A STUDY LEADING TO THE DEVELOPMENT OF POLICIES FOR THE UTILIZATION OF LAND AT EXPRESSWAY INTERCHANGES

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ABSTRACT

The development of expressway systems throughout the nation has provided a high capacity, high speed means of moving traffic. It has also limited land access to specific points along the route where interchanges connect cross routes to the expressway. This access benefit provided at interchanges helps create a demand for intensive land use in these areas. The increase in intensity of land use at an interchange may generate additional traffic to the area and could seriously restrict the traffic carrying capacity of the expressway and of intersecting cross routes.

This thesis examines trends in change in land values and land uses along expressways and particularly at interchange areas in order to determine the nature of shifting land patterns. In order to investigate these changes so that generally comparable land parcels were considered, information furnished by many states was classified as urban, suburban, or rural. These land parcels were analyzed by considering an acre as the unit of change. This analysis indicated that a substantial increase in land value can be attributed to the construction of an expressway facility and particularly to an interchange. In general it was determined that land had a tendency to change to commercial usuage.

After examining shifts in value and use, an examination is made of traffic factors at interchange areas. Research on this phase of the thesis is

limited to bibliographic material. Methods for determining traffic capacities of expressway systems and traffic generating potential of various land uses are theoretical; however, the need for controlling land development is related to the ability of an interchange to accomodate the traffic.

Since land use control is implied at interchange areas, an examination is made of legal means for achieving development control near interchanges. The chapter on legal basis considers the normal means of development control, eminent domain, licensing and police power with consideration given to special applications of these techniques. Particular emphasis is given to the use of design criteria for interchange area developments.

In order to determine if the factors and methods suggested in this thesis are practical, a study is made of the interchange at Lovell Road and Interstate 40 in Knox County, Tennessee. Ramp capacities determined by the Tennessee State Highway Department are analyzed in conjunction with the traffic generating potential of land uses in this area and some conclusions are drawn for the Lovell Road interchange area.

Before developing specific recommendations the limitations of this thesis are discussed with respect to the sparcity of data and the general nature of the research. Finally, recommendations are made for development policies which have general application although they specifically relate to Knox County, Tennessee.

Specific policies developed as a result of this study are:

1. That preconstruction planning of land use and zoning should be accomplished by cooperation between state and local governments.
2. In determining the feasibility of any proposed interchange use, the traffic generating capacity of that should be related to the excess capacity of the expressway and interchange.
3. The effect of any proposed use should be analyzed both in terms of the expressway system and of the surrounding land uses.
4. Appropriate design criteria should be established for each proposed interchange development to insure, as far as possible, protection of the expressway system.

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Wilford Thomas Crossman

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Wilford T. Crossman

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CHAPTER I

INTRODUCTION

Throughout history, urban growth has been guided and influenced by transportation routes. Early communities of the world were located where natural harbors provided shelter for the ships and access from the shipping lanes to the land and to overland routes. Initially, the overland routes were connecting links between seaports serving adjacent land areas. As land travel increased, settlements developed at the crossing of the more important routes. These crossroads served as service centers for caravans and pack trains, feeding stations, and points where goods could be interchanged between travelers going in different directions. Eventually, mechanical power replaced man and beast as the propelling force; and the crossroads which had developed as communities then became service points for the machines. In many cases, such as western towns of the United States, these service centers came into being mainly for the provision of supplies, repairs, and services for the machines and their cargoes. Many of these early American cities were, strictly speaking, service centers for the American railroads or were transfer points for goods from wagon trains to railroads. The advent of the automobile did not change the principal of growth related to transportation ways; it merely introduced a new mode of traffic way--the automotive highway.

Early automotive highways were nothing more than adopted existing wagon and carriage routes for the motor car. As the automobile developed in complexity and sophistication, the old dirt roads which had served the horse so well were no longer suitable for automotive traffic; and macadam black top, asphalt, and concrete highways evolved into the system that we know today.

In observing the strategic location of communities in the older part of the United States, small towns can be noted at intervals of approximately ten miles. Spacing is not an accident but came about because service centers grew up approximately half a day's journey from farm or home. It was believed that the average farmer could take his goods to a market within ten miles and return easily within a day. Likewise, in the older part of the United States political centers developed, substantially as a result of the transportation system. County seats were deemed to serve an area generally no more than twenty miles from the county seat; thus the general geographic areas of counties in the eastern part of the United States is, in most cases, less than twenty miles from the center of the county. In some instances, this political form becomes rather extreme. In counties such as Warren or Jackson County, Tennessee, the political boundaries take an almost circular form, with the County Seat lying in the center of approximately a fifteen-mile radius. In the far west, this pattern is not in evidence mostly because the development of the west was commensurate with the development of the railroad, and transportation between towns allowed the traveler to move far greater distances than the ten to twenty miles per day which seem to be the pattern in the older eastern section of the country. The type of farming also differed considerably. In the east, poultry, eggs, and produce were delivered to the market daily. In the west, grain farming and cattle ranching developed, and the produce or the product did not need to be delivered daily. Cattle could travel on their own feet, and herds were moved large distances from the ranch to the trade center; consequently, western towns did not develop so close to one another.

However, there are examples of patterns very similar to those in the east in the west or along the Pacific Coast where the California Mission Trail shows evidence of towns and communities having grown up around the early missions. These missions were walking or riding distances apart. Consequently, the communities along the Pacific Coast tend to follow the ten to twenty-mile pattern that can be seen in the eastern part of the United States. Not only were transportation systems a definite influence upon the development and location of communities throughout the world and in the United States, but also internal transportation systems within the communities exerted a very definite influence on the type and location of growth within an individual city.

Within communities, transportation routes have historically served as one of the primary influences on surrounding land uses. Central business areas frequently are related to railroads, rivers, port areas or other transfer points or centers of commerce; and while neighborhood commercial centers developed along trolley lines and later street car lines, the concentration of commercial facilities came into being at the end of these lines.[1]

The evolution of the highway as a traffic way for the automobile has developed through several stages. During the early development of the motor car, the road was considered a connecting link between communities or a road to serve the farmer in the form of a farm-to-market facility. Originally, in the United States, road systems became county functions and networks of county roads served the local communities and the farm areas. In time, the network of county roads became state highway systems; and many of the early state highways were an accumulation of connected county roads.

An early stage of highway building was the extension of these connecting links through the major urban centers which they served, thus providing some continuity of travel ways. In time, the major state highway systems--much as we know them today--came into being. The early United States highway system followed much the same pattern. Although this form of highway development did provide some continuity of travel ways from city to city, the inevitable result was a multiplicity of routes converging within an urban area. Up to this time, the function of a road as access to the land was perhaps as important as its function as a traffic way. Soon, however, the concept of a road designed to move traffic with limited access to adjacent land was tried experimentally.

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[1]George C. Fitch, Old Grand Rapids, (Published by the Author, 1927).

Although urban freeways have been known in the United States since the Bronx River Parkway was built in New York in 1923,[2] the nation's first limited access intercity highway or freeway was built by the Tennessee Valley Authority between Coal Creek (now Lake City), Tennessee, and the City of Knoxville. The road was originally built to provide a supply route to Norris Dam, the first of the Tennessee Valley Authority's dams. Today this road remains as a limited access roadway. The concept of limited access was expanded to include the concept of controlled access; and following World War II, highways of this type began to be developed. With the impetus of the Federal Aid Highway Act, providing 90 percent federal funds for interstate construction, the past fifteen years have seen highways being considered as an urban area system. Limited access facilities are provided between areas and integrated into an urban area system.

While the highway system is no means limited to expressways or freeways, it is this type of facility, and particularly, the interchange with the adjacent land area which is the concern of this report.

During the past decade, expressway facilities have been constructed at an unprecedented rate. The major portion of expressway mileage has been developed and is being constructed as interstate highway under federal

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[2] Carlton C. Robinson, "Freeways in the Urban Setting" Traffic Quarterly, (Volume XVII, Number 3, New York: Columbia University Press, 1963), p. 432.

assistance to states authorized by The Federal Aid Highway Act of 1956. However, significant expressway systems have been developed by states, independent of the Federal Interstate system. These systems are both freeways, such as the Los Angeles and Southern California system and U. S. 23 from the Ohio State line to Flint, Michigan; and tollways, such as the Pennsylvania Turnpike, the New York Throughway, and the New Jersey Turnpike. Although many tollways now carry interstate designations, they were not built as part of the federally aided system.

As expressways are constructed, either free or toll, they provide a means of moving high volumes of traffic significant distances at relatively high speeds. Since access to expressways is limited or controlled, there are only a few selected points where expressways serve adjoining land. These points are interchanges. Increased accessibility to the land in the vicinity of interchanges results in increased demand for development of land in these areas. In a paper prepared for presentation to the 63rd National Conference on Government of The National Municipal League, John Howard accurately forecast some of the problems and effects of the interstate system. Mr. Howard pointed out that the freeway system will have great impact upon community growth--"upon how and where" it will happen.

> This impact will result from the drastic change in the relative accessibility of different land areas which the new highways will cause--shifts of the kind that we have always observed when the transportation patterns change. . . . What is significant is that

> the design of the interregional highway system was an act of national planning of great influence on future national patterns of urban growth. . . .[3]

Whether it was intended or not, the Federal Government established a policy for guiding future development patterns at the time it developed the program for the interstate system. The development patterns will substantially be guided by the location of these interchange areas. In general, interchanges occur with greater frequency in the suburban fringe of a highly developed urban area. This affords the population the opportunity to disperse while still being served by the central city functions.

The pressure to allow an intensification of the use of interchange area land is great. Realtors, developers, and property owners are constantly seeking new uses which will yield them a higher return from this land. Public officials are strongly influenced by the prospect of adding to the local tax base, while, on the other hand, highway officials and transportation experts decry the eroding of the function of high capacity expressways to move large traffic volumes..

The dichotomy of the intended function of express highways and the desire for intense development at expressway interchanges create the major planning problems with which this report is concerned. The demand for land

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[3]John T. Howard, "Community Growth--Impact of the Federal Highway Program" (paper presented at 63rd National Conference on Government, Cleveland, Ohio, November 20, 1957).

development at interchanges is great enough and the local governing bodies' desire for "progress" (i.e., nearly any type of tax-producing development) is strong enough to insure that development will occur. It is the intent of this report to determine policies for development which will allow growth at interchange areas which is compatible with the intent of the expressway system. Where compatibility is not to be expected, we hope to, at least, reduce the conflict between high speed, high volume traffic movement, and intense use of land.

CHAPTER II

METHODOLOGY

The overall methodology involved in the preparation of this study consisted of gathering statistical data from various highway departments and planning agencies; compiling and analyzing bibliographic data in regard to traffic control and legal factors; conducting field research required to make specific application of development procedures which have been determined as a result of the study; and finally, preparing recommendations for design criteria at interchanges in general.

After the brief introduction presented in Chapter I, which was developed through a review of the history of transportation systems and, in particular, limited access highways, this report is concerned with relationship between interchanges and the surrounding land area. In order to better understand the economic influence of an interchange or expressway facility through a land area and to also understand the pattern of change in land use and land values, this pattern was examined in considerable detail. Several agencies have studied land value changes in their respective areas. These so called impact studies tend to give a partial picture of trends in any given community. This study was designed to examine the economic impact of expressways and interchanges on a broader basis. Land values, prior to the construction of an expressway or interchange facilities and after the development of these facilities, were tabulated and analyzed. It also was intended to examine the change in land use before and after the construction of an expressway or interchange facility. Each of the several state highway departments and many planning agencies throughout the United States were contacted in order to examine changes in use and value on as broad a basis as possible. Information pertaining to impact studies and change in land use along freeways and adjacent to interchanges was requested. The cooperation of many agencies is greatly appreciated. It is believed that a significant accumulation of information has been obtained and that the summaries determined by compiling the statistics on a broader basis have considerably more validity than any individual accumulation of information by an individual agency. It was found that few planning agencies had a significant enough volume of data so that conclusions could be drawn from any single area. Some difficulty was encountered in establishing a basis upon which land of widely fluctuating values in various areas of the United States could be examined. In order to establish such a basis, the varying sets of values and data were plotted on a normal curve both before and after the development of the interchange, and comparison was not made between individual parcels of values of land but between patterns of the curve before and after the development of an expressway facility.

Upon corresponding with the highway departments and many planning agencies in all fifty states, we received responses from thirty-eight states. Many of the responses indicated, however, that no data was available; and that their agencies had not entered into a program of examining interchange areas. However, significant data were received from Ohio, Michigan, Oregon, Washington, Colorado, Tennessee, Utah, Oklahoma, and Pennsylvania. The original number of cases examined for the study was 7,128. It was decided that the land should be classified according to whether it was related directly to an interchange or whether it was land falling along an expressway between interchanges. Further, it was decided to classify the land as to its relative extent of urbanization. Each parcel in the study was therefore categorized as either an interchange or non-interchange parcel. Furthermore, each parcel was determined to be rural, suburban, or urban in land development pattern. In this regard, rural land was determined to be that land falling between major urban centers in open countryside which was predominantly agricultural or undeveloped. The land which was classified as suburban was the rapidly developing areas immediately adjacent to central cities. The urban category was reserved for those interchanges being developed in presently existing metropolitan areas or cities. In examining the information furnished by the several highway departments, considerable difficulty was encountered when it was attempted to classify each of these 7,000 plus parcels into one of these predetermined categories. Not all of the impact study information was clearly defined so that each parcel could be classified as rural, suburban, or urban. Fortunately, however, the majority of these studies provided maps showing the location of the parcel and its relationship to its community. Even so, it is believed that the categorization of land into these general classifications is subjective at best and is merely a means to develop some reasonable system of analyzing parcels that are in some way comparable. It is certainly not believed that all of the classifications are accurate or valid; however, it is believed that this system is the best simplified approach to analyzing parcels of land scattered widely in different parts of the country and having varying uses and intensity of development. Perhaps if a more sophisticated method of classifying the parcels had been developed at the beginning of this study, the tremendous variation in range of the graphs finally developed would have been somewhat lessened.

As was expected, many of the analyses submitted by the several agencies did not specifically lend themselves to categorizing as was deemed necessary for this study; and because of the eventual inability to arrive at a comparative statistic, several of the pieces of information were eliminated from the study. Further refinement of the raw data showed that a considerable portion of the information necessary for analysis was lacking in some other element. For example, data may have been provided upon the nature of a parcel to be taken for an interchange area, but no data were available for information on the resale at a later date. It was further necessary to place each of the parcels within a unit framework, so that a 120-acre parcel would not be rated with a parcel of a half acre. Because of this, it was decided that the examination would be on a per acre basis. The final breakdown of land categories showed

13,654 acres of non-interchange land and 7,757 acres of land at interchange areas. The vast majority of the non-interchange land, or 12,884 acres, was undeveloped, or rural farm land. Only 748 acres were suburban land, and 22 acres were classified urban. Of the parcels developed in the vicinity of interchanges, 5,460 acres were at rural interchanges; 1,043 acres were at suburban interchanges; and 254 acres were in highly developed urban areas. All of these parcels were then tabulated on a basis of value per acre, use and change in value per acre, and change in use. Each set of figures was analyzed statistically to determine the form of curve that each would take and the change in the form of curve between data for values before and after expressway construction for each of the three categories.

In addition to these statistical analyses of change in land values, the examination of change in land use at interchange areas was considered. In nearly every case where the impact study gives information sufficient for use in the statistical analysis of change in land value, the study indicated the purpose of the sale of the parcel of land. Consequently, it was possible to develop an analysis of the change in land use from the original use before the construction of the expressway or interchange and the use of the parcel of land after the construction of this facility. Furthermore, several of the state agencies provided aerial photographs supporting or documenting the information provided in their impact studies. In many cases, these photographs covered an area considerably larger than that required for the study itself and, therefore, afforded the possibility of examining the change in land use in specific detail for parcels immediately adjacent to the interchange and the general development patterns for areas small distances away from the interchange. Samples of these photographs are included in the appendix to this report.

The remaining chapters of this study involve what is substantially bibliographic research. The material presented in Chapter V, Traffic Factors at Interchanges, is determined from reports and articles of several writers who have placed considerable effort in the study of traffic capacities on highways and on interchange ramps as well as several who have examined the traffic generating capacities of various categories of land use. In addition, personal interviews with representatives of the Tennessee State Highway Department and the Traffic Engineer for the City of Knoxville, as well as members of the planning staff of Barton, Ashman, & Associates of Evanston, Illinois, have helped develop information for the section on traffic factors.

The chapter on Legal Basis For Development Control at Interchanges is also substantially a chapter based upon bibliographic research. The review of material of several writers who have concerned themselves with methods for land acquisition and land use controls at areas adjacent to expressways and interchanges has provided the basis for this chapter. The basic reference material for both the section on traffic factors and the section on legal basis is in ample evidence in the footnotes.

Finally, before arriving at recommendations and conclusions which have general application but are specifically intended to apply to Knoxville and Knox County, it was decided that the concepts involved in developing the report to this point should be tested on a specific interchange in the Knox County area. The interchange selected was at Interstate 40 and Lovell Road. This selection was made because the interchange was a reasonable distance from the center of the city and could be considered suburban land inasmuch as it is a rapidly developing area of the county. Furthermore, the land surrounding the interchange was substantially level, at least as far as land in Knox County is concerned, and was also generally suitable for individual sewage treatment facilities on individual lots. In other words, the land surrounding this interchange was generally developable from the standpoint of geological and topographic conditions. Further consideration was given to selecting the Lovell Road interchange for application of study because a considerable portion of the area has been selected for industrial development but is not yet being developed. Therefore, it is possible to state specifically that some quarters of the interchange are to be developed for an industry which intends to employ a given number of people, but the effect of this industry has not yet taken place. Consequently, it is impossible to analyze the interchange in relationship to the potential effectiveness industry will have on the interstate facility and to determine whether or not this is a logical location for such a facility. The other three quadrants of land have been zoned for various uses, although the actual development pattern at the Lovell Road interchange has not yet begun to emerge. As already noted, considerations were given, in studying this interchange, to the geology of the soils, the topography of the area, the zoning trends, the development patterns, the capacity of the interstate, the interchange ramps, and the traffic generating potential of the proposed land uses in the area. The type of analysis which is given to the Lovell Road interchange is proposed as a method for analyzing interchange developments in general so that planning staffs may make reasonable recommendations for future land uses at such a facility.

The final chapter of this report is a section on recommendations and conclusions. The information gathered in the statistical analysis of land values and land use changes, together with the research material provided for traffic analysis and legal controls and the considerations of the methods for applying land use recommendations for a specific interchange, are drawn together in this chapter. This chapter considers both the traffic conditions at the interchange and the legal basis for control of interchange areas. Recommendations are made for design criteria which can better enable the planner to help proposed uses become more compatible with the expressway and the interchange system so that the potential for land development in each area may thus be achieved with the minimum adverse influence to the traffic capacity of the expressway, its interchange, and the crossroads which service it. This chapter also considers various specific uses which tend to locate near freeway interchanges and seeks to establish sets of recommendations for the development of these uses so that they may be more compatible with the expressway facility and interchange ramps. At the same time, standards for development of the areas are suggested so that landlocked parcels will be avoided by establishing adequate design criteria for the development of any land mass adjacent to an expressway interchange.

Supporting data for the interchange area development policy study is provided in the appendix. Six statistical tables for land value analysis provide a complete set of data for before and after values for rural, suburban, and urban land illustrating the pattern of change in value before and after the construction of interchange facilities. Photographic illustrations are provided by means of aerial photographs as examples of change in land use at several selected interchanges before and after interchange construction. A diagrammatic example of design criteria for interchange areas is provided. An annotated bibliography, showing reference material utilized for the development of this report, is also furnished.

CHAPTER III

ANALYSIS OF ECONOMIC CHANGE IN LAND VALUES

The following analysis indicates results of statistical comparisons of land values determined before the construction of an expressway and values for the construction of an expressway and values for the same parcels after such construction. This analysis is concerned not only with land served by an interchange but also with land adjacent to an expressway but not served by an interchange. Detailed statistical sheets are presented in the appendix for the data represented by the change in value curves presented in this chapter.

I. RURAL NON-INTERCHANGE LAND

As was previously mentioned, "interchange" and "non-interchange" lands were broken down into rural, suburban, and urban categories. The first analysis is that of rural non-interchange land. The examination of these parcels indicated that for the total of 12,884 acres of land, the average value per acre of land prior to the development of a freeway facility was $331.52. Although only 7,547 acres had been resold at the time the impact studies data were tabulated, it was indicated that the average sale price per acre after the development of the interstate facility was $448.64--an increase of $117.12 per acre or 35 percent per acre. It should be noted that one state, the State of

Colorado, had run a control on similar lands which were resold during the same period as that land adjoining the freeway system. The land sold adjoining freeway land was valued at two to two and one-quarter times the price of the control land in the same general area. Unfortunately, such controls were not run with any regularity by other states and significance of this data is limited to a particular area in Colorado where these controls were run.

II. SUBURBAN LAND NOT ADJACENT TO INTERCHANGES

Of the land studied in suburban areas which were not immediately adjacent to interchanges, 748 acres were examined. Of the 748 acres examined, 558 acres were resold after the development of freeway or interstate facilities. The original average value per acre of the suburban area land was $5,561. After the development of the interstate facilities, the average price per acre at which these parcels were sold was $7,987. In the case of suburban land, some random control samples were established by several of the states. The average price per acre of these control samples was $7,806, which is only slightly less than the average price per acre of the entire sample which had been resold. Caution should be exercised in evaluating these samples against the control, inasmuch as this is not a figure which is representative of samples from all states, nor in this case are the controls assured to be land of a strictly comparable nature.

III. URBAN NON-INTERCHANGE LAND VALUES

The third category of land which was studied, that was not directly related to interchange development but was involved in a sale after a freeway facility had been built adjacent to the parcel of land in question, was the area of highly developed urban land. In this case, only 10.3 acres were represented; and the significance of the results are considerably less than for the previous categories. Of the 10.3 acres considered, 9.6 of these acres were resold after the development of an interstate facility. The original average value per acre of urban land not adjacent to interchanges was $29,676. After the development of the freeway facility, 9.6 acres were resold at an average value of $18,278 per acre. Although the sample is small and probably not significant, there is an indication that the tendency to sever the developed urban land from its normal street access or the tendency to provide an expressway facility through a residential area has a depreciating effect upon the development of land, where direct access to the freeway facility is not offered.

It would appear that the claims that a freeway facility depreciates land values, in general, is not true, even though access is denied the parcel of land in question. Both rural facilities and suburban facilities tend to increase the land values along the routes. This is not to imply that a specific use may not decrease in value; for example, a parcel of land adjacent to a freeway facility which is in residential use may not have a continuing value as a residential parcel; however, the actual land value itself would be increased when resale was considered, inasmuch as the potential resale for the land will in all probability be for a change in use.

IV. LAND VALUES AT AREAS DIRECTLY SERVED BY INTERCHANGES

Since the main body of this report is concerned with the planning of land uses around the vicinity of interchanges, a more detailed analysis of change in land values for those parcels directly served by interchange facilities has been undertaken. In determining the shift in land values for these parcels, a direct comparison was desired. In order to make this comparison, only those parcels which were actually sold and had a true before and after land value were used for the analysis. Again the parcels were placed in three categories; rural interchange areas, suburban interchange areas, and urban interchange areas. In each of these three categories a statistical analysis was provided which determined the means, medians, deviations, and measure skewness of the curves which the plotting of land values against frequency of acreage sold would determine. In all three categories a decided similarity of pattern was evident. The graphs following indicate the pattern of land value changes in each of the three categories. The statistical information from which these rounded graphs were plotted is illustrated in the appendix. In examining the frequency data sheets in the appendix, it could be noted that the total acres of land under consideration before the interchange construction and the total acreage after are not always identical. This resulting minor variation in figures comes about from the elimination of the top and bottom approximately 2 percent of the frequency distribution. This was done in order to eliminate extreme values which were not significant in the total calculations. Occasionally, a parcel of land which was originally in the bottom 2 or 3 percent may appear in the main body of the frequency after the interchange construction and subsequent sale of land or, conversely, a parcel of land which was originally in the main body of the frequency could ultimately have fallen in the 2 or 3 percent which was deleted at the top end.

V. RURAL LAND VALUES AT INTERCHANGE AREAS

Approximately 2,062 acres of land were sold at rural interchanges from the samples which were examined for this study. Of these 2,000 plus acres, the original value before interchange construction averaged $303 per acre. The land sold for as little as $70 per acre and as much as $1,000 per acre. The median value was $286.51 per acre, and the standard deviation from the mean was 140.7. Calculations for this sector of the sample indicated that the rural land values, before interchange construction, would be plotted in a skewed curve with a positive skew of .31. After the construction of the interchange and the subsequent sale of many parcels of land, the 2,062 acres have shown a significant increase in average value to $762.86 per acre. The median value also increased to $419 per acre with the standard deviation from the mean increasing to 1,038. This tends to indicate a considerably wider spread in values than was evident before the construction of the interchange. This fact is borne out by the sale price range of $70 per acre to a new high of approximately $8,000 per acre. The general shape of the distribution curve remained reasonably the same, and the curve continued to have a positive skew although the measure of skewness increased to 1.014.

VI. SUBURBAN LAND VALUES

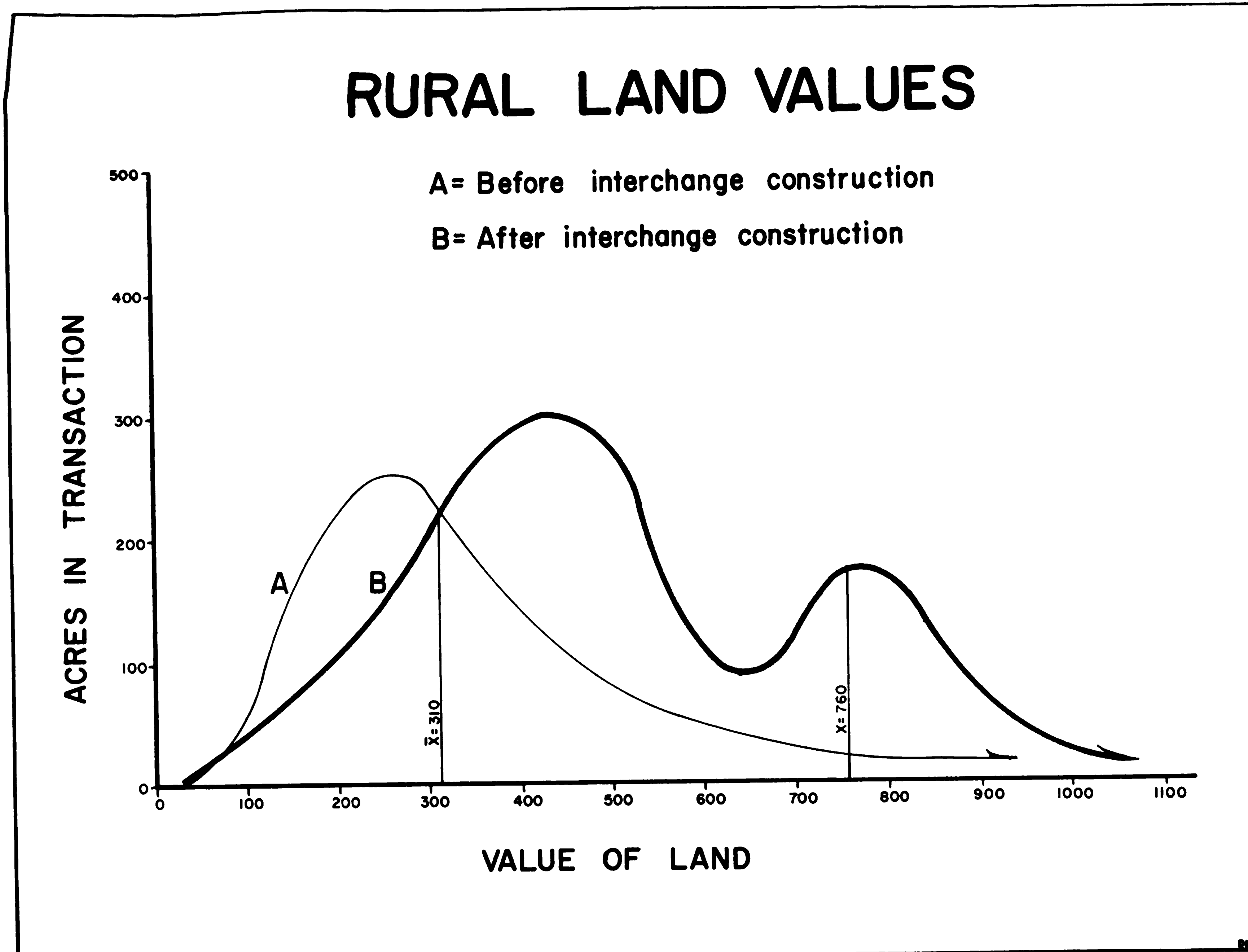
In a similar analysis, parcels of land at interchanges in suburban areas were examined. Of the samples analyzed for this study, 595.3 acres were involved in a transaction subsequent to the construction of an interchange in the suburban area. Of this acreage, the mean value of land before the interchange was constructed was $1,200 an acre; the median value $1,422 an acre. The frequency distribution showed standard deviation from the mean of 1.084, and this frequency strangely showed a negative skew when calculations were made. However, in plotting the frequency distribution it was determined that this data actually fell in a bimodal distribution, with a secondary peak falling to the left of the primary peak; and the shape of the primary distribution curve fell along the same pattern as other curves which had a positive or right hand skew. After the construction of interchanges in suburban areas, the 595.3

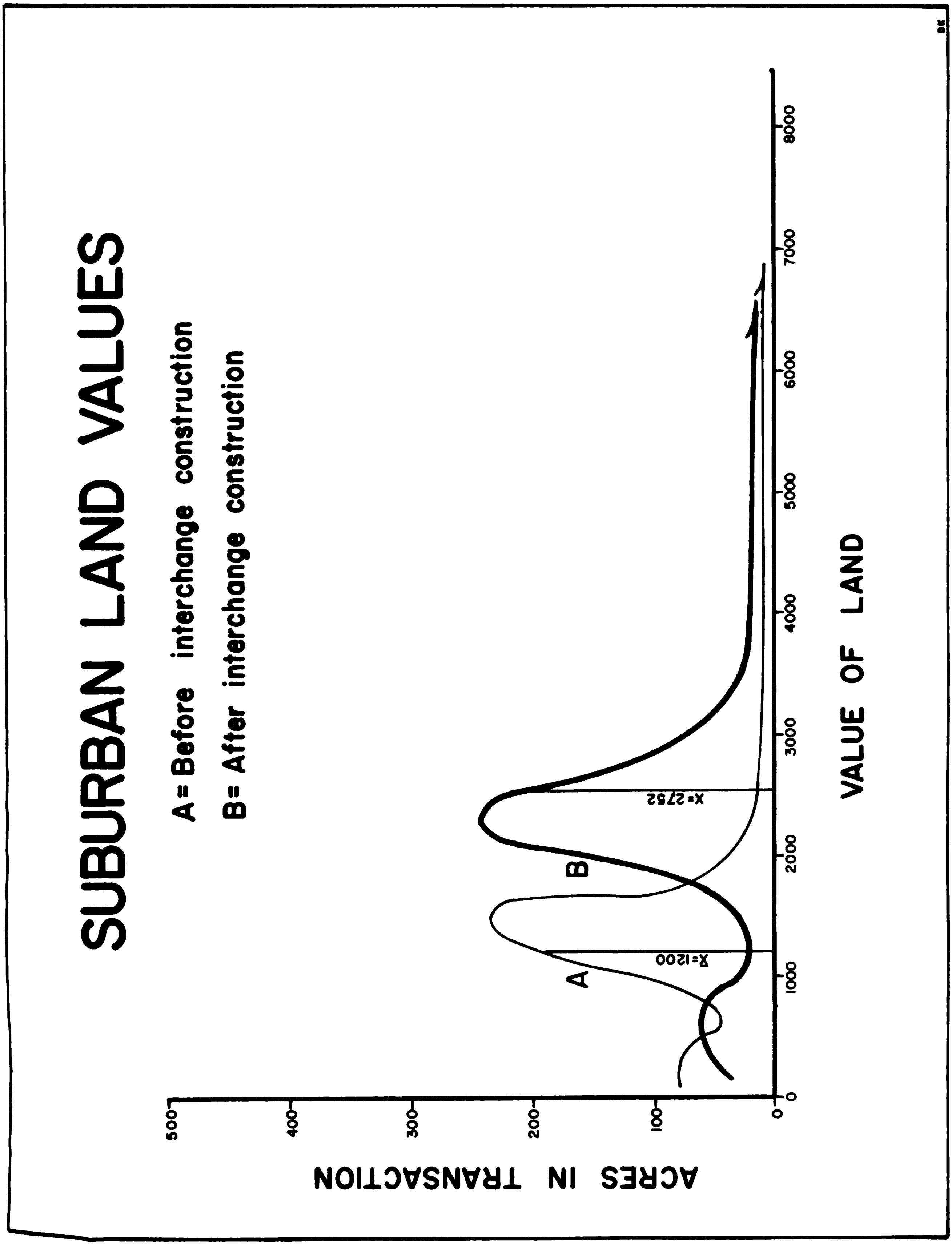
acres of land which were involved in subsequent sales increased in average value to $2,753 per acre. The median also increased to $2,157 per acre. The curve shifted from a negative skew to a positive skew of .43, and the standard deviation increased to $4,146 per acre, again indicating a considerably wider spread in values than was evident before the interchange was constructed. Again, this information was substantiated by the fact that the range of land values before interstate construction was from $100 to $9,000 an acre and after interchange construction from approximately $250 to approximately $37,000 an acre.

VII. URBAN LAND

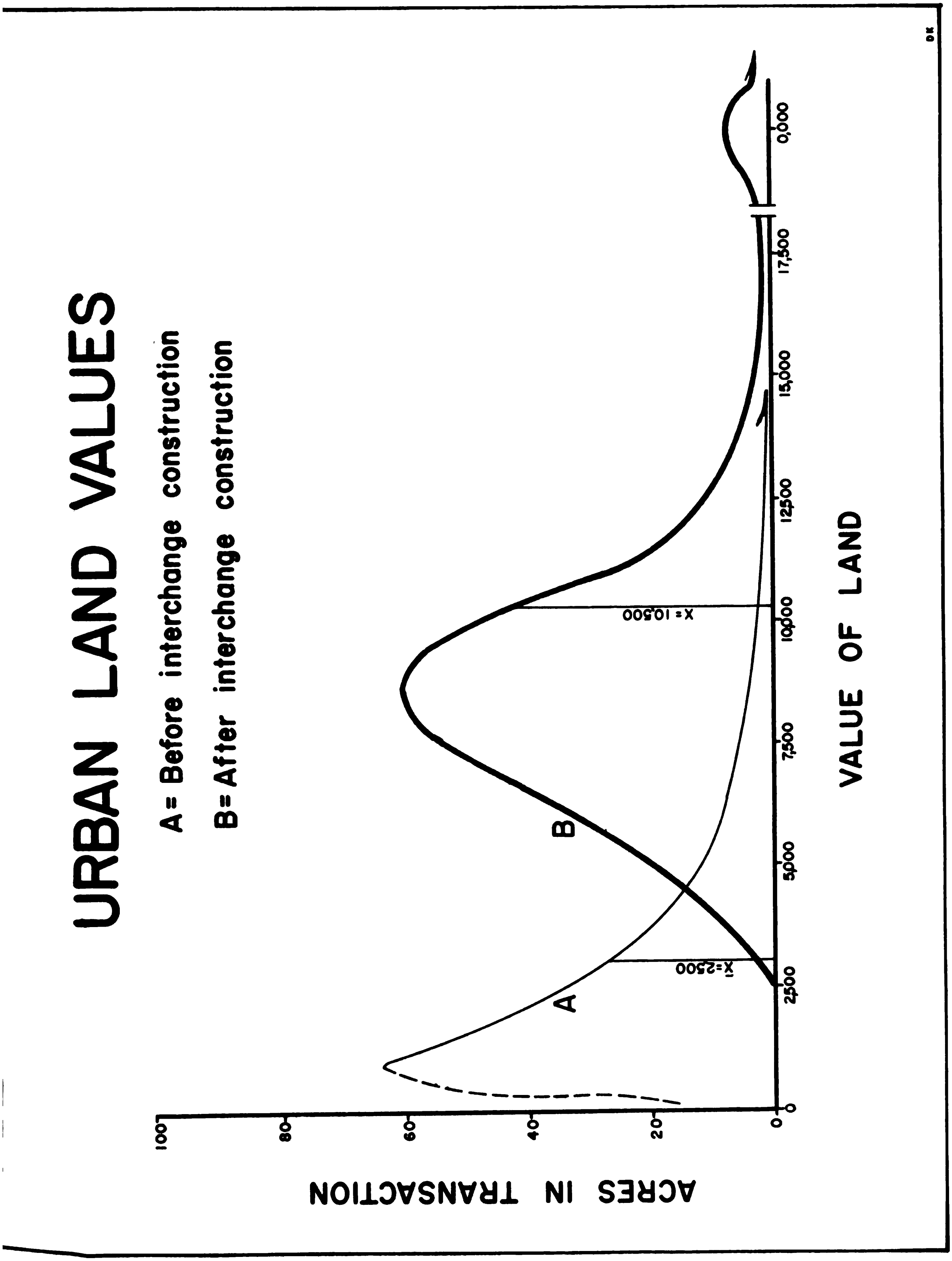
Inasmuch as considerably fewer parcels of urban land were sold, the value of the analysis of urban land is probably less significant than the rural and suburban analysis. The number of acres involved in this study was only 116.4. However, it could be noted that the urban land showed a similar, if not more extreme, pattern than either rural or suburban areas. The average per acre land value prior to the construction of interchange was $2,556. This increased to $10,436 per acre after the interchange construction. The medians showed a similar shift ranging from $906 per acre before interchange construction to $7,293 per acre after interchange construction. Again the standard deviations also increased from $4,551 per acre to $11,252 per acre. These increases in standard deviation would also tend to indicate a considerable increase in the range of sale values. The actual evidence indicated in the frequency charts substantiates this, inasmuch as the values range from $906 per acre to $43,750 per acre before the interchange was constructed; and they ranged from $3,329 per acre to $93,750 per acre after the interchange was constructed. Both the curve for land values before and the curve for similar values after showed a positive skew indicating that the general pattern of the two graphs would be the same. The graphs following illustrate these factors clearly.

The graphs for before and after rural interchange construction indicate the general frequency distribution falls in a similar pattern of non-normal frequency with a severe right-hand skew. The after values tend to be similar in shape to the before values with a shift of the entire curve upward toward higher mean and median values and spreading out over a considerably greater range, thus providing a larger standard deviation. As previously noted, the curve for suburban land values showed a negative skew when calculations were made by routine statistical means. However, examination of the curve shows a slight bimodal tendency which would tend to weigh the values at normally the left-hand side of the curve and, consequently, give a false indication of a negative skewness to this curve. The general shapes of before and after value curves for the suburban areas are extremely similar in patterns; perhaps, being more alike than any pair of curves examined. Again, the pattern is that


RURAL LAND VALUES
A= Before interchange construction
B= After interchange construction
ACRES IN TRANSACTION
500
400
300
200
100
0
A
B
X̄=310
X=760
0
100
200
300
400
500
600
700
800
900
1000
1100
VALUE OF LAND


SUBURBAN LAND VALUES
A = Before interchange construction
B = After interchange construction
ACRES IN TRANSACTION
VALUE OF LAND
0
100
200
300
400
500
1000
2000
3000
4000
5000
6000
7000
8000
A
B
X̄=1200
X̄=2752

RBAN LAND VALUES


URBAN LAND VALUES
A = Before interchange construction
B = After interchange construction
ACRES IN TRANSACTION
VALUE OF LAND
0
20
40
60
80
100
2,500
5,000
7,500
10,000
12,500
15,000
17,500
A
B
X̄=2500
X̄ = 10,500

of a shift of a curve up the value scale so that a higher mean and median are indicated on the same basic form. The final pair of curves--that for the urban area--tend to be less significant, due to a sparsity of data. Although here, too, there is an extremely right-hand skewed curve, the after values also have evidence of a slight tendency toward a bimodal point at the extreme right-hand limits of the curve in the higher value ranges. This will tend to give the after value curve an abnormally high standard deviation and a mean which falls at a point far to the right of the center of the main body of the curve. Examination of the before value curve would indicate that we have a hyperbolic function rather than a normal distribution curve, with the highest number of values being those sold at the lowest price. This can partially be explained by the sparsity of data for these frequencies and by the assumption that if more information were available the curve would have taken a more normal distribution form and some values would have appeared lower than the $906 per acre shown as the lower limit of the frequency range or urban land values. This extension of the curve is indicated by the dotted line on the graph.

Inasmuch as it was part of the purpose of this study to determine the relationship between land values before the construction of the interchange and those after the construction, it is believed that the data herein assembled and presented is significant and clearly indicates the fact that interchange construction has a substantial and significant effect upon the value of adjacent land. In all cases--rural, urban, and suburban--the sales of parcels after the development of interchanges showed a substantial increase in value to those values shown for the very same parcels prior to the construction of the interchange. This increase in value then can be attributed to the increase in accessibility provided to the land in this vicinity by the fact that the interchange to the highway system has been constructed in this locality. It stands to reason that a parcel of land which is continued in a given land use will not experience any significant change in value to the owner. In most cases the added value occurs because the parcel has been sold, and that sale, in all probability, is so that the land may be used for a more intensive type of use. For example, much of the rural land served by the freeway system and served by these interchanges was originally in farming, agricultural, or open type uses. With the service provided to that area by an interchange, these uses may have changed to motels, service stations, or highly valuable commercial uses. Several of these may have shifted from an open usage to a residential usage in the form of subdivisions. The next section of this report examines in some detail this change in land use between the areas before an interchange was constructed and after the construction.

Data for this chapter was acquired from:

[1]Land Economic Studies, Department of Highways, State of Colorado, (Cases 22, 29-84, and 94).

[2]"Interchange Study," Land Economic Studies, State Roads Commission, State of Maryland, (Nos. 1-4).

[3]Three Economic Impact Studies On a Portion of the Baltimore Beltway, State Roads Commission, State of Maryland, pp. 1-20.

[4]Land Economic Study, Right-of-Way Division, Department of Highways, Washington State Highway Commission, (Nos. 1-76).

[5]Land Economic Survey, Right-of-Way Division, Oregon State Highway Department, (Case Studies 1-5 and 30-35).

[6]"Impact of Freeway Construction on Affected Properties" and "Woodburn Retirement Center and Shopping Center," Land Economic Survey, Remainder Parcel Study, Legal Division, Oregon State Highway Department, (Cases 1-24).

[7]"Report of Land Economic Studies in the State of Ohio, The Western Half of the Ohio Turnpike, Research Project HPS-1 (31)," Case History Supplement, Appraisal Bureau, Division of Right-of-Way, Ohio Department of Highways, November, 1962.

[8]Report of Land Economic Studies in the State of Ohio, The North-South Freeway IR-71, Research Project HPS-1 (33), Appraisal Bureau, Division of Right-of-Way, Ohio Department of Highways, September, 1964.

[9]Economic Impact Effect of Interstate Highway 35 on Guthrie, Planning Division, Oklahoma State Highway Department, pp. 1-60.

[10]"Grade Change and Proximity Effects," (Nos. 1, 2, 5, and 6); "Benefits Arising from a Change of Highest and Best Use at an Interchange," (No. 8); "Interchange Benefit to Potential Commercial Land," (No. 9); "Change of Highest and Best Use at a Rural Interchange," (Nos. 10 and 11); "Freeway Oriented Commercial Development at Gaylords' Two Interchanges," (No. 12); "Freeway Oriented Commercial Development Supersedes Scattered Strip Commercial Use," (No. 13); "Interchange Development Along 180 Miles of I-94," (No. 14); Land Economic Study, Right-of-Way Division, Michigan State Highway Department, October, 1964.

[11]T. H. Bovard, Economic Impact of Freeways, (Presented at the Ninth Annual Ohio Engineering Conference, The Ohio State University, Columbus, Ohio), April 8, 1965.

CHAPTER IV

CHANGES IN LAND USE AT INTERCHANGE AREAS

The examination of changes in land use at interchange areas is approached in two manners. First of all the statistical analysis provided by information furnished from the several states' reports indicates a change in number of acres from one use to another.[1] Secondly, a number of agencies contacted in the original phases of the study were cooperative enough to furnish this agency with aerial photographs of areas surrounding interchanges, both before and after the construction of the facility. It should be noted that the statistical information derived from the impact studies provided by the several state highway departments, in actuality, considered only parcels of land, a part of which had been taken for the actual construction of the interstate facility. As a result, these parcels are immediately adjacent to the interchange and, in many cases, involve very small acreage. On the other hand, the aerial photographs attempt to cover a considerably larger area surrounding the interchange, and changes in land use become evident where no actual involvement in interstate purchase transaction is considered. Generally the economic studies showed land changes occurred in a three to five year period after interchange construction although not all studies indicated a time period.

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[1]Footnotes to Chapter III, loc. cit.

I. RURAL LAND

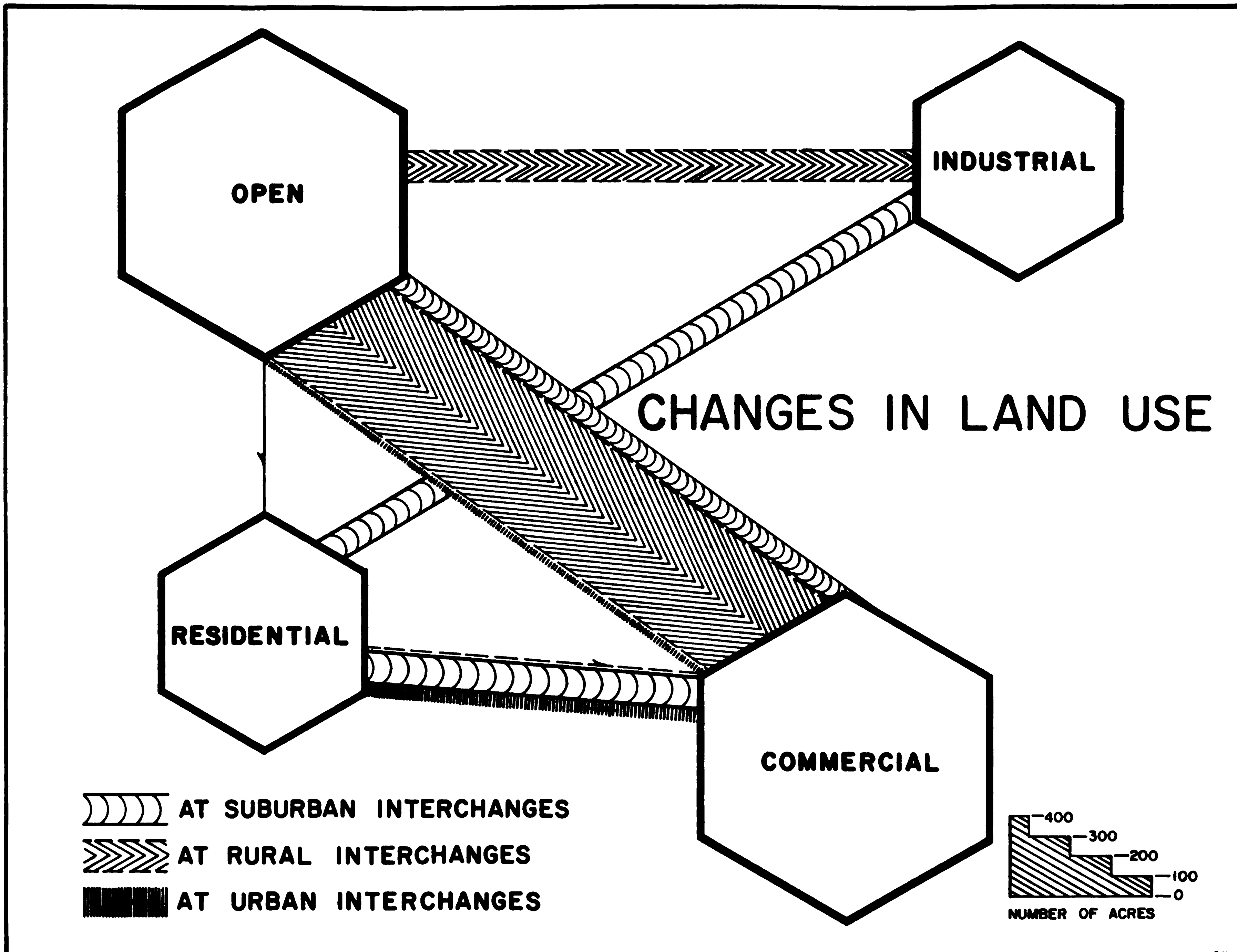
In examining the land area involved in a change in land use before and after the construction of an interchange, it was found that 144 acres changed from open or agricultural use to industrial use; 626 acres changed from an open or agricultural use to a commercial use; while only 4.5 acres changed from an open use to a residential use. At the same time, an additional 4.5 acres which were originally in residential land usage changed to a commercial use. In examining the aerial photographs, it would appear that the predominant change is from an open, agricultural, or undeveloped type use to that of residential subdivisions. The apparent reason that this type of change does not make itself apparent in the statistical examination is that these subdivisions are developed a relatively short distance from the immediate proximity of the interchange and, consequently, do not involve parcels, a part of which were taken for construction of the interchange facility. It appears then that those parcels where a taking is actually involved are, of course, the parcels immediately adjacent to the interchange; and consequently, the highest demand for these parcels appears to be for commercial land uses. It is interesting to note that while it would seem that the change from an open or undeveloped use to a commercial use would create the highest price differential or land value differential, this did not appear to be the case. Of parcels that changed from an open use to a commercial use, the average original value was $288 per acre, while the average value after construction of the interchange or after the change in use was $2,985. At the same time, land which changed from an open or agricultural use to an industrial use, the average original value was $304 per acre; while the average value after construction of the interchange or after the change in use was $7,617 per acre. On the other hand, the extremes in change were certainly far greater to individual transactions involved in commercial usage. For example, one 1.25-acre parcel originally had a value of $195 per acre and when changed to a commercial use had a value of $90,000 per acre. This extreme is, of course, counterbalanced by several parcels similar to a 15.5-acres parcel originally valued at $300 per acre which had a final value of only $1,000 per acre.

II. SUBURBAN LAND

An analysis of suburban areas which have undergone a change in use as a result of the development of an interchange facility indicates a pattern similar to that evidenced in the rural areas. Of the parcels examined, 103 acres of land in the vicinity of interchanges proposed to be constructed were originally open or agricultural use which ultimately changed to commercial use. Unlike the rural area studied, the suburban area was found to be predominantly residential in use; and the majority of change was from residential to industrial and from residential to commercial. It is also interesting to note that while 36 percent of the parcels involved in transactions of rural land changed use from their original function to some new function, 88 percent of all the transactions of suburban land underwent a change of use. Because of this, it was believed to be unnecessary to recalculate means for specific use areas. It was assumed that 84 percent of the original sample of 600.3 acres would substantially have the same mean values as the entire sample. In other words, the value of the land before the change in use averaged $1,200 per acre; and the value of the land after the change in use averaged $2,750 per acre.

III. URBAN LAND

In highly developed urban areas a phenomenon which might be expected was observed. The change in land use of parcels before and after the construction of interchange facilities, in every case, resulted in the parcel of land involved finally becoming a commercial parcel. This does not imply that all parcels of urban land changed to commercial use, inasmuch as several were originally commercial. Of the 116.4 acres of urban land, 25.9 acres of open or undeveloped land at the area of a freeway interchange changed from this open use to a commercial use; and 73.7 acres changed from residential development to commercial development. The original average price of the open land was $2,621 per acre, and the original average price of the residential land was $2,250 per acre. The final average value of commercial land in urban areas was $10,435 per acre. The following flow diagram indicates the relative shift in land use patterns after the construction of an interstate facility, particularly an interchange facility.


CHANGES IN LAND USE
OPEN
INDUSTRIAL
RESIDENTIAL
COMMERCIAL
AT SUBURBAN INTERCHANGES
AT RURAL INTERCHANGES
AT URBAN INTERCHANGES
400
300
200
100
0
NUMBER OF ACRES

Although the data available for the urban area interchange development was somewhat limited and could not deemed to be significant, it should be noted that all of the parcels of land involved in transactions at interchanges in the urban areas finally became commercial parcels. In fact, the predominant trend in changes in land use at interchange areas appears to be to commercial usage. The rural areas changed from predominantly open or agricultural land to industrial, commercial, and residential; however, 81 percent of the total shifted to a commercial category. In suburban areas, the trend was not quite so pronounced inasmuch as only 51 percent of the total change was to commercial uses. The urban area shift was 100 percent ultimate use for commercial purposes.

CHAPTER V

TRAFFIC FACTORS AT INTERCHANGES

In this chapter, it was intended to examine design criteria and traffic generation information in depth, which would have been provided by the State Highway Department and the local Traffic Engineer. However, specific data of this sort has not been made available for this report; and the specific nature of the data which was hoped to be examined will have to be presented in a more generalized form. It has been noted in previous chapters that the development of an interchange facility places a high demand on the adjacent land for a more intensive use than existed in the area prior to the construction of the interchange. The very fact that this increased demand has been created, or the fact that the nature of the land use changes, implies that the traffic generation potential of the parcels of land adjacent to the interchange increases significantly merely as a result of the provision of the interchange. The concern of highway designers and traffic engineers is that this increase in traffic generation potential of the adjacent land will, in and of itself, increase the volume of traffic flowing along the freeway facility and increase the volume of traffic which desires to enter or exit at any given interchange. The ultimate consequence is that the increased demand and the increased volume of traffic then serves to restrict the total volume of traffic which may continue uninterrupted upon the freeway sector. In other words, the provision of an interchange and the subsequent demand for a more intensive land use in the vicinity of the interchange has a tendency to destroy the function for which the freeway and the interchange are designed. In examining the effect upon the freeway system and the capacity of the freeway to continue its intended use, it is also necessary to consider the effect upon the currently existing access routes which, many times, are not improved when the freeway facility is built. Concern of this nature is outlined in a report prepared by the State of North Carolina which points out the problems created by the industrialization of rural North Carolina wherein increasing industrial employment of rural dwellers and the general rise in vehicle ownership have brought new functions and added new traffic to rural secondary roads.[1] In examining the problem of the efficiency of highways and how this efficiency is affected by the growth around interchange areas, J. C. Fry, H. K. Dansereau, R. D. Pashek, and A. Twark have presented a highly technical study which presents a significant approach to the question of whether new highways can be protected by regulating the use of land at interchanges.[2]

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[1]J. W. Horn, "The Impact of Industrial Development on Traffic Generation in Rural Areas of North Carolina," Highway Research Board, Bulletin 347 (Wahington: National Research Council, 1962), pp. 133-142.

[2]J. C. Fry, et. al., "Land Use Planning and the Interchange Community," Highway Research Board, Bulletin 327 (Washington: National Research Council, 1962), pp. 56-66.

In this report, Fry and others point out that society places a unique responsibility on highways and the highway interchanges:

> Broadly interpreted, highways are expected to furnish every land management unit with a direct transportation outlet. This contention is not intended to rule out the importance of other forms of transportation, which most certainly are needed and must be considered an overall analysis of resource mobility, but to point out how sensitive highway use is to changes in the land resource base and to delimit this special relationship for research consideration.[3]

It appears that in their study, Fry and others used what they referred to as a land management unit rather than an acreage allotment or an ownership parcel. By this means they could attribute traffic generation to several so-called land management units for such types of development as shopping centers or other large, significant developments which might by nature take place on a single ownership parcel of land. In their report, Fry and others point out that provision of a freeway interchange increases the number of "land management units" and, consequently, increases the mode of traffic generation at the interchange area. For example, the simple subdivision of land for residential use may take an 80-acre farm which may be considered a single land management unit and subdivide it into 160 to 200 individual residential parcels which may then be considered the appropriate 160 to 200 land management units, or a 200-fold increase in traffic generation potential. As the land use changes in a given

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[3] J. C. Fry, et. al., "Land Use Planning and the Interchange Community," Highway Research Board, Bulletin 327 (Washington: National Research Council, 1962), pp. 56-57.

area in the vicinity of the interchange, not only does the increased intensity of the use alter the total volume of traffic which may flow along the highway network; but it also alters the practical capacity of the network itself by changing the nature of restrictions and, to some extent, the type and nature of the traffic which may be flowing on the freeway. For example, the change in character of a land parcel--or as Fry chooses to call it, a land management unit--from a rural farm to an industrial plan not only changes the total intensity of use of this parcel of land; but it may very well change the nature of the traffic being served at the roadway to this establishment. Consequently, the practical capacity of the highway is altered because more and different kinds of vehicles are entering and leaving, thus adding to the restriction of traffic flow.

Traditionally, an accepted public goal has been the maximizing of economic growth. The bodies of legislative authorities have determined that the desirable pattern of planned development has been one which will contribute to the realization of maximum economic growth. Unfortunately, to a greater degree, planning has tended to adopt these commonly accepted public philosophies even though an examination of past history would indicate that the public costs in roadway construction may be excessive because of this emphasis. For example, consider numerous instances throughout the United States where bypasses have been provided around any number of communities. These bypasses were originally intended to alleviate traffic in the downtown or highly developed areas of the city. But, by their own nature, they have carried high volumes of traffic and because of these high volumes of traffic have been highly suited or highly desirable for commercial and industrial development along these roadways. The ensuing commercial development has tended to allow the use of the bypass, or the local service road serving those establishments which have grown up along it, to receive the benefit of the high volume of traffic which the road was designed to carry. Consequently, the economic growth along the roadway has destroyed the very function of the roadway itself. Again quoting from the Fry report:

> An alternative criterion of planning, when public investment in highways becomes the objective of decision, is the minimizing of the need for new highway construction. If this criterion is accepted as the goal of planning, then a desirable pattern of land use is one that generates and attracts traffic at volumes that can be efficiently absorbed by the existing roadway. Unrealistic as this goal may seem to some at first glance, it is undoubtedly implicit in access control, acquisition of easements, setback control, and other protective measures.[4]

While Fry's report indicates that the objective of his efforts is that of permitting only those kinds of land development which highway networks can accommodate, it is the objective of this study to integrate the type of land uses which can be accommodated by the highway network with the planning of the highway network to accommodate the types of land uses which can be projected for the future. In an attempt to give planners and highway designers some guidelines

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[4]J. C. Fry, et. al., "Land Use Planning and the Interchange Community," Highway Research Board, Bulletin 327 (Washington: National Research Council, 1962), pp. 57-58.

for development of land use policies, Fry and others in their report, determine the design capacity of a highway to be a function of the width of the roadway, the geometric obstructions and the type of surface of the roadway, plus a series of theoretically constant factors. The practical capacity of a roadway then is similar to the design capacity; however, the constants that are determined as restrictions in the design capacity become variables for the practical capacity. These variables are such things as the volume of traffic which enters the highway segment through the intersection; the volume leaving the highway segment; the proportion of different categories of vehicles in the traffic; and other unique factors affecting the given segment of the highway in question. All of these variables are viewed as restrictions to design of traffic flow; and consequently, the practical capacity is less than the design capacity by the amount of these restrictions. Consequently, Fry in his report lists the formula for practical capacity as $AB_C = D_C - H$, H being the variables which restrict the total flow of traffic. In a series of complex formulas and matrices, the Fry report attempts to arrive at a methodology for determining the surplus capacity of a given highway segment. Fry defines the surplus capacity as the excess of practical capacity over the average daily volume, or, by formula, the surplus capacity equals the practical capacity minus the average daily volume. It is deemed in this report that the average volume is composed of four general types of traffic: generated traffic, which is that traffic originated in the interchange study area; attracted traffic, which is that traffic terminating within the interchange study area; local traffic, which is that traffic both originating and terminating within the interchange study area; and through traffic, which is that traffic which neither originates nor terminates within the study area. It is believed that for purposes of this study a fifth category, which could be entitled "interrupted traffic," might also be appropriate. Interruped traffic could be defined as that traffic having an intermediate origin or destination within the study area not being the principal origin or destination for the trip. The general intent of Fry's report is to develop a series of formulas and matrices which would enable the planner to develop a methodology for determining the surplus capacity of an interchange. He could then provide only that variety of land uses which would utilize this excess capacity without increasing the traffic generating units within the study to the point that the total volume on the freeway segment would be further restricted, or the total effect of the interchange area would have an adverse effect upon the freeway system.

Carrying Fry's philosophy a step further, it could be assumed that if the average daily traffic volume exceeded the practical capacity of the freeway segment, then there would not be a surplus capacity but, inactuality, congestion would exist. While this seldom happens on an average daily volume basis, the actual traffic flow for given short periods of time may, in effect, exceed the practical capacity of the freeway for shorter intervals. Consequently, congestion may occur during specific periods of time. While this is a crude attempt to define congestion, the ensuing problem is the identification of the causes of this congestion. Edgar Horwood, The University of Washington, has attempted to provide an outline with commentary on this item. The outline is as follows:

The Problem of Allocating Interchange Congestion

Since the advent of the modern freeway, a great many references have been made both in technical literature and the popular press concerning the traffic congestion which inevitably follows at the intersections to these facilities. However, the problem of allocating this congestion to different influences has not been very adequately dealt with and only minimally researched. The possible causes of this congestion are listed below.

1. Congestion induced by influences close to the interchange.
    a. Inadequate rights-of-way width on roads leading to the interchanges.
    b. Uncontrolled access on approach roads.
    c. The existence of high traffic generating establishments on land close to the freeway interchange.
2. Congestion induced by inadequate highway design or compromises in highway design.
    a. The use of diamond interchanges where higher types are required by the traffic volumes.
    b. Inadequate lane capacity on the approach roads.
    c. Sections with high weaving or merging demands near interchanges.
    d. Insufficient freeway lanes.
3. Congestion induced by influences remote from the interchange.
    a. Crossroads carrying high arterial volumes serving uses significantly remote from the interchange.
    b. Large-scale commercial or residential developments generating significant traffic at remote locations.
    c. Approach roads with generally inadequate right-of-way or access control some distance away from the interchange.

At times all twelve of these influences are mutually operative, and it is indeed a problem to separate one from another. . . .[5]

In noting the results of the Horwood study, the State of Oklahoma in its study of land use and freeway interchanges indicated that traffic generation was only one element contributing to traffic congestion. The key step was determined to be the need to establish the contribution to congestion made by particular land uses. The Oklahoma study reports that information on traffic generation is limited in the broad concept; however, specific uses have highly sophisticated methods of obtaining detailed information for determining the volume of traffic generation.[6]

In general, the types of land use which may be used categorically as traffic generators are: the conventional land uses--commercial, industrial, and residential; and other uses which would include open space uses, such as rural, agricultural, or park and recreational uses. The Oklahoma report indicates a considerable amount of research pertaining to the generating capacities of the various types of land use has been done by several people.[7]

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[5]Edgar M. Horwood, "Land Development Policy at Highway Interchanges," Highway Economic Series Research Report No. 25 (Seattle: Transportation Research Group, University of Washington, 1961), pp. 22-23.

[6]Oklahoma Center for Urban and Regional Studies, Report on the Relationship of Highway Interchange and the Use of Land in the State of Oklahoma (Part I, 1965), pp. IV-5-IV-31.

[7]The Oklahoma study is cited here as a well-researched reference containing several detailed research studies by various authors which indicate research done on residential and commercial traffic generators. If the reader

The Oklahoma report concludes that residential traffic generation has been reasonably well researched and that:

1. It would seem reasonable to assume that the information on residential area generation has been developed to a point which will allow rule-of-thumb projections on trip generation from residential areas. Presumably, the more accurate the information concerning the variables within, the more accurate would be the projection.

2. No research was revealed that dealt specifically with trip generation potential of multi-family complexes in the vicinity of the interchange.

The examination of commercial traffic generators was detailed and complex, and several references were cited which indicated the considerable body of research which has been undertaken pertaining to the determination of traffic generation for commercial shopping areas; particular emphasis, of course, was placed upon shopping centers.[8] The Oklahoma report concludes that:

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of this report wishes more detailed resource information, he is referred to the Oklahoma study and the references noted therein.

[8]Homer Hoyt, "Suburban Shopping Center Effect on Highways and Parking," Traffic Quarterly (Volume X, No. 2, New York: Columbia University Press, April, 1956); C.H.V. Harding, "Planning and Design for Traffic and Traffic Generation," Shopping Centers (Berkley: University of California, Division of Transportation Engineering, 1960); J. Ross McKeever, "Part One: Emerging Patterns," Shopping Centers Restudied, Technical Bulletin No. 30, (Washington: Urban Land Institute, February, 1957); Victor Gruen and Larry Smith, Shopping Towns USA, The Planning of Shopping Centers (New York: Reinbald Publishing Corp., 1960).

1. Apparently a good amount of information has been obtained on trips to commercial areas. However, the information is developed from home interviews and origin destination studies. The information is reported as trips generated from residential areas; and trips are assigned in general categories; such as, convenience, good trips, and shopper good trips.
2. Presumably a large number of traffic evaluations and analyses have been carried out in connection with marketing studies done on shopping centers. The method utilized in such studies appears to be relatively consistent; however, no examples of empirical verification or rejection of reliability of such a study are avialable at the present time.
3. The effect of commercial facilities, such as shopping centers, upon the capacity or traffic volume on an interstate segment or interchange area would vary considerably, depending upon the areas of operation of the shopping center. It is generally conceded that the peak time for traffic load created by shopping center trip generations is the mid-afternoon. This time generally does not conflict with normal traffic volumes related to work journeys and other residentially oriented traffic; however, slight variations in operating times of the shopping center and a small percentage of additional traffic during peak load period at an interchange could create significant congestion.

It should be noted that there appears to be inadequate study given to shopping facilities not necessarily organized in a planned shopping center. Trip generations by automobile will vary considerably with the type of shopping facility; the region as well as the nature and extent of mass transit facilities; and the percentage or extent of walking trade. These factors will vary considerably--particularly when consideration is given to shopping facilities along secondary roads or routes not directly having access to the interchange area.

All of the uses, both residential and commercial, considered up to this point have been uses which were categorized by Fry and others.[9] The major type of land use which would generate that category which was entitled interrupted traffic would be the service oriented land uses, such as service stations, motels, restaurants, and uses of a similar nature. Unfortunately, there is virtually no information available which gives a clue to the trip generating characteristics of most of the uses associated with highway use or need. The trip generating capacity of the motel can be relatively easily determined by the number of units the motel contains plus an estimate of the employee potential plus an estimate of the average percentage of the occupancy of that or similar motels in the area. The determination of the trip generating capacity of the

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[9]As generated traffic or attracted traffic or possibly some unusual cases as local traffic. In none of these instances, however, has the nature of the traffic generation dealt with the category that this report has referred to as interrupted traffic.

service station is slightly more complicated. The American Society of Planning Officials, Planning Advisory Service Report No. 67, indicates that a service station requires 300 to 500 families to maintain itself. This, however, does not give a clue as to the number of stops each family must make at a service station in order for the station to maintain a reasonable volume of business; nor could it make a correct statement of the relationship between the number of families required for average support and the number of daily stops which a highway oriented service station would require for similar sustaining business. It can only be assumed that the total volume of traffic generation created by the single service station at an interchange would be relatively low and not have any grave effect upon the total design of the area. However, the tendency to develop multiple service stations at any or all corners of an interchange can compound the significance of any one such station; and the potential for traffic congestion created by several of such establishments is increased significantly. In a manner similar to the approach considered for motel facilities, the maximum potential trip generating capacity for a restaurant could be determined by the number of seats available and an estimate of the volume turnover that restaurant or restaurants of a similar nature manage to attain. Given these factors, the combined traffic generating potential of any highway oriented service complex; consisting of service stations, motels, and/or eating establishments, could be determined.

Finally, industrial land use at an interchange area is relatively easy to determine. As a trip generating establishment, industrial usage is substantially work trip usage; and a significant number of studies have been carried out which indicate the relationship between the nature of the industrial land use and/or trip generation. Wilbur Smith indicates that work trips are closely related to the number of jobs, and usually average one and a half to two, one-way trips per job.[10] In Smith's study of the Nashville, Tennessee, area, he determined there was no significant variation in trip generation by either white collar or blue collar workers. The overall average was 1.53 trips and 1.73 trips per worker respectively.

Although significant research has been carried out for residential shopping center and industrial land use trip generation data, there appears to be a lack of such information for highway oriented commercial uses, for institutional uses, and for recreational uses. Although, as indicated, there are means of determining the maximum potential trip generating capacity of highway oriented services uses, it must be assumed that the trip generating capacity of open space uses, or recreational uses, is very low and not significant when compared with other types of land uses considered for this report. In determining the potential land use for any given interchange area, these

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[10]Wilbur S. Smith, "Centralized Travel Designed Areas," Traffic Quarterly (Volume XVI, No. 2, New York: Columbia University Press, April, 1962).

factors can be considered, in light of the Fry research technique, which will allow, through these several complex matrices, a determination of the proportion of surplus highway capacity which may be utilized by the various types of land use. This combination of the technique outlined by Fry and others and by the detailed research on trip generation in the Oklahoma study may be a definite asset to the urban planner in determining the most logical potential for a given highway interchange area. In many instances, however, planners may not have the techniques of traffic engineering available to them so that complicated formulas for determining trip generating capacities and surplus capacity of freeways may be impractical. In such cases, it would be well to have empirical rules to aid in guiding interchange development.

CHAPTER VI

LEGAL BASIS FOR DEVELOPMENT CONTROL AT INTERCHANGES

In considering the factors presented in the previous chapters of this report, it becomes evident that the development of a freeway or limited access highway restricts the right of abutting land owners to ingress and egress from the highway and, consequently, concentrates traffic at the points on the highway where access is permitted. On freeways these points of concentration are the interchanges. One result of this concentration of traffic is that land in proximity to the interchange becomes in high demand for a use more intense than its original use or the use of surrounding land parcels. It is this creation of land value and subsequent change of use which tends not only to serve the traffic normally utilizing the interchange, but also acts as a generator of additional traffic and, as a consequence, tends to destroy the function for which the freeway was built.

Because of the generation of additional traffic, many authors have written of the need for land use controls at freeway interchanges.[1] The type

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[1]Erling Solberg, "Roadside Zoning," Highway Research Board, Bulletin No. 55 (Washington: National Research Council, 1952), pp. 49-54; Tennessee State Planning Commission, Highway Access Areas in Tennessee (September, 1962); Verne C. Bechill and Dorothy Tucker, "Protecting Access Areas," The Tennessee Planner (Nashville: Tennessee State Planning Commission,

of legal control which may be exercised and the governmental organization which has jurisdiction over the area depends, to some degree, upon the planning or lack of planning for the freeway facility.

If freeway facilities were planned cooperatively between federal, state, and local governments well in advance of actual construction, there would be no serious legal problem to establishing needed control at interchange areas. Many authorities have written extensively of the need for planning in the development of land areas adjoining freeways at the same time the road facility is planned.[2] Granting that this ideal situation exists, the power of eminent domain is unquestionably a means for acquiring title to and control of needed adjacent land. Such acquisition would allow the government concerned to restrict access to a crossroad interchanging with a freeway. This restriction could be made to apply for a distance far enough from the interchange ramp to insure a minimum of traffic conflict.

Assuming that pre-planning is accomplished, some authorities believe that it may be possible to exercise sufficient control to protect the interchange area by utilizing the police power rather than the more expensive eminent

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1959), pp. 107-114; R. D. Netherton, Control of Highway Access (Madison: University of Wisconsin, 1963); Frank M. Covey, Jr., "Highway Protection Through Control of Access and Roadside Development," Wisconsin Law Review (Madison: Law School, University of Wisconsin, July, 1959), pp. 567-607.

[2] *Loc. cit.*

domain. Stanley N. Nissel points out that it was early recognized in law that owners of property physically abutting upon a public road obtained rights--at least what amounted to rights--in the nature of an easement in their access to the road, even when fee title to the roadbed was in some government authority.[3] Since we have assumed that this road facility has been pre-planned and did not exist originally, it could not be said that abutting owners had any access before to any highway, consequently no previously existing access will have been taken, damaged, or interfered with. In an instance such as this, Nissell[4] cites a California decision[5] wherein the court said that to award compensation for the destruction of a right of access that had not previously existed would be to award a gift of public funds to the complaining abutter. This article emphasizes that the use of the police power in lieu of eminent domain is the prerogative of the states when conditions are such that the police power could appropriately be used.

It is apparent that some leading authorities believe that states could, in many instances, avoid large costs by use of the police power. Perhaps a more serious question involves the willingness of state governments to use

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[3]Stanley N. Nissel, "Control of Access and Police Power Highway Laws," <u>Highway Research Board, Bulletin 205</u> (Washington: National Research Council, 1958), pp. 29-44.

[4]<u>Loc. cit.</u>

[5]Schnider v. California, 38 Cal. 2d 439, 241 P2d 1 (1952).

this means. Examination of the practice in some states would lead to the conclusion that many states would be extremely hesitant to use this method.

One further problem exists when considering not only the expressway right-of-way but also the interchange area. In nearly all instances, the expressway facility will interchange with an existing road. Since, as was pointed out by Nissel, the police power concept may be a feasible approach because no pre-existing right of access is involved, it becomes evident that owners of property abutting existing access roads which interchange with the expressway do have a right to access to this crossroad. Under these conditions it is doubtful that the police power could be used to acquire access rights to the interchanging crossroad.

I. CONVENTIONAL MEANS OF LAND USE CONTROL

Before considering means which may be appropriate to controlling the use of land at freeway interchanges, this report will consider methods frequently used to control, guide, or influence the use of land in any area. In general, these controls fall in three categories.

1. Acquisition of title to one or more land rights.
2. Licensing of enterprises.
3. Use of the police power.

Each of these three categories includes one or more concepts which are adaptable to land areas about interchanges although not all states or all local governments have the necessary authority to utilize each of these methods.

Eminent Domain

The purchase of land or land rights by a public agency, whether by condemnation or by negotiation, will be considered as use of the eminent domain approach, the key being the acquisition of the right by a public agency. Variations in the eminent domain approach depend upon how many and which land rights are acquired and the method of returning land to the developer who will develop its potential. Stanhagen[6] or Horwood, Graves and Rogers[7] provide excellent analyses of these potential variations.

Purchase and Leaseback. Purchase and leaseback involves the acquisition in fee simple of the land in question by a public agency and the execution of the lease for development.[8] Generally these leases are transferred to the original owner; however, the public body has no obligation to make such a

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[6]William Stanhagen, "Highway Interchanges and Land Use Controls," Highway Research Board, Bulletin 288 (Washington: National Research Council, 1961), pp. 32-60.

[7]E. M. Horwood, G. H. Graves, and C. D. Rogers, "An Evaluation of Land Use Control Procedures at Freeway Approaches," Highway Research Board, Bulletin 288 (Washington: National Research Council, 1961), pp. 67-82.

[8]Stanhagen, op. cit., pp. 32-60.

transfer. The lease may stipulate one or more restrictions to the development of the land and thus prevent development altogether or prohibit a use which will have a harmful effect upon the interchange area. Whereas, the most common use of this approach has been for scenic preservation, it could have more general application.

Stanhagen points out that the purchase and leaseback approach has certain advantages over the purchase of development rights or the acquisition of partial land rights:

> Purchase and leaseback have an advantage over the purchase of development rights where experience has shown that jury awards for easements are as high as awards for the fee simple. If the public is going to be compelled to pay excessive amounts for easements, it should acquire the entire fee. It could gradually recoup its expenditures by renting and, when the tract was no longer necessary for the public benefit, by selling the land.[9]

Although it may not appear likely that land at an interchange would not be needed for the public benefit, it is possible that in future years an interchange could be eliminated or relocated. As an example of this possibility, several interchanges in central Knoxville which were constructed prior to interstate standards are under study for possible elimination or relocation.

Urban Renewal Technique. A technique currently used by urban renewal agencies could have application at highway interchange areas. The power of

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[9]Stanhagen, op. cit., p. 40.

eminent domain is used to purchase parcels which the government needs to control the development at interchanges. This land is resold to private developers contingent upon approval of the development plan. Legal restrictions which are desired could be placed upon the land while it was in government ownership. This technique has the advantage of allowing the government to acquire land at raw land prices; prepare the best plan for its development; control the development pattern; and return the land to the tax base of the community. The major point of difference between this approach and the leaseback approach is that the land is resold to a potential developer rather than leased. The major problem is the need for cooperation between state and local governments, since the acquisition of highway lands is usually at the state level while the determination of development policies usually is a local matter.

Development Rights. The purchase of development rights rather than fee simple title presumably has the advantage of avoiding the necessity of purchase of the entire property right and, consequently, reduces the purchase cost. The governing body may acquire this right to prevent development or may resell or lease the development right for a specified use which is compatible with the long range plan of the community. It appears that the effectiveness of the technique of purchasing development rights hinges upon proper administration. If properly administered, development rights can be purchased for less than fee simple title, and by paying for development rights the government would encounter less opposition than it would if it attempted to use the police power without compensation. On the other hand if not properly administered, the cost of purchase of development rights could approach or equal the purchase cost of fee simple title without the benefits.[10]

When control of land at an interchange by acquisition of title is desired, the government must determine whether fee simple or development right purchase is more suitable. Several states, including Tennessee, do not have sufficient authority to condemn excess land in fee simple to permit desired land use control. In these cases thorough investigation into the feasibility of the leaseback system is recommended. In all probability the acquisition of development rights will need to be accompanied by use of police power methods, such as zoning, in order to achieve the desired roadside development.

Licensing Control

Licensing control would require the developer of land in the vicinity of an interchange to be licensed, subject to reasonable conditions intended to insure development consistent with public objectives. Like use of the police power, this means of control involves no cost to the government other than that of administration. Major problems can develop in determining the standards and

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[10]William H. Whyte, Jr., "Securing Open Space for Urban America: Conservation Easements," Urban Land Institute Technical Bulletin No. 36 (1959).

qualifications for granting of licenses. This concept also involves a change in standard licensing procedures. Usually specific use or uses are licensed; whereas, in control land use at an interchange, the concept must be changed to license uses in a particular area. This technique has not been utilized so that it could easily be adapted without discrimination, nor is there a history of court decisions interpreting its legality.

Police Power

Police power regulations consist of zoning and setback controls, subdivision regulations, and official maps. These methods have been tested and tried in court and are of unquestioned legal validity except that some states do not have adequate enabling legislation for each. Official maps are the tool most frequently omitted from state enabling statutes. In general, the police power is exercised at the local government level. Since highways and interchanges are constructed at the state level, much coordination is needed to develop specific police power controls for any interchange area.[11]

Zoning. Zoning has generally failed as means for guiding land use, perhaps because it is prohibitive in nature rather than an incentive for development. In an analysis of patterns of disposition of rezoning applications 41 communities, it was noted that between 61 percent and 80 percent of rezoning

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[11]See Horwood, loc. cit., and Stanhagen, loc. cit., for full discussion.

applications were granted. In nearly 50 percent of these cases, the planning staff itself approved the amendment. Actions by planning commissions and legislative bodies increase the total number of approvals. Experience in Knoxville corresponds with this average. During 1967, 68 percent of all rezoning applications were approved in Knoxville and Knox County. The relative ease with which land can be rezoned reduces the effectiveness of zoning as a control measure. Zoning, or rezoning, tends to react to development trends rather than to guide them. While most zoning authorities agree that it has been an ineffective tool and while they provide an extensive list of shortcimings, zoning is, nevertheless, a widely used means of land use control. It stands to reason that an analysis of specific problems and weaknesses of zoning in communities should be made and remedial steps taken to upgrade zoning in general and, in the context of this report, its relationship to highway problems in particular.

Problems with zoning in Knox County are probably little different from those in other communities.

1. There needs to be a comprehensive policy on land use.
2. Applications for rezoning should be analyzed on firm legal grounds.
3. Planners should periodically review changing conditions to recommend amendments prior to the demands of the market.
4. Administrative procedures should be updated to provide legislative bodies with clear, precise, and legally defined recommendations.

5. When highway oriented rezonings are requested, each request should be analyzed considering the functions of the roadway as well as the functions of adjacent land uses.

Ideally, zoning should be made part and parcel of an overall transportation plan; and the land use and zoning plans should be developed at the same time as the highway routes and interchanges are planned. In Knox County, as elsewhere, it is too late to coordinate highway planning and zoning; however, the transportation plan is an on-going process and regular additions and amendments to the plan could be coordinated with future zoning in these areas. Perhaps the failure to coordinate zoning with development plans has led to the failure of zoning as a development guide. Zoning was a well-established institution long before the current interstate program, yet almost all rezoning at interchanges has followed the market demand for reuse rather than preceded it. Little zoning has been coordinated with the expressway plans from the start.

<u>Subdivision Controls</u>. Subdivision regulations concern themselves with the division of raw land into parcels for resale. If the subdivision of land is considered in terms of commercial and industrial development, as well as residential, some effective means could be established for controlling land development at interchanges. Knox County's subdivision regulations, like most others, require the dedication of satisfactory roads, easements, and

park land, and require certain minimum design standards. There is no reason that similar standards could not be applied at interchanges to require minimum distances from ramps to land access points, parallel frontal roads, and to provide design standards that would enable the land development at interchanges to be compatible with the function of the roadway. Inasmuch as the freeway system is already planned or constructed, it stands to reason that development controls similar to subdivision regulations may afford the local governments a better opportunity for protecting the interchange than will zoning.

Official Map. Although an official map can prevent the erection of buildings within the path of a mapped street, the extension of the regulation to developable land adjacent to an interchange would probably not be upheld in court.[12] The use of the official map concept msut be accompanied by use of eminent domain and the acquisition of the land. The development control potential then becomes that of land ownership. Whereas, Tennessee has provided enabling legislation for Official Maps, Knoxville has not at present passed such an ordinance.

II. SUMMARY

In summary, the significant means of land use control at interchange areas are the same as elsewhere. Eminent domain proceedings hold much

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[12] Opinion of the Law Director, City of Knoxville, Tennessee.

more promise for adequate control than does the use of police power. If eminent domain is used, the cost to local government can be significantly reduced by utilizing a system of leaseback or resale, contingent upon a specific development plan. The major obstacles to these processes are the coordination between state and local governments and the questionable willingness of local authorities to exercise such power.

Use of the police power has proven ineffective in the past; however, it is an accepted practice and could be strengthened if upgraded and coordinated with highway planning. Use of the subdivision type regulations hold some promise, if not for control of specific uses, at least for influencing development patterns to be more compatible with interchange and highway functions. Since transportation planning is a continuing process, immediate steps should be taken to coordinate transportation plans and police power control processes.

CHAPTER VII

THE INTERCHANGE OF LOVELL ROAD AND INTERSTATE 40

I. INTRODUCTION

The intersection of Interstate 40 and Lovell Road is a diamond interchange, with Lovell Road elevated 16 feet 6 inches above the Interstate. The initial contract for grading was let in December of 1958 and the paving contract in April of 1961. The interchange was fully completed and open for traffic in April of 1962. The Lovell Road interchange covers an area of approximately 75 acres. The interstae contains four, twelve-foot traveling lanes, two in each direction, separated by a sixty-foot median strip and was designed to accommodate traffic moving at speeds of 70 miles per hour. Lovell Road is an important connector route between Oak Ridge, Tennessee, and Kingston Pike (U.S. Highway 11 and 70) into Knoxville. The present connection with Interstate 40 places additional importance upon Lovell Road.

Lovell Road is a local county road with only 22 feet of pavement; however, it does have a 60-foot right-of-way, which is approximately 10 feet more than the average right-of-way for a Knox County local road. As Lovell Road approaches the interstate from the north, the right-of-way for the road increases to approximately 85 feet, 700 feet from the center line of Interstate 40. In this area the pavement increases from 22 feet to 24 feet. The pavement from the center line of the interstate is also 24 feet wide to a point 900 feet south of the interstate. The overpass as it crosses over the interstate highway contains two 14-foot traveling lanes for vehicular traffic, plus a sidewalk 2 feet in width.

II. THE PHYSICAL SETTING

No major topographical elements which would inhibit development are present in the vicinity of the interchange. For about 2,000 feet on each side of the Interstate Highway the land is of gentle slope. Beyond this, modest hills are present. The fairly prominent ridge lying south of the Interstate Highway, about 2,000 feet from and parallel to Kingston Pike, hasn't proved to be a development barrier. This ridge is fairly well developed for residences. Illustration 7.1 indicates the degree of slope in the area and indicates that the majority of the area has little restrictive terrain.

Turkey Creek represents a slight obstacle for developments within the interchange area. The creek is parallel to and 400 feet from Lovell Road for distances of about 2,000 feet southesast of the interchange and about 2,000 feet northwest of the interchange. Then the creek approximately parallels Kingston Pike and Dutchtown Drive. Turkey Creek is the backbone of the drainage system for this interchange area. No apparent drainage and/or flooding problems have been evident; the land is gently rolling, and Turkey Creek has a steady fall. At times there is a slight problem caused by a small swampy condition appearing along the flood plain of Turkey Creek, just below the interchange; however, the Tennessee Valley Authority has adequately mapped the areas subject to flood, and county regulations prohibit development in floodways.

The soils in the vicinity of the Lovell Road interchange are the Sequoia, Lindside and Melvin silt loam series. The soils, generally, within the study area of the interchange are of the Litz and Sequoia series, plus the Montevallo series. These soils generally have fair drainage. Wet areas can be expected along the narrow drainways. On the broader, smoother areas the soils have a silty surface underlaid by a yellowish-red clay subsoil. On the smoother slopes, depth to soft shale bedrock averages about 3 feet. On the shorter, stronger slopes the soils are shallow, and soft shale bedrock is usually at a depth of less than 20 inches. Some areas have limestone interbedded with the shale. Over much of this area, most of the surface soil has been washed off.[1] Illustration 7.2 shows a generalization of soil conditions as related to development potential.

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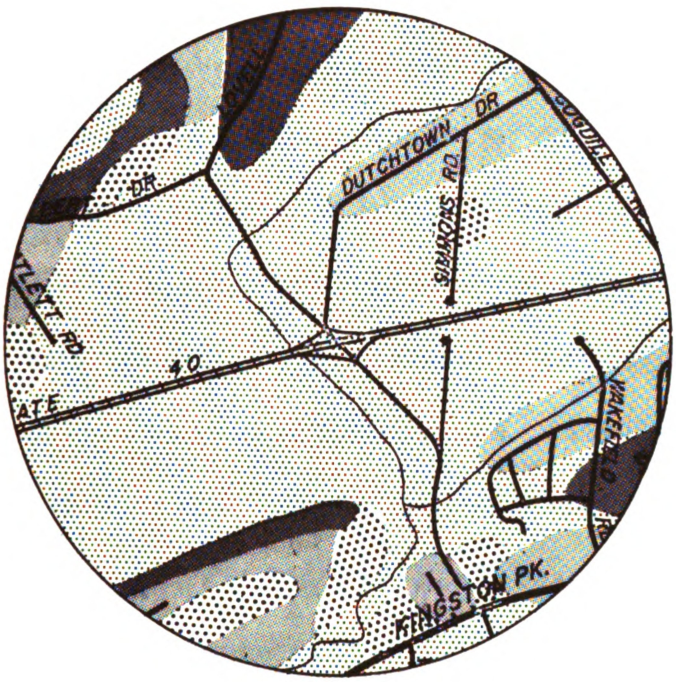
[1]Soil Resources of Knox County, Tennessee. Soil Conservation Service, United States Department of Agriculture, (Knoxville, May, 1964), p. 29.

ILLUSTRATION 7.1

TOPOGRAPHY— PERCENTAGE OF SLOPE



0 - 10 Percent

10 - 15 Percent

15 - 20 Percent

Over 20 Percent

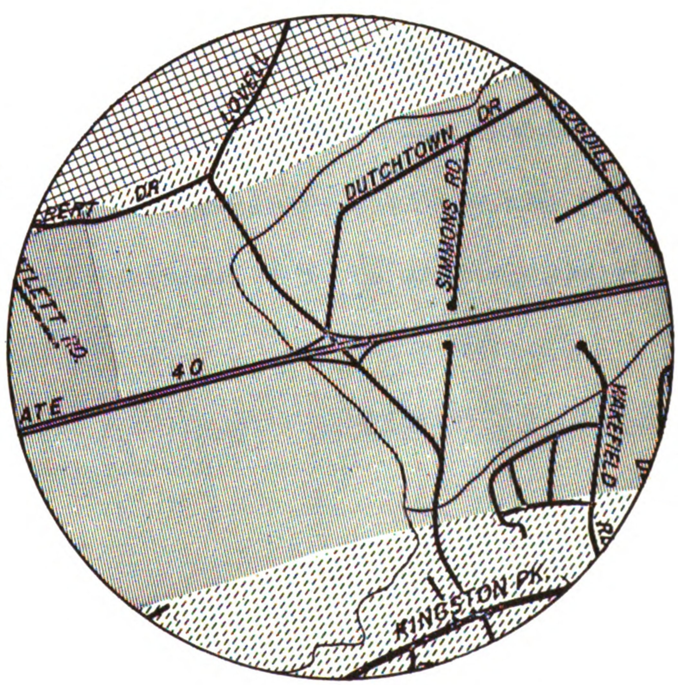
ILLUSTRATION 7.2

SOIL SUITABILITY FOR DEVELOPMENT

Excellent

Fair

Very Poor



III. LAND USE

Land use at the Lovell Road interchange is unique by comparison with interchanges in other areas in the western part of the County. It embraces some industrial firms although the majority of the present land remains vacant, (refer to Illustration 7.3). The area is generally suitable for development, both residential and industrial, although the majority of the residential development has occurred along and adjacent to the Kingston Pike area. Kingston Pike is a road parallel to the Interstate lying approximately one half mile to the south of the Interstate. Less than five percent of the land area within the study area for the Lovell Road interchange is presently developed. The majority of this is devoted to residential use although the majority of the area in the immediate vicinity of the Interchange is either developed in industrial use or has been allocated for industrial use.

The change in land pattern at the Lovell Road interchange is less evident than at several other interchanges in Knox County because substantial acreage in the immediate vicinity of Lovell Road and Interstate 40 was zoned for industrial shortly after the interchange was developed. One new industrial facility has been developed in this area while the balance of the land is currently undeveloped, although a significant tract is presently being graded for a large industrial plant.

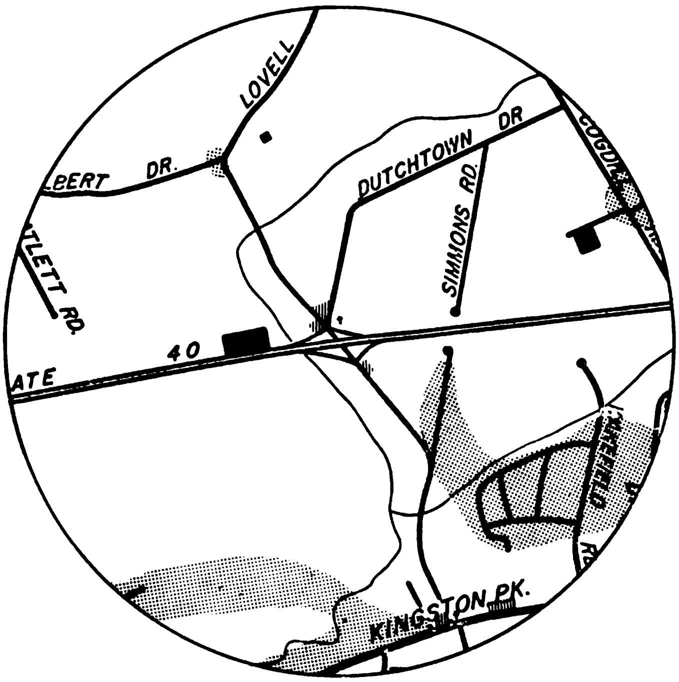
Development trends surrounding Lovell Road interchange area illustrate a pattern which is characteristic of the development in the western portion of Knox County. The Lovell Road interchange is in the path of the great urbanization which has taken place to the west of Knoxville. Generally speaking, this urbanization has been characterized by high quality subdivisions with large lots for septic tank use and by the subdivision of large farm tracts into acreage for relatively expensive homes. A certain number of commercial retail establishments have been built on smaller lots; and some shopping centers have developed closer to the City of Knoxville. Specific development patterns at the Lovell Road interchange have been somewhat different from those nearby in the western part of Knox County. An observation of the changes in land use would indicate that the present allocation of land for industrial use is different from the normal pattern. This, however, makes the Lovell Road interchange unique and particularly appropriate as an example for this study. There would appear to be no special interchange oriented development problems at the present time. The pattern of development has not emerged to the point where conflicts between development pattern and the use of the interchange have occurred, although full use of the land as permitted by zoning could create such conflicts.

IV. ZONING

Prior to the construction of the Interstate and the interchange at Lovell

ILLUSTRATION 7.3

EXISTING LAND USE

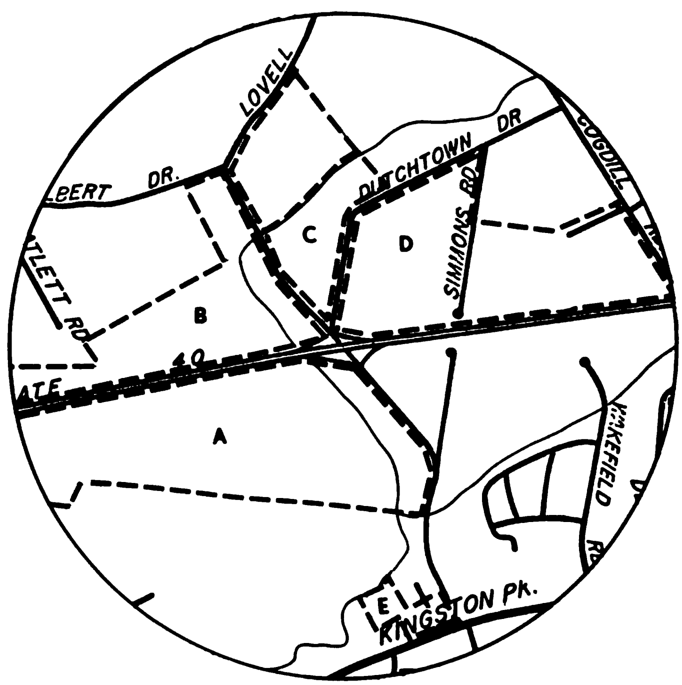


- Undeveloped
- Residential
- Commercial
- Industrial

ILLUSTRATION 7.4

CURRENT ZONING

- A Industrial
- B C D Commercial B
- E Shopping Center



Road, the majority of the land in this area was zoned for agricultural purposes and was, generally speaking, not being used for any economic purpose. Illustration 7.4 indicates the several parcels which have had a change in zoning since the planning of the interchange facility at Interstate 40 and Lovell Road. A brief analysis of these changes in zoning is as follows:

Parcel A is the largest single parcel which has been rezoned since the construction of the interchange. This parcel was rezoned from Agricultural to Industrial. The petition was filed by Harold Hayes, a Realtor representing the Fulton-Sylphon Company, and was proposed as a site for the relocation of the Fulton-Sylphon plant. The industry currently employs approximately 500 persons at their existing plant. The move was proposed for an expansion which could ultimately employ up to 4,000 persons. This rezoning was approved by the Metropolitan Planning Commission in June of 1962, and approval of the amendment to the Zoning Map was granted by the County Board of Commissioners in July of 1962.

Parcel B was originally in an Agricultural zone. It was requested for rezoning by Ceil-Heat, Inc., for relocation of their plant which manufactures electrical heating products. This rezoning request was submitted to the Metropolitan Planning Commission in September, 1962, and was approved by the County Commission in October, 1962. The actual zoning category for this parcel was listed as Commercial "B" which, in Knox County zoning, is essentially a light industrial/heavy commercial zone. The nature of this zone also permitted the establishment of a service station at the extreme corner of the property nearest the interchange.

Parcel C, the third parcel of property, was rezoned on a petition of C. E. Keck from a previous zoning of Agricultural to a new zoning of Commercial "B." The intent for development on this parcel was for a service station-motel-restaurant combination. The rezoning was approved by the Metropolitan Planning Commission in April of 1964 and by the County Commission in May of the same year.

Parcel D is the parcel immediately aoross Dutchtown Road from the Keck property and was petitioned for rezoning by Keller Homes, Inc. This petition was submitted to the Planning Commission in 1960 and was approved by the County Commission in March of 1960. It should be noted that this is, perhaps, the only petition which was submitted to either the Planning Commission or the County Commission prior to the official opening of the Interstate and interchange at this area. The original zoning for this parcel was also Agricultural and the new zoning is Commercial "B." The petitioner indicated that he intended to place a real estate office and service station on this parcel.

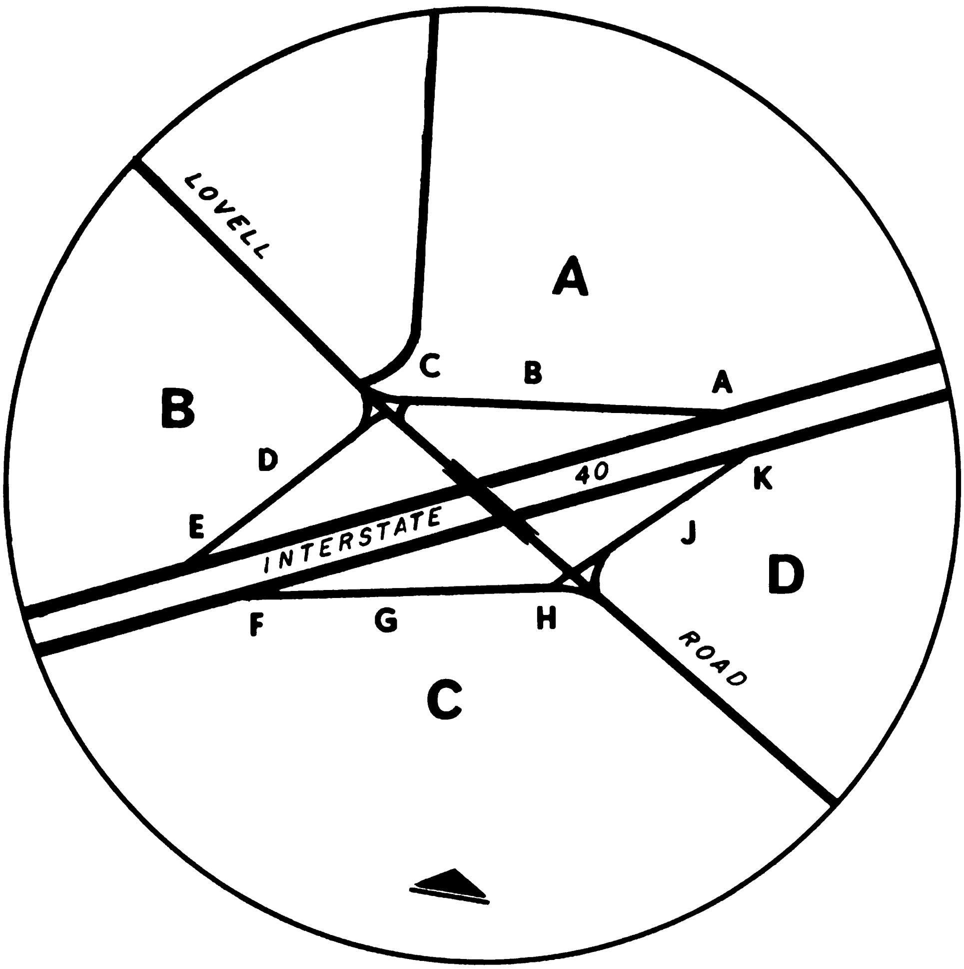
These four are the major rezonings in the immediate vicinity of the Lovell Road interchange. It should also be noted that the parcel of land labeled Parcel E at the corner of Lovell Road and Kingston Pike was rezoned from

Agricultural to Shopping Center. This request was submitted to the Planning Commission in September, 1965, and was approved by the Knox County Board of Commissioners in October of that year. The shopping center intended to service the residential areas which have grown up along Kingston Pike.

V. TRAFFIC CONDITIONS

As indicated in Chapter V on traffic factors, the design of the interchange and the excess capacity, or the amount of congestion at any interchange, has significant influence upon the type of land use which should be permitted at that interchange. Illustration 7.5 shows a diagram of the Lovell Road interchange with traffic movements from the Interstate to Lovell Road and from Lovell Road to the Interstate. These movements can be illustrated by the current demand volume estimated on each ramp, together with the 1988 estimated demand volume and the design capacity of the ramp. The estimates are based upon a projection of the land use patterns which exist in the area at present. For example, in Quadrant A, traffic is moving westerly on the Interstate and off the ramp onto Lovell Road. At the present time the estimated traffic accomplishing this movement is 430 vehicles per hour. It is forecast that by 1988 the traffic demand will increase to approximately 800 vehicles per hour. The limiting factor is the capacity of this ramp termini from the Interstate to Lovell Road. Under present design conditions this allows for only 1,000 vehicles per hour. It should be pointed out, however,

ILLUSTRATION 7.5



RAMP CAPACITY OF I-40, LOVELL ROAD INTERCHANGE

Check Point		Quadrant	Demand Volume/DHV 1968	Demand Volume/DHV 1988	Capacity	Excess Capacity/DHV 1968	Excess Capacity/DHV 1988
A	Diverge	A	750	1,290	1,500	750	210
B	Ramp	A	430	800	1,300	870	500
C	Termini	A	430	800	1,000	570	200
D	Ramp	B	160	360	1,300	1,140	940
E	Merge	B	480	880	1,400	920	520
F	Diverge	C	500	890	1,500	1,000	610
G	Ramp	C	160	360	1,300	1,140	940
H	Termini	C	160	360	1,000	840	640
J	Ramp	D	430	800	1,300	870	500
K	Merge	D	730	1,200	1,400	670	200

that the diverge movement from the Interstate to the ramp could accommodate 1,500 vehicles per hour, and the ramp itself could accommodate 1,300 vehicles per hour. Consequently, a redesign of a sector of Lovell Road could allow more vehicles to exit from the ramp to Lovell Road and could increase the 1,000 limitation to 1,300 which is the limitation of the ramp itself.

Based upon statistics, furnished by the Tennessee State Highway Department,[2] it would appear that, at the present time, there is an excess design capacity on this ramp of 570 vehicles per hour. This excess capacity will be reduced to only 200 vehicles per hour in 1988. However, a certain amount of this reduction is accounted for by considering the expansion of the development patterns which are already under way. Consequently, our concern in this study is the potential for additional development over and above the proposals which exist at the present time. This additional potential should then be limited by the factor which will allow an additional 200 vehicles per hour to exit from this ramp.

By the same token, Quadrant B is providing for traffic movement from Lovell Road onto the Interstate traveling west. This movement is limited by the number of vehicles which can be accommodated on the ramp. At the present time only 160 vehicles per hour demand this movement, however, the

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[2] Tennessee State Highway Department I-40 Ramp Capacity Study, (Knox County, March, 1968).

ramp and interchange are designed to accommodate up to 1,300 vehicles per hour. This indicates an additional capacity at the present time of 1,140 vehicles per hour. The potential movement by 1988 is only 360 vehicles per hour, still leaving an excess capacity of 940 vehicles per hour entering the ramp at Lovell Road. Hence, the excess capacity based upon the forecast of continuing development for Quadrant B is 940 vehicles per hour.

Similarly, the limiting factor for Quadrant C is the ramp termini at Lovell Road, and for Quadrant D is the capacity at the merge point. It must be pointed out that the merge point in Quadrant D has a capacity of 1,400 vehicles per hour while the ramp capacity is only 1,300 vehicles per hour; however, estimated design merging movement for 1988 is 1,200 demand vehicles per hour. It appears from Illustration 7.5 that the limiting factor at the Lovell Road interchange is the excess capacity provided for the movement from westbound Interstate 40 onto Lovell Road and from Lovell Road eastbound onto Interstate 40. For both of these movements, the 1988 excess capacity is only 20 vehicles per hour. The current 1968 excess design capacities are also smaller than for other movements.

It should be noted that these excess capacities can be affected by the development of congestion points along Lovell Road which would slow down the volume of traffic which could exit from the ramp onto Lovell Road. Although the present traffic volume on Lovell Road is extremely low, it is forecast to carry approximately 8,250 vehicles per day according to the 1988 traffic volume assignments.[3] This figure will have to be modified some inasmuch as a full limited access facility will be furnished from Oak Ridge to the Mabry-Hood interchange which will relieve the Lovell Road facility from carrying most of the traffic between Oak Ridge and Knoxville. This should reduce the 1988 forecast by approximately 1,600 vehicles per day which currently can be allocated to Lovell Road instead of Mabry-Hood Road. By reducing the traffic assignment from 8,250 vehicles per day to 6,650 vehicles per day, we can find an average peak hourly traffic of 665 vehicles per hour, which approaches the design capacity of the road.

The limiting factor for development purposes would be the movement from the westbound Interstate traffic onto Lovell Road and return. These movements are substantially from Knoxville to Lovell Road and Lovell Road to Knoxville, which includes traffic going from Knoxville to and from Oak Ridge. With the construction of the new Mabry-Hood facility, the desire for this movement may be decreased so that the excess capacity of 200 vehicles per day is, in actuality, a minimum excess capacity. In attempting to determine the amount of excess capacity or congestion which is forecast, it was decided that the 1968 demand volumes and traffic generating potential for development of land in its present zoning categories would be used. It was assumed that the 1988 demand volume estimates were based upon a projection land use and not an assumption of development to optimum potential.

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[3] Loc. cit.

By utilizing traffic generation standards established by the Tennessee State Planning Commission,[4] we find that for low density development, such as exists in the vicinity of the Lovell Road interchange, it can be estimated that service establishments; such as gas stations, motels, and restaurants, will have a traffic generation potential of 30 vehicles per hour. Churches and theaters have a traffic generation potential of 200 vehicles per hour per acre of lot. Community centers may have a potential of 100 vehicles per hour per acre of lot; shopping centers 40 vehicles per hour per acre; and industrial establishments 9 vehicles per hour per acre. Illustration 7.6 will show the nature of traffic generation potential for the areas currently zoned for development use.

It can be seen that, in accordance with the potential traffic generating capacities of the proposed land uses for these areas, a total of 1,354 vehicles per hour represents the traffic generating potential of the development permitted under existing zoning. Present traffic allocation for eastbound and westbound traffic from the Interstate shows 2,400 vehicles exiting from the Interstate westbound for every 1,200 vehicles exiting from the Interstate eastbound.[5] This allocation is a two to one ratio. Consequently, the traffic

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[4] Highway Access Areas in Tennessee. Tennessee State Planning Commission, (September, 1962), p. 165.

[5] Wilbur Smith and Associates, Knoxville-Knox County Comprehensive Transportation Study. (August, 1964), pp. 137-138.

ILLUSTATION 7.6

TRAFFIC GENERATING POTENTIAL

Zoning Area	Proposed Use	Acres Proposed For Use	Traffic Generating Potential
A	Industrial	72	648
B	Industrial	25	225
C	Service Commercial	0.7	21
D	Service Commercial	10	300
E	Shopping Center	4	160
Total	-	-	1,354

generating potential for any on and off movement would be 903 to 451, representing the total of 1,354. Comparing the 903 vehicles of the traffic generating potential for the existing or proposed land uses in this area to the 1968 excess capacity of the interchange at Quadrant A which is 570 vehicles per hour, congestion over capacity in the amount of 327 vehicles per hour will occur.

If, however, the land use development, as allowed under the present zoning pattern, is further restricted by design criteria these maximum traffic capacities can be limited so that the current and proposed land uses can be developed within the range of excess capacity allowed in this area. Furthermore, it would appear at first glance that there is a certain amount of excessive zoning for each of the proposed uses and that the Commercial B zones are intended for industrial rather than commercial use.

By utilizing design criteria congestion which may occur as a result of the development already proposed can be minimized. Perhaps the greatest need which becomes evident in this instance is that of providing secondary or parallel access roads so that the demand for using the interchange facility will be lessened. It appears that it may also be necessary to arrange an agreement between the various industrial employers in this vicinity so that the impact of each of their work shifts will not occur at the same time. In other words, some system of staggered work shifts should be worked out between the various employers at the interchange. The present nature of the commercial development which has occurred or is proposed to occur in this interchange is considerably less than that which would achieve the maximum traffic generating capacity. Design standards applied to commercial development in this area could help alleviate the potential congestion which appears to be eminent at this interchange. Perhaps some land zoned in excess of demand should be returned to its former category.

It becomes obvious from this analysis that the potential traffic generation in this area already will exceed the capacity of the interchange. As a consequence, recommendations for further rezoning should be held in abeyance until the exact development standards for each of these proposed commercial and industrial facilities have been determined. It is altogether possible that the actual traffic generating capacity of these facilities is less than the potential indicated by the standards. However, at the present time, this is not known and further zoning of commercial and industrial facilities in this area would only serve to allow even more congestion. As was originally pointed out, the major restriction to capacity of the interchange is the point of conflict between the interchange ramp and the local road, in this case Lovell Road. One further action which could help alleviate the potential congestion in this area is an improvement in Lovell Road serving the potential growth area. This would increase the ramp capacity at this point and decrease the total amount of potential congestion.

CHAPTER VIII

LIMITATIONS

Although it is believed that the general methodology utilized in developing this study and the recommendations and conclusions which follow are of considerable value and have considerable validity, certain limitations and restrictions must be kept in mind when the application of these recommendations is used for the development of land use controls at interchange areas.

The statistical information provided in Chapters II and III is severely limited by the lack of data available. Although it is believed that this report incorporated a larger volume of data and an examination of a greater number of parcels of land than other studies, there appears to be significant gaps in the data which has been analyzed. It is believed that had more data been available the curves shown in Chapter II would more closely proximate the statistical normal curve with a right-hand skew than is actually the case. It is also possible to question the validity of the method of categorizing land as rural, suburban, and urban. In analyzing the change in land use the number of parcels available for analysis in the urbanized areas of central cities was severely limited. Although a hundred percent of the samples indicated a change to commercial use, there appears to be an extreme sparsity of information for this particular category. It is believed that the conclusions arrived at in Chapters II and III, through analysis of the economic change in land values and the analysis of change in land use, is valid. However, the gaps noted in the availability of information do tend to limit the value of this analysis.

The traffic data arrived at, through the bibliographic research in Chapter III, suggests methods for specific allocations of traffic capacities for expressway and interchange ramps and at the same time suggests methods for determining the amount of congestion or capacity for excess traffic. At the same time, some methods are suggested for determining the traffic generating capacities of specific land uses which may tend to congregate in the vicinity of interchanges. A serious limitation is developed in the application of this study, inasmuch as the data available is insufficient to apply the complex formulas which have been developed through the research material. It is, consequently, difficult to determine excess ramp capacities and potential congestion which may be created by the development of specific land use functions at the interchange areas. Although an attempt was made to utilize information provided by the Tennessee State Highway Department, some of this data is based upon assumed continuation of development trends and the highway engineers, themselves, were not sure that their determination of ramp and interstate capacities at the Lovell Road interchange was correct. This method of determining excess capacities and the traffic generating capacities of specific land use is applicable only when an agency has available to it the means for obtaining this type of information. In most cases, state highway departments will be able to cooperate with planning agencies. However, if local roads are built on the limited access design, it is conceivable that local county highway commissions, local city engineers, or local traffic engineers may not have the necessary background information available to them to determine the amount of congestion, the excess capacities of ramps, and the traffic generating capacities of specific land uses at various interchanges. Ideally, this type of research should be programmed for computer analysis, which further limits the application to those communities which have computer facilities available.

The analysis of legal data provided in Chapter VI, generally speaking, involved preapplication of land use control measures. In other words, it is generally necessary to take the required legal steps prior to the purchase and design of the expressway system. Unfortunately, in most cases, the efforts to control land use occurred after the development of the expressway and, quite frequently, after the construction of an interchange. Consequently, the pressures of development have already occurred prior to the time when legal methods for control are generally exercised. This study, as have several others, indicates that it is necessary to coordinate planning efforts and highway design efforts prior to the construction of the expressway system and the provision of the interchange facilities. In the past, these coordinated efforts have been frustrated substantially by the tendency of state highway departments to dictate the location and construction schedule for any expressway facility. Presently, more stringent requirements for coordination with local planning, in the State of Tennessee at least, helped to develop proper coordinative procedures for future expressway facilities. Unfortunately, however, most of the interstate systems have already been constructed; and the application of these procedures, consequently, is limited.

Finally, the establishment of control by zoning and subdivision type regulations and design criteria ultimately rests with the local public legislative body. In order to provide the most effective means for applying zoning and design criteria, these legislative bodies must be sold upon the need to coordinate the planning for the entire area with the highway planning needed for development of expressway facilities. If the expressway facility and its interchanges are allowed to develop without adequate preplanning, in most cases the pressure of economic gain and the development of this highly accessible land will exert its full force upon the local public legislative body. Consequently, the extreme pressures for rezoning for development; that is, any development, will be very difficult for local councilmen or commissioners to resist. As a result of this, perhaps the major conclusion of this entire report is that the general efforts to determine land use control and future land use development at interchange areas should be considered at a point in time prior to the development of the expressway facility rather than during the expressway planning and construction stage. Even prezoning of interchange areas will not insure that local legislative bodies will not be influenced to amend such zoning when development is imminent. It would appear, therefore, that design control offers the most acceptable solution to problems of development at interchanges.

CHAPTER IX

RECOMMENDATIONS

In order to establish interchange area development which is compatible with the principal function of the freeway, we should consider both the traffic generating potential of the poposed use and the potential for increasing the amount of traffic conflict. Further, consideration should be given to the compatibility of any proposed use with surrounding land uses, as well as its conformity to an overall plan for the community.

It has been shown that the trend in development proximate to freeway interchanges is for high intensity uses, generally commercial in nature. These trends reflect the real estate market and usually do not consider the overall goals or plans for the effect upon the community or effect upon the traffic capacity of the freeway.

The primary recommendation of this report, as specifically related to the Knoxville-Knox County area, is to establish coordinating procedures between the Technical Coordinating Committee of the Overall Transportation Plan, which is responsible for the future plans and programs for highway development, and planning and zoning bodies in this jurisdiction. At present, this coordination would be simple since the Metropolitan Planning Commission is responsible for planning and zoning in both city and county. Expansion of the transportation planning area could change these procedures. In establishing these procedures, any recommendations for modification of the thoroughfare plan should be accompanied by recommendations for zoning for future use of the area. Although this, or similar techniques, would have been more effective if adopted prior to the planning of the interstate system, immediate implementation of these procedures could avoid future problems.

Inasmuch as all local interchanges have been planned by the state highway department and most have been or are being constructed, it is necessary to consider methods for protecting the freeways at the interchange areas which have already been constructed. In many instances, efforts to guide or control land use and development at these access points will be complicated by the fact that the pressures of the market have already taken effect, and the real or presumed value of the land has already increased to reflect its supposed commercial development.

Often, this presumed commercial value at each or any of the interchanges is in direct conflict with the desires of the citizens of the surrounding neighborhood who wish to preserve the residential or agricultural character of the surrounding community. Therefore, inherent conflict is generated when the interchange area is proposed for zoning for its presumed best use.

One of the first questions which must be answered in planning an interchange area concerns itself with the type of land uses which could be allowed at each area. In this regard the local factors and the existing land uses will vary considerably from neighborhood to neighborhood and from interchange area to interchange area; however, it may be possible to draw some general conclusions regarding needs of various types of land uses for these key locations at interchange areas. A confidential interview with planners at Barton, Ashman, and Associates who have been doing interchange area studies for several state highway departments indicated that there is a considerable variety of potential uses which may utilize, to a high degree, the important access qualities of an interchange area. This discussion further indicated that, in any given instance, it is, perhaps, less important what the particular use allowed is to be than is the design of the area surrounding the interchange and that traffic flow to and from the freeway is protected. The overall traffic generator at the interchange may be designed so that it is compatible with the capacity of the ramp system and of the freeway itself.

In considering planning at interchange areas, there are a few general principles which should be made to apply to virtually any type of interchange development.

1. The best use of an area of land at an interchange should be encouraged in terms of the regional economy and should be consistent with maintaining an effective and safe traffic facility. A key to this recommendation is the maintenance of an efficient and a safe traffic facility.

2. Land should be allocated to uses according to their need for location near the interchange and for the benefits which would be provided to interchange traffic.

3. Interchange land should be developed in <u>depth</u> by providing access to interior tracts and discouraging the development of shallow frontages. This can be done by prohibiting direct access to parcels immediately adjacent to interchange ramps and limiting access for a considerable distance from these ramps, as well as by providing frontal roads both parallel to the access road and parallel to the freeway itself.

4. Similar land uses should be grouped to reduce conflicts, preserve land and development values, and to allow the most efficient arrangement of utilities and other essential services. This concept is little different from the concept of arrangement of land uses in any community so that it can best be served by required public services.

5. As far as possible, allocations of land for various uses should be related to a confident market analysis of the growth prospect for the local area.

6. Land use should be of a type that will allow access points and intersections along the cross route to be minimized--particularly in the vicinity of ramp entrances and terminals.

7. The frontage of development away from the cross routes under service drives and local streets should be encouraged.

8. Adequate building setbacks should be provided along the cross route to reduce distractions to motorists, preserve sight distance, and provide for possible future route widening.

9. The physical appearance of interchange areas should be attractive and visually pleasant. Aesthetic values can be enhanced by accentuating points of natural beauty, employing proper safety sign standards which result in orderly arrangement of buildings, providing adequate open space and attractive landscaping, and controlling the size and placement of signs and billboards.

10. Adequate off-street parking and loading areas should be provided for all types of development.

11. Street and ramp capacities should be adequate to serve both through traffic and estimated local generation. An analysis of this recommendation would indicate that the reversal of these procedures is normal practice. In other words, the street and ramp capacities will normally exist before the new land use or the allowed land use is developed; consequently, the traffic generating capacities of the proposed land use should be considered in terms of the ramp capacities and the through capacities of the freeway and of the access road. In

this respect an analysis of excess capacity, as indicated in Chapter V, would be apprbpriate.[1]

12. Wherever possible, traffic moving to local destinations around the interchange should be separated from through traffic by use of separate and special access provision.

Local experience has indicated that there is a high level of demand for highway oriented or road user services; such as, service stations, motels, and restaurants.[2] Since highway oriented or road user services are considerably less available to the motoring public along the route of freeway, as was formally the case along the major arterial highway, the demand for these services at interchange points is extremely high. Interchanges are inherently adapted to highway oriented services and provide a desirable ingress and egress from the major traffic route, although many authorites contend that this form of commercialization at freeway interchanges may work to the detriment of the freeway. In fact, the road user service facility at interchanges perhaps does less to generate additional traffic on a freeway facility than other types of commercial enterprises. The nature of traffic conflict generated by road user services is that of traffic interruption rather than the generation of additional

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[1]Fry, et. al., op. cit.

[2]Dwyne Marble, "User Services and the Demand for Land at Interchange Points," Highway Research Board, Bulletin 288, (Washington: National Research Council, 1961), pp. 25-31.

traffic. It would appear that these road user services have less detrimental effect to the total volume of traffic which may be handled by a given freeway facility, insofar as a freeway ramp and working lanes have the capacity to handle the interruption of traffic required by service facilities. In view of this, there are certain principles which could be applied particularly to highway oriented or road user services.

1. Road user services require a location in proximity to interchanges and preferably should be visible from the roadway. However, excessive and unattractive signing should be avoided.
2. They should be concentrated in one or two quadrants to reduce unnecessary travel on the cross route, as well as to limit the number of access points required and to provide maximum convenience to the freeway motorists.
3. Motel facilities, in particular, should be set back well away from noise and fumes of the highway. Under normal conditions the most desirable locations for interchange road user services will be those which have the least number of left turns in conflict with cross route traffic engendered by freeway traffic going to and from these areas. Access points to these services, however, should not be located too near ramp terminals.

As has been pointed out in the initial section of this report, the principal demand for land use at an interchange area is for commercial enterprises. As such, consideration must be given to guiding principles for commercial development at an interchange area. Some of these principles are as follows:

1. Major commercial developments, such as regional shopping centers, merit locations near but <u>not</u> immediately adjacent to interchanges. Large scale commercial developments of this type are likely to be found in large urbanized areas. Special analysis should be made of the probable traffic impacts of these developments. In all cases, secondary access to these developments from another major street is desirable. Major commercial developments of this type are significant traffic generators and can have a decidedly adverse influence upon the capacity of the freeway and ramp system to carry out its major function.

2. Community oriented commercial activities have relatively little need for sites adjacent to interchanges. Preferably, they should be located well away from the interchange and associated with the major area or direction of residential development.

3. Commercial developments should be grouped with and located on service roads from local streets with direct access to the cross route kept to a minimum.

As evidenced by the location of the Ceil Heat Corporation at the Lovell Road interchange and the proposed development of the RobertShaw Fulton plant in another quadrant of the same interchange area, industrial development also tends to seek interchange areas. There can be certain basic principles which should guide industrial developments of this type, as follows:

1. Large level sites with adequate utilities should be provided for industrial activities. In some cases, access to a railroad may be desirable.
2. Industrial sites should be near but not necessarily immediately adjacent to an interchange. If the advertising value of the site adjacent to and visible from the freeway is important, access should be provided via a service road or a local street. An example of this type of development can be seen at the Mabry-Hood interchange where a small, light industrial area has grown along the service road to the south of the interstate system.
3. Developments attracting significant traffic should be located on level sites which are approximately the same grade or elevation as the cross route.
4. Industries releasing large numbers of employees at certain hours should be subject to special traffic analysis to evaluate their impact upon local traffic facilities. Secondary access to another major street is extremely desirable. Industries of this type are the significant traffic generators which, like major shopping centers, could act as a serious detriment to the overall capacity of the freeway system to perform its major function--to move traffic.

In analyzing the growth pattern of residential development in west Knox County, we readily find that residential areas have a marked tendency to develop close to an interchange with the freeway system. While residential development should have little need for specific location near an interchange, it may be acceptable in an interchange area where there is no anticipated demand for a more appropriate use. However, a residential development will frequently grow along an access road a short distance from an interchange facility. The nature of the interstate itself, or the freeway itself, will serve as a deterrent for residential type development immediately adjacent to the interchange or to the freeway facility. However, this type of development may be appropriate to protect the interchange area from other activities that would detract from the desired efficiency of the interchange. In general principles aiding development of a residential area will be more related to the access road than to the freeway itself. Some of these principles are as follows:

1. Access and frontage should be oriented to service drives or local streets rather than directly to the access route itself.
2. Buffer strips or planted areas should be provided between residential areas and major cross streets. Similar buffer areas should be developed between residences and adjacent commercial or industrial activities. The development of these buffers is extremely important, in that the land area immediately adjacent to the interchange itself and bordering the freeway is usually to be developed for commercial

or industrial facilities; whereas, the area a short distance away from the interchange is most frequently developed for residential uses. The direct conflict between these uses must be avoided by a provision of adequate buffer strips.

3. Other principles, such as adequate lot size, side yards, and other design features, which are normally considered in the development of the residential areas should, of course, be applied regardless of the location of the residential area. These principles certainly should apply to residences in the vicinity of interchanges.

It is recommended that the City of Knoxville and Knox County pass a joint regulation which would govern the development of interchange area facilities. This regulation should contain specific provisions for a planned development of industrial, residential, and commercial facilities at interchange areas. These planned facilities would be very similar to the planned residential, planned industrial park, or planned shopping center facilities currently considered in the City zoning regulations. In general, the ordinance or regulation should be enacted for the purpose of promoting public health, safety, and general welfare and promoting highway safety and efficiency by protecting the traffic operation of interchanges in the intersecting highways through:

1. Regulation of setbacks to allow safe site distance and prevent encroachment upon the intersecting highway.

2. Control of the location and number of points of access from the abutting roads and driveways to reduce the number and severity of potential traffic conflicts.

3. By regulating the type and arrangement in density of traffic producing land uses.

Such regulations could provide for the orderly development of lands adjacent to interchanges through controlling the type of arrangement and site design of land uses, requiring adequate internal circulation facilities, and by providing for review of site utilities systems. In general, some standards should be set for the development of properties in the vicinity of interchanges and along abutting access routes. Some suggested standards for development at an interchange are as follows:

1. A minimum setback line from the right-of-way of the intersecting highway should be 75 feet. This would allow adequate site distance from the freeway facility and from the intersecting route and avoid conflict at the interchange. Where frontage roads are provided, the setback could be reduced to approximately 40 feet; further consideration could be given to reducing this figure depending upon the distance the frontage road extends from the intersecting access road.

2. Access points from the abutting property to an intersecting highway should be permitted only at designated points. Such access points should be located not closer to the freeway ramp than 500 feet for

road user services, such as motels, restaurants, or service stations. For major commercial facilities, such as shopping centers, this distance should be extended to a minimum of 1,000 feet. The 1,000-foot figure should also be used for industrial developments. Since residential facilities seldom provide a steady flow of traffic, the development of residential facilities could conceivably have access to an intersecting road at a point as close as 500 feet to the interchange. However, it is unlikely that residential development will desire to locate this close to the freeway.

3. Dangerous jogs and poor alignment should be avoided in any access points to the intersecting road. Regulations similar to those in the Knox County Subdivision Regulations should be adopted so that access points on opposite sides of the intersecting roadway will line up as closely as possible or be separated by a minimum of 125 feet.

4. Wherever practical, only one point of access to each two parcels, to be located at their common property line, should be permitted.

A study conducted by Barton, Ashman, and Associates indicates that design may be established to determine proper spacing between interchange ramp terminals and crossroad access points.[3] The design takes the form of complicated equations which can be solved for various traffic volumes in route

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[3]Richard C. Gern and Harvey R. Joiner, Cross Route Access Design in Interchange Areas, (Barton, Ashman, and Associates, January, 1964).

speed values. The recommendations made in the foregoing standards are empirical and do not consider these complicated equations. However, it is possible to arrive at fairly specific distances for each individual instance rather than establishing empirical values for the area as a whole.

In the conclusion, the development of the interchange areas at the Knoxville-Knox County interstate and freeway systems should depend on the land use factors at each of the interchanges. The varying conditions may warrant a variety of decisions; however, a set of standards should be made to apply to any permitted land use at any interchange area. These standards should be contingent, not only upon the particular use and its compatibility with the highway facility in the surrounding area, but also upon the design criteria set forth for the cross route access and the internal circulation system of the proposed development for the area.[4] Specific standards for access to the intersecting highways should be adopted and a specific regulation for the development of interchange areas should be enacted by the City and by the County. Prior to any consideration of future highway development, the Highway Transportation Coordinating Committee should work concurrently with the Knoxville-Knox County Metropolitan Planning Commission to develop

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[4]Review of all rezoning applications in the vicinity of interchanges should consider not only the compativility of land uses but also traffic generating capacities of the proposed use and the ability of the interchange to handle this additional traffic. All staff reports to the planning commission should include this traffic data.

recommendations for potential future land use and specific recommendations for zoning at any highway interchange area. If these procedures are carried out, the future highway development in the Knox County area will, hopefully, avoid the numerous pitfalls which are evident in the existing system.

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Walsh, S. P. "Some Effects of Limited Access Highways on Adjacent Land Use," Highway Research Board, Bulletin 227. Washington: National Research Council, 1959. Pages 78-82.
An explanation of the relationship between limited-access highways and adjacent land use.

X Marks the Spot: Interchange Area Development. H.O.P. Committee of Ohio.
An outline for sound development of interchange changes. N.D.

APPENDIX

APPENDIX A: STATISTICAL TABLES FOR LAND VALUE ANALYSIS

TABLE I

RURAL LAND VALUES BEFORE INTERCHANGE CONSTRUCTION

Position of Intervals	Interval	Frequency	Range Midpoint	fx	x'	fx'	fx'^2
1	70 - 99	33.0	84.5	2,788.50	-7	-231.0	1,617.0
2	100 - 129	97.0	114.5	11,106.50	-6	-582.0	3,492.0
3	130 - 159	162.8	144.5	23,524.60	-5	-814.0	4,070.0
4	160 - 189	126.8	174.5	22,126.60	-4	-507.2	2,028.8
5	190 - 219	310.5	204.5	63,497.25	-3	-931.5	2,794.5
6	220 - 249	232.2	234.5	54,450.90	-2	-464.4	928.8
7	250 - 279	39.0	264.5	10,315.50	-1	-39.0	39.0
8	280 - 309	174.5	294.5	51,390.50	0	-	-
9	310 - 339	221.3	324.5	71,811.85	1	221.3	221.3
10	340 - 369	86.3	354.5	29,816.65	2	172.6	345.2
11	370 - 399	15.0	384.5	5,767.50	3	45.0	135.0

TABLE I (continued)

Position of Intervals	Interval	Frequency	Range Midpoint	fx	x'	fx'	fx'^2
12	400 - 429	198.7	314.5	82,361.15	4	794.8	3,179.2
13	430 - 459	93.0	444.5	41,338.50	5	465.0	2,325.0
14	460 - 489	2.0	474.5	949.00	6	12.0	72.0
15	490 - 519	60.1	504.5	30,320.45	7	420.7	2,944.9
16	520 - 549	72.1	534.5	38,537.45	8	576.8	4,614.4
17	550 - 579	3.4	564.5	1,919.35	9	30.6	275.4
18	580 - 609	57.4	594.5	34,124.30	10	574.0	5,740.0
19	610 - 639	32.0	624.5	19,984.00	11	352.0	3,872.0
25	790 - 819	18.2	804.5	14,641.90	17	309.4	5,259.8
26	820 - 859	5.9	834.5	4,923,55	18	106.2	1,191.6
28	880 - 909	4.2	894.5	3,756.90	20	84.0	1,680.0

TABLE I (continued)

Position of Intervals	Interval	Frequency	Range Midpoint	fx	x'	fx'	fx'^2
31	970 - 999	16.0	984.5	15,752.00	23	368.0	8,464.0
		2,061.4		624,880.15		826.3	

N = 2,061.4

$\overline{X}$ = 303.14

Mdn = 286.51

σ = 140.7

Sk = 0.31

TABLE II

RURAL LAND VALUES AFTER INTERCHANGE CONSTRUCTION

Position of Intervals	Interval	Frequency	Range Midpoint	fx	x'	fx'	fx'^{2}
1	50 - 149	84.7	99.5	8,427.65	-7	-592.9	4,150.3
2	150 - 249	155.2	199.5	30,962.40	-6	-931.2	5,587.2
3	250 - 349	474.0	299.5	141,963.00	-5	-2,370.0	11,850.0
4	350 - 449	364.8	399.5	145,737.60	-4	-1,459.2	5,836.8
5	450 - 549	62.0	499.5	30,969.00	-3	-186.0	558.0
6	550 - 649	102.5	599.5	61,448.75	-2	-205.0	410.0
7	650 - 749	72.1	699.5	50,433.95	-1	-72.1	72.1
8	750 - 849	187.4	799.5	149,826.30	0	0	0
9	850 - 949	18.2	899.5	16,370.90	1	18.2	18.2
10	950 - 1,049	108.5	999.5	108,445.75	2	217.0	434.0
11	1,050 - 1,149	110.9	1,099.5	121,934.55	3	332.7	998.1

TABLE II (continued)

Position of Intervals	Interval	Frequency	Range Midpoint	fx	x'	fx'	fx'^{2}
13	1,250 - 1,349	10.8	1,299.5	14,034.60	5	54.0	270.0
14	1,350 - 1,449	17.5	1,399.5	24,491.25	6	105.0	630.0
17	1,650 - 1,749	6.0	1,699.5	10,197.00	9	54.0	486.0
18	1,750 - 1,849	11.7	1,799.5	21,054.13	10	117.0	1,170.0
19	1,850 - 1,949	26.0	1,899.5	49,387.00	11	286.0	3,146.0
20	1,950 - 2,049	15.6	1,999.5	31,192.20	12	187.2	2,246.4
21	2,050 - 2,149	1.2	2,099.5	2,519.40	13	15.6	202.8
23	2,250 - 2,349	17.0	2,299.5	39,091.50	15	289.0	4,913.0
25	2,450 - 2,549	2.0	2,499.5	4,999.00	17	34.0	578.0
31	3,050 - 3,149	2.1	3,099.5	6,508.5	23	48.3	1,110.9
32	3,150 - 3,249	1.4	3,199.5	4,479.30	24	33.6	806.4
35	3,450 - 3,549	7.7	3,499.5	26,946.15	27	207.9	5,613.3

TABLE II (continued)

Position of Intervals	Interval	Frequency	Range Midpoint	fx	x'	fx'	fx'^2
36	3,550 - 3,649	27.5	3,599.5	98,986.25	28	770.0	21,560.0
38	3,750 - 3,849	12.9	3,799.5	49,013.55	30	387.0	11,610.0
60	5,950 - 6,049	5.0	5,999.5	35,397.05	52	306.8	15,953.6
61	6,050 - 6,149	2.3	6,099.5	14,028.85	53	121.9	6,461.0
64	6,350 - 6,499	5.8	6,399.5	37,117.10	56	324.8	18,188.8
74	7,350 - 7,499	9.0	7,399.5	66,595.50	66	594.0	39,204.0
75	7,450 - 7,549	5.0	7,499.5	37,497.50	67	335.0	22,445.0
79	7,850 - 7,949	4.3	7,899.5	33,967.85	71	305.3	21,676.3

N = 2,062.0 o = 1,038

$\overline{X}$ = 762.86 Sk = 1.014

Mdn = 419.10

TABLE III

SUBURBAN LAND VALUES BEFORE INTERCHANGE CONSTRUCTION

Position of Intervals	Interval	Frequency	Range Midpoint	fx	x'	fx'	fx'^{2}
1	0 - 199	78.2	99.5	7,780.90	-5	-391.0	1,955.0
2	200 - 399	78.4	299.5	23,480.80	-4	-313.6	1,254.4
3	400 - 599	18.2	499.5	9,090.90	-3	-54.6	163.8
4	600 - 799	71.2	699.5	49,804.40	-2	-142.4	284.8
6	1,000 - 1,199	14.5	1,099.5	15,942.75	-1	-14.5	74.5
7	1,200 - 1,399	25.6	1,299.5	33,267.20	0	0	0
8	1,400 - 1,599	249.7	1,499.5	374,425.15	1	249.7	249.7
9	1,600 - 1,799	19.7	1,699.5	33,480.15	2	39.4	78.8
10	1,800 - 1,999	3.0	1,899.5	5,698.50	3	9.0	27.0
11	2,000 - 2,199	12.6	2,099.5	26,453.70	4	50.4	201.6
13	2,400 - 2,599	6.3	2,499.5	15,746.85	6	37.8	226.8

TABLE III (continued)

Position of Intervals	Interval	Frequency	Range Midpoint	fx	x'	fx'	fx'^2
17	3,200 - 3,399	1.4	3,299.5	4,619.30	10	14.0	140.0
23	4,400 - 4,599	1.9	4,499.5	8,549.05	16	30.4	486.4
24	4,600 - 4,799	1.3	4,699.5	6,109.35	17	22.1	375.7
25	4,800 - 4,999	4.8	4,899.5	23,517.60	18	86.4	1,555.2
32	6,200 - 6,399	2.8	6,299.5	17,638.60	25	70.0	1,750.0
38	7,400 - 7,599	1.1	7,499.5	8,249.45	31	34.1	1,057.1
39	7,600 - 7,799	1.3	7,699.5	10,009.35	32	41.6	1,331.2
40	7,800 - 7,999	2.2	7,899.5	17,899.50	33	72.6	2,395.8
43	8,400 - 8,599	1.1	8,499.5	9,349.45	36	39.6	1,425.6
45	8,800 - 8,999	1.7	8,899.5	15,129.15	38	64.6	2,454.8

N = 597.1 o = 1,084.8 Sk = 0.61

$\bar{X}$ = 1,199.95 Mdn = 1,421.58

TABLE IV

SUBURBAN LAND VALUES AFTER INTERCHANGE CONSTRUCTION

Position of Intervals	Interval	Frequency	Range Midpoint	fx	x'	fx'	fx'^{2}
1	0 - 499	51.6	249.5	12,874.20	-5	-258.0	1,290.0
2	500 - 999	66.5	749.5	49,841.75	-4	-266.0	1,064.0
3	1,000 - 1,499	13.5	1,249.5	16,493.40	-3	-40.5	121.5
4	1,500 - 1,999	82.2	1,749.5	143,808.90	-2	-164.4	328.8
5	2,000 - 2,499	267.2	2,249.5	601,066.40	-1	-267.2	267.2
6	2,500 - 2,999	24.8	2,749.5	68,187.60	0	0	0
7	3,000 - 3,499	6.1	3,249.3	19,822.00	1	6.1	6.1
8	3,500 - 3,999	28.8	3,749.3	107,985.60	2	57.6	115.2
9	4,000 - 4,499	2.0	4,249.5	8,499.00	3	6.0	18.0
10	4,500 - 4,999	10.3	4,749.5	48,919.85	4	41.2	164.8
11	5,000 - 5,499	3.5	5,249.5	18,373.25	5	17.5	87.5

TABLE IV (continued)

Position of Intervals	Interval	Frequency	Range Midpoint	fx	x'	fx'	fx'^2
12	5,500 - 5,999	1.3	5,749.5	7,474.35	6	7.8	46.8
13	6,000 - 6,499	4.8	6,249.5	29,997.60	7	33.6	235.2
14	6,500 - 6,999	0.6	6,749.5	4,049.70	8	4.8	38.4
16	7,500 - 7,999	2.2	7,749.5	17,049.90	10	22.0	220.0
18	8,500 - 8,999	1.4	8,749.5	12,249.30	12	16.8	201.6
23	11,000 - 11,499	1.1	11,249.5	12,374.45	17	18.7	317.9
24	11,500 - 11,999	0.8	11,749.5	9,399.60	18	14.4	259.2
26	12,500 - 12,999	1.9	12,749.5	24,224.05	20	38.0	760.0
27	13,000 - 13,499	2.4	13,249.5	31,798.80	21	50.4	1,058.4
29	14,000 - 14,499	1.8	14,249.5	25,649.10	23	41.4	952.2
31	15,000 - 15,499	2.4	15,249.5	36,598.80	25	60.0	1,500.0
33	16,000 - 16,499	1.9	16,249.5	30,874.05	27	51,3	1,385.1

TABLE IV (continued)

Position of Intervals	Interval	Frequency	Range Midpoint	fx	x'	fx'	fx'^2
36	17,500 - 17,999	1.7	17,749.5	30,174.15	30	51.0	1,530.0
39	19,000 - 19,499	3.1	19,249.5	59,673.45	33	102.3	3,375.9
41	20,000 - 20,499	2.2	20,249.5	44,548.90	35	77.0	2,695.0
45	22,000 - 22,499	4.8	22,249.5	106,797.60	39	187.2	7,300.8
55	27,000 - 27,499	2.2	27,249.5	59,948.90	49	107.8	5,282.2
75	37,000 - 37,499	2.2	37,249.5	81,949.90	69	151.8	10,474.2

N = 595.30

$\overline{X}$ = 2,752.81

o = 4,146

Mdn = 2,156.9

Sk = 0.429

TABLE V

URBAN LAND VALUES BEFORE INTERCHANGE CONSTRUCTION

X Value	Frequency	fX	$X - \bar{X}$ x	fx	fx^2
906	60.8	55,084.8	-1,650	-100,320.0	165,528,000.0
1,045	18.7	19,451.5	-1,511	-28,255.0	42,694,362.7
1,275	1.8	2,295.0	-1,281	-2,305.8	2,953,729.8
1,333	1.4	1,866.2	-1,223	-1,712.2	2,094,020.6
1,500	1.2	1,800.0	-1,056	-1,267.2	1,338,163.2
1,737	1.0	1,737.0	-819	-819.0	670,761.0
2,000	5.3	10,600.0	-556	-2,946.0	1,638,420.8
2,177	4.3	9,361.1	-379	-1,629.7	617,656.3
3,334	6.8	22,671.1	778	5,290.4	4,115,931.2
3,408	0.9	3,067.2	852	766.8	653,313.6
6,806	6.1	41,516.6	4,250	25,925.0	110,181,250.0

TABLE V (continued)

X Value	Frequency	fX	$X - \bar{X}$ x	fx	fx^2
8,706	2.0	17,412.0	6,150	12,300.0	75,645,000.0
10,833	1.0	10,833.0	8,277	8,277.0	68,508,729.0
11,411	0.5	5,705.5	8,855	4,427.5	39,205,512.5
17,206	2.8	48,176.8	14,650	41,020.0	600,943,000.0
20,206	1.1	22,733.7	18,111	19,922.1	360,809,153.1
23,189	0.2	4,637.8	20,633	4,126.6	85,144,137.8
43,750	0.5	21,875.0	41,194	20,597.0	848,472,818.0

N = 116.4

$\bar{X}$ = 2,556

Mdn = 906

o = 4,551.35

Sk = 1.08

TABLE VI

URBAN LAND VALUES AFTER INTERCHANGE CONSTRUCTION

X Value	Frequency	fX	$X - \bar{X}$ x	fx	fx^2
3,329	1.2	3,994.8	-7,107	8,528.4	60,611,338.8
3,443	1.8	6,197.4	-6,993	12,587.4	88,023,688.2
3,533	18.7	66,067.1	-6,903	129,086.1	891,081,348.3
4,167	.1	416.7	-6,269	626.9	3,930,036.1
4,815	1.4	6,741.0	-5,621	7,869.4	44,233,897.4
5,000	.1	500.0	-5,536	553.6	3,064,729.6
7,293	60.8	443,414.4	-3,143	191,094.4	600,609,699.2
8,928	2.8	2,499.8	-1,508	4,222.4	6,367,379.2
11,235	5.3	59,544.5	799	4,234.7	3,383,525.3
11,827	6.1	72,144.7	1,391	8,485.1	11,802,774.1
11,863	4.3	51,010.9	1,427	6,136.1	8,756,214.7

TABLE VI (continued)

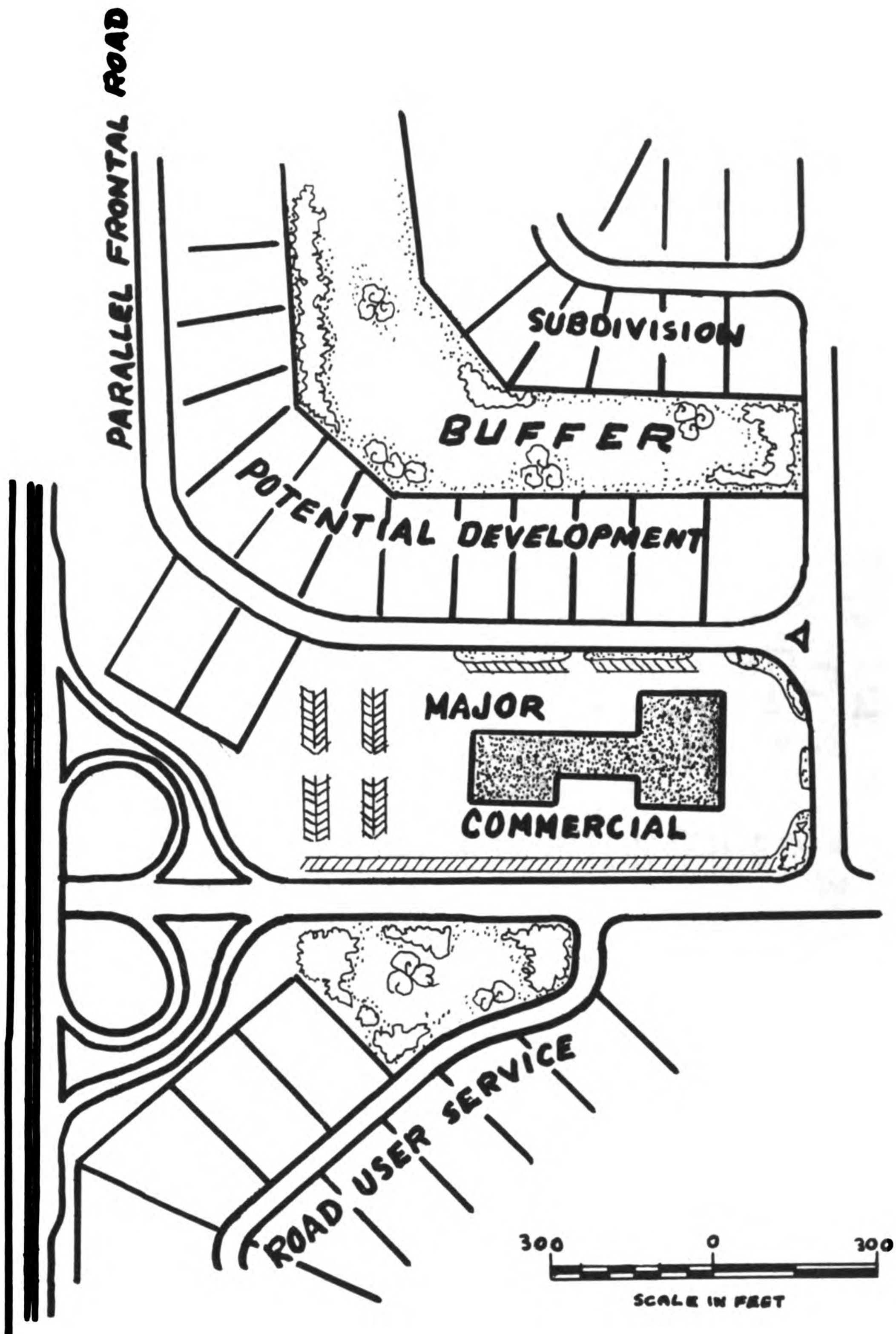
X Value	Frequency	fX	$X - \bar{X}$ x	fx	fx^2
15,295	.9	13,765.5	4,859	4,373.1	21,248,892.9
21,500	1.0	21,500.0	11,064	11,064.0	122,412,096.0
25,532	.5	12,766.0	15,096	7,548.0	113,944,608.0
28,805	6.8	195,874.0	18,369	124,909.2	2,294,482,076.6
47,368	1.0	47,368.0	36,932	36,932.0	1,363,972,624.0
48,181	1.1	52,999.1	37,745	41,419.5	1,567,153,527.5
55,516	2.0	111,032.0	45,080	90,160.0	4,064,412,800.0
93,750	.5	46,875.0	83,314	41,647.0	3,470,611,298.0

N = 116.4 Mdn = 7,293

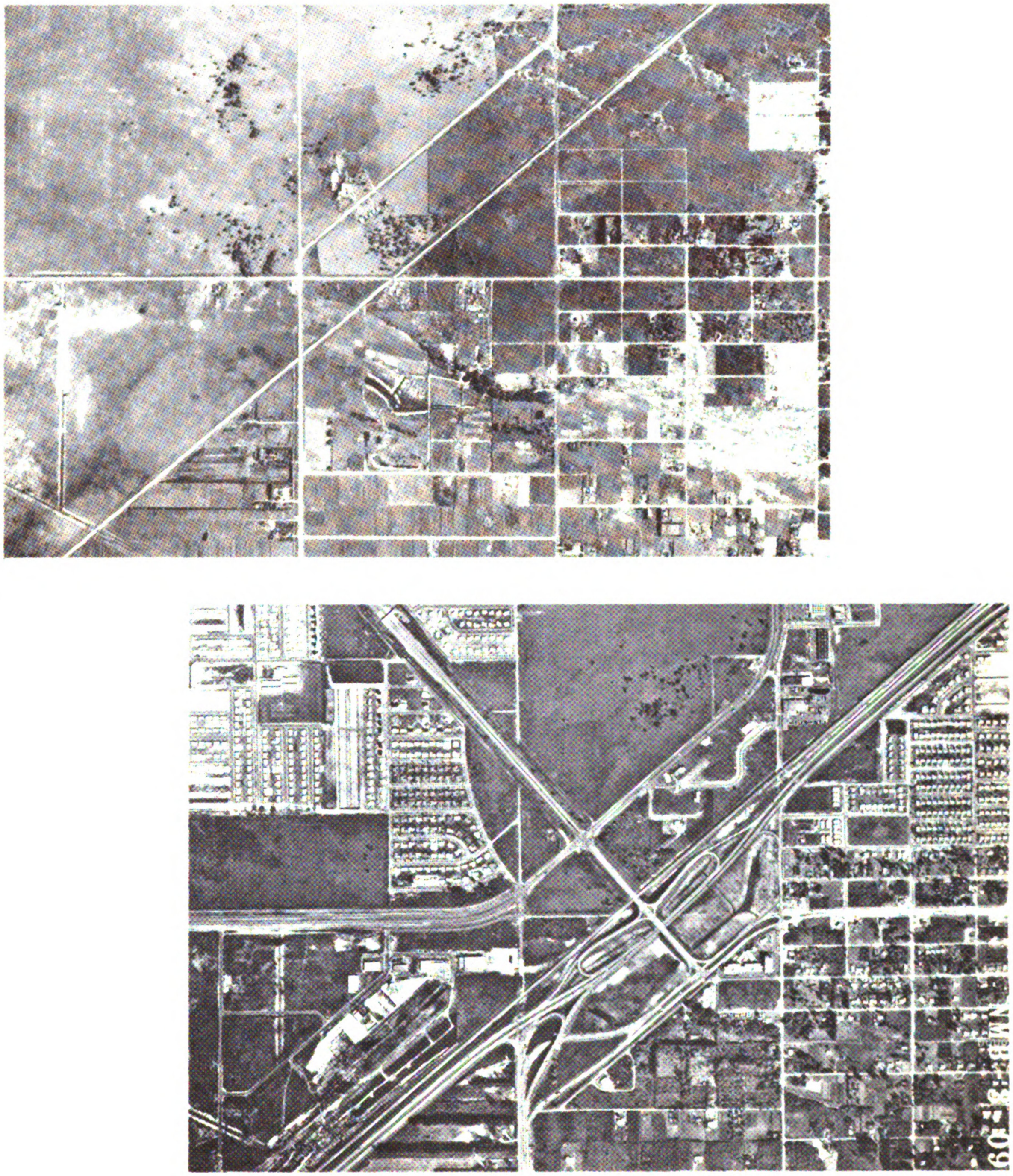
$\bar{X}$ = 10,435.6 Sk = 0.84

o = 11,252

APPENDIX B: DIAGRAMATIC EXAMPLE OF DESIGN
AT AN INTERCHANGE AREA

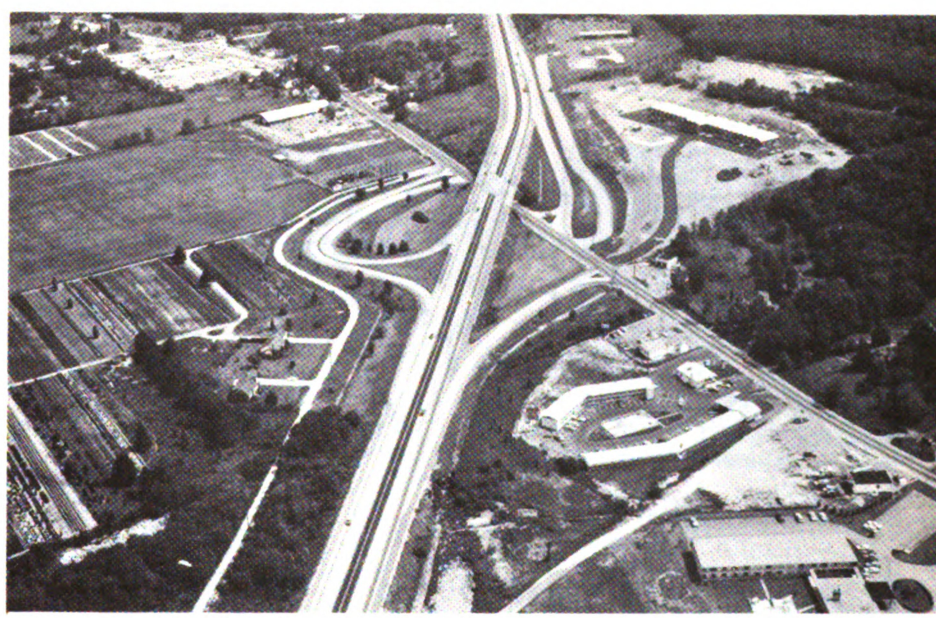


APPENDIX C: PHOTOGRAPHS OF INTERCHANGES



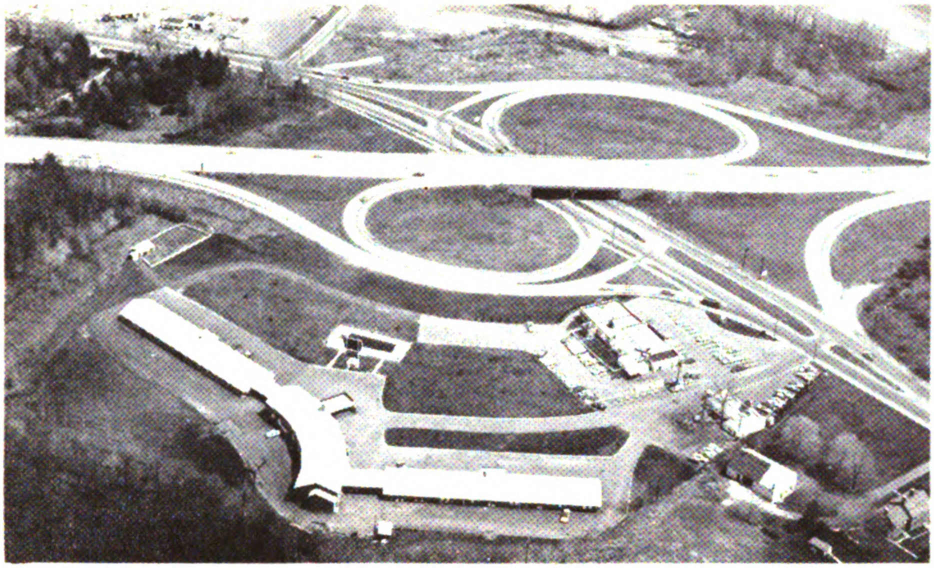
Extensive Urban Development Following Provision of an Expressway Facility

Photographs courtesy Florida State Highway Department



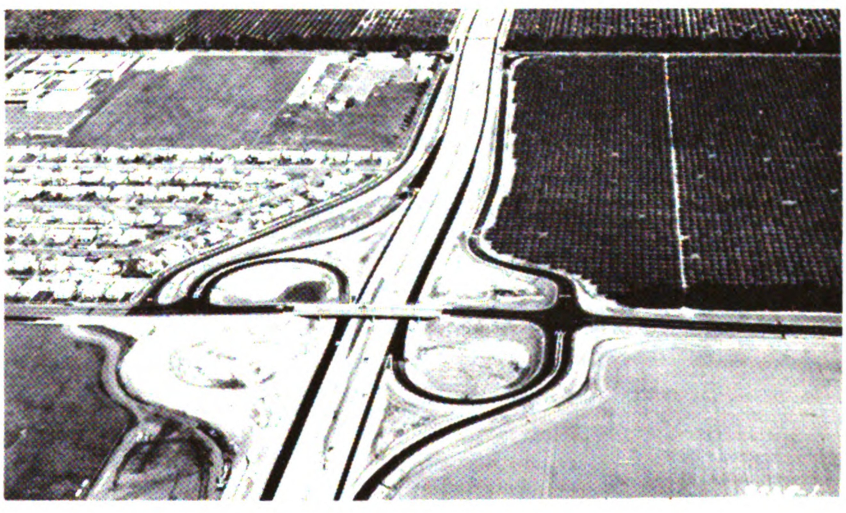
Road User Motel and Service Station Facilities Developed in Three Quadrants After Construction of Interchange

Photographs courtesy Connecticut State Highway Department



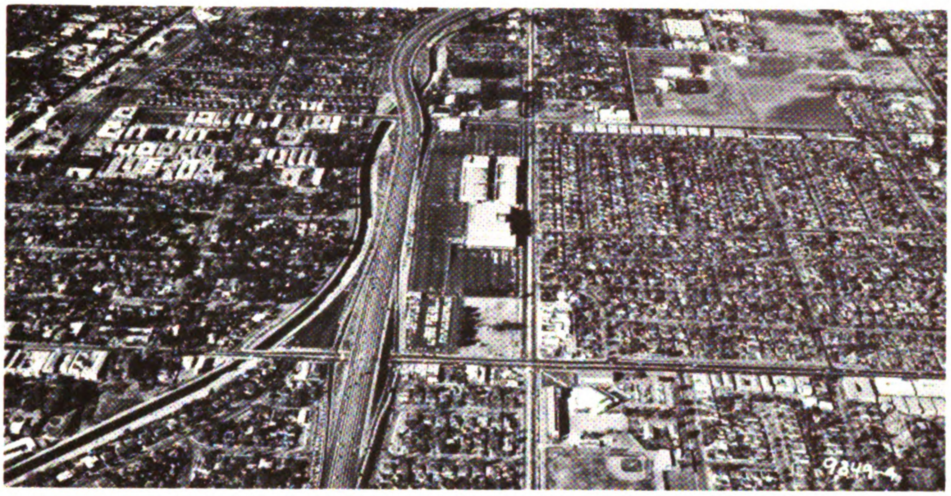
Motel and Retail Facilities Developed at Interchange

Photograph courtesy Connecticut
State Highway Department



Citrus Groves Replaced by Residential Subdivision

Photograph courtesy California
State Highway Department



Shopping Center Replaces Residential Neighborhood in
Highly Urbanized Area at Expressway Interchange

Photograph courtesy California
State Highway Department

Residential Development Near Interchange; Multiple
Dwellings Adjacent to Ramp; Commercial Facilities at
Ramp Termini

Photograph courtesy Ohio State
Highway Department