Cards.

The input cards can be categorized into four groups - the source deck, the parameter deck, the data deck, and the map scan deck. Each deck is discussed in general terms in this section. A detailed explanation of how to prepare the user supplied cards is contained in Section 3.

2.1 The Source Deck. This deck consists of the actual mapping program. The source listing, contained on tape, encompasses the entire program and includes modifications necessary to run the program on an IBM 370/145.

2.2 The Parameter Deck. This deck consists of five basic cards. The parameter card contains information concerning the basic parameters of the system. These parameters are the number of statistical classes (maximum=10), the number of data areas (maximum=300), the number of scan lines (maximum=99,999), the maximum width of the map in print characters (maximum=131), print symbols for the background area and print symbols for those values outside the range of the statistical class limits.

The second card in the parameter deck is the title card. The title of the printed map is specified on this card. The data selection card contains the Fortran format statement which specifies the appropriate data from the data deck to be categorized and mapped. This format statement is based on a format established for the data deck cards. Each time a different data item is selected for mapping, the data selection card is changed.

The statistical class limits card contains the lower and upper limits of each statistical class. A second card can be used if the number of classes exceeds seven. The decimal point must be punched for each limit specified. The print symbols card contains the symbol(s) which will be used for each class interval. A maximum of four characters can be specified on each card resulting in overprinting. A separate print symbols card must be used for each class interval and input in the sequence of the statistical limits specified on the statistical limits card.

2.3 The Data Deck. These cards contain the data which is to be mapped such as population, housing unit, or enrollment statistics. A separate card is required for each area. A sequence identification number is assigned to each data area. The cards must be submitted to the program in this sequence. The format of the data items is flexible and will depend upon the values to be mapped. The number of data items coded is dependent on the format set up for the card by the user. Specific data items to be mapped for any given program run are designated by the data selection card.

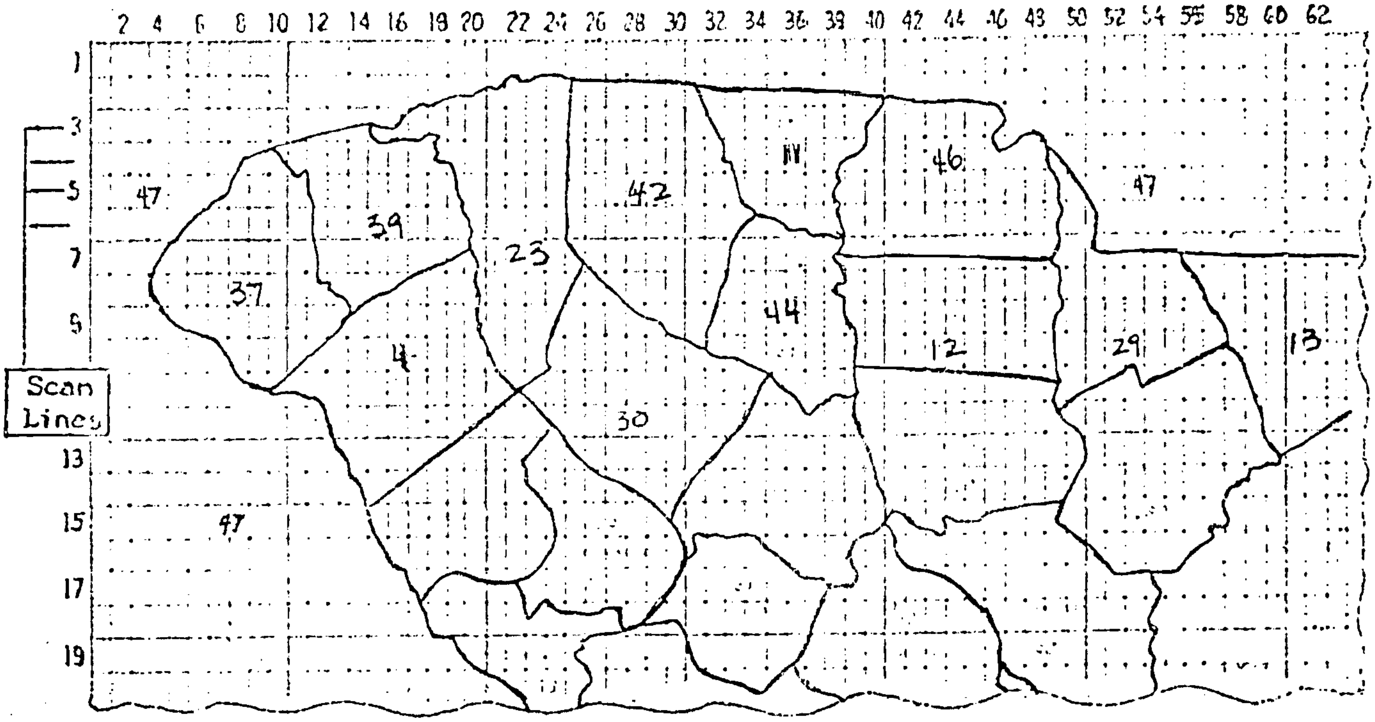
2.4 The Map Scan Deck. This deck is created by overlaying a base map with a grid which measures six lines per inch vertically by ten lines per inch horizontally. The 0,0 point is at the top left of the map. A card or pair of cards is then prepared for each scan line. Examples of the grid overlay and the scan deck are included in Figure F-1. The scan line card contains the scan line number; the number of area segments on the line, including the background; the identification number of the first segment on the line; the ending print position of the first segment; the second area's identification number; the ending point position of the second area; and so on until all segments have been covered. If there are more than twelve segments on a single scan line, a second card is needed. The thirteenth segment is identified starting in Column 7 of the second card. The identification number for the background area is one more than the identification number of the last data area contained in the data deck.

3. Input Card Format.

The format of each of the input cards, excluding the source deck, is presented below. An example of each card type is shown in Figure F-2. If the format of the card is flexible, a suggested format is given.

FIGURE F–1 CONSTRUCTION OF SCAN DECK

a). Grid Overlay and Identification of Data Areas



b) Example of SCAN DECK

scan line segments

Data Area Identification (ID)

End Position for data area

3 6 47 16 23 24 42 32 11 43 46 46 47 94

4 8 47 8 37 10 39 18 23 24 42 32 11 35 46 49 47 99

5 9 47 7 37 11 39 19 23 24 42 33 11 38 46 49 29 50 47 94

6 10 47 5 37 12 39 20 23 24 42 33 44 35 11 38 46 49 29 51 47 94

7 10 47 4 37 12 39 18 4 20 23 25 42 32 44 38 46 49 29 51 47 94

8 13 47 3 37 13 38 16 4 20 23 24 30 27 42 32 44 38 12 49 29 56 13 67 35 72

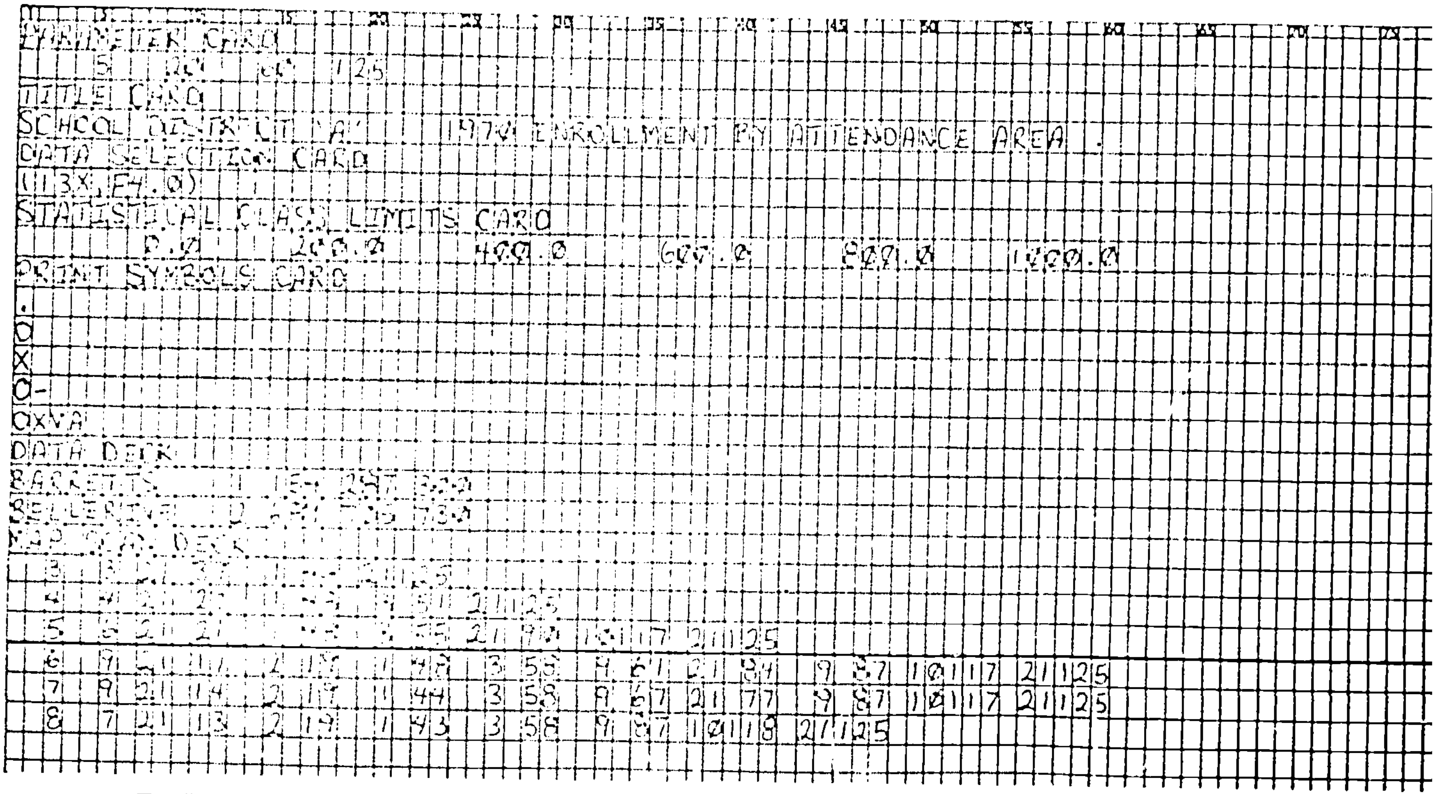
A8 47 94

9 12 47 4 37 13 … 38 12 49 29 57 13 68 35 74 47 94

10 12 47 7 37 11 … 49 29 57 13 69 35 75 17 76 47 94

A Second Card Is Used If There Are More Than 12 Segments on a Scan Line

FIGURE F–2 GRAPHIC DISPLAY PACKAGE INPUT CARD FORMAT



```
PARAMETER CARD
    5  20   60  125
TITLE CARD
SCHOOL DISTRICT NA      1970 ENROLLMENT BY ATTENDANCE AREA
DATA SELECTION CARD
(13X,E4.0)
STATISTICAL CLASS LIMITS CARD
       0.0      200.0      400.0      600.0      800.0      1000.0
PRINT SYMBOLS CARD
.
O
X
O-
OXVA
DATA DECK
BACKETTS     1  [illegible] 257 320
BELLERIVE    0  [illegible] 733
MAP DATA DECK
 3  8 21 37  [illegible]
 4  [illegible] 21 25  [illegible] 50 21 125
 5  6 21 21  [illegible] 55 21 90 10 17 21 25
 6  9 20 17  2 17  1 48  3 55  8 67 21 84  9 87 10 117 21 125
 7  9 21 14  2 17  1 44  3 58  8 67 21 77  9 87 10 117 21 125
 8  7 21 13  2 19  1 43  3 58  9 87 10 118 21 125
```

The Parameter Format

Col. 1 - 2	Not used.
Col. 3 - 5	The number of statistical classes into which the data is to be divided. A maximum of ten classes is allowed in the program.
Col. 6 - 10	The number of data areas to be mapped. A maximum of 300 is allowed in the program.
Col. 11 - 15	The number of scan lines on the map. A maximum of 99,999 lines is allowed in the program.
Col. 16 - 20	The width of the map to be printed in print characters. A maximum width of 131 print positions is allowed in the program.
Col. 21 - 72	Not used.
Col. 73 - 76	The print symbols for the background area. If no symbols are desired,the columns are left blank.
Col. 77 - 80	The print symbols for data values which fall outside the range of the specified statistical class limits. If the class limits have been defined to include all possible data values,these columns can be left blank.

The Title Format

Col. 1 - 80	The title desired for the map.

The Data Selection Format

Col. 1 - 80	The Fortran format statement, enclosed in parentheses, which designates the specific data on a data deck card which is to be read and mapped.

The Statistical Class Limits Format

Col. 1 - 10	The lower limit of the first statistical class expressed as a decimal.
Col. 11 - 20	The upper limit of the first statistical class expressed as a decimal.
Col. 21 - 30	The upper limit of the second statistical class expressed as a decimal.
Col. 31 - 40	The upper limit of the third statistical class expressed as a decimal.
Col. 41 - 80	The upper limits of the fourth through seventh statistical classes expressed as a decimal. If more limits are to be specified,a second card is needed and the above format is continued.

The Print Symbols Card

Col. 1 - 4	A symbol to represent the first statistical class. Symbols placed in the second, third and fourth columns will result in the overprinting of these characters. A separate card is needed for each statistical class.
Col. 5 - 80	Not used.

The Data Card Format

Col. 1 - 10	The name of the data area.
Col. 11 - 13	The sequence or identification number of the data area.

The remaining columns have a flexible format. The suggested format is the following:

Col. 14 - 23	The first data field.
Col. 24 - 33	The second data field.
Col. 34 - 73	The third, fourth, fifth and sixth data fields.
Col. 74 - 80	Not used.

The Map Scan Format

Col. 1 - 3	The scan line number.
Col. 4 - 6	The number of data area segments on the scan line including the background segments.

Col. 7 - 9	The identification number of the first data area on the scan line.
Col. 10 - 12	The ending print character position of the first data area.
Col. 13 - 15	The identification number of the second data area on the scan line.
Col. 16 - 18	The ending print character position of the second data area.
Col. 19 - 78	The identification numbers and ending print character positions of the third through twelfth data areas on the scan line. If there are more than twelve data areas on a scan line, a second card is used beginning in Column 7.
Col. 79 - 80	Not used.

4. Submission to the Computing System.

To obtain a run of the mapping program the cards must be submitted in a specified sequence. The example given in this Appendix uses the job control language necessary for execution in an IBM 370/145 DOS-VS environment.

```
// JOB (standard JOB card)
*$$ JOB (JOB name)
*$$ LST FNO=4111,CLASS=T
// OPTION LINK
// EXEC FFORTRAN
 [C-Map Fortran Source Deck]
/*
// EXEC LNKEDT
// EXEC
 [C-Map Parameter Deck, Data Deck, Scan Deck]
/*
/&
*$$EOJ
```

5. Systems Output.

The systems output consists of two sections. In figure F-3 some of the user input variables are listed. The map title, the number of data areas, the number of statistical classes, the range of each class along with its associated print symbol are listed for easy reference. Figure F-4 shows a sample of the actual map produced.

FIGURE F-3 PARTIAL LISTING OF USER INPUT FOR GRAPHIC DISPLAY PACKAGE

```
     5    20    60   125
SCHOOL DISTRICT @A@      1970 ENROLLMENT BY GRID
%13X,F4.0□
                0.          200.          400.          600.          800.        1000.
.
O
X
O-
OXVA

CHOROPLETH MAPPING PROGRAM

SCHOOL DISTRICT @A@.    1970 ENROLLMENT BY GRID

CASES --  20

MAP CLASSES --    5

SCAN LINES --   60

DATA FORMAT   --%13X,F4.0□

FIRST CASE --            154.00

LAST CASE   --           367.00



CLASSIFICATION

                0.0
                    ...
                    ...
           200.00
                    000
                    000
           400.00
                    XXX
                    XXX
           600.00
                    888
                    888
           800.00
                    ■■■
                    ■■■
          1000.01
```

FIGURE F—4 SAMPLE CHOROPLETH MAP