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ABSTRACT

Since the service requirements of a utility depend on the distribution of population and land use in the service area, the planning for future requirements depends on accurate projections of future distributions. This systems approach model organizes land use data as an aid to facility planning. Included as variables are residential, commercial, governmental, and residual land areas, and employments, population density, and urban change rates. Computer program specifications, miscellaneous data inputs, and debugging hints are also included. (RA)

Preliminary

TECHNICAL REPORT

LAND USE SYSTEMS MODEL

February, 1971

For

SOUTHEASTERN VIRGINIA PLANNING DISTRICT COMMISSION

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TECHNICAL REPORT

LAND USE SYSTEMS ANALYSIS MODEL

1. GENERAL DESCRIPTION

The present and future distribution of the population and land use are basic inputs to the systems analysis of a utility. Where the people reside and where their employment and other activities are located provide the location of the demand for services. In the case of a water utility, the distribution system is particularly sensitive to these factors, but the basic water supply is somewhat less sensitive due to the heavy reserves needed to accommodate wet industries.

With the above requirement in mind, the population and land use component or sub-system of the utility analysis system was prepared. The subsystem was prepared in the format of a land use systems analysis model because of the large number of analysis areas, the need for forecasts for intermediate years, and to allow for easily changing the assumptions as applied to all or part of the service area.

The land use systems analysis model is a generalized configuration designed to allow for a manageable manipulation of a wide range of assumptions in the location and magnitude of urban growth and change. It has been simplified through the generalization of data so as to encourage successive simulations both to inputting differing opinions as to the metropolitan area's growth configuration and to test the effect of various combinations of development policies. Care was taken to assure that the model is not so generalized or simplified as to simplify away the basic analytical problem.

This model does not complete with or substitute for an information system designed to provide timely data on the location of the existing land use population and employment. Rather the model organizes and generalizes such data and uses it as a basis for forecasting future patterns. The model is not deterministic and does not compete with deterministic models such as a "gravity model". All values entered and all outputs are the result of direct judgements of a planner. The computer acts as a convenient and speedy compiler, manipulator, tabulator and report writer.

Some Characteristics of the Model

The model deals with relatively small increments of the land in the urban area, usually subdivisions of Census Tracts. Inputs for the current year are: the area of the segment; the current population; current housing units;

gross residential land in use; commercial, service and governmental employment; gross land in use for those uses; industrial and similar employment; gross land in use for those uses; and residual and open uses of land.

Future values are entered for the land quantities as envisioned at a state of maturity or for fifty years hence. Population and employment are computed from the land values by use of a density per acre. The maturity values are interpolated back to the current values by the computer for five year increments based on straight line development curves inputted as a date of beginning and a date of ending of the basic development push. Inputs for each segment are listed to facilitate the entry of alternative data. Summaries are provided for each census tract, for each utility analysis area, for each political jurisdiction and for the region as a whole. Further detail and conventions used in handling the data are explained later in this report.

The Concept of Maturity

It is recognized that all parts of the metropolitan area are in a constant state of flux. Some portions are relatively stable while others are changing rapidly as measured in a real estate time frame. Well located farm land can become urbanized within a very few years of its market ripeness. Other portions present an entirely different situation such as a slum area where densities are being drastically reduced because of social, economic and government action pressures. Within the analysis period these areas can be expected to be rebuilt as residential, commercial or industrial areas or viable combinations of these. Stable land use areas can be expected to go through cycles of obsolescence and renewal. A good residential neighborhood can be expected to experience cycles of younger and older populations with resulting changes in total population and numbers of school children and at the end still be considered a desirable neighborhood.

The forecasting attribute of the model always portrays a segment of the metropolitan area at a state of optimum development. Thus when summed, the growth curve will always exceed the average metropolitan growth curve. Some areas of good potential will "make it" and some will not. It is difficult, if not impossible to identify the industrial district or residential district which will not reach its potential for reasons which are not obvious from current observation. Additionally, the model does not account for decreases in population to be experienced by residential areas on the down phase of their cycle when it is most likely that they will be rebuilt as residential and not phase out in favor of another land use. To account for such occurrences would require a detailed curve for each area analyzed and would complicate the model to such an extent as to seriously endanger its continued utility as an analytical tool.

Additionally, as a facility design tool, the model must treat each area relative to its optimum development. Most facilities have an exceptionally long life and their capacities cannot be altered every few years to fit new demand patterns. Prudent design decisions usually are based on the top side of a neighborhood development curve.

Future populations portrayed in the model must be interpreted as design populations for the individual segments. The summation of the small area design populations only approximates the projected total population. This summation will always be above a straight line projection for the metropolitan area as a whole because the interpolation technique ignores the short-run decreases in population as the neighborhoods go through their ageing cycles.

2. DATA INPUTS

LOCATOR AND CONTROL FIELDS

Data Field 1, Columns 1 through 5.
Card Serial Number (First Card)

The data pertaining to each statistical area is contained on a pair of cards. The first card of the pair has the number 1 in column 5 and the second card of the pair has the number 2 in column 5. Cards are numbered serially in columns 1 through 4.

Data Field 2, Columns 6 through 11.
Census Tract Number

The Census Tract is an important control area for which periodic data on housing units and population is provided. A summary is prepared by Census Tract, and all smaller areas are additive to tracts.

Data Field 3, Columns 12 through 16.
Utility Analysis Area

Data must be grouped conveniently for input into the utility analysis subsystem, in this case the Flow Net Analysis System. In every case the utility analysis areas are accumulations of existing statistical areas. Entries to the left of the field to allow for subsequent division if needed.. First digit identifies the political jurisdiction: 1, Norfolk; 2, Portsmouth; 3, Virginia Beach; 4, Chesapeake; 5, Suffolk; 6, Nansemond Co. Isle of Wight & Southampton Cos. are handled on an ad hoc basis.

Data Field 4, Columns 17 through 21.
Southeast Virginia Planning District Commission Statistical Area Number

These areas are the least common denominator of all of the currently used statistical areas in the planning jurisdiction (excepting of course the Census block statistics). Their extent of fragmentation is largely in response to identifying with traffic analysis sub-zones and with being additive to Census Tracts. There are probably too many statistical areas and many of the smaller ones have lost their validity. They have been a good device for data management, but the time has now arrived for merging those which are of no value into the appropriate neighboring zone. The computer itself has no particular problem with excessive fragmentation, but it must be remembered that the inputs are generated by humans and that the problem of quality control is most difficult--the more statistical areas, the more exposure to location errors in generating data. It should be a general rule to tend to gravitate back toward Census Tracts whenever feasible rather than to generate different combinations of areas. The Flow Net inputs could have been based on Census Tracts in the vast majority of situations had the special statistical areas not existed.

Data Field 5, Columns 22 through 25.
Ground Coverage of Statistical Area

This is a quality control entry. Both the present and future distribution of land uses must add to this control figure. In this model all areas are recorded to the nearest full acre. It is believed that there is considerable difficulty with the figures supplied by the Planning District Commission. The measurements were given to the hundredths of an acres, but comparing them with the City of Norfolk data, there are probably errors up to 25 percent. Difficulties include accurate mapping of the statistical area boundaries, interpretation of water boundaries and possibly others. It is recommended that a fairly precise map be prepared which accounts for all of the area in a political jurisdiction, including water and marsh areas. Measurement should be carefully done to the nearest acre with an accuracy within 5 percent for smaller areas and possibly less for the larger areas. Approximate figures written to the tenths or hundredths of an acre should not be considered final. A remeasurement work program is recommended. Consistent rules should be set down and water and marsh areas should be measured concurrently. There will be room for considerable discussion as to how to handle water and marsh. For instance, should land area go to the pierhead line, to the bulkhead line, or to the current shoreline, on navigable bodies of water.

RESIDENTIAL COMPONENT

Data Field 6, Columns 26 through 29.
1970 Allocated Population

The 1970 population is the base year and basis for calibration of many analysis models. In this case it was determined by proportioning the preliminary Census Tract population counts to the statistical areas in the same housing unit pattern recorded in 1965. Exceptions were occasionally made where air photos revealed decided changes in land use. When the block statistics for the 1970 Census are published these data can be precised.

Data Field 7, Columns 30 through 33.
1970 Allocated Occupied Housing Units

Housing units counts are a common means of estimating intercensal populations and are therefore used in this model. Occupied housing units are used because they compare with Census population figures. Field counts are likely to be the gross number of units, but in many areas such as slums or where there is current large scale construction, the occupied unit count is much more useful.

Data Field 8, Columns 34 through 37.
1970 Gross Residential Land

Gross residential land includes not only the lot areas used for residences (net residential land) but also the land used for normal and minor infrastructure. Items generalized into this category include streets (except expressways), small playgrounds, churches and the like. Other local infrastructure would have been included except for the need to provide a land factor to match employment figures in other categories. The gross residential density concept is advantageous in estimating the population yield of land changing from open to urban.

Data Field 9, Columns 38 through 41.
Maturity Gross Residential Land

This quantity is the planners estimate of the amount of land in the statistical area which will be used for gross residential purposes at the maturity condition or the year 2020.

Data Field 10, Columns 42 through 44.
Maturity Housing Units per Gross Residential Acre

This is the planners estimate of the average gross residential density of the statistical area as it applies to the housing unit factor. This model uses whole numbers, although in very low density areas, fractions may sometimes be wished for. It is felt that such precision is unwarranted when dealing with a 50 year horizon.

Data Field 11, Columns 45 through 47.
Maturity Population per Housing Unit

The average occupancy per housing unit has been the greatest source of error in estimat intercensal populations. This model allows for refinement in this estimation by providing for tenths of a person per average housing unit. Column 46 is always a decimal point. Residential land times housing units per acre times population per housing unit yields the statistical area population.

Data Field 12, Columns 48 through 51.
Growth Curve for Residential Development

The 1970 estimated population is a given and the computer calculates the maturity population from the previously discussed factors. A requirement for the utility analysis is to provide design populations by five year intervals. This is done by computer interpolation. Entries are made designating the last two numbers of the five year interval in which the interpolation is to begin and end. This is a straight line curve which approximates the likely reality, but works fairly well in newly urbanizing areas. It works least well in areas which are following a sine curve during the forecast period. The limitations should not be taken too critically by users who can be satisfied with a smooth growth curve for the metropolitan area as a whole.

COMMERCIAL AND GOVERNMENT COMPONENT

Data Field 13, Columns 52 through 55.
1970 Commercial and Government Employment

This entry represents the sum of the employment assigned to each statistical area by the Virginia Employment Service and SVPDC for the year 1966. These include groups 3 through 6 on the tabulation which represent SICs 52 through 94. There was some difficulty detected in Norfolk where occasionally the land uses reported did not harmonize with the type of employment assigned. Small numbers of employment, generally less than ten, found in a statistical area dominated by a different classification were merged into the dominant classification. For instance, if a shopping center indicated seven manufacturing employees and 453 commercial employees the entry was 460 commercial.

Data Field 14, Columns 56 through 58.
1970 Commercial and Government Land

This quantity consists of that land which is identifiable as used by the employment groups listed under Field 13. A considerable portion of this area would be considered in the gross component of the gross residential land if it were not for providing a vehicle to process employment. Government land provides a very difficult problem. In this field it is intended that only that portion of such land as contributes to concentrations of employment be entered. Large nominally open spaces have been allocated to the open and residual land category. For example, the airport employment is concentrated at one sector of a very large expanse of land. This sector has been assigned an acreage of influence, while the runway and clear zone areas have been assigned to open space. It is believed by the Consultant that the portrayal of large portions of the metropolitan area as consuming land at very low densities of employment, can lead to misinterpretation. It is better that large but essential open areas be excluded from the demand for infrastructure and handled on an ad hoc basis. Residential neighborhoods on government landareclassified residential rather than government.

Data Field 15, Columns 59 through 61
Maturity Government and Commercial Land

This field represents the portion of the statistical area which will be used for the subject functions at maturity.

Data Field 16, Columns 62 through 64.
Maturity Employment per Gross Acre

This entry represents the assumed average number of employees to be found per gross acre of land in the commercial and government component. Employment per gross acre times the maturity commercial and government land equals the total maturity employment.

Data Field 17, Columns 65 through 68.
Commercial and Government Land Absorption Growth Curve

The years for beginning and ending the interpolation of employment growth are entered here and operate as does the residential growth curve explained under data field 12.

INDUSTRIAL COMPONENT

Data Field 18, Columns 1 through 5.
Card Serial Number (Second Card)

This number identifies this card which is a continuation of the data on the first card for that statistical area. The number in column 5 will always be a 2. Serial numbers in the first four columns were used for the different jurisdictions as follows: 0 to 399, Norfolk; 400 to 699, Virginia Beach; 700 to 799, Portsmouth; 800 to 999, Chesapeake; 1000 to 1199, Nansemond County; 1200 to 1299, Suffolk. There are a considerable number of unused serial numbers within each range.

Data Field 19, Columns 6 through 9.
1970 Industrial Employment

This entry is the sum of groups 1, 2 and 7 of the Virginia Employment Commission tabulation. These are SIC 10 through 39 and 40 through 49--Manufacturing, Wholesale Trade, Mining, Construction, Transportation & Public Utilities.

The two digit groupings are not adequate to match the generalized land use. In many cases, known shopping centers were found to have employment in these industrial type categories. The alternative chosen was deemed to provide the least difficulty in visualizing the character of the land use. This points up the fact that an economic code should be supplemented by a simple one digit land use character code in any detailed data bank. The necessity for this is illustrated by an electric company which may have giant coal piles, a generating station, a heavy equipment shop-warehouse-storage yard, and business offices. Each of these have drastically different land use implications, and greatly differing infrastructure requirements.

Data Field 20, Columns 10 through 13.
1970 Gross Industrial Land

This land is identified with the employment assigned to data field 19.

Data Field 21, Columns 14 through 17.
Maturity Industrial Land

This entry represents the planners estimate of the portion of the statistical area to be dominated by industry and industrial character land uses. A modest amount of vacant land was assumed in the gross figure, but larger unused tracts were assigned to open land.

Data Field 22, Columns 18 through 20.
Maturity Employment per Industrial Acre

This entry represents the average employment per gross acre of industrial type land. Maturity industrial land times maturity employment per acre yields maturity employment.

Data Field 23, Columns 21 through 24.
Industrial Land Absorption Growth Curve

The year of the beginning and ending of the interpolation are indicated. Note that land absorption and employment are treated as being proportional to each other.

Data Field 24, Columns 25 through 28.
1970 Open and Residual Land

This is a single entry, but if more information were available, could well be segregated into that land which should be considered permanent open space (including marsh and water) and that land which is available for development. In the latter case, permanent open space would be another data field and would be number 26.

As noted earlier, open space includes the larger parks, golf courses, freeways, airport runway systems, marshes and the essentially open portions military installations. The smaller open spaces have been grossed into the other land use classifications.

Data Field 25, Columns 29 through 33.
Maturity Open and Residual Land

This entry is the planners estimate of the permanent open land plus the unused developable land to be left in the statistical area at maturity. It should be noted that a small vancancy rate has been built into the other land use categories and is not represented here unless of considerable size.

3. COMPUTER PROGRAM SPECIFICATIONS

Sorts: Input dataarein two card couplets. Column 5 of the first card will always have a number 1 while column 5 of the second card will have the number 2. Any other sorts are permissible as long as the couplets remain in sequence.

Definition: the letter "f" refers to data fields.

A. Consistency checks and record.

1. Identify errors if f5 does not equal f8 plus f14 plus f20 plus f24.

2. Identify errors if f5 does not equal f9 plus f15 plus f21 plus f25.

3. Print-out all input data.

B. Computations.

1. Maturity population equals f9 x f10 x f11.

2. Interpolate results of operation B1, above, back to 1970 population (f6). Keep 1970 population (f6) level until beginning of change as indicated by columns 48 and 49 (75 equals 1975; 00 equals 2000). Keep population level from end of interpolation as indicated by columns 50 and 51 to the year 2020. Interpolate change by 5 year increments between the limit dates.

3. Maturity commercial and government employment equals f15 x f16. Use limits from field 12.

4. Interpolate results of specification B3 using general rules of specification B2.

5. Maturity industrial employment equals f21 x f22.

6. Interpolate results of specification B5 using general rules of specification B2 but limits from field 17.

7. Print-out interpolations,Specs. Bs; B4; B6,for each statistical area as listed in f4.

C. Tabulations.

Summarize by the following discrete areas:

a. Census Tract (f2).

b. Utility Analysis Area (f3).

c. By Jurisdiction (each digit in column 12).

d. The entire deck.

All information contained in the following data fields and calculations:

1.	f5	8.	f15
2.	f6	9.	f19
3.	f7	10.	f20
4.	f8	11.	f21
5.	f9	12.	f24
6.	f13	13.	f25
7.	f14		

The results of the interpolations of specifications B2; B4; B6. Provide plain language headings and spacing for easy reading as feasible.

4. DEBUGGING AND CONTINUING USE OF THIS MODEL

This urban land use systems analysis model is designed in a simplified and generalized form so that it might be useful and continuously in operable condition for analytical use in solving a wide range of planning and engineering problems. It should be useful for transportation analysis, utility analysis and solid waste disposal analysis as well as many others.

Data have been gathered from several sources which in turn have been prepared by several different technical staffs. There are many thousands of numbers. It is normal that some of these numbers will be less than adequate for some purposes. (The degree of aggregation and the use of preliminary census figures as a control have made the first iteration suitable for the basic water system analysis as specified in the work program.) Inconsistencies have arisen which could not be thoroughly reconciled with the materials at hand. The Consultant has used the philosphy that it is better to enter the best estimate available than to labor over the input to such an extent that critical engineering decisions are made without the advantage of the land use analysis system. It is much easier (and more likely to be done) to modify a first approximation than to face a pile of blank paper.

There are several types of bugs in a model such as this. First there is the probability that in a few instances the source data has been misentered on the data cards. There are quality checks to eliminate most of this, but it is not reasonable to expect that all errors have been caught. This type of error, if substantial, can be detected by reflection on the situation by a knowledgeable person, or more likely when the information is being put to a practical application and something does not correlate properly.

Another point of error is in collecting and recording the basic data. Geographic misplacement is likely to be a common problem when dealing with small areas. Gross errors are easy to detect, but small ones are most difficult. Some errors, such as in degree of precision (if a careful procedure is used) are expected to cancel out. Absolute precision, like infinity is impossible to reach.

There are inconsistencies or lack of desired precision due to the rules or manner under which the data were collected or organized. Different staffs are likely to give differing interpretations to a program specification.

Lastly, for the entries pertaining to the future, there are honest differences of professional opinion. In some cases the difference may have great merit and be obviously superior to the entries of the first iteration, while in other cases the alternative cannot be supported as being materially more correct. The benefit of an analysis system such as this is that differing interpretations can be substituted with relative ease and new iterations produced at minimal cost.

In any event a debugging process is called for. It should begin with discovering the gross deviations. Minor problems can be recognized as probably existing and be compensated for. Many will be washed out as the data are aggregated into summaries for larger geographic areas. The inherent uncertainty of the future makes many of the minor errors unimportant.

This discussion of error should not be interpreted as degrading the usefulness of the present body of information, but any preparation of this magnitude which does not recognize the possibility or causes of potential error must be suspect on its face.

Recommended First Round Debugging Procedure

The following work items are recommended for the first round of debugging. If carefully done, the data will be just as reliable, or more so, than any yet used for utility or other analysis for the metropolitan area. It is better to have something "pretty good" available for use than have the perfect product forever forthcoming. The priority tasks recommended are:

1. Make plastic overlays for the recent highway department photography showing statistical areas and census tracts.

2. Examine each statistical area on the aerial photo and use personal knowledge to judge the reasonableness of the input data. If the basic area measurement appears to be grossly off or if the developable area appears off, a quick check can be made by counting squares on a transparent grid.

3. Field check any areas where there is considerable doubt that cannot be resolved by the procedures suggested above.

4. Make a quick reapportionment based on the best judgement so that the data deck can be readily corrected and be available for immediate use.

5. Alert the jurisdictions as to geographic areas where periodic resurveying activity would be most productive.

6. Discuss the inputs relating to the future with planners of each jurisdiction using Delphi methods (give and take among experts) and make any significant changes agreed upon.

7. Make corrections on the detailed data input portion of the printout and have corrected cards punched. Rerun the corrected deck through the entire program. This can be labeled the second iteration.

8. Revise the deck and prepare alternative forecasts as time and resources permit.

Longer Term Work Program

Work with the body of data available for analysis suggests that if it is to be used as a continuing analysis tool, there are several aspects of the data which should be precised. This possible lack of precision is not critical and does not negate the usefulness of the present analysis. It is rather a matter of housekeeping. Some of the activities suggested are as follows:

1. Review the statistical areas in view of consolidating away those which no longer have a logical function. Some SA's have been nearly if not completely eliminated by freeway construction. Others may have had a reason for a separate identity when drawn, but new development has made them an integral part of an adjoining SA. The direction of reduction should always be toward conformity with Census Tracts in the absence of other important factors.

2. Prepare a more precise map of the revised SA's.

3. Measure to a precision of about 5 percent the area of each SA for use as a control.

4. Measure the water and marsh area, i. e., the area not subject to development, of each SA. The residual will be the gross developable area.

5. Provide a match with the detailed data banks of each jurisdiction. Such data banks can be based on a card for each parcel or each use on multiple use parcels, or especially for less complicated portions, one card for each block. A separate card for each employing activity, other than households, is highly desirable. Permanent street area should be calculated for each SA so that the sum of all land uses will add up to the measurement of the SA. The economic code for classification (S. I. C. is preferable) should be at least at the three digit level with a suffix type functional code of one or possibly two digits. This suffix will indicate for a larger firm whether the use is a manufacturing plant, a store, an office, a warehouse, etc.

Future Use of the Model

As this model is used, modifications and new specifications will suggest themselves. This can be done rather easily, but it is urged that the system be kept simple. Complexity destroys the utility of the analysis system and is likely to work against keeping the data current and frequent manipulation of the model to test planning policies. As a general rule, there should not be more than two cards of input. For a basic data bank, a single card deck has much to say for it. The principal virtue of one card is that the fewer number of data items are much more likely to be reliable and current.

This land use systems analysis model is one of the infinite number of sub-systems which would be needed to explain the complexity of a metropolitan area. It can work with or be augmented by any of these which might be developed. It could be fed by detailed data from a land use and employment data bank. It would also be a great step forward in the process of metropolitan analysis to add an economic analysis and forecasting sub-system. The operational format for such a sub-system has been worked out.

A logical extension of the above mentioned sub-systems is to cost out alternative development patterns. With all three of the basic sub-systems in operation it would be most interesting to test for such drastic possibilities as what would happen to the metropolitan area if the Navy reduced its activity to say 40 percent of the current level. Revelations exposed by such an exercise could have a profound effect upon both public and private policies. For example, the push for diversification of the economy might be sleeping when it should be hyperactive considering the odds that results will be needed earlier than expected.

5. RESIDENTIAL DENSITY ESTIMATION

Density Assumptions

Gross residential density as used in the analysis can best be defined by examining its position in a hierarchy of density classifications. These are as follows:

Net Residential Density is the ratio of population to the lot area that the population occupies.

Gross Residential Density in its calculation includes the land classified as net residential plus that land needed for the support of the residential development. This includes such things as the local streets, small parks, church sites, school grounds, small shopping areas and similar uses of land. These may be termed residential intrastructure.

Gross Density is the ratio of population to a larger more heterogeneous section of a study area in which there is likely to be an averaging of industrial districts, railroad yards, water bodies, large parks and other non-residential spaces with the residential areas.

It can be seen that for the purpose of providing generalized land use forecasts for smaller areas, net residential density is much too specific to work with and gross density can be most misleading under circumstances where there is a tendency for some of the smaller areas being analyzed to be dominated by land uses other than residential. For example, a very high density residential section may be included in a service area which is almost entirely non-residential thus causing an uncritical evaluation to indicate exceptionally low density type development.

Gross residential density is selected as the most appropriate concept for land use allocation. A parallel concept has been used for allocating commercial and industrial land use.

In visualizing development in future years, numbers have been rounded consistent with the degree of confidence the analyst has in his prediction. Trends are the most common basis upon which to assess the future, but it must be realized that most trends at some point change or even reverse--some sooner and some later. They can be influenced by public (utility) policy. Because of this phenomenon, the systems analysis procedure as used here, provides a convenient procedure for measuring change so that programs and forecasts can be adjusted as the direction and degree of change becomes evident. No one can predict the history of the future, but it must be handled head-on as is done here, or handled indirectly and in a most general way as has often been done in the past. Every engineering design must have a basis expressed in definite numbers, be they carefully considered or guessed.

Classification by Gross Residential Density Character

For the purpose of looking far into the future (to the year 2020) four general types of residential areas are envisioned as an aid in clarifying the forecasts. In some cases an entire service area can be classified in one of these categories while in others more than one or all may be represented. In the latter case, the forecast density for use in engineering will be a weighted average. These standard type densities are as follows:

A. Highest Density. These areas will be characterized by low rise multiple dwelling structures with a minimum of open space; some medium rise (4 to 6 story) apartments, and an occasional high-rise structure.

Such an area is envisioned to provide an average of 1,000 square feet of net lot area for each dwelling unit (although some will be much more dense). This would translate into an average figure of 20 housing units for each gross residential acre. With such density of development the average occupancy per dwelling would be two persons, yielding an average population of 40 people per gross residential acre. An occasional area useful in analysis may be identifiable which contains much higher densities.

B. High Density Open Type (Garden) Multiple Housing. This type of development is characterized by town houses and walk-up apartments with some yard space usually readily accessible to each unit. The typical average lot area per unit is set at 2,200 square feet which would yield about 12 housing units per gross residential acre. The average population per housing unit is envisioned at 2.2 persons which would yield a population density of 26 persons per gross residential acre.

C. Medium Density Single Family. Developments of this character are likely to contain single family houses on medium sized lots with some duplex or fourplex development and an occasional walk-up apartment. Such an area would have an average net lot area of 8,000 square feet which would yield 3.5 housing units per gross residential acre. This type of development is likely to have an average of three persons per unit which would provide a population of eleven persons per gross residential acre.

D. Low Density. There are likely to be considerable areas where most of the lots are large relative to the usual character of development. These are likely to persist if of good quality, but it should be remembered that such large lots offer a long run opportunity for assembly into parcels suitable for higher density development. The average lot size in such areas is envisioned as being 20,000 square feet which yields 1.5 housing units per gross residential acre. Such an area could be expected to maintain an average occupancy of 2.5 persons per housing unit which yields a population of four persons per gross residential acre.

More often than not a service area will contain a mixture of one or more of the above residential character types. The mixing can be through change in building types from one part of the area to another or because of transitional development throughout the fabric of the neighborhood.

TABLE 1

RESIDENTIAL CHARACTER TYPES FOR LONG RANGE ESTIMATION

Residential Character Type	Average Lot Area (Sq. Ft.)	Average Housing Units Per Gross Residential Acre	Average Population Per Housing Unit	Average Population Per Gross Residential Acre
A. Highest Density	1,000	20	2	40
B. High Density Open Type, Multiple Housing	2,200	12	2.2	26
C. Medium Density Single Family	8,000	3.5	3	11
D. Low Density	20,000	1.5	2.5	4

Current experience indicates that very few major utility analysis areas will be developed with only the lower two density types represented. Open type, multiple housing is likely to be strongly represented. Planned Unit Developments of multiple housing are currently popular and modular housing is about to appear. The experience of the last two decades is not necessarily indicative of what will happen in the next two decades.

The rapidly accelerating cost of providing government services is tending to dictate more efficient utilization of land already provided with services thus reducing the tendency for continued urban sprawl. It is becoming critical that government pursue policies which encourage more efficient urban development.

Indeed, projection of the past as a forecasting technique is subject to considerable possible error. The use of a systems analysis technique allows for analysis of alternative growth assumptions, thus reducing the long term dependence upon development trends which may be in the process of changing direction.

TABLE 2

GROSS LAND REQUIREMENTS FOR RESIDENTIAL DEVELOPMENT
AREA PER HOUSING UNIT (Sq. Ft.)

	Density			
	Highest	High	Medium	Low
Average Lot Area	1,000	2,200	8,000	20,000
Streets & Alleys	400	600	2,350	5,000
Local Shopping	130	180	260	260
Schools, Recreation, Churches	600	600	1,000	1,000
Vacancy & Misc.	180	250	840	2,620
TOTAL (Sq. Ft.)	2,220	3,650	12,450	28,880
Housing Units per Gross Residential Acre	20	12	3.5	1.5