VISUAL DISPLAY OF SPATIAL INFORMATION: A CASE STUDY OF THE SOUTH END DEVELOPMENT POLICY PLAN

by

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ABSTRACT

This thesis documents two study projects for the South End Development Policy Plan undertaken by the Boston Redevelopment Authority. These two projects--Demographic and Socioeconomic Profile of the South End, and Land-use Patterns in the South End--were conducted by applying computer technology in Geographic Information Systems. Findings of these studies were presented on a regular basis to a "community working group" of South End residents, in an effort to encourage community participation in the planning process, and also to test the role of visual display mechanisms in facilitating spatial information management and analysis.

Visual display is an instrument to access and view complex spatial information. Such an instrument may serve in the modelling of spatial relationships and processes. Maps in both paper and electronic forms are the media of communication in the process of spatial analysis, as well as the means of presentation of such analysis to the policy makers and general public at large. Due to an increase in the complexity in spatial information management, maps can no longer be static. The same geographic area can be represented by different maps, at different levels of detail and aggregation, and associated with different topologies. Maps can be used to render data of enormous volume and complexity in a variety of color and shade pattern choices. More importantly, maps give the eye immediate access to geographical proximity, and therefore emphasize the role of distance as an explanatory factor in spatial analysis. If carefully designed and well presented, maps can complement, and even replace, data in tabular form as the predominate means of spatial analysis.

In this thesis, a four-component framework is used in phasing the whole process of spatial information management. The process involves boundary and attribute data manipulation, aggregation, presentation and interpretation. The four components are structural, operational, communicational and functional, and each is illustrated in the two study projects.

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Chapter 1

AN OVERVIEW

This thesis documents a case study of the application of computer technology in Geographic Information Systems (GIS) to the South End Development Policy Plan process currently taking place at the Department of Neighborhood and Housing, Boston Redevelopment Authority (NHD, BRA). Specifically, it examines the effectiveness of the visual display of spatial information in promoting and facilitating interactive planning between NHD and the selected members of the community planning working group.

The South End is one of sixteen neighborhoods in the city of Boston. It is a small neighborhood of slightly over one square mile in area and houses about 4 percent of the city's total population. Primarily a residential neighborhood, it also has other mixed land uses including commercial, industrial and medical complexes. Throughout the 1980's, it has experienced tremendous revitalization in the wake of a renewed interest in resettling to downtown areas by people of more affluent backgrounds. This trend has had a mixed impact on the community, traditionally identified as the most racially and socially diversified neighborhood in Boston. Gentrification brought a wave of condominium conversion, drove up housing costs and aggravated the allocation of scarce resources. More recently, in an effort by the city to promote further economic growth, the South End was chosen as one of the prime locations for the pharmaceutical industry--partly because of the high concentration of medical institutions in the area. Two of the city's major transportation upgrade projects--the Central Artery and the Third Harbor Tunnel--meet at the fringe of the area, promising quick access to the airport, and good development potential for a large stock of vacant land.

At this junction of opportunities and challenge, the local residents have taken the initiative to plan and manage the area's growth. In May 1989, the BRA began a planning process called the South End Development Policy Plan to address the concerns of the community. Local residents self-selected themselves into a community working group to work together with the technical staff of the BRA on a wide range of issues. The end product of the planning process will be a comprehensive land-use plan, and a set of recommendations on use of the city owned vacant parcels. The plan is due in October 1990 for public discussion.

The complex nature of issues involved, their multiple origins and effects, and the spatial patterns relevant to planning, all require innovative approaches to information management. In addition, presentation of analysis results becomes a non-trivial concern in the context of facilitating the discussion among the working group members. These considerations led to the adoption of a GIS solution.

A GIS provides the tools for storage, retrieval, processing, and presentation of spatially oriented data. This technology has experienced remarkable growth in the 1980's due to the rapid development of microcomputers and an increasing demand for spatial information management. A GIS has the capacity to integrate various disciplines and analyses that use a geographic base, and may greatly increase the power of applications of science to problem solving and decision making. Most of its applications to date have been to do facility management and to automate routine tasks. More recently, there have been an increasing number of applications of GIS to urban planning, often designed to combine resources in census information, assessing data, and other information at a parcel level. In applying GIS technology to urban planning, the system is constantly being pushed to its limits, as is our knowledge about what GIS can really do, versus what we expect it should do.

In the context of applying GIS to the process of creating the South End Development Policy Plan, the special focus of this thesis is on the interaction between the users (e.g. working group members) and the system during the analysis of spatial information and its visual display. The visual display of spatial information in this thesis is defined as an instrument for accessing, viewing and linking databases to a common spatial frame in the of maps. A close analogy would be the definition of a "view" of databases in the form of tables in the Standard Query Language (SQL) database management. This definition emphasizes the exploratory power of visual access to spatial information. This definition is also a departure from the conventional role maps play in conveying spatial information in that maps in this process are considered primarily as a tool for analysis, instead of an end product.

The thesis is comprised of two integrated parts:

1) Documentation of two projects in data collection, manipulation, analysis and presentation. The demographic project uses thirty variables from the 1980 federal census to describe the overall socioeconomic profile of the neighborhood. The land-use project assesses the current state of land-use in the area and its vicinity using data for 841 assessing blocks from the 1990 fiscal assessing data.

2) Discussions on definition and application of a four-component, staged approach to spatial information management. The discussions are centered around the issue of how to make spatial information more visible in the process of analysis, and accessible to the general public when the analysis results are presented. The visual display mechanisms are then assessed in terms of their efficiency and effectiveness in facilitating the planning process.

The political processes of community planning, and the technology of GIS and their increasing applications in urban planning contexts are each distinct subjects of discussion in their own rights. The author does not intend to get into the full breath and depth of each of these subjects. Rather, by joining these two subjects at the point where the visual display of spatial information serves the community planning process, the I hope to share this new area of application of GIS with the planning community. At a time when GIS appears to be more accessible to urban planners than ever before, discussion of what we know about GIS and what we can realistically expect from it should prove beneficial.

This thesis will also be a working document of applying GIS to community planning. While hoping that all the objectives may be achieved, it is also important to document what can not be done and why. GIS is a new tool of computer applications in spatial information management, with a large number of technical problems in data matching and manipulation that are still overwhelming. Issues of working with data at different level of aggregation, over different time spans, collected and stored in different forms, and at different level of accuracy--all are problems to be tackled. A detailed documentation of these problems will certainly be invaluable.

There are seven chapters in the thesis. To fully understand the context of this work, Chapters Two and Three include background information on the study area, and give the methodological framework of the research. Chapter Two provides the background for the later study projects by providing information about the study area and current planning issues (the South End and the South End Development Policy Plan). Chapter Three describes the methodology employed in the planning process (GIS and its visual display mechanisms). Chapters Four and Five describe each of the two projects--demographics and land-use. The sixth and concluding chapter summarizes findings, presents directions for future research, as well as recommendations to the BRA regarding strategies in adopting GIS at an agency level. It also looks beyond GIS in the discussion of a conceptual Spatial Decision Support System (SDSS).

Chapter Two

THE SOUTH END
AND THE SOUTH END DEVELOPMENT POLICY PLAN

This chapter is about the neighborhood of the South End. It gives a detailed account of its current conditions, describes its setting of surrounding neighborhoods, and discusses briefly its history. To help understand the context of the South End Development Policy Plan, other previous planning efforts, public and private alike, are also introduced. Following these introductions, the origin, objectives, and organization of the South End Development Policy Plan is explained. The chapter ends with a discussion of the political implications of the Plan beyond the expected set of land-use recommendations.

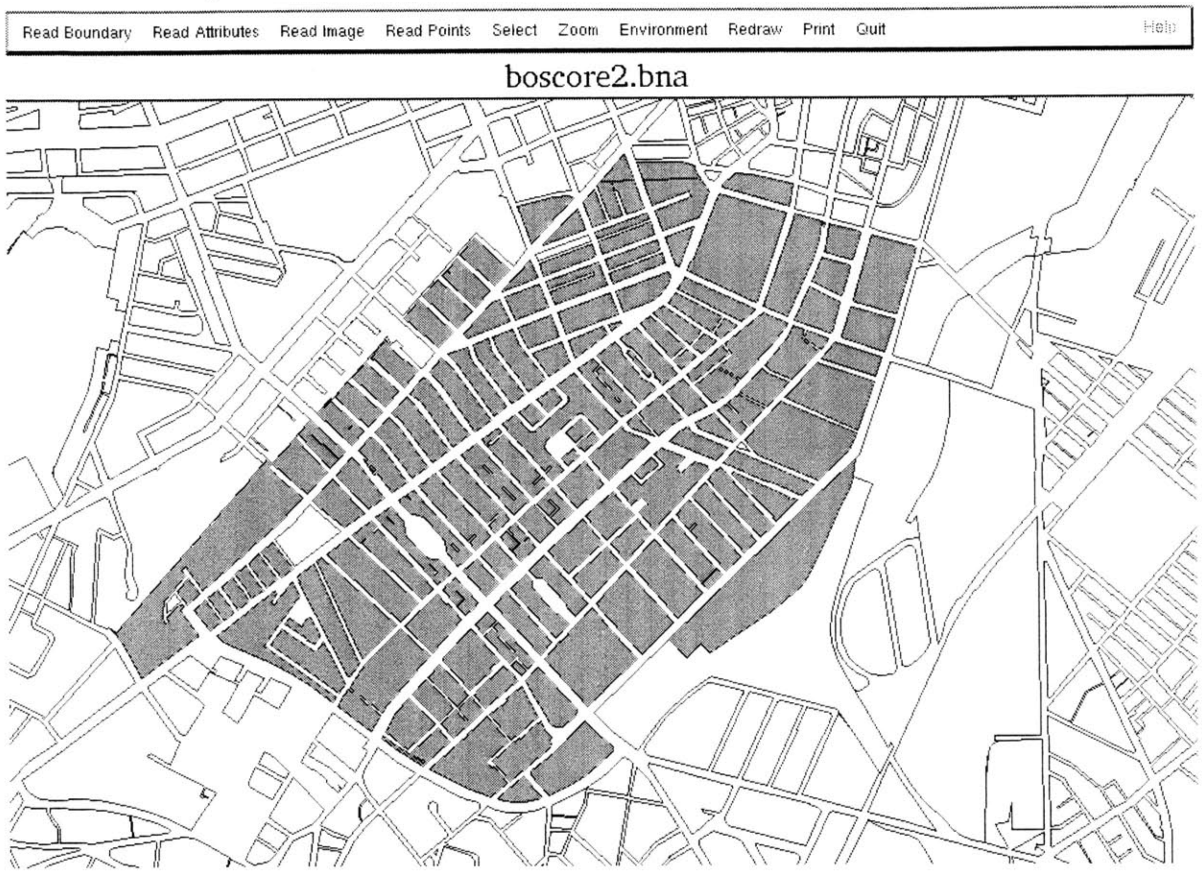
2.1 The South End

The South End is one of sixteen neighborhoods in the City of Boston used by BRA in its planning. It is perhaps the City's most cosmopolitan area, containing a diverse mix of ethnic and income groups, despite being little over one square mile in size and housing only 4 percent of Boston's total population. It is a neighborhood with a rich history; a neighborhood that has been buffeted by continuous development booms and depressions. It has evolved with the city through its period of natural expansion, as well as with the later more controlled growth. An intricate inner-city neighborhood, in which different population and income groups often have competing goals and interests, the South End is a challenging and vibrant place in which to live, work and invest (Figure 2.1.1).

The commercial economy of the South End is divided into neighborhood retail and service stores north of Shawmut Avenue, light manufacturing firms and medical institutions along Harrison and Albany Streets, and wholesaling businesses in the nearby South Bay/Newmarket district. Large employers include Boston City and University Hospitals, New England Nuclear, Teradyne, Digital, Stride Rite manufacturing firms, New England Telephone, City Public Works Department, and the Newmarket wholesaling facilities. Together, these firms comprise 80 percent of all South End employment (BRA 1988).

Starting from the north, in a clockwise direction, there are six neighborhoods bounding the South End Planning district--Back Bay/Beacon Hill, Central, South Boston, North Dorchester, Roxbury, and Fenway-Kenmore. These neighborhoods each have distinctive characteristics. These

Figure 2.1.1 The South End Planning District



characteristics all have a presence in portions of the adjacent South End (Figure 2.1.2).

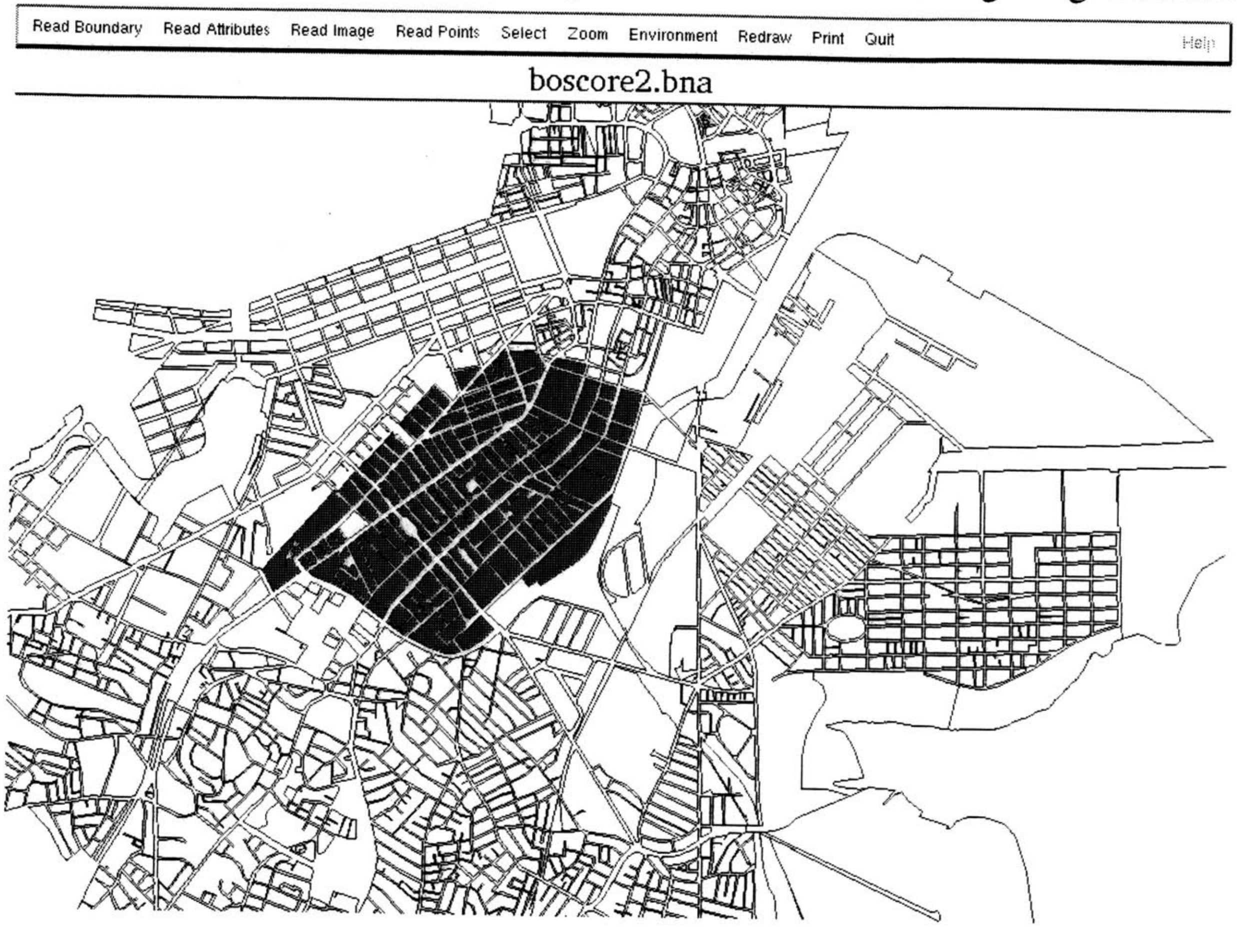
The Back Bay/Beacon Hill neighborhood primarily houses a white, affluent population of 30,000. Over 90 percent of the district's residents are white, with small numbers of Black, Hispanic and Asian inhabitants. The increasing majority of residents are middle-aged adults who are well-educated, employed in professional and managerial positions, and have relatively high incomes. The Bay Village extends into the South End and shares the same socioeconomic profile as Back Bay/ Beacon Hill. This area represents approximately 30 percent of the total South End population as of 1980.

The Central Planning District includes the downtown area, Chinatown and the North End. Chinatown shares a boundary with the South End. As of 1980, over 3,000 Chinese inhabited Chinatown. These residents worked primarily in restaurants, shops and a dwindling garment industry. Family income was low, as was educational attainment. On the other hand, households composed of families and married couples were much more common than in the city as a whole. Castle Square in the South End, on the other side of the Mass Turnpike from Chinatown, was developed in the 1980's, and houses a large Chinese population.

Roxbury, to the south of the South End, is the neighborhood home to a large black population, and a growing community of Hispanic and Caribbean Islander residents. As of 1985, 76 percent of its 58,861 population were Black. Two-thirds of Roxbury households were families, a larger share than many of Boston's neighborhoods. Correspondingly, Roxbury had a large share of young people (32 percent under 18). The resident work force was over-represented in blue-collar and semi-skilled service jobs but showed an upward trend in professional employment. A portion of the South End--Lower Roxbury, shares similar demographic profiles with Roxbury. This portion of the South End contains over 20 percent of the South End's total population.

Three other adjacent neighborhoods--South Boston, North Dorchester and Fenway-Kenmore--are separated from the South End by areas that are sparsely populated, and therefore have less impact on the social profile of the community. South Boston and North Dorchester are separated by the Southwest Expressway and the Newmarket Industrial Area, and Fenway-Kenmore by the Northeastern University. Nevertheless, proposed industrial development in the Newmarket area, and expansion by Northeastern University, will undoubtedly influence both neighborhoods at their fringe, and integrate these areas more closely (BRA 1988).

Figure 2.1.2 The South End Planning Distrcit and Its Bounding Neighborhoods



For the South End, as of 1985, racial composition was 46 percent black, 34 percent White, 11 percent Asian, and 10 percent Hispanic. Since 1980, the South End's population had grown by 2,826 to 29,951, following a 4,300 gain in the decade of the 1970's. While the South End retained a significant proportion of families, primarily with lower incomes, recent trends reveal the growth of more affluent, smaller, middle-aged professional households. Median income, poverty, and unemployment rates are very close to Boston averages, due largely to the increased presence of upper-middle income households mixed with poorer families (BRA 1989a; BRA 1989b; BRA 1989c).

2.2 A Historical Overview of the South End

Through the 1800's, the South End evolved from a residential neighborhood of three- and four-story single-family row-houses into an area with mixed functions. Industrial developments along the district's southern and eastern edges attracted working class population. Gradually, single-family homes were divided up into multiple-dwelling units and lodging rooms. By the turn of the century, the South End had become the largest lodging house district in the entire United States. It was by then filled with enclaves of immigrants. For the first half of this century, the South End was a major port of entry, home to a rich and varied ethnic mix of immigrants and first-generation Americans. It was a neighborhood of inexpensive living, associated with alcoholism, prostitution and drug trafficking in the minds of many Bostonians (BRA 1988).

After the first 100 years of relative harmony in this working class, ethnically diverse sub-section of Boston, three main forces came into play and profoundly altered the course of development of this community. These three forces were: the construction of the Prudential Center, Copley Square on adjoining railroad land; the 1960's urban renewal projects which fundamentally altered the cultural and architectural context of the area; and a renewed interest in inner city neighborhoods including the South End. These three forces all have and will continue to impact the area.

In the early 1950's, urban renewal activities began to impact the neighborhoods on the fringe of the South End. The South End Urban Renewal Plan was formally adopted by the City Council in December of 1965, after extensive community involvement (BRA 1965). The Plan's basic objectives were, "to eliminate blight and incompatible land uses in order to provide a stable environment for residential, commercial and industrial activities." From 1965 to 1979, more than $135 million in public money was spent in the South End. The Plan combined site clearance and redevelopment to achieve the proposed goal of constructing 6,300 new housing units for low-income families, and other infrastructure improvements.

In the late 1970's, in the wake of renewed interest in downtown areas throughout the country, the South End began to experience resettlement of affluent professionals seeking to avoid long drives from suburban areas to downtown work places. A number of trends occurring on a national level have also influenced the South End in an unprecedented way. These trends include: changes in economic structure from manufacturing to service-related sectors; decreases in family size; increases in women's labor force participation and higher incidence of dual income families; and higher levels of educational attainment. Combined, these trends have resulted in a fundamental shift in the population base of the South End, as well as other inner-city neighborhoods. The out-migration of working class families and in-migration of highly educated, often single and professional population, has a number of planning implications.

2.3 Planning Efforts Prior to the South End Development Policy Plan

The development boom that so changed Boston in the 1980's has had a particular impact on the South End. State, city and federal programs succeeded in stimulating economic development and creating new housing in the neighborhood throughout the 1960's, 1970's and 1980's. In response to these developments, a variety of planning initiatives, both public and private, have taken place to address particular aspects of the impact on the area. Some of these efforts merit brief account here as an introduction to the South End Development Policy Plan.

South End Landmark District: In 1977, a group of South End residents petitioned the Boston Landmarks Commission to designate the area a landmark district. The purpose of the designation is to recognize and protect the architectural and historical characteristics which make the area unique and worthy of preservation. After two years of extensive work by a 10-member South End Study Committee and involvement of the neighborhood, a portion of the South End planning district was designated as a Landmark District for its significance as a substantially-intact area of mid-19th century row houses (The Boston Landmarks Commission 1983).

Density and the Downzoning Amendments: The development and condominium conversion boom that changed the South End in the early 1980's helped stimulate the economy of the neighborhood. It also had a number of negative side effects, among which the dramatic increase in the demand for public services caused concerns in the neighborhood. In 1986, local residents began a process of examining the impact of increased density and petitioned for down-zoning in hope of slowing down development. As a result of a one-year study, an amendment was approved by the BRA board (Thomas Planning Services, Inc. 1987). The amendment has two major components:

1. Those parts of the South End that were zoned as "H-3" districts would be redesignated as "H-2" districts; and

2. A "density limitation overlay" district would be created to limit the number of smaller units (under 750 square feet) in renovated South End buildings.

South End Neighborhood Housing Initiative (SENHI): In an effort to redevelop many of the city-owned parcels to supply the growing South End housing market, the city and the neighborhood began the SENHI program in 1986 (BRA 1986). Some 600 units of housing will be added to the existing stock. One third of these units will be affordable to low-income families, one third to moderate-income families, and the rest will be sold at market rates. While SENHI Phase I is in progress, part of the planning mission of the Development Policy Plan described in this thesis is to recommend disposition of the remaining city parcels for SENHI Phase II.

South End Open Space Needs Assessment: In 1987, the BRA hired Boston Urban Gardeners, Inc. (BUG) to prepare an open space needs assessment to provide the city and the community members with an overview of open space issues to be considered in the course of planning for the South End. In the report, released in February 1988, BUG made recommendations for use of a number of potential open space parcels (BUG 1988). The study was based on 1980 census data and extensive resident interviews.

Other planning initiatives that have had an impact on the South End include planning efforts concerning the Roxbury IPOD/Lower Roxbury Sub-district, the Boston City Hospital, the Washington Street Corridor, Chinatown, and the Newmarket Industrial District. The impact of these plans are either partial or indirect to the neighborhood due to their limits in spatial dimension in relation to the South End. Nevertheless, potential outcomes of these planning efforts should be incorporated into the Development Policy Plan in that they are part of the larger context which may dictate the future of the neighborhood.

2.4 The South End Development Policy Plan and Community Participation

After suffering much malaise in the 1960's and 1970's, the South End has experienced tremendous revitalization and growth throughout the 1980's.

While sparking investment and prosperity, such growth has also exerted pressure on the allocation of resources in the neighborhood, spurred speculation, and caused a variety of concerns among local residents. In particular, residents are concerned about gentrification, which causes displacement and drives up housing costs; and with institutional expansion, which aggravates the already dilapidated infrastructure and service facilities. Institutions and other large land owners, on the other hand, are looking into the growth potential of the area well into the 1990's and beyond. The two mega-projects of transportation--the Central Artery and the Third Harbor Tunnel--meet at the edge of the South End. Also, the proposed medical and pharmaceutical industry area is ready for expansion. Other surrounding neighborhoods--Back Bay/Beacon Hill, Roxbury, Chinatown--have all experienced significant changes in the past decade and have affected the South End. It is at this junction of change, challenge and opportunity that the South End decided to initiate the Development Policy Plan.

In October 1988, BRA director Stephen Coyle met with a group of South End community activists at the headquarters of the South End Historical Society. The Director spoke of his interest in initiating a process to create a comprehensive "development policy plan" for the South End. Such a plan would gather the best resources available to frame and discuss problems and issues of concern; and would draft a series of recommendations on how to channel and manage development, growth and investment in the community. The final product will be designed to guide planners and policy-makers at every level of government as they make decisions about life in the South End.

On January 27, 1989, the South End Development Policy Planning Process was announced with a BRA mailing to local residents. A general community meeting was scheduled for May 31, 1989, to explain the goals and objectives of the South End Development Policy Plan to neighborhood residents.

The work program for the Development Policy Plan includes ten phases extended over a 16-month schedule. The phases of the program are as follows:

1. Determine planning methodology and work plan;
2. Data collection;
3. Analysis;
4. Identify initial goals and objectives;
5. Determine the scope and content of the plan;
6. Prepare options;

7. Assess selected district-wide options;
8. Select and refine a final option for the draft Policy Plan document;
9. Draft implementation strategy for the Plan;
10. Prepare graphics for the final Development Policy Plan document.

At the time this thesis was being written, the program was in phase 7--assess selected district-wide options.

The South End Policy Plan as a final document will contain the following:

1. A proposed land-use plan;
2. Recommended zoning revisions (if necessary);
3. Recommended policies for transportation, traffic and parking;
4. Guidelines for development of BRA owned parcels;
5. Urban design guidelines for future development;

The Plan is due on October 1, 1990.

To maintain the highest possible degree of neighborhood participation in the planning process, the BRA adopted the concept of a ″town meeting″ to channel the community involvement. Well advertised community meeting were organized to give residents access to information and allow opportunities for spirited discussion. Decisions were made when consensus was reached on various points. To implement such a planning strategy, local residents were asked to nominate ″working group″ members--those who can devote time and energy to the process. In May, 1989, Mayor Raymond Flynn appointed 29 people, from over one hundred nominees to serve on the ″South End Development Policy Plan Working Group.″

At the time this thesis is being written, the working group is holding meetings on a regular basis, approximately every two weeks. Members are given considerable latitude in setting the group's agenda and meeting schedules. They are responsible for delivering regular reports to the community through various channels.

The working group started its work with the BRA in July 1989. A substantial amount of time was devoted to identifying planning issues and missions. As the process developed, the working group found increasing need to concentrate efforts on a variety of issues that needed detailed study. As a result of such concerns, the working group decided to set up four subcommittees--demographic/socio-economic, land-use, urban design, and transportation. These sub-committees have since worked simultaneously on this set of subjects with technical assistance from BRA staff members. In a typical situation, the sub-committee would report to the working group on the finding of analyses on the subject and their broader implications to the Development Policy Plan. The working group then assesses the adequacy of the analysis and makes recommendations to the sub-committee on further steps to take to improve the study and the final report.

2.5 Planning Issues

The formulation of the four sub-committees underlines the significance of the set of planning issues identified by the working group. In essence, the study of the issues described below constitutes the substance of the Development Policy Plan.

Demographic/socioeconomic

The practice of planning often focuses on the allocation of physical resources in a socially optimal fashion. In the context of the Development Policy Plan, the demographic study tries to bridge the set of social objectives with the physical mechanism by which such objectives can be achieved. The key objective of this study is to use census data and other complementary sources of information to identify the socioeconomic characteristics of the South End neighborhood. Simply put, the study intends to answer the question, "who are we?"

In connection with answering this question, ways to achieve some of the planning missions should be identified. Early in the planning process, such planning missions were reflected in a meeting when working group members were asked to talk about their visions of the neighborhood in a twenty to thirty-year future. Here are issues that related to the socioeconomic profile of the neighborhood:

1. Preservation of the celebrated qualities of life, such as diversity of the people who make up the South End;
2. Encouraging more families, especially those with children, to come settle and prosper in the neighborhood;
3. Commitment to social services, care for elderly and the physically challenged;
4. Enhancement of job opportunities and revitalization of local business;
5. Establishment of a balance of social factors shaping the neighborhood.

These issues seem to have a common theme--the impact of gentrification. Whether there have been increased opportunities for employment, higher income and educational opportunities for the South Enders, or a perceived improvement in life in the neighborhood, is this simply the result of a basic shift in the population itself--an out-migration of working class families and in-migration of highly educated, single or married couples without children, and professional population? If so, what are the planning implications of this trend?

Land-use

Another major component of the South End Development Policy Plan is a comprehensive land-use plan. Such a plan will provide a framework on which to build a policy for future growth. The land-use study will provide information on current land-use patterns in the area, especially land-use related to residential, commercial, institutional, and industrial functions. Another important component of the land-use study is to prepare a list of current data on the city-owned parcels, which are at the direct disposal of the neighborhood. In conjunction with the land-use study, which will result in a set of recommendations and issuance of Request for Proposals on the public-owned vacant land. Zoning recommendations and possible revisions are also expected.

Urban Design and Transportation

As mentioned in previous sections, the South End neighborhood possesses architectural characteristics unique to the city. It is an almost intact neighborhood with substantial amounts of mid-19th century row houses. Other architectural assets include the intimate pedestrian scale of the area, consistent street wall and setbacks, scale and proportion. These factors will be considered in the resulting zoning recommendations, as well as in recommendations on the development of the city-owned parcels. In addition, assessment of open space need is expected to be a factor in forming a coherent urban design scheme.

One of the side effects of the gentrification is the large increase in the number of households in the neighborhood. While the population in the area increased by about 50 percent from 1970 to 1985, the number of automobiles jumped by nearly 150 percent. Parking needs therefore come high on the planning agenda. Another factor that demands planning is the type of mass transportation replacement to be implemented after the removal of the elevated Orange Line. These issues need to be addressed in conjunction with the studies on demographics and land-use.

2.6 Beyond the Current Physical Planning

Urban policy processes in the United States have long been characterized as pluralistic and involve consensus building. The process of the South End Development Policy Plan is no exception in this respect. The very process of identifying planning issues, negotiations among interests groups, and building consensus as to what to recommend to the general public by the representatives of the neighborhood, are all equally important, if not more important, than the product of the final plan.

In an introduction to the planning process, BRA identified a number of objectives to benefit the planning and larger political process:

> The South End Development Policy Planning process will help staff at the BRA and in other city departments become even more aware of the problems, concerns and aspirations of the South End residents. Simply by increasing contact between residents and city officials through the planning process, a better understanding should develop.
>
> Also, local residents should come to better understand how city government works: What are the responsibilities of the various city departments and agencies? Who can be most helpful in responding to a particular problem? How can a concerned resident better affect policy creation or decision-making? How are our tax dollars spent, and are they being used wisely?
>
> Aside from learning more about the mechanics of city government, residents should develop a keener understanding of how the political process works. There are costs and benefits associated with every decision, and planning often means a series of trade-offs and compromises designed to maximize benefits and minimize problems...
>
> Also, the initiation of a widespread effort like the South End Development Policy Plan Planning Process will help residents get to know one another better and feel more a part of the vibrant South End community. One of the most impressive benefits of the SENHI program was the way people of different viewpoints and backgrounds came together to work for community change. Some powerful friendships have been formed, and the South End is better off for this new spirit of cooperation and compromise. We hope this trend continues through this new effort (BRA 1989d).

2.7 Conclusions

Clearly, the planning goal here is treated as more than a set of expected land-use policy recommendations. It is a whole political process, the success of which depends very much on the participation of the parties involved, and the way by which the participation is facilitated. In the next Chapter, I will explain how an innovative approach in spatial information management can help to achieve this set of objectives.

Chapter Three

METHODOLOGY, GIS AND PLANNING

The fact that the Policy Plan will result in a small set of land-use proposals does not reflect, however, the extremely complex nature of the planning process it has to go through. Political, economic, environmental, social, and cultural factors all come into play in various forms and at different stages of the process, demanding careful examination and reconciliation. The planning mission in this sense is to locate physical resources in a socially optimal fashion. This pragmatic task is heavily dependent on spatial information, and its successful management and communication.

As stated in the introductory chapter, this thesis is a case study of the application of computer technology in the planning process. More focused, it is about using the visual display of spatial information to assist decision making. To characterize this, it is fair to say that the thesis can be viewed in part as a discussion on methodology from a functional perspective. To proceed to the discussion on the mechanics of such approach when applied to planning, it is fundamental to lay some theoretical ground with regard to the computer modelling philosophy and the particular issues of the selected modelling approach.

This chapter begins with a presentation of the computer modelling approaches in the political process, characteristics of spatial information, and the technical problems involved. GIS is then introduced as a general solution to the problems within the framework of computer modelling. Within the domain of GIS, I further look into the function and mechanics of visual display of spatial information as a way to facilitate communication for the purpose of conducting analysis, promoting better communication of the analysis results, and enhancing the productiveness of the larger political process planning it is to serve.

3.1 Computer Modelling Approaches in the Political Process

Before we discuss the nature of spatial data and the dependence of planning on its management, a fundamental understanding of the role of computer modelling in the political process is important. This understanding should bring us close to the political nature of community planning, and sharpen our focus on what we can expect from spatial information management and under what circumstances. In the following discussion, I introduce a theoretical framework of computer modelling established by Dutton and Kramer.

Dutton and Kramer observed that the rise of computer modelling in political processes has resulted in, or intensified at least, a widening gap of knowledge between experts, on the one hand, and lay policy officials and the general public, on the other hand. This poses a fundamental conflict between democracy and technology: between involving broad constituencies in the policy making process, and concentrating expertise and policy influence in the hands of a technical elite. They further maintain that there are four perspectives with regard to the control and interests served in the modelling process. These four perspectives are discussed below.

The Rational Perspective views policy making as largely and increasingly "scientific." Presumably, there are technically or scientifically appropriate theories embedded within the models and rules for operationalizing them for specific analyses. Thus, the quality of any particular analysis rests upon the ability of technical experts to apply these theories and rules independent of political guidance. The information produced by modelling in any particular instance is not intended to "determine" policy choice but only to add to the larger base of information used by policy makers. Thus, "incorporation" is the most important stage in the modelling process.

The Technocratic Perspective views models as a complex technology controlled by the new priests of the information society and poorly understood by politicians, bureaucrats, or the public. From this perspective, the manifest role and explicit purpose of models is to promote and transfer the ideas of the model experts. The expert can embody an approach to problem solving in a computer model that greatly extends the reach and utilization of these ideas.

The Partisan Perspective of modelling contrasts most sharply with that of the rational perspective. From the partisan perspective, models are tools of propaganda and persuasion of special interests in the policy process. They are adopted with the intention of legitimating choices that have already been arrived at by those who control policy decisions--the dominant political coalition in an organization.

The Consensual Perspective of modelling differs significantly from the most prevalent conceptualizations described above. From the consensual perspective, models are primarily tools for negotiation, bargaining, and interactive decision-making among the representatives of conflicting interests and opinions in the policy process. Modelers are not isolated and independent within such a process, nor are they simply the instruments of politicians. Rather, they pursue the modelling process with indirect guidance, consulting broadly among the array of participants that represent different interests involved in the policy choice. Modelers attempt to anticipate the reactions of various groups and interests to the technical choices they make in order that their choices are viewed as correct and that the product of their efforts are accepted (Dutton and Kramer 1986).

We want to consider these modelling philosophies because they define the larger political, organizational and institutional environment in which computer modelling is carried out. I choose largely to ignore this issue in later discussion, but not because it is something trivial in the whole process. On the contrary, one has to be keenly aware of the presence of political, organizational, and institutional factors, and modify the methodology of information management accordingly. If the policy making process is staged as introduction (identification of issues), collection and incorporation of information, analysis, bargaining and negotiation, and adaptation, then two perspectives--rational and consensual--are manifest in the incorporation and adoption stages. These two approaches give the most flexibility to the identification of issues and adaptation of policies. Their primary functions are to assist in the incorporation and enlargement of knowledge base, and to facilitate the negotiation process.

Given the political nature of the policy planning process, I consider that the rational and consensual perspectives provide a good understanding of the role of information management and one of its tools--computer modelling. These two perspectives further define the set of pragmatic tasks to be undertaken when conducting the real modelling work, and are the approaches used in this thesis work. I will now turn to the discussion of the characteristics of spatial information, and its relevance to planning.

3.2 Planning and Its Dependence on Spatial Information

What is spatial information? Spatial information is information associated with geographic units, and may be used to describe processes that happen in space. Like any other kind of information, it is about our knowledge of the world. Planning is often concerned with activities in space, and planning information can often be represented by spatial data.

First of all, spatial data are data defined by spatial units, just like data on flows of stock are defined by time. It is meaningless to talk about an income of $8,000 without specifying whether it is daily, weekly, monthly, or annual. By the same token, it is meaningless to talk about population without specifying the spatial units--census block, tract, planning district, etc. To take a further look, spatial units can be one, two or three dimensional.

Distance is one dimensional whereas area measurement is two dimensional. Most spatial data however, can be perceived as being three dimensional--amount of stock in an area--like population density, floor area ratio. The information is three dimensional because it needs three vectors to define, X and Y coordinates to define location, and a Z coordinate to measure the magnitude of a phenomenon, **implicitly as a function of that particular location.** We often represent such Z coordinates, or attribute data, on two-dimensional maps that we call "thematic" maps.

Spatial information gives us additional knowledge about the world. It also requires additional data to represent. Data about location and boundaries need special attention in their own right. In particular, spatial data are often not well regulated in the process of collection and storage, as compared to data denominated by time. We seldom see data on income in the form--$4,500 per 0.89 year, and $12,000 per 1.21 year. On the other hand, it is a fact of life that we have to deal with spatial data coming with almost certainly different spatial units. When we add up the thirteen census tracts pertaining to the South End Planning District, we find the aggregated area is slightly larger then the planning district. Census tract boundaries do not conform with assessing block boundaries, and they both change over time!

Secondly, spatial data describes spatial processes. Spatial processes can be understood through two distinct yet related phenomenon--the dynamics of change, and the causality of the change. The first aspect of the process needs to be understood in the context of time, whereas the second needs to be understood in the context of topology. The issue of gentrification, for example, is a dynamic spatial process--occurring over time, in a topological context. It is caused by some spatial elements, such as the rediscovery of the advantage of living in the inner-city; and it causes other spatial processes, such as change in housing stock to accommodate the new population groups, and a shift in the population base of a certain area.

To understand the process of gentrification in this context has tangible planning implications. For instance, the median household income of the South End in 1980 was below Boston's. By 1985, the income was above the city's median. It doubled in a five year interval. This may easily lead to the conclusion that the economic opportunity for the local residents was greatly increased during this period. Going one step further, given the traditional employment in this area was primarily in manufacturing, services, and other blue-collar industrial jobs, one may infer that these industries were thriving. However, what happened was exactly the opposite. The traditional manufacturing industries declined, as did the employment opportunities for the working class families. On the other hand, more professional-oriented service industrial flourished with the economic boom of the City of Boston. As a result, the area experienced an out-migration of working class families, and an in-migration of young professionals with higher educational attainment. Consequently, the kinds of facilities that should be planned for, definition of development potentials, and designation of land-use, all require different thinking from the situation in which gentrification has not occurred. Furthermore, if further gentrification of this kind is not desirable to the community, what can planning do to intervene? This question may find solutions in the understanding of this spatial process.

To illustrate the importance of the second aspect of the spatial process--causality in a topological context--let's take a closer look at the issues of diversity. It is well known that the South End neighborhood is the most racially diversified neighborhood in the entire city. Statistics from the 1980 census confirm this argument:

Table 3.1.1
Racial Composition of the South End and Boston

	% Black	% Hispanic	% White	% Asian
S.E.	44.6%	11.8%	37.3%	10.7%
Boston	22.4%	6.4%	70.0%	2.7%

The standard deviation of the South End racial composition is 15.1%, based on the percentage share of these four racial groups, whereas Boston's is 26.8%. Can one conclude that the area is a racially better integrated one than Boston as a whole? After looking at the topological context of the area, the answer is no. As explained in Chapter two, the South End is bounded by three racially distinct neighborhoods--Back Bay, Roxbury, and Chinatown, predominantly inhabited by White, Black, Hispanic, and Asian Americans respectively. Furthermore, each of these neighborhoods extends into and thus is represented in the South End. Let's now look at another table:

Table 3.1.2
Percentage Spread of Racial Composition by Census Tract

	Highest	Lowest	Range	Boston Average
% Black	91.1%	9.4%	81.7%	22.4%
% White	79.0%	2.5%	76.5%	70.0%
% Asian	60.1%	0.2%	59.9%	2.7%
% Hispanic	34.3%	2.0%	32.3%	6.4%

One can see that, as a matter of fact, racial segregation is very serious in the area. After this pattern was presented to the community planning working group, a member made a further observation that even the most integrated census tract has a progression of White, Hispanic, and Black residential enclaves within it!

I conclude that planning is indeed very dependent on spatial information and its successful management. Furthermore, the implementation of a plan is a spatial process, carried through in the present and into the future, with an aim to intervene in the distribution of resources to counter-balance market forces, and thereby achieve desirable social outcomes.

3.3 A Framework of the Technical Problems in Spatial Information Management

We have now navigated through the computer modelling approaches to political process, and characteristics of spatial information relevant to planning. We now proceed to the pragmatic tasks of computer modelling. The following discussion is aimed at framing the technical problems in their multiple dimensions of complexity. I think there are four issues of computer modelling under the general framework of rational and consensual perspectives. I have divided the four issues into structural, operational, communicational, and functional components. The framework may then be completed by incorporating a feedback loop between the functional component and the structural component. Other interactions between the components are also important. For example, choices of operational factors influence structural design decisions. In the following discussion, I will present these four components in their chronological orders when the study projects were conducted.

Structural--From what time and in what spatial frame do data come, and how can we access them on a comparable basis? Structural differences in spatial databases are the first things encountered in spatial database management. Spatial information comes with different spatial units. One good example is the relationship between census tract, assessing parcel, and the aggregation of both in many ways. Spatial data are also geo-referenced in different ways--by address, parcel identification number, tract number, etc. Differences in time frames is another source of frustration--the centennial Federal census, annual assessing data, etc. In addition, data are meant to carry different types of information--census data are about stock at one point in time, while data about zoning variance cases are about flow of stock over a time frame. Given these complications, the task is to manipulate these data so as to perform analysis at the desired level of data aggregation and in a comparable time frame. This becomes the first hurdle to pass in spatial information management. I think, based on my experience, that the time spent on this task is likely to take more than 80% of the total modelling time.

There is yet another dimension to this task. From the previous discussion on computer modelling, using the rational perspective, we realize that enlarging the knowledge base for policy making is of paramount importance to this perspective. Therefore, on top of aligning boundary files and data once, we have to be concerned with how to keep the state of alignment under the circumstance of increasing volumes of data. The desirable solution is to maintain the **access by which to incorporate** the evolving databases, rather than the products of the incorporation. The product of incorporating databases has had an increasingly shorter life-cycle, as a result of quicker access to the databases which generated the products. Work in this area has attached much importance to the mechanics of accessing databases, and the dynamics of incorporating them for use in policy analysis.

Operational--Given the variety of forms spatial data come in, how can we operationalize the analysis effectively and efficiently? Once spatial data are updated to comparable time frames and their boundary files aligned, problems arise in operationalizing the analysis. Many planning problems are voiced vaguely, not due to ambiguity in language per se, but rather because they reflect the fact that these problems have multiple origins and effects. Taking the issue of "diversity" again, we see that it is identified as a distinguishing characteristic of the South End. The community wants to preserve diversity through regulated growth. But how do we measure diversity to begin with? How do we identify factors leading to it, quantify its impact on other physical and social aspects of the neighborhood, and what can we do to preserve it? This problem represents, in a larger sense, the problem of **representing information with data, and prescribing the appropriate measurement and analysis.** Poor operationalization of the analysis not only wastes time, but leads to a misunderstanding of the nature and magnitude of issues being addressed.

Communicational--How are data and their analysis best communicated? With the steady increase in volume of spatial data processed and presented for policy process, effective data communication becomes increasingly crucial. Communication in a planning context may be defined at three levels, involving planners, decision makers, and the general public, respectively. Planners engaged in data analysis need quick, yet comprehensive understanding of data acquired for manipulation and analysis. In many cases, knowing the pattern of how data deviates spatially may be more important than knowing their general characteristics, described by conventional descriptive statistics such as the mean, median and standard deviation. At the next level, the planner is responsible for presenting summaries of selected variables to the decision makers to help them evaluate the importance of these variables in the social and economic landscape of the area. Good communication reveals relationships, leads to hypothesis building and testing. After the nature and magnitude of linkages are identified, planners and decision makers are responsible for communicating the policy recommendations to the general public for feedback. The communication at this stage should be easy to understand and unbiased.

Functional--What do we do with the analysis? Planning is about the future, and is conducted based on sensible assessments of what happened in the past, and what caused it to happen. However, planning can not (let alone should it) dictate in a direct way the likelihood of certain social outcomes. All it can do is to exercise its power in zoning and other physical growth regulations to attempt to achieve desirable results. Therefore, simulation of the impact of selected variables becomes an indispensable tool for policy reasoning. Such simulation, or "what if" analysis, requires building linkages between variables, databases, and their corresponding geographic boundaries.

In summary, these four types of problems pose great challenges to the successful management of spatial information, and in turn their successful resolution affects the quality of planning. Today, we are often working on the structural component, experimenting on the functional and communicational, and thinking about the functional tasks. The fast growth and spread of micro-computer technology, and especially the introduction of Geographic Information System (GIS), provide new avenues for more efficient spatial information management for planners.

3.4 GIS

The advent of computer technology has given rise to the adoption of a new tool of spatial information management--Geographic Information Systems (GIS). Following its introduction on the microcomputer platform in the mid-1980's, GIS has progressed quickly to affect the way that spatial information is acquired, stored, analyzed, and presented.

The essence and strength of a GIS lies in its power to create linkages--linkage between data and their spatial units, linkage among the spatial units themselves, in a topological fashion; and the consequent strengthened linkage between computer modelling and the real world it is to represent. Here is a good definition of the nature and component of GIS from a planning perspective:

A GIS deals with three conceptually distinct types of 'objects': a container, which is geographic space; its contents, which include natural and man-made objects, people, and physical and social events; and processes, governed by rules or laws of causation, which involve the contents of the container, and which lead to steady state flows, cyclical variation, or change.

A GIS therefore must contain means for defining the container, storing and accessing its contents, and describing or simulating the processes which may be considered significant. The container, space, has various different representations, and this implies means for reconciling and manipulating them. The contents are inventoried from different sources and change in different ways, so that the management of their descriptions (data) and its relations with space requires still other means. The representation of processes still other problems. These respective issues are addressed in general terms by computer mapping, by data management, and by modelling (Harris 1989).

It is not my intention here to become involved in the conceptual discussion about a GIS. Rather, this brief introduction should lead us right into a concentration on the mechanics of the linkages between GIS components, and between GIS and its users. We now turn to the discussion of a core interest in the thesis--visual display of spatial information.

3.5 Visual display of Spatial Information

As implied, the power of a GIS lies in its ability to process large volumes of spatial data, and display it at different levels of aggregation on maps. Furthermore, such data can be overlaid in a complex fashion that will enable us to see some pattern of spatial concentration in the physical, economical, social, and environmental phenomenon we are trying to understand and manage through planning. Specifically, the advantage of a GIS in assisting the planning process is a function of revelation of spatial patterns and processes.

The visual display of data on maps at the initial stage of data collection gives us a spatial plot of descriptive statistics. Where are the tax exempt properties in the South End? Where are the single parent families? How does property value distribute and vary over the whole area? What are the demographic characteristics in a block, along a street, or in a circled target area? By plotting information on maps, we not only can have a quick and intuitive understanding of information such as the total, percentage, and mean values of interesting variables, but we will also have a much better understanding of the spatial deviation of such variables.

We may also use a GIS to overlay different kinds of information that we suspect is associated with other factors--**a spatial cross tabulation of data.** Does the percentage of absentee landlords in a block have a negative effect on property value, tax default, and other neighborhood disamenities? How can the high level of speculative purchase of property along the Washington Street corridor be explained? Does crime rate correlate with type of residential building types? If we see such patterns do exist as a function of location, then what is the magnitude of such correlation, and what causes what?

In the process of applying GIS to planning, we increasingly ask the following question: "How can a map help us to do data analysis more effectively?"; as opposed to the question: "Given the result of the analysis, how can we put it on a map?" In other words, we are searching beyond the conventional role of maps, which is a spatial interpretation of the results of a piece of analysis. The reason is simple. With increasing volumes and complexity of spatial information being acquired, processed and manipulated for analysis, the ability of our minds to deal and digest just tabular information diminishes. For example, a table containing information for 841 assessing blocks may be more than twenty pages long, and could hardly make sense to anyone--professionals and laymen alike. Under such circumstances, visual display of such information becomes an indispensable, if not the only, way to facilitate spatial information analysis.

Visual display of spatial information in this context is defined as an instrument for accessing, viewing and linking databases in the form of maps. This definition stresses the nature of such an instrument in terms of its dynamics, flexibility and use-specificity. It is dynamic--graphical elements that make up the map (shade pattern, color, boundary, etc.) change in an instant according to the way data are broken into ranges and the way the map extent is specified(e.g., a window showing portions of a map). It is flexible--maps show absolute numbers, percentages, stocks and flows, overlay of different variables, etc. It is use-specific--the validity of a map depends on the type of analysis it is designed to assist. More advantageously, such an instrument combines "visualized" data with corresponding access to geographical proximity and therefore to the role of distance as an explanatory factor.

However, just like tables are condensations of information in a tabular form, maps are **condensations of data in a graphical form.** This nature has resulted in the fact that maps can be (and almost certainly will be) deceptive. How we condense the information, and in what graphical format we put it, are two prime sources of possible deception. Furthermore, the way in which a map can be deceptive differs according to its communicational intent.

When we read maps designed by ourselves in the course of data analysis, we can be misled by the way data are broken into ranges, and by the geographic boundaries they represent. When others read the same maps, they may also be misled by the shade patterns and colors.

Given these pitfalls, each map, or a frame of display in general, needs careful design in its own right to optimize its function of carrying information. In turn, frames of display need to be organized with one another so as to facilitate the analysis in an efficient and unbiased way. This section discussed some concerns in the design and organization of visual displays in the framework provided in the preceding section--structural, operational, functional, and communicational. This will lead us to the detailed discussion of the design of maps in the following two chapters on actual study projects.

3.6 Conclusions

In this chapter, we have gone a long way to define, in a hierarchial fashion, the theoretical framework of visual display of spatial information. In real life, 80 percent of the time devoted to this thesis has been in the discussion and understanding of the political process, relevant information, appropriate computer modelling approach, and preparation of data for analysis. Even so, many of the identified approaches were not adopted, tasks were not undertaken, and analyses were not carried out, due to limitations in time and software capability. Nevertheless, the following two descriptions of the study projects on demographics and land-use would never have been possible without solving these problems in a larger context.

In the next two chapters, we will look further into the process of applying GIS to the analysis of planning issues. The study projects will be approached within the framework established in this chapter, and will explore the power of visual display through descriptions and designs of various forms of maps.

Chapter Four

THE DEMOGRAPHIC STUDY

4.1 Introduction

In this chapter, I will describe the first of the two proponent study projects in this thesis--the project of the demographic and socioeconomic profile of the South End neighborhood. After some reiteration of the planning context of the study, I will focus primarily on the discussion of methodology, approached from the framework established in the last chapter. In particular, discussions on the design of maps as visual displays of spatial information will be approached from the four technical components of structural, operational, communicational, and functional. Then I will present a survey of working group members on issues of adequacy and relevance of this study to the Policy Plan. I conclude this chapter with discussions of success, problems, and directions for further efforts.

As argued in Chapter Three, the objective of computer modelling throughout the planning process is to build, link, and enlarge a knowledge base for decision-making. Furthermore, the intention of this thesis is to explore the mechanics of visual display of spatial information to facilitate such a process. Therefore, discussions on the derivation of planning issues and the implications of the findings are treated as background. For a detailed account of the full breath and depth of the study, readers are recommended to refer to the final documents on the Development Policy Plan, which will be available by the end of the planning process in October,1990.

4.2 Planning Issues Relating to the Demographic Study

The key objective of this study is to use census data and other complimentary sources of information to identify the demographic and socioeconomic characteristics of the South End neighborhood. Simply put, the study intends to answer the question, "Who are we?"

In the context of the South End Development Policy Plan, this study tries to bridge the set of social objectives and the physical mechanism by which such objectives can be achieved. At this point, it is beneficial to the understanding of this study that we briefly review some of the social objectives the working group members have identified. As documented in the minutes of the working group meeting early in the planning process, members voiced their concerns and envisioned the future of the South End. Many of the expressed issues were closely related to the socioeconomic characteristics of the neighborhood. The following list is by no mean exhaustive, but will suffice to demonstrate the underlying nature of the demographic study:

1. Preservation of the celebrated qualities of life such as the diversity/heterogeneity of the people who make up the South End.
2. Encouragement of more families, especially those with children, to come to, settle and prosper in the neighborhood.
3. Commitment to social services, care for elderly and the physically challenged.
4. Enhancement of job opportunities and revitalization of local business.
5. Balance of social factors shaping the neighborhood.

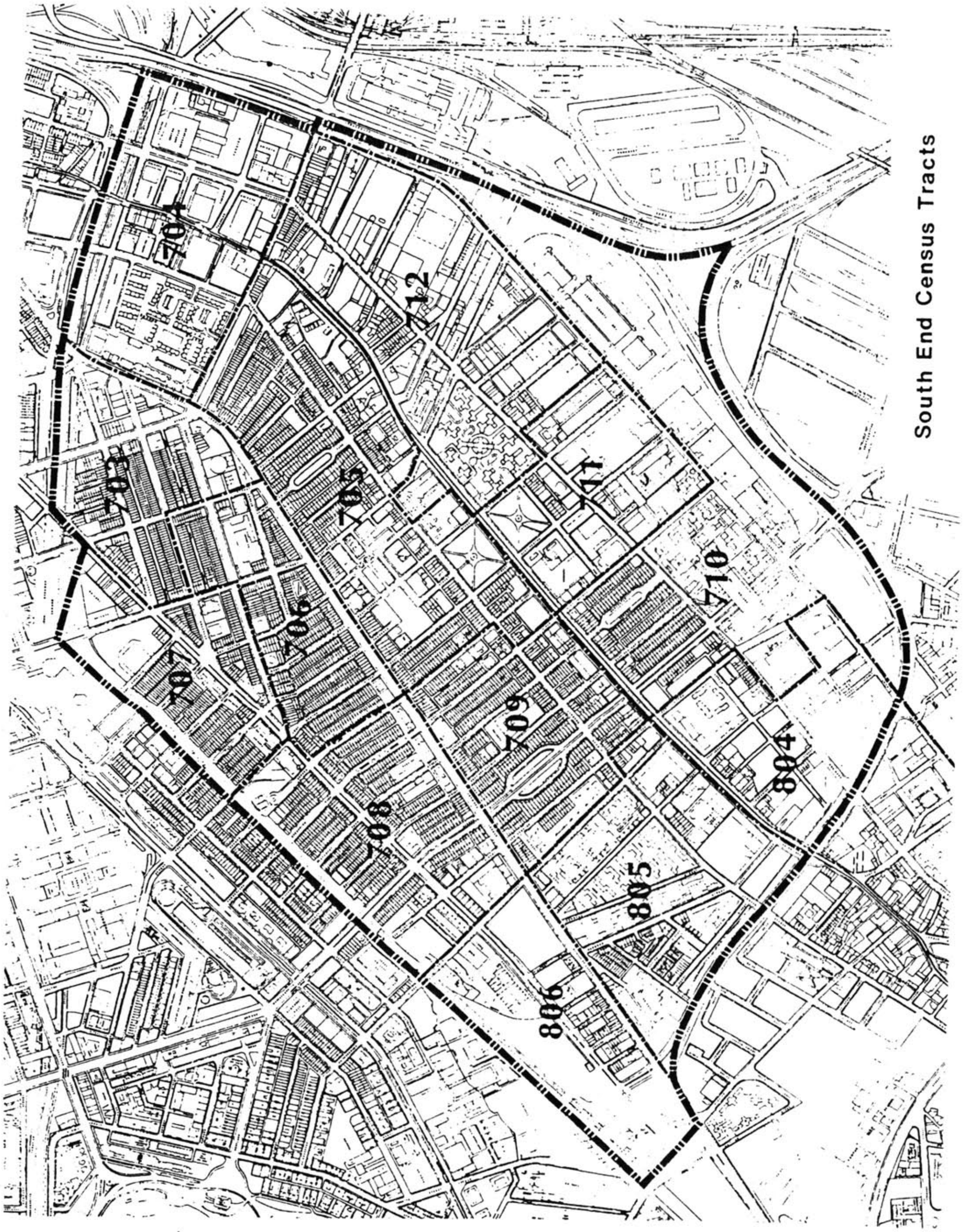
To evaluate these planning missions in a quantitative fashion, there are a number of approaches with regards to the types of data available, and to their time frame. Aside from the early identified source of data--the 1980 federal census, the BRA Research Department conducted two Household Surveys, in 1980 and 1985, respectively. Since the results were presented at a planning district aggregated level, they did not support the desired census tract level study. Even though the 1985 Household Survey results were considered for an effort to update the census information, they were not part of the computer modelling information base.

4.3 Methodology

Based on the theoretical framework established in Chapter Three, this section will present the study project from the vantage point of the four components identified--structural, operational, communicational, and functional. The study project uses 31 variables from the 1980 census, across thirteen census tracts making up roughly the South End Planning District. The boundaries were digitized using ARC/INFO software. The study project started in January, and was presented to the working group in February. Total amount of time in data entry, map digitization, and map plotting is estimated at over 100 hours.

<u>4.3.1 The Structural Component</u> The structural component in this study mainly included problems in delineation of the study area. Census tracts do not exactly conform to the boundary of the South End Planning District. This was the first problem encountered in the study. There are roughly thirteen census tracts pertaining to the South End (Figure 4.2.1). Among them, census tracts 703, 804, 806 extended beyond the planning district boundary. So far as the study is concerned, discrepancies in the South End total calculation may be particularly caused by tract 703, which includes Bay Village and is densely populated. Technically, a census tract can be further broken into census blocks. Some blocks can therefore be excluded from the

FIGURE 4.2.1 Census Tract Boundaries and the South End Planning District



tract in order to conform more closely to the planning district boundary. However, data on blocks with populations less than 400 are not reported for privacy reasons. This means that even if we can successfully align the tract boundaries to the planning district, we still may not be able to determine what portion of data of the divided tracts should be included in vs. excluded from the planning district. As a result, it was decided to go along with a slightly larger area than the South End, defined by the thirteen census tract boundaries. Other problems in the structural component include the outdatedness of the census data. Since this problem is so predominant, I will discuss it separately in section 4.5.

4.3.2 The Operational Component The operational component includes problems of establishing measurements and the assessment of their adequacy in representing planning issues. The second step in the study reflects such an undertaking, mainly in locating information in the census, and forming measurements. With regard to the expressed planning issues, 31 census variables were chosen for analysis (13 of these variables are displayed in Figure 4.3.2 to 4.3.16). They can be grouped into the following categories:

1. racial composition;
2. age composition (in selected age groups);
3. employment composition;
4. composition of family types;
5. income composition;
6. income level and distribution.

Most of these variables come in the form of absolute numbers, aggregated by census tract. However, data in their raw forms are not necessarily best for mapping for a number of reasons. They are not on a comparable basis to other aggregated data, such as those for the South End and Boston; they don't have a common "unit" by which comparisons are sensible across different variables and/or different tracts. In addition, there is no "cap" on the absolute numbers. This makes it harder for choosing color or shape patterns in the overall map format design. To illustrate these problems, Table 4.3.1 is constructed for two variables from the census data--number of persons employed in professional or managerial occupations, and number of persons over 65 years of age. Both variables are presented in both absolute numbers and percentage terms. Mean values of the four column numbers are calculated, as are the standard deviations. The coefficient of variation (C.V.) is the standard deviation relative to the mean, and measures the relative magnitude of the standard deviation.

Table 4.3.1 Comparison of Employment and Age Group data, as in absolute numbers and percentages

Census Tract	Emply in Prof. & Mngmt	% of Labor Force	Age 65 and +	% of Total Pop
703	959	46.7%	297	9.5%
704	68	10.1%	217	11.9%
705	750	27.7%	547	10.2%
706	844	51.2%	206	7.8%
707	278	30.1%	112	7.3%
708	545	37.5%	399	14.1%
709	363	29.1%	286	10.5%
710	337	34.7%	75	4.3%
711	51	31.1%	341	32.9%
712	50	16.7%	133	11.2%
804	63	11%	55	3.3%
805	259	20.4%	324	7.6%
806	25	8%	41	4%
Mean	353	32.3%	233	15%
Std	313	18.1%	145	18.1%
C.V.	0.89	0.55	0.62	1.17

From Table 4.3.1, one can see that absolute numbers can be misleading when compared with each other without reference to the total. In the first case, employment numbers vary significantly, whereas their percentages show a lesser degree of deviation. The second case is the opposite, the seemingly unified numbers mask the degree of variation among the percentages. In both cases, percentages help to reveal the patterns of statistical deviation among different census tracts. Given these concerns, percentage terms are often better suited than absolute numbers in mapping.

Next, decisions need to be made regarding what percentage terms should be used--should the percentages be calculated on a base for each census tract alone, or for the whole South End? For percentage of White, for example, should it be calculated as a percentage of the White population in the total population of a particular census tract, or the percentage share of the White population of the South End total? In this case, one can see that there is no definitive advantage of one approach over the other. I chose the percentage-by-each-tract approach, since I consider the approach more indicative of the characteristic of each tract in its own right.

Other problems in the operationalization are more difficult to tackle. The issue of diversity, for instance, it is an issue constantly touched upon at various meetings of the working group. What do people really mean by diversity? Is the South End a diversified neighborhood in terms of its racial composition type? Or its age composition? Is the degree of diversity consistent across the whole area? How might statistical measures be established? Quite experimentally, the way I approached this problem was to first identify some variables that may contribute to the concept of diversity (racial composition and employment type in this case), then I measured the degree of deviation of each components' percentage share (how much the percentage share of White, Black, Hispanics, and Asian American in each census tract deviated from the theoretical mean, which should be 25%). Next, these deviations were transformed into an index, indicating the racial integration level from low to high. This measurement was then put on a thematic map to show the spatial dispersion. The results are revealing--we can not only see the degree of diversity in racial composition and employment by each tract, but can also understand the spatial pattern of diversity (Figure 4.2.2).

4.3.3 The Communicational Component The communicational component is the focal point of the methodological discussion in this section. The central problem to address here is the presentation of analysis results.

Data presented in tabular form are easy to understand and, generally, are unbiased. However, when the volume of data increases dramatically, the ability of our minds to coordinate these data decreases. For example, one will have little problem reading data on median income across the thirteen census tracts in South End, and will have little difficulty in understanding and remembering them. But in the case of our study, we have more then thirty chosen variables, across thirteen census tracts, plus the South End and Boston aggregates. This results in 15 times 30 equals 450 numbers. In addition, if we desire these data in both absolute number and percentage terms, we have to read 900 numbers! Just to make the case even more frustrating, implications of the influence from location are buried in the geo-coding numbers--the Tract number. How can we present such comprehensive spatial information just by means of reading data in tabular forms? In such cases, visual presentations of spatial data become indispensable.

In this study, thematic maps were used to serve this purpose. A thematic map presents data for reading in a shade or color pattern that corresponds to their range or value. In effect, it can be thought of as a picture carrying a large volume of data in a small space. Furthermore, all that data, thanks to the graphics, can be thought about in many different ways at many different levels of analysis--ranging from the contemplation of general overall patterns to the detection of very fine (spatial) unit-by-unit detail.

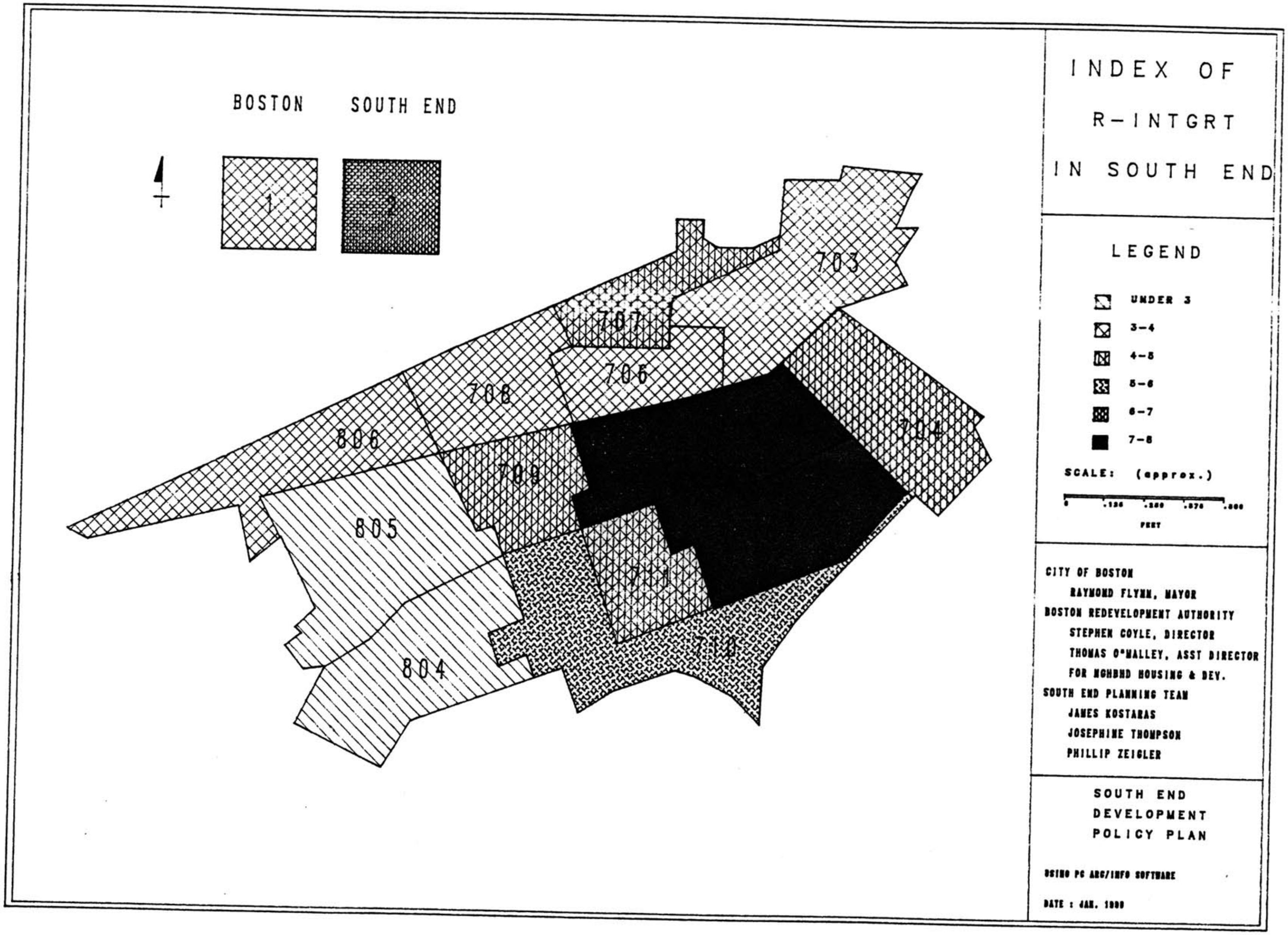


Figure 4.3.2 Index of Racial Integration in the South End

However, such display of data in the form of maps is a condensation of data in graphic form, and is thus subject to several sources of bias--the way data are condensed and the visual form in which they are displayed. The first potential source of bias, referred to as the way the data are condensed, means that data must be broken into ranges. For example, we transform a whole spectrum of continuous numbers into six categories. The way these numbers are broken down must be subjective--do we break them down according to an even interval, or make each range contain an equal number of occurrences? A second kind of possible bias is in the visual display of such data ranges. People's perception of color and shape patterns are different. Moreover, thematic maps assume that each unit of shade is homogenous within each region, which is certainly an approximation to the real world. A final source of bias relates to the differential size of the shaded regions. Larger regions, for example, appear more dominant. Given these pitfalls of thematic mapping, the presented maps are suggested as a convenient "index" to the real data.

It is hard to establish a set of rules that can universally safeguard the quality of thematic maps, and their practical intent, which is to serve analysis in an unbiased fashion. However, some general design guidelines for statistical graphics may suffice to guide map design for this study. I choose to present here a set of such guidelines established by Tufte:

> Excellence in statistical graphics consists of complex ideas communicated with clarity, precision, and efficiency. Graphical display should
>
> - show the data;
> - induce the viewer to think about the substance; rather than about methodology, graphic design, the technology production, or something else;
> - avoid distorting what the data have to say;
> - present many numbers in a small space;
> - encourage the eye to compare different pieces of data;
> - reveal the data at several levels of detail, from a broad overview to the fine structure;
> - serve a reasonably clear purpose: description, exploration, tabulation, or decoration;
> - be closely integrated with the statistical and verbal descriptions of a data set. (Tufte 1983)

As an example of applying this set of rules to the map format design in the demographic study, I decided to present, for each study variable, a South End and a Boston average. This is done by adding two squares at the upper left corner of each map to be shaded, together with the other thirteen census tracts. This proved to be efficient in increasing the volume of data carried on each map, providing depth to the study, and encouraging the eyes of viewers to compare different pieces of data in a larger context. For instance, from the map on employment integration, we learn that the South End average is at the same level with Boston's. The "Back Bay" portion of the South End has the lowest integration index, due to high concentrations of employment in management and professionals (Figure 4.3.3).

In addition to these characteristics of visual display mechanics, there is yet one more dimension to the advantage of thematic mapping approach to data presentation. It is manifest in the context of the planning process--the communication among decision makers. As discussed in the computer modelling section in Chapter Three, beyond the purpose of providing a knowledge base for decision making, computer modelling of this kind is also meant to serve the purpose of providing a framework for negotiation. It is my experience from participating in the working group meetings that the way I read a map is quite different from that of the working group members. Working group members tended to approach the maps by first focusing on their particular census tract. Since they can easily relate to their own areas, comparisons among different tracts were enhanced by added knowledge pieced together from different members during a meeting.

4.3.4 The Functional Component After the mechanics of visual display are examined, it is time to take a closer look at the maps. The functional component of the project is discussed in terms of what spatial patterns can be detected from the visual display, and what planning implications can be derived (though this second aspect is beyond the scope of the discussion in this thesis and will be omitted).

First of all, the resulting thematic maps show some spatial patterns. Recall from Chapter Three that spatial patterns can be manifest in two ways--topological relationship and spatial processes. Let me illustrate both. In the first case, the map showing the racial integration index indicates that the South End as a whole has a more diversified mix of different racial groups than Boston (Figure 4.3.2). In addition, it is less integrated on its fringes--the portions of the South End that are bounded by Back Bay, Roxbury and Chinatown share the same index as the city's average. It is at its core that the South End shows a much higher index of integration--Census Tracts 705 and 712. This map shows clearly the topological context of racial composition of the area. With regard to revealing spatial processes, maps can be grouped together by their similar spatial patterns to detect association among different variables. To illustrate this, let's examine maps on Percentage of White, High School Graduates, Employment in Management and other Professional occupations, Families with Married Couples, and Level of Median Income. We can detect strong patterns of correlation, and a consistent spatial distribution (Figures 4.3.4-8), among these variables over the study area. On the flip side, maps for Percentages of Black, Employment in

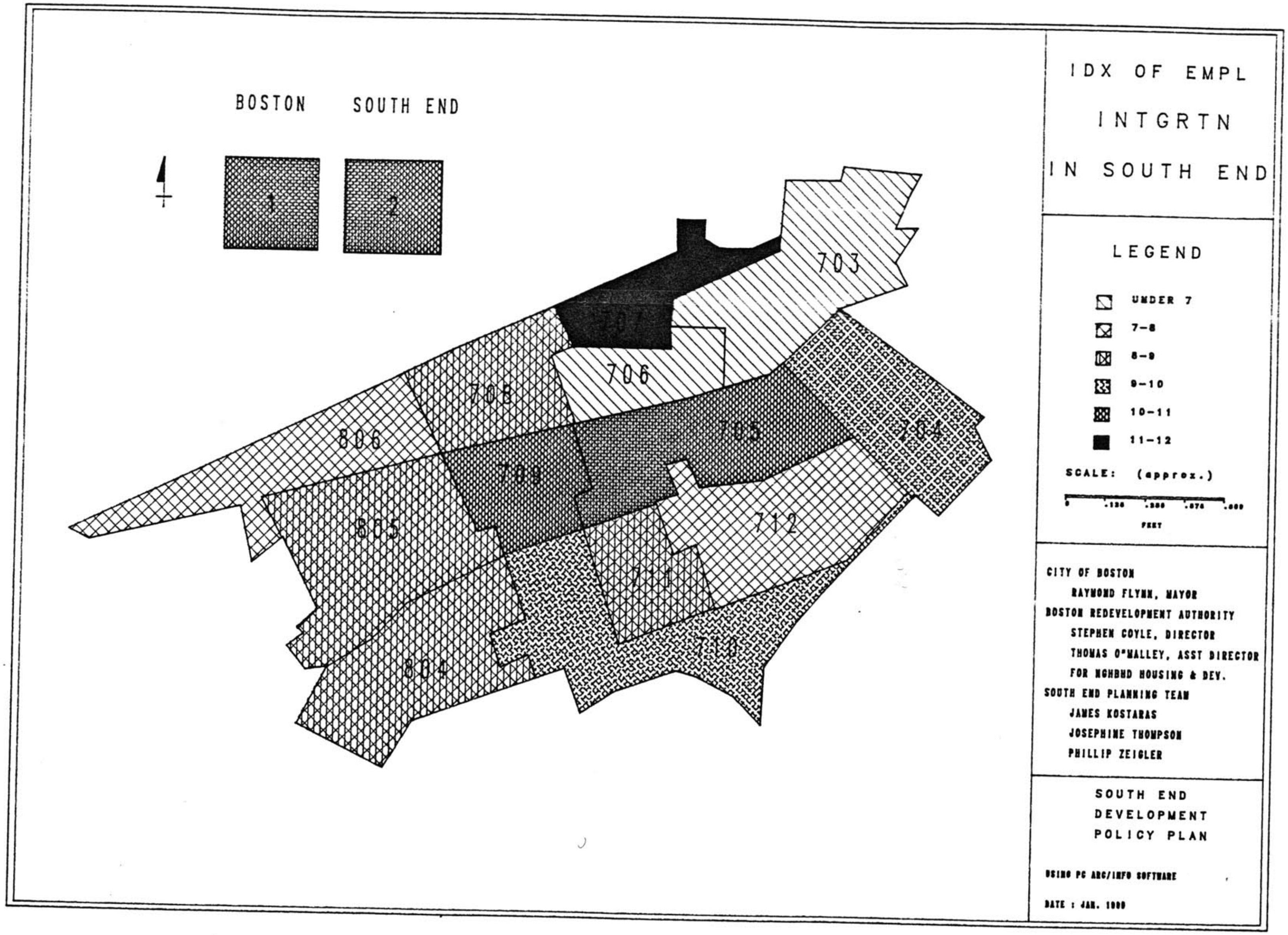


Figure 4.3.3 Index of Employment Integration in the South End

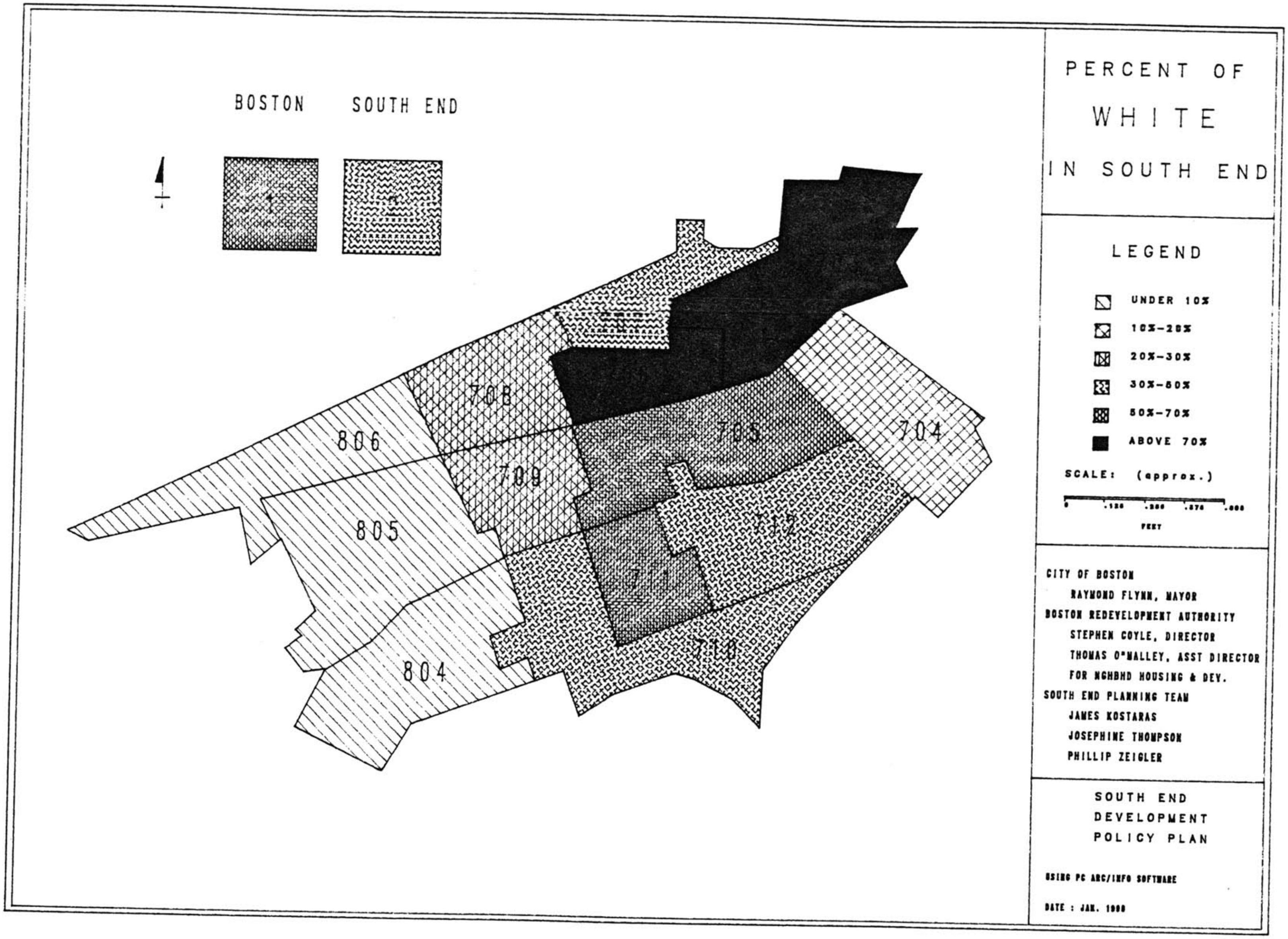


Figure 4.3.4 Percentage of White Population in the South End

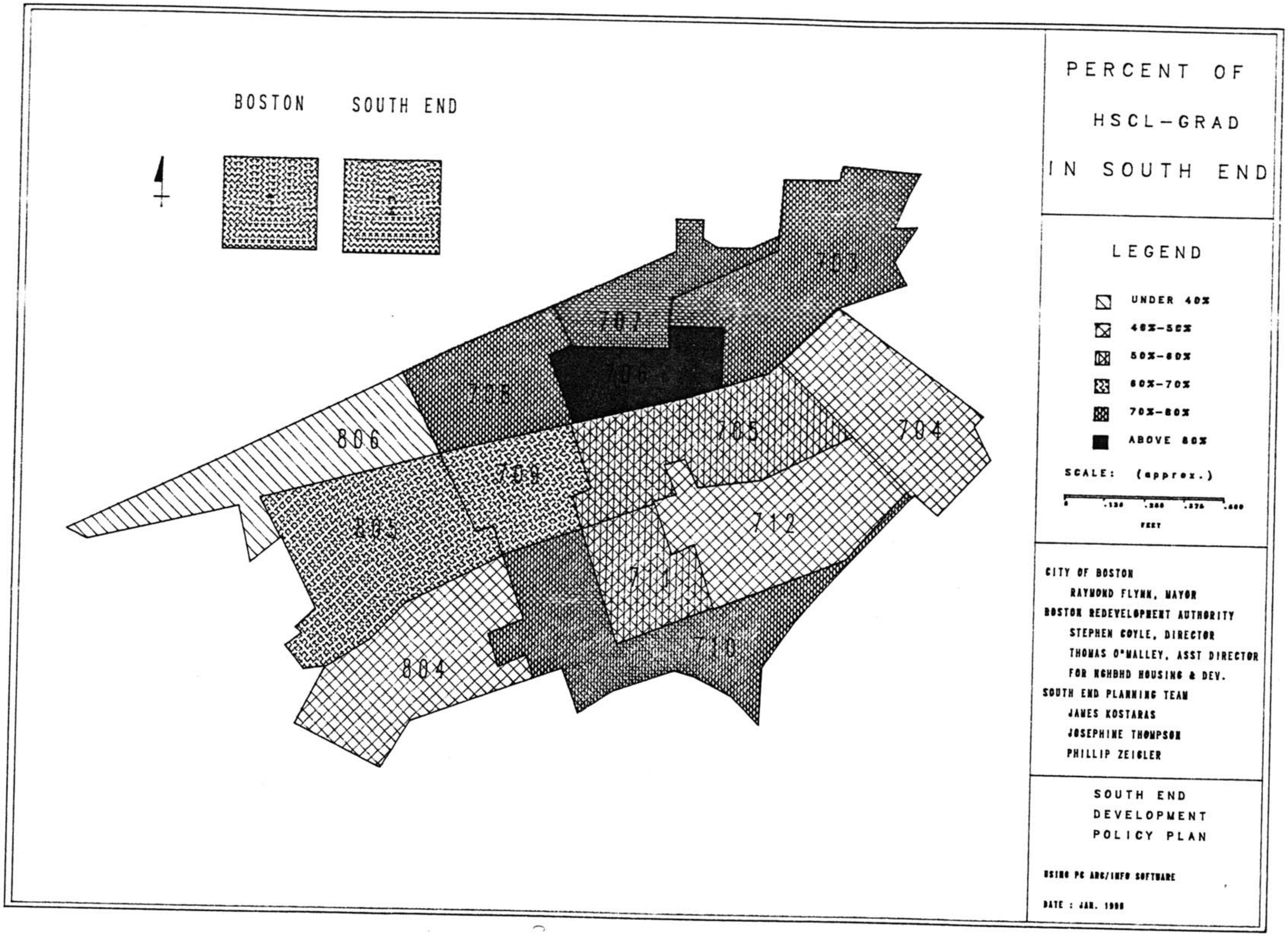


Figure 4.3.5 Percentage of High School Graduates in the South End

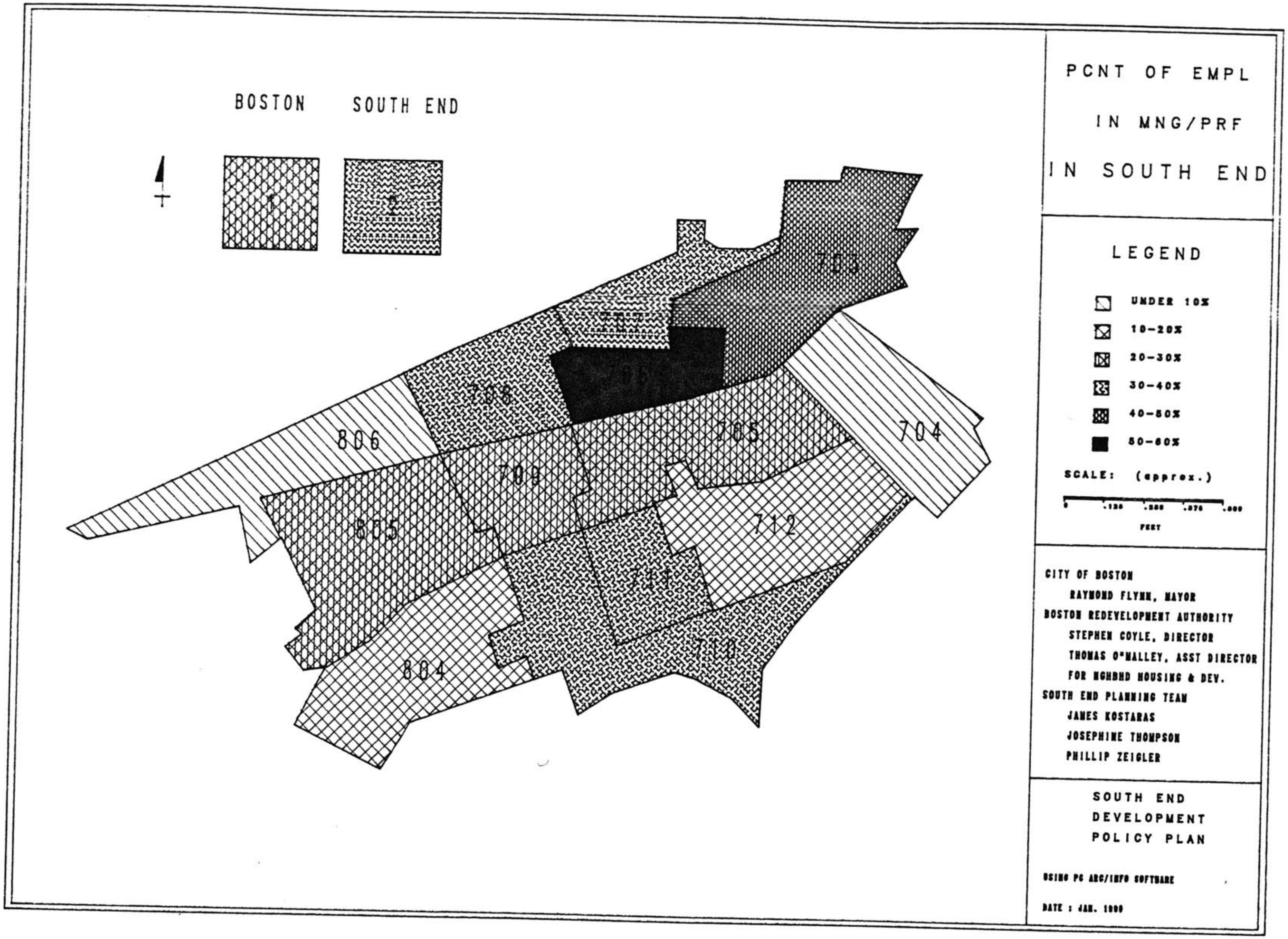


Figure 4.3.6 Percentage of Employment in Management and Other Professional Occupations in the South End

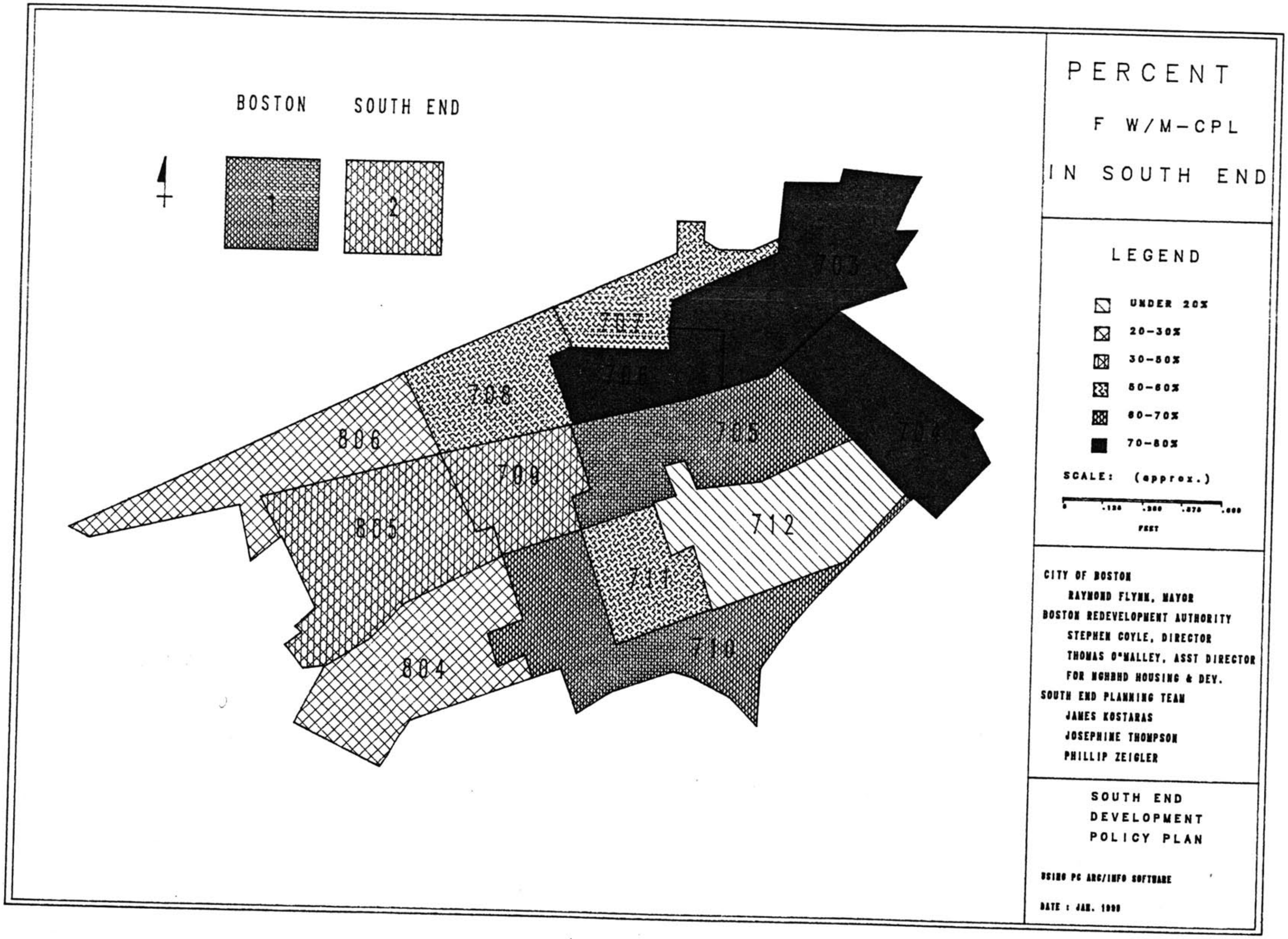
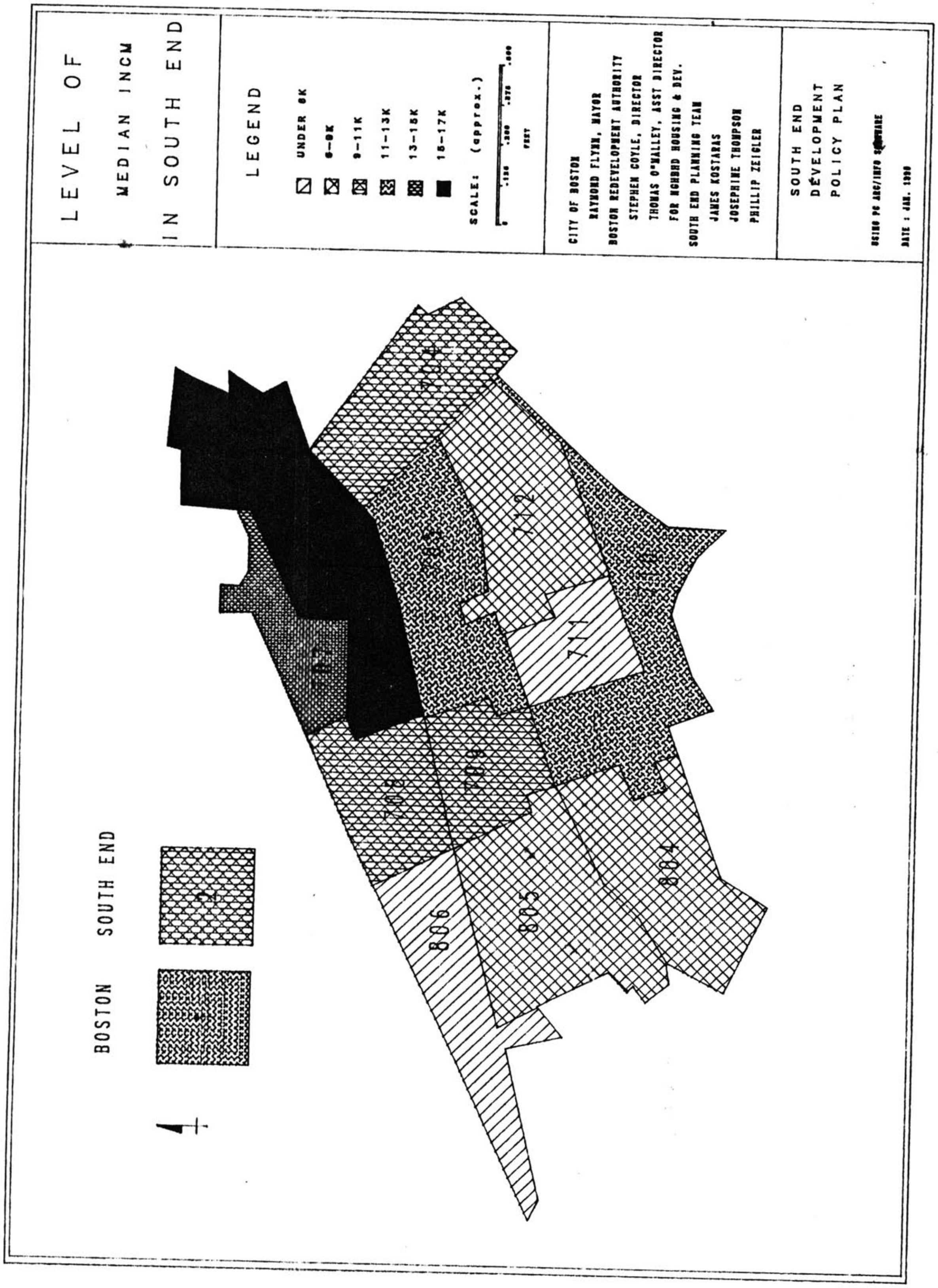


Figure 4.3.7 Percentage of Families (Married Couples with or without Children) in the South End

Figure 4.3.8 Level of Median Income
in the South End



Services, Families with Female Head and with Children, Poverty, and Percentages of Persons in Age Group 0-4, 5-9, 10-14, 15-20, show reverse spatial patterns (Figures 4.3.9-16).

One more dimension of such visual exploration using these maps is that by comparing these patterns, statistical outliers can be approached in a much more sensible way then with pure statistical modelling, such as regression. Looking at Figure 4.3.3 again, we find that census tract 707 shows a surprisingly high level of employment integration. This is surprising, because this census tract normally shares the same socioeconomic profile with other "Back Bay" tracts in the area. It turns out that this census tract contains several subsidized housing structures, and may thus house a diversified group of residents with different employment backgrounds. Another constant outlier is Census Tract 704, home to a large Asian American population. For instance, it has the highest level of percentage in families with married couples, yet one of the lowest levels of median income. This pattern is contradictory to the general pattern supported by virtually all other tracts, shown in Figures 4.3.5-8. This may be explained by the general characteristics of the Asian American community--concentration of employment in services and manufacturing and, on the other hand, the adherence to more traditional family structures.

In this section we discussed the issues involved in, and functions served by, visual display of spatial information. Given careful operationalization and design, thematic maps help to facilitate spatial analysis in a number of ways. They reveal the topological relationship of spatial units--there is a certain spatial relation and transition between adjacent census tracts, and the area as a whole reflects the spatial transition from different adjacent neighborhoods. Also, when presented together, thematic maps can show correlations of different variables, and thus may help in the derivation of planning implications at a later stage. They also help to mark outliers on the map, and help us to find explanations in a spatial context. To test these propositions, a survey form was designed to obtain feedback from the working group members. This is discussed in the next section.

4.4 The Survey

In conjunction with the study, a survey form was designed to get feedback from the working group members. The survey focused on issues of the design of maps, the relevance of map content to the planning issues, and the adequacy of the study and its presentation. Furthermore, I wanted to learn some statistics about how comfortable these working group member were with computer technology and statistical analysis in general. Also, I thought some knowledge of each member's background, as reflected in the length of

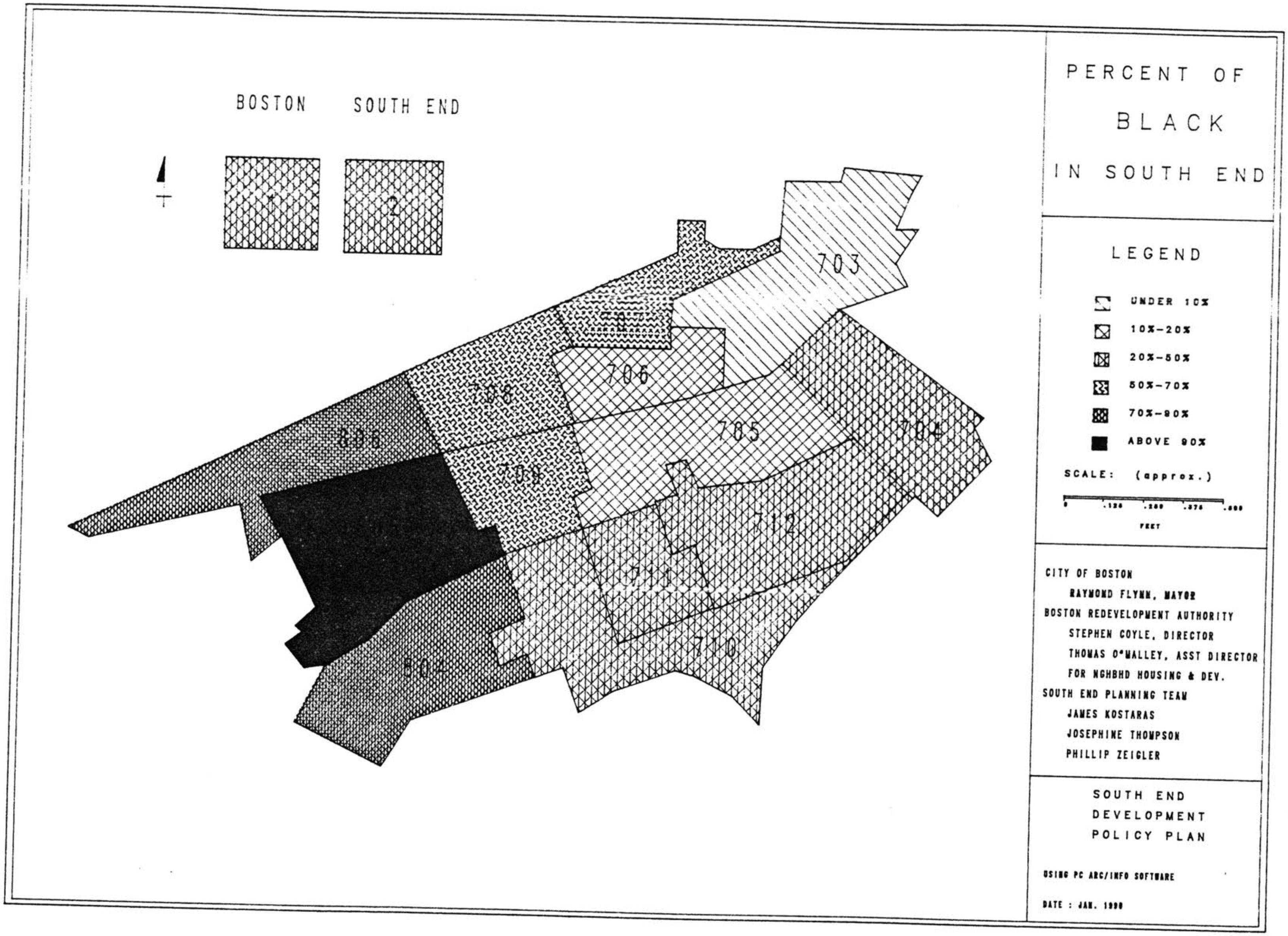


Figure 4.3.9 Percentage of Black Population in the South End

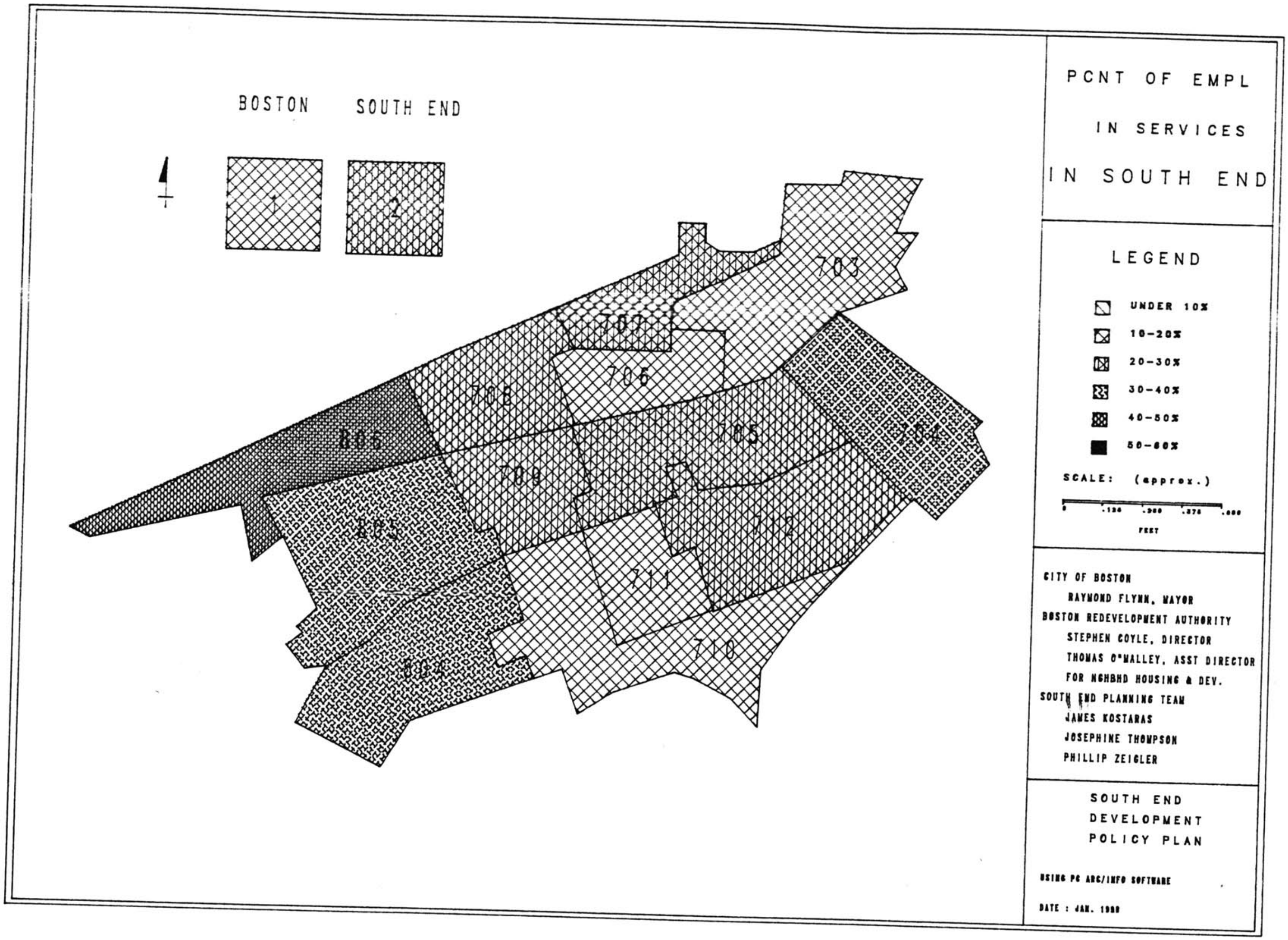


Figure 4.3.10 Percentage of Employment in Services in the South End

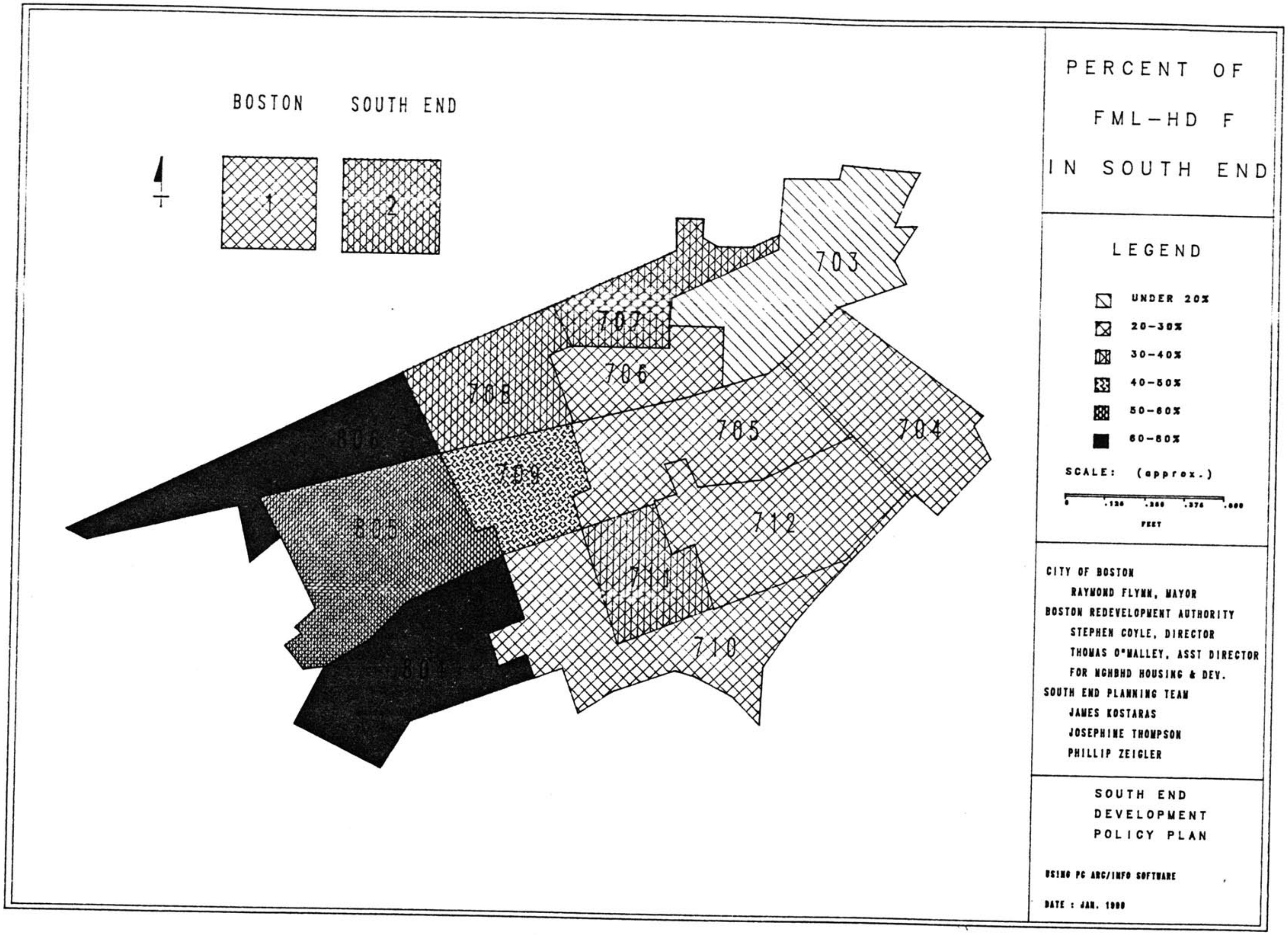


Figure 4.3.11 Percentage of Female-headed Families with Children in the South End

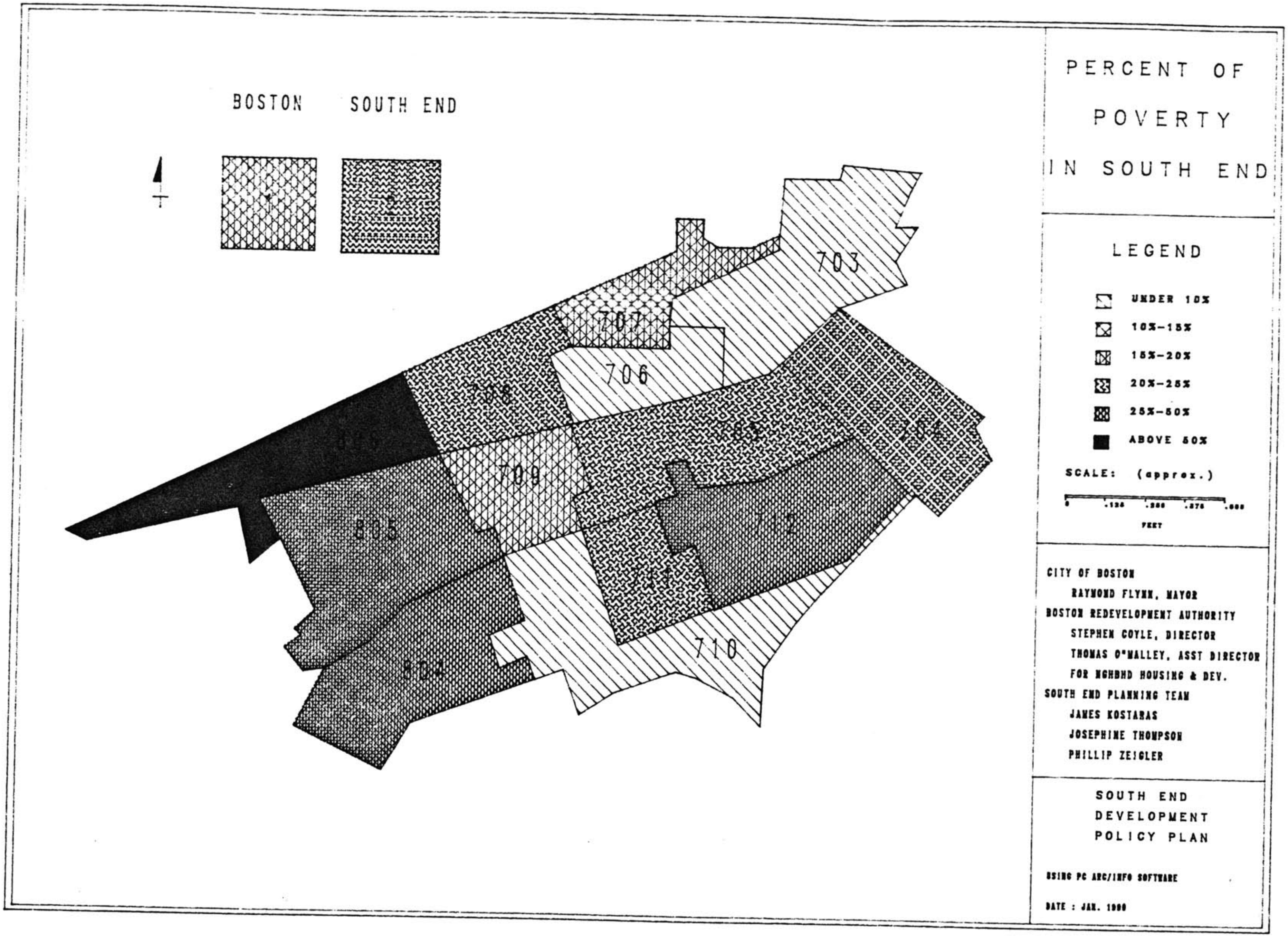
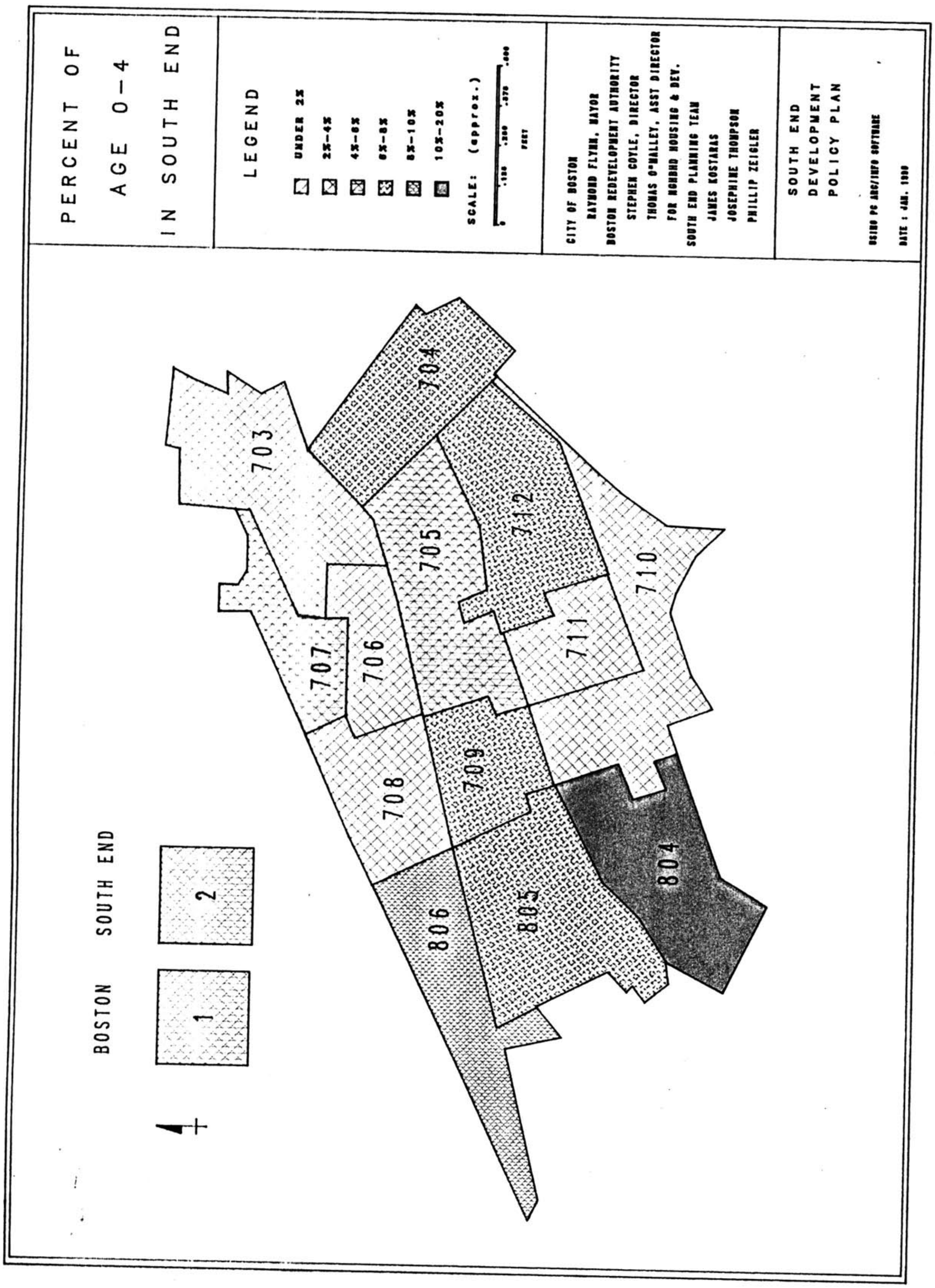


Figure 4.3.12 Percentage of Families Below the Poverty Line in the South End

Figure 4.3.]3 Percentage of Persons in Age Group
0-4 in the South End



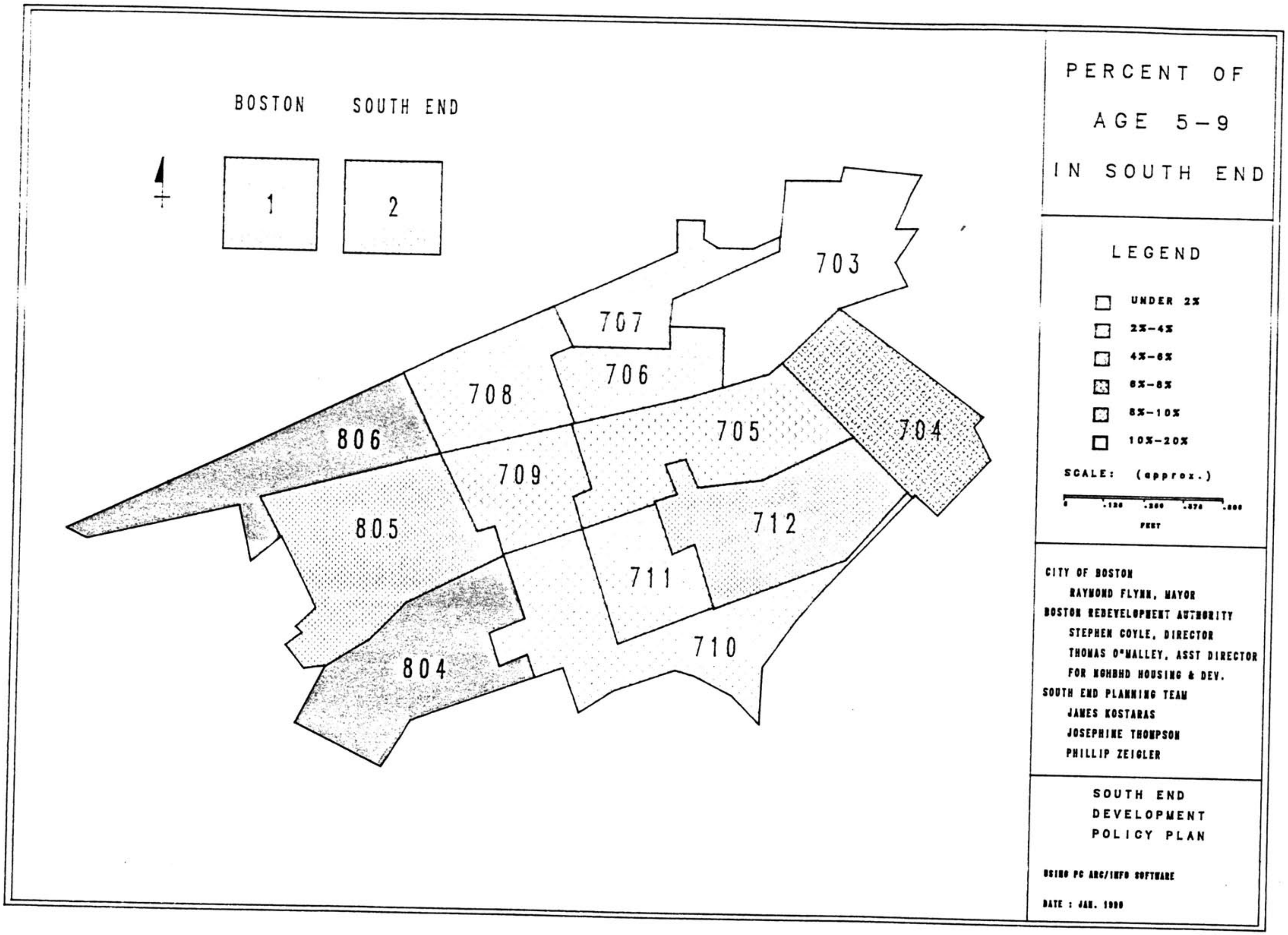


Figure 4.3.14 Percentage of Persons in Age Group 5-9 in the South End

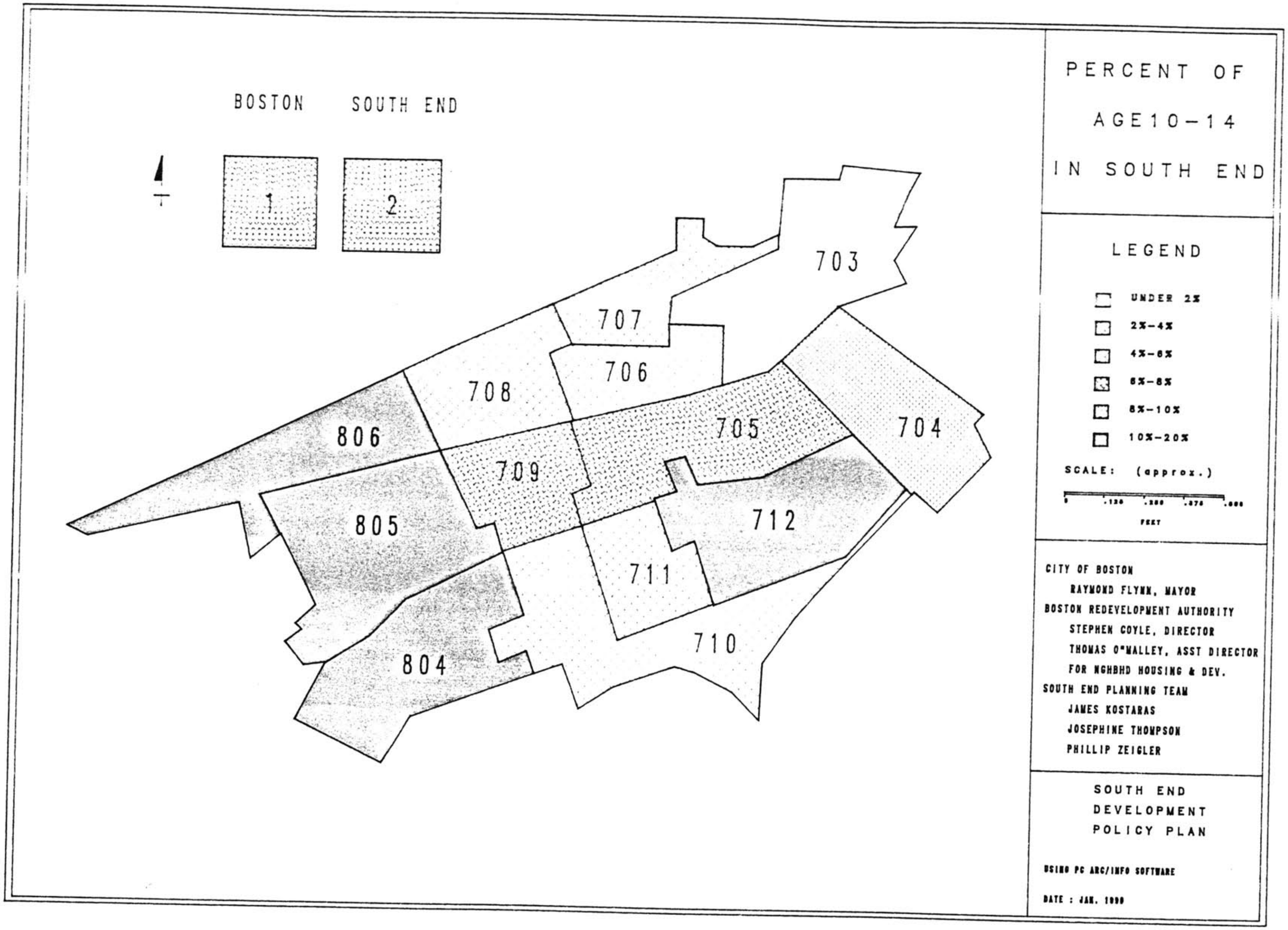


Figure 4.3.15 Percentage of Persons in Age Group 10-14 in the South End

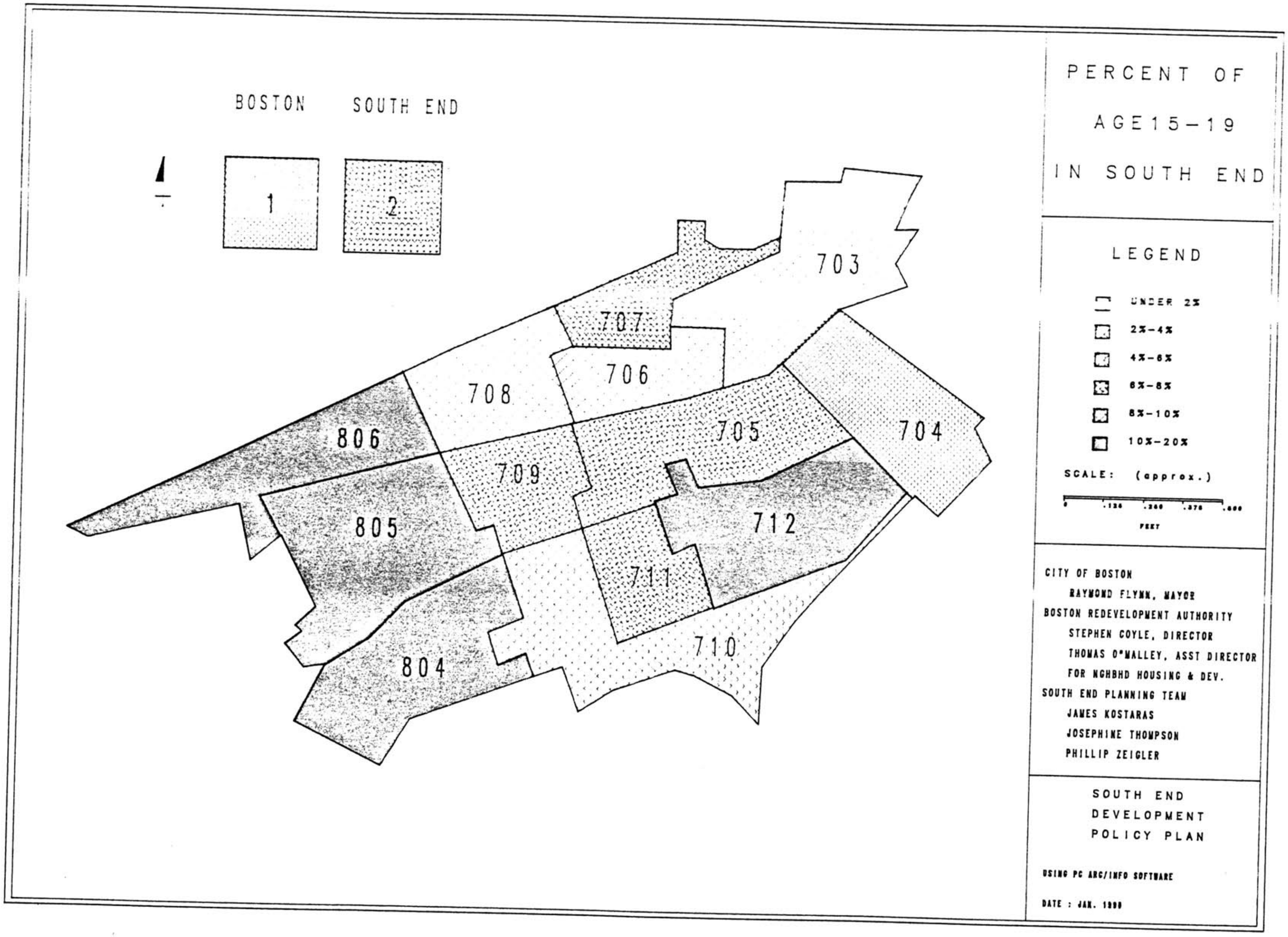


Figure 4.3.16 Percentage of Persons in Age Group 15-19 in the South End

residency in the area, tenure status, and age, might help in later study projects.

The first survey was distributed at the February presentation of this study. The result has been frustrating. Out of thirty forms, only six were returned to date. Poor attendance at the following meetings, a feeling of the irrelevance of the survey to the planning process, and my inexperience in survey follow-ups, may all contribute to this response failure. Nevertheless, I think surveys of this kind should be carried out whenever possible in future study and research. We still know very little about how different kinds of visual choices may distort the presentation of spatial analysis. Nor do we know how the general public may interpret these maps. These issues will be increasingly crucial with the increase in intensive use of maps as a tool in spatial information management, and the political process it serves. Paper maps will increasingly become just a small selection of interactive on-screen queries, in the form of electronic maps. This may result in an increasing information gap between the analyst and the general audience, who may only read the paper maps.

From the limited responses, there is still some useful feedback. Some people complained about the incorporation of non-South End areas into the study area (census tracts 804, 805, and 806 represent Lower Roxbury, which to some participants do not belong to the South End); some suggested better labeling of the maps; most pointed out that the data for 1980 are so out-dated that it is hard to make a judgement on its implications to planning in 1990. Most respondents indicated they were home-owners, and had a length of residence in the area ranging from five to twenty five years. Most people felt modestly comfortable with computer, with a lesser degree of familiarity with statistics. Also, from my regular attendance at the meetings, informal feedback suggests people were not used to the intensive use of maps as the major media for presentation of analysis results.

A copy of the survey form is enclosed in Appendix A.

4.5 Problems In Updating the Data

From the survey, as well as in discussions with the demographic subcommittee, it is clear that the mismatch of the 1980 census data and the 1990 assessing data to be used in the land-use study poses a significant problem in interpreting the study results. In particular, the South End is a neighborhood that has gone through tremendous changes in the 1980's. A match of the 1990 census data with the 1990 assessing data would be ideal. There are a number of alternatives that may allow the working group to "infer" the current situation based on other information.

We have considered updating the data with the help of some commercial firms who do census update and forecast annually. Data would be available by tracts. However, the method they used to update the data is often to simply run a linear regression to "trend up" the data from the 1980 base. We don't feel it is prudent to believe such a method can effectively capture the dramatic change the South End has undergone in the 1980's.

The BRA Research Department conducted two household surveys in 1980 and 1985, respectively. This is considered an important complement to the census data. However, the survey reports data only by planning district, which means only aggregated data at the South End level is available. Moreover, there is some inconsistency with regard to the classification of data. The ways that employment types, age group and family composition are broken down differs from that of the census. The BRA survey also excludes persons living in group quarters from the total population. This results in an average 7% loss of total population city-wide. In the case of the South End, such percentages may be even higher. These problems in essence blocked our effort to update the census to the 1985 level using the surveys.

Another alternative we considered was a qualitative forecasting method called the "consensus forecast." This method requires a group of experts giving their individual forecasts on a set of variables which otherwise are difficult to forecast. These individual forecasts are then aggregated to represent the group's best knowledge on the trends they believe will occur in the future. This method is generally considered superior to statistical modelling when doing long range forecasts, since the latter can not sufficiently pick up events shaping the long term future that are hard to express in numbers. The obvious problem of this method in our case is that to conduct the forecast, each member would be required to write down roughly 400 numbers relating to the chosen thirty variables across thirteen census tracts. This did not prove to be practical.

The last possible solution to the out-dated data is to ask the BRA Research Department to conduct a survey especially tailored to fit the need of our planning needs. This alternative would certainly need more resources and would be time consuming.

As expected, structural problems in data sources proved to be overwhelming. Given the fact that the data is ten years old, and that the new 1990 census data can be expected about a year from the time the study results are presented, effort in updating the data in a spatially comparable way to link to other study projects was deemed to be inefficient. As a final consensus of the working group members, the final Development Policy Plan is subject to modifications due to new findings from the 1990 census data.

4.6 Conclusion

This project uses GIS technology on the PC platform, and is manageable in terms of volume of data and digitization of boundaries. The uniqueness of this project is that maps replaced tables as the primary way of presenting data to a citizen group. Therefore, the spatial dimension of the socioeconomic profile becomes an indispensable factor. Aside from this advantage, working group members have had easier access to information due to the ease in reading maps. In addition, map presentation of more aggregate spatial information built a prototype for the later study of land-use. Working group members got used to reading maps, and referring to them in discussions. The lasting advantages of such an approach is yet to be seen, when the volume of data increases dramatically, as when the geographic boundary of the study area expands to include surrounding neighborhoods.

The dominating task of this project is to normalize data in various forms in order to be mapped on a comparable basis. The resulting thematic maps are used to analyze and present spatial patterns of associations among the study variables. In the process of analysis, some measurements were established (as were the two indicators or the level of integration in racial composition and employment) in an effort to analyzed issues of multiple origins and effects. These efforts helped the working group members to understand the issues in a spatial context, as well as in a spatial process.

Chapter Five

THE LAND-USE STUDY

5.1 Introduction

This chapter documents the second study project in this thesis--the land-use study. Following the same format as in the last chapter, I will first discuss the background of the study project, then methodological concerns, and finally assess the project's adequacy in supporting the planning process. Again, the major part of this chapter will be devoted to the discussions of issues involving design and application of maps using the four components as a framework.

Through acquisition, manipulation, analysis and presentation of the fiscal 1990 assessing data, this study provides background information and addresses particular issues of land-use to support the South End Development Policy Plan. The study was completed at the end of April, 1990. At the time this thesis was written, the study had not yet been presented to the working group members. Therefore, surveys for feedback on this study are not available for discussion.

There are 27,713 parcels in the delineated study area. A complete data file pertaining to these parcels is over thirteen megabytes in size. As input to analysis, this fact marks a dramatic difference from the last study project, where we were dealing with a much smaller task in terms of data entry and boundary digitization using a PC platform. Complex structures in software linkage, advanced database queries, and instant on-screen map display characterize this study project, which was performed using a workstation platform. This project took an estimated time of over two hundred hours.

5.2 Background

As stated above, this study project had two focal points. The first was to gain some insight into the overall land-use patterns in the area. It tried to answer the question: "What characterizes the land-use pattern in the South End, and how does it differ from other adjacent neighborhoods?" In most cases these questions are addressed through assessing information in terms of predominant land-use, percentage of vacant land, floor area ratio, assessed building value, land value and combined value. The land-use pattern information will provide a background knowledge base for later more specific studies.

Second, there were some specific land-use issues identified by the working group members that need more attention. Among these specific issues were patterns of residential density, commercial land-use, commercial/residential land-use, industrial land-use, and institutional land-use. On the technical side, there were additional problems to be solved and additional measurements to be established, in order to study these issues in depth. These concerns will be discussed in the operational component section later in this chapter.

There had been scattered efforts to study the land-use patterns in three studies prior to the Development Policy Plan process (Thomas Planning Services 1987; The University Hospital 1989; EDIC 1988). These studies are scattered in two respects. The vantage point from which each study was conducted differs markedly (residential, institutional, and industrial, in these three cases), and methodology and data sources vary from study to study. As a result, study area boundaries differ, time and spatial frames of data are confusing, and the utility of these studies to the master plan was thereby limited. In addition to these frustrations, the availability of data and the ability to disaggregate and locate them in the area proved overwhelming. This is documented in the study by the Thomas Planning Services: "Problems arose as much of the data needed for density measurement was unavailable or could not be located..much of the information was available only for the South End as a whole..(Thomas Planning Services 1987)." A comprehensive land-use study to follow on and unify these earlier efforts needed to incorporate a larger area, use the most updated database, perform the analyses at a more disaggregate level, and address all of the land-uses--residential, commercial, institutional, industrial, etc. With these objectives identified, we now turn to the discussion of the methodological concerns.

5.3 Methodology

In operationalizing the study, several aspects were considered in order to adequately address the concerns listed above. There were decisions to be made concerning the delineation of the study area, determination of the level of aggregation, and choice of computer hardware/software to perform analytical and display functions. I will first give a brief review of these issues before proceeding to the examination of the project in the framework of the four components.

5.3.1 Pre-modelling Decisions

Delineation of Study Area. As discussed in Chapter Two, one of the characteristics of the South End is its diversity of land-use. It is also adjacent to neighboring areas possessing richly varied land-use patterns. To fully understand the land-use situation in the South End proper, inclusion of its neighbors may be beneficial. Before this proposed study, extension of the study area would definitely have led to steeply increasing resource requirements in both manpower and budget. Now we are free to choose more extended boundaries in light of the availability of GIS technology. After due consideration of factors influencing the future of the South End, a study area was defined. Comprising 841 assessing blocks, the study area includes South End, Back Bay and Prudential Center to its west, Chinatown and the downtown financial district to its north, Newmarket and part of South Boston to its east, Roxbury and part of Northeast University to its south. The area is slightly larger than two square miles, or roughly twice the size of the South End planning district alone.

Determination of the Level of Aggregation. Assessing data comes in spatial units of a parcel, and can be considered as the counterpart of the federal census for land and buildings in terms of details of information. However, for planning purposes, analysis at the parcel level may not be optimal. The sheer size of the attribute database is too big for quick access and manipulation. Maps based on parcel boundaries may be too detailed for effective visual display, and the privacy of land owners may be hard to protect. Therefore, analyses at the block level (in the case of a typical residential block, this may represent around forty parcels) will be used in this study. The flip side of this aggregation is its implications for complicated database manipulation, which became the main technical problem tackled in this project.

Hardware/Software Choice. The boundary file pertaining to the study area was originally in PC ARC/INFO format, and the attribute file was in dBase format. For data aggregation, using INFORMIX on a workstation platform was the most viable way to handle the database. Results of data manipulation were then exported to Xmap. Xmap is a thematic mapper developed at the Computer Resources Lab (CRL) at MIT, on a workstation platform. It has the desirable features of high speed, high quality output, and interactiveness. Based on initial screen display and analysis, selected maps were plotted on using PC ARC/INFO, taking advantage of its capabilities in providing high quality cartographic output.

5.3.2 The Structural Component

One major technical difference between the land-use project and the demographic project was that the volume of data was tremendous. The complete master file contained over 27,700 parcels, with information across over 100 database "fields". The file is over thirteen megabytes in size. Reducing the file to a manageable size, while maintaining the relevant information for land-use study, and preparing the database to provide maximum flexibility to facilitate interactive on-screen queries became the major task of the structural component. To illustrate this point, I will give a step-by-step account of the technical tasks undertaken in manipulating the data.

Step 1--Extracting data parcels from the city's assessing file. From the delineated study area, a "ward-precinct-block (wpb)" file was dumped out of the ARC/INFO coverage. A "ward-precinct-block" number is a geo-coding for each unique assessing block. This file was used to extract all parcels which fell into any of the assessing blocks in the study area. There were 8 wards, containing 841 assessing blocks, which in turn contained over 27,700 assessing parcels. Out of the over 100 dBase fields, less than ten were chosen for the study. They contained information on the square footage of the structure and land parcel, assessed value for both, and their land-use and property type classifications. In addition, information on parking type, and ownership code for residential properties were included. The reduced file was about 1.5 megabytes, a much more manageable size.

Step 2--Loading the reduced file (referred to as the master file in later operations) to other database management packages. In this case INFORMIX-SQL on the workstation platform was chosen for its power and flexibility. To load the file, ASCII file delimiters had to be changed from a format with double quotes for text and commas separating different fields to a format where all fields are separated by a vertical bar ("|"), in order to import it into INFORMIX-SQL.

Step 3--Aggregating the master file up to the assessing block level. Data were grouped by their "wpb" numbers and, within each distinct "wpb" number, by different land-use classifications. Data being aggregated included square footage for both land and structure, and assessed value for both. This operation resulted in a table similar to that shown in Table 5.3.1. Notice that each block contains a different mix of land-use. The structure of this table is not flexible when it comes to doing queries based on some mathematic operations, such as calculating the percentages of a particular land-use type in the total, or finding the per square foot assessed value for certain kinds of land-uses.

Step 4--Using an outer join to transform the aggregated table into one that contained each possible land-use/wpb combination for each block, leaving a null value for missing data. An outer join is a join between two tables that forces one of the two to adopt the "skeleton" of the other. In our case, we want to join Table 5.3.1 with Table 5.3.2. This operation resulted in Table 5.3.3.

table 5.3.1

wpb	land-use	landsf	gfa	landval	bldval
301010	r1	xxxx	xxxxx	xxxxx	xxxxxxx
301010	r2	xxxx	xxxxx	xxxxx	xxxxxxx
301010	rc	xxxx	xxxxx	xxxxx	xxxxxxx
301010	ea	xxxx	xxxxx	xxxxx	xxxxxxx
301010	cc	xxxx	xxxxx	xxxxx	xxxxxxx
301010	cl	xxxx	xxxxx	xxxxx	xxxxxxx
301020	r1	xxxx	xxxxx	xxxxx	xxxxxxx
301020	r4	xxxx	xxxxx	xxxxx	xxxxxxx
301020	cm	xxxx	xxxxx	xxxxx	xxxxxxx
301030	i	xxxx	xxxxx	xxxxx	xxxxxxx
301030	e	xxxx	xxxxx	xxxxx	xxxxxxx
301030	ea	xxxx	xxxxx	xxxxx	xxxxxxx
301030	cl	xxxx	xxxxx	xxxxx	xxxxxxx
301030	rl	xxxx	xxxxx	xxxxx	xxxxxxx
.					
.					
.					

JOIN WITH

table 5.3.2

wpb	land-use
301010	r1
301010	r2
301010	r3
301010	r4
301010	rc
.	
.	
.	
301010	ea
301020	r1
301020	r2
301020	r3
301020	r4
301020	rc
.	
.	
.	
301020	ea
301030	r1
.	
.	
.	

RESULT IN

table 5.3.3

wpb	land-use	lands	gfa	landval	bldval
301010	r1	xxxx	xxxxx	xxxxx	xxxxxxx
301010	r2	xxxx	xxxxx	xxxxx	xxxxxxx
301010	r3				
301010	r4				
301010	rc	xxxx	xxxxx	xxxxx	xxxxxxx
.					
.					
.					
301010	ea	xxxx	xxxxx	xxxxx	xxxxxxx
301020	r1	xxxx	xxxxx	xxxxx	xxxxxxx
301020	r2				
301020	r3				
301020	r4	xxxx	xxxxx	xxxxx	xxxxxxx
301020	rc				
.					
.					
.					
301020	ea				
301030	r1				
.					
.					
.					

table 5.3.4

polyid	wpb	R1	R2	R3	R4	RC	RL	CC	CD	CM	CP	CL	C	EA	E	I	A
95	301010	xxx	xxx			xxx	xxx										
102	301020			xxx	xxx	xxx			xxx	xxx							xxx
117	301045	xxx	xxx	xxx	xxx			xxx	xxx	xxx							
118	301055																
121	301075														xxx	xxx	
130	301080													xxx	xxx		

<u>Step 5</u>--Transposing Table 5.3.3 into four tables, containing information on land square footage, gross floor area, land value, and building value. The characteristics of these tables are that they finally become a matrix with a distinct "wpb" number in the rows and the land-use classifications in the columns. This structure is shown in Table 5.3.4. This structure makes queries and, in particular, those with mathematical functions, conceptually and operationally easy. Technically, it was necessary at this step to update the tables so that each null cell took the value of zero. This was necessary since, in a mathematical operation, a null value will result in a null value in the result. For instance, in summing up the total square footage of land, only those blocks with a complete mix of sixteen land-use classifications will return a numeric value, while the others will be null since at least one of the cells involved in the operation is null.

<u>Step 6</u>--Unloading the query result to an ASCII file for mapping. Since the four tables now in the database have an identical structure, with the same number of rows and columns, it is easy to query the database using multiple tables. We can "grab" different columns in different tables for our queries involving numerical calculations. For instance, we may want the residential FAR only for housing types R1 to R4. We can query to find this in two different tables--"gfa" and "landsf" for those blocks that have at least one of the four housing types, summing up both the square footage for structure and land, and dividing the sum of structure square footage into the land square footage. We can then unload the result from INFORMIX-SQL to a plain ASCII file, and change the text delimiter back to the format which Xmap can read.

In summary, the task of the structural manipulation of the database in this project was to reduce the size of the database to a manageable size, aggregate the relevant information according to a desirable classification criterion, and output the result of the query to some mapping tools for visual display. This task was the single most time consuming undertaking in the entire project, taking up roughly 80% of the total project time.

<u>5.3.3 The Operational Component</u>

The next undertaking of the study project involved establishment of indicators and measurements. This is to identify, within the assessing database, meaningful indicators and measurements to help evaluate the nature and magnitude of problems and concerns with land-use. There are a variety of ways to render "land-use patterns". Density measurements (expressed in terms of floor area ratio--FAR), percentage of particular uses in a block, assessed value of land or/and structure, etc. Using these measurements requires a conceptual matrix. One dimension of the matrix is breakdown of uses, and the other dimension indicates the extent of a particular use--measured in land square footage, FAR, or assessed value.

In the assessing database, two variables are useful in grouping parcels into different land-use functions--"landuse" and "property type". The "landuse" classification contains sixteen different land-use designations, ranging from residential (with ten different variations), commercial (with three variations), industrial, institutional (under two different classifications), and finally, vacant land (under two different classifications). These 16 designations are given in the following table:

Table 5.3.5 Assessing Land-use Designations:

R1	Single-family
R2	Two-family
R3	Three-family
R4	4-6-family
A	7+Apartments
CD	Condominium Unit
CM	Condo Master Deed
C	Commercial
CC	Commercial Condo
RC	Residential/Commercial
I	Industrial
E	Tax-exempt Except Chapter 121A
EA	Chapter 121A Tax-exempt
RL	Vacant Residential Land
CL	Vacant Commercial Land

In general, this classification was sufficient in identifying different landuse functions and was in fact used in the study. However, for more detailed study involving cross referencing among different land-use classifications, this classification would be insufficient. For instance, many institutional uses are all classified under "tax exempt properties". This makes it hard to further differentiate land-use functions involving separation of uses by the ownership of state, city, BRA, private institutions, and religious institutions. In such cases, the assessor's classification of "property type" should be used. Property type is a much more detailed classification, with nearly one hundred different uses. In the case of institutional uses, there is detailed coding to separate properties owned by federal, state, city, educational, religious and many other types of institutions. This classification was not chosen for this study, since the operation to aggregate data by nearly hundred classifications was simply not manageable for the scope of this work. However, this classification would be useful should some decisions need more accurate information.

Based on the land use classifications, several variables will be applied to assess the physical as well as the fiscal magnitudes of the identified uses. These variables may include "gross floor area (gfa)", "land square footage (landsf)", "land value (landval)", "building value (bldval)", "number of stories", etc. Combinations of these variables, such as floor area ratio, land/building value per square foot, can then be calculated and analyzed. The exact way that data were combined and manipulated will be discussed in the functional component discussion later in this section.

To summarize, the operational component of this study project involved decisions on what data to extract from the thirteen-megabyte master file, at what level to aggregate, by what criterion, and finally, what data to aggregate (landsf, gfa, landval, bldval, etc.). In fact, these decisions had to be made **before** the structural manipulation of the database as documented in the previous section, since they influenced the design of the database structure.

5.3.4 The Communicational Component

Because of the particular characteristics of this project--large data file, complex data structures etc., the nature of visual display of spatial information in this study project differs from the demographic study in a number of ways. Among them, the most distinguishing feature is that on-screen display of spatial information became an increasingly indispensable tool in the process of data manipulation and analysis. The concern for interactiveness in such analysis tends to outweigh the concern for the graphic and cartographic design of the maps. In the demographic study, we had a total of fifteen "polygons" to map, and they were easily represented by six shade patterns. In the land-use study, we have 841 "polygons" for each map, and Xmap allows a maximum of 64 shade patterns to represent these data. A certain degree of interaction is needed between database, map contents, and map extent. In the following presentation, I try to define and illustrate "interactiveness" in terms of the flexibility, user-specificity, and dynamics of visual explorations of spatial patterns.

Flexibility in this context demands a host of map manipulation functions, such as changing map extent (zooming in and out); highlighting a certain range of data in a particular display frame; changing the way in which data are broken down into groups (equal number of occurrences, or equal intervals of data range, or user defined); and multiple window displays. To illustrate, let's consider a feature called the "density dial", a development in Xmap that allows for instant change in a high-lighted data range (Ferreira & Thompson 1990). This feature allows the user to define a span of certain ranges in the data to be highlighted. For instance, the user may decide to highlight 20% of the total data range, out of a total of 64 data ranges. As the cursor on the density dial moves from the low to the high end of the data spectrum, "polygons" in the map that falls into this moving 20% bracket will be highlighted. Another use of such a function is to define a data range, regardless of the possible number of occurrences. Using this instrument, I produced Figures 5.3.1-5, to render residential FARs according to different ranges. Recall from earlier discussions on the land-use issues, that the South End Residents are concerned with increased residential density in the area, and had petitioned for a change in zoning from "H-3" to "H-2" for residential uses. "H-3" and "H-2" in essence reflect the allowed net FARs in a certain zone. Figure 5.3.5 shows that most of the residential blocks in the South End have a FAR in the neighborhood of 2.5.

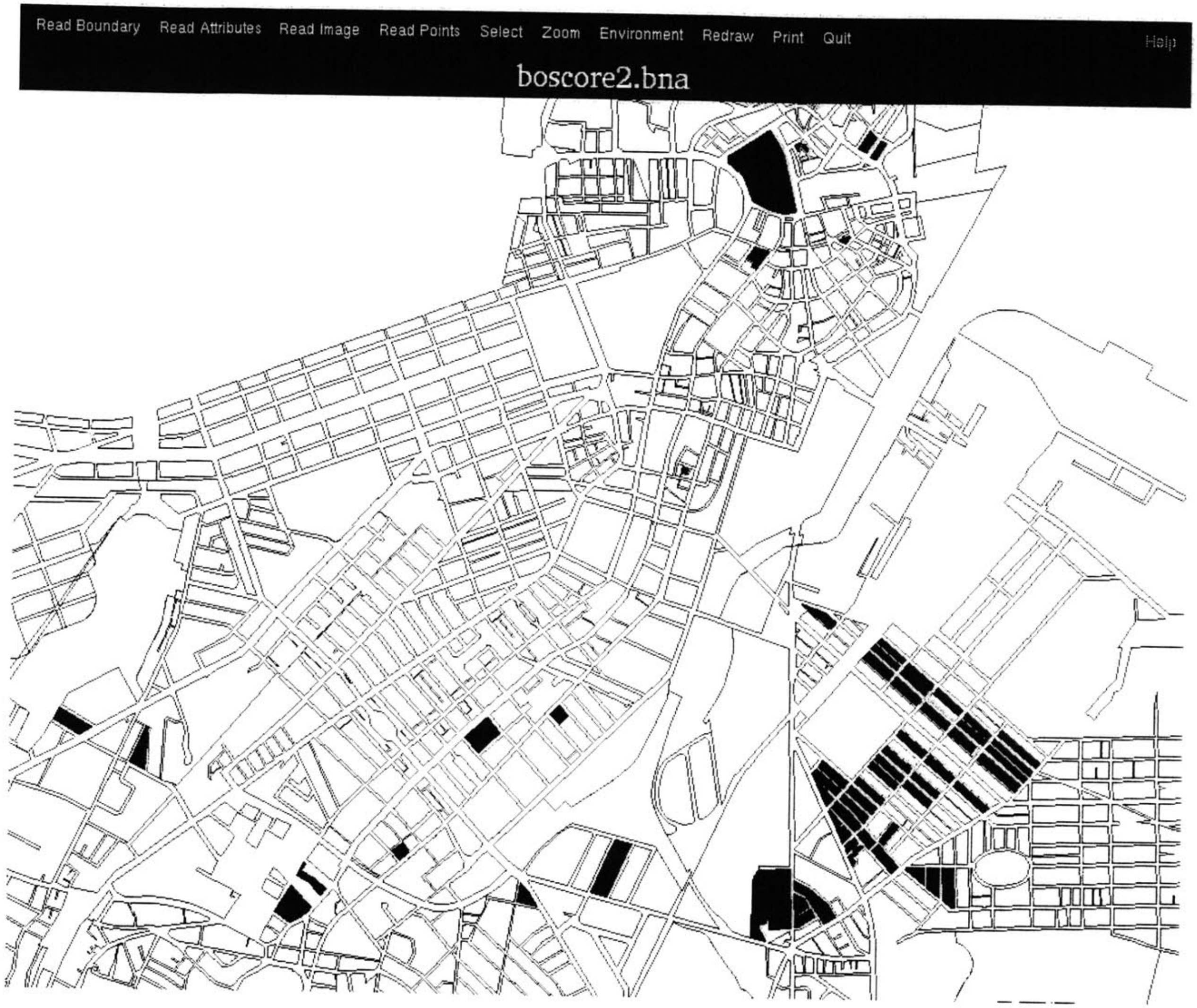
Flexibility can also be facilitated by features of multiple-window-display on a workstation, where different frames of display can be viewed and manipulated simultaneously. Figure 5.3.6 shows three frames of display on the same screen, providing information on assessed land per square foot for R1, R2, and R3 uses.

User-specificity requires the system to be facilitating in linking the mapping tools with database management tools. As stated in the introductory chapter, I consider visual display mechanisms as an instrument in accessing and viewing databases. For example, we may want to know combined assessed value of both land and structure in single family use, while displaying only those assessing blocks pertaining to the South End. To do this, there are five tables involved--land square footage (in table lmaster), building square footage (in table bmaster), assessed value for land (in table lvmaster), and assessed value for building (in table bvmaster), and a table containing "wpb" numbers of blocks in the South End (in table link). We need to extract the information by ordering from the database the following combination of variables:

```
select
r1lbv_se = (r1lv + r1bv) / (r1l + r1b)
from lmaster, bmaster, lvmaster, bvmaster, link
where link.wpb = lmaster.wpb
```

where	r1lbv_se	assessed value/sf for land and buildings combined for blocks in the South End only
	r1lv	total assessed value for land within a block
	r1bv	total assessed value for buildings within a block
	r1l	total square footage of land within a block
	r1b	total square footage of buildings within a block

Figure 5.3.1 Residential FAR



With Value Between 0 and 1 Highlighted

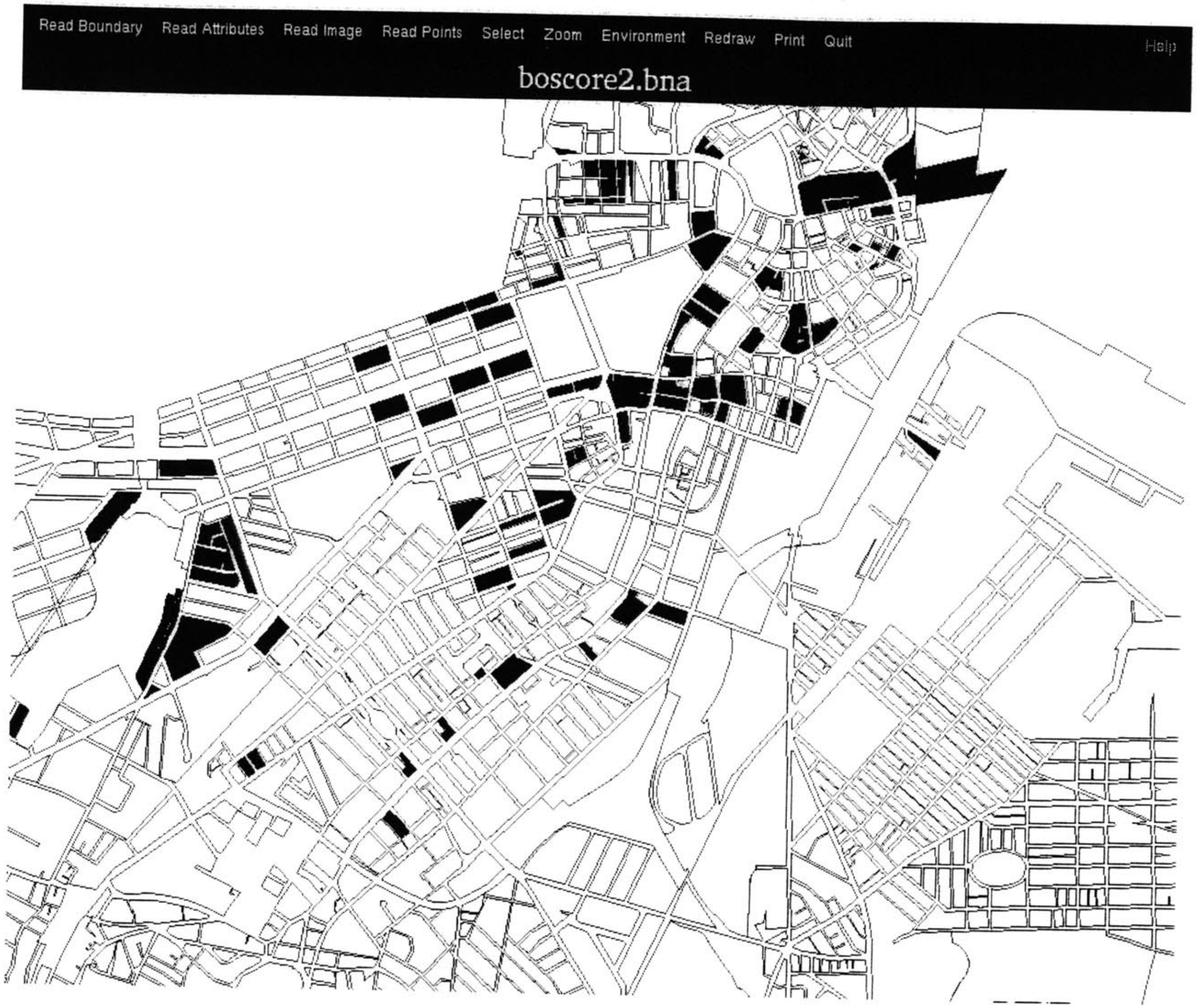
Figure 5.3.2 Residential FAR

With Value Between 1 and 2 Highlighted

Figure 5.3.3 Residential FAR

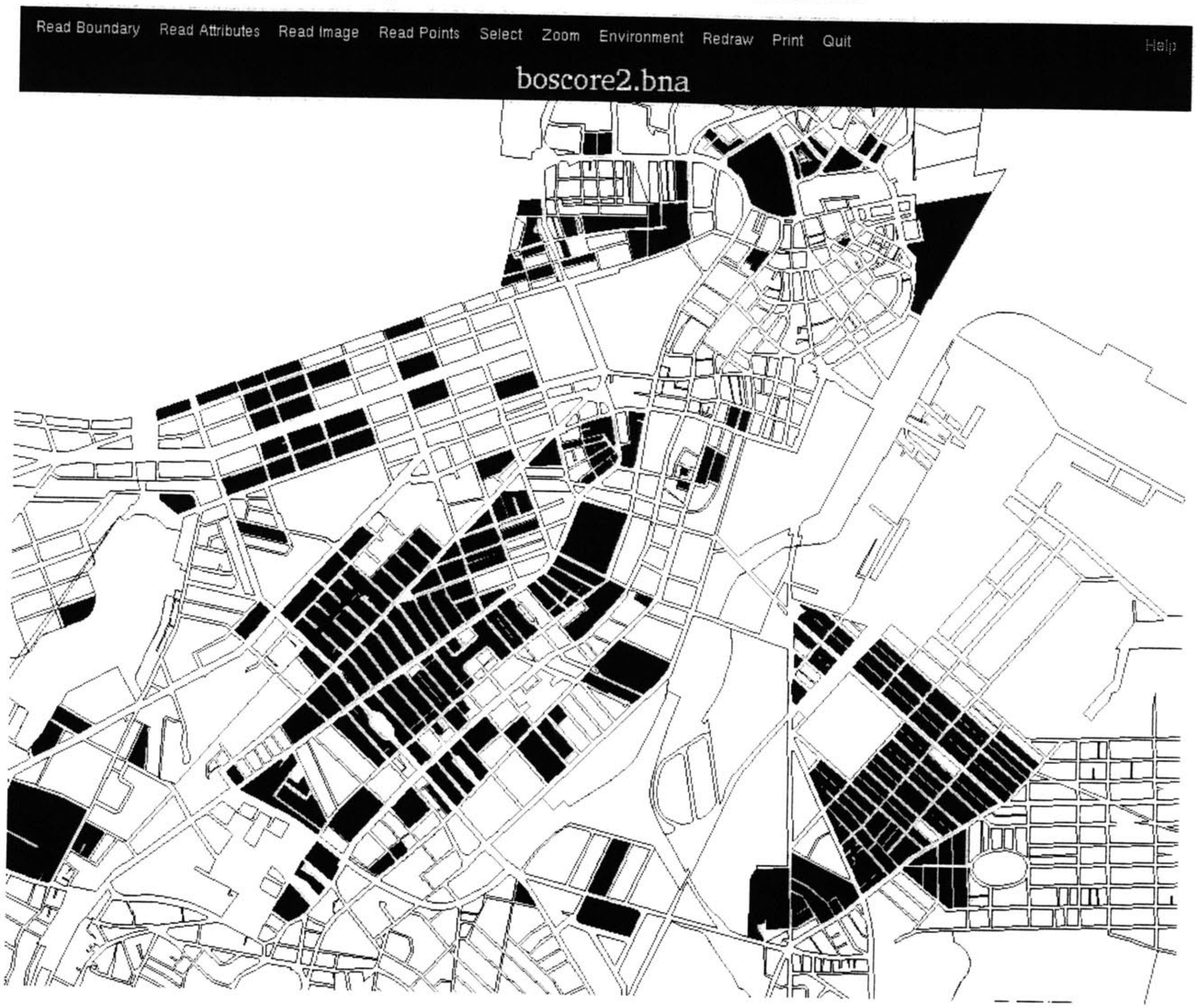
With Value Between 2 and 3 Highlighted

Figure 5.3.4 Residential FAR



With Value Above 3 Highlighted

Figure 5.3.5 Residential FAR



With Value Below 2.5 Highlighted

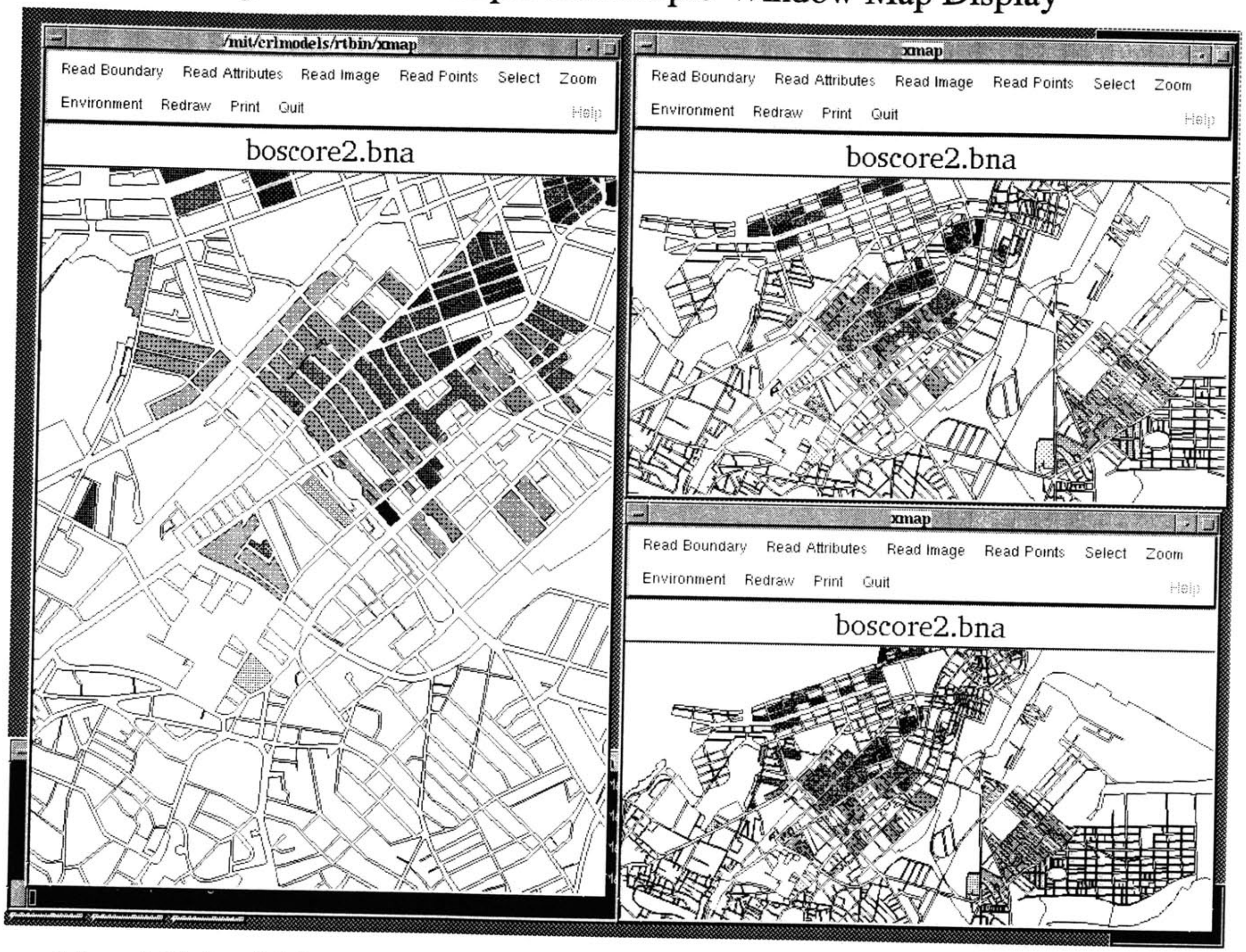
Figure 5.3.7 is a screen dump of mapping, database management and text editing windows, and Figure 5.3.8 shows the query result. Comparing it with Figure 5.3.9, where the same is presented for the entire study area, it is evident that such manipulation is needed on occasions when information in relation to spatial units only in the focus area is desired. Such mechanism will be particularly helpful when doing spatial aggregation, such as building traffic zones on top of assessing blocks.

Dynamics of visual display suggests the importance of the speed of on-screen display. I propose that unless the next frame of display is produced before the user's memory of the last display frame fades away, spatial queries can not be facilitated in an effective fashion. It is beyond the scope of this thesis to quantify such a proposition. However, I feel that if the time interval exceeds one minute between two frames of display, it is hard for the mind to correlate the two effectively.

Another aspect of the communicational component, not addressed adequately here due to time constraints, is the quality of final deliverable products of such analysis. Figures 5.3.10-11 are both representations of gross FAR for all uses in a block for the entire study area. Figure 5.3.10 is a screen dump from Xmap, where as Figure 5.3.11 is a color plot using PC ARC/INFO ARCPLOT module. Xmap does not have a full set of cartographic features, such as labeling shade patterns and text. But is has a set of rich, fine-grain shade patterns to interpret numeric data. Such shades give the eye a clear representation of the distribution and magnitude of the rendered variables. On the other hand, ARC/INFO does have the desirable cartographic features in making the map more presentable and easy to read. However, choice of colors is limited by the capacity of the plotter, and the ability of the eye to correlate to color keys and text labelling. With only six colors, which is about one-tenth of the Xmap shades used in Figure 5.3.10, the ARC/INFO plot may be subject to more mis-interpretation of data than the Xmap plot. In addition, Xmap products, being black and white and printed off the lazar printer, are superior when it comes to mass-reproduction.

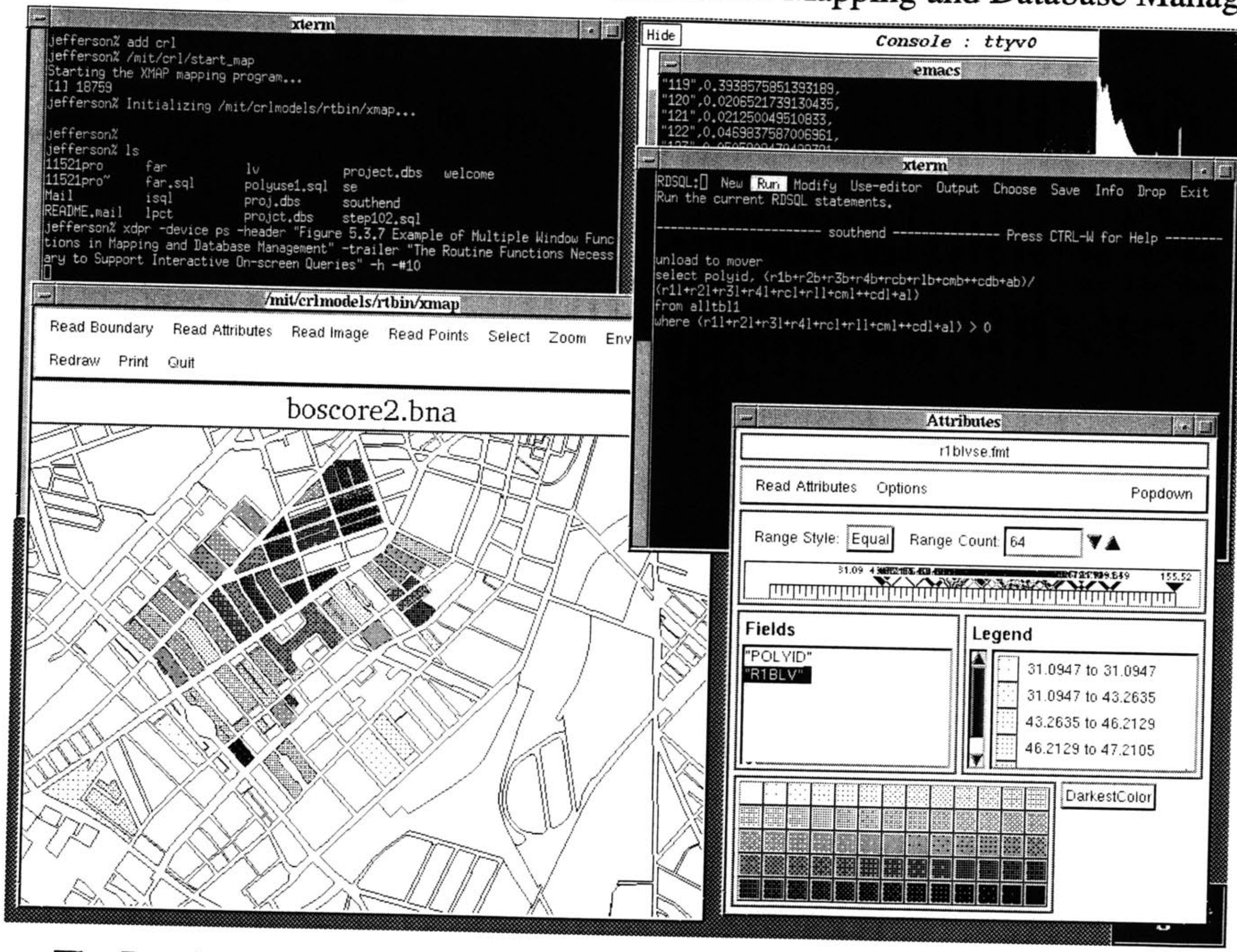
In summary, this series of demonstrations clearly marks the difference in the interactiveness of on-screen query in the form of maps. Visual display becomes flexible, both in terms of its contents and its physical extent; it becomes use-specific, in that users define and design the map according to the objective of spatial information query; it becomes dynamic, in the sense that the user is encouraged by continuous detection of spatial patterns, both in terms of the rendered variable itself, and in terms of its relation to other variables, which may already be displayed, in storage, or yet to be rendered. Finally, the products of this dynamic process can be enhanced by carefully selecting the desirable mix of cartographic features and graphic qualities for

Figure 5.3.6 Example of Multiple-Window Map Display



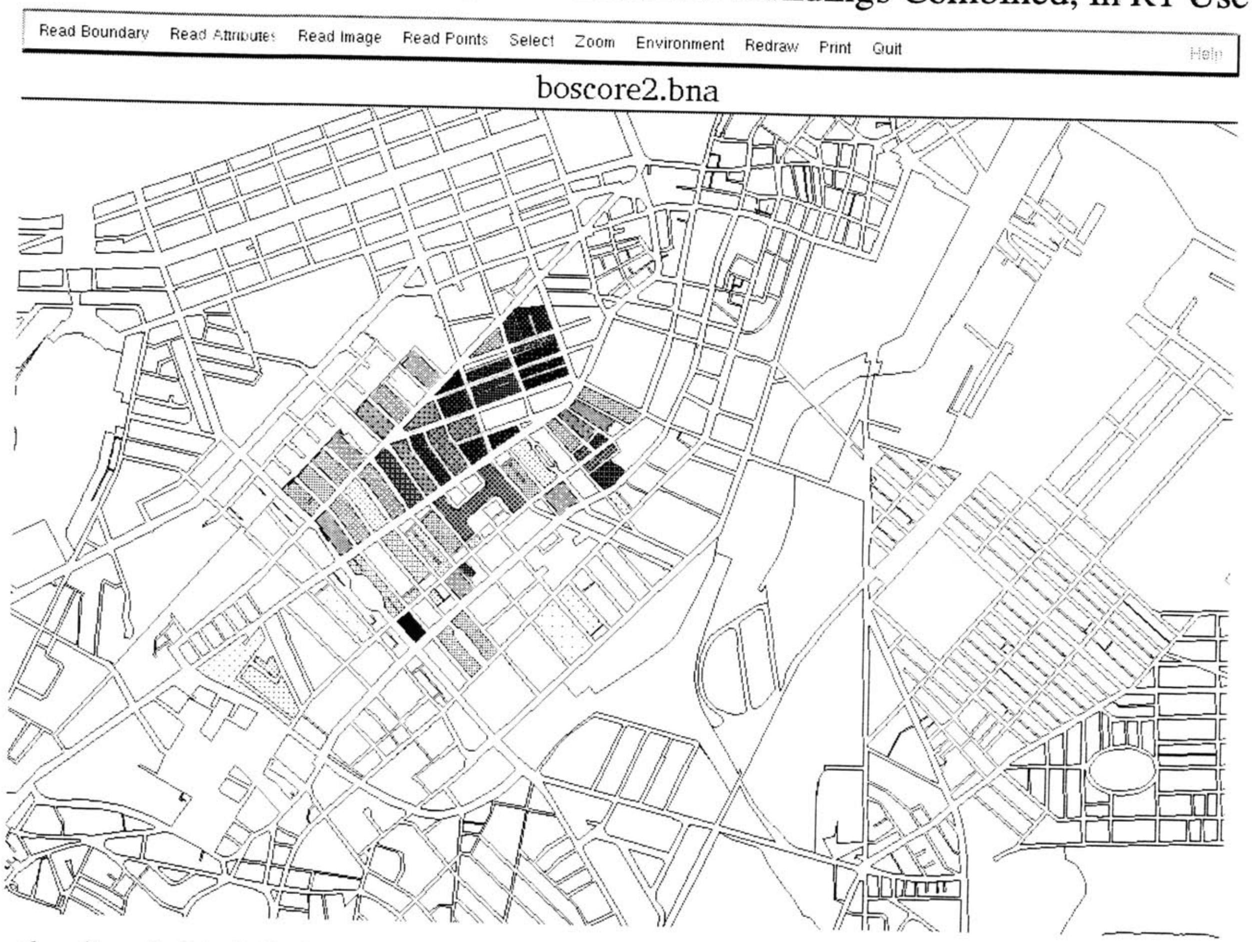
Assessed Land Value/sf for R1, R2 and R3 Are Shown in the Three Windows, Respectively

Figure 5.3.7 Example of Multiple Window Functions in Mapping and Database Management



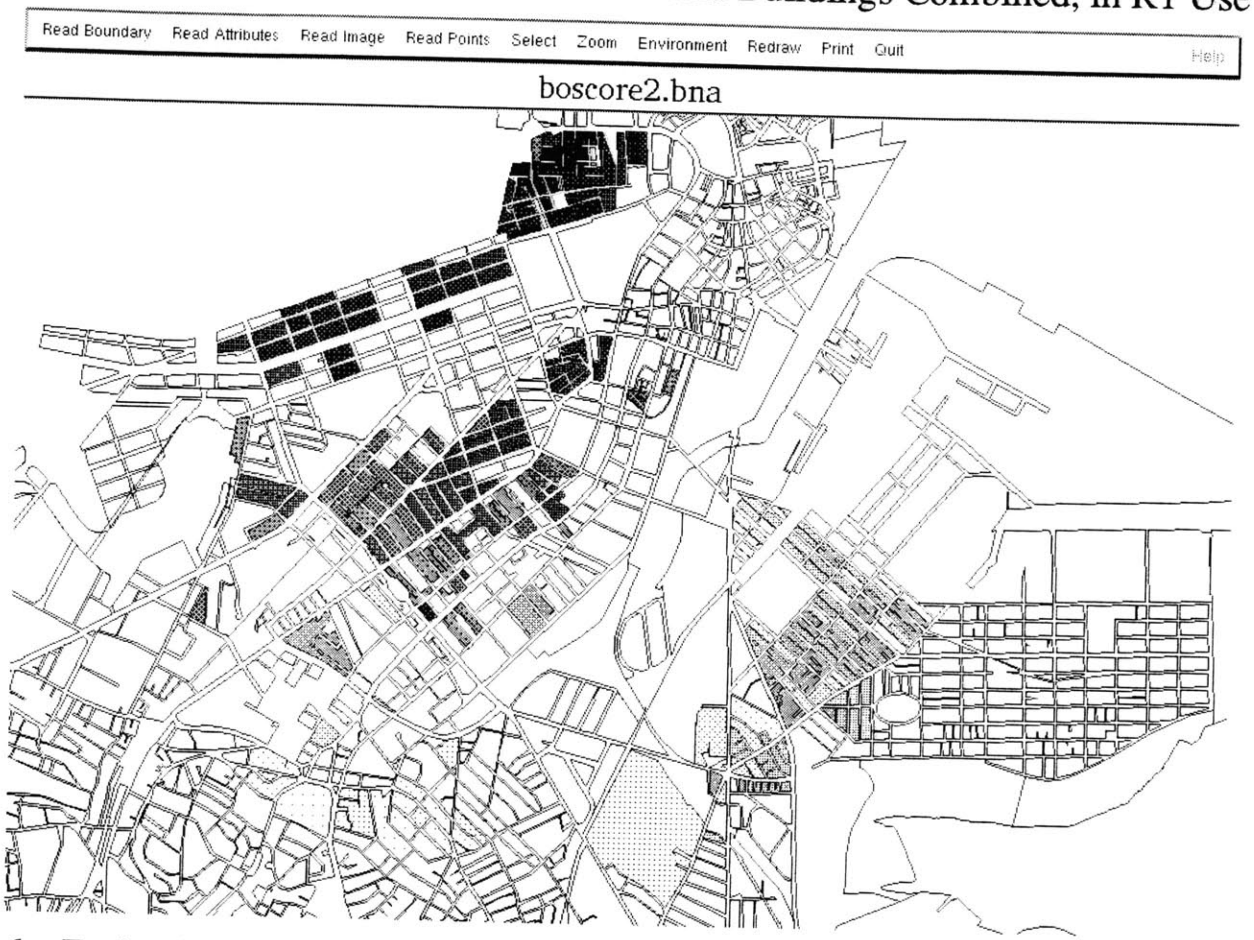
The Routine Functions Necessary to Support Interactive On-screen Queries

Figure 5.3.8 Assessed Value/sf for Land and Buildings Combined, in R1 Use



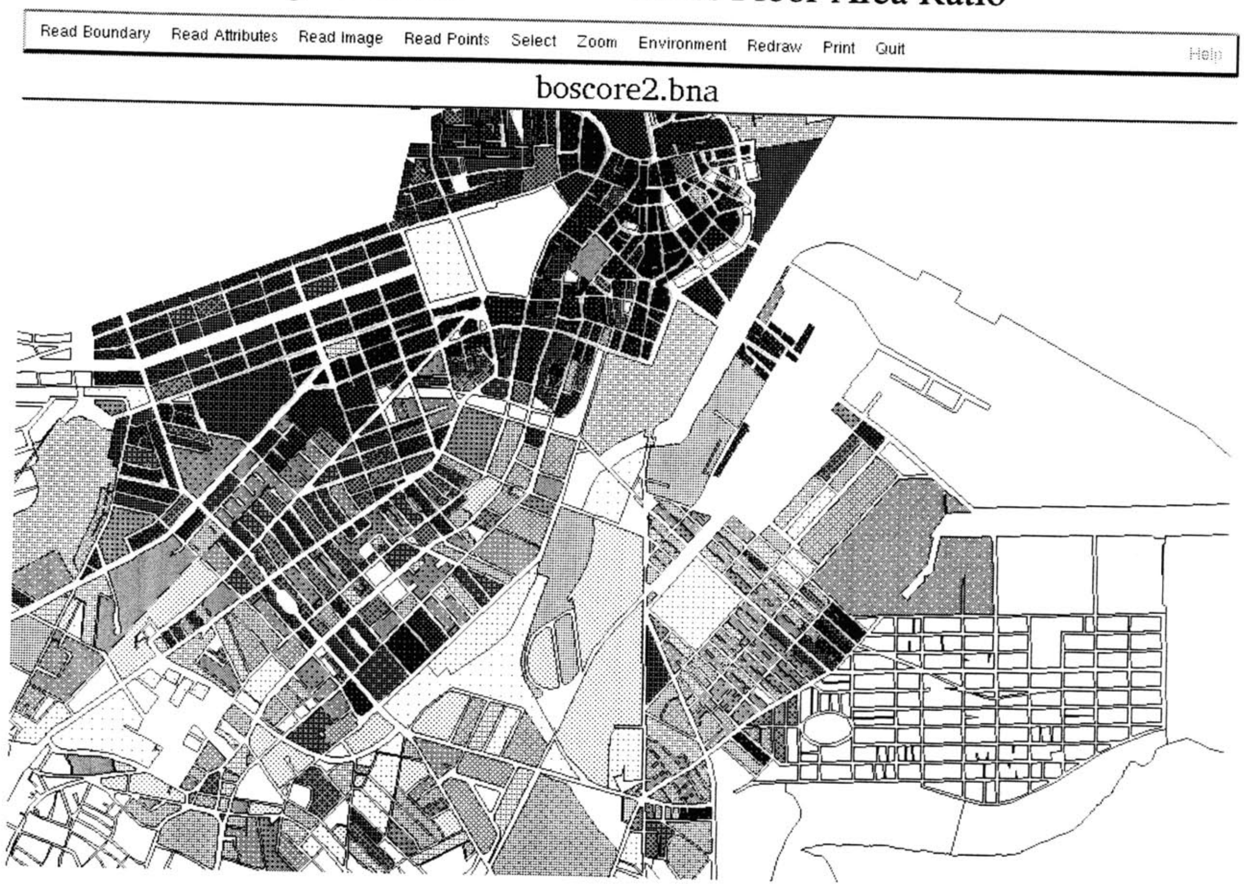
For the South End Only. The Darkest Shade Represents a Value of 155 Dollars/sf

Figure 5.3.9 Assessed Value/sf for Land and Buildings Combined, in R1 Use



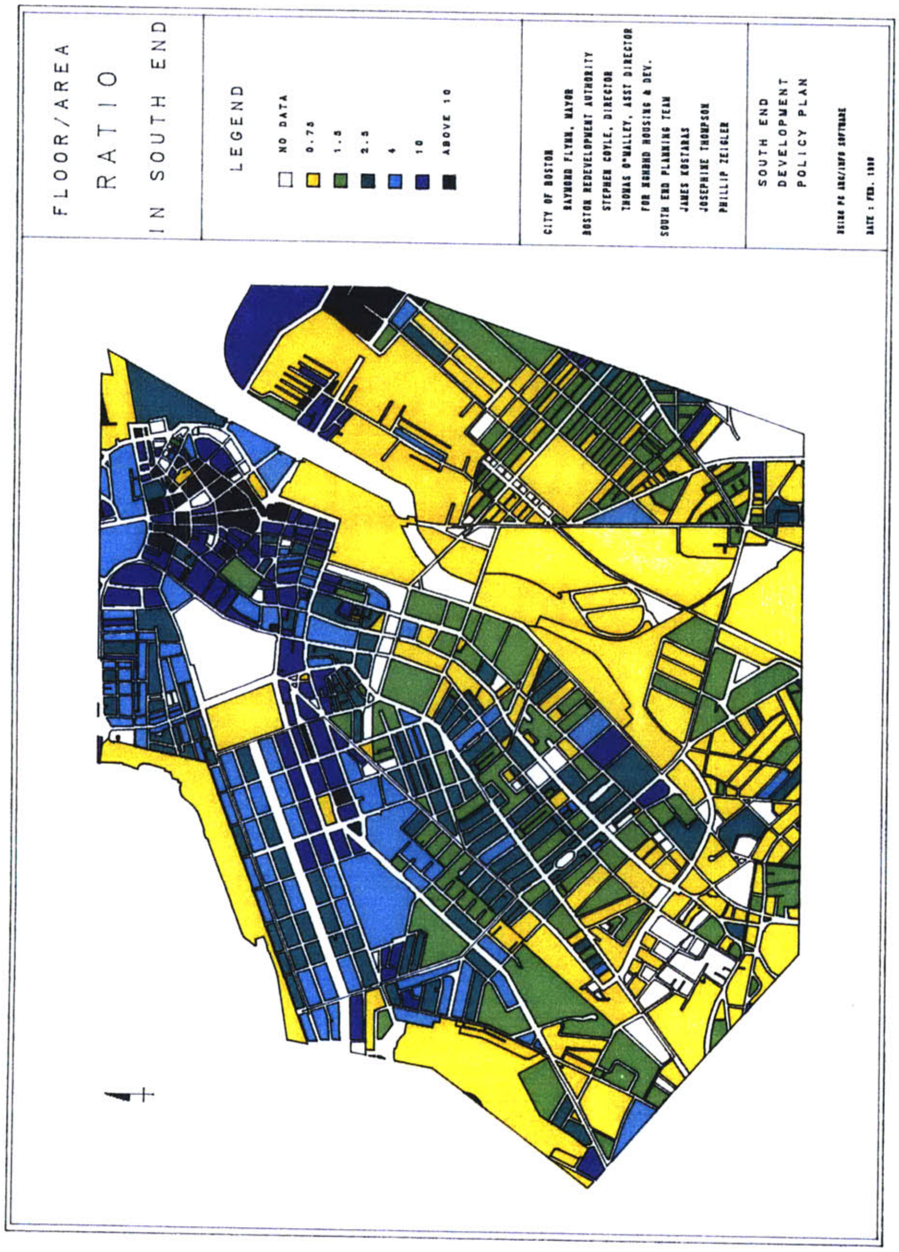
For the Entire Study Area. The Darkest Shade Represents a Value of 269 Dollars/sf

Figure 5.3.10 Gross Floor Area Ratio



The Darkest Shade Represents an FAR of 28.4

Figure 5.3.11 Gross FAR, Color Plot From ARC/INFO



presentation.

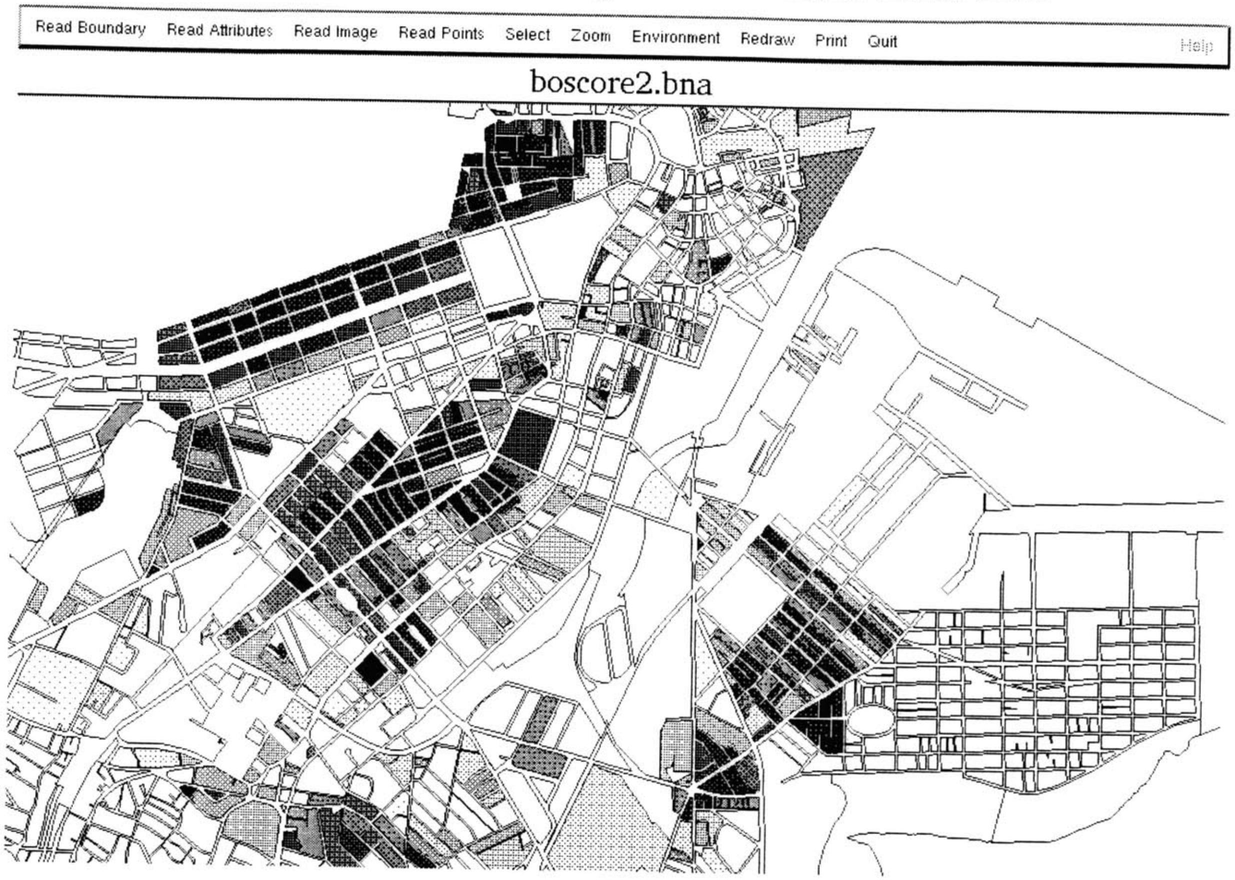
5.3.5 The Functional Component

At the time this thesis was written, presentation of the study project lagged behind schedule. This was due to the fact that data manipulation took longer than expected. Therefore, much of the functional aspects of the visual display can not be discussed here in depth. In the following discussion, I will present some preliminary findings, and project some planning implications when possible.

With an increasing volume of data and consequently larger amounts of analysis results, the visual display of spatial information needs more careful design and selection. For instance, there are sixteen different land-use categories in the assessing file, across data on building square footage, land square footage, assessed value for building, and assessed value for land. If we map all of them, this would result in 64 maps. In addition, floor area ratio, percentage of a certain land-use type of the total, and many other desirable measurements can be derived from these four basic categories, making the total number of possible combinations of maps mount into the hundreds. Under such circumstances, we increasingly have to ask ourselves, "Why do we need this particular data map?" In dealing with the functional component of this project, this question is answered in two ways. First of all, we need maps to show overall land-use patterns. Secondly, maps now can be used to address specific policy issues, based on the measurements we have established.

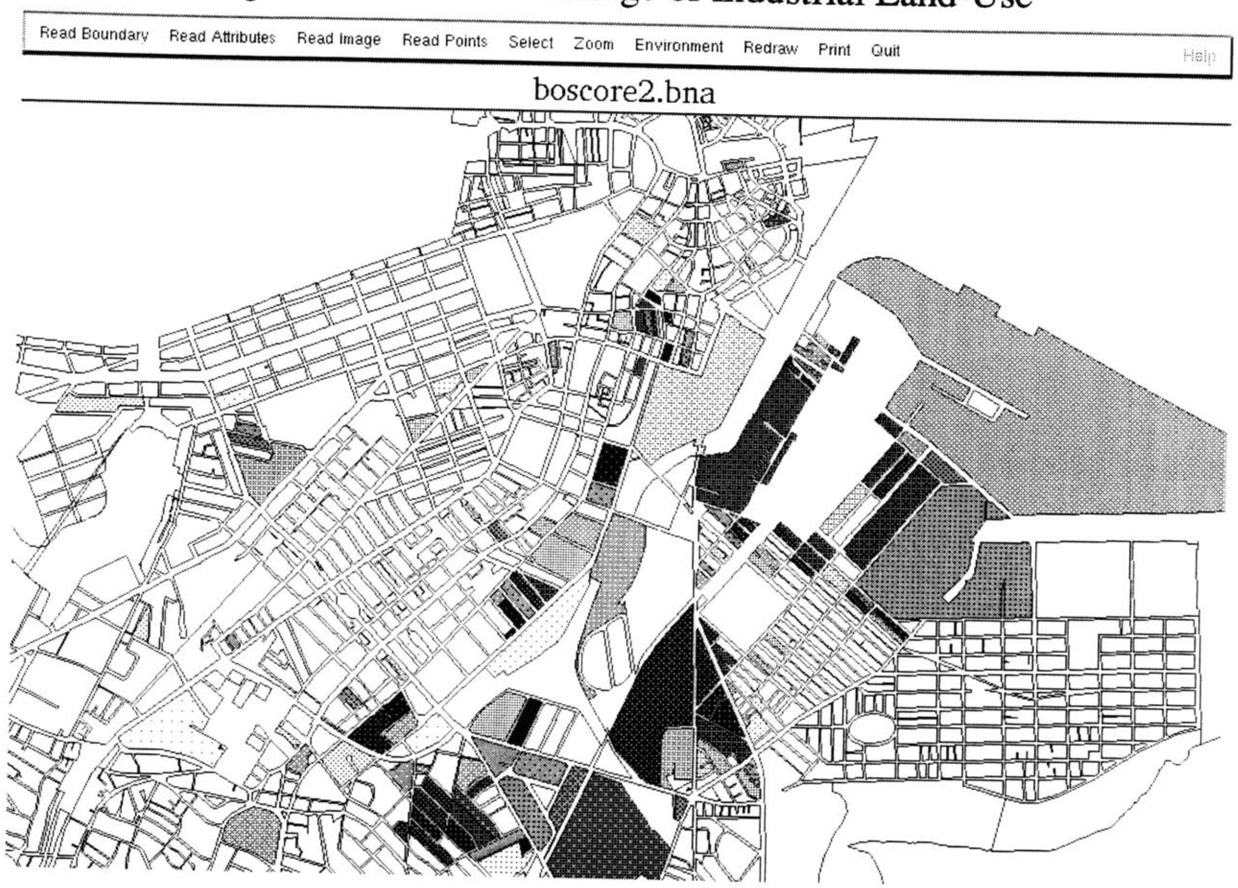
Overall Patterns, as shown by percentages of land-use in different classifications. Figure 5.3.12 shows the percentage of residential land-use in the study area. We can see that the South End is primarily a residential area. However, it is separated by land that has little or no residential function, surrounding all of the neighborhood. From the subsequent Figures 5.3.13-16, we can see that land-uses in industrial, vacant, and institutional (which is approximately represented by land-use types "E" and "EA"), and commercial land surround the area, with industrial and vacant land to the south-east, commercial land to the north, and mostly institutional land to the west/north-west side of the South End. This overall pattern suggests that the South End, as a residential neighborhood, is more subject to influences from changes in other land-uses. These changes are caused by decisions from the surrounding institutions, market forces, and potential development on those vacant land parcels. Exclusion of these forces and their representing agents from the Policy Plan process may severely limit the scope of the plan and its effectiveness.

Figure 5.3.12 Percentage of Residential Land-Uses



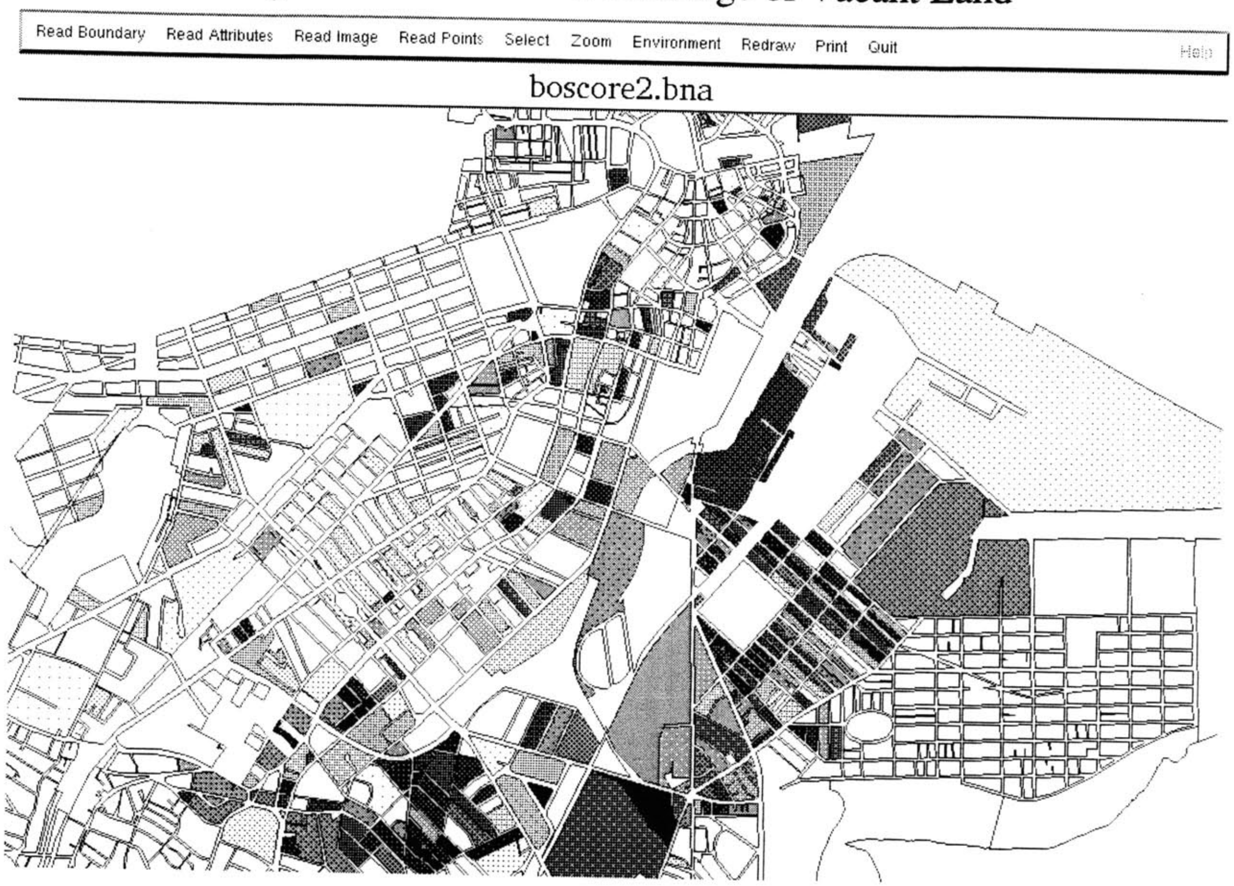
The Darkest Shade Represents a Value of 100%

Figure 5.3.13 Percentage of Industrial Land-Use



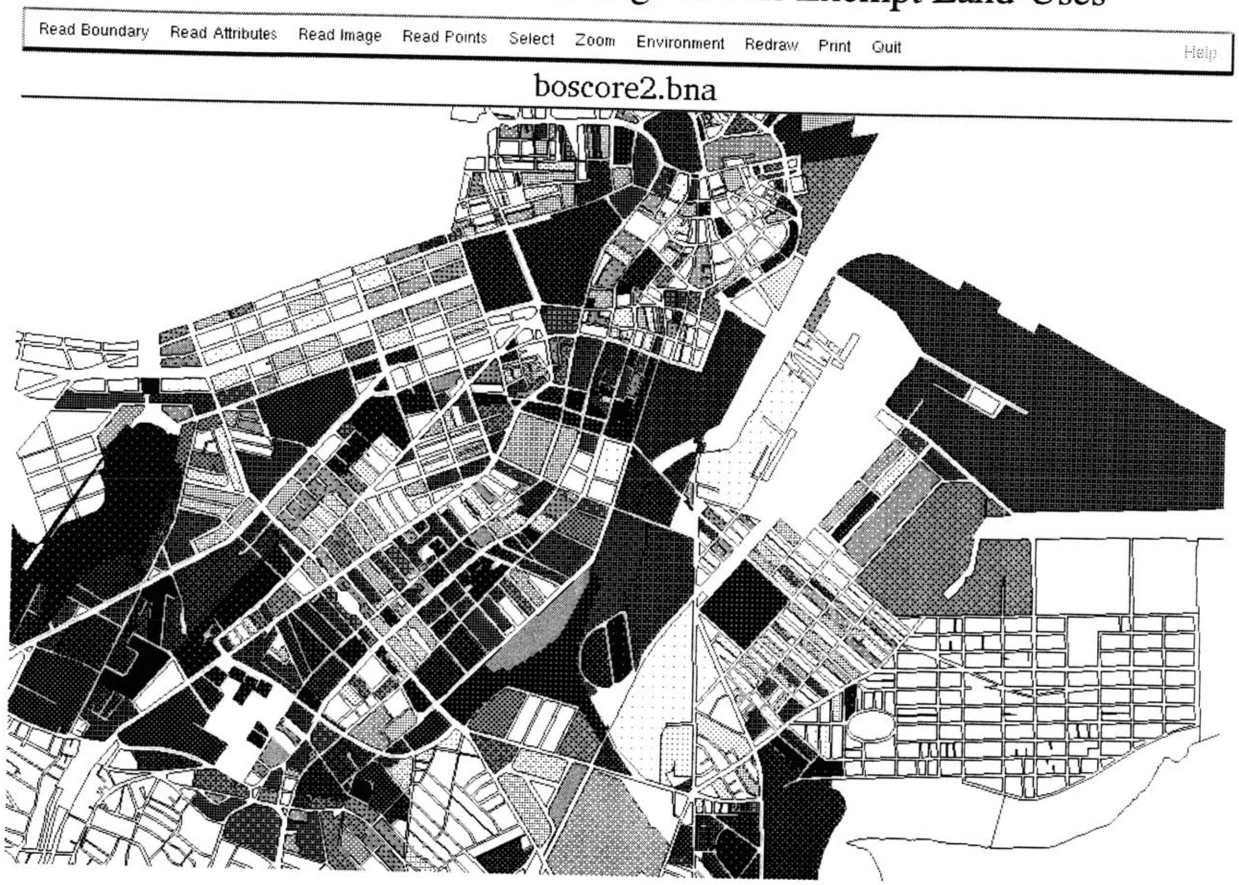
The Darkest Shade Represents a Value of 100%

Figure 5.3.14 Percentage of Vacant Land



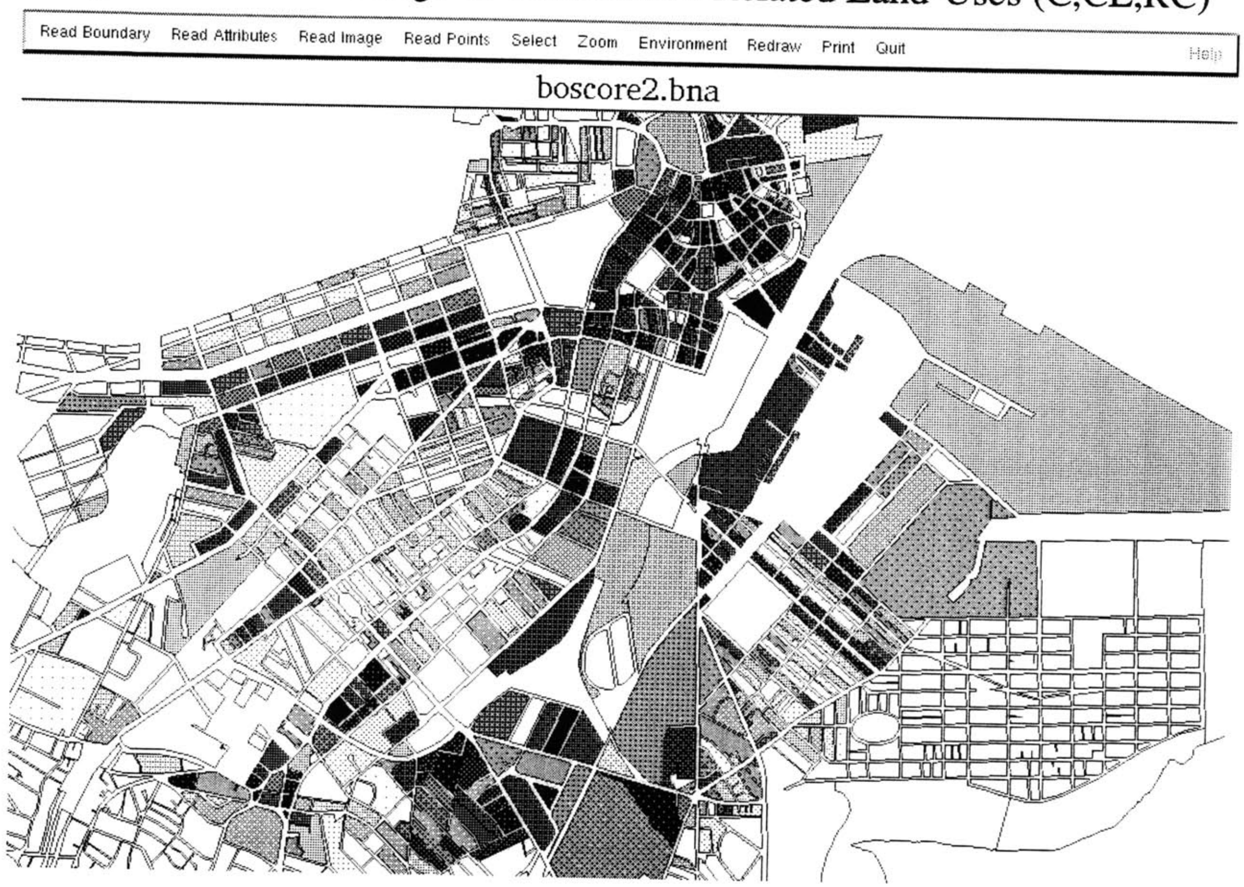
The Darkest Shade Represents a Value of 100%

Figure 5.3.15 Percentage of Tax-Exempt Land-Uses



The Darkest Shade Represents a Value of 100%

Figure 5.3.16 Percentage of Commercial Related Land-Uses (C,CL,RC)



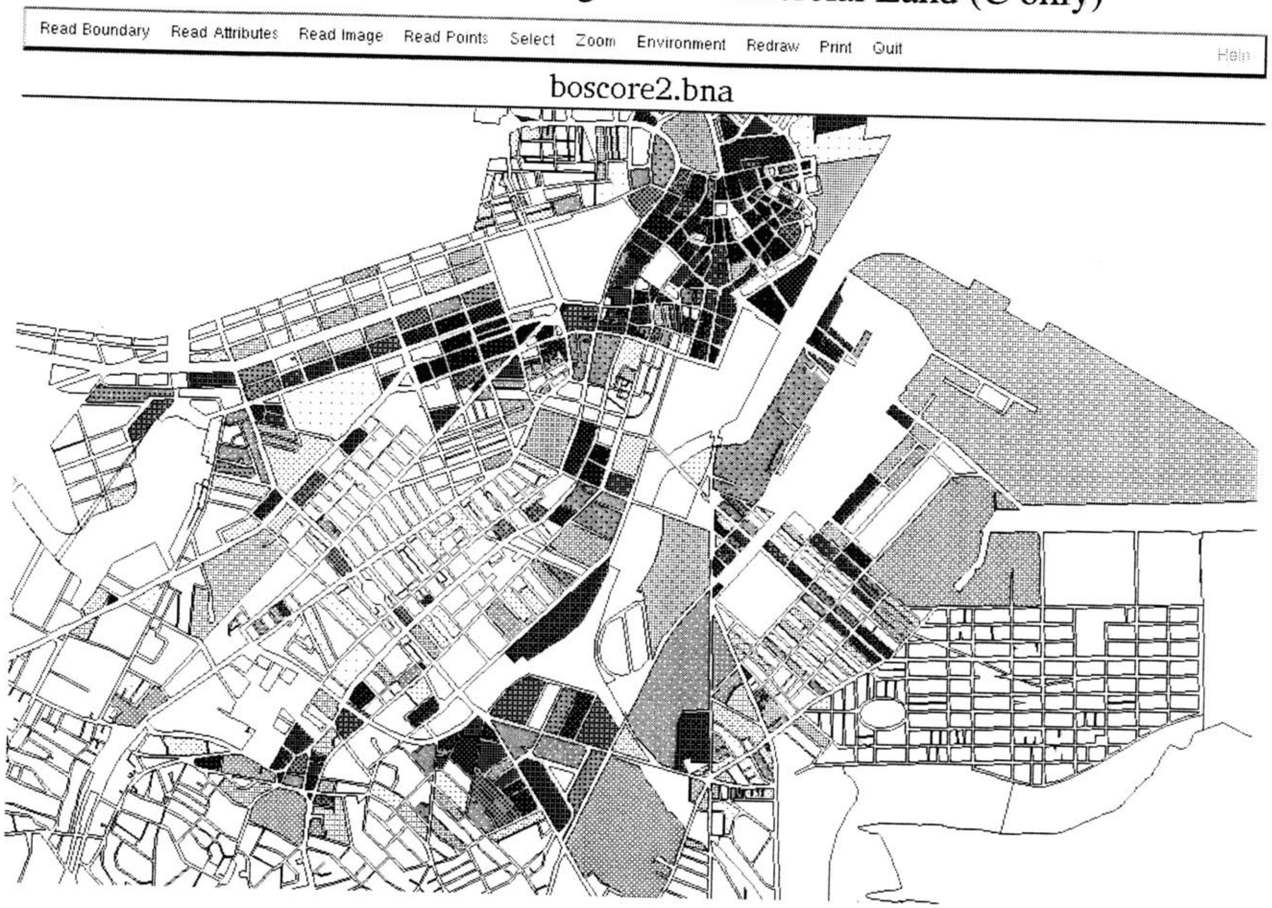
The Darkest Shade Represents a Value of 100%

Specific Issues, as in the case of commercial land-uses. The community has long maintained that there is a lack of commercial/retail facilities in the area. Identifying commercial land-use patterns in the South End thus becomes an important item on the planning agenda. Two maps are designed to present the commercial land-use patterns. Figure 5.3.16 shows the percentage of commercial-related land-use, whereas Map 5.3.17 shows the percentage of commercial land-use, excluding residential/commercial and commercial vacant land. Comparing the two maps, one can see that the South End does maintain a relatively low level of commercial-related land-uses in the overall pattern, with virtually no exclusive commercial land. Can the scattered commercial pattern of residential/commercial mixed use support the neighborhood? Does the neighborhood need more larger scale commercial services, and if so, where can they be located? These are some of the planning issues that surfaced from the detection of such patterns.

Another selected issue is the pattern of uses in "r1" to "r4" residential types. Historically, the South End was an area dominated by row-houses, which can be roughly measured as "r1" to "r4" types. A map was designed, showing the percentage of land square footage designated to "r1-4" uses, out of the total residential land-uses in a block. Figure 5.3.18, shows that the South End indeed has a higher percentage share of land-uses in r1 to r4, in particular as a inner-city neighborhood, as compared with Back Bay and Beacon Hill. What can planning and zoning do to preserve such a pattern, if it is desirable? What needs to be done to not only restrict conversions on the basis of land-uses, but also to encourage families and other social factors to support such uses? Can and should planning counter balance the market force of gentrification, which has resulted in increasing condo conversions in the last decade? Again, from the analysis and the spatial patterns it reveal, may relevant planning questions can be derived.

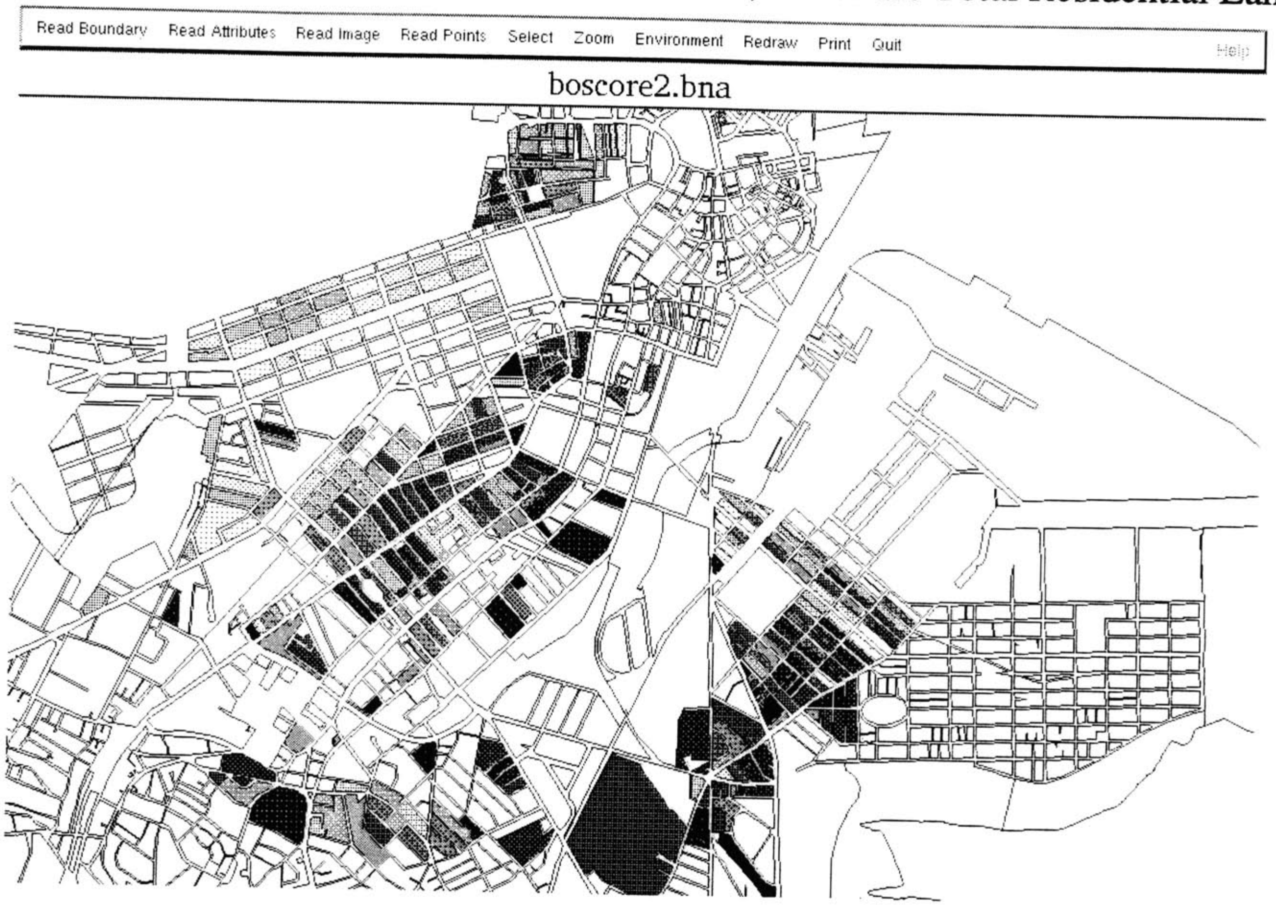
As demonstrated, the functional component of the project concentrated on the selection of variables and their combinations from the database, for the purpose of addressing policy issues in a direct way. This is particularly important when we are dealing with a large database, and the resulting numbers of maps can be limitless if no selection is made. By reaching the functional component of the project, we have successfully designed and built the database and its linkage to the visual display mechanisms. Some spatial patterns were detected. The functional component, being an end to the process on the one hand, may generate more questions than it answers and thus provide further input to the beginning of the next loop. A new structural design concept may be the result of such input, and would be implemented in the structural component of the next level of spatial analysis.

Figure 5.3.17 Percentage of Commercial Land (C only)



The Darkest Shade Represents a Value of 100%

Figure 5.3.18 Percentage of Land in R1-4 Uses, out of the Total Residential Land



The Darkest Shade Represents a Value of 100%

5.4 Conclusion

This study project succeeded in achieving its objectives, as presented in section 5.2. It extended the study area boundary and in doing so helped to reveal patterns of land-use in the South End as a function of adjacency to other areas. It used the most authoritative and comprehensive information--the assessing data in its most current form, and thereby addressed land-use issues from a perspective that can unify other previous land-use studies. It used the assessing block as its spatial unit, which is an improvement over previous studies when detailed information was hard to locate. Most important of all, it established a database structure and linkage, and prototyped the visual display mechanism as a tool in facilitating interactive spatial queries. In doing so, it makes further study of its kind easier. For instance, if information about historic land-use patterns is desired, it would be much easier to do the needed spatial queries by the same routines. All that changes is the master assessing file.

With regard to visual display of spatial information, the interactiveness of spatial query and analysis dominate this study project. If the demographic study can be characterized as "telling stories", then this project can by symbolized as "looking for stories to tell".

Due to time limitations, many other possible ways to further utilize this computer model were not explored. Among these extensions are possible linkage of the land-use study to the demographic study. The land-use computer model may be useful in projecting population by blocks, through applying a weighted factor of residential building square footage per person by different housing types. Also, the study may be used to provide data input for transportation modelling. The study also has some definite zoning implications, as detailed FARs can now be precisely mapped.

Chapter Six

CONCLUSION

In this chapter, I sum up the lessons form the study projects, and present suggestions for future research directions. These suggestions include directions for completion of the land-use and zoning studies for the South End Policy Plan, and recommendations to the BRA regarding strategies in the adoption of GIS in their future planning initiatives. Beyond the concerns of the policy planning process, I further discuss improvements to make maps better serve the purpose of interactive spatial analysis. The discussions are channelled into a conceptual structure of a Spatial Decision Supporting System (SDSS) that will match planning purposes.

6.1 Learning from the Projects

This thesis first of all represents a portion of the learning curve in adopting GIS technology to city planning. The progression in complexity of database management and visual display mechanisms is evident in the two study projects. The demographic study is PC based, involves digitization of the boundaries and entering attribute data manually. The key points of interest were in the normalization of the study variables in the structural manipulation, and the detection of spatial patterns of correlations and spatial distributions among them. Moreover, additional insight was gained by a spatial interpretation of outliers in such modelling. Such an effort is a positive step towards modelling spatial processes. The land-use study involves enormous data transfer--boundary as well as attribute data. Complex data queries and manipulations were routine tasks in the implementation, and this required a workstation platform. The study and the visual display of the results were aimed at understanding the overall pattern of the land and building inventory in the South End and its bounding neighborhoods. From this analysis, some special patterns of land-use were derived.

The implications of following such a learning curve are extensive. In real planning practice, such progression reflects the increasing complexity of information management, due to the proliferation of widespread computer tools (Ferreira 1990). Having gone through this development in understanding the nature of the tasks and in choosing appropriate computer tools to perform them will prove to be an invaluable experience. Also important is the fact that such a learning curve represents an increase in inter-departmental dependence on data and resource sharing in an institutional setting. Through this thesis, I have also come to a better understanding of the institutional aspects of applying GIS technology. These two projects did not have to involve GIS system design and implementation. For the duration of the thesis, I have been working as an intern at the BRA. It was assumed that the computer resources needed to adequately and efficiently conduct the studies was not a concern. However, the issues of sharing data, software/hardware availability, financial resources during the project implementation, supporting staff, and technical assistance, all were keenly felt. In fact, without the generous and continuous system and staff support from the CRL of the School of Architecture and Planning at MIT, even the simplest demographic study would have been difficult, if not impossible. In a broader context, many of the other previous and ongoing GIS efforts in Boston provided crucial input into the land-use project. These efforts include the city's ten-year, multi-million dollar GIS project which used an Intergraph system to digitize the entire city at a parcel level; a further effort at the CRL, MIT in aggregating the parcel boundary files into the block level; and the consistent efforts in regulating data collection and storage by the city's Assessing Department. All of these together have made the required information readily available to carry out the South End land-use study. These facts lead to my increased awareness of the institutional environment which may determine the very success of GIS implementation.

Needless to say, skills gained from thesis work relating to the use of particular software packages were tremendous. INFORMIX-SQL, Xmap, ARC/INFO, are among a host of supporting packages that I learned to use intelligently. As such, in depth knowledge was gained regarding the pros and cons of particular packages, in relation to others. Especially valuable experience was obtained in data transfer among packages.

Another beneficial aspect of the two study projects is that I was exposed to a rich decision making context. By working with the working group members on a regular basis, I was able to understand how spatial information is communicated and utilized. Aside from the fact that some of the analysis results were directly input into the planning process, I am also satisfied with the fact that the working group members learned substantially about their neighborhood. This should prove to be beneficial beyond the duration of the Policy Plan.

6.2 Directions for Further Research

The fact that over 80% of my thesis time was devoted to model building suggests that continuous use of this model will capitalize on some of the up-front cost. For this matter, expansion of these projects is desirable. A first step in such a direction would be to extend the time horizon of the study projects. For instance, given the fact that a data structure has been set up for the assessing data, it will take little time to load assessing data of previous years into the same structure to model change in land-use patterns over time. Efforts of a similar nature would also be beneficial in updating the demographic study when the 1990 census is available.

A second direction of future efforts should be geared towards building linkages between the two study projects. Given the richness of information provided by the land-use study, linking this source to other aspects of the Policy Plan may be beneficial. For instance, data on residential land-use may imply detailed patterns of population density and distribution, data on commercial and industrial land-use may be helpful in identifying sources of employment (and in particular their impact on gentrification). These sources, combined with data on parking from the assessing file, may be useful input to a transportation model.

A third prospect of further enhancing what was done is to continue to incorporate new knowledge into this decision support system. A zoning study, for instance, can be built based on the existing boundaries and attribute data structures. Complex spatial queries could then carried out, answering questions even more relevant to planning. For instance, "development potential" is a concept that is relevant to the Policy Plan. Vacant land, city-owned properties, under-utilized land--all provide development potential and, in turn, require careful planning. However, without the zoning information, "development potential" can only be vaguely captured by measurements such as "percentage of vacant land", FAR, ratio of assessed building value to land value, etc. But how are these identified parcels zoned? The same value for land zoned for residential uses versus commercial uses represents drastically different development potential. In addition, the likelihood of change through zoning variances for a particular area may give extra meaning to "development potential". Given these, incorporating a zoning study into the existing projects may be the next step to take. By the same token, the long proposed but yet unrealized, transportation study can be linked to these studies.

While these suggestions all focus on expanding the horizon of the computer modelling scope and enhancing the internal linkage among proponent study projects, I would like in particular to recommend continuing efforts being made to learn how people respond to spatial information and its representation. A false assumption I made before the demographic study presentation is that one does not need a trained eye to read maps. The survey, although limited in its scope and success, did inform me of the issues of getting scientific feedback on the effectiveness and efficiency in communicating spatial information. While maps do give people easier assess to spatial information compared to tabular data, it is important to remember that they also result in dramatic increases in the volume of information being communicated. Each map in the land-use study carries at least one hundred numbers on one sheet of paper, and in most cases is browsed for a fraction of a second. Ignoring this fact is basically ignoring the communicational component of the process, and will jeopardize the very success of such efforts in supporting decision making.

In summary, there are a number of ways in which a knowledge base for planning decision support can be expanded. There are also a number of issues to be addressed to make such a knowledge base and the mechanics of using it more efficient and relevant in a planning context. As such, the visual display functions need to be further enhanced. To this end, I present some recommendations to BRA regarding strategies in adopting GIS technology in its future planing initiatives.

6.3 Recommendations For Strategies in Adopting GIS at BRA

The City of Boston has committed a considerable amount of resources toward building a GIS system. The entire city can now be accessed at a parcel level on a computer. A previous GIS project, referred to as the Centralized Land Use Information System (CLUIS) project, has had success in supporting planning initiatives at a community level:

> The system enables planners and community advisors to go beyond their street corner observations, site visits, conventional wisdom, and common sense. Through the CLUIS system, the planners and advisors can gain insight into neighborhood patterns, document perceived problems, and clearly present findings to city agencies. Further, the community can do 'what if...?' analysis to anticipate problems or propose solutions to current land use conflicts.(Brown 1989)

With the surfacing of more specific GIS projects in a planning context, however, a strategy of adopting GIS at an agency wide level is needed.

It is my observation that until a more easily accessible set of application functions can be built on top of the existing GIS on the one hand, and an agency-wide effort to evaluate the benefit of applying GIS to planning initiatives be carried out on the other hand, spatial analysis in supporting planning can only be conducted on a piecemeal basis. Identifying problems from the past experiences in applying GIS, and anticipating problems in the future initiatives in a realistic fashion form the basis for the first recommendations I present.

This argument is two-fold. On the supply side, analytical functions within a GIS are currently far from facilitating. Extraction, aggregation and manipulation of assessing boundaries are slow and cumbersome. In addition, functions of juxtaposing other boundaries such as that of the census tracts and planning districts is not yet a routine function provided. The attribute data manipulation presents an even more challenging task. At present, knowledge about what is where in different sources of information is beyond manageable to a planner. In addition to these obstacles, lack of statistical functions within current GIS systems seriously blocks efforts in obtaining working knowledge in a spatial setting. To overcome these difficulties, one has to have considerable knowledge about a number of proponent GIS packages, boundary and attribute files, and be able to use mechanism of frequent file transfer among different packages. Furthermore, even if one masters the knowledge to undertake a GIS project, the irregularity in time schedule due to data acquisition, unsecured system support, and uncertain analysis output present practical problems in fitting into a steadily progressing, rigid planning schedule in a timely manner.

On the demand side, planning is issue-oriented, which implies a lack of consistency in its demands for database management. For the South End policy plan, the value and validity of the entire database may soon vanish after the process terminates, if the necessary database maintenance and use are not carried out. As such, so long as the cost of building such s database far exceeds the benefit, conventional planning schemes will still prevail. Such schemes involve limited database management, minimum statistical analysis, and pencil/marker paper map presentation. Given this, it is important to realize and advocate that, what should remain after this GIS project is an established routine of database query and boundary manipulation. This can be readily replicated to other planning initiatives as long as the routine is clearly defined and well documented, and the master database is readily available.

While these problems are not atypical to any adoption of new technology in an institution, they do tend to block the wide-spread application of GIS to immediate planning needs. Nevertheless, these problems should not be viewed as negatives against a long term strategy that begins with the current explorations. The agency should start a long range plan of exploring GIS potentials and preparing for its gradual adoption based on the following steps.

First, the BRA should encourage wide-spread awareness of GIS potentials. The product of the South End Policy Plan, together with the previous CLUIS project, should be demonstrated as much as possible. Putting aside the overwhelming technical problems encountered, the results of these two project have been encouraging and well received. There seems to be an emerging interest in further pursuing GIS on other occasions. As a matter of fact, this

GIS project would not have been possible without the demonstration of the CLUIS project and its consequent educating effect.

Secondly, the BRA should assess these two GIS project in terms of their sophistication, relevance to planning, and productivity. The scope, details, and in depth knowledge gained from this land-use study far exceed that of previous studies, such as the South End Density Impact Assessment. Furthermore, this land-use study provides additional knowledge about patterns in adjacent neighborhoods at almost no additional cost. The findings many benefit ongoing planning initiatives in these districts, Roxbury and Chinatown in particular. In addition, considerable savings can be achieved by referencing to the information in these two study projects in the upcoming transportation study for the South End Policy Plan. These uses should be recognized as significant in improving productivity.

Thirdly, the agency should take gradual steps in identifying a set of routine planning tasks and their dependence on different sources of information, determine the level of spatial aggregation needed to retain detail without losing efficiency, and document data structures, query routines, and transfer mechanisms.

Lastly, the BRA should embark on efforts in regulating and standardizing the collection and storage of information. For instance, the BRA Household Survey should be modified to be compatible with the federal census, both in terms of boundary and data definition. Another effort in the same direction is to make zoning data available in electronic form, and geo-code by the parcel identification number.

To summarize, I think the application of GIS in the South End Policy Plan process was an invaluable experiment. It tested the readiness of the agency in adopting new technology, as well as the strength of system support from the GIS industry. Under current circumstances, I recommend that BRA take gradual steps based on the assessment of existing GIS projects, and prepare itself for final adoption as the GIS industry increasingly supplies tools for spatial analysis with improved ease of use.

6.4 Further Improvement in GIS, and SDSS

What can be learned from this thesis work beyond the immediate setting of serving a master plan of a community? In this section, I make a closer examination of the GIS system configuration, and propose a more appropriate system that will better suit planning need--Spatial Decision Support System (SDSS).

In this thesis, "GIS" has been equated with a spatial analysis device. Definitions of a GIS often focus on the capture, storage, manipulation, analysis and display of spatial data--implying that GIS is designed to support spatial decision-making. Current research suggests, however, that for many spatial problems, GIS falls short in supporting decision-making effectively: analytical modelling capabilities are lacking and system designs are not flexible enough to accommodate variation in either the context or the process of spatial decision-making (Densham & Goodchild 1989). These problems give rise to the conceptual definition of a Spatial Decision Supporting Systems (SDSS).

A SDSS is a multi-dimensional combination of three computing functions--database management, statistical analysis and modelling, and mapping. These three parts are linked by the device of user interface to enhance the decision making process, aided by the computer, to become interactive, integrative, and participative. Each of these three parts has been adequately addressed in the literature and is beginning to be supported by a maturing industry. We also see emergence of a two-part combination to produce new functions as in the case of GIS, which is a combination of mapping and database management. However, the inflexibility of GIS in its incorporation of statistical analysis and modelling, and its lacking in more sophisticated user interface, currently block its application in more complex spatial decision making contexts.

Particularly, the user interface for a SDSS will need to make the data and the whole modelling process much more visible to the analyst. The ability to examine data in its spatial context is enormously important. A simple map gives the eye immediate access to geographical proximity and therefore emphasizes the role of distance as an explanatory factor. A map and the underlying geographic domain is a common ground for holding information coming through different channels. The analytical potential created by linking different sources of data is far more efficient than pure database matching. Ideally, a visual display device in SDSS should be a three dimensional coordinate system for the display of numeric data. In the X-Y coordinate system, a base map is defined in two alternate ways. First, and most commonly, the two dimensional system defines the "hard" boundaries by which data are input or transferred. We normally use such a system to document boundaries such as census tracts, assessing blocks and parcels, and planning districts. A second alternative in using the system is to define the "soft" boundaries where data can be displayed by their numeric range. Such boundaries override the "hard" boundary and emphasize the importance of understanding spatial patterns by the magnitude of the data range. An example of this type of use is the "temperature zone" map used in weather forecasting. Such a function may give additional power to interactive visual display. The third dimension, represented by the Z axis, is currently rendered by different colors and shade patterns in thematic mapping. It should be further explored and utilized, based on normalized data, to find better analysis of spatial linkage among variables. This function can be thought as a "spatial regression" where spatial correlation can be effectively modelled and presented (Chou 1989).

This thesis introduced a positive step towards exploring a SDSS as an improvement over GIS. It experimented with the role of maps, and their functions in presenting statistics. In doing so, the spatial dimension of the statistics becomes evident in the process of analysis. I can anticipate that once complex structural manipulation of both the boundary and attribute database are accomplished, adding a particular set of algorithms on a routine basis to such a system, making it suitable to particular analytical needs should be feasible. As such, improved features in statistical analysis, and strengthened visual communication functions, will provide planners and decision makers with better tools in accessing spatial information and conducting analysis.

6.5 Final Conclusions

"Diagnoses without prescriptions", may largely characterize this thesis and the embedded study projects. What was accomplished is the definition and exploration of new ways to detect spatial patterns in a real planning context. Definition of planning issues before the spatial analysis, and derivation of planning implications after the analysis, often came second to the methodological concerns. The focal point of the methodological concerns is how to conduct and present planning analysis with better visual tools. I think that recognizing the significance of visual display of spatial information is, and will increasingly be, instrumental in facilitating spatial analysis. This is so because the rapid development of GIS technology has resulted in, and will further demand, creative use of many visual tools in general, and maps in particular.

Under such circumstances, the mechanics of using maps has changed from being static and product-oriented to being dynamic and process oriented. To summarize, maps as the tool for spatial analysis have a new set of characteristics, and raise new issues:

Characteristics

Maps are becoming dynamic. One is no longer given a paper map to work with. Instead, "boundary files" are supplied as input for spatial analysis. Determination of maps in terms of their physical extent, level of aggregation, and ways of referencing, all become non-trivial tasks.

Maps are becoming user-specific. Instead of being given a dozen of maps to read to support an argument, analysts and policy makers are given a frame of display, a set of views to look at databases, across databases, and across different study areas. Such a process is exploratory.

Advantages

Maps are efficient. They condense large volumes of data into graphic form.

Maps are revealing. Besides carrying information that can be expressed in tabular data, maps reveal spatial patterns of association that otherwise are hard to model or detect.

Issues

Reading maps requires training.

Producing maps, and the underlying frame of display, is not easy. File manipulation, cross-referencing among boundaries and attributes, and data structure design to support interactive display, are all enormous undertakings.

Interpreting maps needs assistance. Maps can and almost certainly will be deceptive. The ways data are broken down to ranges, and the color or/and shade patterns to represent them are two main potential sources of deception. Therefore maps, especially for presentation purposes, need to be carefully designed.

Improving maps is becoming easier. Maps of better quality, due to ease in design and production, may help us overcome the pitfalls and possible deceptions.

This set of issues in turn puts more emphasis on computer modelling. The tasks of designing databases, maintaining the real time connection between database management, mapping, text editing, and statistical analysis tools takes a longer time then performing the analysis itself. From the established framework, where such task is approached using the four components developed in this thesis, one has to be constantly aware of the nature of the undertaking at different stages of the model building and application.

The four-component, staged approach to solving complex spatial information management proved to be very helpful throughout this thesis work. The identification of the spatial unit with which data are contained, referenced, and manipulated is the central undertaking of the structural component. Establishment of appropriate measurements and indicators to address planning issues and objectives characterizes the operational component. Design of display frames, in the form of both paper and electronic maps, is the focal point of the communicational component, and is also a key subject of this thesis. Interactiveness of the on-screen display and comprehensiveness of paper maps are believed to serve communicational purposes between analyst, planners, decision makers, and the general public at large. Finally, data manipulation, analysis and presentation should serve as a functional input to the planning process. The success of all the previous components can not be claimed unless its helps to reveal spatial patterns and associations that are otherwise hard to discern. Moreover, this four component framework may lead to an iterating loop when modifications in the functional component demand corresponding changes in the structural design of the database. By doing so, spatial analysis will truly become dynamic and supportive.

With this, we will also come to a better understanding and appreciation of upcoming applications in using geo-information in a more wholly integrated approach. Jack Dangermond, president of ESRI, sees more growth ahead in an area he refers to as ″geo-processing″. ″Geo-processing″, he predicts, will become (a popular application) like word-processing. ″More people will be able to know about geo-information. As the problems of our society become more complicated, geo-information processing will be increasingly important to managing data and providing ways for decision makers to understand the relationships among phenomena (Lang 1988).″ Toward this end, what has been explored, examined and established in this thesis will certainly be proven beneficial.

Appendix A

Survey Form for the Demographic Study

To: South End Development Policy Plan Working Group Members
From: South End Planning Team, NHD, BRA
Re: Survey on the Demographic Study

We are using state-of-the-art computer technology to assist us in data collection, processing, analyses and presentation. South End is the first neighborhood in the city to benefit from such initiative. With more analysis on its way, feedback from the working group members becomes crucial. The objective of the following survey is simple--we ask your opinion on how we are doing and how we can improve. We invite your active input on the demographic study recently presented to the working meeting. The assessment will be in terms of the relevance of the study to the Policy Plan, and in terms of the technical quality of the study itself.

We plan to conduct surveys of similar nature regularly through the remainder of the policy planning process. We will keep you informed of the survey results and the initiatives we take as a result. Also, we are counting on this regular feedback mechanism as a way to better facilitate communication among working group members.

It will probably take you five to ten minutes to fill out this questionnaire, and it can save us days of guessing and frustration. Please return the questionnaire using the enclosed envelop at your earliest convenience, or bring it to the next meeting. We appreciate your cooperation very much and look forward to seeing you soon.

On a scale of one to five please rate the adequacy of the maps used in the study in addressing the following issues

	Poor		Average		Excellent
Racial Diversity/Integration	1	2	3	4	5
Age Distribution	1	2	3	4	5
Family/Household Composition	1	2	3	4	5
Income Distribution	1	2	3	4	5
Poverty Distribution	1	2	3	4	5
Employment Diversity	1	2	3	4	5

On a scale of one to five please comment on the general aspects of this study:

	Poor		Average		Excellent
Accuracy	1	2	3	4	5
Detail	1	2	3	4	5
Information Summarized in Tables	1	2	3	4	5
Relevance to Policy Planning	1	2	3	4	5

How should the scope of the study be extended? Please Rank your preference (1--5; lowest--highest)

	Lowest				Highest
Update the data	1	2	3	4	5
Compare the study area with its vicinity	1	2	3	4	5
Identify the associations among the presented socioeconomic variables	1	2	3	4	5
Disaggregate the unit of study (i.e. from the census tract down to the block)	1	2	3	4	5
Others______________________________	1	2	3	4	5

What particular findings from the study confirmed what you understood about the neighborhood?

What particular findings from the study surprised you ?

Overall, did the demographic study meet your expectations? Please explain briefly.

Please tell us your preferences in terms of what issues to address next in our upcoming studies (zoning variance, real estate transaction, transportation...just to list a few)

<u>This part is optional, but we encourage your response so that we can better match up our analysis results with your needs.</u>

On a scale from one to five, tell us how comfortable you feel with computer technology:

Very Uncomfortable   Very comfortable

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1   2   3   4   5

On a scale from one to five, tell us how comfortable you feel with Statistical analysis:

Very Uncomfortable   Very comfortable

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1   2   3   4   5

Your Name:____

Address:____

Occupation:____

Age:	[ ] 20-29,	[ ] 30-39,	[ ] 40-49,	[ ] 50-59,	[ ] 60-69,	[ ] 70+
Tenure:	[ ] Renter			[ ] Homeowner		
Length of Residency in South End:	[ ] 0-5,	[ ] 6-10,	[ ] 11-15,	[ ] 16-20,	[ ] 21-25,	[ ] 26+

Again, thank you for your cooperation.

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