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POPULATION ESTIMATES AND PROJECTIONS FOR NUCLEAR POWER PLANT SAFETY ANALYSES AND EVACUATION PLANS: THE SHOREHAM NUCLEAR POWER STATION METHODOLOGY

by

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CHAPTER I

INTRODUCTION

Population Estimates Required for Final Safety Analyses

Before a nuclear power station operating license is granted by the Nuclear Regulatory Commission (NRC), the applicant must submit a Final Safety Analysis Report. Until late 1979, the reports were to be prepared according to the guidelines entitled "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," Revision 1, October 1972. The NRC had required that population estimates and projections to the year 2020 be made for the area within a fifty-mile radius of the reactor's core. The circle was composed of sixteen polar grids, 22.5 degrees each, centered on the major compass directions. The area was further divided into one-mile radius increments for the portion within five miles of the plant, five-mile increments for the area between five and ten miles from the reactor, and ten-mile increments for the land between ten and fifty miles from the core. The population estimates for each sector had to be prepared for both year-round residents and transients. It was not necessary to project seasonal populations by sector under the former guidelines.[1]

The accident at the Three Mile Island nuclear power plant in the spring of 1979 caused the NRC to review the safety analysis guidelines and the procedure for obtaining an operating license. In December 1979, the agency published a proposed rule amending the emergency planning requirements. Assuming that the proposal is adopted, NRC concurrence with state and local emergency response plans is now required prior to issuance of an operating license. Plants currently possessing a license must receive concurrence within 180 days after the amendment's effective date or January 1, 1981, whichever is sooner.[2] The emergency plans submitted in safety analysis reports shall contain, but not necessarily be limited to, the following elements:

> Organization for coping with radiation emergencies, assessment action, activation of emergency organization, notification procedures, emergency facilities and equipment, training, maintaining emergency preparedness, and recovery. The applicant shall also provide an analysis of the time required to evacuate various sectors and distances within the plume exposure pathway EPZ for transient and permanent populations.[3]

In January 1980, criteria for preparation of emergency response plans were published for interim use and comment. The planning objectives of the "Request for Evacuation Time Estimates (after Notification)" are to assure that (1) a range of protective actions is available for the plume exposure pathway, (2) guidelines for the choice of protective actions are developed, and (3) protective actions for the ingestion exposure pathway, appropriate to the locale, have been developed.[4] The state governments and the organizations operating nuclear plants are to prepare emergency plans consistent with Environmental Protection Agency recommendations regarding exposure to airborne radiation and with Food and Drug Administration and Health, Education, and Welfare recommendations pertaining to contamination of human food and animal feeds.[5]

Evacuation time estimates are required for the entire area within ten miles of the facility[6], and the population distribution is needed for the fifty-mile radius around the plant. The format in which the population estimates are to be presented is described in Table 1. The new interim rules require additional detail. The circle of fifty-mile radius about the reactor is still divided into sixteen polar grids, but more subdivisions are now prescribed. One-mile increments are to be used for the area within ten miles of the reactor, and five-mile increments thereafter. Thus estimates and forecasts must be prepared for very small geographic areas for both year-round and seasonal populations.

TABLE 1

SECTOR AND ZONE DESIGNATIONS FOR POPULATION DISTRIBUTION MAPS WITHIN EMERGENCY PLANNING ZONES

Centerline of Sector In Degrees True North From Facility	22 1/2° Sector	Miles From Facility	Zone
0 & 360	A	0-1	1
22 1/2	B	1-2	2
45	C	2-3	3
67 1/2	D	3-4	4
90	E	4-5	5
112 1/2	F	5-6	6
135	G	6-7	7
157 1/2	H	7-8	8
180	J	8-9	9
202 1/2	K	9-10	10
225	L	10-15	15
247 1/2	M	15-20	20
270	N	20-25	25
292 1/2	P	25-30	30
315	Q	30-35	35
337 1/2	R	35-40	40
		40-45	45
		45-50	50

SOURCE: Nuclear Regulatory Commission and Federal Emergency Management Agency, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, for Interim Use and Comment, NUREG-0654 FEMA-REP-1 (Washington, D.C.: U. S. Government Printing Office, January 1980): table J-1.

NOTE: An area is identified by a Sector and Zone alphanumeric designator. Thus, area A1 is that area which lies between 348 3/4 and 11 1/4 degrees true north from the facility out to a radius of 1 mile. Area G4 would be that area between 123 3/4 to 146 1/4 degrees and the 3- and 4-mile arcs from the facility. The number of permanent and maximum (including transients) persons within each of area segments constructed as above is the definition of population. The letters I and O have been omitted from sector designators so as to eliminate possible confusion between letters and numbers.

State and Local Emergency Response Plans

The NRC cannot order a state or local government to prepare an emergency plan for a nuclear facility, nor can it ensure cooperation between local government and any other organization which chooses to develop a plan. The roles of the utility companies[7], local governments, and planning agencies are, then, unclear. Whichever party assumes responsibility for preparing the plan must receive concurrence from the state, the locality, and the NRC. The utility has a financial interest, of course, in the completion and acceptance of an emergency response plan. The state government has a responsibility to protect the health and safety of its citizens, and therefore would be interested in the development of a quality plan. Also, the state regulates the utility and has a responsibility to the rate-payers and to the stockholders. In fact, the state may even own or operate the plant. The local government is also concerned with the safety of its citizens, and perhaps with the facility as a property tax revenue source. Some of the parties or individuals involved may be opposed in principal to the construction and operation of a nuclear power station for financial and environmental reasons. Therefore, the motivation of the groups involved are mixed. In addition, the capabilities of the organizations to prepare such a plan will differ from place to place and over time. For these reasons, it is not surprising that the NRC did not specify that any one group prepare the plan.

In one case, that of the Indian Point reactor, a privately-owned utility operates the plant but the Power Authority of the State of New York (PASNY) owns it. PASNY hired a consulting firm to prepare its evacuation time estimates.[8] The authority will then seek concurrence from the state and the NRC. The Shoreham Nuclear Power Plant, also located in New York, is owned and will be operated by the Long Island Lighting Company. In this instance, the state and county, jointly, are developing an emergency plan. New York and Suffolk County are relying upon their staff, the Long Island Regional Planning Board[9], and the Long Island Lighting Company (LILCO) for assistance.

New York State Evacuation Plan for the Shoreham Nuclear Power Station

New York is concerned with the physical transportation of persons from the ten-mile radius about the plant. Therefore, the area has been divided into twenty-seven evacuation districts whose boundaries are major roadways. Originally, when the planning process began in 1979, sixteen areas had been delineated, but were revised early in 1980. Two large evacuation areas were subdivided and three new areas were added. In some cases, the original areas did not quite reach the edge of the ten-mile radius. New districts were added so that the state evacuation area's outer boundaries would lie at least ten miles from the site of the plant.

Population estimates and projections to the year 2020 are required for the state evacuation areas for summer (seasonal) and winter (year-round) residents. The boundaries do not coincide with the NRC polar grids, but the estimates must be consistent. The state has decided to use the Long Island Regional Planning Board's (LIRPB) population projections to the year 1995, and the Bureau of the Census projections thereafter. The problem then, is to devise a methodology for estimating and forecasting population that will (a) be as accurate as possible for small areas, (b) be consistent with the LIRPB and New York State Department of Commerce (NYSDOC) figures, (c) allow transformation from NRC to state zones and vice versa, and (d) be possible to update as necessary when new information, such as the 1980 Census, becomes available or when federal and state requirements for the emergency plan are revised. The demographic analysis should meet or exceed current federal and state requirements and be acceptable to professionals in the fields of demography and planning. Accuracy is important because human life and safety are involved. If the forecasts are in error, as forecasts almost always are, then the error must be one of over-estimation or of insignificant under-estimation. A plan to evacuate too many people is preferrable to a plan for too few. Thus a slight upward bias in the projections is not necessarily a drawback.

Objectives

The purpose of this report is to describe and evaluate the methodology chosen by LILCO to estimate and project the population distribution within ten miles of the Shoreham Nuclear Power Station. Several population projection methodologies are available, but few if any are considered reliable for small areas; that is, counties, minor civil divisions (MCD's), and census tracts. The choice of a method or model depends upon factors such as data availability and quality, the size of the area, the time span of the projections, the complexity of the methods, the presence of special populations, the impact of government decisions on the local population, the function of the postcensal estimates, the time unit used in the model and the extent of census undercount.[10] Characteristics of the area for which population projections are to be made should also be considered to the extent that they affect population growth.

Chapter II will describe the area surrounding the plant, namely the Village of Shoreham, the Towns of Brookhaven and Riverhead, Suffolk County and Long Island. Local factors which may influence future population growth in the area, such as the topography and climate, the current population level and density, employment centers, transportation facilities and land use patterns, will be addressed. Chapter III contains a review of existing methodologies for estimating population, particularly for small areas such as MCD's and census tracts. The usefulness of each method for the Shoreham Plant's Safety Analysis Report and emergency response plan will be discussed. Chapter IV explains the methodologies of the LIRPB and of the NYSDOC regional population projections chosen by New York State as control forecasts for the emergency plan. Next, LILCO's technique for estimating the current and future population distribution for both NRC and state evacuation zones, consistent with the control forecasts, is presented. The results of the studies made by LILCO in 1973 and 1979-80 for the NRC and New York State will be compared and shown along with the control forecasts of regional population. A summary of findings on the adequacy of this and other available methodologies for meeting NRC and state regulations regarding emergency response plans is contained in Chapter V.

CHAPTER II

CHARACTERISTICS OF SHOREHAM, NEW YORK AND ITS VICINITY

The preparation of reasonable population estimates and projections is facilitated by a knowledge of the special characteristics of the study area. Both geographic and socio-economic factors can affect the development potential and future population levels of a region. Topography, climate, population level and density, employment characteristics, wage levels and income, transportation facilities and accessibility to other areas, and general land use patterns help to determine a region's attractiveness to people and firms, relative to other localities. Understanding the distinctive features of Long Island in general, and particularly of Suffolk County, Brookhaven and Riverhead towns, will aid in choosing an appropriate forecasting methodology and in assessing the likelihood of its results.

Geography, Topography and Climate

Long Island, which is the largest island adjoining the continental United States, extends approximately 118 miles east-northeast from the mouth of the Hudson River. The east end of the island is composed of two forks; the northern peninsula is about twenty-eight miles long, and the southern one is about forty-four miles in length. In Peconic and Gardiners Bays, between the two forks, are Shelter Island and privately owned Gardiner's Island.[11] There are four counties on Long Island: Queens and Kings to the west, which are part of New York City, Nassau County bordering the city, and Suffolk County to the east. The topography of Suffolk County is quite consistent from west to east but is variable from north to south. Bluffs on the north shore range from thirty to one hundred feet above sea level. There are two morainal ridges which traverse the island from west to east, with the southern one running through the center of the island and from there along the south fork. An outwash plain, composed of sand and fine gravel, slopes from the southern morain to the sea. Between the two ridges are extensive areas of sand and fine gravel, also. The few streams are located at Smithtown on the north, by Riverhead at the bifurcation, and near Great River and Yaphank to the south.[12]

The climate of Suffolk County, influenced by the Atlantic Ocean, is characterized by moderate summers and comparatively mild winters. There is an early spring and extended autumn, with a growing season of about two hundred days. The prevailing winds are from the northwest during the winter and from the southwest during the warmer months. Average annual precipitation is 45.0 inches; the minimum was 25.9 inches in 1965 and the maximum was 59.0 inches in 1897.[13] Normal annual heating degree days are approximately 5100 and cooling degree days, 1200.

Suffolk County is approximately 905 square miles in area, with a maximum length of 86 miles and a maximum width of 21 miles. There are ten towns, twenty-nine incorporated villages, and numerous school and special districts in the county.[14] Beaches line the major shores and bays; Fire Island on the south shore is predominantly a beach resort area. Lake Ronkonkoma and Lake Panamoka are the only sizeable inland bodies of water.

The ten-mile radius about Shoreham is almost entirely within the Town of Brookhaven. A small portion of western Riverhead is also included. Brookhaven contains about 252 square miles of land, making it the largest of the ten towns. The Shoreham Nuclear Power Station site is located in Brookhaven, on the north shore of Long Island. The plant is situated in the northern portion of the site, at latitude 40 degrees, 57 minutes, 39.6 seconds and longitude 72 degrees, 51 minutes, 56 seconds. The developed part of the site is bounded on the north by the Long Island Sound, on the east by marshland, on the south by North Country Road, and on the west by the "Shoreham West" property. "Shoreham West" is a 429 acre site also entirely owned by LILCO. The Shoreham site is 499 acres of which 80 acres in the northern portion are being developed for the plant. The site is hilly, varying from sea level to two hundred feet above sea level. The wetlands along the east and west boundaries extend almost one-half mile from the shore inland; the remainder of the property is mostly wooded. Wading River Creek flows through the wetlands on the east side.[15]

Population Level and Density

The population of Suffolk County as of January 1, 1980 is estimated at 1,337,447, only slightly above the prior year's total of 1,333,949. Census data for 1950 and 1970 show that the number of people grew from 0.3 million to 1.1 million during that period. The Town of Brookhaven was the fourth largest town in population size in 1950 at 44,522, and became the second largest by 1970 at 245,260. This rapid growth led the Town Board to request a special interim census, which was taken on April 26, 1975 and resulted in a count of 320,677 persons. LILCO has estimated the January 1, 1980 population at 356,886, making Brookhaven the largest of the ten towns in population.[16]

Population density in Suffolk County has increased from 299 persons per square mile in 1950 to 1,222 in 1970 and 1,451 in 1980. Brookhaven's density was 171 in 1950, 943 in 1970, and 1,373 in 1980. As a comparison, Queens has a density of about 18,000 persons per square mile while Nassau County's density is 4,816. Density decreases as distance from New York City increases:

Nassau's density is about one-fourth of Queens' and Suffolk's density is less than one-third of Nassau's. The average figure for Suffolk is somewhat misleading, though. The five western towns all have a density greater than 1,300 persons per square mile but the five eastern towns all have densities less than 400.[17]

Population Centers

Within the Town of Brookhaven, there are twenty-five places or communities whose boundaries were recognized by the 1970 census. These communities had a total population of 155,052 in 1970, or about 63 percent of the town total. Only five of the communities are within the ten-mile radius or the state evacuation zones; these are shown in Table 2. Riverhead, in the adjoining Town of Riverhead, is on the outer edge of the ten-mile circle and is therefore included in Table 2. The geographic location of the communities is illustrated in Figure 1.

Other significant population clusters within the ten-mile radius have been defined by the LIRPB. These are East Shoreham, Rocky Point, Sound Beach and Wading River. Table 3 presents the 1970, 1979 and 1980 population counts for these clusters.

TABLE 2

POPULATION OF PLACES WITHIN TEN MILES OF THE SHOREHAM NUCLEAR POWER STATION

Community	1970 Population	1979 Population	1980 Population
Shoreham	524	566	574
Port Jefferson Station	7,403	7,456	7,484
Port Jefferson	5,790	6,315	6,407
Yaphank	8,793	11,341	11,484
Belle Terre	678	877	889
Riverhead	7,585	7,200	7,048

SOURCE: Long Island Lighting Co., Shoreham Nuclear Power Station Unit 1, Applicant's Final Safety Analysis Report, Vol. 1, revision 16 (Mineola, New York: LILCO, April 1979), p. 2.2-3; Robert J. Panzarella, Long Island Lighting Co., workpapers for 1980 revisions to Final Safety Analysis Report; Long Island Lighting Co., Population Survey 1980 (Mineola, New York: April 1980), pp. 34-35, 38.

TABLE 3

POPULATION OF OTHER SIGNIFICANT CENTERS WITHIN TEN MILES OF THE SHOREHAM NUCLEAR POWER STATION

Community	1970 Population	1979 Population	1980 Population
East Shoreham	2,141	3,434	3,435
Rocky Point	3,460	4,412	4,547
Sound Beach	4,878	7,376	7,573
Wading River	2,768	3,798	3,806

SOURCE: Long Island Lighting Co., Shoreham Nuclear Power Station Unit 1, Applicant's Final Safety Analysis Report, Vol. 1, revision 16 (Mineola, New York: LILCO, April 1979), p. 2.1-3; Robert J. Panzarella, Long Island Lighting Co., workpapers for 1980 revisions to Final Safety Analysis Report; Long Island Lighting Co., Population Survey 1980 (Mineola, New York: April 1980), pp. 34-35, 38.

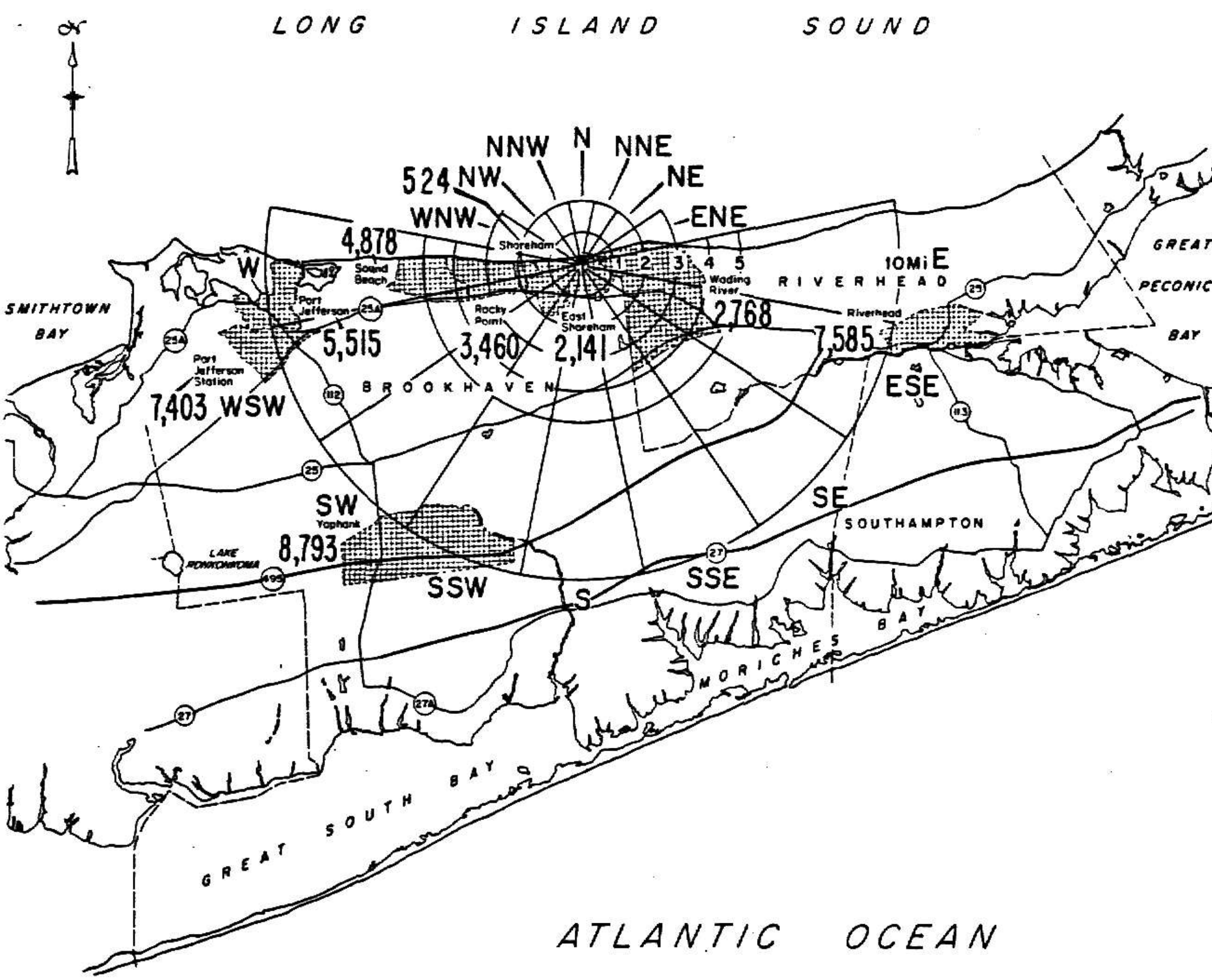

FIGURE 1

INCORPORATED VILLAGES, UNINCORPORATED PLACES AND LOCALITIES - 1970 10-MILE RADIUS

Employment Centers and Major Industries

The LIRPB has identified ten major employment centers in Suffolk County but only one -- Port Jefferson-Port Jefferson Station -- is located in the ten-mile radius. It covers 9 square miles and in 1970 had 5,210 work trip destinations, or 569 jobs per square mile. The Port Jefferson center was the smallest of the ten in terms of number of destinations and was the second smallest in jobs per square mile. Approximately 69 percent of the center's workers live within 5 miles of Port Jefferson; 36.5 percent live within 3 miles of the center. The vast majority (90.6 percent) travel to work by private automobiles.[18]

In 1970, there were less than 3,200 work trips recorded from inside the ten-mile radius to major employment centers: about 2,200 to Port Jefferson, less than 750 to Stony Brook-Lake Grove, 107 to Bethpage, and 101 to Commack-Hauppauge. The latter three centers are more than 10 miles from Shoreham.[19] As of 1979, there are nine firms employing one hundred or more persons, within the ten-mile area, or close to the outer boundary:[20]

Company	Number of Employees
Brookhaven National Laboratory	3,500
Embassy Vinyls	110
Grumman Aerospace Corp.	3,343
Lawrence Aviation Industries, Inc.	300
Patriot Security Service, Inc.	300
Peerless Photo Products, Inc.	122
Redactron Corp.	498
Strathmore Concrete Corp.	110
Thomas Wilson & Co.	280

In 1970, 53.7 percent of Suffolk County's employed were white-collar workers; 32.4 percent were blue-collar workers; 13.4 percent were service workers; 0.6 percent were in agriculture. Of 388,984 employed persons, 84,684 worked in manufacturing industries; 79,702 in trade; and 113,498 in services. The labor force increased by 79.4 percent between 1960-70 while population grew 69.0 percent. Male labor force participation rate declined slightly to 73.4 but the rate for females rose 113.4 percent to 34.2.[21]

In 1970, Brookhaven's total employment was 81,939. Industries employing at least 10 percent of the total were manufacturing durables, retail trade, and educational services. Machinery and transportation equipment were the major durable goods manufacturing industries. Riverhead's total employment was 6,848 in 1970. Employment by industry for both 1960 and 1970 is shown for the two towns in Table 4.

TABLE 4

INDUSTRY OF EMPLOYMENT OF TOWN RESIDENTS*

	Riverhead		Brookhaven	
Industry	1960	1970	1960	1970
MINING	8	15	80	67
CONSTRUCTION	398	626	4,019	6,658
MANUFACTURING	667	885	8,369	15,178
Durables	389	671	5,421	10,491
Furniture, Lumber, Wood Products	17	15	204	274
Metal Industries	20	19	639	1,209
Machinery	140	155	1,085	3,312
Transportation Equip.	143	367	2,346	4,090
Other Durables	69	115	1,147	1,606
Non-Durables	278	214	2,948	4,687
Food & Kindred Products	220	121	752	641
Textile & Apparel Prods.	13	37	1,318	1,865
Printing, Publishing, Allied Industries	34	42	479	1,049
Other Non-Durables	11	14	399	1,132
TRANSPORTATION, COMMUNICATION, UTILITIES	276	577	2,761	6,640
Railroad & Railway Express Service	10	4	374	641
Other Transporation	36	196	1,035	3,112
Communications, Utilities, Sanitary Services	230	377	1,352	2,887
WHOLESALE & RETAIL TRADE	989	1,494	6,380	17,065
Wholesale Trade	198	254	991	2,465
Retail Trade	791	1,240	5,389	14,600
SERVICES	895	1,917	8,858	26,328
Business & Repair Svcs.	91	304	902	3,188
Personal Services	230	287	1,491	2,707
Private Households	115	97	518	381
Other Personal Svcs.**	115	190	973	2,326

TABLE 4 - Continued

	Riverhead		Brookhaven	
Industry	1960	1970	1960	1970
SERVICES (cont.)				
Profess. & Related Svcs.	574	1,326	6,465	20,433
Hospitals	100	219	1,628	3,254
Educational Services	222	573	2,132	10,479
Other Profess. Svcs.	252	534	2,705	6,700
PUBLIC ADMINISTRATION	329	566	1,290	5,212
OTHER (incl. unclassified)	1,481	768	4,926	4,791
T o t a l	5,043	6,848	36,683	81,939

SOURCE: U.S. Bureau of the Census, cited by Nassau-Suffolk Regional Planning Board, "A Profile of the Nassau-Suffolk Labor Force," by Pearl M. Kamer, Long Island Economic Trends: Technical Supplement (Hauppauge, New York: NSRPB, March 1973), pp. 77-78.

*1960 data refers to persons 14 and older; 1970 data refers to persons 16 and older.

**Includes entertainment and recreation services.

The percentage of Suffolk residents working in Suffolk fell between 1960 and 1970, from 63.9 to 60.9, while the percentage working in Nassau rose from 14.1 to 15.1. The percentage commuting to New York City decreased from 15.8 to 15.0. However, the absolute numbers increased for each place of work. There were 93,310 new jobs in Suffolk, plus 30,007 more Suffolk residents held jobs in Nassau and 23,919 more worked in New York City. The place of work of Suffolk County, Brookhaven Town, and Riverhead Town residents in 1970 is shown in Table 5.

The LIRPB has noted that:[23]

> In 1974, 57% of Nassau-Suffolk's manufacturing workforce were employed in one of five "defense-related"industries: fabricated metals, non-electrical machinery, electric and electronic equipment, transportation equipment and instruments. In 1972, these industries accounted for 60% of all value added in manufacturing.

While the economy of the SMSA is still dependent upon the defense industry, it is becoming more diversified. Few firms, however, have re-located from New York City to Nassau-Suffolk since 1970. There has been migration from Nassau County to Suffolk County, which represented 11 percent of Suffolk's new plant employment between 1964 and 1976. The geographic origins of Suffolk's manufacturing employment created by new plants and expansions, 1964-76, are:[24]

TABLE 5

PLACE OF WORK: SUFFOLK, BROOKHAVEN AND RIVERHEAD RESIDENTS - 1980

	Place of Residence		
Place of Work	Suffolk County	Brookhaven Town	Riverhead Town
Manhattan CBD	13,397	1,599	28
Rest of Manhattan	13,698	1,707	13
Kings CBD	1,282	178	0
Rest of Kings	7,424	1,173	13
Queens	18,677	3,033	26
Bronx	2,014	301	18
Richmond	100	25	0
N.Y.C., not specified	908	143	0
Nassau	59,989	8,610	179
Westchester	1,944	302	29
Suffolk	229,368	56,587	6,104
Rockland	55	20	0
Jersey City	30	6	0
Rest of Hudson	243	75	0
City of Newark	116	34	0
Rest of Middlesex	1,041	164	7
Rest of Newark SMSA	509	113	0
Bergen	719	104	6
Passaic	514	106	15
Middlesex	246	31	0
Other	8,699	1,552	112
Not Reported	21,519	5,014	292
Total	382,492	80,877	6,842

SOURCE: U.S. Bureau of the Census, cited by Nassau-Suffolk Regional Planning Board, "A Profile of the Nassau-Suffolk Labor Force," by Pearl M. Kamer, Long Island Economic Trends: Technical Supplement (Hauppauge, New York: NSRPB, March 1973), pp. 106-107.

Place of Origin	Percentage
New York City	37.2
Intra-county expansions	31.5
Newly formed companies	14.5
Moves from Nassau	11.2
Moves from elsewhere	5.6
Total	100.0

The SMSA has lost jobs to other states between 1961 and 1976. The New York State Department of Commerce reports that Nassau-Suffolk lost 1,910 jobs to Florida, 1,825 to New Hampshire, 1,367 to California, 1,291 to New Jersey, 1,204 to Connecticut, and 838 to other counties in New York.[25]

These statistics suggest several problems impeding the manufacturing growth of Suffolk County. First, the base is dominated by "defense-related" firms so changes in government defense spending affects the region's stability. In addition, the emphasis on durable goods production renders the area vulnerable to cyclical swings. The advantage of "defense-related" durables manufacturing is the relatively high wages paid; the substitution of non-durable industries could result in lower wages per employee. A second weakness is the fact that only 5.6 percent of the new plant employment represents in-migration of firms from outside the New York Metropolitan Region. This suggests that manufacturers do not view Suffolk County as a desirable location. Of the 12,200 manufacturing jobs which left Nassau-Suffolk, half remained in the Northeast, so it does not appear that climate is a great influence. "If manufacturing jobs from New York City and Nassau are no longer forthcoming, Suffolk's manufacturing growth could be severely curtailed."[26] The third problem is that new firms in Suffolk tend to be small. Such firms may be under-capitalized and thus more likely to fail than larger firms. During 1979, 76 new firms located in Suffolk but employed only 945, for an average of 12.4 employees per firm. There were 8 new establishments in Brookhaven Town; these employed 132 persons for an average employment size of 16.5.[27]

Eastern Suffolk has a somewhat different economy than the remainder of the SMSA. Farming, fishing, and tourism are the major activities in the "east end." The county ranks first in New York State in terms of value of agricultural sales. The most important crops were potatoes, nursery products, flowers, sod, and vegetables. Duck and other poultry sales constitute a major portion of agricultural sales, also.[28]

The Nassau-Suffolk income level is the highest in New York State. Suffolk County's median family income was $12,084 in 1969; the mean was $13,382. The growth in real family income, 1959-69, was 48.4 percent. Median family income in Brookhaven was $11,143 and in Riverhead, $9,644.[29] Table 6 gives the income distribution for the county and the two towns within the ten-mile radius.

TABLE 6

DISTRIBUTION OF FAMILIES BY
INCOME CLASS, 1969

Income Class	Percentage of Families		
	Suffolk	Brookhaven	Riverhead
Under $1,000	1.5	1.8	2.8
$1,000-1,999	1.5	1.8	1.9
$2,000-2,999	1.9	2.5	3.4
$3,000-3,999	2.4	3.0	5.7
$4,000-4,999	2.6	3.5	5.7
$5,000-5,999	3.1	4.0	6.0
$6,000-6,999	3.7	4.3	5.7
$7,000-7,999	4.8	5.6	6.1
$8,000-8,999	5.9	6.6	8.1
$9,000-9,999	6.4	7.4	7.1
$10,000-11,999	15.6	16.8	14.4
$12,000-14,999	18.6	17.8	13.6
$15,000-24,999	25.4	20.8	15.9
$25,000+	6.6	4.2	3.6

SOURCE: U.S. Bureau of the Census, cited by Nassau-Suffolk Regional Planning Board, "A Profile of the Nassau-Suffolk Labor Force," by Pearl M. Kamer, Long Island Economic Trends: Technical Supplement (Hauppauge, New York: NSRPB, March 1973), pp. 90-91.

Disposable income per household for the Nassau-Suffolk SMSA was estimated to be $24,856 in 1978, the fifth highest of all SMSA's. If adjusted for inflation, however, little improvement would be seen over the 1969 levels.

Land Use Patterns

Transportation Routes

The major transportation routes on Long Island have an east-west orientation. These are Routes 495, 27, 27A, 25, 25A, and the Northern and Southern State Parkways. Of these, the Long Island Expressway (Route 495) and the two parkways are limited access highways. The parkways extend from western Suffolk to New York City and thus do not lie within the ten-mile radius. Roads with a north-south direction within the ten-mile area are Routes 46 (William Floyd Parkway), 21 (Rocky Point-Yaphank-Middle Island Road), 112 (Port Jefferson-Patchogue Road), and 347 (Port Jefferson Highway). Routes 46 and 347 are four-lane limited access highways; the others are generally two-lane roads. The major roads and airports are shown in Figure 2.

The Long Island Railroad has three branches within the ten-mile radius, all with an east-west orientation. The railroad is used as a commuter line, primarily to transport workers to New York City. Little freight (two trains per week) is carried, partly

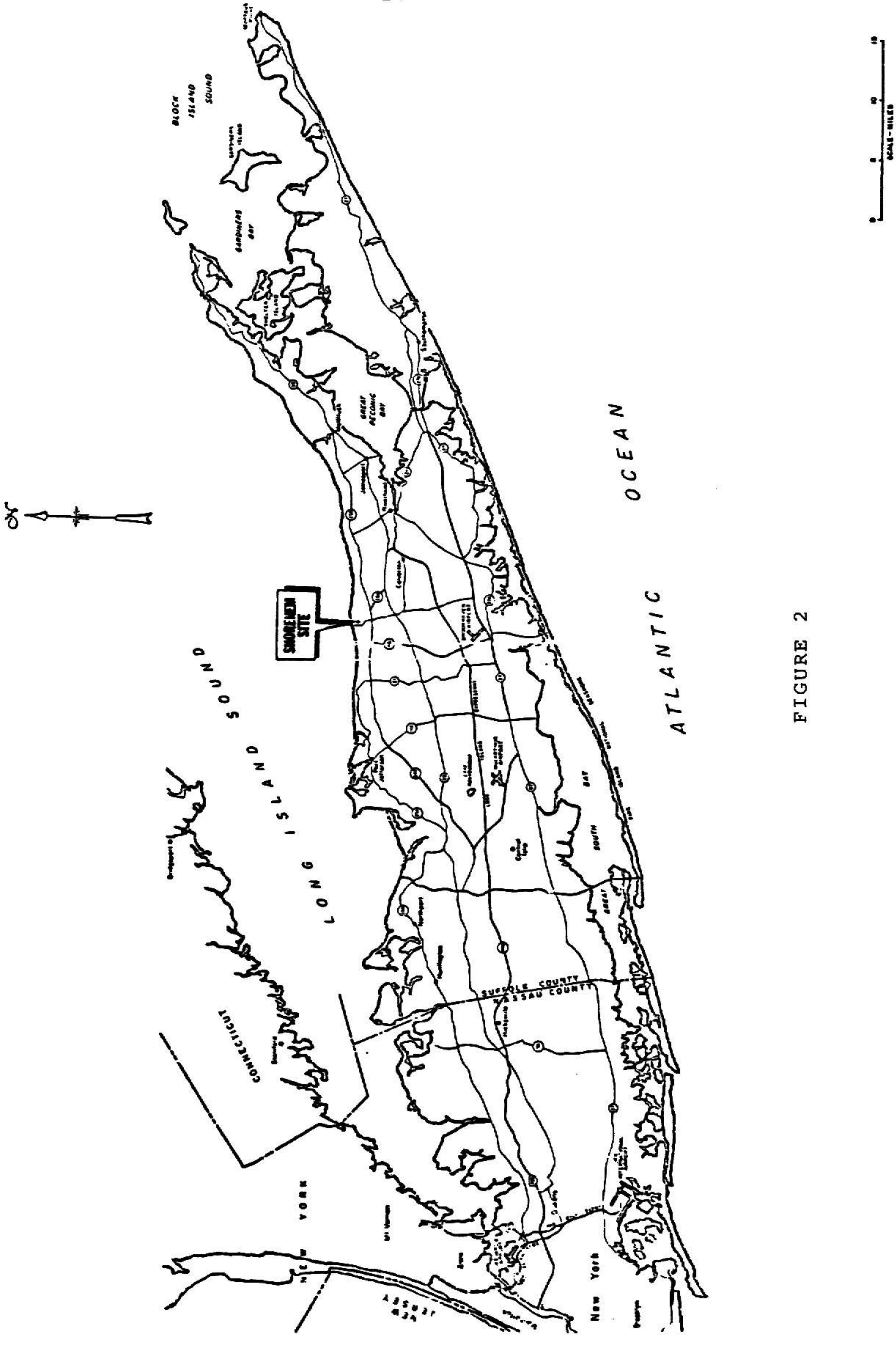
LONG ISLAND SOUND
ATLANTIC OCEAN
SHOREHAM SITE
SUFFOLK COUNTY
NASSAU COUNTY
CONNECTICUT
NEW YORK
New York
BLOCK ISLAND SOUND
GARDINERS BAY
GREAT PECONIC BAY
SOUTH BAY

FIGURE 2

because the bridges cannot accommodate modern "piggyback" cars. The northern branch extends from Hicksville in Nassau County to Port Jefferson Station. The central or main line runs from Pennsylvania Station to Riverhead, and from there to Orient Point on the north fork. Regular service terminates, for all practical purposes, at Ronkonkoma. The southern line extends from Hicksville to Montauk Point on the south fork.

Bus service is very limited in Suffolk County. The Town of Huntington is experimenting with a local transit service, and the railroad connects with bus lines from Yaphank to Orient Point. Otherwise, private automobile is the major means of transportation for residents of Suffolk County.

There are four airports within the county: Long Island MacArthur in Islip, Grumman-Peconic in Calverton, Coram Air Park in Coram, and Brookhaven Airport in Shirley. MacArthur is the major commercial airport, but lies outside the evacuation area. The Grumman-Peconic River Airport is leased by Grumman Aerospace Corp. from the Department of Defense, and is used for official government business only, such as testing military aircraft. Coram Air Park is a private airport with a single, unpaved runway, used for lessons with small, private planes. Brookhaven Airport is municipally owned and has two paved runways and facilities for about sixty-four light aircraft. In 1974, there were about 104,000 takeoffs and landings at this airport. Occasionally a large company-owned craft, such as a Lear Jet or Gulfstream, uses Brookhaven Airport. The low-level approach patterns of all except Grumman-Peconic River are not within the ten-mile radius of the Shoreham Nuclear Plant.[31]

Parks and Recreational Facilities

Within the evacuation area, there is one state park, two county parks, and one town park, totalling 3,770 acres. There are 584 acres of nature preserves,[32] numerous beach and boating facilities, and 9 golf and country clubs. In addition, there are several scout, church, and youth organization camps in the area. Riverhead Raceway, about nine miles from the site, holds midget and stock car races. Parr Meadows was designed to be a quarter horse race track but is no longer in business. It may be used occasionally for rock concerts, etc. Table 7 lists the parks and recreational facilities, their locations, distance from the nuclear plant, and state evacuation zone designation. There are also eleven historical sites within the evacuation area; these are shown in Table 8.

TABLE 7

PARKS AND RECREATIONAL FACILITIES WITHIN TEN MILES OF THE SHOREHAM SITE

Area	Location	Acres	Distance & Direction From Site (Miles)	State Evacuation Zone
Wildwood State Park	Rt. 25A, Wading River	699	3.6 E	J
Southhaven/Suffolk Cty. Park (AKA Carman's River Park)	Horseblock Road, North Patchogue	1,323	10.0 S	M
Peconic River County Park	Wading River Rd., Manorville	2,010	4.0 SSE	H
Reeves Park/Beach (Pr)	Park Road, Riverhead	16	8.2 E	P
Brookhaven State Park	William Floyd, Ridge	2,137	NA	C
Daniel R. Davis Sanctuary	Mount Sinai Road, Coram	51	9.2 SW	K
Cathedral Pines	Bartlett Road, Yaphank	321	7.4 SSW	L
Cranberry Bog County Nature Preserve	Manorville	211	NA	I
Wading River Beach	Creek Road, Wading River	7	0.6 NE	E
Hulse Landing Road Beach	Hulse Landing Road, Wading River	8	2.8 E	E
Cedar Beach	Mount Sinai Harbor, Mount Sinai	NA	8.6 W	K
Mount Sinai Yacht Club (Pr)	Harbor Beach Road, Mount Sinai	NA	8.0 W	K
Ralph's Fishing Station	Shore Road, Mount Sinai	NA	8.8 W	K

TABLE 7 - Continued

Area	Location	Acres	Distance & Direction From Site (Miles)	State Evacuation Zone
Pine Hills Golf Club	Wading River-Manor Road, Manorville	900	5-10 SSE	N
Shoreham Country Club	Woodville Road, Shoreham	NA	2.4 W	A
Spring Lake Country Club	Middle Country Road, Middle Island	180	7.8 SW	G
Middle Island Country Club	Yaphank Avenue, Middle Island	250	7.8 SSW	L
Baiting Hollow Ctry. Club (Pr)	Flag Drive, Baiting Hollow	193	6.4 E	P
Harbor Hills Country Club	Fairway Road, Port Jefferson	126	9.6 W	K
Rock Hill Golf Club (Pb)	Clancy Road, Manorville	269	9.2 SSE	O
Spring Lake Golf Club	Bartlett Road, Middle Island	180	8.6 SW	G
Tall Tree Golf Club (Pb)	Rt. 25A, Rocky Point	NA	4.4 WSW	F
Sandy Pond Golf Club (Pb)	Roanoke Avenue, Riverhead	NA	9.6 E	P
Camp Francoise Barstow	Landing Road, Miller Place	61	7.0 W	F
Camp Baiting Hollow	Sound Avenue, Baiting Hollow	185	4.6 E	J

TABLE 7 - Continued

Area	Location	Acres	Distance & Direction From Site (Miles)	State Evacuation Zone
Camp Wauwepex	Manorville Road, Wading River	640	2.2 SE	D
Camp DeWolfe	New North Road, Wading River	71	1.4 ENE	E
Dorothy P. Flint Nassau County 4-H Club	Sound Avenue, Riverhead	140	5.4 E	J
St. Joseph's Villa	North Country Road, Wading River	(2)	0.5 W	A
Riverhead Raceway	Rt. 58, Riverhead	NA	8.8 ESE	O
Parr Meadows	Rt. 495 and Rt. 46	NA	NA	M

SOURCE: Long Island Lighting Co., Shoreham Nuclear Power Station Unit 1, Applicant's Final Safety Analysis Report, Vol. 1, revision 16 (Mineola, New York: LILCO, April 1979), Table 2.1.3-8; Robert J. Panzarella, Long Island Lighting Co., Mineola, New York.

NOTE: (Pr) = private; (Pb) = public; NA = not available.

*Property is owned by the Long Island Lighting Co.; buildings are leased by the operators of the camp.

TABLE 8

HISTORICAL SITES WITHIN A TEN MILE RADIUS OF THE SHOREHAM SITE

Name	Location	Distance & Direction From Site (Miles)	Description
Marconi's Radio Shack (Pb)	Rt. 25A, Rocky Point (Grounds of Rocky Point School)	3.6 WSW	Built in early 1900's; Marconi carried out many of his radio experiments here
Congregational Church (Pb)	South Road & North Wading River Road, Wading River	0.8 ESE	Built in 1740; oldest active Congregational Church
Lester Davis, Sr. House (Pr)	Rt. 25 & Rt. 112, Coram	9.6 SW	Used for town meetings for over 50 years; by appointment only
Baiting Hollow Congregational Church (Pb)	North Road, Baiting Hollow	6.8 E	Built in 1803; noted for its entrance doors
Miller Homestead (Pr)	North Wading River Road, Wading River	1.2 ESE	Built in 1799; changes in styles of windows chronicle changes in history; used as a tavern, homestead & post office
Wading River Historical Society (Pb)	North Country Road & Gabriel Mills Roads, Wading River	0.8 SE	Contains an extensive library & various artifacts from the 1800's
Trinity Evangelical Lutheran Church (Pb)	Rt. 25A, Rocky Point	3.4 WSW	Built in 20th Century

TABLE 8 - Continued

Name	Location	Distance & Direction From Site (Miles)	Description
Tesla Laboratory (B)	North Country Road, Shoreham (on grounds of Peerless Photo Products, Inc.)	2.4 WSW	Built in early 1900's
Elmer House (Pr)	North Country Road, Shoreham	2.0 WSW	Built in 1700's
Seldon Farm (B)	North Country Road, Wading River	0.5 SE	Built in 1720; not in use at this time
The Farmers Museum (Pr) (AKA Keillor Collection and Farms)	Parker Road (North Country Road), Wading River	2.8 ESE	"Century Farm" cited in 1945 by New York State Agricultural Society; also, collection of primitive farm & home implements; by appointment only

SOURCE: Long Island Lighting Co., Shoreham Nuclear Power Station Unit 1, Applicant's Final Safety Analysis Report, Vol. 1, revision 16 (Mineola, New York: April 1979), Table 2.1.3-9.

NOTE: (Pr) = private, by appointment only; (Pb) = public historical site or used for public purposes; (B) = business or industrial use.

Residential Land Use

There are 108 municipalities in the Nassau-Suffolk region; only the Village of Dering Harbor on Shelter Island has no zoning, and the Village of Atlantic Beach has its zoning power retained by the Town of Hempstead. "The Villages of Bellport, Lawrence and the City of Glen Cove have architectural review board provisions embodied in their ordinances ... All of the zoning ordinances in the Region represent density by requiring minimum lot sizes without regard to soil conditions, topography, ground water supply or natural coverage."[33] The density range for single family homes varies from 1,800 square feet to 5 acres per unit. The range for multi-family residential use ranges from 6 to 435 dwelling units per acre. The LIRPB commented on these allowable densities:[34]

> This remarkable spread of densities implies a wide variety of house choices and living styles where, in fact, this is not so. In actuality, the people of the Nassau-Suffolk Region either live in single family detached homes which they own, or in apartments which they rent. The available choice does not include townhouses, semi-detached, two-family homes, studio apartments, penthouses, terrace homes, apartments above shops or other varieties of dwelling types in existence today. As a consequence of this limited choice structured by zoning, the Region suffers downtown decay, traffic congestion, and general inefficiency of land utilization.

What has been said of the Nassau-Suffolk SMSA applies to a greater extent to Suffolk County. There is less variety in housing types in Suffolk than in Nassau; that is, more detached single family homes and fewer apartments. Multi-family residences and homes built on less than quarter-acre lots are found in four locations: (1) south of Route 25, east of Rocky Point-Yaphank Road, west of William Floyd Parkway, (2) north of East Moriches Riverhead Road, just northeast of Port Jefferson-Westhampton Road, (3) at the south end of Edwards Avenue, and (4) at the east end of the Long Island Expressway-County Road 58. The north shore is characterized by half-acre and larger lots, the south shore and central area by quarter-acre and larger lots.[35]

The Town of Brookhaven adopted its zoning ordinance for unincorporated areas on January 27, 1937 and revised it on August 8, 1961. There are nine residential districts for single family units, ranging in minimum lot size from five thousand to forty thousand square feet. Two multi-family districts each have three acre minimums, for four to six thousand square feet per dwelling unit. Cumulative zoning is allowed for certain commercial districts. All site plans are reviewed by the town's planning board.[36] There are three incorporated villages within the town: Belle Terre, Port Jefferson, and Shoreham. Belle Terre has only one district (R1) with a minimum lot size of one acre. No two-family houses or apartments are allowed. The maximum lot coverage is 20 percent. This ordinance was adopted August 8, 1952 and has not been revised. The

Village of Shoreham adopted a zoning ordinance July 30, 1927 and revised it in 1951. There are two residential districts; one has a minimum lot size of thirty thousand square feet, the other, one acre. No two-family dwellings or apartments are permitted. The Port Jefferson ordinance was enacted July 8, 1963 and was revised April 28, 1965. There are four single family districts whose minimum lot sizes vary from fifteen thousand square feet to one acre. Two multi-family districts exist, requiring from 18,500 to 100,000 square foot lots. There is also a residence-office district and a professional-apartment district.[37]

The total land area of Brookhaven Town is 160,400 acres, of which 106,730 were vacant in 1966. Of the vacant land, 97,730 acres were zoned residential, 4,420 were commercial, and 4,580 were industrial. Belle Terre contains 580 acres, with 350 of them vacant in 1966, and all residentially zoned. In 1966, 150 out of Shoreham's 300 acres were vacant, and all were zoned residential. Port Jefferson has a total land area of 1,800 acres of which 870 were undeveloped in 1966. Of the vacant areas, 760 were residential, 30 were commercial, and 80 were industrial.[38]

The Town of Riverhead contains no incorporated villages. Its total land area is 43,590 acres of which 29,750 were vacant in 1966. The vacant land was zoned as follows: 26,300 acres residential, 840 commercial, 2,610 industrial. The town's zoning ordinance was passed May 5, 1959 and was revised May 27, 1969. Two single-family districts have minimum lot sizes from 22,000 to 40,000 square feet. One district allows apartments on a minimum of three acres, two-family houses on twenty thousand square feet, or single-family dwellings on fifteen thousand square feet. Partial cumulative zoning of apartments in commercial districts is allowed.[39] It should be noted that most of the residentially zoned vacant land is in agricultural use at this time.

Educational, Religious, Medical and Other Land Uses

There are twenty-nine educational facilities within the ten-mile radius. Of these, six are located within two miles of the site. Twenty are elementary schools, two are junior-senior high schools, three are senior high schools, one is a junior high school, and one is a primary school. There is one nursery-play school and one orphanage. There are twenty-six churches in the evacuation area, two of which are within one mile of the plant. One hospital, Mather Memorial in Port Jefferson, is barely within the ten-mile radius. Another is located just outside the evacuation area, in Riverhead. The Medical Research Center at Brookhaven National Laboratory accepts only patients referred by doctors for special research programs; it has a capacity of only thirty-six beds. There are three nursing homes within ten miles of Shoreham: Ridge Rest

Home (58 beds), 4.0 miles southwest, Woodhaven Manor Nursing Home (80 beds), 9.4 miles west-southwest, and Woodhaven Home for Adults (40 beds), 9.4 miles west-southwest. The Suffolk County Farm, a prison honor farm, is 9.5 miles south-southwest of the site. Its capacity is 152 persons.[40]

Commercial and Industrial Land Use

According to the 1969 zoning map, Suffolk County's commercial and industrial development is located: (1) along Routes 25, 25A, and 112, (2) on Montauk Highway, (3) along William Floyd Parkway south of Route 25, (4) at Grumman-Calverton, (5) at the intersection of William Floyd Parkway and the Long Island Expressway, (6) between Route 112 and William Floyd Parkway, (7) south of the Long Island Expressway and Long Island Railroad tracks but north of Sunrise Highway, and (8) in Riverhead along County Road 58.[41] Much of the commercial development can best be described as "strip commercial," and the industrial as rare (except for the major employers mentioned above). In the unincorporated portion of Brookhaven, there were 3,075 acres of commercially zoned land in use, and 2,205 acres vacant, as of 1973. Of the industrially zoned land, 1,705 acres were in use and 6,435 were vacant.[42]

Military Facilities

The military facility closest to the plant site is the Nike Missile Site, which was deactivated in 1975. The Naval Weapons Industrial Reserve Plant, at Calverton, is partly within the ten-mile radius. The land area of the naval plant is 6,951 acres, and is owned by the government. About three thousand acres and all of the buildings are leased by Grumman Aerospace Corporation. The Grumman-Peconic River Airport is located on this government-owned site.[43]

The preceding discussion of the region surrounding Shoreham describes a suburban and rural area of low density and high income. The evacuation area is approximately forty to sixty miles from Manhattan. About 11 percent of the residents work in New York City and another 11 percent in Nassau County. The majority, approximately 75 percent, work in Suffolk County. Transportation routes to the western employment centers of Nassau County and New York City are few and congested. In Wheaton's study, reducing travel speed increased the steepness of wealthy households' bid curves, and resulted in a more compact city.[44] Rising energy costs decrease the likelihood of continued suburbanization in central and eastern Suffolk. In his discussion of factors favoring non-metropolitan growth, Alonso points out that the energy crisis may modify these factors, because "the expansion of the urban field depends in part on the cost of moving people and goods..."[45] The rising property taxes and the cost of new single-family homes will also deter new residential development. The preferences of the current residents are for "more of the same" in housing, and drastic zoning changes are not likely. Upzoning tends to be accompanied by downzoning in another place, by acquiring park land or through agricultural preservation districts. The evacuation area appears to be too distant from the largest employment centers to attract many more long-distance commuters; the land is not cheap enough to outweigh the transportation costs.

As Nelson points out,

> In order for the consumer to be indifferent between the two locations, the price of housing at the more distant (less accessible) location must be sufficiently less such that the consumer is compensated for any additional costs incurred. The most obvious incremental costs are those incurred in the journey-to-work...[46]

Goodman found that "suburb-to-city movers, more than any other intra-SMSA movers, cite commuting and cost considerations as reasons for moving."[47]

Neither is the area attracting any new, large firms. Existing industry is dependent upon defense spending, which is not likely to increase by enough to cause a boom in Brookhaven. Other large employers in the town are the State University at Stony Brook and Brookhaven National Laboratory. The former has nearly completed its expansion and the latter is not growing. Both are unusual in that they resulted largely from government policy and expenditure. It cannot be expected that more such facilities will be built in the area. Agriculture, tourism and fishing should remain important for the "east end," with tourism somewhat limited by the congested traffic routes. In short, the growth of this area is expected to slow in the future.

CHAPTER III

POPULATION PROJECTION METHODOLOGIES

When applied in demographic analyses, the terms "estimate," "projection," and "forecast" have rather subtle differences in meaning. During the year in which a census is taken, the census count is unquestionably a "current population estimate." A few years later, a current estimate may also be called a projection or a forecast, however, if it is based upon prior years' census data. Thus postcensal estimates can be projections or forecasts. A projection may be based upon any useful assumption, however hypothetical, while the term forecast is generally reserved for the most probable projection.[48] In this report, the terms estimate or postcensal estimate will refer to current population estimates for non-census years; the terms projection and forecast will be used interchangeably to apply to estimates for future years.

Data sources are of two general types, direct and indirect. Direct data is obtained from censuses, population registers, surveys and other recorded information on births, deaths, and migration. Indirect data consists of school enrollment figures, gas and electric meters, employment statistics, voter registrations, and housing construction, alteration and demolition permits.[49] Primary direct data includes records of government statistical offices and agencies, such as registration and vital statistics data, birth and death rates and ratios, current population estimates, life tables, net reproductive rates, and net intercensal migration. Secondary sources, both official and unofficial, are yearbooks, textbooks, atlases, and gazetteers such as those published by the United Nations, U. S. Bureau of the Census, or the National Center for Health Statistics.

Small area data is found in decennial census publications, in special censuses made at the request and expense of local governments, in Current Population Reports (for areas larger than fifty thousand people), and in state and local censuses. Not many state and local census are conducted now; in 1965 only two were made, one in Kansas and one in Massachusetts. Other sample surveys containing useful information are published by the Bureau of Labor Statistics (labor force data), the U. S. Public Health Center (National Health Survey), and the U. S. Department of Agriculture (farm population statistics).

Registration systems cover employment under Social Security, aliens, the armed forces, voters, births, deaths, marriages, and in some cases labor, as in states where persons under a certain age must obtain a work permit. Partial registers include the Old-age, Survivors, Disability, and Health Insurance (OASDHI), Continuous Work History Sample, military service records, voter lists, school enrollment data, and school censuses. Miscellaneous data sources are tax office records, city directories, church memberships, postal delivery stops, building and demolition permits, and utility meters at residential addresses.[50]

Most of the direct data is available only at the national or state level; small area data is generally available for census years only. The term "small area" is occasionally used to refer to any subdivision of a nation, but more often denotes minor civil divisions (MCD's). Primary or major civil divisions consist of the states, capital cities, and cities larger than 100,000 persons. Secondary and tertiary civil divisions are counties and townships; these, together with municipalities, constitute the MCD's. Townships are not necessarily densely settled population centers, and may have no government at all. Some or all incorporated municipalities (cities, towns, and villages) in a state may be MCD's. The Census Bureau recognizes yet another geographic subdivision, the incorporated place, which is a nucleated settlement but not necessarily a political or administrative unit. The paucity of data pertaining to MCD's is one reason why "the amount of analytical work done on population data for minor civil divisions has been quite limited."[51] Nevertheless, it is often necessary to estimate and project the population of small areas, with whatever data is available. The estimates will undoubtedly be tied to the most recent direct data available, and will use indirect or symptomatic data to a greater extent than will large area estimation techniques.

Census data is generally considered to be the most reliable information available on population, but how accurate is it? The U. S. Census is de jure, that is, it measures the population at the place of usual residence. Military services members, college students, and institutional inmates are counted at their current location, not at their former home. Persons with more than one residence are counted at the place where they are most of the time, taking into account the length of stay, both past and prospective. Those with no residence, such as migrant workers, vagrants, and travelling salesmen are simply counted where they happen to be at the time the census is taken. Americans visiting abroad are counted at their usual home, but those employed abroad are excluded. Foreign diplomats in this county are also excluded, but foreigners working or studying here are included.[52] That is, foreigners in this country legally are counted.

Errors in the census can be traced to several causes: the design of the census, inadequate instructions, missing or erroneous maps, wrong responses, loss of forms, and office errors in tabulation and typing.[53] Wolfenden lists similar principal sources of error: "(a) accidental or wilfull misstatements by the individuals enumerated, (b) carelessness or lack of training on the part of the enumerators, (c) the difficulty of uniform classification, and (d) the possibility of the entries on the schedule being wrongly inserted, or of the census clerks misreading those entries, and other errors of tabulation."[54] There are also deficiencies in the census count for ages zero and one due to incomplete birth registration and under-reporting at the time the census is taken.[55] Use of a de jure method forces the reallocation of births and deaths of non-residents to their place of usual residence; this is important to cities and locations of regional hospitals because up to 23 percent of the deaths and 37 percent of the births can be non-residents.[56] The reallocation process, though, can be another source of error.

It is important to remember that the census may not be counting the same people in which the forecaster is interested, and that the enumeration itself may be incorrect. However, the error will probably be insignificant in most cases, because most gross undercounts and overcounts are reported by communities during pre-publication reviews. When a forecaster wishes to treat a subpopulation in a different manner than the Census Bureau does, adjustments can be made to the census data; it is merely necessary to be aware of the nature of the census enumeration rules so that appropriate adjustments can be made. The census data is considered the best available and should serve as the starting point for postcensal estimates and projections, or as the basis for such a starting point when adjustments must be made for special population groups.

Certain principles should be kept in mind when forecasts are made. First, the smaller the area, the greater the error to be expected. This is due to the nature of the data available and to migration, a larger and volatile element in population change. Second, "the further into the future the projections are carried, the greater the error probably will be."[57] Third, "... complexity does not guarantee accuracy, and greatly increased detail can contribute to lack of control of the projection process, and difficulty in understanding the results."[58] One must be able to project each of the variables involved in the model. Fourth, there are special populations which do not necessarily parallel general population trends. These special groups, such as military personnel, college students, and institutional inmates, should therefore be forecasted separately. Fifth, administrative decisions and government policy can affect the population size of small areas by means of highway construction, federal and state financing of housing, zoning and building permit regulations, construction for water and sewerage, etc. Although determining future policy impacts involves much uncertainty, the probable course of government action should be considered.[59]

Siegel notes that it is not possible to forecast the population of small areas accurately, given present knowledge and techniques, and that empirical evidence on which is the best methodology is lacking. One reason given for the lack of publications on the topic is that many small area forecasts are developed solely for use within a particular organization, or are distributed on a very limited basis. Other reports include forecasts as an incidental feature and thus may not be included in a review of population forecasting methods or tested for accuracy ex post. "For the most, the Census Bureau has eschewed entering the field of small area forecasting because of the lack of a tested and reliable method and has left it to outsiders."[60] After reviewing 130 forecasts or groups of forecasts, Siegel concluded that a wide variety of small area methods are in use and that no consensus on the best methodology had evolved; the method used is generally chosen on the basis of practical considerations or subjective judgments as to reliability. The accuracy of a small area forecast depends upon the accuracy of the latest census count, of the current population estimate, and of any national projections used as a guide, as well as on the particular methodology chosen. More reasonable projections will be made when the economic prospects, national and local, are considered in the forecasting process. This is especially true for localities where net migration may be more important than natural increase in determining the level of population.[61] Greenberg points out that "The choice of a model is best made by considering its relative accuracy, the type of population data available, the quality of available data, the scale of the analysis, the length of the projection period, the purpose of the projections, and the budget and time frame implications of the projection study."[62]

Extrapolation Techniques

Many graphical and mathematical extrapolation techniques have been used to estimate and project population for areas of all sizes. Arithmetic progression is frequently used between censuses because of its simplicity and, under normal circumstances, reasonable results. A geometric progression has also been commonly applied to particular age, race, and sex groups, each of which draws its multiplier from prior censuses. It cannot be assumed then, that the total population follows its own geometric progression, because the sum of several geometric progressions is not itself a geometric progression. If it is desirable to use a step-down procedure which preserves the total for the whole population, then this method cannot be used. A modified geometric approach would compute arithmetic progressions for each group or locality and then multiply each by the ratio of the total population's geometric progression result to its arithmetic progression result. Another variation, A. C. Water's First Method, forces the sum of the group values to equal the total population's geometric progression by assuming that the ratio of each group to the total increases in arithmetic progression:

$$(p/P)_t = a+bt$$

$$p_t = (a+bt)P_t$$

$$= (a+bt)P_1R^t$$

where: p = group's population
P = total population
t = time
R = geometric rate

This method does not allow for a stationary population in any group, for then the ratio p/P would follow a geometric progression rather than an arithmetic one. A. C. Water's Second Method allows for stationary populations by assuming that:

(1) $p_t = mp_1 + np_2$

(2) $P_t = mP_1 + nP_2$

(3) If $p_2 = p_1$ then $p_t = p_1$

These assumptions imply the following:

(1) $m + n = 1$

(2) $m = (P_2 - P_t) / (P_2 - P_1)$

(3) $p_t = \frac{P_2-P_t}{P_2-P_1} \cdot p_1 + \frac{P_t - P_1}{P_2 - P_1} \cdot p_2$

This method permits the subdivision of results but in certain cases results in a mean population higher than that of the arithmetic progression's mean. The mean of the geometric should be less than that of the arithmetic progression. Under A. T. Traversi's method, the mean population is assumed to lie between the arithmetic and geometric means. The arithmetic is calculated and then scaled down.

The disadvantage is that subsequent subdivisions disturb the original calculations.[63]

The arithmetic and geometric methods are only useful for intercensal estimation. Either extrapolation technique ignores the forces underlying population change and could, especially in the case of geometric progression, yield fantastically high projections. Rates of population growth often slow when densities increase to a certain level, so mathematical curves approaching asymptotes are sometimes chosen. One example is Verhulst's logistic curve:

$$\frac{1}{P_t} \frac{dP_t}{dt} = m - nP_t$$

$$P_t = \frac{B}{1+Ce^{-kt}}$$

The curve follows an S shape, first increasing at an increasing rate, then rising at a decreasing rate never to reach the asymptote.[64] Unfortunately, the curve will vary considerably with the choice of the data's time horizon. It is not a linear model and the ceiling must be estimated from another source, or be solved for on the computer using iterative techniques. As with the progression methods, the logistic curve cannot be used to explain why the population is growing and cannot accommodate the impact of any policy, economic, or long-term demographic changes.

Ratio-Correlation Methods

Isard notes that "Population growth in any given area may exhibit a relationship to population or other growth in another area if there are interconnections among the social, economic, political, and biological factors governing growth in the two areas."[65] When one area is contained within the other region, geographically, it is natural to assume that such interconnections exist. This assumption forms the basis for ratio and correlation methods. The ratio methods may utilize constant ratios of the smaller area's population (or growth) to the larger area's population (or growth), or may allow for changing ratios, perhaps through trending. Once the percent distribution of the parent population among the geographic subdivisions is observed for one or more time periods, it is projected and applied to an independent population forecast for the parent region. The ratio method ignores internal migration, which is a major factor in the redistribution of population among small areas.[66] This "step-down" technique does have one advantage; it makes use of the greater reliability and detail available at a larger scale of analysis.[67] Schmitt and Crosetti examined ex post forecasts for twenty cities to investigate the accuracy of the ratio method. They used logistic or linear methods to project ratios and applied the ratios to 1940 and 1950 census data. They concluded that forecasting accuracy is not closely related to the size of the city, that twenty-year forecasts are almost twice as inaccurate as ten-year forecasts, and that the high degree of forecasting error characteristic of the ratio method indicates it to be of limited value.[68] Loomer, in a reply to Schmitt and Crosetti's article, criticized the authors' method of assessing the accuracy of the ratio method, claiming that they (1) included so many cities of very rapid or spasmodic growth that the ratio method was undervalued for cities of relatively steady growth, and (2) probabably did not fully exploit the possibilities of selecting and modifying their formulas to best fit the data for each individual city in the test sample. Loomer stated that the ratio method is probably one of the most useful tools in population forecasting for the long-term, for a community whose economy is dependent upon larger or adjacent areas, and when it is implemented with proper statistical formulae selected and modified to fit the particular area.[69]

Closely related to the ratio method is the apportionment technique, in which forecasts are prepared for each subregion, totalled, and compared to an independent forecast for the entire area. Then, either the smaller area forecasts or the projection for the entire region is modified, or both. If the larger area's projection is considered more reliable, as is most often the case, a ratio is computed between the two and the forecast for each subregion is adjusted.[70]

Another ratio method employs censal ratios. First, the ratio of symptomatic data to census data is computed. Second, the ratio is extrapolated, and next, the ratio is divided into current or forecasted symptomatic data, depending upon whether a current population estimate or a forecast is sought. The symptomatic data must be accurate and available for all time periods under consideration, and the number of cases of the "event" should be high in relation to population size. The ratio should also be fairly stable, or changing in a predictable way, because any error in the ratio is directly translated into an error of the same size in the population forecast. School enrollment data, utility meters, bank receipts, retail trade, building permits, postal drops, voting registration, welfare recipients, auto registrations, birth and death statistics, and tax returns are examples of such symptomatic data. A single censal ratio is seldom used, but a combination of them is commonly applied.[71]

Regression analysis can be used to estimate population from symptomatic data or to project ratios. This method may be more satisfactory than holding ratios constant or simply applying a time trend. However, correlation with economic data may be more appropriate for estimating migration than it is for estimating total population levels.[72] In making forecasts, it is entirely possible that forecast errors in the socio-economic independent variables may render the resulting population forecast no better than one calculated from simpler methods. Isard has serious doubts about the validity of using regression equations for projections aside from the difficulty of forecasting the input variables. First, past causal relationships may not persist into the future. Next, correlation need not imply causation. Third, the statistical requirements for a best linear unbiased estimate may not be met.[73]

Cohort Survival, Component, and Composite Models

Although most models that project population at levels smaller than the state are non-component models because of data limitations, component models may be used in conjunction with ratio and correlation methods to produce small area forecasts. Cohort methods divide the benchmark population into age and sex groups and forecast each separately. The survival rate method does not require use of local vital statistics; the population of a particular age-sex cohort is carried forward in time via survival rates obtained from life tables or census data. The problem with cohort survival models is that they cannot handle migration, an important factor in local population change. Also, survival rates may not be equal across geographic areas. Short-distance mobility and migration rates vary considerably from one part of the country to another, "reflecting such factors as differential age-sex structure, the rate of natural increase ..., economic opportunities, and climatic and other amenities."[74] Migration alters the age-sex distribution of the population, so that application of national survival rates to the benchmark population distribution will not yield accurate forecasts.

Cohort component methods disaggregate population change into births, deaths, and net migration. This more refined approach applies survival rates and age-sex-specific fertility rates to the base year population and allows for migration on a net or gross basis. "The analytical value is that each component is determined by different factors and has qualitatively different consequences for population growth."[75] The Hamilton-Perry formula holds cohort change rates constant:

$$nP^{t+k}_{a+k} = \frac{nP^{t}_{a+k}}{nP_{a}} \; nP^{t}_{a}$$

where: P = population
a = initial age at second census
n = size of age interval
t = year of second census
k = intercensal interval in years

The recent age-specific birth rates need not be held constant, however, alternative assumptions are possible. The rates may be projected independently, or by comparing the local area's rates to those of the parent area and then projecting the ratio for use with previously prepared projects for the parent area.[76] The problems of choosing appropriate fertility and mortality rates for a cohort model are dwarfed by the difficulties in estimating migration.

Smith states that migration may be more important than births and deaths when a given community, county, or state is being studied, but the data on emigration and immigration leaves much to be desired. "...The paucity of reliable information about international migrations of populations is matched only by the lack of comprehensive materials relating to internal migration."[77] In addition to the semi-permanent moves made each year, hundreds of thousands are continually travelling to follow the crops or the construction jobs. Both types of migration can affect a local area's population level, so a method of estimating the flow is necessary.

The definition of migration is somewhat arbitrary because it involves movement across borders, which are themselves arbitrary. Large provincial borders are too gross for most purposes and MCD boundaries are too detailed. "This means that for most practical purposes the commune or county boundary is taken as the migration-defining boundary because it is the only choice between the two extremes."[78] *Direct information on persons* who change residence across borders within a country is available only in nations where there is a system of residence registration or where a migration questions has been part of the census form.

Bogue describes two basic methods for estimating internal migration, the vital statistics method and the survival ratio method. For the former, two censuses and fairly complete birth and death records are needed. The natural increase minus the actual population is taken to equal net migration. The latter does not require accurate vital statistics, only survival rates. The difference between the estimated surviving population and the actual count is called net migration. Both are residual methods, so "All errors and discrepancies in the basic data enter directly into the determination of the residual and are defined, therefore, as in-migration or out-migration...It is only where the net balance of error is near zero that the residual can be interpreted as a reliable measure of net migration."[79] Shryock mentions a third method, described as crude but commonly used: the national growth rate method. If the migration rate calculated for the region exceeds that estimated for the nation (by a method such as those described above), then net in-migration is assumed to have occurred.[80] The Census Methods I and II involve the use of school enrollment data. In Method I, the difference between local and national percent changes in enrollment equals the percent change in net migration. In Method II, the expected enrollment without migration is computed by means of survival rates; the difference between this expected enrollment and the actual is migration.[81]

The migration estimation techniques described above are used for current estimates only. Any component projection methodology would have to rely upon these estimates for historical data, however.

Bogue reports certain empirical findings and hypotheses that should be considered before attempting to forecast the migration component: (1) the volume of migration fluctuates with the level of economic prosperity, and is a necessary element of population adjustment; (2) rates of in-migration and out-migration are not independent of each other, for a high immigration rate tends to be accompanied by a high emigration rate; (3) a high proportion of all migration streams are between communities of the same type; (4) the migration rate varies with the type of origin and destination, the direction of migration, and the age and other characteristics of the migrant; and (5) the size, direction, and net effects of migration vary over time and space. In general, persons in their late teens to early thirties, men, professionals, and unemployed persons are more migratory. Common mistakes in estimating and predicting migration are (1) viewing human migration as though it were birds or insects, (2) assuming that laws of mechanics, gravitation, of electrostatics apply to migration, and (3) assuming that migration is of one type only. In particular, Bogue attacked the intervening opportunities hypothesis for taking "as its model the semi-attentive shopper or half-informed job seeker."[82]

Nalbandian points out that the main problem with census component methods, particularly Method II, is migration estimation. The application of the migration rate for school-age children to the total population is the major flaw; therefore, Method II cannot be recommended for post-censal population estimation, and should be entirely avoided.[83] Problems are even present with decennial census migration data: illegal entry to and exit from the country is not recorded, and for internal migration, only one migration per decade is recorded and that only for interstate moves. Migration within a state is not counted, migrants who died between the two censuses are omitted, as are those who left and returned within the decade.[84]

Bogue's vital rates-composite model combines the various cohort methods. "Estimates are made separately for different age groups, sex groups, and color groups, and the individual estimates are summed to secure an estimate of the total population, providing the advantages of the total estimate as well as estimates of age-sex and color groups."[85] Separate estimates are made for the population over forty-five (by sex), for females aged fifteen to forty-four, for males aged fifteen to forty-four (civilian and military separately), for the population aged five to fourteen, and for children under five (by sex). The fact that the number of males between fifteen and forty-four is estimated from the number of females of the same age group can compound errors. Although Nalbandian suggests several improvements to the composite method, he could not solve the migration prediction problem.

The cohort models are only useful on a larger scale of analysis, for the nation, multi-state region, or, possibly the state. For smaller areas, especially MCD's, adequate data does not exist for the proper implementation of such models. The data is poorest for migration and for small area cohort breakdowns in post-censal years. The cohort methods cannot be recommended for direct use in small area forecasting, but may have applications in conjuntion with other methods, such as ratio, correlation, and land use techniques as control figures.

Land Capacity Methods

Land use methods center on the spatial aspect of population growth; the location of the incremental population is as important as the fact that total population grows. The saturation, or density ceiling, method is most commonly used. Given a pattern of land use as defined by zoning ordinances, the number of dwelling units by type which can be accommodated is calculated. The number of persons per household must then be projected so that the housing unit count can be converted to a population ceiling.[86] The results can be combined with other projection methodologies such as the logistic curve (as an asymptote), or other mathematical equations or spatial distribution models (as a constraint). One advantage of this method is that it is a practical means of limiting the levels of population projections when other techniques are thought to have an upward bias. It provides detail on the probable distribution of the population, and allows the forecaster to investigate the impact of changes in certain zoning regulations. It can be readily adjusted when land is taken out of use, as when farmland preservation programs are implemented or nature preserves are created. The method is well suited to small areas like census tracts and MCDs.[87] The obvious disadvantage of land capacity methods is the difficulty in forecasting maximum density, since zoning ordinances can change. In addition, projections of average household size can be in error. However, any forecast can be rendered obsolete when administrative policies or laws change, and problems of predicting household size are no greater than those encountered in other methodologies. The benefits of having saturation figures for very small geographic areas and an ultimate population distribution, which can be adjusted when laws and land availability change, seem to outweigh the disadvantages. An example of this method, the LIRPB's "208" Report, will be described in Chapter IV.

Market Force Models

Labor market forecasting models project migration on the basis of its known labor market determinants instead of extrapolating it mechanically. "Unfortunately, what looks like a better mousetrap has yet to prove its worth in the prototype models."[88] Morrison compares two labor market models, one developed by the Bureau of Economic Analysis and Economic Research Service, the other by the National Planning Association. He finds that the forecasts disagree significantly, diverge too swiftly from the trend of the recent past, and do not demonstrate accuracy superior to the Census Bureau's purely demographic projections. The *ex post* testing for 1970-73 shows poor agreement between forecasted and actual rates of change, with $R^2 = 0.13$. For some metropolitan areas, even the direction of change is incorrect.

For areas smaller than a Standard Metropolitan Statistical Area (SMSA), Morrison notes that uncertainty about the course of migration increases and the amount of available data with which to judge the validity of assumptions decreases. The present state of the art for labor market approaches, especially for small areas, is primitive. The root of the problem may be that the variable one attempts to explain, namely net migration, provides little basis for judgment. "...The tendency to treat 'net migrants' as though they were real people continues to be a major stumbling block in most small-area projections."[89] The nature and causes of the inward and outward flows should be treated separately, rather than netted out. Such data is not available for small areas, and the situation is not much better for larger areas.

The Energy Research and Development Administration describes a residential allocation model developed by the National Bureau of Economic Research (NBER). The NBER model has a detailed treatment of the housing market, including filtering, aging, demolition, structural modification, and construction. Its major assumption is that a household chooses a dwelling unit type and location to maximize its real income, and knows its workplace when the choice of residence is made. There have been no successful calibrations yet. Aside from the fact that the NBER model is not operational, there is one deficiency pointed out by ERDA: the emphasis on the functioning of the market place is unbalanced; certain locational influences such as neighborhood environment and other social considerations are not treated.[90]

It is possible to take employment forecasts obtained by shift-share, input-output, economic base, or regional econometric models and convert them to population forecasts through ratios like participation rates. The spatial distribution of the population can be derived by minimizing travel time to work, minimizing costs, or maximizing income. Housing costs, the availability of land, the location of services, and zoning can be incorporated. The disadvantages of such models are several. First, errors in the employment forecasts can be compounded by errors in the ratios used to obtain population. Second, population is often an exogenous input to an econometric model, as a factor in labor supply. This suggests that an iterative process is needed. Third, most allocation models will not be realistic for long range forecasts because they do not allow for multiple wage earners with a joint location decision which is suboptimal for any one wage earner but optimal for the group. Fourth, and most important, models of this type are more applicable at the state level or above due to lack of data at the MCD level.

Spatial Distribution Models

Gravity Models

The gravity formulation postulates that the likelihood of a household choosing a site in a given zone is inversely proportional to the k^{th} power of the distance or travel time from major centers of employment. Inputs to the model are (1) the number of households in a given zone in the current period, (2) travel time to the central business district, and (3) total projected population for all zones. A computer is needed to solve n linear differential equations, which may include capacity constraints for the zones. There is a calibration phase in which the best value of k must be chosen. ERDA states that some satisfactory results have been achieved with gravity models, and that this formulation is a component of most major land use forecasting models.[91]

The current justification for the gravity model, according to Isard, is "...Simply that everything else being equal the interaction between any two populations can be expected to be directly related to their size; and since distance involves friction, inconvenience, and cost, such interaction can be expected to be inversely related to distance."[92] Thus there is no theoretical basis for the choice of k or of weights, if any, assigned to the measures of mass (population). The gravity model is an interesting descriptive tool, but may not be as useful when it comes to forecasting.

Lowry Models

Lowry models are an extension of the basic gravity model to include an employment location model. The assumption made is that many households locate with respect to service industries such as schools or retail stores, so a service industry location model is incorporated. First, a gravity model is used to allocate households with respect to basic employment centers in a zone. The employment location model distributes services required to support the households, and then the gravity model is used again to allocate households in relation to services. Inputs required are (1) basic industries in a given zone, (2) vacant residential sites in the zone, and (3) business and industrial sites within the zone.[93]

Maser illustrates the two types of gravity models used in the Lowry method, the first being an "attraction constrained gravity model," the second, a "production constrained gravity model":

Attraction Constrained Gravity Model

$$T_{ij} = B_j D_j W_i d_{ij}^{-k}$$

$$B_j = 1/(E_i W_k d_{ij}^{-k})$$

$$\text{Constraint:} \quad E_i T_{ij} = D_j$$

$$C_i = E_j T_{ij}$$

$$O_i = C_i \ (1/AR)$$

where:
T_{ij} = number of trips from zone (i) to work in zone (j)
D_j = number of jobs in zone (j)
W_i = measure of atractiveness of zone (i) as a home site
d_{ij}^{-k} = distance between zone (i) and zone (j) where k is a predetermined function
C_i = number of resident workers living in zone (i)
O_i = resident population
AR = activity rate, E_T/P where E_T is total employment

Production Constrained Gravity Model

$$T_i j = A_i O_i W_j d_{ij}^{-k}$$

$$A_i = 1/E_j W_j d_{ij}^{-k}$$

$$\text{Constraint:} \quad E_j T_{ij} = O_i$$

where: W_j = a measure of the attractiveness of zone (j) as a service center

$$S_j = E_i T_{ij}$$

$$D_{1j} = S_j PSR$$

where: S_j = total service trips

PSR = ratio of service employment to total population

After the production contained model is solved, the service employment is added to the basic employment for input to the attraction constrained model. An equilibrium distribution should be achieved after four or five iterations.[94]

Maser voices some reservations on the use of interaction models such as the gravity and Lowry methods. They are basically static models that ignore processes of change, so these models can provide only limited insight into the future. Also, additional assumptions should be added to the models to account for leakages, that is, interaction between the given zone and other regions. Difficulties may arise in partitioning the area into zones, choosing a central point for each zone, and measuring distances. Furthermore, the Lowry model utilizes an export base multiplier which has certain limitations concerning (1) the weakness of the initial assumption, that exports are the primary source of growth, (2) the use of short-run multipliers for long range forecasts, and (3) the inverse variation of the basic sector's size with the zone's size.[95]

Technical difficulties with economic base models are mentioned by Isard: (1) employment data will mask wage level differences and productivity change; (2) unearned income is not incorporated; (3) it is difficult to separate basic from service activity; (4) the ratios, and the conclusions, will be greatly affected by the size of the base area chosen; (5) the basic-service ratio will vary over time, and at any point in time the ratio may be inaccurate because multiplier effects have not yet shown up; and (6) the multiplier is an average which does not apply to any one industry. "...A regional multiplier derived from the basic-service ratio of an economic study has a strictly limited degree of usefulness and validity. As an instrument for projection, it can be used only under certain ideal conditions. Even then, it can give no more than an average or approximate value."[96] Given that Tiebout calls the export base theory a short-run concept,[97] and Isard doubts its usefulness for any type of projection, the export base method probably has little value for long term small area projections.

Intervening Opportunities Models

These residential allocation models assume that the "Probability of a household choosing a site is a monotonically decreasing function of the number of equivalent sites nearer than it to the center of employment or commerce."[98] Inputs to the model are the number of vacant sites in zone (i), an ordinal accessibility measure for zone (i), and total expected population growth.

Applications of the model have not met with much success, according to ERDA. Disadvantages mentioned for residential allocation models in general would apply to the intervening opportunities type as well.

Cluster, Opportunity, and Trend Model

The Cluster, Opportunity, and Trend (COT) Model attempts to model three things: (1) the tendency of people to locate where others live, (2) the desire to be close to one or more centers of activity, and (3) the tendency of people to build homes in areas where development has been recent.

Hartung tests the COT model for Long Island with 1955-59 data to predict 1960-69 population by town.[99] The location of the households is emphasized rather than prediction of the total volume of new units, and the calibration seeks to minimize root mean square error (RMSE).[100] Each component, cluster, opportunity, and trend, is assigned a fixed percentage of new dwelling units. Varying the weights will cause the COT to exhibit different characteristics. If the cluster weight is 100 percent, the new dwelling units are allocated proportionally to total existing dwelling units; if the opportunity weight is 100 percent, zones are ordered around the center(s); if the trend weight is 100 percent, then the new dwelling units are distributed as the previous year's were. Initial calibration for 1955-59 assigns a zero weight to the cluster component but RMSE is only 2.8 percent. For the 1960-69 period, the RMSE is 22.1 percent. Another calibration with 1955-69 data results in a 12.5 percent weight for the cluster component, 15.1 percent for opportunity, and 72.4 for trend, with RMSE equal to 3.6 percent.[101] This final calibration is used to forecast the distribution of new households on Long Island.

Hartung assumes no changes in zoning, and uses the LIRPB's 1966 vacant land analysis to derive a residential capacity index for each town. When a town reaches the saturation point, only the cluster and trend components are invoked and other towns receive the majority of the new dwelling units. Assuming 12,500 new units per year, two towns in Nassau County reach capacity by 1976. The dwelling unit forecast is converted to population through the LIRPB's projected household sizes for Nassau, western Suffolk, and eastern Suffolk. In retrospect, it is known that an annual increase of 12,500 dwellings was too high. Hartung also presents a scenario which assumes 10,000 units would be added each year;[102] these estimates are compared with LILCO's current population estimates in Table 9. Out of the nine towns modeled, Hartung's COT estimates are higher than the actual population for eight; because his assumption that 10,000 new houses would be added each year is high, one would expect the model's estimates to be high for every town. Brookhaven is the only town for which COT produces a low population estimate.

TABLE 9

COMPARISON OF COT 1980 POPULATION FORECAST BY TOWN
WITH LILCO 1980 CURRENT POPULATION ESTIMATE
BY TOWN, SUFFOLK COUNTY*

Town	COT 1980 Estimate	Percent of County	LILCO 1980 Estimate	Percent of County
Babylon	231,804	16.4	219,822	16.5
Huntington	240,334	17.0	217,783	16.3
Islip	328,212	23.2	312,416	23.4
Smithtown	139,509	9.9	124,303	9.3
Brookhaven	348,346	24.7	356,886	26.7
Southampton	55,619	3.9	46,587	3.5
Riverhead	27,909	2.0	21,793	1.6
East Hampton	19,217	1.4	15,598	1.2
Southold	21,480	1.5	20,114	1.5
Total	1,412,430	100.0	1,335,301	100.0

SOURCE: John V. Hartung, "Residential Land Use Models with Application to Long Island" (Ph.D. dissertation, Polytechnic Institute of Brooklyn, 1973), table 8.2-2; Long Island Lighting Co., Population Survey 1980 (Mineola, New York: LILCO, April 1980), table 2.

*Excludes Shelter Island

Comparing COT and actual values for each town's population as a percent of the total, the model overestimates for five towns and is correct for one. A better test, though, is the allocation of new population, 1970-80, which is shown on in Table 10. For seven out of nine towns, the COT model overestimates the share of new units. It correctly estimates one town's share and is very low for Brookhaven: 35.9 percent versus the actual 53.2. The Long Island calibration of the COT model cannot, then, be used "as is" for population distribution forecasts in the ten-mile radius around Shoreham, because the area is primarily in Brookhaven.

Greenberg-Krueckeberg-Mautner (GKM) Model

The GKM model uses the relationship between the rate of change in population density and the level of density, established by regression analysis, and a limit on the density.[103] Density in 1970 is the model's starting point; when one MCD has reached its density ceiling growth spills over into another MCD. The projections for MCD's are adjusted to county totals by using either the MCD growth rates or shares of county population.

Growth rates are estimated by a Newling-type model:

$$1+r_{d_t} = A d_t^{-k}$$

where: r_d = growth rate for a density ceiling group

TABLE 10

COMPARISON OF COT POPULATION GROWTH ALLOCATION WITH ACTUAL POULATION GROWTH DISTRIBUTION, 1970-80, SUFFOLK COUNTY*

Town	COT Population Growth, 1970-80	Percent of Total Growth	Actual Population Growth, 1970-80	Percent of Total Growth
Babylon	28,234	9.8	16,252	7.7
Huntington	40,162	14.0	17,611	8.4
Islip	49,332	17.2	33,535	16.0
Smithtown	24,852	8.7	9,646	4.6
Brookhaven	103,086	35.9	111,626	53.2
Southampton	19,465	6.8	10,433	5.0
Riverhead	9,000	3.1	2,884	1.3
East Hampton	8,237	2.9	4,618	2.2
Southold	4,676	1.6	3,310	1.6
Total	287,044	100.0	209,915	100.0

SOURCE: John V. Hartung, "Residential Land Use Models with Application to Long Island" (Ph.D. dissertation, Polytechnic Institute of Brooklyn, 1973), pp. 95,99; Long Island Lighting Co., Population Survey 1980 (Mineola, New York: LILCO, April 1980), table 2.

*Excludes Shelter Island

k, A = constants
d_t = density at time t

The critical density is $A^{1/k}$, and density in time t+1 equals Ad_t^{1-k}. The MCDs are grouped into three types, urban, suburban, and rural. Scatter diagrams are used to determine the cluster groups of densities, and ordinary least squares is applied to the logarithmically transformed data to obtain values for the constants.[104]

Greenberg offers several variations of the GKM model. The user has the option of constraining the projections at any or all levels above the MCD: county, state, or nation. A step-down method would then adjust the MCD projections to meet the constraints. The federal and state level projections would generally be component models, which Greenberg recommends for long range forecasts. Also, various extrapolation techniques, with or without a step-down adjustment, are included as options in the program.

The Census Bureau criticized the GKM approach for assuming that density patterns from 1950 and 1960 would be maintained in the future. "In addition, the model assumes that the relation between different geographic areas at a single point in time is valid as a guideline for future growth of a single geographic area during the passage of time."[105]

In spite of the wide variety of models available for population forecasting, few have been judged acceptable for small area population prediction. Component methods are usually reserved for county level and above, and for SMSAs. Cohort methods can be applied to MCDs using census data and sympomatic data, such as school enrollment, but the migration estimation step is weak. Mathematical extrapolation and regression analysis share two problems: the number of time periods included in the data base tends to affect the results, and there is no assurance that forces creating growth in the past will continue to operate in the same fashion. Extrapolation and time dependent equations make little attempt to explain why growth occurs; at least regression and correlation techniques have some explanatory value. There remains, however, the difficulty of forecasting the independent variables and satisfying the statistical requirements. Labor models have been tried as a means of estimating migration for component models and for describing the housing market allocation process. Both attempts have not proven especially successful. Spatial allocation models require a separate forecast of total population to be distributed among the zones delineated. Those that are currently operational have not been shown to be superior to the other methods available, though. Gravity model variations are probably the most commonly used spatial allocation models, but are more useful as a descriptive device than as a forecasting tool. Ratio-stepdown methods are an improvement over simple extrapolation in that they can take advantage of the greater reliability and detail available at a larger scale of analysis. As with the spatial allocation models, the ratio approach requires an independent total forecast which is to be distributed over small areas. Land capacity models are the only ones recommended for small areas, although, they, too, have disadvantages. If the zoning can be accepted as given, then the saturation point for dwelling units can be calculated, but household size must still be projected. Capacity methods must then be combined with one of the other methodologies to produce a time path of growth from the current population to the saturation level. No one method clearly stands out as the best, particularly for small geographic areas like MCDs. The result is that many methodologies for small area population forecasting are eclectic combinations of the approaches described above. The exact choice depends upon data availability and quality, time and budget constraints, the purpose of the study, the length of the projection period, and the scale of the analysis.

CHAPTER IV

THE POPULATION PROJECTION METHODOLOGY FOR THE SHOREHAM NUCLEAR POWER STATION EMERGENCY RESPONSE PLAN

Control Forecasts

Land Capacity

New York State, Suffolk County, and LILCO agreed to base the emergency plan's population distribution on an updated version of the LIRPB's long range population forecast published in November 1976. The forecast, prepared pursuant to the provisions of Public Law 92-500 for use in waste treatment planning, is commonly referred to as the "208" Report. A land capacity methodology was chosen as the most appropriate one for waste treatment management planning. Projections were needed for the years 1980, 1985, 1990, and 1995 for thirty large, irregularly shaped drainage basins in Nassau and Suffolk Counties. Forecasts were also wanted for other small geographic subdivisions of the bi-county region for facilities planning. The land capacity method is suitable for small area population projections and provides flexibility in altering boundaries.

Projections were prepared for the 13 towns, 108 municipalities, 126 school districts, and 30 drainage basins in Nassau and Suffolk Counties. Base year (1975) estimates were obtained from

LILCO's Population Survey 1975, because "The Nassau-Suffolk Regional Planning Board considers the Long Island Lighting Company's population estimates for January 1, 1975 as the most accurate available for the Bi-County area ..."[106] Base year estimates, trend analysis, and the concept of land capacity were combined, in a series of six steps, to produce the forecast.

Identification and Tabulation of All Vacant Land Zoned for Residential Uses

Residential land was tabulated with the help of aerial photographs, tax maps, assessment records, and field surveys. Both scattered parcels in built-up areas and land in large estates were included in the enumeration. Zoning maps were used to assign vacant acreage and scattered lots to the applicable zoning categories, and the number of zoning-exempt lots were recorded. For each municipality or school district, the acres of vacant land, together with their zoning categories, were tabulated so that the number of potential building sites could be calculated.

Calculation of Potential Building Sites

Parcels that had already been subdivided were assigned a number of potential dwelling units equal to the number of lots. Other vacant sites in developed areas were analyzed to determine whether more than one lot could be obtained per site under existing zoning. Land that was part of a large estate and other vacant acreage were multiplied by a yield per acre factor based upon recent experience with conventionally designed subdivision plats. These factors varied from 6.8 lots per acre for zoning lot sizes of 4,000 square feet, and 0.8 lots under one acre zoning, to 0.16 lots per acre in five acre[107] zoning categories. The LIRPB noted that "Recent observations suggest that the pattern of zoning on Long Island has become relatively stable. Changes to higher density are often offset by other changes to a lower density or by a land acquisition, thus minimizing the impact of any change in the ultimate saturation calculation."[108]

Tabulation of Housing Units by Occupancy Status

The LIRPB relied upon 1970 census data for a count of vacant, occupied, and seasonal dwelling units for each municipality and school district in the two counties. The change in housing stock between 1970 and 1974 was estimated with building permit data and LILCO's meter book records. These units were allocated to the appropriate school districts after a review of aerial photographs and office records, with verification through visual inspection when necessary.

Calculation of Potential Dwelling Units

The potential total number of dwelling units consisted of the sum of existing units and all new units possible under existing regulations. It was assumed that all existing housing would eventually be utilized, but that seasonal and vacant year-round housing would exist in eastern Long Island until after 2000.

Estimation of Household Size

A probable average household size at capacity was estimated for each of the projection areas. Items considered in the projection process were (1) household size in 1970, (2) estimated current (1975) household size, (3) the declining birth rate, (4) income, (5) ethnicity, and (6) the mix of housing types in each locality. The LIRPB expected that the trend toward fewer persons per household, the lower birth rates, and the aging of the population would continue. The typical family moving into the Nassau-Suffolk area would be in the thirty-five to forty-nine year old cohort with children in the ten to nineteen age group. More families with those age characteristics would have the income to purchase the typical Long Island dwelling unit.

Estimation of Population at Zoned Capacity

This final step consisted of combining the total number of existing and potential dwelling units from the second step with the person per household factors from the fifth step. Appendix A contains the 1970 and 1975 population and housing data for school districts wholly or partly within the ten-mile radius around the

Shoreham site. Household size in 1970 varied from a low of 3.1 in Shoreham-Wading River and Riverhead school districts to a high of 4.17 in the Middle Country School district. The Brookhaven Town household size was 3.64 excluding the State University at Stony Brook; Riverhead Town's person per household factor was 3.1. At saturation, the household sizes would range from 3.2 to 3.94. Of the 78,307 dwelling units in Brookhaven in 1970, 12,318 were vacant or seasonal. In Riverhead, there were 7,933 units of which 1,849 were vacant or seasonal. Total units at capacity were forecasted to equal 99,066 in Brookhaven and 8,535 in Riverhead.[109]

The twenty-year projections were prepared on the township level; a step-down apportionment technique was then used to derive projections for the municipalities and school districts. The historical growth rates, 1970-75, for each town, as well as building permit data and school enrollment figures, were the basis for selection of projected growth rates. Town population growth was allocated to the component areas once shares had been determined. The percentage of town growth chosen for a sub-area depended upon factors such as (1) general development trends, (2) growth of the sub-area relative to growth of other areas, (3) availability of land, (4) desirability of the sub-area, including accessibility, (5) the type and cost of housing present, and (6) presence or absence of impediments to development. Given the lack of information on existing illegal two-family homes and uncertainty regarding local enforcement policy in the future, this type of dwelling was not considered in the analysis. Efforts to preserve farmland, shorefronts, wetlands and other ecologically valuable areas were considered in that lower growth rates were assigned to regions containing such land. Certain drawbacks associated with trend analysis, which were discussed above, would apply to this portion of the LIRPB's methodology.

Over 93 percent of the SMSA's growth is expected to occur in Suffolk County; more than 62 percent of Suffolk's growth is forecasted to be in Brookhaven and Islip Towns. Brookhaven's population is projected to increase from 317,489 in 1975 to 546,198 in 1995; Riverhead's population is expected to increase from the 1975 level of 21,184 to 34,752. Much of Suffolk County's growth will occur in the western and central school districts, according to the LIRPB.[110] Table 11 shows the 1975 population for school districts wholly or partly within the ten-mile radius, along with their projected growth rates for each five year period between 1975 and 1995. Densities varied from 0.07 persons per acre to 4.09 in 1970, and are forecasted to range from 0.63 to 6.73 persons per acre in 1995. Land area and densities for the school districts within ten miles of the nuclear plant are given in Table 12. None of the school districts are projected to reach saturation by 1995, but Middle Country, William Floyd, and Shoreham-Wading River will be within 90 percent of their capacities, given current zoning regulations.[111] Table 13 shows the percent of total saturation attained by each district by 1975 and 1995.

TABLE 11

POPULATION PROJECTIONS FOR SCHOOL DISTRICTS WHOLLY OR PARTLY WITHIN TEN MILES OF SHOREHAM

School District	Population 4/26/75	1975-80 % Change	1980-85 % Change	1985-90 % Change	1990-95 % Change	Projected Population - 1995
Comsewogue	19,183	5.4	5.3	4.3	5.0	23,313
Port Jefferson	6,387	2.7	1.8	2.4	8.3	7,408
Mount Sinai	4,803	59.5	38.7	25.6	9.0	14,537
Miller Place	8,947	30.0	24.5	18.8	13.2	19,465
Rocky Point	10,345	16.6	15.7	23.3	23.5	21,257
Middle Country	52,912	11.9	7.5	3.4	2.3	67,328
Middle Island	29,878	44.0	33.8	24.5	21.2	86,817
South Manor	2,054	22.0	30.7	43.0	61.4	7,574
West Manor	188	60.6	98.0	90.8	93.0	2,202
William Floyd	26,629	36.5	30.2	21.2	2.6	58,864
Shoreham-Wading River (pt)	4,511	41.8	31.5	20.7	18.9	12,070
Riverhead (pt)	933	55.1	41.0	29.3	26.8	3,346
Eastport-East Manor (pt)	841	40.8	60.1	65.9	114.1	6,734
Total Town	320,677	18.1	15.9	12.6	10.5	546,198

SOURCE: Nassau-Suffolk Regional Planning Board, Population Estimates and Projections, 1975 to 1995, Interim Report Series: 1 (Hauppauge, New York: NSRPB, November 1976), table A-19.

TABLE 12

LAND AREA AND POPULATION PER ACRE FOR SCHOOL DISTRICTS
WHOLLY OR PARTLY WITHIN TEN MILES OF SHOREHAM

School District	Area (Acres)	1970 Density	1995 Density
TOWN OF BROOKHAVEN			
Comsewogue	4,930	3.63	4.73
Port Jefferson	2,400	2.65	3.09
Mount Sinai	3,170	0.61	4.59
Miller Place	3,800	1.50	5.12
Rocky Point	6,230	1.33	3.41
Middle Country	10,000	4.09	6.73
Middle Island	33,620	0.41	2.58
South Manor	6,110	0.25	1.24
West Manor	3,780	0.03	0.58
William Floyd	10,260	1.42	5.74
Shoreham-Wading River(pt)	4,570	0.53	2.64
Riverhead (pt)	2,400	0.14	1.39
Eastport-East Manor (pt)	10,440	0.07	0.65
Town Total	166,930	1.47	3.27
TOWN OF RIVERHEAD			
Shoreham-Wading River(pt)	3,540	0.41	1.23
Riverhead (pt)	39,130	0.44	0.76
Town Total	43,410	0.44	0.80

SOURCE: Nassau-Suffolk Regional Planning Board, Population Estimates and Projections, 1975 to 1995, Interim Report Series: 1 (Hauppauge, New York: NSRPB, November 1976), table A-29.

TABLE 13

PERCENT OF TOTAL SATURATION, 1975 AND 1995, FOR SCHOOL DISTRICTS WHOLLY OR PARTLY WITHIN TEN MILES OF SHOREHAM

School District	1975 (Percent)	1995 (Percent)
TOWN OF BROOKHAVEN		
Comsewogue	65.2	79.2
Port Jefferson	72.3	83.8
Mount Sinai	28.0	84.8
Miller Place	37.6	81.7
Rocky Point	32.8	67.5
Middle Country	71.5	90.9
Middle Island	20.1	58.4
South Manor	7.7	28.5
West Manor	2.6	30.8
William Floyd	41.8	92.5
Shoreham-Wading River (pt)	25.2	67.4
Riverhead (pt)	8.9	31.9
Eastport-East Manor (pt)	2.0	15.7
Town Total	39.1	66.1
TOWN OF RIVERHEAD		
Shoreham-Wading River (pt)	37.7	90.4
Riverhead (pt)	9.6	14.8
Town Total	10.2	16.8

SOURCE: Nassau-Suffolk Regional Planning Board, Population Estimates and Projections, 1975 to 1995, Interim Report Series: 1 (Hauppauge, New York: November 1976), tables A-34 and A-38.

The Brookhaven Vacant Land Analysis and Master Plan

The Town of Brookhaven, as part of its comprehensive planning program undertook a vacant land analysis in 1973. School district boundaries and zoning categories were drawn on aerial photographs taken in April 1973. The vacant area included farmland, sand and gravel pits, large estates, privately owned wetlands, large semi-private open tracts (golf courses, religious holdings, special camps), and residential infill. It was assumed that: (1) future development would be in accordance with current zoning ordinances, (2) new homes would be built on the interior of deep blocks only if access were available and the plot were large enough to contain legally-sized lots, and (3) the vacant portions of large estates would eventually be developed. Table 14 gives the number of residential infill lots and total vacant acreage for school districts within ten miles of the site.[112]

Vacant acreage was converted to potential dwelling units via yield per acre factors, as follows: (1) district A1, minimum lot size 40,000 square feet, yielded 0.6 units per acre; (2) district A, minimum lot size 30,000 square feet, yielded 0.9 units per acre; (3) district B1, minimum lot size 22,500 square feet, yielded 1.4 units per acre plus a park; (4) district B, minimum lot size 15,000 square feet, yielded 2.0 units per acre; districts C and D, minimum lot size 9,000 square feet, yielded 3.3 units per acre.

TABLE 14

RESIDENTIAL INFILL LOTS AND VACANT ACREAGE FOR SCHOOL DISTRICTS WHOLLY OR PARTLY WITHIN TEN MILES OF SHOREHAM

School Districts	Infill Lots	Vacant Acreage
Port Jefferson	5	110
Comsewogue	160	1,180
Mount Sinai	30	2,260
Miller Place	160	1,950
Rocky Point	210	4,100
Shoreham-Wading River	60	2,300
Middle Country	640	1,700
Middle Island	1,015	13,630
West Manor	0	940
South Manor	250	3,820
South Haven	0	810
William Floyd	2,125	2,080
Eastport	0	1,640
Riverhead	55	1,600
Total	5,215	48,870

SOURCE: Raymond, Parish & Pine, Inc., "Draft Memorandum to the Planning Board, Town of Brookhaven, New York, as part of Comprehensive Planning Program" (Tarrytown, New York: Raymond, Parish & Pine, Inc.: June 1974), tables 1 and 2 (mimeographed).

Brookhaven was estimated to be capable of holding 110,000 more dwelling units, of which about 15,000 were under construction by June 1974. Approximately 7,500 potential units were of the infill type.[113]

To estimate the future population, a factor of 3.7 people per dwelling unit (1.8 for retirement communities) was used, based upon 1970 census data. Combining potential dwelling units with person per household ratios produced a possible increase of 400,000 persons in Brookhaven Town. The projection could be high due to public acquisition of land and natural inefficiencies of the land, or low because of inadvertent omission of "old-filed" subdivisions and the fact that conversion of seasonal units to year-round use was not considered. There were about 1,500 seasonal units in Rocky Point, 600 in Miller Place, and 1,100 in William Floyd when the vacant land analysis was made. Converted dwelling units would probably not accommodate 3.7 persons, however.[114]

This vacant land analysis and holding capacity estimate was a major input to the Brookhaven Master Plan, completed in December 1974. The plan justified a maximum population of the town at 750,000, slightly more than twice the 1975 population. Changes recommended by the plan were the lowering of residential densities (1) in eastern Brookhaven, (2) on the south shore, (3) in central Ronkonkoma and the surrounding wetlands (from one-quarter to two acre minimum lot size), and (4) on the north shore cliffs. Two new population centers were encouraged, one in Rocky Point along a proposed extension of Route 347, and the other in Manorville south of the Long Island Expressway.[115]

New York State Department of Commerce Projections

The New York State Department of Commerce (NYSDOC) has prepared population projections that extend to the year 2020. These projections, considered official by the Census Bureau, are used in the emergency response plan for the period 1995 to 2020. Issued in December 1977, the NYSDOC forecast is derived from a cohort component model. The model is intended to project state and county populations only, so the county growth rates are applied, for the emergency response plan, to all sub-areas providing that no sub-area exceeds its saturation population level. The NYSDOC growth rates are only used to expand the base population to 2020, however; group quarters and other special populations are handled separately.

In estimating migration, NYSDOC has tried to account for: (1) recent trends in population density, (2) housing and zoning trends, (3) proximity to highly urbanized areas and transportation routes, (4) growth trends of metropolitan areas, and (5) any special censuses taken since the last major census.[116] Despite these considerations, the 1968 series projection for Suffolk County in 1980 was over 24.0 percent high; the 1977 revision was only 1.4 percent high for 1980, however. Table 15 contains a comparison of the 1968 and 1977 series of population projections made by NYSDOC. The 1995-2020 growth rate has been reduced from 58.7 percent in the old series to 24.8 percent in the more recent projections.

The NYSDOC projections are used for the last twenty-five years of the emergency response plan for three reasons. First, the LIRPB forecast only extends to 1995. Therefore, the methodology with small area detail is simply not available for the later years. Second, most long-term projections do use some type of component methodology. Trends in births, deaths, and migration may diverge so that their net effect varies widely from that in the base year, and a component model allows for such demographic trends.[117] Third, the parties involved in the evacuation planning process have jointly agreed to rely upon this official projection series for the time period not covered by the LIRPB "208" Report.

LILCO 1979 Population Survey

The population distribution study was initiated in May 1979; at that time the most recent current population estimate available was for December 31, 1978-January 1, 1979. This estimate was published in the Population Survey 1979 of April 1, 1979, and became the base year value for control forecasts and sub-area projections. LILCO's annual current population estimate utilizes the

TABLE 15

NYSDOC POPULATION PROJECTIONS FOR
SUFFOLK COUNTY 1980-2020

Year	1968 Series	1977 Series	1980 Actual
1980	1,663,000	1,355,900	1,337,400
1985	2,022,000	1,476,800	
1990	2,463,000	1,604,400	
1995	2,974,000	1,716,400	
2000	3,383,000	1,807,300	
2010	4,096,000	1,969,300	
2020	4,720,000	2,142,100	

SOURCE: New York State Department of Commerce, "Population Projections," Albany, New York, Demcember 1977; New York State Department of Commerce, Demographic Projections for New York State Counties to 2020 A.D. (Albany, New York: NYSDOC, June 1968), table 1; Long Island Lighting Company, Population Survey 1980 (Mineola, New York: April 1980), table 2.

most recent census data available and active residential electric meter data to derive population counts for each community and town in the Nassau-Suffolk SMSA, as well as the Fifth Ward of Queens (Rockaway Peninsula). Person per meter ratios are derived for the census year by reconciling meter route maps and census tract maps. These ratios are reviewed annually and adjusted for known changes. For instance, meters are coded by type of dwelling unit; an increase in apartment complexes of two to five units per complex would probably cause the person per meter factor to decline for that area. Condominium, apartment, and senior citizen housing trends are incorporated to the extent possible. Group quarters such as university dormitories and state hospitals are added to the base population after surveying the institutions to obtain their current population count. The resulting estimate is remarkedly accurate: LILCO's January 1, 1975 count for Brookhaven Town was 321,150; a special census enumeration of April 26, 1975 showed a current population of 320,677; the difference is 0.1 percent.

It was necessary to link the three estimates or forecasts to obtain one control forecast for the 1980-2020 time frame. The first step involved extrapolation of the 1979 base year estimate to 1980. Given the small magnitude of 1978-79 population growth, it was decided to apply the same rate to obtain the 1979-80 increase. The exception was Riverhead Town, which has lost thirty-four persons, net, and whose population was held constant for the 1979-80 period. Once the 1980 figures were calculated, it was possible to apply LIRPB growth rates to the sub-areas to obtain projections to 1995. One adjustment was made to the LIRPB figures. The 1976 projections had anticipated development of about 10 percent of the former Radio Corporation of America Global Communications, Inc. (RCA) property in Brookhaven and Southampton. The 7,200 acres were acquired by New York State, however, to remain forever undeveloped. After consultation with the planning board, the projections for Middle Island and Rocky Point school districts were revised downward by 1,055 and 907 persons, respectively, in 1985 and 3,307 persons and 6,845 persons, respectively, by 1995. Next, the growth rates from the NYSDOC projections, 1995-2020, were calculated and applied to the 1995 base. The result was a control forecast for municipalities, towns, and Suffolk County for the entire planning period of 1980-2020.

Nuclear Regulatory Commission Zones

Current Year-Round Population Estimates for NRC Sectors

The first step in calculating population by zone was to draw the NRC sector boundaries on LILCO meter route maps. The maps were drawn to a 800 foot to the inch scale, sufficient to show all roads and important land uses. Sixteen sectors were delineated by the 22.5 degree angles centered on major compass directions from the reactor's core. These sectors were subdivided by drawing a series of concentric circles with radii of one through ten miles. Of the 160 zones thus formed, 66 could be eliminated because they included only portions of Long Island Sound or LILCO plant property, in the exclusion zone. For the remaining ninety-four NRC zones, it was necessary to estimate current population.

Meter book maps were adjusted for any boundary changes that had occurred during the previous year by referring to year-end computer printouts of meter routes. Then the meter books were allocated to NRC sector bands, in cases where a book fell entirely within a band. Otherwise, it was noted which zones the various portions of a meter book overlapped. The meter districts' code numbers and the designation "all" or "part" were marked on the maps; for those meter books lying entirely within a zone, the active residential meter count for 1979 was entered on the map.

For meter districts overlapping two or more NRC zones, percentage allocations had to be computed. Several sources of information were consulted in this procedure: aerial photographs taken April 30, 1977, the Hagstrom Suffolk Atlas, a map of the Suffolk County farmlands program, maps of the former RCA property, and field inspection. Various landmarks, hotels and motels, parks and recreational facilities were located by means of travel guides, planning agencies' catalogues, interviews with government departments and planning boards, and visual inspection. A more complete list of sources is given in Appendix B, Table B-1.

The meters were not generally distributed on the basis of land area in each zone. Given that meter routes are established so that each can be read in approximately the same time, differences in the number of meters per book indicated differences in dwelling type and density. A larger number of meters per district might imply the presence of apartment complexes, for example. If multi-family homes, parks and nature preserves, or industrial parks are located within a meter district, then the residential meters cannot necessarily be distributed evenly to the emergency response plan zones. Once the percentage allocations of meter books to zones was determined, the total number of meters per book was multiplied by the percentages to obtain the number of meters per zone. This process produced the base number of meters, a proxy for households, per zone.

In order to discover the population of group quarters, all customers with on-site housing were contacted. These special populations included facilities such as Brookhaven National Laboratory, orphanages, jails, and school dormitories. Hospitals were handled separately in another portion of the emergency response plan. The meters, the January 1, 1979 population, and the maximum population of such on-site living quarters were matched to the appropriate NRC zone and were added to base population at a later step in the analysis.

To convert meter counts to population, persons per meter per census tract were calculated. For Brookhaven, data from the Special Interim Census of April 26, 1975 was combined with computer listings of active residential electric meters for April 30, 1975. For Riverhead, the latest available census data was the 1970 decennial enumeration, which was combined with March 31, 1970 meter book computer printouts. First, person per census tract ratios were calculated for the portions of both towns which were within the ten-mile radius. Census tract maps, updated for new tracts added to Brookhaven Town in 1975, were overlayed with NRC sector boundaries to determine which tracts should be included in the study. All sets of maps were drawn to the same scale, 800 feet per inch, for this purpose. Each meter book was assigned a person per meter factor from the tract in which it was entirely or mostly contained. Where senior citizen communities were located, a ratio of 1.5 persons per meter was used. For each meter book, the number of meters was multiplied by the person per meter ratio to obtain a preliminary population estimate.

Preliminary results for the sub-areas were then aggregated to the community level and compared with the Population Survey 1979 figures. The latter were calculated from meters and persons per meter by type of dwelling unit for each community, and formed a part of the control forecast. Therefore, the preliminary population estimates were adjusted to agree with the Population Survey 1979 results. The adjustment was accomplished by changing the person per meter per tract ratios so that population totals for communities would be equal. Table 16 shows the adjustment calculation for the four community aggregates. Final year-round base population for each NRC sector was computed by multiplying the adjusted person per meter per tract factors by the meters, for each sector. Special populations were added to the appropriate sectors to yield final year-round population in 1979 for the NRC zones.

Projected Year-Round Population for NRC Sectors

The process of extrapolating 1979 population estimates to 1980 estimates was described above (p. 93). To project the 1980 estimate to 1995, the LIRPB's "208" Report was used. School district boundaries were drawn onto the meter book maps to determine which meter routes were contained in each school district. Then, the growth rates for each school district were applied to meter books' populations for each NRC sector. The "208" Report growth rates were first adjusted for the change in the potential development status of the former RCA property, however (p. 94). Deriving the 1995-2020 forecast consisted of applying the NYSDOC growth rates to the base year population of each sector. These growth rates were

TABLE 16

ADJUSTMENT FACTORS TO BE APPLIED TO PRELIMINARY PERSON PER METER PER TRACT RATIOS

Community Group	Preliminary 1979 Population	Population Survey 1979 Population	Adjustment Factor
1. Old Field, Poquott, Setauket-South Setauket	9,914	9,715	0.9799
2. Yaphank, South Yaphank, South Medford, East Patchogue, West Bellport, North Bellport, Brookhaven	50,337	49,376	0.9809
3. Belle Terre, Port Jefferson, East Setauket, Mount Sinai, Miller Place, Coram, Terryville, North Selden, Shoreham, Sound Beach, Rocky Point, East Shoreham, Middle Island-Ridge	98,220	96,753	0.9851
4. Mastic	10,919	11,639	1.0659
5. Manorville, Center Moriches, East Moriches, Northeast Moriches, Eastport	16,281	16,178	0.9937
6. North Centereach	16,465	16,451	0.9991

SOURCE: Robert J. Panzarella, Long Island Lighting Co., Mineola, New York.

uniform throughout Suffolk County, so no boundary adjustments or allocation procedures were necessary. After the base population and special population projections were completed, special and base populations were added to produce total year-round, or winter, population for the NRC sectors. Sample worksheets, illustrating the translation of active meters to current population and extrapolation of current population to 1995, and a letter regarding a special population, are contained in Appendix B. Table 17 shows the 1980-95 growth rates by school district from the "208" Report and the 1995-2000 growth rates from NYSDOC, which are combined to obtain a single 1990-2000 rate of increase for each school district. All school districts are projected to grow at 9.0 percent 2000-2010 and 8.8 percent 2010-2020.

Seasonal Population

Seasonal and Second Homes

The primary source of data on seasonal and second homes is the 1970 Census of Housing. The Special Interim Census for Brookhaven, taken in 1975, did not provide any housing statistics, and electric meter data is not useful because many households do not close their accounts at the end of the summer. Even if all seasonal customers did have their meters locked, it would be difficult to garner the information from company records for the geo-

TABLE 17

SCHOOL DISTRICT POPULATION INCREASES, 1980-2000

School District	1980-90 Percent Increase	1990-95 Percent Increase	1995-2000 Percent Increase	1990-2000 Percent Increase
BROOKHAVEN TOWN				
Shoreham-Wading River	58.7	18.9	5.3	25.2
Rocky Point	13.6*	5.2	5.3	10.8
Miller Place	47.8	13.2	5.3	19.2
Mount Sinai	74.1	9.0	5.3	14.8
Comsewogue	9.8	5.0	5.3	10.6
Middle Island	60.8*	20.7	5.3	27.0
Middle Country	11.2	2.3	5.3	7.7
West Manor	77.8	93.0	5.3	103.2
South Manor	86.9	61.4	5.3	70.0
William Floyd	57.8	2.6	5.3	8.0
Eastport-East Manor	65.6	114.1	5.3	125.4
Port Jefferson	4.3	8.3	5.3	14.0
Riverhead	82.3	26.8	5.3	33.5
RIVERHEAD TOWN				
Shoreham-Wading River	65.1	11.2	5.3	17.0
Riverhead	24.4	14.2	5.3	20.2

SOURCES: Nassau-Suffolk Regional Planning Board, Population Estimates and Projections, 1975 to 1995, Interim Report Series: 1 (Hauppauge, New York: NSRPB, November 1976), tables A-19 and A-23; New York State Department of Commerce, "Population Projections" (Albany, New York: NYSDOC, December 1977); Robert J. Panzarella, Long Island Lighting Co., Mineola, New York.

*Adjusted for the sale of the 5,200 acre RCA property to New York State.

graphic areas of concern. The 1970 census data on seasonal homes is available by tracts and can be allocated to emergency response plan zones.

School districts within the ten-mile radius having the highest proportion of seasonal housing are Rocky Point and Miller Place, on the north shore.[118] These and other school districts are experiencing a decline in the number of seasonal dwellings, because many are converted to year-round use. In fact, many are two-family homes where one household is year-round and one is seasonal. The new seasonal units are being constructed in the Hamptons on the south shore, because the ocean shore is more popular than the Long Island Sound shore which tends to be rocky and steeply sloped.

Given that within the ten-mile radius, the trend is toward a constant or decreasing number of seasonal homes, the number was held constant throughout the forecast period. Then the summer population would, if it is in error, be overstated.

The census tract housing data for seasonal dwelling units was allocated to NRC zones through (1) field inspection, (2) aerial photographs, (3) atlases, (4) discussions with the LIRPB, and (5) discussions with property owners' associations in the area. A person per household factor of 3.5 was assigned to the seasonal dwellings to obtain a summer population estimate. Considering the age structure of the seasonal area, this might be high; however, the summer population might include more than one household or several unrelated individuals per dwelling in some cases. The allocation of the 4,782 seasonal units to NRC sectors, and the associated population estimates are shown in Table 18.

Hotels and Motels

Hotel and motel population is another component of the seasonal population to be estimated. There are nine hotels and motels within ten miles of the site, with capacities ranging from four to one hundred units. The establishments were assigned to the proper zones by their addresses; Table 18 lists the hotels and motels, their sector bands, and capacities.

An occupancy of 100 percent was assumed for the summer, and 50 percent for the winter (the off-season). A person per unit factor of 3.5 was used for both seasons.

Campsites

Recreational facilities which allow camping are Wildwood State Park, Camp Francoise Barstow, Camp Baiting Hollow, Camp Wauwepex, Camp DeWolfe, Dorothy P. Flint Nassau County 4-H Club, and St. Joseph's Villa. There are about 800 campsites within the ten-mile radius to accommodate about 2,800 persons. Again, a 100 per-

TABLE 18

HOTELS AND MOTELS WITHIN TEN MILES OF SHOREHAM

Establishment	Sector-Band	Capacity
Judges Hotel Wading River-Manor Road Wading River	SE 1 - 2	10 Persons
Wading River Motel Route 25, Wading River	SE 3 - 4	32 Units
Holiday Inn Route 25, Riverhead	ESE 5 -10	100 Units
Terryville Motor Lodge 1371 Route 112, Mount Sinai	WSW 5 -10	48 Units
Grace Court Motel Route 25 Middle Island-Ridge	S 4 - 5	18 Units
Riverhead Resort Motel Route 25, Riverhead	ESE 5 -10	56 Units
Vera's Lake Motel Mill Road, Yaphank	SSW 5 -10	20 Units
Arco Motor Inn Middle Country Road Middle Island-Ridge	SSW 5 -10	4 Units
"Un-named" Motel 29 Tyler Street Rocky Point	WSW 2 - 3	13 Units*

SOURCE: Robert J. Panzarella and Denis Toner, Long Island Lighting Co., Mineola, New York.

NOTE: Two motels are outside the ten-mile radius, but are in the New York State evacuation Zone S: Swiss Motel, ESE, 10+ miles, 21 units and Weeping Willow Motel, ESE 10+ miles, 20 units. The latter is closed.

*At least 4 or 5 of these units had separate mailboxes indicating a more permanent use by some renters.

cent summer occupancy is assumed, and a factor of 3.5 persons per site is used. Some campgrounds, such as the Boy Scout camps, are used occasionally in the winter on weekends. A 50 percent occupancy is therefore assumed for the winter season.

Brookhaven National Laboratory

This research facility provides on-site housing for some of its employees: temporary quarters for new employees, and apartments for summer and temporary employees. As of January 1979, the capacity was 905, but the number of residents would only approach 830 during the summer. A summer population of 850 was assigned to Brookhaven National Laboratory in this study, versus 425 in the winter.

Sports and Other Recreational Facilities

The Parr Meadows Quarter Horse Track is located 7.8 miles south-southwest of the site. The track is closed at this time, and it is unknown whether it will reopen. The grandstand capacity is 25,000, and approximately 1,000 employees and horse owners could be present. There are parking facilities for 7,500 automobiles. In September 1979, an outdoor concert held at Parr Meadows attracted an estimated 16,000 persons.

Other recreational facilities within the ten-mile site were listed in Table 7. The maximum daily attendance for each was determined by contacting the owners, operators, or government agency in charge of the establishments. When no other information could be obtained, potential attendance was estimated through field inspection. The total for the places listed in Table 7 was 25,335 persons, maximum daily attendance, including the campers mentioned above.

The summer net increase in population is 19,060, plus a possible additional 22,213 daytime visitors at recreational facilities. The geographic distribution of the seasonal homes (population of 16,736) is shown in Table 19. In contrast, the Comprehensive Public Water Supply Study estimated Brookhaven's seasonal population at 7,000 in the 1980-2020 period.[119] The methodology used by LILCO attempted to account for all seasonal populations including daytime visitors to recreational facilities. Some double-counting has probably occurred, because park visitors could well be residents of the ten-mile radius. In addition, Brookhaven residents may very well travel outside the town limits to visit other areas.

The seasonal home population plus hotel and motel customers, campers, and seasonal increases in special populations are added together to form an estimate of the net summer increase in

TABLE 19

DISTRIBUTION OF SEASONAL HOMES WITHIN
THE TEN MILE RADIUS, 1979

Compass Direction	Distance in Miles 0-1	1-2	2-3	3-4	4-5	5-10	Total
N	0	0	0	0	0	0	0
NNE	7	0	0	0	0	0	7
NE	42	0	0	0	0	0	42
ENE	280	332	105	0	0	0	717
E	18	245	612	70	158	1,785	2,788
ESE	0	0	0	0	0	245	245
SE	0	0	21	0	0	175	196
SSE	0	0	882	536	0	350	1,768
S	0	0	0	0	0	808	808
SSW	0	0	0	0	0	668	668
SW	0	0	0	0	0	315	315
WSW	10	88	210	140	70	280	798
W	94	262	1,050	1,400	1,486	3,892	8,284
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
Total	451	927	2,880	2,146	1,814	8,518	16,736
Cumulative Total	451	1,378	4,258	6,404	8,218	16,736	-

SOURCE: Robert J. Panzarella, Long Island Lighting Co., Mineola, New York.

population. The seasonal population is held constant from 1979-2020, so the summer net increase by zone is added to the winter distribution for each year of the forecast period to obtain the summer distributions. The 1980 winter or year-round population by NRC sector is presented in Table 20 and the 2020 projection is shown in Table 21. The total percent increase in year-round population, 1980-2020, is projected to be 106.9, or approximately 1.8 percent per year, compounded. Recreational facilities' visitors are not counted as summer or winter residents, so only the four types of seasonal populations mentioned above are added to year-round counts. Therefore, 19,060 persons are added to the 1980 through 2020 winter figures, yielding a 90.1 percent summer population increase. This amounts to a 1.6 percent compound annual increase.

New York State Zones

The zonal boundaries originally designated by Suffolk County and New York State are shown in Figure 3. The zones are delineated by major roadways and approximate the ten-mile radius. These zones are designed to facilitate the physical evacuation of persons from the ten-mile radius, and make it possible to estimate the evacuation times after notification, which the NRC requires. As originally drawn, the zones in some areas extended farther than ten miles from the plant site, and in other areas did not extend

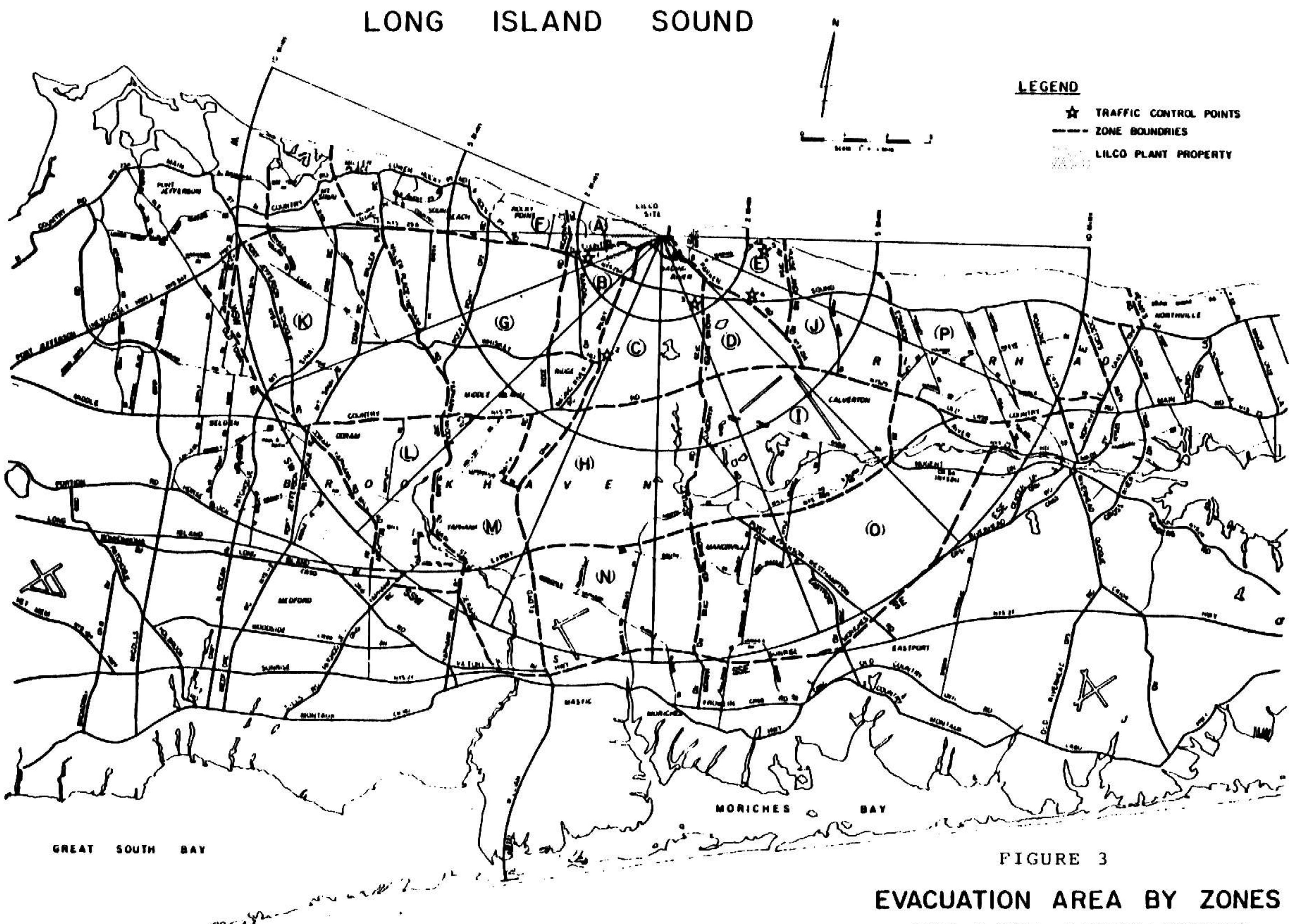

FIGURE 3

EVACUATION AREA BY ZONES AND ZONE DESIGNATIONS

TABLE 20

DISTRIBUTION OF YEAR-ROUND POPULATION
WITHIN THE TEN MILE RADIUS, 1980

Compass Direction	Distance in Miles						
	0-1	1-2	2-3	3-4	4-5	5-10	Total
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	6	0	0	0	0	0	6
ENE	38	366	45	0	0	0	449
E	32	695	1,348	230	302	1,914	4,521
ESE	152	452	372	26	710	3,825	5,537
SE	25	530	299	165	0	1,197	2,216
SSE	74	62	1,038	857	49	3,194	5,274
S	35	61	0	24	724	7,860	8,704
SSW	7	228	536	2,941	798	4,601	9,111
SW	7	762	23	0	207	15,639	16,638
WSW	83	1,425	886	498	247	22,424	25,563
W	214	828	1,768	2,362	2,762	16,301	24,235
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
Total	673	5,409	6,315	7,103	5,799	76,955	102,254
Cumulative Total	673	6,082	12,397	19,500	25,299	102,254	-

SOURCE: Robert J. Panzarella, Long Island Lighting Co., Mineola, New York.

TABLE 21

DISTRIBUTION OF YEAR-ROUND POPULATION
WITHIN THE TEN MILE RADIUS, 2020

Compass Direction	Distance in Miles 0-1	1-2	2-3	3-4	4-5	5-10	Total
N	0	0	0	0	0	0	0
NNE	0	0	0	0	0	0	0
NE	14	0	0	0	0	0	14
ENE	88	459	79	0	0	0	626
E	74	1,495	2,402	411	435	3,218	8,035
ESE	348	1,037	690	50	1,516	7,256	10,897
SE	60	1,235	494	250	0	4,337	6,376
SSE	173	147	2,479	2,056	89	11,816	16,760
S	83	143	0	60	1,706	19,833	21,825
SSW	16	539	1,112	5,073	1,853	10,855	19,448
SW	16	1,795	54	0	502	33,351	35,718
WSW	154	2,548	1,326	754	369	43,368	48,519
W	505	1,711	2,656	3,524	4,125	30,825	43,346
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
Total	1,531	11,109	11,292	12,178	10,595	164,859	211,564
Cumulative Total	1,531	12,640	23,932	36,110	46,705	211,564	-

SOURCE: Robert J. Panzarella, Long Island Lighting Co., Mineola, New York.

the full ten miles. In February 1980, the zonal boundaries were revised to incorporate, where feasible, the entire ten-mile radius. Zones F and K were subdivided into five parts, and Zones Q, R, and S were added. Zone Q contains the area west of F from Crystal Brook Hollow Road to Main Street (Route 112) in Port Jefferson, between Route 347 on the south and Long Island Sound to the north. Zone R is west of L, extending to Port Jefferson-Patchogue Road and having Horseblock Road and the Long Island Expressway as southern boundaries. Zone S is in the Riverhead area, east of Zone O. Its northern boundary is Old Country Road (County Road 58); the southeastern and eastern limits are Riverhead Center Drive and Osborne Avenue.

The population estimation methodology for the state-county evacuation is exactly the same as that followed for the NRC sector-bands. The geographic area encompassed is slightly different, and, of course, the number and boundaries of the zones are different. The winter population in 1980 was 98,928 under the original zone allocation and 113,620 under the revised plan. The 1980 winter population for NRC zones was 102,254. The base winter population counts differ due to geographic coverage and the number of motels and hotels included. Table 22 shows the hotels and motels included in the state evacuation area. The original zone scheme (A-P) excluded the Riverhead Resort Motel and the Swiss Motel, but the former was included in the NRC sectors. The re-

TABLE 22

HOTELS AND MOTELS WITHIN THE STATE AND COUNTY DESIGNATED EVACUATION ZONES

Location and Name	Capacity	Zone
Wading River		
Judges Motel	10 Persons	D
Wading River Motel	32	D
Riverhead		
Riverhead Resort Motel	56	S
Swiss Motel	21	S
Holiday Inn	100	O
Weeping Willow Motel*	20	S
Port Jefferson		
Elk Hotel		Q
Terryville Motor Lodge	48	K
Ridge		
Grace Court Motel	18	C
Arco Motor Inn	4	C
Yaphank		
Vera's Lake Motel	20	L
Rocky Point		
"Un-named" Motel	13	F

SOURCE: Robert J. Panzarella and Denise Toner, Long Island Lighting Co., Mineola, New York.

*Closed.

TABLE 23

SUMMARY OF PROJECTED POPULATIONS OF THE TWENTY-SEVEN STATE AND COUNTY DESIGNATED EVACUATION AREAS*, 1980

Evacuation Area	Winter	Summer
A	3,209	4,409
B	2,854	2,854
C	2,649	4,499
D	325	575
E	2,915	4,315
F1	2,463	3,263
F2	4,930	6,330
F3	4,273	4,773
F4	4,206	4,406
F5	2,665	7,285
G	6,135	6,635
H	1,271	1,896
I	1,270	1,470
J	1,764	4,214
K1	13,541	13,641
K2	6,202	6,202
K3	8,073	8,073
K4	2,148	2,148
K5	2,049	2,649
L	5,023	5,673
M	5,339	5,939
N	8,746	8,846
O	3,546	4,246
P	2,990	5,190
Q	7,458	7,783
R	5,998	5,998
S	1,578	1,728
Total	113,620	135,040

SOURCE: Robert J. Panzarella, Long Island Lighting Co., Mineola, New York.

*After revision of zone boundaries.

TABLE 24

SUMMARY OF PROJECTED POPULATIONS OF THE TWENTY-SEVEN STATE AND COUNTY DESIGNATED EVACUATION AREAS*, 1985

Evacuation Area	Winter	Summer
A	4,219	5,419
B	3,750	3,750
C	3,446	5,296
D	359	609
E	3,495	4,895
F1	2,717	3,517
F2	5,333	6,733
F3	5,047	5,547
F4	5,236	5,436
F5	3,181	7,801
G	7,843	8,343
H	1,514	2,139
I	1,448	1,648
J	2,165	4,615
K1	17,269	17,369
K2	8,146	8,146
K3	8,944	8,944
K4	2,762	2,762
K5	2,784	3,384
L	6,573	7,223
M	6,993	7,593
N	11,443	11,543
O	4,337	5,037
P	3,312	5,512
Q	7,605	7,930
R	6,905	6,905
S	1,713	1,863
Total	138,539	159,959

SOURCE: Robert J. Panzarella, Long Island Lighting Co., Mineola, New York.

*After revision of zone boundaries.

vised zones now include both in Zone S. The summer populations in the NRC and state areas differ due to variation in base year-round units, seasonal homes, and motel and hotel units included. Tables 23 and 24 summarize the 1980 and 1985 summer and winter population by (revised) evacuation areas. At this time, the New York State-Suffolk County emergency evacuation plan only requires projections through 1985.

When the population distribution was estimated for the Final Safety Analysis Report in 1973-74, only the winter population had to be projected to 2020. No state plan existed, so there were no zonal distributions required for evacuation of persons. At that time, the 1980 and 2020 winter projections were 92,180 and 309,113 respectively. The current study estimates 1980 year-round population at 102,254 and 2020 year-round population at 211,564. For 1980, the population count was increased in the zero-to-two and five-to-ten mileage bands; the figures for all mileage bands were decreased in 2020 by 8 to 64 percent and the total by 31 percent. Table 25 compares the new forecast to the former Final Safety Analysis Report's projection.

TABLE 25

COMPARISON OF FORMER* AND REVISED SHOREHAM NUCLEAR POWER STATION POPULATION DATA, WINTER OR YEAR-ROUND POPULATION

Mileage Band	FSAR*	Revised 1980	Change	FSAR	Revised 2020	Change
0 - 1	545	673	128	1,665	1,531	(134)
1 - 2	5,395	5,409	14	17,295	11,109	(6,186)
2 - 3	5,137	6,315	1,178	28,319	11,292	(17,027)
3 - 4	11,325	7,103	(4,222)	33,936	12,178	(21,758)
4 - 5	6,799	5,799	(1,000)	32,884	10,595	(22,289)
5 - 10	62,979	76,955	13,976	195,014	164,859	(30,155)
Total	92,180	102,254	10,074	309,113	211,564	(97,549)

SOURCE: Robert J. Panzarella, Long Island Lighting Co., Mineola, New York.

*Final Safety Analysis Report of April 1979, with population projections prepared in 1973-74.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to describe and evaluate the methodology chosen by LILCO, together with Suffolk County and New York State, to estimate the population distribution within ten miles of the Shoreham Nuclear Power Station. Factors relevant to the choice of a method or model were considered, namely: purpose of the forecast, data availability and quality, geographic size of the study area, time span of the forecast, complexity of the methods, presence of special populations, impact of government regulations, unique local characteristics of the study area, and flexibility of the methodology.

A methodology was required which would satisfy both the NRC regulations and the state-local planning needs, so that LILCO could obtain the operating license for the Shoreham plant. The NRC regulations called for a summer and a winter population forecast for ninety-three sectors within ten miles of the plant site. In addition, the Commission required that time estimates for evacuation be prepared and receive the local government's concurrence. In the Shoreham Nuclear Power Station case, the state and county jointly accepted the responsibility of evacuation planning. Twenty-seven zones bounded by major roadways were delineated, and LILCO was asked to provide the population data consistent with selected control forecasts. The control forecasts were the LIRPB's 1975-95 land capacity study (adjusted to reflect sale of the former RCA property to New York State and to match the 1979 LILCO population survey) and the 1995-2020 NYSDOC projections which were accepted as "official" by the Census Bureau. It was necessary to apply the NYSDOC growth rates to the 1995 estimate to form a single projection series.

The characteristics of the ten-mile radius were reviewed to ascertain the potential for population growth. The climate was found to be conducive to growth, but fragile soil conditions were a deterrent. Preservation of the ground water supply would conflict with development of much of the area; the morainal soil is very permeable and high density development could destroy the aquifers. Zoning regulations in Brookhaven were enacted to protect the land and to preserve open space, particularly forests and wetlands. The area, if developed according to existing zoning, would remain a low-density single family home area. No major employment centers were found in the ten-mile radius, and few establishments employed over one hundred persons, except for Brookhaven National Laboratory. Existing transportation routes, being rather congested, would not entice many more long-distance commuters to locate in the study area. Visual inspection and census data revealed an aging population, implying a decreasing household size. Therefore, the growth potential was found to be limited.

Several types of demographic models were examined to determine their applicability to this type of small-area forecasting problem. Arithmetic and geometric methods were found to be useful only for intercensal population estimates. Both extrapolation techniques ignored the underlying causes of change and would tend to yield fantastically high results. Also, the choice of the data base's time span would greatly affect the results. Aside from the lack of explanatory power, such techniques could not accommodate the impact of policy, economic, or long-term demographic changes.

The ratio or step-down method was faulted for ignoring migration, but had the advantage of reliance upon more sophisticated analyses performed at a larger scale. The ratio method, then, could be combined with other methods when necessary. Censal ratio methods were considered useful for intercensal estimates and short-run projections. Regression analysis might be employed in conjunction with ratio techniques to forecast ratios or migration. In general, though, regression analysis was found to be unreliable for long range demographic projections. Forecast errors in the independent variables could render the resultant forecast no better than one calculated through other means. In addition, statistical correlation need not imply causation, and, moreover, past causal relationships may not persist in the future.

Cohort models were discovered to be applicable only to national and state areas, and possibly to counties. For smaller areas, adequate data was found lacking, especially for migration estimation. Cohort methods would be appropriate for control forecasts, and could be combined with other available methods to produce small area forecasts.

Land capacity models were the most promising small-area forecasting technique, although the results must be combined with other projection methods to obtain the timing of growth and to convert dwelling units to population levels. Land use methods were found to be well suited to small-area population forecasting, in particular for MCDs and census tracts. Advantages of this methodology were: (1) provision of detail on the spatial distribution of the population, (2) allowance for impact analysis with respect to zoning change, and (3) development of a saturation value which could be used as an asymptote or a constraint in mathematical models.

Most of the labor market models examined have not undergone successful calibrations even on the SMSA scale. For MCDs, data availability on migration is very limited, so labor market models may lack a quality data base. Also, these models often ignore locational influences such as neighborhood desirability. If employment forecasts were used to determine population, errors in the employment projections could be compounded by errors in the conversion ratios. Another problem is that many econometric models require an exogenous population input, the very thing which is sought as a result.

Spatial allocation models, like ratio and apportionment methods, require an independent forecast of the total population to be allocated to constituent areas. The gravity formulations have often been applied in land use forecasting models, with some satisfactory results. However, gravity models are generally more useful as a descriptive device. The underlying theory is static and rather simplistic and, therefore, may not be useful for long range forecasting. The choice of the number of centers, measures of mass, weights, and measures of distance pose some difficulties, and in a multiple center model a computer would be necessary. The COT model applied to Long Island had very limited success in predicting the growth in Brookhaven Town, and would require modification and re-calibration. Mathematical models are, in general, smoothing devices which can be used to project trends and turning points. Their resultant forecasts may not be acceptable indications of the magnitude of future population. The allocation models as a group have some value in predicting the spatial distribution of population, but have not been proven superior to other methods.

The GKM model was the only method specifically designed for MCDs and for application to nuclear power plant analyses. The GKM model employs a step-down apportionment technique based upon population densities of the sub-areas, and growth which occurred between prior censuses. The assumption that the relationship among geographic sub-areas, determined at a single point in time, will remain fixed is probably not valid. In addition, the derivation of patterns of change in density from two years of data (two censuses) is not likely to be sufficient for long range forecasting. The GKM computerized algorithm is too simplistic and mechanistic as it stands; further refinements would be needed before implementation, such as introduction of land capacity constraints rather than use of a mathematically derived ceiling.

No single methodology was found to be superior for small areas. Given the scarcity of data for MCDs, a combination of techniques would be appropriate for forecasting the population of areas below the county level. If reliable forecasts are available for a larger area encompassing the group of MCDs, such forecasts can be apportioned to the sub-areas by means of trended ratios, land capacity studies, or spatial distribution models. The use of control forecasts can minimize the grosser errors inherent in the several techniques described above. Perhaps the most valuable aid to forecasting small area populations is careful review of the locality's growth potential, so that unreasonable results stemming from application of relatively simplistic methods available are avoided.

The methodology chosen for the Shoreham Nuclear Power Station emergency response plan is a combination of several approaches outlined above. Two control forecasts are utilized: a land capacity forecast for 1980-95 and a cohort-component model for 1995-2020. Growth rates from these projections are applied to the LILCO 1979 population survey results, which is basically a censal ratio current population estimate. Census and electric meter data, together with maps, atlases, travel guides, aerial photographs and field inspection are then used to allocate 1980-2020 growth to NRC and state-county zones. Seasonal and special populations were forecasted separately by use of census data and communications with operators, owners, or government agencies in charge of the establishments. When decisions involving judgment were necessary, care was taken to maintain a conservative approach. In this case, a conservative method is one which, if in error, is biased upwards. Thus some amount of double-counting and rounding of estimates to the next higher number occurs, intentionally.

The result is a set of population distributions, summer and winter, 1980-2020, for two sets of evacuation zones. The distributions are consistent with one another and with the control forecasts designated by New York State and Suffolk County. The projection methodology has the added advantage of flexibility; it can incorporate changes in zonal boundaries, zoning, or control forecasts with minimum difficulty. The estimated distributions should prove satisfactory for the evacuation plan and NRC safety analysis which are prerequisites for issuance of an operating license.

FOOTNOTES

1. Long Island Lighting Co., Shoreham Nuclear Power Station Unit 1, Applicant's Final Safety Analysis Report, Vol. I (April 1979), pp. 2.1-1 through 2.1-14.

2. Nuclear Regulatory Commission, "10 CFR Part 50 Emergency Planning, Proposed Rule," Federal Register 44, no. 245, 19 December 1979, 75167.-75169.

3. Ibid., p. 75172.

4. Nuclear Regulatory Commission and Federal Emergency Management Agency, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, for Interim Use and Comment, NUREG-0654 FEMA-REP-1 (January 1980), p. 50.

5. Ibid., p. 52.

6. Ibid.

7. Generally a utility company will hold the nuclear power plant operating license, but other types of organizations could operate a plant, such as a municipality, a power authority, or a research laboratory.

8. Interview with Ms. Julie Hoover and Ms. Rosenblatt of Parsons Brinckerhoff Quade and Douglas, New York, New York, 7 March 1980.

9. The Long Island Regional Planning Board (LIRPB) was formerly called the Nassau-Suffolk Regional Planning Board (NSRPB).

10. Henry S. Shryock, et al., The Methods and Materials of Demography, ed. Edward G. Stockwell (New York: Academic Press, 1976), p. 442; U.S. Department of Commerce, Bureau of the Census, Guide for Local Area Population Projections, Technical Paper 39 (Washington, D.C.: U.S. Government Printing Office, n.d.), pp. 4-5.

11. New York Power Pool and Empire State Electric Energy Research Corporation, Report of Member Electric Systems, Vol. 1 (Albany, New York: NYPP, 1980), p. 139.

12. Holzmacher, McLendon & Murrell, Comprehensive Public Water Supply Study, Suffolk County, New York, CWPS-24, Vol. 1 (Melville, New York: 1968), pp. 1-12.

13. Ibid.

14. Ibid.

15. Long Island Lighting Co., Shoreham Nuclear Power Station Unit 1, Applicant's Final Safety Analysis Report, Vol. 1, revision 16 (Mineola, New York: LILCO, April 1979), pp. 2.1-1, 2.1-2.

16. Idem, Population Survey 1980 (Mineola, New York: LILCO, April 1980), p. II and Table 2.

17. Ibid., p. IV.

18. Nassau-Suffolk Regional Planning Board, "The Pattern of Work-trips to Major Employment Centers: The Nassau-Suffolk SMSA," by Pearl Kamer, Long Island Economic Trends Quarterly Supplement (Hauppauge, New York: NSRPB, September 1975), pp. 3-5.

19. Ibid., p. 15.

20. Long Island Lighting Co., Long Island Almanac Quarterly Report (July, August, September 1979), pp. 16-21; Idem, Long Island Almanac Quarterly Report (October, November, December 1979), p. 4; Long Island Lighting Co., Final Safety Analysis, Table 2.2.1-1.

21. Nassau-Suffolk Regional Planning Board, "A Profile of the Nassau-Suffolk Labor Force," by Pearl Kamer, Long Island Economic Trends: Technical Supplement (Hauppauge, New York: NSRPB, March 1973), pp. 1-3.

22. Ibid., p. 42.

23. Idem, Nassau-Suffolk's Changing Manufacturing Base: A Case Study of a Suburban Labor Market, by Pearl M. Kamer, Research Monograph Series, no. 1 (Hauppauge, New York: NSRPB, 1977), p. 1.

24. Ibid., p. 8.

25. Ibid., p. 10.

26. Ibid., p. 12.

27. Long Island Lighting Co., Long Island Almanac Quarterly Report (January, February, March 1980), p. 10.

28. Holzmacher, pp. 5-9.

29. Nassau-Suffolk Regional Planning Board, "Profile," pp. 3, 89.

30. Standard Rate and Data Service, 1979 Market Data Survey (Skokis, Illinois: SRDS, August 1979).

31. Long Island Lighting Co., Final Safety Analysis, pp. 2.2-6, 2.2-7.

32. In addition, New York State purchased the 7200 acre R.C.A. property, 5,200 acres of which lies within the ten-mile radius, which will remain undeveloped.

33. Nassau-Suffolk Regional Planning Board, Zoning: Inventory and Analysis (Hauppauge, New York: 1970), pp. 1, 125.

34. Ibid., p. 125.

35. Ibid., Zoning 1969 map.

36. Ibid., pp. 79-80.

37. Ibid., pp. 96, 114.

38. Ibid., pp. 79, 96, 114.

39. Ibid., p. 86.

40. Long Island Lighting Co., Final Safety Analysis, p. 2.1-12; Robert J. Panzarella, Long Island Lighting Co., workpapers.

41. Nassau-Suffolk Regional Planning Board, Zoning, Zoning 1969 map.

42. Raymond, Parish & Pine, Inc., "Vacant Land Analysis: Draft Memorandum to the Planning Board, Town of Brookhaven, New York as part of Comprehensive Planning Program" (Tarrytown, New York: June 1974), Table 4.

43. Long Island Lighting Co., Final Safety Analysis, pp. 2.2-2, 2.2-3.

44. William C. Wheaton, "Income and Urban Residence: An Analysis of Consumer Demand for Location," American Economic Review 67 (September 1977): 628-30.

45. William Alonso, "Metropolis Without Growth," The Public Interest 53 (Fall 1978): 85.

46. Jon P. Nelson, "Accessibility and the Value of Time in Commuting," Southern Economic Journal 43 (January 1977): 1321-22.

47. John L. Goodman, Jr., "Reasons for Moves Out of and Into Large Cities," Journal of the American Planning Association 45 (October 1979): 412.

48. Peter A. Morrison, Overview of Population Forecasting for Small Areas (Santa Monica, California: Rand Corporation, June 1975), p. 2.

49. Shryock, p. 409.

50. Ibid., pp. 11-25.

51. Ibid., pp. 64-65.

52. Ibid., pp. 50-52.

53. Ibid., p. 54.

54. Hugh H. Wolfenden, Population Statistics and Their Compilation (Chiago, Illinois: University of Chicago Press, 1954), p. 32.

55. Ibid., p. 34.

56. Ibid., pp. 66-67.

57. U. S. Department of Commerce, Bureau of the Census, Guide for Local Area Population Projections, [by Richard Irwin], technical paper no. 39 (Washington, D.C.: U. S. Government Printing Office, n.d.), p. 5.

58. Ibid., p. 6.

59. Ibid., pp. 6-9.

60. Jacob S. Siegel, "Forecasting the Population of Small Areas," Land Economics 29 (February 1953): 75.

61. Ibid., pp. 72-83.

62. Michael A. Greenberg et al., Local Population and Employment Projection Techniques (New Brunswick, New Jersey: Center for Urban Policy Research, Rutgers-The State University of New Jersey, 1978), p. 8.

63. Wolfenden, pp. 80-87.

64. Ibid., pp. 89-90; Harold F. Dorn, "Pitfalls in Population Forecasts and Projections," Journal of the American Statistical Assciation 45 (September 1950): 320, 327.

65. Walter Isard et al., Methods of Regional Analysis; An Introduction to Regional Science (Cambridge, Massachusetts: The M.I.T. Press, 1960), p. 15.

66. Shryock, p. 454.

67. Greenberg, p. 17.

68. Robert C. Schmitt and Albert H. Crosetti, "Accuracy of the Ratio Method for Forecasting City Population," Land Economics 27 (November 1951): 348.

69. Harlin G. Loomer, "Accuracy of the Ratio Method for Forecasting City Population: A Reply," Land Economics 28 (May 1952): 180.

70. Isard, p. 18.

71. Shryock, pp. 421, 426.

72. Ibid., p. 461.

73. Isard, pp. 19-23; Greenberg, p. 19.

74. Shryock, pp. 379, 399-400.

75. Morrison, p. 3.

76. Shryock, pp. 456-59.

77. T. Lynn Smith, Fundamentals of Population Study (New York: J. B. Lippincott Company, 1960), pp. 417-421.

78. Donald J. Bogue, "Internal Migration," in The Study of Population, eds. Philip M. Hauser and Otis Dudley Duncan (Chicago, Illinois: University of Chicago Press, 1959), p. 489.

79. Ibid., pp. 491-92.

80. Shryock, pp. 377-78.

81. Wolfenden, p. 80; Greenberg, p. 14.

82. Bogue, pp. 495-505.

83. Myron Krikor Nalbandian, "Methods of Population Estimation for Small Areas, with Specific Application to Rhode Island," (Ph.D. disseration, Brown University, 1959, p. 111, vol. 23/03 Dissertation Abstracts International), pp. 201-8.

84. Ibid., pp. 8-10.

85. Ibid., p. 127.

86. U. S. Department of Commerce, Bureau of the Census, p. 27.

87. Ibid.; Greenberg, pp. 18-19; Nassau-Suffolk Regional Planning Board, Population Estimates and Projections, 1975 to 1995, Interim Report Series, no. 1 (Hauppauge, New York: NSRPB, November 1976), pp. 1, 6 (hereafter cited as Nassau-Suffolk Regional Planning Board, "208" Report).

88. Morrison, p. 4.

89. Ibid., p. 13.

90. Office of Planning, Analysis and Evaluation, Energy Research and Development Administration, Models and Methodologies for Assessing the Impact of Energy Development, ERDA 77-91 (Washington, D.C.: U. S. Government Printing Office, September 1977), p. 7 (hereafter cited as ERDA).

91. Ibid., p. 3.

92. Isard, p. 515.

93. ERDA, pp. 3-4.

94. Ian Maser, Analytical Models for Urban and Regional Planning (Newton Abbot, Great Britain: David and Charles Limited, 1972), pp. 109-120.

95. Ibid., pp. 68, 122-24.

96. Isard, pp. 189-204.

97. Charles M. Tiebout, "Exports and Regional Economic Growth," in Regional Development and Planning, eds. John Friedmann and William Alonso (Cambridge, Massachusetts: The M.I.T. Press, 1964), p. 258.

98. ERDA, p. 4.

99. Ibid, p. 5.

100. John V. Hartung, "Residential Land Use Models with Application to Long Island," (Ph.D. dissertation, Polytechnic Institute of Brooklyn, 1973), pp. 49-50.

101. Ibid., p. 82.

102. Ibid., p. 95.

103. U. S. Department of Commerce, Bureau of the Census, p. 22.

104. Greenberg, pp. 22-53.

105. U. S. Department of Commerce, Bureau of the Census, p. 28.

106. Nassau-Suffolk Regional Planning Board, *"208" Report*, p.2.

107. Upper Brookville's five-acre minimum lot size was declared unconstitutional on March 26, 1979 by the New York State Supreme Court, Appellate Division.

108. Nassau-Suffolk Regional Planning Board, *"208" Report*, pp. 1-4 and tables A-6 and A-10.

109. Ibid., pp. 4-6.

110. Ibid., pp. 5-7 and tables 3-4.

111. Raymond, Parish & Pine, Inc., pp. 1-4.

112. Ibid., pp. 6-7.

113. Ibid., pp. 7-9.

114. Ibid., p. 10.

115. Brookhaven Planning Board, "The Brookhaven Master Plan," Patchogue, New York, December 1974; Robert J. Quinn, "New Master Plan Blueprints Brookhaven's Growth" *Long Island Business Review* (Plainview, New York), 21-27 May 1975; Tom Morris, "A Town's Plan to Stop sprawl" *Long Island* (New York) *Newsday*, 12 December 1974, pp. 4, 30.

116. New York State Department of Commerce, *Demographic Projections for New York State Counties to 2020 A.D.* (Albany, New York: NYSDOC, June 1968), p. 4.

117. Greenberg, p. 8.

118. Town of Brookhaven Planning Board, *The Brookhaven Master Plan*, by Raymond, Parish & Pine, Inc. (Patchogue, New York, March 25, 1975), p. 46.

119. Holzmacher, pp. 81-82.

APPENDIX A

DEMOGRAPHIC AND HOUSING DATA FOR SCHOOL DISTRICTS AND MUNICIPALITIES WITHIN TEN MILES OF SHOREHAM

TABLE A-1

DEMOGRAPHIC AND HOUSING DATA FOR SCHOOL DISTRICTS AND MUNICIPALITIES WITHIN TEN MILES OF SHOREHAM

	Comse-woque	Port Jeffer-son	Mount Sinai	Miller Place	Rocky Point	Middle Country	Middle Island	South Manor	West Manor
1970 Data									
Population	17,911	6,349	1,948	5,717	8,255	40,861	13,803	1,499	118
Household Size	3.94	3.39	3.76	3.34	3.31	4.17	3.85	3.42	3.37
Occupied Units	4,549	1,873	518	1,710	2,493	9,792	3,589	438	35
Vac. Yr.Round Units	172	92	30	134	439	467	406	46	4
Seasonal Units	50	37	46	736	1,088	262	418	57	5
1976 Estimates									
Special Census-4/26/75	19,183	6,387	4,803	8,947	10,345	52,912	29,878	2,054	188
Vacant Acreage	1,180	316	2,260	1,950	4,100	1,924	-	3,820	940
Lot Yield of Vac.Acre.	2,330	401	3,130	2,560	3,890	4,691	25,442	6,220	1,870
Lots on Filed Maps	-	-	-	-	-	-	-	-	-
Scattered Vac. Lots	172	339	30	160	210	707	9,663	250	-
Total Avail. Lots	2,502	740	3,160	2,720	4,100	5,398	35,105	6,470	1,870
Vac. Yr.Round Lots	172	92	30	134	439	467	406	46	4
Seasonal Units	50	37	46	736	1,088	262	418	57	5
Occupied Units	4,872	1,909	1,277	2,677	3,124	12,682	7,764	600	56
Total Existing Units	5,094	2,038	1,353	3,547	4,651	13,411	8,588	703	65
Total Existing & Potential Units	7,596	2,778	4,513	6,267	8,751	18,809	43,693	7,173	1,935
Projected Average Household Size	3.88	3.18	3.80	3.80	3.60	3.94	3.40	3.70	3.70
Saturation Popula.	29,443	8,836	17,149	23,815	31,504	74,046	148,556	26,540	7,160

SOURCE: Nassau-Suffolk Regional Planning Board, Population Estimates and Projections, 1975 to 1995, Interim Report Series: 1 (Hauppauge, New York: NSRPB, November 1976), tables A-6 and A-10.

*Includes all school districts in the town.

**Excludes State University at Stony Brook.

TABLE A-1 - Continued

	William Floyd	Shoreham-Wading River(pt)	River-head(pt)	Eastport-East Manor(pt)	Brookhaven Town Total*	Shoreham-Wading River(pt)	River-head(pt)	Riverhead Town Total*
1970 Data								
Population	14,525	2,419	344	706	245,260	1,441	17,277	18,909
Household Size	3.16	3.54	3.41	3.27	3.64**	3.1	3.1	3.1
Occupied Units	4,594	684	101	216	65,989	469	5,551	6,084
Vac. Yr.Round Units	1,213	189	11	20	5,175	26	371	399
Seasonal Units	401	281	14	26	7,143	197	1,214	1,450
1976 Estimates								
Special Census-4/26/75	26,629	4,511	933	841	320,677	1,818	19,145	21,184
Vacant Acreage	2,080	2,330	1,600	8,120	-	417	27,122	28,070
Lot Yield of Vac.Acre.	5,035	2,870	2,485	11,365	-	625	N.A.	56,216
Lots on Filed Maps	-	-	-	-	-		N.A.	-
Scattered Vac. Lots	2,125	90	55	25	-	90	N.A.	-
Total Avail. Lots	7,160	2,960	2,540	11,390	122,701	715	54,632	56,216
Vac. Yr.Round Lots	1,213	189	11	20	5,175	26	239	267
Seasonal Units	401	281	14	26	7,143	197	1,214	1,450
Occupied Units	8,424	1,385	274	273	86,748	569	6,177	6,818
Total Existing Units	10,038	1,855	299	319	99,066	792	7,630	8,535
Total Existing & Potential Units	17,198	4,815	2,839	11,709	221,767	1,507	62,262	64,751
Projected Average Household Size	3.70	3.72	3.70	3.66	3.66**	3.2	3.2	3.2
Saturation Popula.	63,633	17,895	10,504	42,823	820,709	4,822	199,239	207,203

SOURCE: Nassau-Suffolk Regional Planning Board, Population Estimates and Projections, 1975 to 1995, Interim Report Series: 1 (Hauppauge, New York: NSRPB, November 1976), tables A-6 and A-10.

*Includes all school districts in the town.

**Excludes State University at Stony Brook.

TABLE A-1 - Continued

	Municipalities - Brookhaven Town					Municipalities - Riverhead Town	
	Belle Terre Village	Port Jefferson Village	Shoreham Village	Unincorporated Area	Town Total	Unincorporated Area	Town Total
1970 Data							
Population	678	5,515	524	245,260	245,260	18,909	18,909
Household Size	3.53	3.23	4.19	3.17**	3.64**	3.1	3.1
Occupied Units	192	1,706	125	56,559	65,989	6,084	6,084
Vac. Yr.Round Units	21	81	29	4,554	5,175	399	399
Seasonal Units	2	22	2	6,853	7,143	1,450	1,450
1976 Estimates							
Special Census-4/26/75	794	5,800	556	288,689	320,677	21,184	21,184
Vacant Acreage	0	206	0	-	-	28,070	28,070
Lot Yield of Vac.Acre.	0	206	0	-	-	56,216	56,216
Lots on Filed Maps	-	-	-	-	-	-	-
Scattered Vac. Lots	49	317	30	-	-		
Total Avail. Lots	49	523	30	120,623	122,701	56,216	56,216
Vac. Yr.Round Lots	21	81	29	4,554	5,175	267	267
Seasonal Units	2	22	2	6,853	7,143	1,450	1,450
Occupied Units	226	1,786	138	76,211	86,748	6,818	6,818
Total Existing Units	249	1,889	169	87,618	99,066	8,535	8,535
Total Existing & Potential Units	298	2,412	199	208,241	221,767	64,751	64,751
Projected Average Household Size	3.60	3.10	4.10	3.68**	3.66**	3.2	3.2
Saturation Popula.	1,073	7,477	816	776,248	820,709	207,203	207,203

SOURCE: Nassau-Suffolk Regional Planning Board, Population Estimates and Projections, 1975 to 1995, Interim Report Series: 1 (Hauppauge, New York: NSRPB, November 1976), tables A-6 and A-10.

*Includes all school districts in the town.

**Excludes State University at Stony Brook.

APPENDIX B

SOURCES USED BY LILCO TO ESTIMATE THE POPULATION DISTRIBUTION WITHIN TEN MILES OF SHOREHAM

TABLE B-1

INFORMATION SOURCES FOR ESTIMATION OF THE POPULATION DISTRIBUTION BY ZONES WITHIN TEN MILES OF SHOREHAM

Population Estimates and Forecasts

Michael Batutis. Principal Demographer, New York State Department of Commerce, Albany, New York. Interviews, 20 June 1979 and 31 July 1979.

Arthur Kunz. Deputy Director, Long Island Regional Planning Board, Hauppauge, New York. Interviews May 1979 through September 1979.

Long Island Lighting Company. Hicksville, New York. List of residential accounts on Valentine Road, Shoreham, New York, 1980.

________. Hicksville, New York. List of residential active electric meters of 31 March 1970.

________. Hicksville, New York. List of residential active electric meters as of 30 April 1975.

________. Hicksville, New York. List of residential active electric meters as of 31 December 1978.

________. Population Survey 1979. Mineola, New York: LILCO, April 1979.

Nassau-Suffolk Regional Planning Board. Population Estimates and Projections, 1975 to 1995, Interim Report Series: 1. Hauppauge, New York: NSRPB, November 1976.

________. U. S. Census '70, vol. 1, Number of Inhabitants. Hauppauge, New York: NSRPB, 1971.

________. U. S. Census '70, vol. 4, Housing Inventory. Hauppauge, New York: NSRPB, 1972.

New York State Department of Commerce. "Population Projections." Albany, New York: NYSDOC, December 1977.

U. S. Department of Commerce, Bureau of the Census. Special Interim Census, Town of Brookhaven, New York, April 26, 1975. Washington, D.C.: U. S. Government Printing Office, 1975.

TABLE B-1 - Continued

Peggy Wagner. Planner, Long Island Regional Planning Board. Interviews. May 1979 through September 1979.

W. S. Webster. Manager, Staff Services Division, Brookhaven National Laboratory, Associated Universities, Inc., Upton, New York to Kathleen A. Donnelly, 29 May 1979.

Signe Wetrogan. Population Projections Division, U. S. Department of Commerce, Bureau of the Census. Interview. Albany, New York, 20 June 1979.

Recreational Facilities

Francis A. Hyland. Chief Engineer, Long Island State Park and Recreation Commission, Belmont Lake State Park, Babylon, New York. Interview. 10 September 1979.

Long Island Business Review. *1979 Long Island Recreation and Visitors Guide*. Plainview, New York: Long Island Business Review, 1979.

Long Island Tourism Commission, Inc. *I Love New York, Long Island Travel Guide*. Long Island MacArthur Airport, Ronkonkoma, New York: 1979.

Riverhead Tax Assessor's Office. Tax records for Camp Grant property. Riverhead, New York, 1979.

Maps and Other Locational Guides

Hagstrom Co., Inc. *Hagstrom Suffolk Atlas*. New York: Hagstrom Co., Inc, 1978.

Charles Lind. Chief, Cartographic Division, Suffolk County Planning Department. Hauppauge, New York. Interview. 22 May 1979.

Long Island Lighting Company. Aerial photographs of Shoreham site and vicinity. Hicksville, New York: LILCO, April 30, 1977.

New York State Department of Environmental Conservation. Project Q-UA-Suffolk-51.1, Map no. 9809 and Project Q-UA-Suffolk-51.2, Map no. 9808. Albany, New York.

TABLE B-1 - Continued

Suffolk County Planning Department. Map of Farmlands Program, Phase 1 and Phase 2. Hauppauge, New York, September 1979.

________. Suffolk County Catalogue. Hauppauge, New York, 1975.

TABLE B-2

SHOREHAM EVACUATION AREA 1979 POPULATION BASED ON JANUARY 1, 1979
ACTIVE RESIDENTIAL ELECTRIC METERS -- SAMPLE WORKSHEET

Area	Meter District	Meter Book	Percent Amount	Total Meters	Area Meters	1975 Census Tract	Tract Persons Per Meter	Population	Special Population	Total 1979 Population
SSW 2-3	871	60	60	203	122	1584.04	2.902	354	0	354
		34	30	349	105	1584.04	1.500*	158	0	158
		43	2	506	10	1584.04	1.500*	15	0	15
SSW 3-4	871	43	98	506	496	1584.04	1.500*	744	0	744
		34	70	349	244	1584.04	1.500*	366	0	366
		60	20	203	41	1584.04	2.902	119	0	119
		42	100	398	398	1584.04	1.500*	597	0	597
		32	100	291	291	1584.04	1.500**	437	0	437
		30	10	239	23	1584.04	2.902	67	0	67
		28	98	182	178	1584.04	2.902	517	0	517
		45	10	160	16	1584.04	2.601	42	0	42
S 2-3	871	--- Brookhaven State Park (undeveloped) ----------								0

SOURCE: Robert J. Panzarella, Long Island Lighting Co., Mineola, New York.

NOTE: Area abbreviations stand for compass directions and distance in miles from the reactor's core.

*Leisure Village retirement community.

**Leisure Knolls retirement community.

TABLE B-3

SHOREHAM EVACUATION AREA 1980 POPULATION BASED ON 1978-79 GROWTH IN ACTIVE RESIDENTIAL ELECTRIC METERS -- SAMPLE WORKSHEET

Area	Meter District	Meter Book	Census Tract	1979 Population	1979-80 Decimal Increase	1979-80 Population Increase	1980 Population	Special Population	1980 Total Population
SSW 2-3	871	60	1584.04	354	.0179	6	360	0	360
		34	1584.04	158	.0179	3	161	0	161
		43	1584.04	15	.0179	0	15	0	15
SSW 3-4	871	43	1584.04	744	.0179	13	757	0	757
		34	1584.04	366	.0179	7	373	0	373
		60	1584.04	119	.0179	2	121	0	121
		42	1584.04	597	.0179	11	608	0	608
		32	1584.04	437	.0179	8	445	0	445
		30	1584.04	67	.0179	1	68	0	68
		28	1584.04	517	.0179	9	526	0	526
		45	1584.03	42	.0179	1	43	0	43
S 2-3	871	--- Brookhaven State Park (undeveloped --							0

SOURCE: Robert J. Panzarella, Long Island Lighting Co., Mineola, New York.

NOTE: Area abbreviations stand for compass directions and distance in miles from the reactor's core.

TABLE B-4

EXPANSION OF 1980 POPULATION OF EVACUATION AREAS TO 1990

Area	Meter District	Meter Book	School District	1980 Population	School District Expansion Factor 1980-90	1990 Population	Special Population	1990 Total Population
SSW 2-3	871	60	SWR 1	360	1.587	571	0	571
		34	MI 12	161	1.000*	161	0	161
		43	MI 12	15	1.000*	15	0	15
SSW 3-4	871	43	MI 12	757	1.000*	757	0	757
		34	MI 12	373	1.000*	373	0	373
		60	SWR 1	121	1.587	192	0	192
		42	MI 12	608	1.000*	608	0	608
		32	MI 12	445	1.000**	445	0	445
		30	MI 12	68	1.608	109	0	109
		28	MI 12	526	1.608	846	0	846
		45	RP 9	43	1.136	49	0	49
S 2-3	871	--- Brookhaven State Park (undeveloped)						0

SOURCE: Robert J. Panzarella, Long Island Lighting Co., Mineola, New York.

NOTES: SWR = Shoreham-Wading River; MI = Middle Island; RP - Rocky Point; area abbreviations stand for compass directions and distance in miles from the reactor's core.

*Leisure Village retirement community.

**Leisure Knolls retirement community.

TABLE B-5

EXPANSION OF 1990 BASE POPULATION OF EVACUATION AREAS TO 2000

Area	Meter District	Meter Book	School District	1990 Population	School District Expansion Factor 1990-2000	2000 Population	Special Population	2000 Total Population
SSW								
2-3	871	60	SWR 1	571	1.252	715	0	715
		34	MI 12	161	1.270*	204	0	204
		43	MI 12	15	1.270*	19	0	19
SSW								
3-4	871	43	MI 12	757	1.270*	961	0	961
		34	MI 12	373	1.270*	474	0	474
		60	SWR 1	192	1.252	240	0	240
		42	MI 12	608	1.270*	772	0	772
		32	MI 12	445	1.270**	565	0	565
		30	MI 12	109	1.270	138	0	138
		28	MI 12	846	1.270	1,074	0	1,074
		45	RP 9	49	1.108	54	0	54
S								
2-3	871	--- Brookhaven State Park (undeveloped) ---						0

SOURCE: Robert J. Panzarella, Long Island Lighting Co., Mineola, New York.

NOTES: Area abbreviations stand for compass directions and distance in miles from the reactor's core. SWR = Shoreham-Wading River; MI = Middle Island; RP = Rocky Point.

*Leisure Village retirement community.

**Leisure Knolls retirement community.

TABLE B-6

EXPANSION OF 2000 POPULATION OF EVACUATION AREAS TO 2020

Area	2000 Base Population	2000-2010 Expansion Factor	2010 Base Population	2010-2020 Expansion Factor	2020 Base Population
SSW 0-1	14	1.090	15	1.088	16
SSW 1-2	454	1.090	495	1.088	539
SSW 2-3	938	1.090	1,022	1.088	1,112
SSW 3-4	4,278	1.090	4,663	1.088	5,073
SSW 4-5	1,562	1.090	1,703	1.088	1,853
SSW 5-10	10,278	1.090	11,203	1.088	12,189

SOURCE: Robert J. Panzarella, Long Island Lighting Co., Mineola, New York.

NOTE: Area abbreviations stand for compass direction and distance in miles from the reactor's core.

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

Upton, New York 11973

(516) 345-2525

May 29, 1979

Ms. Kathleen A. Donnelly
Economist, Economic Research Dept.
Long Island Lighting Company
250 Old Country Road
Mineola, New York 11501

Dear Ms. Donnelly:

Your letter dated May 24, 1979 addressed to Mrs. Dorothy Metz regarding a resident person-per-meter count for the Brookhaven National Laboratory area, has been referred to me.

The following is the information you requested:

1. Total occupancy on or about January 1, 1979 is approximated to have been 410 persons. It should be noted however, that occupancy rates are characteristically low during the winter months and peak during the May to October period at or near 100% per paragraph 2.

2. One hundred percent occupancy of on-site housing would be 905 persons. The probability of this occurring is near zero, not every bedroom equipped for two persons is occupied by two persons. More probably 100% occupancy would be extant with about 830 persons.

3. There are no current or forecast plans to increase or decrease on-site housing facilities.

4. There are no housing units individually metered.

If you have any other questions, please do not hesitate to call me.

Very truly yours,

W. S. Webster

W. S. Webster, Manager
Staff Services Division

WSW:jdp

SELECTED BIBLIOGRAPHY

Alonso, William. "Metropolis Without Growth." The Public Interest 53 (Fall 1978): 68-86.

Bogue, Donald J. "Internal Migration." In The Study of Population, pp. 486-509. Edited by Philip M. Hauser and Otis Dudley Duncan. Chicago: University of Chicago Press, 1959.

Brookhaven Planning Board. Brookhaven Master Plan. Patchogue, New York: Brookhaven Planning Board, 1974.

Dorn, Harold F. "Pitfalls in Population Forecasts and Projections." Journal of the American Statistical Association 45 (September 1950): 311-34.

Goodman, John L., Jr. "Reasons for Moves Out of and Into Large Cities." Journal of the American Planning Association 45 (October 1979): 407-16.

Greenberg, Michael R.; Krueckeberg, Donald A.; and Michaelson, Connie O. Local Population and Employment Projection Techniques. New Brunswick, New Jersey: Rutgers, the State University of New Jersey, Center for Urban Policy Research, 1978.

Hartung, John V. "Residential Land Use Models with Application to Long Island." Ph.D. dissertation, Polytechnic Institute of Brooklyn, 1973.

Holzmacher, McLendon & Murrell, Consulting Engineers. Comprehensive Public Water Supply Study, Suffolk County, New York. CPWS-24, vol. 1. Melville, New York: Holzmacher, McLendon & Murrell, 1968.

Hoover, Julie, and Rosenblatt, S. Parsons, Brinckerhoff, Quade and Douglas, New York. Interview. 7 March 1980.

Isard, Walter. Methods of Regional Analysis an Introduction to Regional Science. Cambridge, Massachusetts: The M.I.T. Press, 1960.

Long Island Lighting Co. Long Island Almanac, Quarterly Report. Quarter 4, 1978, Quarters 2-4, 1979, Quarter 1, 1980. Mineola, New York: Long Island Lighting Co.

________. Population Survey 1979. Mineola, New York: Long Island Lighting Co., 1979.

________. Population Survey 1980. Mineola, New York: Long Island Lighting Co., 1980.

________. Shoreham Nuclear Power Station Unit 1, Applicant's Final Safety Analysis Report, vol. 1, revision 16. Mineola, New York: Long Island Lighting Co., 1979.

Loomer, Harlin G. "Accuracy of the Ratio Method for Forecasting City Population: A Reply." Land Economics 28 (May 1952): 180-83.

Maser, Ian. Analytical Models for Urban and Regional Planning. Newton Abbot, Great Britain: David and Charles Limited, 1972.

Morris, Tom. "A Town's Plan to Stop Sprawl." (Long Island) Newsday, 12 December 1974, pp. 4, 30.

Morrison, Peter A. Overview of Population Forecasting for Small Areas. Santa Monica, California: Rand Corporation, 1975.

Nalbandian, Myron Krikor. "Methods of Population Estimation for Small Areas, with Specific Application to Rhode Island." Ph.D. dissertation, Brown University, 1959. (Microfilm)

Nassau-Suffolk Regional Planning Board. Long Island Economic Trends: Technical Supplement, A Profile of the Nassau-Suffolk Labor Force, by Pearl M. Kamer. Hauppauge, New York: NSRPB, 1973.

________. Nassau-Suffolk's Changing Manufacturing Base: A Case Study of a Suburban Labor Market, by Pearl M. Kamer. Research Monograph Series Number 1. Hauppauge, New York: NSRPB, 1977.

________. Population Estimates and Projections 1975 to 1995. Interim Report Series: 1. Hauppauge, New York: NSRPB, 1976.

________. Quarterly Technical Supplement, Long Island Economic Trends, The Pattern of Worktrips to Major Employment Centers: The Nassau-Suffolk SMSA. Hauppauge, New York: NSRPB, 1975.

________. Zoning: Inventory and Analysis. Hauppauge, New York: NSRPB, 1970.

Nelson, John P. "Accessibility and the Value of Time in Commuting." Southern Economic Journal 43 (January 1977): 1321-29.

New York State, Office of Planning Coordination. Demographic Projections for New York State Counties to 2020 A.D. (1968).

Panzarella, Robert J. Long Island Lighting Co., Mineola, New York. Notes. (xeroxed).

Quinn, Robert J. "New Master Plan Blueprints Brookhaven's Growth." (Melville, New York) Long Island Business Review, 21-27 May 1975.

Raymond, Parish & Pine, Inc., Consulting Engineers. "Vacant Land Analysis, Draft Memorandum to the Planning Board, Town of Brookhaven, New York, as part of Comprehensive Planning Program." Tarrytown, New York: Raymond, Parish & Pine, Inc., 1974.

Report of Member Systems of the New York Power Pool and the Empire State Electric Energy Research Corporation, vol. 1. Pursuant to Section 5-112 of the Energy Law of New York State. Albany, New York: New York Power Pool, 1980.

Schmitt, Robert C. and Crosetti, Albert H. "Accuracy of the Ratio Method for Forecasting City Population." Land Economics 27 (November 1951): 346-48.

Shryock, Henry S.; Siegel, Jacob S.; and Associates. The Methods and Materials of Demography. Edited by Edward G. Stockwell. New York: Academic Press, Inc., 1976.

Siegel, Jacob S. "Forecasting the Population of Small Areas." Land Economics 29 (February 1953): 72-88.

Smith, T. Lynn. Fundamentals of Population Study. Chicago, Illinois: J. B. Lippincott Company, 1960.

Standard Rate and Data Service. 1979 Market Data Survey. Skokie, Illinois: Standard Rate and Data Service, 1979.

Tiebout, Charles M. "Exports and Regional Economic Growth." In Regional Development and Planning, A Reader, pp. 256-60. Edited by John Friedmann and William Alonso. Cambridge, Massachusetts: M.I.T. Press, 1964.

U. S. Department of Commerce, Bureau of the Census. Guide for Local Area Population Projections. Technical Paper 39.

U. S. Energy Research and Development Administration, Office of Planning, Analysis and Evaluation. Models and Methodologies for Assessing the Impact of Energy Development. ERDA 77-91.

U. S. Nuclear Regulatory Commission. Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, for Interim Use and Comment. NUREG-0654, FEMA-REP-1. (1980).

________. "Proposed Rules, 10 CFR Part 50, Emergency Planning." Federal Register 44, no. 245, 19 December 1979, 75167-74.

Wheaton, William C. "Income and Urban Residence: An Analysis of Consumer Demand for Location." American Economic Review 67 (September 1977): 620-31.

Wolfenden, Hugh H. Population Statistics and Their Compilation. Chicago, Illinois: University of Chicago Press, 1954.

POPULATION ESTIMATES AND PROJECTIONS FOR NUCLEAR POWER PLANT SAFETY ANALYSES AND EVACUATION PLANS: THE SHOREHAM NUCLEAR POWER STATION METHODOLOGY

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Issuance of an operating license for a nuclear power plant is contingent upon concurrence by the Nuclear Regulatory Commission (NRC) with a state and local emergency response plan, and upon acceptance by the NRC of the applicant's Final Safety Analysis Report. Both the evacuation plan and the safety analysis require projection of the population distribution within a ten-mile radius around the plant site. The NRC divides the circle into 160 sectors for which population forecasts are necessary; the state or local evacuation areas will generally be dependent upon the area's transportation system.

This study reviews the available small area population projection techniques and describes the methodology adopted by the Long Island Lighting Co. (LILCO), Suffolk County, and New York for the Shoreham Nuclear Power Station emergency response plan and safety analysis. Characteristics of the ten-mile radius around Shoreham are examined to assess the region's potential for population growth. Topography and climate, current population's age structure, level and density, major industries and employment centers, land use patterns and transportation routes are described. From this investigation it is concluded that future population growth will proceed at a slower rate.

Several population projection methodologies are reviewed for possible application to the Shoreham area. Component methods are usually reserved for Standard Metropolitan Statistical Areas, counties, states, and the nation. Cohort methods can be applied to minor civil divisions (MCDs) using census and symptomatic data, but the migration estimation step is weak. Extrapolation and regression analysis share two problems: the number of observations in the data base affects the results, and there is no assurance that forces creating growth in the past will continue to operate in the same fashion in the future. While regression analysis may help to explain causal patterns, there is difficulty in forecasting input variables and in satisfying statistical requirements.

Labor market models have been investigated as a means of estimating the migration component and of allocating dwelling units spatially, with the attempts not proving particularly successful. Operational allocation models have not generally been superior to other available methods. Gravity formulations are the most commonly used spatial allocation models, but they appear to be more useful as a static descriptive device.

Ratio-stepdown methods are an improvement over extrapolation in that they can take advantage of the greater reliability and level of detail present at a larger scale of analysis. The ratio and apportionment approaches, like the allocation models, require a separate forecast of total population.

Land capacity models are the only ones specifically recommended for small areas, but they, too, have disadvantages. If the current zoning can be accepted as given, then the saturation point for dwelling units can be calculated, but household size must still be projected. Capacity methods are combined with one of the other techniques described above to produce a time path of growth from the present to the saturation population level.

No one small area forecasting methodology stands out as the best, so most techniques for MCDs are an eclectic combination of approaches. Choice of a model will depend upon (1) the purpose of the study, (2) data quality and availability, (3) time and budget constraints, (4) length of the projection period (5) the size of the study area, and (6) local characteristics influencing population growth.

The method chosen for the Shoreham area to satisfy NRC and state and local planning requirements is a combination of censal ratio, land capacity, cohort component, extrapolation and ratio-stepdown approaches. A control forecast for 1980-2020 is derived through application of growth rates to base year population estimates. The base estimate utilizes a censal ratio technique, with active residential electric meters as the sympotomatic data. The 1980-95 growth rates are obtained from the Long Island Regional Planning Board's land capacity forecast. The 1995-2020 rates of increase are calculated from the New York State Department of Commerce's cohort component model forecast for Suffolk County.

Base year population for NRC sectors and state planning zones is determined through use of census data, meter route and other maps, aerial photographs, field inspections, atlases, cataloges and travel guides. Meters per zone and persons per meter per census tract are calculated. Once the current population is derived, growth rates from the control forecasts are applied. Seasonal and special populations are projected separately. Population distributions for summer and winter 1980-2020 result, one series for the NRC zones and one for the state and local evacuation areas. The projections are consistent with one another and with the control forecasts, and can be adapted when zonal boundaries or the control forecasts are altered.