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# DEVELOPMENT OF A SHELTER ALLOCATION AND USE PLAN FOR BOSTON

*Prepared for:*

DEPARTMENT OF DEFENSE
OFFICE OF CIVIL DEFENSE
WASHINGTON 25, D.C.

CONTRACT NO. OCD-OS-62-135





STANFORD RESEARCH INSTITUTE
MENLO PARK, CALIFORNIA

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*January 1963*

# DEVELOPMENT OF A SHELTER ALLOCATION AND USE PLAN FOR BOSTON

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*By: Leland H. Towle and John G. Gregory*

*SRI Project No. IM-4021*

*Approved:*

Robert A. Harker

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## PREFACE

This document is a research report. The contents are intended for use by the federal government as a basis for guiding local communities in developing and maintaining community shelter use plans. However, this report in itself does not constitute such a plan, even for the City of Boston (the pilot city upon which the research has been performed), because it was not within the scope of the study to develop such a plan in every detail. Furthermore, the planning approach, techniques, and methodologies reported on within this document should not be construed as being officially advocated by the federal government. At such time as the federal government might adopt portions of this document for general use by local communities, official distribution of those portions will be made from the Office of Civil Defense, incorporated, probably, in the Federal Civil Defense Planning Guide.

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# I INTRODUCTION

The task of the current study, reported on in part in this document, is entitled "Analysis of Community Shelter Systems." This task was performed by Stanford Research Institute at the request of the Department of Defense, Office of Civil Defense. Following is a brief summary of the scope of the task:

> Identify and study in depth the elements of complete community shelter systems and associated supporting systems, including delineation of functions placed upon local communities in organizing, establishing and operating such systems and analysis of their performance capabilities. Preliminarily, emphasis will be placed upon the development, on a short term basis, of recommendations to solve problems of communities in planning for use of the shelters identified and stocked in the National Fallout Shelter Survey, Marking, and Stocking Program. . .

Because the scope of the study is extremely broad, the task was divided into parts. A major part was to develop a planning guide to assist individual communities in developing and placing in operational readiness a shelter use plan. This guide, to be prepared originally by the Institute will be incorporated in the Federal Civil Defense Planning Guide, to be published and distributed by the Office of Civil Defense (OCD). To prepare such a guide, research was conducted to determine appropriate approaches and methods for developing a shelter use plan. As requested by OCD to obtain a broader definition of the problem, several research teams were used to develop plans for several cities. Selection of the teams and the pilot cities is discussed in the document reporting the over-all research performed in conjunction with the "Analysis of Community Shelter Systems." The research report presented here was prepared by the "Boston team."

One of the first tasks of the Boston team was to formulate a concept of the objectives and scope of their particular study. It was concluded that the primary objective was to develop a plan for allocating people to fallout shelters. The secondary objective was to identify and evaluate problems associated with the development and implementation of a city-wide shelter use plan. The study was to result, not in a planning guide for

Boston, but in a complete research report in terms of the approach, methodology, and results of developing a shelter allocation plan for Boston. In addition, problem areas observed during the course of the research which had implications on the broader shelter use plan would be included. This report was to be written in such a manner that: it could be used in the preparation of the planning guide; it could be useful to the City of Boston in developing its shelter use plan; and although it was to be a completely separate report, it could become a part of the general research report covering the "Shelter Systems" task.

The study was to be limited to the City of Boston; i.e., it would not cover metropolitan Boston. Although this limitation was necessary from the standpoint of time and research funds, it became evident soon after the study was initiated that communities in metropolitan areas would have to coordinate their plans and in some cases develop a plan that was more inclusive than that for an individual community. This need is discussed in this report.

Approach Taken by the Research Team

The approach taken by the Boston team included the following six steps:

1. Survey of background literature
2. Field work--information and data collection
3. Data analysis and evaluation
4. Development of a plan
5. Oral presentation of the study--critique of the plan
6. Preparation of a written report

The first step, and one which was actively pursued during the entire study, was to obtain and evaluate a variety of literature which might be useful in understanding the programs and problems of civil defense or which might be useful directly in developing a shelter allocation and use plan. This literature ranged from the LIVE book to OCD memoranda to state and local governments and to shelter plans prepared by a number of communities and organizations. Much of the literature was most useful to the research team as background information, but some will be especially useful to local civil defense (CD) planning groups in developing a shelter

use plan. A selected list of the latter documents is contained in Appendix A.

The initial field work was performed to obtain general background knowledge of the progress and problems associated with the National Fallout Shelter Survey, Marking, and Stocking Program and the implications of importance to the development of a shelter allocation and use plan. Discussions were held with personnel of the California State Disaster Office, San Francisco Disaster Council and Corps, and the District of Columbia Civil Defense Office to obtain views from organizations that are already advanced well in the program. Discussions were also held with various personnel in the Office of Civil Defense, to obtain the federal viewpoint. An interview was held with personnel from the Department of Commerce, Bureau of the Census, to determine the extent to which census statistics would be useful in allocating people to shelters.

The most concerted effort in collection of data and information to assist in the development of a shelter allocation plan for Boston was conducted during a two-week field trip in the Boston area by the research team. Detailed discussions were held with personnel from the Office of Civil Defense, Region One Office; the State of Massachusetts Civil Defense Agency; and the City of Boston, Civil Defense Department. Discussions were also held with members of the U.S. Army Corps of Engineers, New England Division. This group had contract administration responsibility over the three architect-engineering (A&E) firms conducting the National Fallout Shelter Surveys in Boston. The A&E firms were also interviewed. Other discussions were held with persons in a number of departments of the City of Boston which have particular relationships to civil defense--the Massachusetts Transit Authority (MTA) which is a political subdivision unto itself as far as civil defense is concerned and which has jurisdiction over the rapid transit and bus transportation networks in the city, and the John Hancock Mutual Life Insurance Co. and Gillette Safety Razor Co., both of which have done outstanding jobs of civil defense planning for their own employees. A more complete list of individaals and organizations contacted in Boston is contained in Appendix B.

The next major step was to assimilate the large quantities of data and information obtained during the field work. Analyses and evaluation of the data and information are discussed in detail in the text of this report. The preliminary analyses led to the development of a proposed shelter allocation plan for Boston; more detailed analyses were then performed to derive a methodology for general allocation and, ultimately, specific assignment of people to shelters. The specific background and knowledge of the Boston team in city and community planning and problem-solving was particularly useful and the study as ultimately completed is heavily oriented toward a city planning approach.

An oral presentation of the study and its results was given before three groups in the Boston area--the Federal OCD Region One Office, Massachusetts Civil Defense Agency, and Boston Civil Defense Department. Several other city departments and the MTA were also represented in the latter meeting. The purpose of these presentations was to obtain a full critique of the plan as developed by the Boston team from persons particularly familiar with the City of Boston and with civil defense. The results of this critique were valuable in finalization of the study and in clarification of the various subjective aspects of civil defense planning and problems. During these presentations the Boston team stressed the fact that their plan is in no sense a final or official plan for Boston, since such a plan can come only from the Office of Civil Defense.

## Terms Used in the Report

A number of terms used in this report may require clarification. Some of these terms are becoming part of the "language" of civil defense, and others have been defined in a certain manner to suit their use in this particular study. Only the more important ones are mentioned here; the others are self-explanatory.

In this report, "allocation plan" is defined as a plan indicating how people should be moved into shelter. "Use plan" is defined as a plan which indicates how shelters are to be used and maintained. The "use plan" includes within it the "allocation plan" in addition to all the other aspects of planning for shelter use--licensing, marking and stocking, communications, public information, and so on. "Use plan" includes all functions leading up to actual use of shelters and maintaining a shelter system. It does not include planning for the problems to be faced by people within individual shelters once their use has been initiated, and it does not include planning for the post-attack emergence of people from shelters.

Another term used in this report is "protection factor" (PF). Protection factor is a number representing the degree or factor by which radiation is reduced (shielded), thus affording protection to people. For example, a PF of 100 for a certain building means that persons within that building will receive only one one-hundredth (1/100 or 0.01 or 1%) of the radiation dose they would receive outside the building. Certain PF ranges have been assigned categories by the federal government, as follows:

| Protection Factor | PF Category |
|---|---|
| 20-39 | 1 |
| 40-69 | 2 |
| 70-99 | 3 |
| 100-149 | 4 |
| 150-249 | 5 |
| 250-499 | 6 |
| 500-1000 | 7 |
| Over 1000 | 8 |

PF categories have not been used in this report. It should be noted however, that they are used extensively in the data prepared as a result of the National Fallout Shelter Surveys.

Terms peculiar to this report include: stocked shelter, unstocked refuge, and makeshift refuge. Stocked shelters are those identified during the National Fallout Shelter Surveys as meeting the criteria for stocking with federal supplies (i.e., a PF of 100 or more and capacity for 50 or more people).* Unstocked refuges are those shelters identified during the National Fallout Shelter Surveys as not meeting the minimum requirements of PF (and therefore will not be stocked with federal supplies) but which do have a PF of at least 40 (i.e., unstocked refuges will have PF's ranging from 40 to 99). Makeshift refuges are defined as shelters of use only if no higher quality protection is available. Primarily they will consist of home basements or other shelters having a PF of less than 40.

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* Up to and including the time this study was performed and the report was drafted, these criteria were also applied in determining whether a shelter facility would be licensed and marked. In November 1962, in order to take maximum advantage of existing protection, the Office of Civil Defense adopted as an interim measure a policy of marking shelters with PF 40-99. In January 1963, this was extended to provisioning these shelters. OCD now uses the terms, "shelter" for PF over 100, "interim shelter" for PF 40-99, and "expedient shelter" for PF less than 40. Because this study was nearly complete and time was limited, the plans developed for Boston were not changed. However, the implications of these changes may be extensive as is discussed in Appendix C.

## Acknowledgments

The authors wish to acknowledge with appreciation the interest, cooperation, and assistance extended to them by the many organizations and individuals contacted in regard to this study. Too numerous to be mentioned here individually, they include persons at all levels of government and private enterprise.

The Institute research team performing the study consisted of the authors of this report, supported by the able research assistance of Carol Davis. The study was conducted under the administrative and technical guidance of Rogers S. Cannell, Director, Emergency Planning Research.

## II CONCLUSIONS AND SUMMARY

### Conclusions

The major conclusions of this study are as follows:

1. The shelter allocation plan for the City of Boston should consist of two stages.

   a. In the first stage, initiated upon the sounding of the alert, persons should walk to the nearest shelter that is within one (1) mile (based on a 30-minute time allowance) and await further instructions. If stocked shelter is not available within this distance or if the available capacity is expected to be filled by persons closer to the shelter, then unstocked (lower protection) refuges or makeshift refuge should be used, in that order. A certain amount of shelter space that does not meet federal criteria for stocking will have to be used and should be marked as "unstocked refuge."

   b. The second stage of the plan should be initiated by CD officials after the local attack situation is evaluated. In this stage, inadequately sheltered persons should be moved to higher protection shelters, if possible. The movement can occur either before or after arrival of fallout from the attack. The extent to which people are instructed to move, their mode of travel, the time available for travel, and the distance that can be traversed cannot be predetermined--inherently these decisions must depend upon the actual situation.

2. The planning factors for Stage One--and indeed the rationale underlying the two-stage plan itself--should be based on likelihood that the worst fallout situation may occur. It has been determined that a nuclear "hit" in or close to the City of Boston could cause fallout to arrive in some parts of the city 30 minutes after the blast. Given this time and the likelihood that most people will have to walk to shelter, the distance that can be traversed is estimated to be 1 mile. Derivation of this distance includes a few minutes for "reaction" time and queueing time at the shelter.

3. Planning factors for Stage Two cannot actually be determined until the local situation is evaluated. To ease the burden of "on-the-spot" planning, especially in cases of pre-fallout movements of people where every minute is important, a number of postulated plans should be developed. The plan most nearly approximating the actual attack situation would be taken "off the shelf" after Stage One has been implemented, modified as appropriate, and initiated. For post-fallout movement of people, which should not be performed for several hours after fallout has arrived, sufficient time will be available in which to determine planning factors and movements of people and the use of an "off-the-shelf" plan is not so important.

4. An appropriate approach for allocating people to shelters in Boston is one which first solves the problem in a general manner and then considers specific assignment of people to shelter. Instructions should be prepared for informing people of the plan and its use based upon the general allocation determinations. These instructions can be made more specific later.

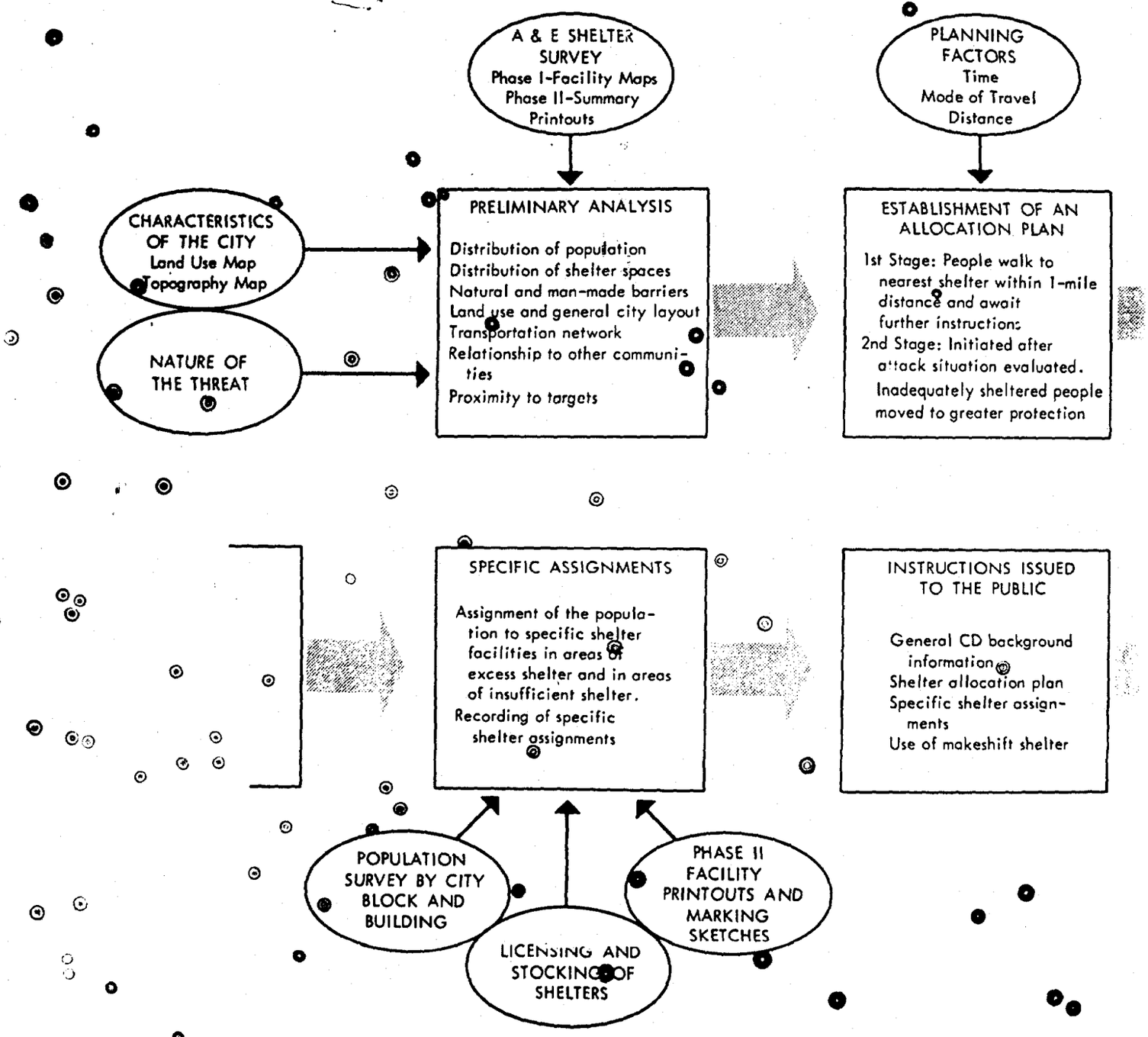
5. The shelter allocation plan developed for Boston may be applicable to some other cities or communities, but it will not be applicable to all. The methodology that has been developed for both the general allocation and the specific assignments of people to shelters should be applicable to most cities and communities. The planning approach used in this study should be applicable to all cities and communities, although in many, planning will be considerably more simple.

## Summary

Before a shelter allocation plan could be developed for Boston certain characteristics of the city and a general idea of the relationships between shelter spaces and population had to be determined (see Figure 1). It was found that the number of shelter spaces (1,440,025) identified in Phase II of the National Fallout Shelter Survey as meeting federal criteria for marking and stocking exceeded by nearly 20 percent the estimated peak population (1,214,700). However, these shelter spaces are not distributed throughout the city in any way comparable to the distribution of population. Although the largest peak population occurs during the daytime, the situation at night is only slightly improved. It was found that only 29 out of 156 standard locations (census tracts) in the city had shelter spaces (PF 100 and over) in excess of the peak daytime population within these standard locations (SL's). These 29 SL's contain 89 percent

FIGURE 1

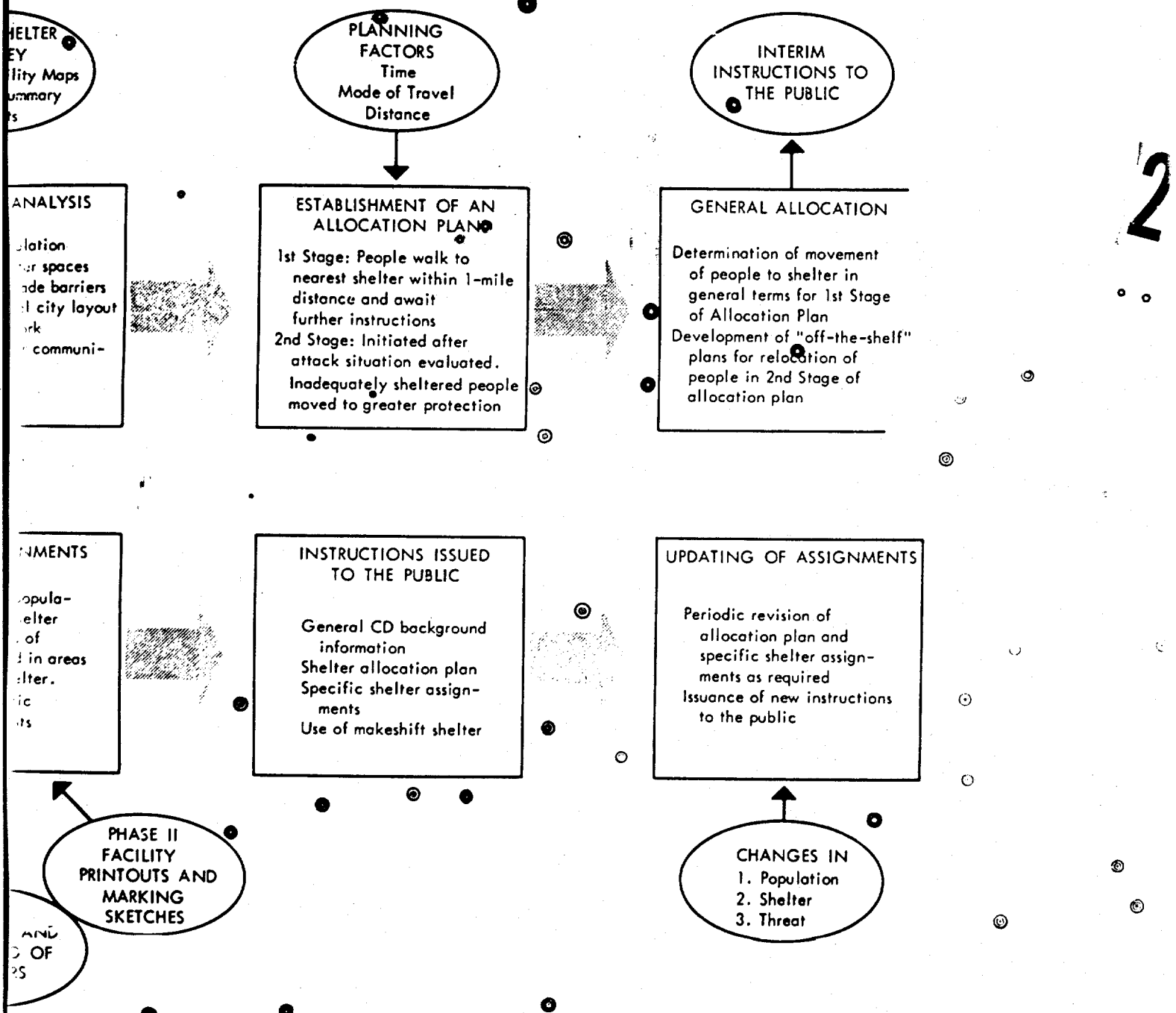
DEVELOPMENT OF A SHELTER PLAN




SOURCE: Stanford Research Institute.

FIGURE 1

DEVELOPMENT OF A SHELTER PLAN



of all shelter spaces having a PF of 100 or more, 75 percent of spaces having a PF of 70-99, and 69 percent of spaces having a PF of 40-69. (The latter do not meet the federal criteria for stocking and have been referred to in this report as "unstocked refuges.") However, these 29 SL's contain only 39 percent and 18 percent of the estimated peak daytime and nighttime populations, respectively, and represent only about 10 percent of the total land area in the city.

The magnitude of the problem of allocating people to shelter thus determined, it was then appropriate to consider plans which ultimately would allow maximum use of these poorly distributed shelter spaces. The first question that arises is how much time is available in which to get people to shelter? Obviously, given enough time all persons in Boston could be accommodated in stocked shelters. The amount of time needed, however, cannot be assured. A target analysis of Boston is not necessary to determine that the likelihood of an attack on the city or adjacent to it is a real one. Boston is a major population center, an important East Coast port city, has a large Navy shipyard, etc. In the estimation of the research team, any reasonable likelihood that a city will be a target or in close proximity to a target should automatically signal the need for developing a fallout shelter plan that allows for the worst fallout hazard.

It is <u>not</u> appropriate to extrapolate this decision to state that one should plan for the worst blast hazard. Were this the case, the result would often be one of doing nothing because the degree of protection from a major blast (10-20 megatons or more) is negligible at the present time. Therefore, one is forced to retreat slightly and decide a plan should be developed that is primarily based on the degree of fallout protection available currently for the majority of the population. There will also, of course, be some degree of protection from blast. With a continuing program, the time may arrive when degree of protection available has advanced to the point where a plan whose objective is full protection from blast is realistic. In the meantime, a plan formulated to maximize protection of the population from fallout is realistic for many situations. For example, a nuclear accident, an Nth power attack, a limited war, or even an all-out war wherein Boston is a target but the weapon misses and "hits" a mile out to sea--all these possibilities make a plan for protection of the population from fallout a desirable goal. The remaining problem of formulating an allocation plan, making a general allocation of people to shelter, and finally making specific assignments of people to shelter is relatively straightforward, although it may be time-consuming.

The time allowed for people to reach protection from fallout is determined to be about 30 minutes--in this time fallout can begin arriving

in certain parts of the city from a close blast. No time has been allowed between time of alert and time of blast because no more than a few minutes can be assured, and for planning purposes it is preferable to assume the worst situation. To determine the distance that can be traversed in the given 30 minutes, consideration has to be given to the mode of travel. For the majority of persons in Boston, the only realistic mode of travel will be walking. The extremely high population density, combined with a situation of potential panic, probably will cause vehicular traffic to become jammed very early after an alert has sounded. In the planning approach, walking must therefore be assumed. The distance that can be traversed will probably average about 1 mile--this assumes a few minutes for reaction time and queueing time at the shelter.

The time-distance estimate is perhaps more conservative than a stopwatch determination will yield, but the need for being in shelter before fallout arrives cannot be overstressed. Fallout arriving 30 minutes or so after blast will build up rapidly and the radiation intensity will be extremely high compared with fallout a few hours old. A few minutes of exposure to fallout in trying to reach shelter can more than offset the advantage gained by reaching a higher protection shelter.

The methodology used in determining the number and location of persons capable of reaching stocked shelter and unstocked refuge in Stage One of the plan was based upon the time-distance relationship combined with the location of persons in relation to shelter spaces. A planning approach was used in which full use of maps became an integral part of the methodology. Thus, land use, natural and man-made barriers, transportation network, and so on were considered. The expected effects of human behavior were also considered. For example, it was assumed a person would not pass up a nearby shelter in order to leave it available for persons farther away. Thus, in the plan, persons nearest shelters were allocated first, followed by allocations of persons to fill excess spaces until either the 1-mile distance limitation or the limitation of available spaces was reached. Persons still remaining unsheltered were then allocated to unstocked refuge in the same way. Those persons still remaining unsheltered would have to use makeshift refuge.

The results of general allocation of people to shelter in Stage One are shown below in terms of percentages of persons sheltered in various types of shelter.

| | Stocked Shelters | Unstocked Refuges | Makeshift Refuge |
|---|---|---|---|
| Percent of day population | 64% | 12% | 24% |
| Percent of night population | 51 | 17 | 32 |

During the daytime, 53 percent of the total stocked shelter spaces would be utilized. At nighttime this percentage decreases to 33 percent.

Methods for allocating people to shelter in Stage Two follow the procedure used in Stage One, at least for pre-fallout movements. Cases were developed in the study in which the allocation was performed: (1) assuming fallout would arrive 2 hours after Stage One was implemented and (2) assuming fallout would arrive 10 hours after Stage One was implemented. In the first case, all persons in East Boston and Charlestown would be able to reach stocked shelter. Improvements would also occur in other parts of the city. In the second case, all persons in the city would be able to reach stocked shelter.

A third case was also developed in the study; it was assumed fallout arrived immediately after Stage One had been completed. It was determined that movement of people to areas of higher protection could begin after about two days for persons in PF 40 refuges and in areas of highest radiation intensity, assuming a one-hour sortie would be needed for some of these persons to reach stocked shelters. It was also determined that separate calculations are necessary to determine the optimum time for movement of people who are in differing PF refuges, have received different cumulative doses, will spend different periods of time in different fields of radiation intensity during sortie, and who have different degrees of protection during sortie. The net result of the sorties should be that all persons will be able to reach stocked shelter. Of course, the practical problems associated with post-fallout movements will be great, and the likelihood of reaching this ideal may be small. Detailed consideration of these problems was beyond the scope of the present study.

Specific assignment of people to shelter is a considerably more involved and time-consuming procedure than is general allocation. Furthermore, it must be based upon general allocation. Therefore, it is recommended that persons be instructed in the use of this two-stage plan and the general allocation movements. This can be considered an interim measure, but a very useful one, during the time specific assignments are being developed. The methodology used in making specific assignments is similar to that used in general allocation of people to shelter, except that the planner begins working with buildings, then city blocks, working

up to groupings of blocks. Slightly different approaches must be used for areas having a general excess of shelter spaces and areas having a general insufficiency of shelter spaces. In either case, more detailed population information than that resulting from the National Fallout Shelter Survey must be developed by the local CD organization. Also, a detailed record-keeping system must be established to account for assignments being made and for instructing persons in these assignments.

In addition to developing a shelter allocation plan for Boston and developing methods to be used in the general allocation and specific assignment of people to shelter, some consideration was also given to other factors which become a part of the city's over-all shelter use plan. Largely, specific factors given consideration in this study are related to or have special implications as a result of the two-stage allocation plan developed. The need for coordination between the CD organization and other city departments and special groups is established. Civil defense must have assistance from outside groups if it is to perform its job. The need for informing the public both about general civil defense and about the shelter allocation plan and its use is also established. Other requirements that are considered in some detail include: a continuing licensing, marking, and stocking program and keeping the plan up to date; an adequate two-way communications network between a control center and shelters and between shelters; data handling and record keeping; and CD personnel and assistance from other groups to maintain and implement the shelter use plan. All of these requirements are basic to the satisfactory initiation and implementation of the two-stage shelter allocation plan.

Some of the problems of generalizing the Boston plan and methods for use by other cities and communities were considered. Here, differences between other cities or communities and Boston in terms of population density, general city layout, relationship between distribution of population and shelter spaces, proximity to potential targets, and so on become of utmost importance. Some cities or communities probably can borrow the plan and methods exactly; however, most would have to make modifications to fit their situations more nearly. The planning approach used and developed throughout this study, of course, is applicable to all cities and communities.

## III DEVELOPMENT OF A SHELTER ALLOCATION PLAN

The allocation of people to fallout shelters is essential to any shelter use plan. Shelters, in themselves, are of no value unless they actually can be used to protect people from fallout. Consideration of the various "in-shelter" and post-attack problems of the civil defense program is predicated on the assumption that people will use shelters and will be protected from the effects of fallout. Therefore, each local CD organization is responsible for developing a plan for the allocation of people to shelters which is appropriate to the needs and situation of the particular community. With such a plan as the cornerstone, steps can then be taken to make the allocation plan operational and to develop the remainder of the shelter use plan.

Because each community differs from all others, no single shelter allocation plan is universally acceptable. Moreover, even within the same community, differences exist which may warrant several separate allocation plans. However, the various communities do have in common the need for a systematic planning approach to the solution of their individual problems. Development and implementation of an allocation plan are quite complex operations, if only because of the sheer number of people and shelters involved. Therefore, an analytical framework which could be used by various communities should be helpful. In fact, if the local CD organization does not adopt a systematic approach in the development of its shelter use plan, a great deal of effort will be spent unnecessarily, a less than optimum plan may be proposed, and the time required to reach the operational stage may be considerably lengthened.

This section, along with Sections IV and V, outlines the approach used in developing a shelter allocation plan for the City of Boston. The methodology, if not some of the specific solutions, should be helpful to other communities.

### Preliminary Analyses

Before a particular shelter allocation plan can be formulated, certain information must be generated and preliminary analyses and evaluations must be performed. The nature of the problem facing the individual community must be understood prior to any attempt to formulate a solution.

## Primary Data Inputs to the Analysis

The information provided each local CD organization as a result of Phases I and II of the A&E survey is the primary input to the analyses. Table I shows this information in outline form. Various portions of this information were used at different stages in the development of an allocation plan for Boston. Except where noted otherwise, the data used in Section III of this report can all be obtained from the Phase II summary printouts.

Inasmuch as the field work in Boston was undertaken before the Phase II summary printouts were available, the research team utilized a punched card system to generate the needed information. Data from Phase I summary printouts and Phase II marking sketches were punched into IBM cards which then were summarized and tabulated to provide data which the local CD organization will have available from the Phase II summaries.

Appendix D describes in detail the handling of data in the punched card system and the type of information obtained.

## Population

The 1960 resident population of the City of Boston as defined by the U.S. Census is 697,197. The A&E estimate of peak daytime population is 1,214,695; the estimate of peak nighttime population is 938,376. As can be seen, there is a considerable difference in the three population statistics.* Although the U.S. Census figure was obtained by an actual count of persons and the A&E figures are only estimates, it is still preferable to use the A&E day and night population figures in the development of the allocation plan. The Census figure is for 1960, whereas the A&E estimates are for 1962. More important, the A&E figures are a

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* In making their estimates, the A&E firms began with the resident census population of a particular census tract (standard location) and then adjusted this number to reflect the estimated peak or maximum population of the census tract that would occur during the daytime and during the nighttime. These adjustments were made in different ways for different census tracts according to the particular situation of the tract and the availability of additional information.

# Table I

## DATA ACCUMULATION AND DISTRIBUTION FALLOUT SHELTER SURVEY

### PHASE I DATA

| Base Maps and Address Lists | Address Cards | Address Card Lists | Protection Factor Lists | FOSDIC XEROX PRINTS | Standard Location SUMMARY | County Summary | State Summary |
|---|---|---|---|---|---|---|---|
| Base Map | Census Serial No. | Census Serial No. | Day & Night Population | Page Number | Standard Location Code | Standard Location Code | Standard Location Code |
| Standard Location Code | Field Office Code | Field Office Code | Field Office Code | Field Office Code | Day & Night Population | Day & Night Population | Day & Night Population |
| Facility No. | Contract No. | Contract No. | Contract No. | Contract No. | Field Office Code | Field Office Code | Field Office Code |
| Location of Facility | Standard Location Code | Standard Location Code | Standard Location Code | Standard Location Code | Contract No. | Contract No. | Contract No. |
| Day & Night Population | Page No. | Page No. | Number of Stories (ST) | Number of Stories (ST) | Peak Unsheltered Population | Peak Unsheltered Pop. | Peak Unsheltered Population |
| | Facility No. | Facility No. | Facility No. (FAC) | Facility No. | Capacity in spaces | Capacity in spaces | Capacity in spaces |
| Address Lists | Part No. | Part No. | Part No. (PT) | Part No. (PT) | and Number of Shelters | and Number of Shelters | and Number of Shelters |
| Architect Engineer | Revision No. | Revision No. | Revision No. (REV) | Revision No. (REV) | in each of 8 P. F. | in each of 8 P. F. | in each of 8 P. F. |
| Contract No. | Building Name | Building Name | Building Name | Building Name | Categories | Categories | Categories |
| City or Town | Building Address | Building Address | Building Address | Building Address | Summation of above | Summation of above | Summation of above |
| State | Use Classification Code | Use Classification Code | Use Classif. Code (USE) | Use Classif. Code (USE) | item in P. F. | item in P. F. | item in P. F. |
| Standard Location Code | | State | Ownership Code (OWN) | Ownership Code (OWN) | Categories 4-8 | Categories 4-8 | Categories 4-8 |
| Facility No. | | County or City | Physical Vulnerability | Physical Vulnerability | Total Buildings and | Total Buildings & | Total Buildings & |
| Name & Address of Facility | | | Code (PV) | Code PV | Buildings Rechecked | Buildings Rechecked | Buildings Rechecked |
| Name & Address of Facility Owner | | | Year Built (YEAR) | Year Built (Year) | Building with Shelters Cat. 4 | Building with Shelters Cat. 4 | Building with Shelters Cat. 4 |
| | | | Survey Method Code (SM) | | Balance | Balance | Balance |
| | | | Story | Story | | | |
| | | | Contribution Wall A (A) | Area Dimensions | | | |
| | | | Contribution Wall B (B) | Heights | | | |
| | | | Contribution Wall C (C) | Sketch of Building | | | |
| | | | Contribution Wall D (D) | | | | |
| | | | Contribution Roof (CL) | | | | |
| | | | Total Contribution (TOT) | | | | |
| | | | P F Categories (PF) | | | | |
| | | | TOTAL Floor Area (Floor) | | | | |
| | | | Reduced Area (S-AREA) | | | | |
| | | | Area of Core (CORE) | | | | |
| | | | Volume (VOLUME) | | | | |
| | | | Shelter Capacity (PEOPLE) | | | | |

| DISTRIBUTION | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OCE Division | | | | | | | | | | | 1 | 1 |
| Contracting Office | | 1 | | 1 | | 1 | | | 2 | | 2 | |
| Region 1 OCD | | | | 1 | | | | | | | 1 | 1 |
| State C.D. Director | | | | 1 | | 1 | | | 1 | | 2 | |
| Local C.D. Director | 1 | | | 1 | | 1 | | 1 | 1 | | | |
| Architect Engineer | 1 | | | | | 1 | | | | | | |
| Total | 2 | 1 | | 4 | | 4 | | 1 | 4 | | 6 | 2 |

## Table I (continued)

PHASE II DATA

| Special Facility Address Cards | Sketch or Description of Shelter | Report of Status of Shelter Licenses | Phase II Data Collection Form XEROX Prints | Phase II Lists | Phase II Summaries |
|---|---|---|---|---|---|
| Census Serial Number<br>Field Office Code<br>Contract Number<br>Standard Location Code<br>Page Number<br>Facility Number<br>Part Number<br>Revision Number<br>Facility Name<br>Facility Address<br>Use Classification Code | Description or sketch of each Shelter, depicting or locating the Shelter Area. Indicates Shelter Capacity and location of marking stickers, also building address, standard location code, and facility number | Weekly report indicating status of receipt of executed Fallout Shelter License or Privilege Forms | Name and Address of Facility<br>Standard Location Code<br>Field Office Code<br>Contract Number<br>Facility Number<br>Part Number<br>Revision Number<br>Special Facility Type<br>Rodent & Insect Data<br>Data on Existing Spaces<br>Data on Improved Spaces<br>Improved Shielding Analysis<br>Improved Ventilation Analysis<br>Improved Electrical Analysis | Instructions to be issued later | Instructions to be issued later |

| DISTRIBUTION | | | | | |
|---|---|---|---|---|---|
| OCE Division | | | 1 | | |
| Contracting Office | 1 | 1 | 1 | | |
| Region 1 OCD | | 1 | 1 | | |
| Station C.D. Director | | 1 | 1 | | |
| Local C.D. Director | | 1 | | 1 | |
| Architect Engineer | | | | | |
| Total | 1 | 4 | 4 | 1 | |

Source: U.S. Army Corps of Engineers, New England Division.

closer approximation of the numbers of people actually in the city during the day and at night. The Census figure includes only those people who meet the Census definition of resident. As a result, this figure does not include those people who are in the city for purposes of work, shopping, or pleasure during the day or night but whose homes are located outside the city. Moreover, the resident figure does not include transients living in hotels and motels, students whose permanent homes are in some other community, military personnel who maintain a legal residence elsewhere, and persons who are institutionalized but are not residents of the community. For a city such as Boston, a considerable number of people do not meet the definition of resident but still must be protected from fallout in the event of an emergency.

It should be noted that the total peak population of Boston for either day or night is the result of the sum of the peak populations for each individual census tract. Since the peak population would not necessarily occur at the same time or on the same day of the week for every one of the census tracts in the city, the summation of peak population by census tracts would probably be greater than the peak population of the city as a whole. However, this fact does not invalidate the use of the A&E estimates since the assignment problem for the city is solved area by area within the city and not by matching total population to total shelter space in the entire city.

## Fallout Shelter Spaces

The number of fallout shelter spaces identified by the A&E firms in Phases I and II is tabulated below:

| | |
|---|---|
| Number of spaces with PF 40-69 | 1,000,713* |
| Number of spaces with PF 70-99 | 435,633* |
| Number of spaces with PF 100 and over | 1,449,199** |
| Total number of spaces with PF 40 and over | 2,885,545 |

Phase II data are used in preference to Phase I data wherever possible, because Phase II information has greater accuracy and reliability. The

---

* From Phase I survey information.
** From Phase II survey information.

difference between Phase I and Phase II shelter data is considerable; Appendix D discusses in detail the differences found for the City of Boston. It would be advisable for local CD organizations to wait until they have received the Phase II summaries before undertaking the development of a shelter allocation plan.

The distribution of shelters and shelter spaces (PF 100 and greater) in Boston according to shelter size is shown in Figures 2 and 3.

On the basis of these figures it is apparent that the number of shelter spaces with a PF of 100 and over is greater than the peak daytime population. Furthermore, it appears that only about one-third of the facilities identified as having this quality shelter would be required because 90 percent of all the shelter space is located in facilities having a capacity of more than 500 people.

However, conclusions based upon a superficial "first look" are premature. The gross statistics on shelter space and population do not reflect where people are located and where the shelter space exists. The relationship between the locations of people and shelters is extremely important and must be studied in some detail before valid conclusions can be reached. The necessity for additional analysis which takes location into consideration will become apparent later in this report.

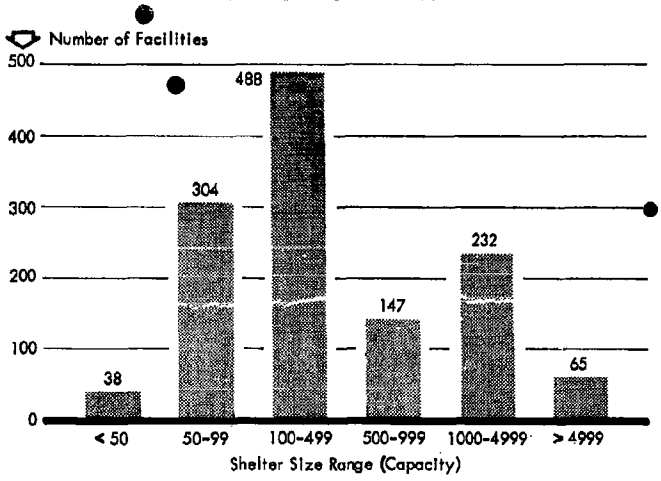
## Selection of a Base Map

In considering the locations of people and shelter, maps of a city are helpful. A base map of the city showing streets and major landmarks should be selected; several copies will be needed for use in the analysis of the shelter allocation problem. The scale of the map should not be so large as to make it unwieldy nor should it be so small that certain census tract information cannot be shown. The map of Boston used by the research team during the preliminary analyses was at the scale of 1 inch equal to 1,600 feet. Listed below are several sources where such a map might be obtained for other communities:

1. City engineers
2. City planning departments
3. Utility companies
4. Chambers of Commerce
5. Commercial street map companies

FIGURE 2

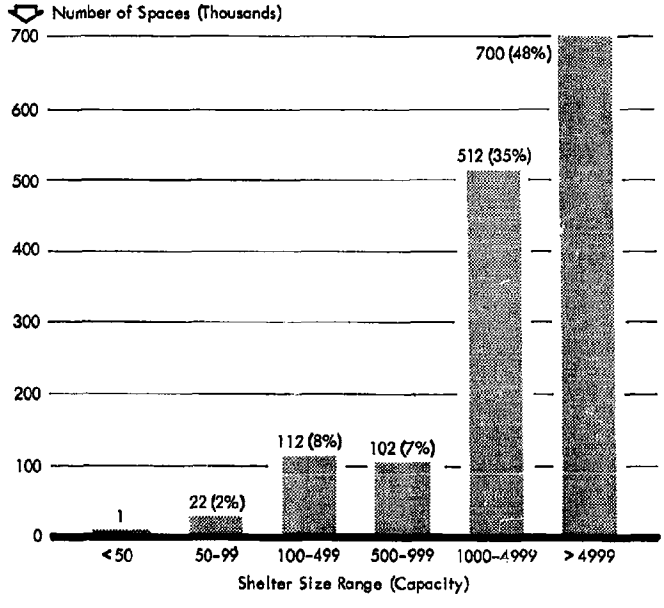
DISTRIBUTION OF PF 100 AND OVER FACILITIES
BY SHELTER SIZE RANGE




SOURCE: Developed by Stanford Research Institute from Phase II data.

FIGURE 3

DISTRIBUTION OF PF 100 AND OVER SPACES
BY SHELTER SIZE RANGE




SOURCE: Developed by Stanford Research Institute from Phase II data.

On one copy of the base map, Standard Location (SL) boundaries should be drawn and the SL numbers should be indicated. The location of SL boundaries can be determined from the shelter location maps furnished by the A&E firm in Phase I. Also, because SL boundaries are identical with those of census tracts, the maps included in the U.S. Census publications, Census Tract Statistics or City Block Statistics, can be used. A base map showing location of SL boundaries in Boston is shown in Figure 4 (in the pocket at the end of this report). This map is basic to understanding not only Table II but also the other maps in this report. In Figure 4, only major streets as defined by the Boston City Planning Board are shown.

Shelter Location Map

Also in the preliminary analyses, a map showing the exact location of the various shelters identified by the A&E firms will be needed. The location of each shelter can be shown by drawing a small circle, square, or triangle on the map or by using map pins obtained from an office supply house. The size of each facility can be indicated by color coding, and the PF can be indicated by the shape of the dot drawn on the map or of the pinhead used. The coding system used by the research team for Boston was as follows:

| Capacity of the Facility (number of spaces) | Color Code |
|---|---|
| 50-99 | Black |
| 100-249 | Gray |
| 250-499 | Green |
| 500-999 | Red |
| 1,000-4,999 | Orange |
| 5,000 & over | Yellow |

| PF of the Facility | Code |
|---|---|
| 100 & over | Circle |
| 40-99 | Triangle |

Of course, various other coding systems could be developed.

Included in the Phase II summary of shelter facilities are the facility number, capacity, and PF category for each facility identified as having shelter. Maps provided by the A&E's in Phase I show the location of each shelter by facility number. By looking up each facility by its number on the Phase II summary and then locating each of these numbers on the Phase I map, a shelter location map characterizing the shelter by size and PF can be prepared. The Phase I A&E maps cannot be used directly because they indicate all facilities for which protection calculations were made and many of these were eliminated as being inadequate in Phase II. Moreover, in Boston the A&E's used several different maps in various scales.

The A&E data include all shelters, regardless of whether they are licensed. If the shelter licensing program is already completed, the local CD organization may choose only to indicate the location of licensed shelters rather than showing all shelters identified by the A&E's.

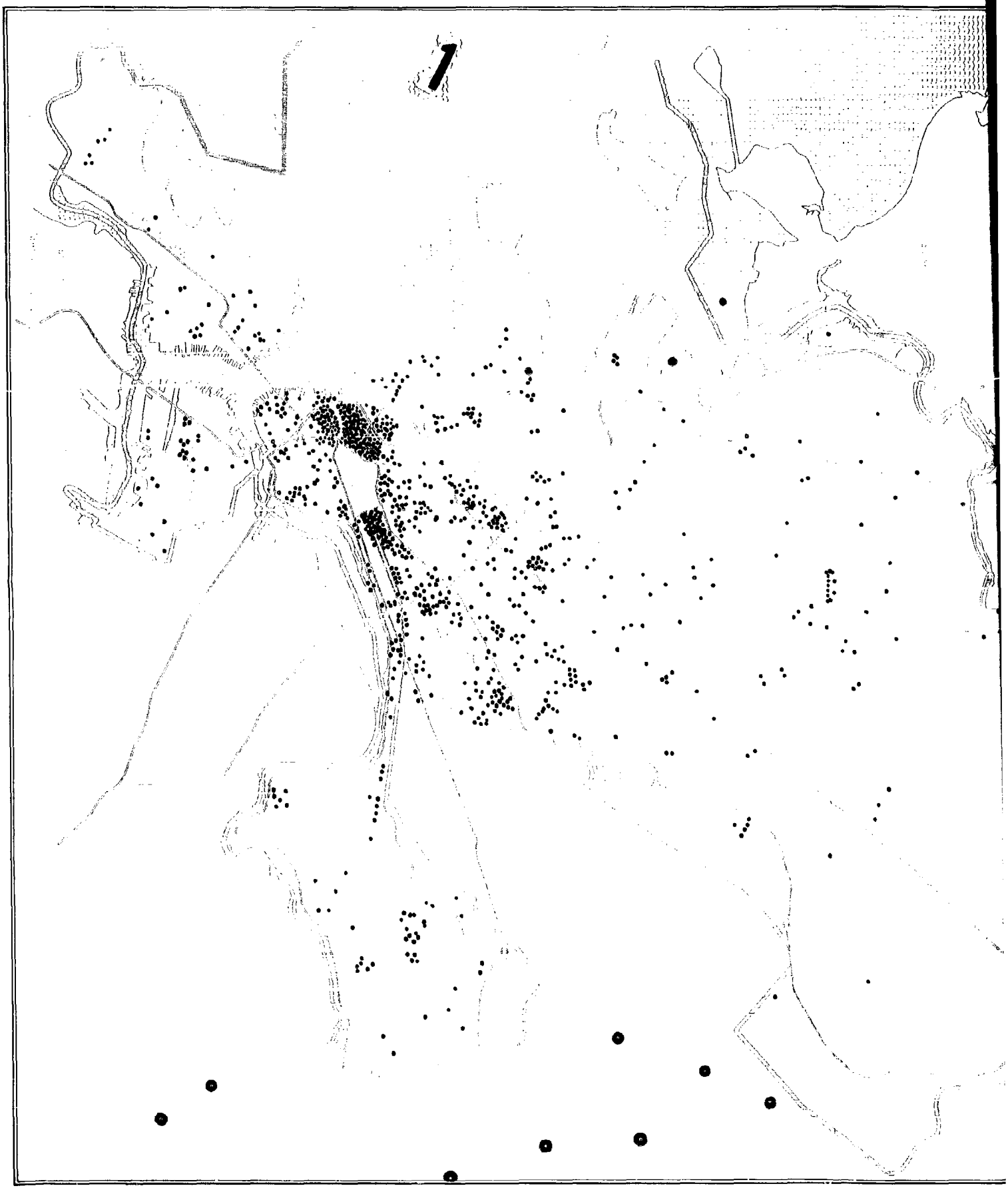
A great number of the shelters will probably be concentrated in a relatively small downtown area. Therefore, it is advisable to use a larger scale map for indicating shelter locations than the base map previously mentioned; otherwise there will not be enough room on the map to show all the shelters. Another alternative is to use a blowup or larger map for those specific areas which have heavy shelter concentrations.

The shelter location map for Boston is shown in Figure 5. The problem of uneven distribution of shelters that must be solved by the allocation plan becomes apparent from considering this map. In all probability, it will be found in other cities, as in Boston, that shelters are not distributed evenly over the city.

## Tabulation of Shelter Location vs Distribution of People

The location of shelters is only one aspect of the problem of allocating people to shelters. Even more important is the location of people in relation to the location of shelters. Calculations must be made to determine which areas in the city do not have enough shelter space to accommodate the people in that area and which areas have adequate or even excess shelter capacity.

For the preliminary analysis, the quickest and most effective way to look at this people-shelter relationship is by standard location, because necessary population and shelter data available from Phase II



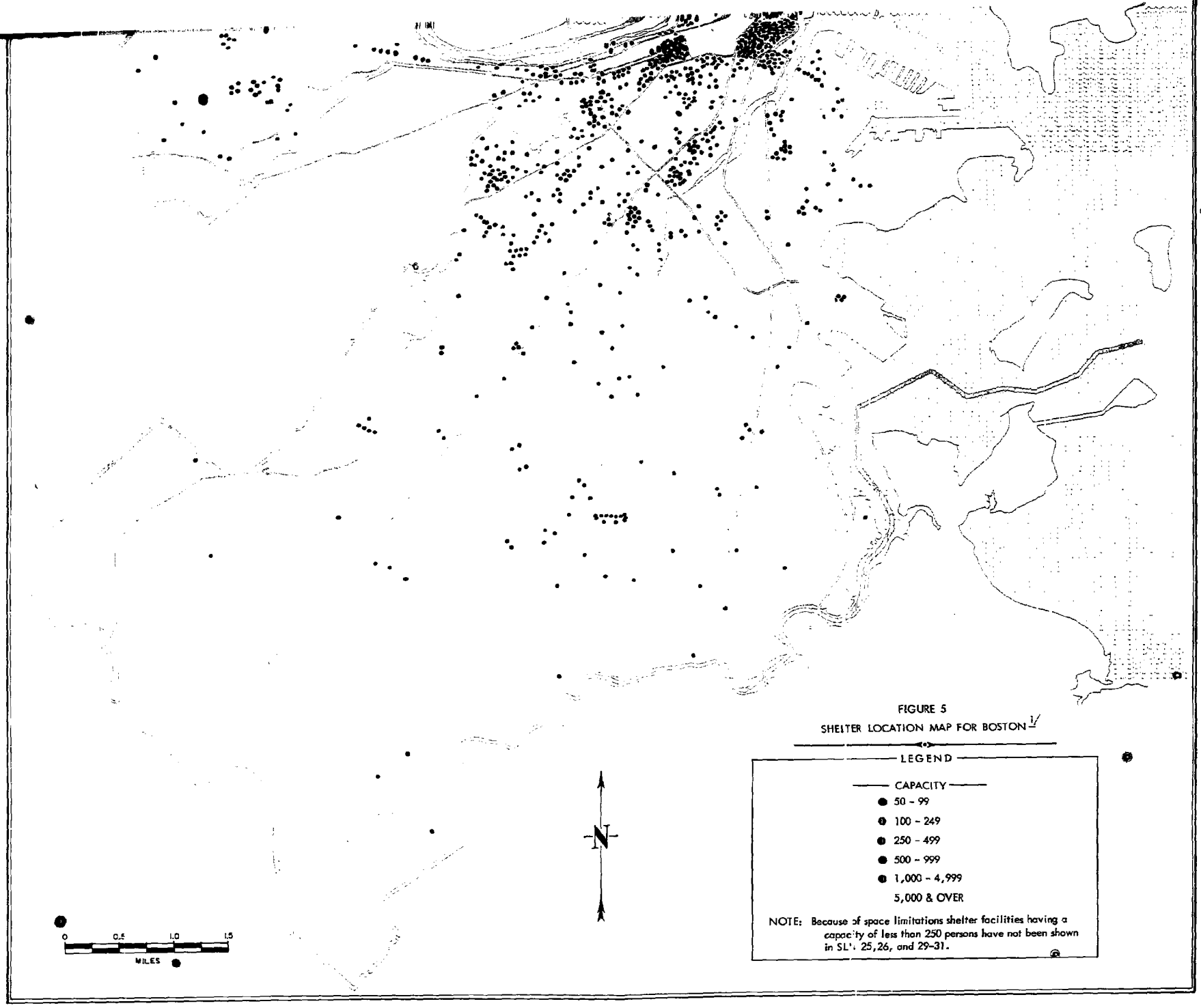



FIGURE 5

SHELTER LOCATION MAP FOR BOSTON 1/

SOURCE: Developed by Stanford Research Institute from Phase II marking sketches and A & E Phase I base maps.

1/ PF 100 and over facilities as identified in Phase II.

are summarized by standard location and boundaries of the standard locations are easily determined.

For each standard location, the number of unsheltered people or the number of excess shelter spaces, as the case may be, should be calculated both for day and for night. The calculation consists simply of subtracting population from the number of shelter spaces. If the result is positive it represents excess spaces; if the result is negative it represents unsheltered people. These calculations should first be made using the number of shelter spaces in the PF 100 and over range. The calculations should be made again using the number of spaces in the PF 40 and over range because, in some standard locations, facilities of the lower PF may have to be used. Space with a PF of 20-39 was not included in the calculations for Boston because this space was thought to be no better than the protection which people would probably have in the basements of their own homes. During the Boston study, separate calculations were also made for the PF 60 and over range; however, it was found that this intermediate determination was not really necessary because, when the protection criterion was set below PF 100, it was generally necessary to change the criterion all the way to PF 40 before significantly increasing the available space. Table II shows the calculations which were made for the City of Boston.

By subtracting the number of people from the number of shelter spaces, the assignment of people in a standard location to the available shelter in that standard location has been made. The result of the subtraction shows how many people still need protection, where they are located, and the number and location of unused shelter spaces. The assumptions underlying these calculations are that the people within a standard location would be able to get to the shelters in that standard location and that there would be no cross-movement between standard locations. For purposes of the preliminary analyses, these assumptions are acceptable and necessary to obtaining a quick over-all picture of the shelter allocation problem. In Section IV these assumptions will be refined and the shelter-people relationship will be considered in greater detail.

## Graphic Representation of People-Shelter Relationships

Table II shows most of the information important to the allocation problem, but it is in a form which is difficult to analyze. Although the SL numbers are a statement of location, it is almost impossible to visualize the entire problem just by looking at the tabulations and a map showing SL boundaries. The representation of all the information on

Table II

POPULATION, SHELTER SPACES, AND UNSHELTERED PEOPLE OR EXCESS SHELTER SPACES BY STANDARD LOCATION FOR THE CITY OF BOSTON[a]

| Standard Location (SL) Number | Shelter Spaces: PF 100 & over | Shelter Spaces: PF 70-99 | Shelter Spaces: PF 40-69 | Daytime: Pop. | Daytime: PF 100 & over Spaces minus Pop.[b] | Daytime: PF 40 & over Spaces minus Pop.[b] | Nighttime: Pop. | Nighttime: PF 100 & over Spaces minus Pop.[b] | Nighttime: PF 40 & over Spaces minus Pop.[b] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1,055 | 289 | 562 | 30,000 | 28,945- | 28,094- | 7,200 | 6,145- | 5,294- |
| 2 | 1,013 | 33 | 529 | 3,000 | 1,987- | 1,425- | 4,500 | 3,487- | 2,925- |
| 3 | 138 | 0 | 2 | 3,100 | 2,964- | 2,962- | 5,300 | 5,164- | 5,162- |
| 4 | 561 | 600 | 610 | 2,600 | 2,039- | 829- | 4,500 | 3,939- | 2,729- |
| 5 | 2,195 | 2,033 | 1,430 | 2,900 | 705- | 2,758+ | 5,200 | 3,005- | 458+ |
| 6 | 54 | 107 | 87 | 1,800 | 1,746- | 1,552- | 3,200 | 3,146- | 2,952- |
| 7 | 0 | 48 | 180 | 1,200 | 1,200- | 972- | 2,000 | 2,000- | 1,772- |
| 8 | 354 | 0 | 433 | 2,000 | 1,646- | 1,213- | 2,400 | 2,046- | 1,613- |
| 9 | 52 | 543 | 2,204 | 2,200 | 2,148- | 599+ | 2,600 | 2,548- | 199+ |
| 10 | 7,179 | 1,571 | 1,280 | 900 | 6,279+ | 9,130+ | 1,700 | 5,479+ | 8,330+ |
| 11 | 824 | 1,450 | 705 | 1,300 | 476- | 1,679+ | 2,300 | 1,476- | 679+ |
| 12 | 2,559 | 2,717 | 4,719 | 6,000 | 3,441- | 3,995+ | 4,000 | 1,441- | 5,995+ |
| 13 | 730 | 4,189 | 2,745 | 2,792 | 2,062- | 4,872+ | 2,127 | 1,397- | 5,537+ |
| 14 | 7,632 | 13,789 | 35,236 | 12,500 | 4,868- | 44,157+ | 3,900 | 3,732+ | 52,757+ |
| 15 | 739 | 11 | 34 | 1,500 | 761- | 716- | 2,500 | 1,761- | 1,716- |
| 16 | 379 | 1,150 | 2,783 | 3,000 | 2,421- | 1,512+ | 4,200 | 3,621- | 312+ |
| 17 | 3,904 | 1,558 | 17,287 | 4,000 | 96- | 18,749+ | 1,000 | 2,904+ | 21,749+ |
| 18 | 635 | 1,102 | 899 | 2,500 | 1,865- | 136+ | 800 | 165- | 1,836+ |
| 19 | 72 | 0 | 28 | 1,600 | 1,528- | 1,500- | 2,100 | 2,028- | 2,000- |
| 20 | 0 | 0 | 12 | 1,400 | 1,400- | 1,388- | 2,500 | 2,500- | 2,488- |
| 21 | 30 | 142 | 54 | 2,000 | 1,970- | 1,774- | 2,800 | 2,770- | 2,574- |
| 22 | 524 | 76 | 1,383 | 2,000 | 1,476- | 17- | 2,400 | 1,876- | 417- |
| 23 | 9,801 | 2,018 | 6,980 | 4,000 | 5,801+ | 14,799+ | 5,000 | 4,801+ | 13,799+ |
| 24 | 4,871 | 272 | 6,275 | 3,000 | 1,871+ | 8,418+ | 3,500 | 1,371+ | 7,918+ |
| 25 | 198,694 | 37,216 | 72,191 | 70,000 | 128,694+ | 238,101+ | 1,300 | 197,394+ | 306,801+ |
| 26 | 17,495 | 1,595 | 7,701 | 6,000 | 11,495+ | 20,791+ | 3,600 | 13,895+ | 23,191+ |
| 27 | 172 | 527 | 4,379 | 4,000 | 3,828- | 1,078+ | 2,200 | 2,028- | 2,878+ |
| 28 | 83,167 | 7,747 | 15,760 | 9,000 | 74,167+ | 97,674+ | 1,300 | 81,867+ | 105,374+ |
| 29 | 471,893 | 91,501 | 169,104 | 151,250[c] | 371,894+ | 632,499+ | 30,000 | 441,893+ | 702,498+ |
| 30 | 8,945 | 4,205 | 20,302 | 25,100 | 16,155- | 8,352+ | 11,500 | 2,555- | 21,952+ |
| 31 | 22,402 | 7,626 | 15,305 | 9,800 | 12,602+ | 35,533+ | 7,900 | 14,502+ | 37,433+ |
| 32 | 1,336 | 812 | 1,715 | 3,150 | 1,814- | 713+ | 800 | 536+ | 3,063+ |
| 33 | 180 | 2 | 81 | 300 | 120- | 37- | 500 | 320- | 237- |
| 34 | 31,203 | 9,149 | 18,261 | 22,000 | 9,203+ | 36,613+ | 800 | 30,403+ | 57,813+ |
| 35 | 15,697 | 5,477 | 16,243 | 7,000 | 8,697+ | 30,417+ | 2,000 | 13,697+ | 35,417+ |
| 36 | 63,423 | 8,688 | 10,117 | 10,000 | 53,423+ | 72,228+ | 3,500 | 59,923+ | 78,728+ |
| 37 | 143 | 64 | 698 | 2,550 | 2,407- | 1,645- | 2,200 | 2,057- | 1,295- |
| 38 | 12,879 | 5,704 | 4,702 | 3,200 | 9,679+ | 20,385+ | 1,000 | 11,879+ | 22,285+ |
| 39 | 369 | 172 | 753 | 5,500 | 5,131- | 4,206- | 5,300 | 4,931- | 4,006- |
| 40 | 3,203 | 1,729 | 2,674 | 5,900 | 2,697- | 1,706+ | 3,300 | 97- | 4,306+ |
| 41 | 32,959 | 23,198 | 44,608 | 28,900 | 6,059+ | 74,165+ | 12,000 | 20,959+ | 89,065+ |
| 42 | 5,799 | 761 | 6,010 | 4,900 | 899+ | 7,670+ | 2,800 | 2,999+ | 9,770+ |
| 43 | 74,296 | 8,996 | 33,884 | 22,050 | 51,246+ | 94,126+ | 12,800 | 61,496+ | 104,376+ |
| 44 | 21,320 | 3,316 | 11,161 | 8,700 | 12,620+ | 27,097+ | 5,800 | 15,520+ | 29,997+ |
| 45 | 15,990 | 5,579 | 12,111 | 18,350 | 2,360- | 15,330+ | 28,500 | 12,510- | 5,180+ |
| 46 | 1,819 | 718 | 5,592 | 2,200 | 381- | 5,929+ | 4,000 | 2,181- | 4,129+ |
| 47 | 3,087 | 1,938 | 7,667 | 2,800 | 287+ | 9,892+ | 8,000 | 4,913- | 4,692+ |
| 48 | 16,704 | 7,572 | 27,819 | 5,000 | 11,704+ | 47,095+ | 6,700 | 10,004+ | 45,395+ |
| 49 | 19,936 | 16,246 | 43,188 | 16,000 | 3,936+ | 63,370+ | 6,500 | 13,436+ | 72,870+ |
| 50 | 21,351 | 13,523 | 34,165 | 22,975 | 1,624- | 46,064+ | 36,900 | 15,549- | 32,139+ |
| 51 | 28,896 | 23,213 | 40,018 | 26,400 | 2,496+ | 65,727+ | 11,200 | 17,696+ | 80,927+ |
| 52 | 641 | 34 | 1,350 | 3,500 | 2,859- | 1,475- | 3,800 | 3,159- | 1,775- |
| 53 | 271 | 636 | 1,991 | 3,600 | 3,329- | 702- | 4,300 | 4,029- | 1,402- |
| 54 | 63 | 20 | 428 | 2,600 | 2,537- | 2,089- | 3,700 | 3,637- | 3,189- |
| 55 | 439 | 391 | 1,845 | 1,750 | 1,311- | 925+ | 2,200 | 1,761- | 475+ |
| 56 | 2,703 | 1,156 | 6,806 | 4,075 | 1,372- | 6,590+ | 2,300 | 403+ | 8,365+ |
| 57 | 4,333 | 2,527 | 8,415 | 7,025 | 2,692- | 8,250+ | 6,250 | 1,917- | 9,025+ |
| 58 | 39,674 | 39,286 | 72,516 | 12,376 | 27,298+ | 139,100+ | 3,861 | 35,813+ | 147,615+ |
| 59 | 0 | 0 | 0 | 2,293 | 2,293- | 2,293- | 2,000 | 2,000- | 2,000- |
| 60 | 722 | 961 | 434 | 3,405 | 2,683- | 1,288- | 3,727 | 3,005- | 1,610- |
| 61[d] | 18,321 | 3,885 | 15,828 | 11,294 | 9,654+ | 29,387+ | 2,083 | 18,885+ | 38,578+ |
| 62 | 473 | 235 | 689 | 6,902 | 6,429- | 5,505- | 5,526 | 5,053- | 4,129- |
| 63 | 0 | 17 | 59 | 11,356 | 11,356- | 11,280- | 4,465 | 4,465- | 4,389- |
| 64 | 0 | 117 | 65 | 3,650 | 3,650- | 3,468- | 3,033 | 3,033- | 2,851- |
| 65 | 375 | 0 | 581 | 5,697 | 5,322- | 4,741- | 5,263 | 4,888- | 4,307- |
| 79 | 3,087 | 1,959 | 4,290 | 4,600 | 1,513- | 4,736+ | 3,300 | 213- | 6,036+ |
| 80 | 1,497 | 434 | 2,622 | 4,400 | 2,903- | 153+ | 4,700 | 3,203- | 147- |
| 81 | 1,606 | 1,317 | 4,026 | 3,400 | 1,794- | 3,549+ | 2,800 | 1,194- | 4,149+ |
| 82 | 0 | 19 | 93 | 4,500 | 4,500- | 4,388- | 4,200 | 4,200- | 4,088- |
| 83 | 915 | 93 | 211 | 4,375 | 3,460- | 3,158- | 4,450 | 3,535- | 3,231- |
| 84 | 3,460 | 1,114 | 1,589 | 4,700 | 1,240- | 1,463+ | 3,200 | 260+ | 2,963+ |
| 85 | 2,329 | 510 | 2,556 | 2,100 | 829+ | 3,895+ | 3,300 | 371- | 2,695+ |
| 86 | 17,156 | 7,179 | 25,252 | 30,250 | 13,094- | 19,337+ | 16,850 | 306+ | 32,737+ |
| 87 | 732 | 687 | 1,544 | 4,100 | 3,368- | 1,137- | 4,000 | 3,268- | 1,037- |
| 88 | 6,682 | 2,473 | 1,929 | 4,900 | 1,782+ | 6,184+ | 4,200 | 2,482+ | 6,884+ |
| 89 | 26,307 | 2,748 | 9,785 | 9,000 | 17,307+ | 29,840+ | 8,400 | 17,907+ | 30,440+ |
| 90 | 7,958 | 635 | 5,219 | 11,450 | 3,492- | 2,362+ | 6,250 | 1,708+ | 7,562+ |
| 91 | 835 | 28 | 24 | 3,200 | 2,365- | 2,313- | 3,800 | 2,965- | 2,913- |
| 92 | 1,903 | 7,186 | 23,434 | 12,197 | 10,294- | 20,328+ | 11,340 | 9,437- | 21,185+ |
| 93 | 155 | 0 | 0 | 5,702 | 5,547- | 5,547- | 6,932 | 6,777- | 6,777- |
| 94 | 231 | 58 | 310 | 4,263 | 4,032- | 3,664- | 5,730 | 5,499- | 5,131- |
| 95 | 0 | 0 | 0 | 4,128 | 4,128- | 4,128- | 5,421 | 5,421- | 5,421- |
| 96 | 0 | 1,127 | 1,215 | 4,254 | 4,254- | 1,912- | 4,441 | 4,441- | 2,099- |
| 97 | 0 | 0 | 0 | 3,447 | 3,447- | 3,447- | 4,225 | 4,225- | 4,225- |
| 98 | 0 | 0 | 0 | 5,180 | 5,180- | 5,180- | 5,689 | 5,689- | 5,689- |
| 99 | 0 | 0 | 11 | 4,337 | 4,337- | 4,326- | 5,461 | 5,461- | 5,450- |
| 100 | 122 | 56 | 660 | 5,952 | 5,830- | 5,114- | 6,450 | 6,328- | 5,612- |
| 101 | 469 | 524 | 629 | 5,117 | 4,648- | 3,495- | 4,167 | 3,698- | 2,545- |
| 102 | 210 | 75 | 420 | 6,320 | 6,110- | 6,115- | 8,192 | 7,982- | 7,487- |
| 103 | 228 | 470 | 228 | 6,608 | 6,380- | 5,682- | 8,875 | 8,647- | 7,949- |
| 104 | 126 | 184 | 716 | 4,745 | 4,619- | 3,719- | 5,253 | 5,127- | 4,227- |
| 105 | 1,224 | 222 | 870 | 7,067 | 5,843- | 4,751- | 7,164 | 5,940- | 4,848- |
| 106[d] | 170 | 0 | 28 | 4,262 | 1,780- | 1,752- | 5,635 | 3,153- | 3,125- |
| 107 | 823 | 676 | 784 | 5,350 | 4,527- | 3,087- | 6,100 | 5,277- | 3,817- |
| 108 | 357 | 1,008 | 1,703 | 3,400 | 3,043- | 332- | 4,500 | 4,143- | 1,432- |
| 109 | 400 | 508 | 393 | 3,800 | 3,400- | 2,499- | 4,050 | 3,650- | 2,749- |
| 110 | 800 | 146 | 787 | 4,800 | 4,000- | 3,067- | 5,700 | 4,900- | 3,967- |
| 111 | 168 | 135 | 64 | 5,250 | 5,082- | 4,883- | 7,650 | 7,482- | 7,283- |
| 112 | 1,561 | 14 | 2,333 | 5,600 | 4,039- | 1,692- | 5,400 | 3,839- | 1,492- |
| 113 | 302 | 63 | 965 | 4,400 | 4,098- | 3,070- | 6,600 | 6,298- | 5,270- |
| 114 | 72 | 56 | 209 | 5,500 | 5,428- | 5,163- | 4,800 | 4,728- | 4,463- |
| 115 | 1,716 | 1,313 | 1,941 | 5,550 | 3,834- | 580- | 6,550 | 4,834- | 1,580- |
| 116 | 0 | 0 | 0 | 2,600 | 2,600- | 2,600- | 3,300 | 3,300- | 3,300- |
| 117 | 0 | 1,309 | 710 | 2,350 | 2,350- | 331- | 2,700 | 2,700- | 681- |
| 118 | 0 | 0 | 0 | 2,575 | 2,575- | 2,575- | 3,750 | 3,750- | 3,750- |
| 119 | 881 | 16 | 619 | 7,600 | 6,719- | 6,084- | 9,450 | 8,569- | 7,934- |
| 120 | 1,040 | 549 | 1,686 | 5,500 | 4,460- | 2,225- | 7,350 | 6,310- | 4,075- |
| 121 | 1,386 | 302 | 1,604 | 10,200 | 9,814- | 7,908- | 10,600 | 9,214- | 7,308- |
| 122 | 98 | 26 | 164 | 6,875 | 6,779- | 6,589- | 11,000 | 10,904- | 10,714- |
| 123 | 1,237 | 100 | 1,078 | 4,650 | 3,413- | 2,235- | 4,950 | 3,713- | 2,535- |
| 124 | 5,482 | 6,879 | 7,309 | 25,000 | 19,518- | 5,330- | 24,950 | 19,468- | 5,280- |
| 125 | 0 | 84 | 0 | 2,050 | 2,050- | 1,966- | 2,000 | 2,000- | 1,916- |
| 126 | 0 | 0 | 11 | 2,750 | 2,750- | 2,739- | 2,850 | 2,850- | 2,839- |
| 127 | 491 | 5 | 225 | 8,200 | 5,709- | 5,479- | 8,175 | 7,684- | 7,454- |
| 128 | 204 | 0 | 798 | 8,400 | 8,196- | 7,398- | 10,104 | 9,900- | 9,102- |
| 129 | 949 | 0 | 92 | 4,950 | 4,001- | 3,909- | 7,200 | 6,251- | 6,159- |
| 130 | 124 | 67 | 587 | 4,200 | 4,076- | 3,422- | 6,350 | 6,226- | 5,572- |
| 131 | 0 | 0 | 80 | 4,425 | 4,425- | 4,345- | 6,300 | 6,300- | 6,220- |
| 132 | 0 | 24 | 17 | 8,400 | 8,400- | 8,359- | 9,000 | 9,000- | 8,959- |
| 133 | 185 | 65 | 180 | 10,771 | 10,586- | 10,341- | 13,973 | 13,788- | 13,543- |
| 134 | 158 | 0 | 632 | 10,065 | 9,907- | 9,275- | 11,944 | 11,786- | 11,154- |
| 135 | 283 | 0 | 456 | 6,797 | 6,514- | 6,058- | 7,673 | 7,390- | 6,934- |
| 136[d] | 678 | 206 | 1,668 | 7,600 | 5,868- | 3,992- | 7,477 | 5,743- | 3,869- |
| 137 | 346 | 144 | 651 | 7,509 | 7,163- | 6,368- | 7,687 | 7,341- | 6,546- |
| 138 | 167 | 150 | 285 | 4,539 | 4,372- | 3,937- | 5,578 | 5,411- | 4,976- |
| 139 | 1,464 | 475 | 451 | 6,955 | 5,491- | 4,565- | 8,667 | 7,203- | 6,277- |
| 140 | 498 | 0 | 260 | 3,637 | 3,139- | 2,879- | 4,074 | 3,576- | 3,316- |
| 141 | 173 | 224 | 141 | 4,521 | 4,348- | 3,983- | 4,964 | 4,791- | 4,426- |
| 142 | 130 | 492 | 240 | 7,413 | 7,283- | 6,551- | 9,804 | 9,674- | 8,942- |
| 143 | 96 | 43 | 53 | 10,312 | 10,216- | 10,120- | 14,572 | 14,476- | 14,380- |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 19 | 72 | 0 | 28 | 1,600 | 1,528- | 1,500- | 2,100 | 2,028- | 2,000- |
| 20 | 0 | 0 | 12 | 1,400 | 1,400- | 1,388- | 2,500 | 2,500- | 2,488- |
| 21 | 30 | 142 | 54 | 2,000 | 1,970- | 1,774- | 2,800 | 2,770- | 2,574- |
| 22 | 524 | 76 | 1,383 | 2,000 | 1,476- | 17- | 2,400 | 1,876- | 417- |
| 23 | 9,801 | 2,018 | 6,980 | 4,000 | 5,801+ | 14,799+ | 5,000 | 4,801+ | 13,799+ |
| 24 | 4,871 | 272 | 6,275 | 3,000 | 1,871+ | 8,418+ | 3,500 | 1,371+ | 7,918+ |
| 25 | 198,694 | 37,216 | 72,191 | 70,000 | 128,694+ | 238,101+ | 1,300 | 197,394+ | 306,801+ |
| 26 | 17,495 | 1,596 | 7,701 | 6,000 | 11,495+ | 20,791+ | 3,600 | 13,895+ | 23,191+ |
| 27 | 172 | 527 | 4,379 | 4,000 | 3,828- | 1,078+ | 2,200 | 2,028- | 2,878+ |
| 28 | 83,167 | 7,747 | 15,760 | 9,000 | 74,167+ | 97,674+ | 1,300 | 81,867+ | 105,374+ |
| 29 | 471,893 | 91,501 | 169,104 | 151,250[c] | 371,894+ | 632,499+ | 30,000 | 441,893+ | 702,498+ |
| 30 | 8,945 | 4,205 | 20,302 | 25,100 | 16,155- | 8,352+ | 11,500 | 2,555- | 21,952+ |
| 31 | 22,402 | 7,626 | 15,303 | 9,800 | 12,602+ | 35,533+ | 7,900 | 14,502+ | 37,433+ |
| 32 | 1,336 | 812 | 1,715 | 3,150 | 1,814- | 713+ | 800 | 536+ | 3,063+ |
| 33 | 180 | 2 | 31 | 300 | 120- | 37- | 500 | 320- | 237- |
| 34 | 31,203 | 9,149 | 18,261 | 22,000 | 9,203+ | 36,613+ | 800 | 30,403+ | 57,813+ |
| 35 | 15,697 | 5,477 | 16,243 | 7,000 | 8,697+ | 30,417+ | 2,000 | 13,697+ | 35,417+ |
| 36 | 63,423 | 8,688 | 10,117 | 10,000 | 53,423+ | 72,228+ | 3,500 | 59,923+ | 78,728+ |
| 37 | 143 | 64 | 698 | 2,550 | 2,407- | 1,645- | 2,200 | 2,057- | 1,295- |
| 38 | 12,879 | 5,704 | 4,702 | 3,200 | 9,679+ | 20,085+ | 1,000 | 11,879+ | 22,285+ |
| 39 | 369 | 172 | 753 | 5,500 | 5,131- | 4,206- | 5,300 | 4,931- | 4,006- |
| 40 | 3,203 | 1,729 | 2,674 | 5,900 | 2,697- | 1,706+ | 3,300 | 97- | 4,306+ |
| 41 | 32,959 | 23,498 | 44,608 | 26,900 | 6,059+ | 74,165+ | 12,000 | 20,959+ | 89,065+ |
| 42 | 5,799 | 761 | 6,010 | 4,900 | 899+ | 7,670+ | 2,800 | 2,999+ | 9,770+ |
| 43 | 74,296 | 8,996 | 33,884 | 23,050 | 51,246+ | 94,126+ | 12,800 | 61,496+ | 104,376+ |
| 44 | 21,320 | 3,316 | 11,361 | 8,700 | 12,620+ | 27,097+ | 5,800 | 15,520+ | 29,997+ |
| 45 | 15,990 | 5,579 | 12,111 | 18,350 | 2,360- | 15,330+ | 28,500 | 12,510- | 5,180+ |
| 46 | 1,819 | 718 | 5,592 | 2,200 | 381- | 5,929+ | 4,000 | 2,181- | 4,129+ |
| 47 | 3,087 | 1,938 | 7,667 | 2,800 | 287+ | 9,892+ | 8,000 | 4,913- | 4,692+ |
| 48 | 16,704 | 7,572 | 27,819 | 5,000 | 11,704+ | 47,095+ | 6,700 | 10,004+ | 45,395+ |
| 49 | 19,936 | 16,246 | 43,188 | 16,000 | 3,936+ | 63,370+ | 6,500 | 13,436+ | 72,870+ |
| 50 | 21,351 | 13,523 | 34,165 | 22,975 | 1,624- | 46,064+ | 36,900 | 15,549- | 32,139+ |
| 51 | 28,896 | 23,213 | 40,018 | 26,400 | 2,496+ | 65,727+ | 11,200 | 17,696+ | 80,927+ |
| 52 | 641 | 34 | 1,350 | 3,500 | 2,859- | 1,475- | 3,800 | 3,159- | 1,775- |
| 53 | 271 | 636 | 1,991 | 3,600 | 3,329- | 702- | 4,300 | 4,029- | 1,402- |
| 54 | 63 | 20 | 428 | 2,600 | 2,537- | 2,089- | 3,700 | 3,637- | 3,189- |
| 55 | 439 | 391 | 1,845 | 1,750 | 1,311- | 925+ | 2,200 | 1,761- | 475+ |
| 56 | 2,703 | 1,156 | 6,806 | 4,075 | 1,372- | 6,590+ | 2,300 | 403+ | 8,365+ |
| 57 | 4,333 | 2,527 | 8,415 | 7,025 | 2,692- | 8,250+ | 6,250 | 1,917- | 9,025+ |
| 58 | 39,674 | 39,286 | 72,516 | 12,376 | 27,298+ | 139,100+ | 3,861 | 35,813+ | 147,615+ |
| 59 | 0 | 0 | 0 | 2,293 | 2,293- | 2,293- | 2,000 | 2,000- | 2,000- |
| 60 | 722 | 961 | 434 | 3,405 | 2,683- | 1,288- | 3,727 | 3,005- | 1,610- |
| 61[d] | 18,321 | 3,885 | 15,928 | 11,294 | 9,654+ | 29,367+ | 2,083 | 18,865+ | 38,578+ |
| 62 | 473 | 235 | 689 | 6,902 | 6,429- | 5,505- | 5,526 | 5,053- | 4,129- |
| 63 | 0 | 17 | 59 | 11,356 | 11,356- | 11,280- | 4,465 | 4,465- | 4,389- |
| 64 | 0 | 117 | 65 | 3,650 | 3,650- | 3,468- | 3,033 | 3,033- | 2,851- |
| 65 | 375 | 0 | 581 | 5,697 | 5,322- | 4,741- | 5,263 | 4,888- | 4,307- |
| 66 | 417 | 185 | 1,106 | 6,274 | 5,857- | 4,566- | 6,672 | 6,255- | 4,964- |
| 67 | 475 | 558 | 2,371 | 3,745 | 3,270- | 341- | 4,780 | 4,305- | 1,376- |
| 68 | 453 | 23 | 875 | 5,549 | 5,096- | 4,198- | 3,866 | 3,413- | 2,515- |
| 69[d] | 500 | 0 | 12 | 2,164 | 1,515+ | 1,527+ | 1,061 | 2,618+ | 2,630+ |
| 70 | 0 | 0 | 0 | 1,508 | 1,508- | 1,508- | 1,573 | 1,573- | 1,573- |
| 71 | 83 | 17 | 454 | 3,189 | 3,106- | 2,635- | 3,403 | 3,320- | 2,849- |
| 72 | 0 | 0 | 0 | 1,630 | 1,630- | 1,630- | 1,809 | 1,809- | 1,809- |
| 73 | 604 | 1,275 | 1,379 | 5,332 | 4,728- | 2,074- | 4,730 | 4,126- | 1,472- |
| 74 | 510 | 1,276 | 2,519 | 2,983 | 2,473- | 1,322+ | 3,631 | 3,121- | 674+ |
| 75 | 80 | 0 | 240 | 2,691 | 2,611- | 2,371- | 3,270 | 3,190- | 2,950- |
| 76 | 0 | 0 | 0 | 3,734 | 3,734- | 3,734- | 4,141 | 4,141- | 4,141- |
| 77 | 201 | 48 | 976 | 3,816 | 3,615- | 2,591- | 4,015 | 3,814- | 2,790- |
| 78 | 4,325 | 1,096 | 2,047 | 4,300 | 25+ | 3,168+ | 1,800 | 2,525+ | 5,668+ |
| 97 | 0 | 0 | 0 | 3,447 | 3,447- | 3,447- | 3,447 | 3,447- | 3,447- |
| 98 | 0 | 0 | 0 | 5,180 | 5,180- | 5,180- | 5,689 | 5,689- | 5,689- |
| 99 | 0 | 0 | 11 | 4,337 | 4,337- | 4,326- | 5,461 | 5,461- | 5,450- |
| 100 | 122 | 56 | 630 | 5,952 | 5,830- | 5,114- | 6,450 | 6,328- | 5,612- |
| 101 | 469 | 524 | 629 | 5,117 | 4,648- | 3,495- | 4,167 | 3,698- | 2,545- |
| 102 | 210 | 75 | 420 | 6,920 | 6,710- | 6,115- | 8,192 | 7,982- | 7,487- |
| 103 | 228 | 470 | 228 | 6,508 | 6,280- | 5,682- | 8,875 | 8,647- | 7,949- |
| 104 | 126 | 184 | 716 | 4,745 | 4,619- | 3,719- | 5,253 | 5,127- | 4,227- |
| 105 | 1,224 | 222 | 870 | 7,067 | 5,843- | 4,751- | 7,184 | 5,960- | 4,848- |
| 106[d] | 170 | 0 | 28 | 4,262 | 1,780- | 1,752- | 5,635 | 3,153- | 3,125- |
| 107 | 823 | 676 | 784 | 5,350 | 4,527- | 3,067- | 6,100 | 5,277- | 3,817- |
| 108 | 357 | 1,008 | 1,703 | 3,400 | 3,043- | 332- | 4,500 | 4,143- | 1,432- |
| 109 | 400 | 508 | 393 | 3,800 | 3,400- | 2,495- | 4,050 | 3,650- | 2,749- |
| 110 | 800 | 146 | 787 | 4,800 | 4,000- | 3,067- | 5,700 | 4,900- | 3,967- |
| 111 | 168 | 136 | 64 | 5,250 | 5,082- | 4,883- | 7,650 | 7,482- | 7,283- |
| 112 | 1,561 | 14 | 2,333 | 5,600 | 4,039- | 1,692- | 5,400 | 3,839- | 1,492- |
| 113 | 302 | 63 | 965 | 4,400 | 4,098- | 3,070- | 6,600 | 6,298- | 5,270- |
| 114 | 72 | 56 | 209 | 5,500 | 5,428- | 5,163- | 4,800 | 4,728- | 4,463- |
| 115 | 1,716 | 1,313 | 1,941 | 5,550 | 3,834- | 580- | 6,550 | 4,634- | 1,580- |
| 116 | 0 | 0 | 0 | 2,600 | 2,600- | 2,600- | 3,300 | 3,300- | 3,300- |
| 117 | 0 | 1,309 | 710 | 2,350 | 2,350- | 331- | 2,700 | 2,700- | 691- |
| 118 | 0 | 0 | 0 | 2,575 | 2,575- | 2,575- | 3,750 | 3,750- | 3,750- |
| 119 | 881 | 16 | 619 | 7,600 | 6,719- | 6,084- | 9,450 | 8,569- | 7,934- |
| 120 | 1,040 | 549 | 1,686 | 5,500 | 4,460- | 2,225- | 7,350 | 6,310- | 4,075- |
| 121 | 1,386 | 302 | 1,604 | 11,200 | 9,814- | 7,908- | 10,600 | 9,214- | 7,308- |
| 122 | 96 | 26 | 164 | 6,875 | 6,779- | 6,589- | 11,000 | 10,904- | 10,714- |
| 123 | 1,237 | 100 | 1,078 | 4,650 | 3,413- | 2,235- | 4,950 | 3,713- | 2,535- |
| 124 | 5,482 | 6,879 | 7,309 | 25,000 | 19,518- | 5,330- | 24,950 | 19,468- | 5,280- |
| 125 | 0 | 84 | 0 | 2,050 | 2,050- | 1,966- | 2,000 | 2,000- | 1,916- |
| 126 | 0 | 0 | 11 | 2,750 | 2,750- | 2,739- | 2,850 | 2,850- | 2,839- |
| 127 | 491 | 5 | 225 | 5,200 | 5,709- | 5,479- | 8,175 | 7,684- | 7,454- |
| 128 | 204 | 0 | 798 | 9,400 | 8,196- | 7,398- | 10,100 | 9,896- | 9,098- |
| 129 | 949 | 0 | 92 | 4,950 | 4,001- | 3,909- | 7,200 | 6,251- | 6,159- |
| 130 | 124 | 67 | 587 | 4,200 | 4,076- | 3,422- | 6,350 | 6,226- | 5,572- |
| 131 | 0 | 0 | 80 | 4,425 | 4,425- | 4,345- | 6,300 | 6,300- | 6,220- |
| 132 | 0 | 24 | 17 | 8,400 | 8,400- | 8,359- | 9,000 | 9,000- | 8,959- |
| 133 | 185 | 65 | 180 | 10,771 | 10,586- | 10,341- | 13,973 | 13,788- | 13,543- |
| 134 | 158 | 0 | 632 | 10,065 | 9,907- | 9,275- | 11,944 | 11,786- | 11,154- |
| 135 | 283 | 0 | 456 | 6,797 | 6,514- | 6,056- | 7,673 | 7,390- | 6,934- |
| 136[d] | 678 | 206 | 1,668 | 7,600 | 5,866- | 3,992- | 7,477 | 5,743- | 3,869- |
| 137 | 346 | 144 | 651 | 7,509 | 7,163- | 6,368- | 7,687 | 7,341- | 6,546- |
| 138 | 167 | 150 | 285 | 4,539 | 4,372- | 3,937- | 5,578 | 5,411- | 4,976- |
| 139 | 1,464 | 475 | 451 | 6,955 | 5,491- | 4,565- | 8,667 | 7,203- | 6,277- |
| 140 | 498 | 0 | 260 | 3,637 | 3,139- | 2,879- | 4,074 | 3,576- | 3,316- |
| 141 | 173 | 224 | 141 | 4,521 | 4,348- | 3,983- | 4,964 | 4,791- | 4,426- |
| 142 | 130 | 492 | 240 | 7,413 | 7,283- | 6,551- | 9,804 | 9,674- | 8,942- |
| 143 | 96 | 43 | 53 | 10,312 | 10,216- | 10,120- | 14,572 | 14,476- | 14,380- |
| 144 | 144 | 1,161 | 956 | 5,313 | 5,169- | 3,052- | 6,094 | 5,950- | 3,833- |
| 145 | 4,483 | 10 | 1,620 | 6,000 | 1,517- | 113+ | 4,700 | 217- | 1,413+ |
| 146 | 19,266 | 11,344 | 23,112 | 11,000 | 8,266+ | 42,722+ | 7,500 | 11,766- | 46,222+ |
| 147 | 0 | 202 | 6,460 | 6,000 | 6,000- | 662+ | 10,000 | 10,000- | 3,338- |
| 148 | 16,277 | 2,888 | 8,026 | 7,000 | 9,277+ | 20,191+ | 9,600 | 6,677+ | 17,591+ |
| 149 | 1,294 | 72 | 347 | 7,000 | 5,706- | 5,287- | 10,000 | 8,706- | 8,287- |
| 150 | 651 | 251 | 304 | 3,000 | 2,349- | 1,794- | 5,800 | 5,149- | 4,594- |
| 151 | 458 | 378 | 3,018 | 5,000 | 4,542- | 1,146- | 8,600 | 8,142- | 4,746- |
| 152 | 1,088 | 71 | 3,249 | 4,000 | 4,912- | 1,592- | 9,400 | 8,312- | 4,992- |
| 153 | 0 | 0 | 0 | 4,908 | 4,908- | 4,908- | 6,333 | 6,333- | 6,333- |
| 154 | 890 | 53 | 879 | 5,277 | 8,387- | 7,455- | 7,737 | 6,847- | 5,915- |
| 155 | 290 | 9 | 0 | 7,694 | 7,404- | 7,395- | 9,940 | 9,650- | 9,641- |
| 156 | 393 | 0 | 253 | 12,200 | 11,805- | 11,552- | 13,073 | 12,678- | 12,425- |
| Total | 1,449,199 | 435,633 | 1,000,713 | 1,214,695 | 234,504 | 1,670,850 | 938,376 | 510,823 | 1,947,169 |

a. Data on P F 100 and over are from Phase II, and the remaining data are from Phase I, of the National Fallout Shelter Survey.

b. Positive numbers indicate excess shelter spaces; negative numbers indicate unsheltered people.

c. The population figure given in the Phase I summary printout was 99,999; this figure is incorrect, probably because room for 6-digit numbers was not allowed for in programming the printer. The figure shown here is the true figure as estimated by the architect-engineers.

d. The shelter spaces for this standard location have been adjusted to account for subway tunnels that were not surveyed by the architect-engineers. For further explanation of this adjustment, refer to Section VI.

Source: Developed by Stanford Research Institute from data contained in the National Fallout Shelter Survey Phase I summary printout and Phase II marking sketches of shelter areas.

maps is helpful in bridging the gap between numerical data and locations within the city.

Four different maps, showing the following conditions are required:

1. Daytime use of shelters with PF of 100 and over
2. Daytime use of shelters with PF of 40 and over
3. Nighttime use of shelters with PF of 100 and over
4. Nighttime use of shelters with PF of 40 and over

There are, of course, several ways in which the information can be expressed on a map. Outlined below are instructions which follow the method used by the research team in the study of Boston.

1. Place the base map with SL boundaries on a drafting table and lay a sheet of tracing paper over the map so that the base map can be read through the tracing paper.

2. Within each standard location, write on the tracing paper the number of people who are unsheltered or the number of unused shelter spaces. Red numbers are used to indicate unsheltered people and green numbers to indicate excess space.

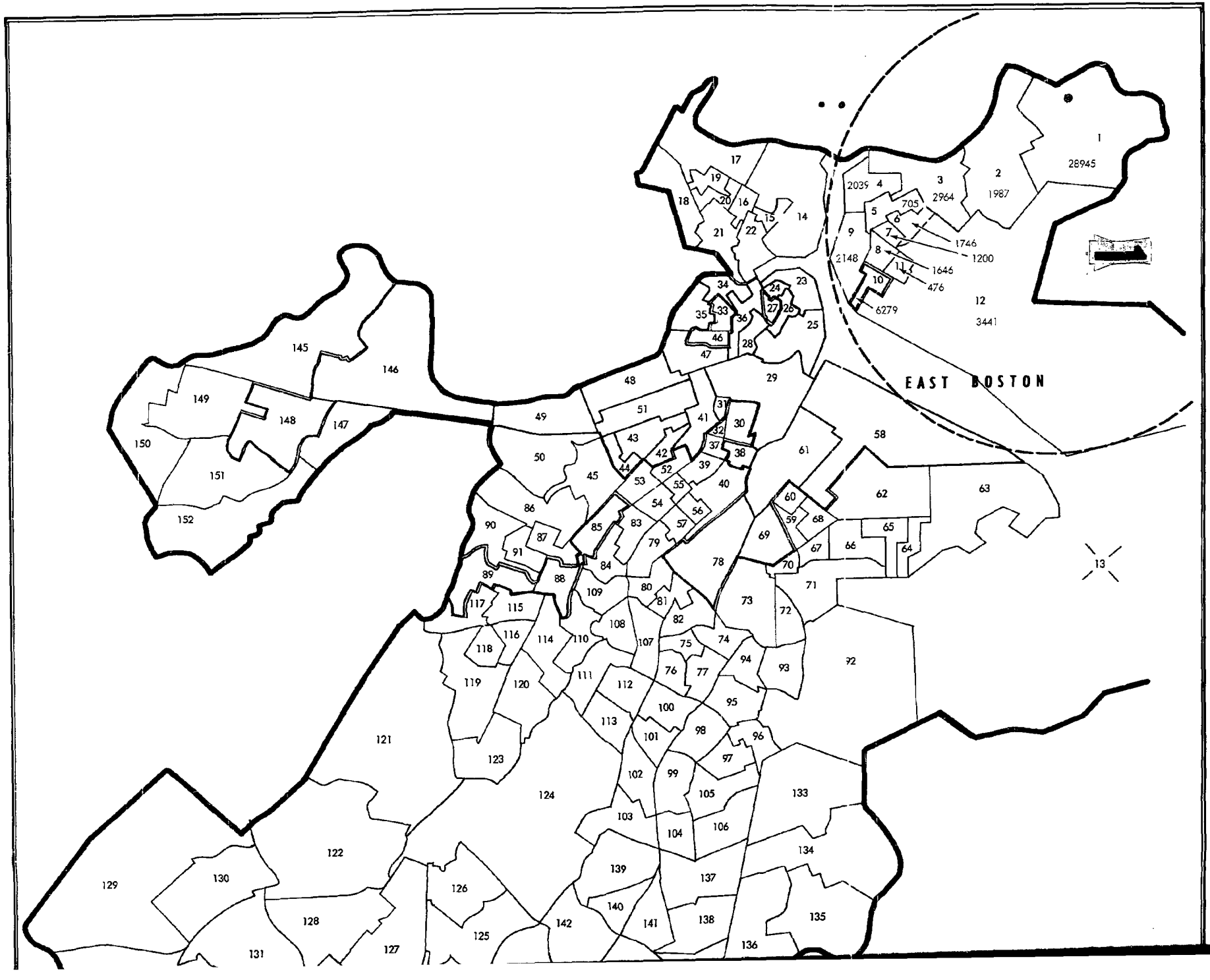
3. For those standard locations with red numbers, draw in the SL boundaries with a red pencil or felt-tipped marking pen. Repeat the process for those standard locations with green numbers, using a green pencil or pen.

4. In black, write in each of the SL numbers.

5. Using new sheets of tracing paper, repeat steps 1 through 4 until a map has been created for each of the previously mentioned day and night conditions.

Large-scale maps for each of the four conditions were prepared and used during the study. For illustrative purposes, only the map for the "daytime, PF 100 and over" condition is shown in the report (Figure 6). Also, because a smaller scale map is more appropriate here, excess shelter spaces or unsheltered people are only shown for one area of the city (East Boston, SL's 1-12). Comparison of Figure 6 and Table II will further aid the reader in understanding the development of these maps.

During the study of Boston, maps were also developed showing, for each standard location, the percentage of excess shelter through the use


EAST BOSTON
28945
1987
2964
2039
705
1746
1200
1646
476
6279
2148
3441

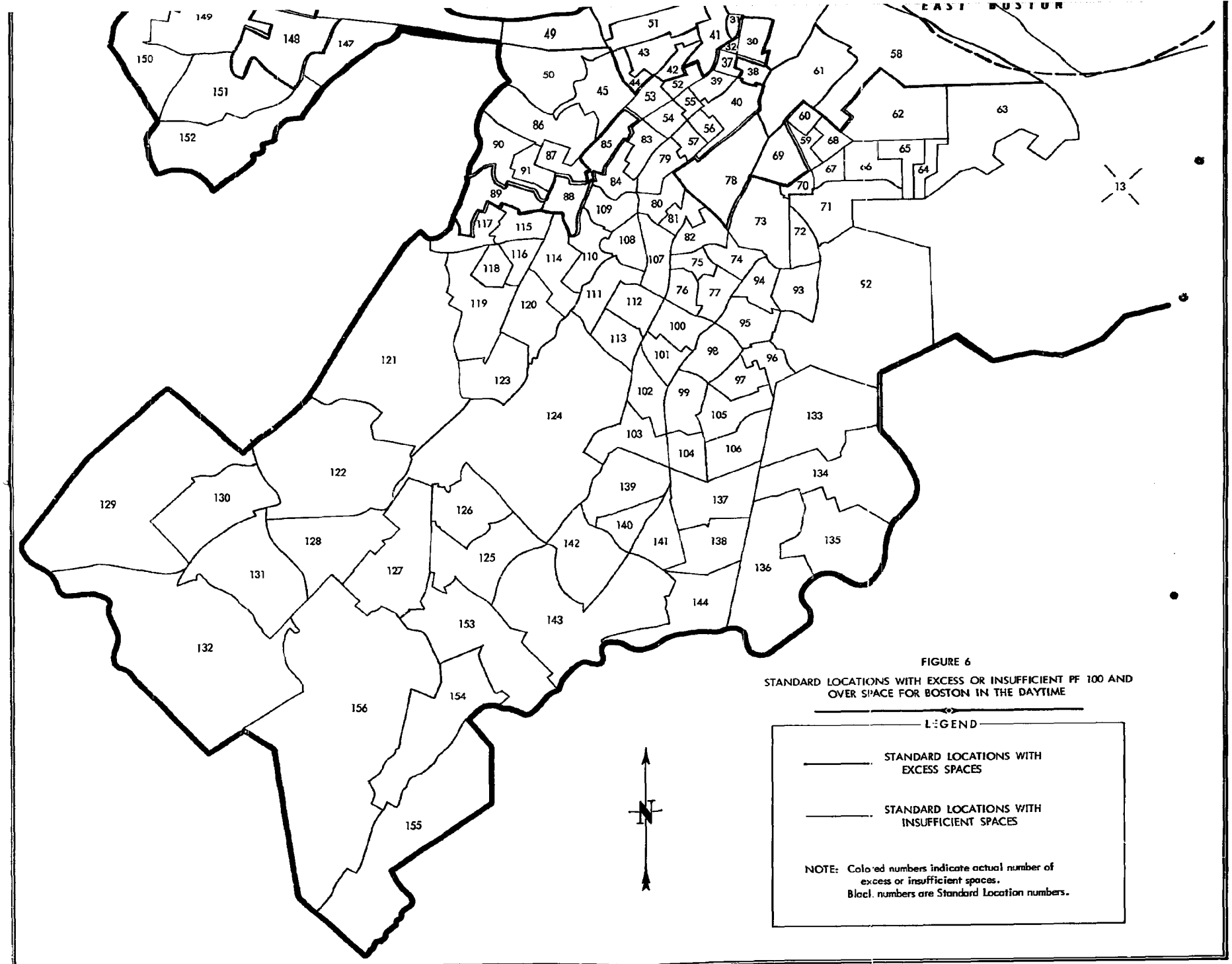



FIGURE 6

STANDARD LOCATIONS WITH EXCESS OR INSUFFICIENT PF 100 AND OVER SPACE FOR BOSTON IN THE DAYTIME

SOURCE: Developed by Stanford Research Institute from Phases I and II data.

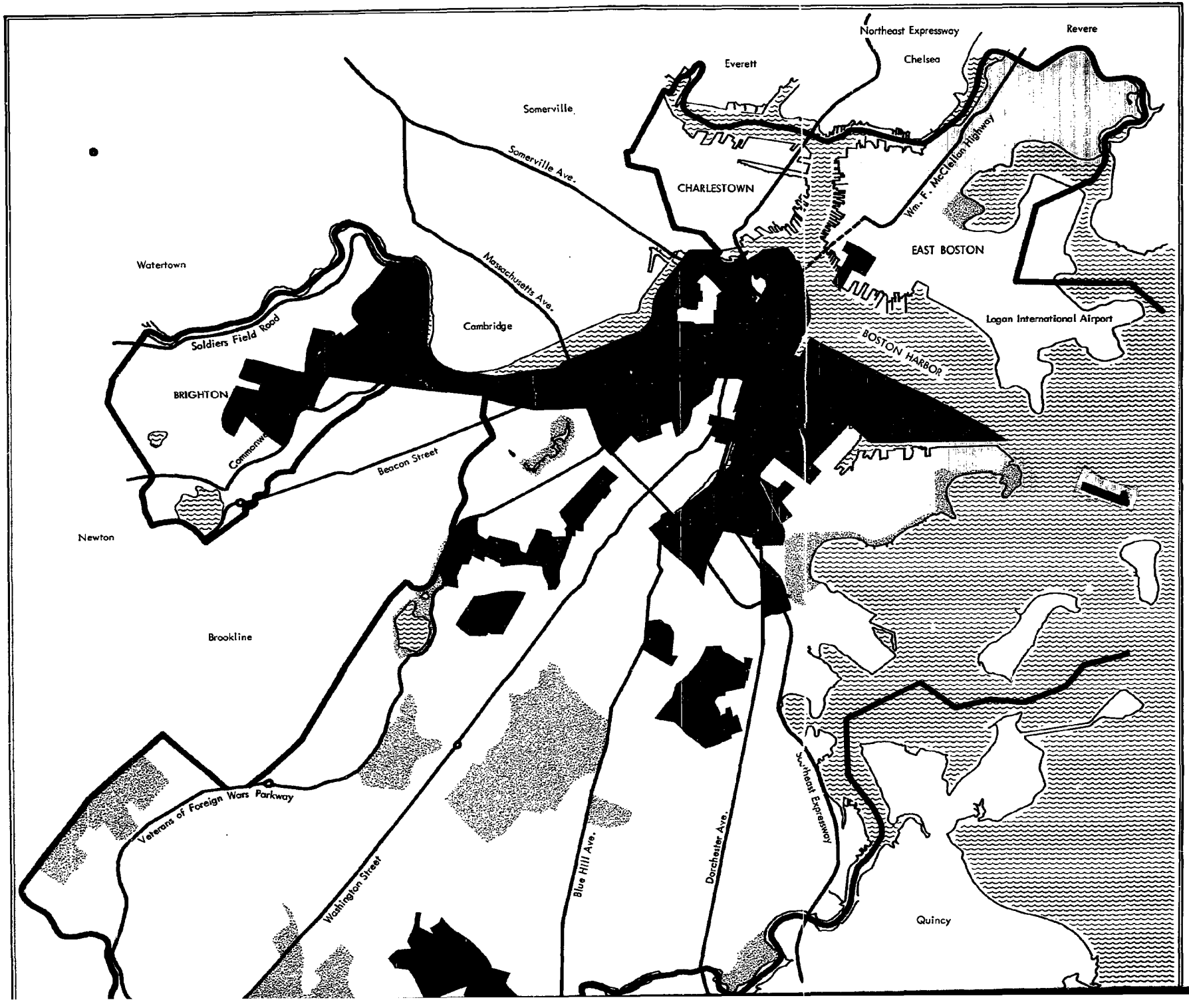
of color coding. These maps were used in conjunction with the previously described map tracings but did not prove as useful as had been expected. The rationale behind their use was that knowledge of the proportion of the people who were unsheltered would be helpful in evaluating the problem. Two thousand people without shelters in an area with a total estimated population of 4,000 was considered a much greater problem than the same number unsheltered in an area with 50,000 people. Although this is true, it proved just as easy to check the population listed on the tabulation sheets for the few standard locations where it was needed.

The use of colored dots to represent the number of unsheltered people or excess space was also considered. However, a dot intended to indicate 1,000 people might really represent anywhere from 500 to 1,499 people, and intolerable inaccuracies would result when specific assignments of people to shelters were made later in the study. Furthermore, it is actually easier to use the true number than a graphic (dot) representation. The method outlined in the above paragraph appeared, therefore, to be the most suitable for the purposes of the study.

## Analysis of People-Shelter Relationship in the City of Boston

A generalization of the graphic analysis of the people-shelter relationship is shown in Figures 7 and 8. As can be seen, a large portion of the City of Boston does not have adequate shelter, even when the protection standard is lowered from PF 100 to PF 40. Areas with adequate shelters include "downtown" Boston and sections of the city with large apartment houses, commercial structures, public buildings, and universities. The residential areas are generally without adequate shelter. The nature and location of this problem do not change materially from daytime to nighttime. The greatest difference is that at night there is more unused shelter in the commercial and institutional areas than there is during the day. Similarly, in the areas which lack sufficient shelter, there is an increase in the number of people without shelter at night when those who work or go to school return home.

The tabulation below summarizes the problem which exists in Boston as a result of the differing locations of people and shelters. This tabulation shows the percentage distribution of shelter space, population, and land area among 29 standard locations having excess PF 100 and over space and 127 standard locations having insufficient PF 100 and over space, based on daytime population.


Northeast Expressway
Revere
Everett
Chelsea
Somerville
Somerville Ave.
CHARLESTOWN
Wm. F. McClellan Highway
EAST BOSTON
Watertown
Massachusetts Ave.
Cambridge
Logan International Airport
Soldiers Field Road
BOSTON HARBOR
BRIGHTON
Commonwealth Ave.
Beacon Street
Newton
Brookline
Veterans of Foreign Wars Parkway
Washington Street
Blue Hill Ave.
Dorchester Ave.
Southeast Expressway
Quincy

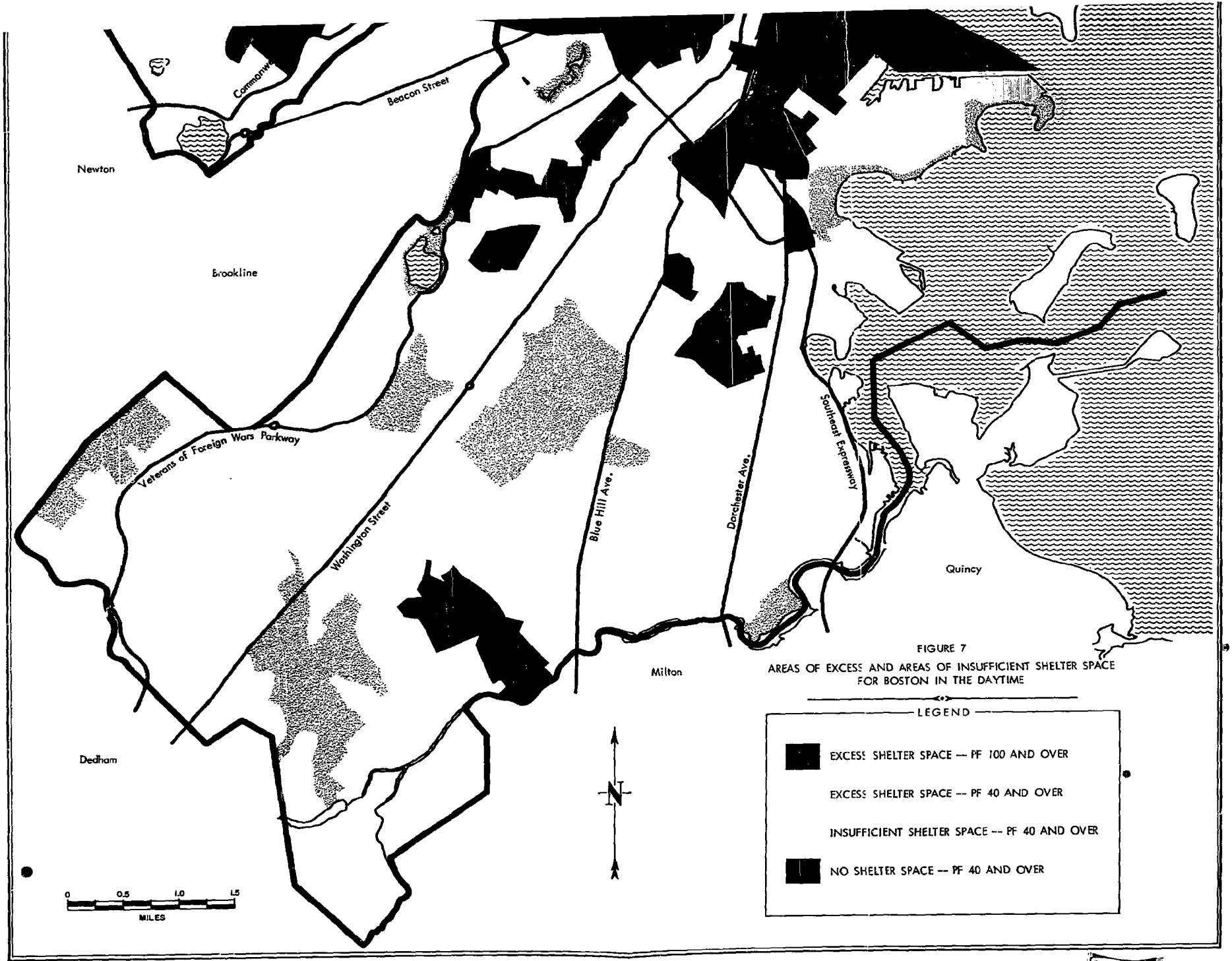
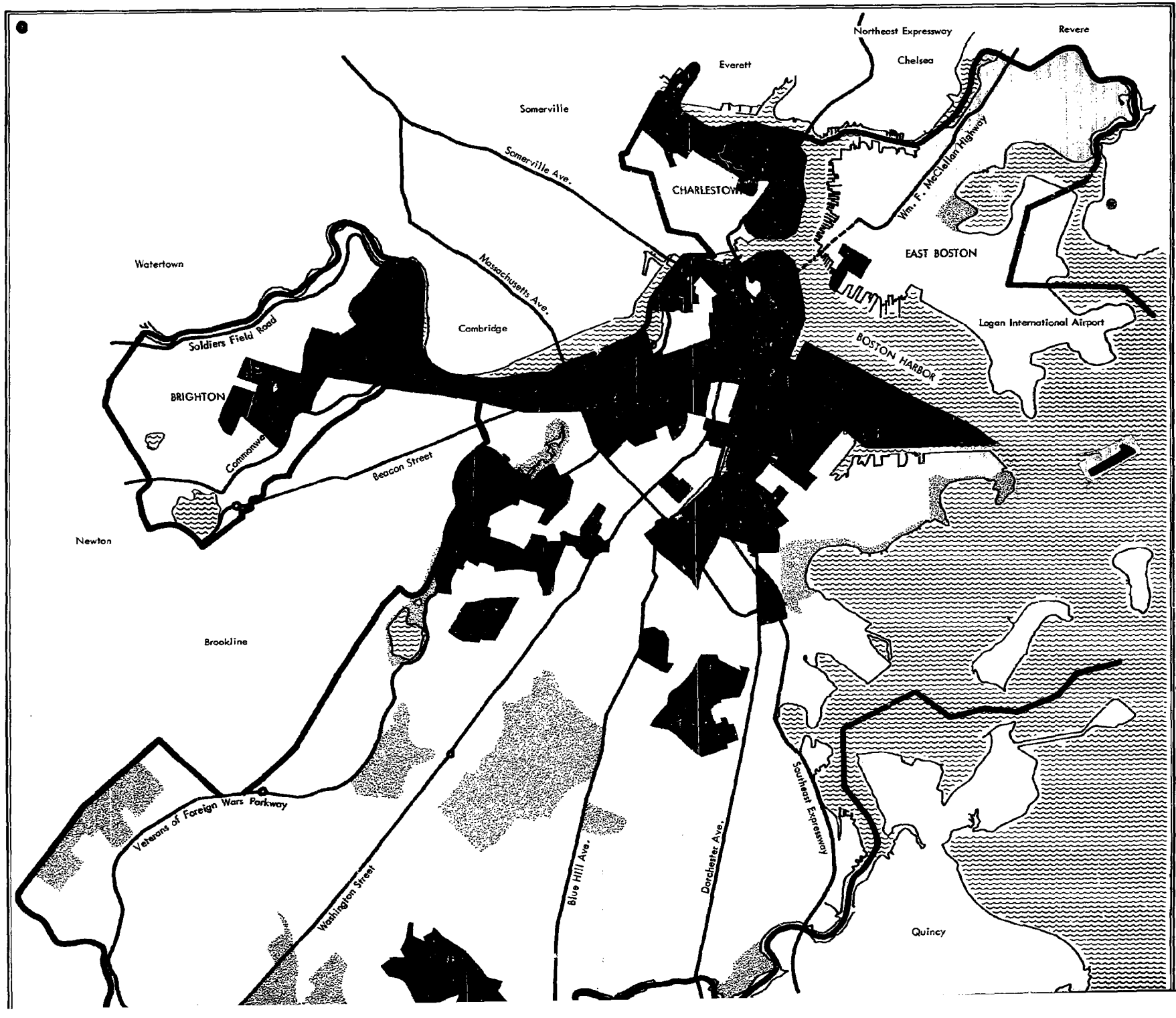



FIGURE 7

AREAS OF EXCESS AND AREAS OF INSUFFICIENT SHELTER SPACE FOR BOSTON IN THE DAYTIME

SOURCE: Developed by Stanford Research Institute from Phases I and II data.


Northeast Expressway
Revere
Chelsea
Everett
Somerville
Somerville Ave.
CHARLESTOWN
Wm. F. McClellan Highway
EAST BOSTON
Watertown
Massachusetts Ave.
Logan International Airport
Soldiers Field Road
Cambridge
BOSTON HARBOR
BRIGHTON
Commonwealth Ave.
Beacon Street
Newton
Brookline
Veterans of Foreign Wars Parkway
Washington Street
Blue Hill Ave.
Dorchester Ave.
Southeast Expressway
Quincy

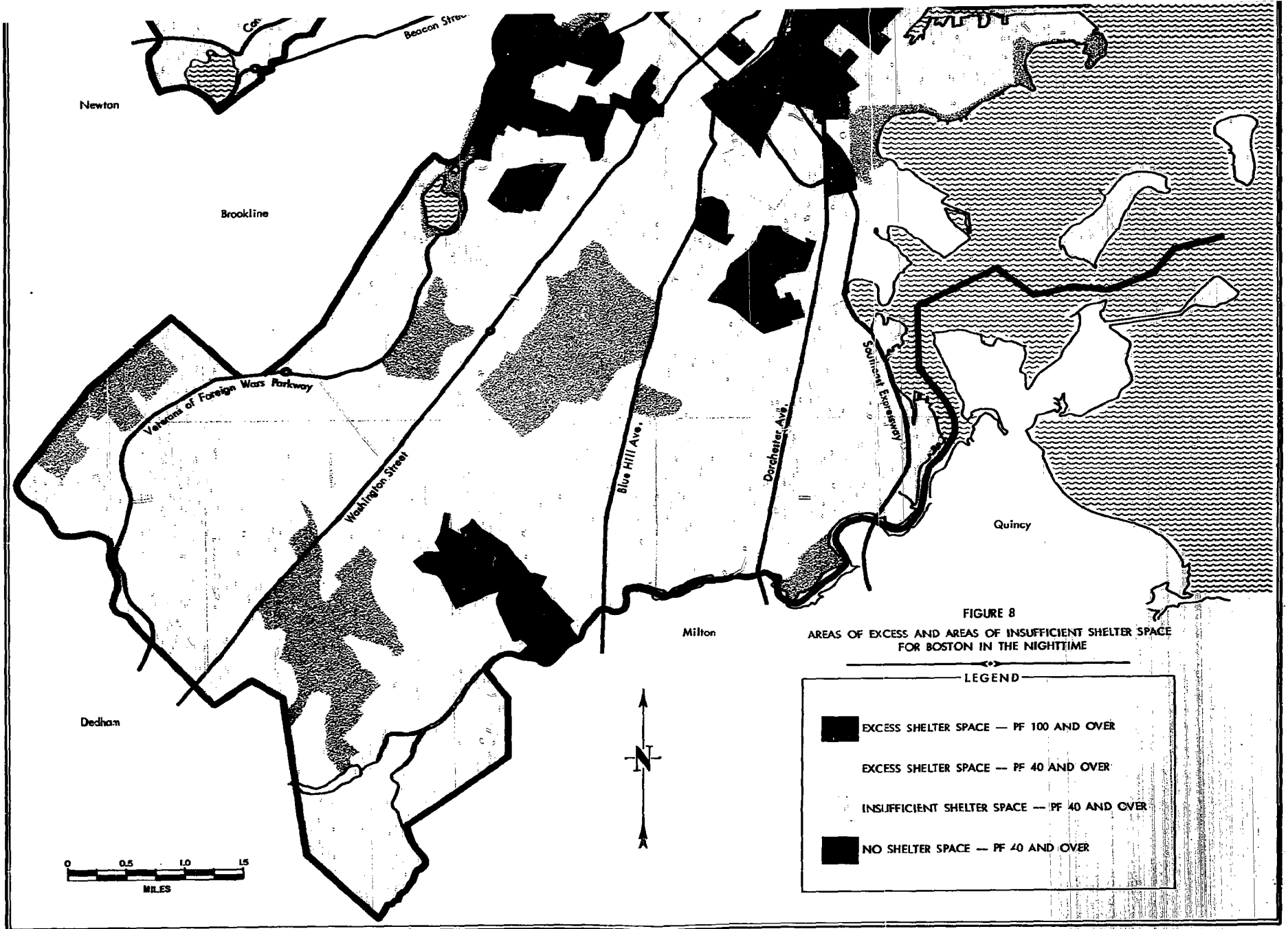



FIGURE 8

AREAS OF EXCESS AND AREAS OF INSUFFICIENT SHELTER SPACE FOR BOSTON IN THE NIGHTTIME

SOURCE: Developed by Stanford Research Institute from Phases I and II data.

| | PF 100 & Over Space | PF 70-99 Space | PF 40-69 Space | Population Day | Population Night | Estimated Land Use |
|---|---|---|---|---|---|---|
| SL's with excess space | 89% | 75% | 69% | 39% | 18% | 10% |
| SL's with insufficient space | 11 | 25 | 31 | 61 | 82 | 90 |

Almost 90 percent of the PF 100 and over space is located in areas which make up only about 10 percent of the total area of the city. Although 39 percent of the peak daytime population is also found in this same area, only 18 percent of the peak nighttime population is there. The problem is not greatly improved even when the 1.4 million spaces with a PF of 40-99 are used, because the major portion of this space also is located in the same areas that already have excess shelter space.

## Factors Affecting the Movement of People

The foregoing analysis of the people-shelter relationship indicates that no matter what specific allocation plan is formulated, mass movement of people to shelters will be necessary to the extent that it is possible. As a result the factors affecting the movement of people in Boston had to be considered.

### Physical Barriers

Physical barriers, either natural or man made, are probably the most important factor when considering the movement of large masses of people. These barriers form impediments to movement from one place in the city to another. In some cases, the barriers completely prevent movement in a particular direction; in other cases, movement in a certain direction may be significantly slowed. U.S. Geological Survey and Corps of Army Engineers maps, 7.5 minute series at a scale of 1:24,000,* are both excellent sources of information on physical barriers. These topographical maps provide extensive detail on the locations of various natural and man-made features.

In studying the location and nature of these barriers in the City of Boston, tracing paper was placed over a base map and the important barriers were drawn in. By highlighting the various characteristics in

* One inch is equal to 24,000 inches (2,000 feet).

this way, a quick and over-all understanding was obtained. In Boston, the most important barrier is water (see Figure 4). The Boston Harbor with its various channels and the Charles, Mystic, Chelsea, and Neponset rivers effectively impede the movement of people. Several of the expressways, railroads, cemeteries, and large park areas slow down movement in certain directions. In Boston, the terrain and street patterns are more important to movement in small areas than they are on a large scale.

These various barriers, because they affect the movement of people, allow the city to be broken down into parts which are meaningful and of a manageable size for further analysis. The City of Boston can be divided into East Boston, Charlestown, and Boston proper. Within Boston proper, South Boston can be broken out to a certain extent. Brighton is also somewhat separated from the main part of Boston but only by the city boundaries of Brookline, a barrier which in reality has little influence on how and where people will move.

### Transportation Network

The various transportation networks provide ways of moving people in addition to the basic method of walking. The system of railroads, rapid transit, and primary streets in Boston are shown in Figure 9.* Because they have their own rights of way, there is less chance that the railroad and rapid transit portion of this network will become inoperative in an emergency than will the city streets, but the primary streets are shown because they too might possibly be used for the movement of people. As can be seen from these maps, a rather extensive transportation system exists in Boston which must be considered in developing a shelter allocation plan. Most of the system radiates out from the core of the city and there are only a few cross-town routes.

### Land Use

The various purposes (commercial, industrial, institutional, multifamily residential, and single-family residential) for which the land in the city is used and the general locations of these uses are

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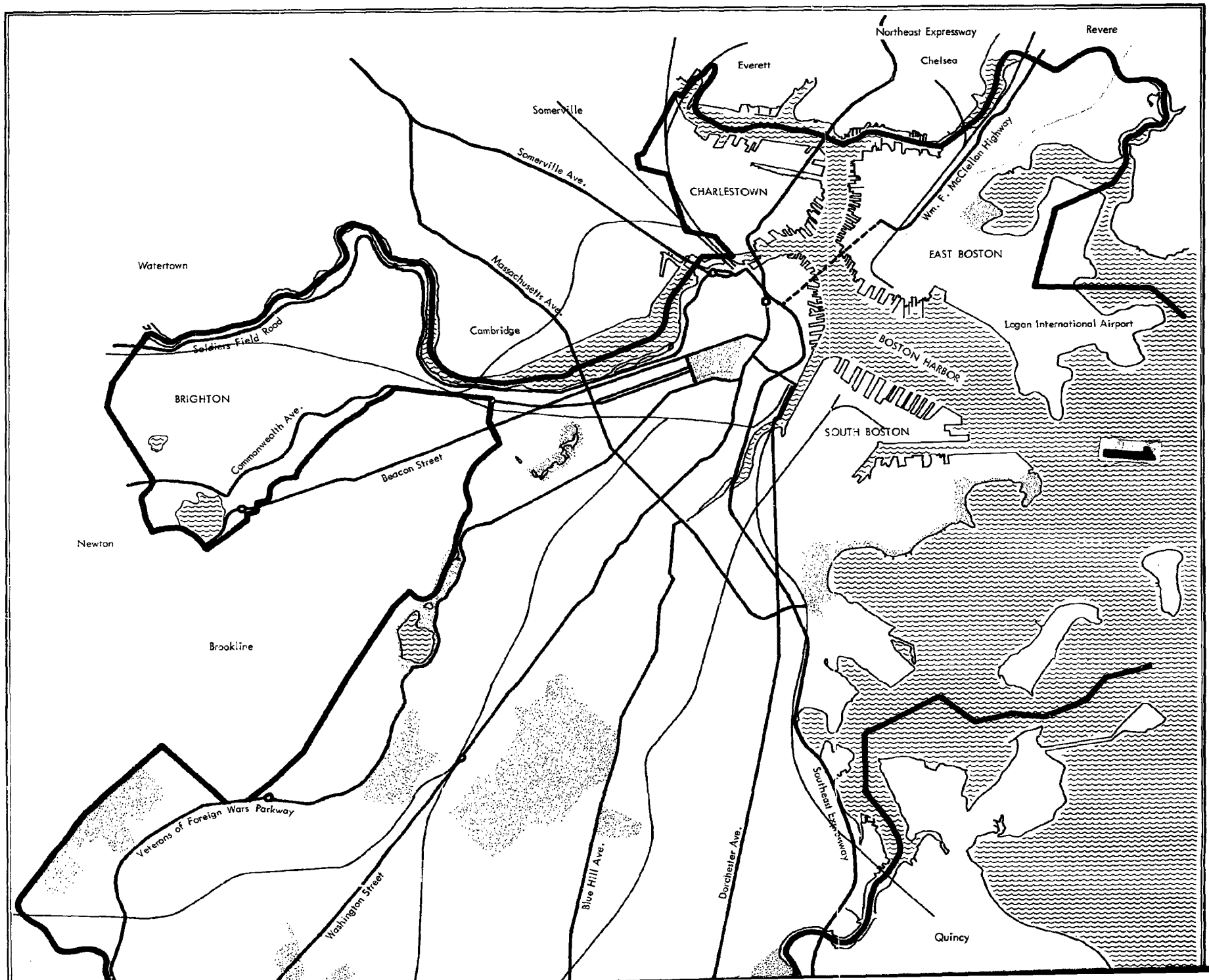
* Only that portion of the rapid transit network with its own right of way and only the predominant major streets defined by the City of Boston Planning Board are shown.


Northeast Expressway
Revere
Everett
Chelsea
Somerville
Somerville Ave.
CHARLESTOWN
Wm. F. McClellan Highway
EAST BOSTON
Watertown
Massachusetts Ave.
Cambridge
Logan International Airport
Soldiers Field Road
BOSTON HARBOR
BRIGHTON
SOUTH BOSTON
Commonwealth Ave.
Beacon Street
Newton
Brookline
Veterans of Foreign Wars Parkway
Southeast Expressway
Blue Hill Ave.
Dorchester Ave.
Washington Street
Quincy

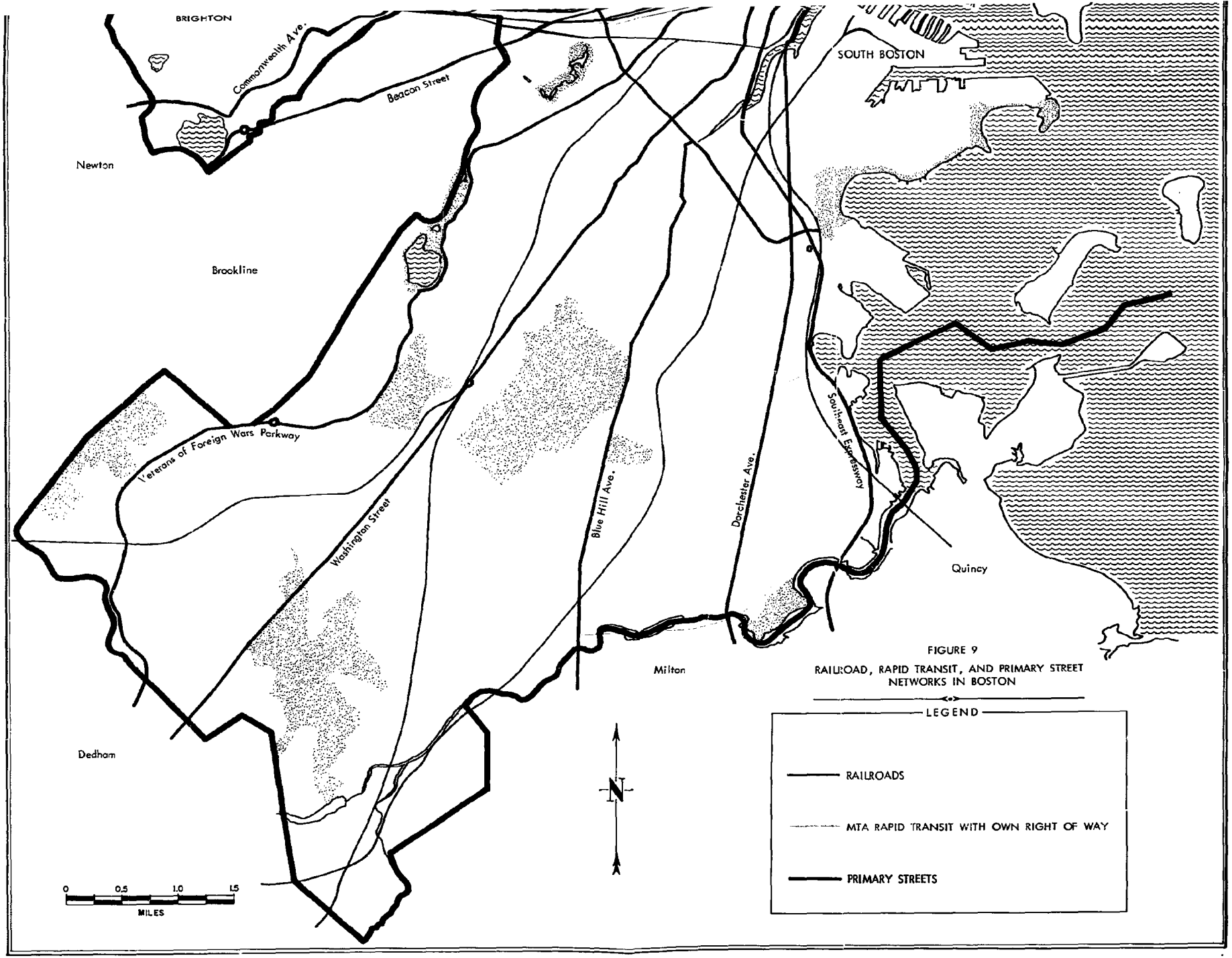



FIGURE 9

RAILROAD, RAPID TRANSIT, AND PRIMARY STREET NETWORKS IN BOSTON

SOURCES: Massachusetts Transit Authority. U.S. Geological Survey maps (7.5 Minute Series).
City of Boston Planning Board.

also important when considering the movement of people. A land use map for the City of Boston was obtained from city planning groups; a generalization of this map is shown as Figure 10. If such a map is not available in other communities, similar information can be obtained from zoning maps, aerial photographs, Sanborn Maps which are keyed to a Dun and Bradstreet or city directory, the Chamber of Commerce, or real estate organizations.

The land use map indicates the kind of structures which might be expected in a particular area of the city and helps to explain the reason for street patterns in various areas. In certain cases a particular land use may become a partial barrier to the movement of people (e.g., a factory area, railroad yards, institutional grounds, vacant land). Knowledge of land use is also helpful in explaining night-day population changes, breaking the city into meaningful parts, and estimating population within sections of a standard location. It also aids in knowing the location of specific companies, schools, and other organized groups which may perform their own civil defense planning and shelter their people.

### Relationships to Neighboring Communities

The city's physical relationship to other communities must be considered whenever planning the movement of people. Corporate boundaries are only legal or "paper boundaries" and cannot be expected to influence how and where people will actually move. In a metropolitan area, one community often runs into another with no perceptible physical change except for a sign stating that a different municipality has been reached. Movement of people between communities is to be expected and should be planned for. The existing transportation network functions as a metropolitan system and not as a separate entity within any one particular municipality. Cooperation and coordination among local CD organizations is therefore mandatory if a realistic shelter use plan is to be developed. Even though this study has concerned itself only with the City of Boston, as mentioned in the Introduction the Boston Civil Defense organization will have to consider community relationships.

## The Shelter Allocation Plan

Subsequent to performing the preliminary analysis and evaluation of data and information and prior to actual formulation of a simple but practical allocation plan, a number of conditions and assumptions must


Nor-heast Expressway
Revere
Everett
Chelsea
Somerville
Somerville Ave.
Wm. F. McClellan Highway
Watertown
Massachusetts Ave.
EAST BOSTON
Cambridge
Soldiers Field Road
Logan International Airport
BOSTON HARBOR
BRIGHTON
SOUTH BOSTON
Beacon Street
Newton
Brookline
Veterans of Foreign Wars Par
Washington Street
Blue Hill Ave.
Quincy

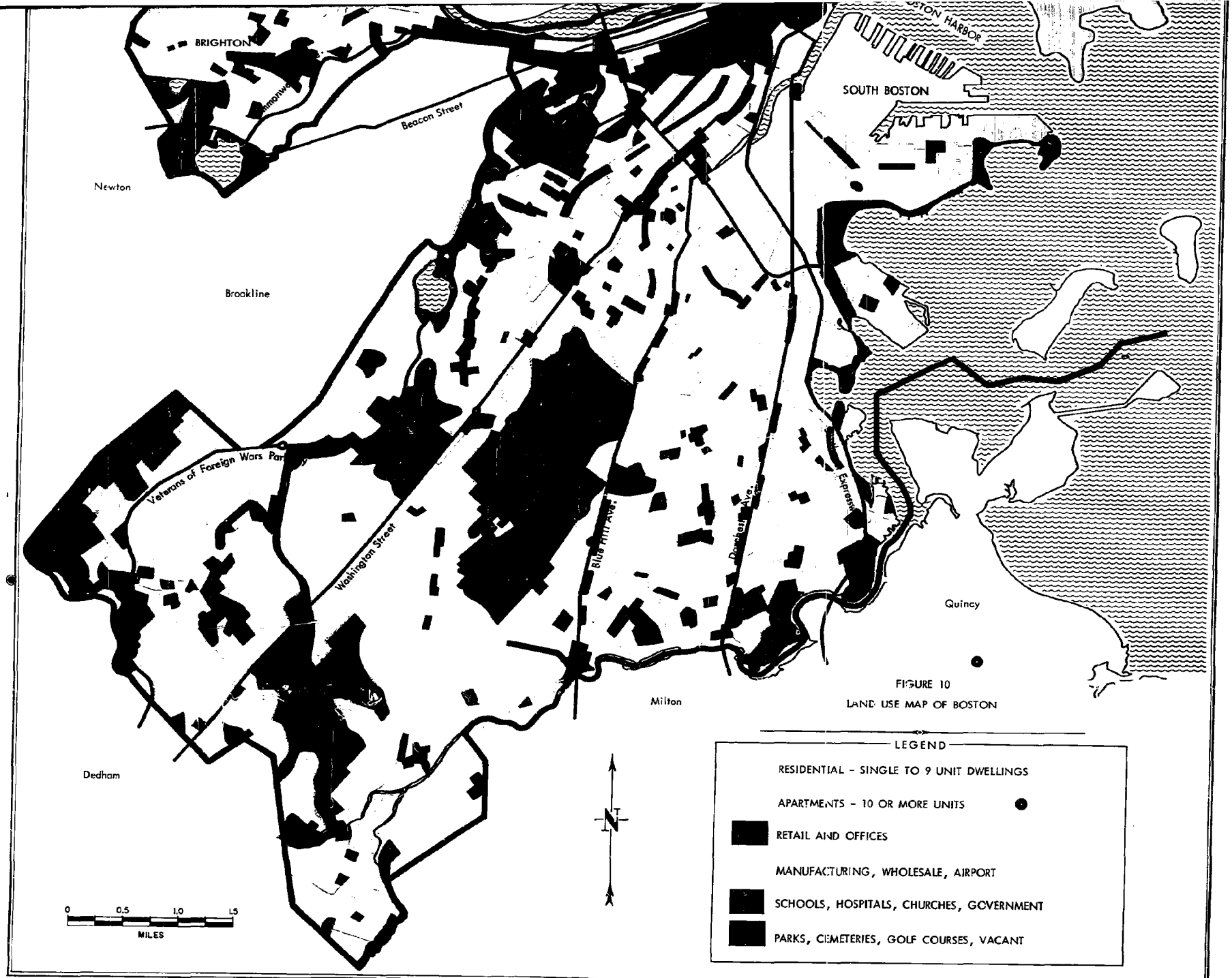



FIGURE 10
LAND USE MAP OF BOSTON

SOURCE: Developed by Stanford Research Institute from Land Use in Greater Boston, 1960, Greater Boston Economic Study Committee.

be considered. This step is necessary for two reasons: it assists in formulation of a plan; and it reveals limitations and potential problems of the plan. Limitations and problems beset almost any plan developed; recognition of these obstacles can point to ways in which the plan can be modified and improved at a later date.

## General Conditions and Assumptions

### Current Federal Civil Defense Program Posture

At present the federal program is aimed toward a series of interim measures. This has been stated publicly many times and is recognized by most CD officials at all levels of government. Thus, the community plan for sheltering people will also be an interim measure; it should, however, make maximum use of available shelter to the extent feasible. As the scope of the federal program becomes broader, the community plan can also be modified and improved. It may be many years before adequate quantities of dispersed but properly distributed (in relationship to location of people) and hardened (blast-proof) shelters are available within every community. Until this goal is reached, efforts should be directed toward plans which take best advantage of protection which is available now.

### The Primary Threat

The primary threat for which this plan is developed is assumed to be fallout. Planning for a lesser hazard is unrealistic and planning for hazards worse than this is inconsistent with the current availability of protection and the current program posture. Admittedly, some shelters capable of withstanding varying degrees of blast, thermal effects (fires), and instantaneous radiation are available in some communities. However, these cannot be the focal point of a shelter plan now because they can serve only a small proportion of the population and because as a first step (or in an interim plan) the most needed protection for the largest proportion of the population will be from fallout. Of course, the use of these "hardened" facilities as an integral part of the shelter allocation plan means that occupants will have protection from "close-in" hazards as well as the fallout hazard.

It also should be pointed out that, at present, the shelters that are to be used as protection from fallout also provide the best protection presently available from blast. Although the ability of these shelters to be of significant protection in this respect is

limited, their use is supported by the argument that "any protection is better than none."

## Desirability of a Plan or Destination for Every Individual

The "man on the street" historically has held and probably continues to hold what has been called an apathetic or defeatist attitude toward civil defense, its programs, and its plans, especially during periods when the threat of nuclear war appears very remote. On the other hand, his reactions during crisis periods dictate the need for developing a plan which provides for everyone. Each individual wants to know "what he should do" and/or "where he should go" were an attack to become imminent. Therefore, the plan must account for this desire, even though for some people the plan may allow only minimal protection. During a crisis period, at least, people seem to accept the face that some people will receive greater protection than others. Furthermore, as specific individuals request such information from the local CD office, an answer should be readily available. This by itself, in time, can greatly assist in building confidence in the CD program.

## Need for Maximizing the Number of Survivors

The major objective of this plan should be to maximize the number of survivors (from fallout). However, the limitations of administration, costs, human behavior, and so on also must be considered in this connection. Therefore the plan must allow for these limitations.

## Civil Defense Planning Group and Communications Network

It is assumed that a competent planning group is available within the CD office (or is available to assist the CD office) to develop, maintain, and update an allocation plan. Furthermore, it is assumed that this group also will be available for immediate post-attack analysis, evaluation, and planning. It is also assumed that a two-way communication network is available to carry out post-attack planning and direction. More detailed discussion of the planning group and communications network is given in Section VI.

## Informing the Public of the Plan

For any plan to be successful, the people affected must be informed. Of course it is hoped the allocation plan will never have to

be implemented, but is is imperative that the public have full knowledge of the plan and how to use it. Otherwise, should the plan have to be implemented, the most elaborate planning will have been wasted. The resulting chaos will be in inverse proportion to the degree the public is informed. This need is discussed more fully, especially with regard to the allocation plan proposed in this study, in Section VI.

## Progress in Licensing, Marking, and Stocking Shelters

It has been assumed, for the purposes of developing the plan in this study, that all facilities identified during Phase II of the National Fallout Shelter Survey as having a PF of 100 or more would be licensed, marked, and stocked with supplies. It is recognized that this is an ideal which may never be reached, and discussion of progress in this respect is given later (Section VI). Failure to meet this ideal will not affect the approach used in developing the plan, the plan itself, or the methodologies of general allocation or specific assignment of people to shelters. It will, however, affect the numbers which have been generated for Boston.

## Statement of the Allocation Plan

The plan which has been formulated and which is proposed as being appropriate for the City of Boston consists of two parts (each is actually a plan) and is called a "two-stage shelter allocation plan."

### First Stage

1. Upon alert (either pre- or post-attack) each person goes to the nearest shelter within the time available.

2. An individual's destination will be in the following order of preference, consistent with expected availability:

   a. Marked and stocked shelter (PF of 100 or more)
   b. Marked but unstocked refuge (PF of 40-100)
   c. Makeshift refuge (e.g. home basement)

3. People remain in shelter or refuge until otherwise informed officially.

Second Stage

1. This stage is initiated after Stage One has been implemented and the local attack situation has been evaluated.

2. It consists of movement of inadequately sheltered persons to stocked shelters or to unstocked refuges with improved protection, consistent with

   a. Time available for movement, and
   b. Distance to be traveled.

3. In post-attack situations where a fallout (radiation) hazard exists, movement will be either to stocked shelters of high protection or to areas of lower radiation intensity if low PF shelter or refuge will be adequate for survival and if stocks (food, water, medical supplies, etc.) are available.

The first stage of the allocation plan can be developed in detail prior to its actual use, whereas the second stage, being dependent upon the actual attack situation, cannot be developed in detail until the time it is to be used. However, as will be discussed later, a certain amount of preplanning for the second stage can be performed and it may be appropriate to develop several "off-the-shelf" plans.

The formulation of this two-stage plan is a direct result of the preliminary analysis discussed earlier in this section, particularly the relationship between distribution of people and distribution of shelter spaces, and consideration of the general conditions which have been discussed.

Inherent in the plan is the likelihood that under certain circumstances the community (in this case Boston) either will be a target or will be in close proximity to a target. A detailed target analysis was not performed on the City of Boston, because it is a known fact that the city is a major population center. This would no doubt make it a target if population centers are targets. The facts that it has a major port, has a Navy shipyard, and is close to other potential targets of a strategic nature also give rise to this likelihood. Therefore the allocation plan must allow for the worst fallout situation; this places a severe limitation on time for people to get to shelter. Clearly, for those communities where it can be determined that they would not be within a target area, the limitation on time would not be severe and the allocation plan might not have to be initiated in stages.

It has already been discussed earlier in this section and shown in Figures 5 through 8 that the distribution of shelter (PF 100 and over) spaces does not match either the day or night population distribution. The areas where excess shelter space occurs are limited primarily to the "downtown" part of Boston. Furthermore, the majority of the lower PF refuge space (PF 40-100) occurs in those standard locations which also have excess shelter space. Thus even by including refuge space with the higher protection shelter space there are many standard locations where there are not enough spaces to accommodate the daytime population within those standard locations. The situation at night is about the same. Most of the standard locations which do not contain sufficient shelter or refuge space to accommodate the people normally located in those areas are generally found in the periphery of the city and are primarily residential in character. The distance between these areas and the downtown part of the city is in most cases 4 to 10 miles. It is evident, therefore, that in the worst fallout situation (that occurring from a blast close to the city with early arrival of fallout) there would not be enough time for most people in these outlying areas to reach available shelter in downtown Boston. If the situation were not that serious, there might be more time; this condition is planned for in Stage Two of the proposed plan. In addition, post-fallout movement of people to higher protection can be planned as discussed later under "Case C."

In the outlying areas, the insufficient quantity of public shelter or refuge space and the inability of people to reach excess shelter in the downtown area means that a relatively large proportion of the people will have to use makeshift shelter. Fortunately, in the City of Boston as in many other older eastern cities, most homes have basements. A small amount of effort at the time an alert is sounded, such as covering the basement windows with earth, would provide persons in the basement with a protection factor of from 10 to 50, which during the early fallout period could mean the difference between surviving and not surviving. Movement to higher protection shelter after the actual attack situation has been evaluated might then be possible. The need for being inside shelter at the time early fallout arrives cannot be overstressed, as is shown later in the report.

In summary, the major findings which led to the formulation of this particular allocation plan were as follows:

1. The determination that the relationship between location of people and location of shelter spaces is unevenly balanced in the relative quantities involved.

2. The decision that the likelihood of early arrival of fallout warranted a plan which would allow for this possibility.

3. The imposition of the major conditions that each person should have a destination and that the plan should maximize the number of survivors to the extent possible.

Appropriateness of the Plan for the City of Boston

Many reasons why the two-stage allocation plan is believed appropriate for the City of Boston have been implied in the earlier discussion. The plan does give everyone a destination in the case of attack, and it is believed the plan will maximize the number of survivors from fallout for most of the types of attack which can be postulated. Admittedly, the plan is not particularly effective against a major attack on the City of Boston itself, where the hazards from blast far outweigh the hazards from fallout (at least initially). But as stated earlier, this is an interim plan which only takes advantage of the protection which is available; even in case of a major attack on the city, large numbers of people in the periphery of the city will benefit from the plan.

The plan in its first stage takes into account the fact that the actual attack situation will be unknown initially, and it does satisfy the need of providing protection for the worst fallout situation (which may be likely in this city). By assuring that people are within shelter or refuge at the time fallout arrives, it provides for the likelihood that the initial radiation intensity will be extremely high in certain areas of the city. This, of course, satisfies the thesis that any shelter is better than no shelter, especially at the time of arrival of early fallout.

This plan, in its second stage, allows for follow-up plans to fit more nearly the actual situation within the city. The opportunity for ultimate improvement in the protection of inadequately sheltered persons is thus assured. For example, there still may be 2 or 3 hours to move people after the first stage of the plan has been implemented and before fallout is expected to arrive. If fallout has already arrived after the first stage of the plan has been completed, then plans can be made to move inadequately sheltered people to higher protection shelters or areas of lower radiation intensity. This can be done through knowledge at the time of the location of people, their degree of protection, the geographical distribution of fallout and its radiation intensity, and location of available shelter space. Plans can be arranged so that people are moved

in order of urgency to areas of greater protection; the time, direction, and destination of persons moved are planned in such a way that an individual's accumulated radiation dose is kept to a minimum.

The two-stage allocation plan is also appropriate because it recognizes that while there will be more than sufficient stocked shelter space to accommodate the population of the entire city (day or night), the shelter spaces are not properly distributed to match the location of the population. Ultimate use of nearly all shelter space can be the objective of the second stage of the plan, if this is appropriate for the actual situation. Post-attack movement of people will be perhaps more feasible within this city than many others, because the railroad and rapid transit network, which is quite extensive and evenly distributed throughout the city, can be made a part of the plan. Use of these transportation networks can assure rapid movement of people from nearly any point in the city to almost any other point, affording them a nominal degree of protection during the movement.

Finally, the proposed two-stage plan is appropriate to a one-signal alert, which has been suggested to replace the present two-signal system. The latter system consists of a steady, continuous sound to indicate a probable attack, followed by a "warbling" sound to indicate that attack will be made at any moment. The two-signal system is confusing to much of the public and it is hoped that use of one signal will end this confusion. For the two-stage plan, one signal is all that is necessary to inform people that they should proceed immediately to their shelters.

## Alternative Shelter Allocation Plans

Several alternative shelter allocation plans have been considered and for one reason or another have been deemed inappropriate. Some of these alternatives will be discussed briefly here, with an indication of their advantages and disadvantages.

One alternative would be to plan for the most likely actual situation that can be postulated. Of course, such a plan must be based upon a detailed target analysis within and around the city or community. Such a plan has certain advantages and probably it is most appropriate for communities which can determine that they will be a hundred miles or so from the nearest target under all but the most unlikely circumstances. If this determination is not that clear, however--if it would be reasonable to conclude that the community might be a target or close to one--then this plan does not appear as appropriate as planning for the worst fallout

situation at least in a first stage plan. The latter is not dependent upon a detailed target analysis and thus upon a calculation which cannot really predetermine the actual situation.

Another alternative would be to plan for mass movement of all persons in the city or community to the general locations where stocked shelter exists. This plan could be based upon the use of vehicular transportation, walking, or a combination of these modes of travel. The advantage of this plan is that everyone would be protected by the best shelter available at the earliest possible time. The disadvantages are that the plan is probably too general and thus could create or add to the confusion. It does not take into account the time necessary for people to reach shelter and the possibility that people will still be traveling when fallout arrives. A plan based upon the use of vehicular transportation for moving people at the time of an alert is probably unworkable, except in very small communities where the number of vehicles and number of people being moved would be small and adequately accommodated by the highway or road systems. In larger communities, private automobiles would soon become tangled in the worst traffic jam imaginable unless the most strict policing and control could be performed, which would be very doubtful. The use of public transportation would require elaborate planning and organization; even if this were obtained, the short time available for movement of a confused, perhaps hysterical public makes the planned use of public transportation highly questionable. Use of vehicular transportation can be considered when there is sufficient time for adequate planning and organization.

Another plan which has been considered is that of "immediate take-cover." The advantage of this plan, of course, is that those persons close enough to adequate shelter will not only be protected immediately from fallout but could also be protected from many of the blast effects. The disadvantage is that those persons not close enough to enter adequate shelter immediately will lose valuable time--time which could be used in reaching adequate shelter and protection from fallout. The chances that these people would survive blast effects by immediate take-cover are rather slim. Inasmuch as there will be time for movement of people to shelter before fallout arrives and because fallout is to be considered the primary threat, delays in reaching shelter are not advisable.

Another plan that has been considered is one which communicates to the people at the time the alert is sounded what they are to do or what exact plan they are to follow. Its main advantage is that a plan can be initiated immediately that is based upon the actual situation. The disadvantage is that it will probably be very difficult to direct and control

people immediately following an alert. Trying to communicate an unfamiliar plan or destination to them, or one contrary to what they may have anticipated, will only add to the confusion. It is believed that this plan would not be successful in maximizing the number of survivors.

Another plan is in fact a combination of two of the alternative plans already discussed. In this plan, there would be general mass movement of persons to shelter upon the alert signal; however, a follow-up signal would be used to inform them, if arrival of fallout is imminent, that they should take cover immediately. The advantages of this plan combine those mentioned earlier under the separate parts of this plan. The major disadvantage is that the second signal can come at any time after a half-hour or so. The people therefore have no idea how much time they will have for movement, and they may not reach their destinations. In this case they would be going from one door to another trying to find a shelter which had available space and perhaps ultimately seeking a refuge or makeshift shelter in a neighborhood with which they are unfamiliar.

Many other plans can be formulated--from the "do nothing" plan which is obviously ridiculous to the most elaborate or complex plans which in some respects are just as ridiculous. None, however, appears as appropriate for the City of Boston as the two-stage plan which has been proposed.

## Implications of the Two-Stage Plan

Certain implications arise as a direct result of the two-stage plan. The plan assumes, in its first stage, that all three degrees of shelter--stocked shelter, unstocked refuge, and makeshift refuge--will be used. Current federal plans are to license, mark, and stock only those shelters accommodating over 50 people and having a PF of 100 or more; this is adequate only in part for the needs dictated by the proposed two-stage allocation plan. In addition to licensing and marking shelters that will be stocked, it will be necessary to license and mark shelters referred to in this study as unstocked refuges. It will be necessary in marking to distinguish between stocked shelters and unstocked refuges, and it is recommended that these terms be employed. Thus all licensed shelters meeting the federal criteria would be marked "Stocked Shelter" and the refuges (shelters not meeting the federal PF requirement) would be marked "Unstocked Refuge." However, licenses should be sought and marking performed only on those refuges that will have to be used--in areas of the city where excess stocked shelter exists, refuges will not be needed and should not be licensed and marked. On the signs marking both stocked

shelters and unstocked refuges, the capacity of the protection area should be indicated. It is not believed appropriate to indicate the PF because this will only hinder the allocation or specific assignment of people to the shelters or refuges. The PF could range anywhere from 40 to 5,000; if a person has a knowledge of the PF he may attempt to pass up a shelter of PF 200, for example, to which he has been directed in order to seek one having a PF of 1,000. It is believed, however, that the "unstocked refuge" sign should indicate that it is for temporary use only and that persons entering such a refuge may ultimately be moved to a stocked shelter of higher protection. Makeshift refuges, of course, would be neither licensed nor marked.

Another implication arising as a direct result of the two-stage plan has to do with the instructions given the public. In the first stage, a large number of people will be instructed to seek makeshift refuge until the situation can be evaluated because they cannot reach stocked shelter in the time available. In most cases, these people will use either their own or a neighbor's home basement. These instructions will appear to be a reversion to the home shelter program, which many people now think has been replaced by the National Fallout Shelter program. The fact that this is not true will have to be fully explained to people in order to retain their belief in civil defense and its program. These people will also need to be informed as to the best ways to protect themselves in makeshift refuges, and as to what quantities of food, water, and other supplies to provide. People who seek protection in unstocked public refuges must also have been instructed in types and quantities of supplies to take with them. In the early days of this plan, prior to the time an extensive communications system is assured, people should also be instructed to carry portable radios with them to shelters or refuges. People in unstocked and makeshift refuges will need to be able to measure radiation intensity and accumulated dose, if they are to be able to plan post-attack movements. Therefore they will need to be instructed in the purchase and use of cheap but adequate ratemeters and dosimeters.

In the planned and directed movement of people in the second stage, very close coordination will be required among the people being moved, the CD personnel directing the movement, and persons who are assisting in the movement. For example, in a post-fallout situation people must board railroad or rapid transit trains in a timely but orderly fashion if these trains are to be useful at all. Therefore in the plan for using these vehicles there must also be planning to assure a cleared path for travel, personnel to operate these vehicles, and persons to assist in boarding passengers. Radiation monitoring must be an integral part of the pre-movement planning and of the movement operation.

These implications are but a few of the many that exist. Many other considerations will become apparent to CD planning staffs and their assisting groups as they further develop the plan toward actuality. As questions or problems arise they should be written down, filed for later reference, and then periodically monitored until satisfactory solutions are obtained. This process should not cease with the development and adoption of a plan; it should continue indefinitely as the plan is updated, modified, and improved.

## Planning Factors Derived for Use with the Two-Stage Plan

The three major planning factors which must be determined for both the first and second stages of the shelter allocation plan are: (1) time available for moving people, (2) mode of travel which should be used during the movement, and (3) distances people can be moved. These factors must be determined before general allocation of people to shelter, specific assignment of people to shelter, or instructions to the public can be made.

Several general guidelines can be followed in determining these factors. These will be discussed first to indicate their applicability to any city using this plan and then the specific planning factors used in this study for Boston will be discussed.

In determining time available for movement, one might consider distance from the nearest blast as being the primary factor. In turn, the type, size, and direction of the blast would affect this determination. Superimposed on this would be the speed and direction of prevailing winds at the time. Because the first stage of the two-stage plan is predicated on the worst fallout situation, these many parameters are reduced to one simple question--how soon can fallout arrive if the blast is adjacent to the city but far enough away so that only fallout, and not blast effects, is the primary threat? The speed with which fallout travels then becomes the guiding principle. In addition, there may be time after the alert is sounded and before the attack occurs, but this time cannot be planned for. The attack could occur within 5 minutes after the alert, or in some communities it could occur after 5 or more hours.

In the second stage, of course, the time available for movement depends upon the time at which fallout is expected to arrive (based upon evaluation of the actual attack) which again will depend upon the location of the blast(s) and the speed with which fallout travels. If planning is for post-fallout movement of people, the time available for

movement will depend upon the total accumulated dose which people will be allowed to receive. Once this is determined, the time for movement can be calculated from the accumulated dose received up to the time of movement, plus the dose expected to be received during the movement (considering radiation intensity at the point of departure, over the travel route, and at the destination in conjunction with the protection received during travel), plus the accumulated dose to be received during time spent in shelter at the destination and dose that may be accumulated after final emergence from the shelter.

The mode of travel used by people in movement to shelter depends on several factors--number of people traveling, direction(s) of travel, availability of public transportation, availability of private transportation, and the ability to use the roads and highways. It is difficult to show guidelines upon which to actually instruct people in how to travel to shelter. During the first stage, it is probably unrealistic even to consider vehicular travel except in the smallest of communities where road systems are more than adequate to handle the flow of traffic. Public transportation could probably not be pressed into service in time to be very effective, even in smaller communities.

In the second stage the amount of time available for pre-fallout movement will also enter into the determination of mode of travel. As this time becomes longer, the likelihood becomes greater that public transportation could be used, at least in combination with walking. For post-fallout movement, the use of vehicular transportation will probably be mandatory for at least a portion of the travel. However, in this case time will have been available to adequately plan and organize this movement and streets will not be clogged with thousands of people trying to move in the same direction at the same time. This movement can be more easily directed and controlled.

The distance that can be traveled during movement of people to shelter is primarily a direct result of the other two planning factors--time and mode of travel. In addition, time taken for responding to the alert and initiating the movement, as well as time taken in lining up at the shelter, will reduce the distance that could be traveled. Other factors, of course, include the weather, time of day, number of people traveling on the same routes to shelters, and natural and man-made barriers that must be circumvented. In the first stage, the distance that can be traveled will generally be less than that which can be traveled in the second stage. This is because the time for travel will be shorter, more people will be traveling, reaction time will be greater, and control over direction of movement will be less.

## First Stage Planning Factors for Boston

### Time--30 Minutes

The time available for people to get to shelter during the first stage in Boston was determined to be about 30 minutes. No time has been allowed between the alert and the actual attack. This 30-minute time is conservative for planning purposes and allows for the fact that for fallout this early, people must be in shelter or refuge before fallout arrives. (If the fallout were 10 hours old or more, this requirement would not need to be quite so strict.) The decrease of dose rate with time is indicated in Figure 11; for example the radiation intensity at the end of 6 hours will be 10 percent of that at the end of 1 hour after the blast, and at 48 hours the intensity is only 1 percent.*

### Mode of Travel--Walking

The only reasonable mode of travel during the first stage in Boston is walking. Admittedly, some people in vehicles at the time of the alert may successfully reach stocked shelter that they would not have reached by walking. Some others may be able to use their own automobiles in the same way. But it is apparent that the roads and streets will very soon become unusable for vehicular traffic because of traffic jams, abandoned vehicles, and mass movement of people on foot. The majority of the people will start or end up walking to shelters or refuges, and for planning purposes it will be closer to the actual situation to base the general allocation or specific assignment of people on walking as the travel mode.

### Distance--1 Mile

This determination contains perhaps the most flexibility of the three planning factors--the other two are fairly well established

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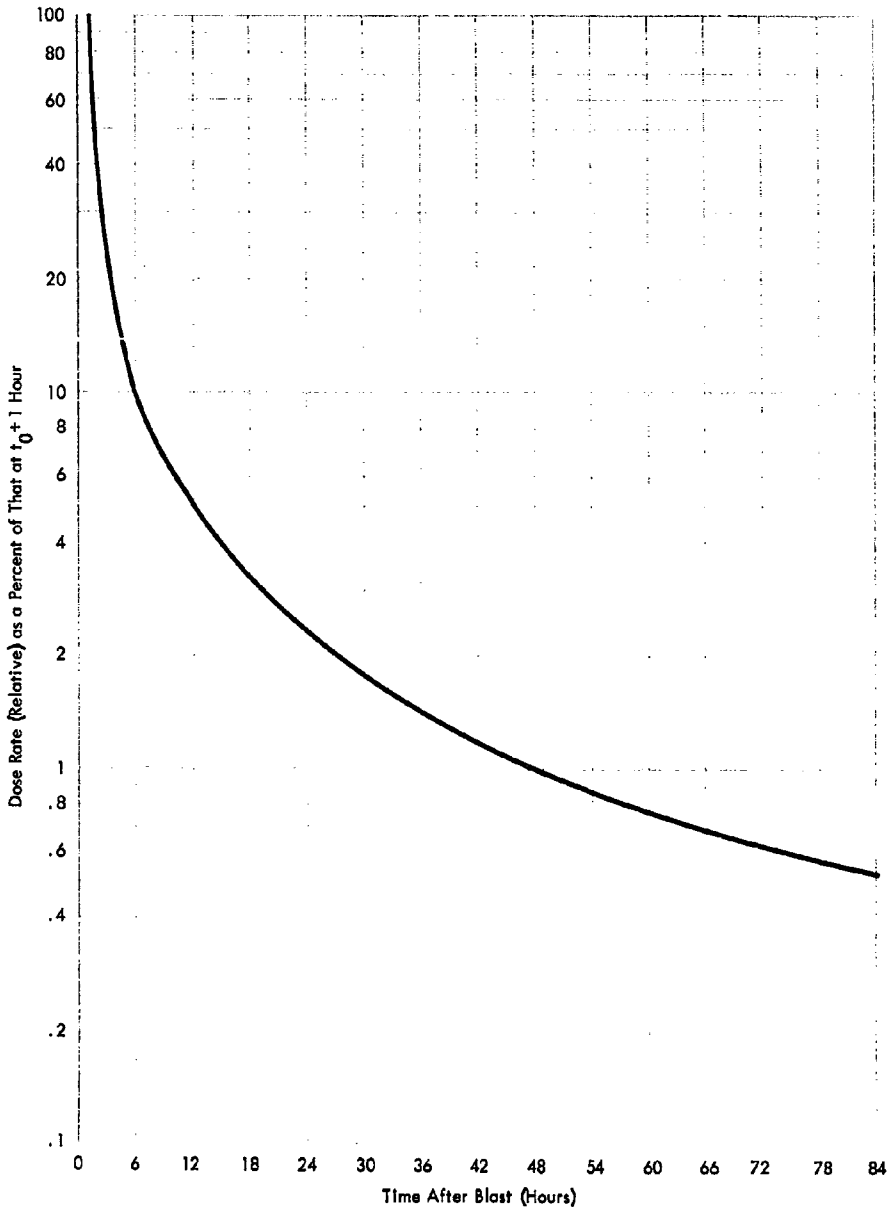
* Figure 11 represents the actual expected decay curve; this curve is slightly different from the straight line (log-log) calculated using the theoretical $t^{-1.2}$ equation. The latter line generally coincides with the former, with some exceptions . For example, the straight line indicates that the drop of intensity to 10 percent of its value at 1 hour occurs at 7 hours instead of 6 hours.

FIGURE 11

DECREASE OF DOSE RATE WITH TIME




SOURCE: U.S. Dept. of Defense, Defense Atomic Support Agency, The Effects of Nuclear Weapons (prepared for the U.S. Atomic Energy Commission), April 1962.

merely by the assumption that the plan will provide for the worst fallout situation. First, the distance that can be traversed is dependent upon the actual time available for travel. A portion of the 30 minutes available for movement to shelter will be consumed as "reaction time" (to the alert) and "queueing time" (at the shelter). For Boston, it is estimated that perhaps 10 of the total 30 minutes will be used for these purposes. For a given 30 minutes, therefore, a distance of only 1 mile could be traversed, based on a walking rate of 3 miles per hour. Under normal conditions of climate, during the day, and in areas relatively free of large masses of people, most people could walk at a rate of 3 to 4 miles per hour.

For planning purposes it is best to select a distance that will most nearly fit the actual situation and that includes a consideration for less than ideal circumstances. The factors which would tend to reduce the distance that could be traversed were mentioned earlier. At night, for example, a person could probably not travel as rapidly. On the other hand, the large masses of people trying to reach shelter (also an impediment to travel) will be less at night than during the day in most locations because of the differences in population distribution. These two factors might tend to counteract one another. The type of weather at the time will also have an effect on distance planning. Travel in rain, wind, or snow will be slower than in warm, sunny weather. Natural and man-made barriers will decrease the crow-flight distance that a person can travel. However, this factor is known and in determining the movement of people it will be taken into account by moving people along streets rather than in straight lines. On the positive side, the urgency of the situation will probably cause people to travel more rapidly than they would normally.

The distance that can be traversed in the first stage is seen, therefore, to be quite variable. For planning purposes in the general allocating or specific assigning of people to shelter it seems appropriate to use 1 mile as the distance that can be walked in the 30 minutes by the majority of the people under the likely conditions at the time.

## Second Stage Planning Factors for Boston

Determination of the same three factors--time, mode of travel, and distance--must also be made for the second stage of the plan. However, because the second stage plan is not initiated until after the actual attack situation is analyzed and evaluated, a true plan with specifically determined planning factors cannot be developed until that time. In lieu

of complete "on-the-spot" planning in which no pre-planning has been performed, "off-the-shelf" planning can be used. These two types of planning will be discussed, and three examples or cases have been prepared for the latter.

## "On-the-Spot" Planning

This type of planning is performed after the first stage of the allocation plan has been implemented. The planning factors are determined at that time, the over-all plan is developed, and people are instructed further.

Guidelines could be given here to indicate how the planning factors can be determined, but for the most part they follow the general guidelines given earlier in this section on planning factors. More specifically, they would follow the pattern or rationale used later in conjunction with the three cases given under "Off-the-Shelf" Planning.

The primary advantage of "on-the-spot" planning is that a plan is formulated or developed from the beginning that is based upon the data and information being fed to the planning group. This information will indicate the scope of the attack, hits that have been made, hits expected, intensities and expected patterns of fallout, and so on; this will allow the planning group to make the necessary determinations and arrive at a timely plan.

The disadvantages are several. A well-organized and very competent planning group will have to be available, and consideration must be given to the possibility that even though this group may exist on paper, it may not have reached the "center" where the planning and decision-making are to occur. Necessary data and information may be slow in arriving at the "center" during the early time following the alert. These two factors might combine so that valuable time would be lost in developing a full-scale plan. While rapid planning may not be necessary for some attack situations, it will be necessary for others. For example, if fallout has already arrived, there will be several hours to develop a plan which mobilizes railroad and rapid transit facilities and personnel to assist in the movement of people. On the other hand, if fallout is not expected to arrive for 2 or 3 hours after the first stage of the plan has been implemented, there will be need for an immediate plan for moving people to higher protection.

## "Off-the-Shelf" Planning

The major part of this type of planning is performed during the normal course of planning general allocation and specific assignment of people to shelter and refuge. Essentially it consists of developing a number of different plans--perhaps a dozen or so--to fit a series of postulated likely situations. At the time Stage One of the allocation plan has been implemented, the second stage plan most nearly fitting the actual attack situation is pulled "off the shelf," modified as necessary to meet actual conditions, and then initiated. The major advantage of this type of planning is that the bulk of the planning work has already been performed prior to the time the plan is actually required. In addition, the preparation of a number of alternative plans will make the planning group aware of the many factors and problems that have to be considered prior to the time a plan is required. In a sense, it overcomes many of the disadvantages of "on-the-spot" planning while at the same time retaining a large part of the major advantages of "on-the-spot" planning.

"Off-the-shelf" planning does have some disadvantages, of course. At the time a second stage plan is to be implemented, there may be a tendency, especially if time is short, merely to implement a plan without waiting for necessary data and information to modify it so as to truly fit the situation. Another closely related disadvantage is that the knowledge that plans have been prepared may lull the planning group into the belief that every situation has been covered, when in fact this may not be the case. A degree of "on-the-spot" planning will almost always be necessary.

To show how "off-the-shelf" planning could be performed and to indicate the probable results of such planning, three cases have been prepared. Planning factors have been determined and general allocation of people to shelter and refuge has been performed for each case. Planning factors are discussed in this section and general allocation in Section IV.

Case A. In Case A it has been postulated that fallout will not arrive for 2 to 3 hours after the first stage of the allocation plan has been implemented. The time planning factor to be used in the second stage in moving people from low quality refuge to stocked shelters or higher quality unstocked refuge is taken as 2 hours because, with the uncertainty involved, it is better to take the lower time limit so that people are not still moving when the fallout arrives. The "age" of the fallout is still young enough so that this is important (see Figure 11).

The most appropriate mode of travel for the people being moved in Boston is walking. It is conceivable that some vehicular transportation could be used but an extremely well-organized and carefully developed plan for mobilizing and controlling vehicles would be required. The likelihood of being able to implement such a plan in the time available seems doubtful.

The distance that can be traveled in the 2 hours available will be about 5 miles. (This assumes, of course, that people actually have 2 hours to travel, i.e., that this time is not used up in drawing up the plan and communicating instructions to the people.) This time-distance relationship is realistic because people probably will not delay in reacting to the instructions, not quite as many people are moving as in the first stage, and those who are moving will do so under greater direction and control than in the first stage. Although the distance of 5 miles has been chosen for this particular case, it can of course be modified to suit conditions. For example, it might be appropriate to cut this distance by half if the plan is initiated at night, during the winter, with several inches of snow and ice on the roads and a temperature well below freezing.

Case B. In Case B it has been postulated that fallout will not arrive for 10 hours after the first stage of the allocation plan has been implemented. The time available to relocate people in unstocked shelters and makeshift refuges to stocked shelters is therefore about 10 hours.

For planning purposes, the mode of travel is again taken as walking. With 10 hours time available, a certain amount of vehicular transportation could be used. This would depend upon a well-organized and developed plan for mobilizing vehicles and persons to operate the vehicles and direct the movement. If people were to use their own automobiles, traffic direction and control would be required. With 10 hours available this could probably be worked out if vehicles and any other obstructions left in the streets during the first stage could be removed. However, in the 10 hours available, vehicles should not have to be used except to move young children, the elderly, and the sick; all people in the City of Boston should be able to reach available space in stocked shelters. The maximum distance involved would be 12 miles which could easily be walked by the able in 10 hours, and most of the people would not have to travel that far.

A question that is bound to arise is, "If there are 10 hours before fallout arrives, why not evacuate the city because the next bomb

might be aimed for the city?" Certainly evacuation is a more reasonable objective if there is adequate protection and if supplies of food, water, medical necessities, etc., are available at the destination. This will probably not be the case for some time. Furthermore, while it is possible that the next bomb will be aimed at the city, many other circumstances are also likely. If fallout is not due to arrive for 10 hours and the decision has been made to move people over this time, then it has been determined likely that no bomb will be detonated on or near the city during this time. To make such a determination requires the knowledge that the attack is over either because it was an accident or was caused by an Nth power, or was a limited war in that truce has been called and agreed upon by both parties. If one of these or a similar situation is not the case, then the decision to have people move over this time probably would not be made.

Case C. In Case C it has been postulated that fallout arrives shortly after the first stage of the plan has been completed and before the second stage can be initiated. In this case, there will be many hours for developing a second stage plan and mobilizing equipment, vehicles, and personnel to assist in carrying out the plan. In addition to the three major planning factors to be determined--time, mode of travel, and distance--some other major points must be established. At what time after the fallout has arrived should people be moved? Which people should be moved first? Over what route should they travel? Should they be moved into the downtown part of Boston where there are excess stocked shelter spaces, or should they be moved to areas where the radiation intensity is low enough that home basements or other refuge facilities provide adequate protection? Obviously, none of these questions can be answered until the actual attack situation has been evaluated and the fallout patterns, radiation intensities, and urgency of moving certain people has been established. For purposes of this hypothetical case, it is assumed that all people in refuges will be moved to available stocked shelter spaces in the city. The distribution of fallout, urgency of moving certain people first, and routes to be used (or avoided) during the movement will be discussed later.

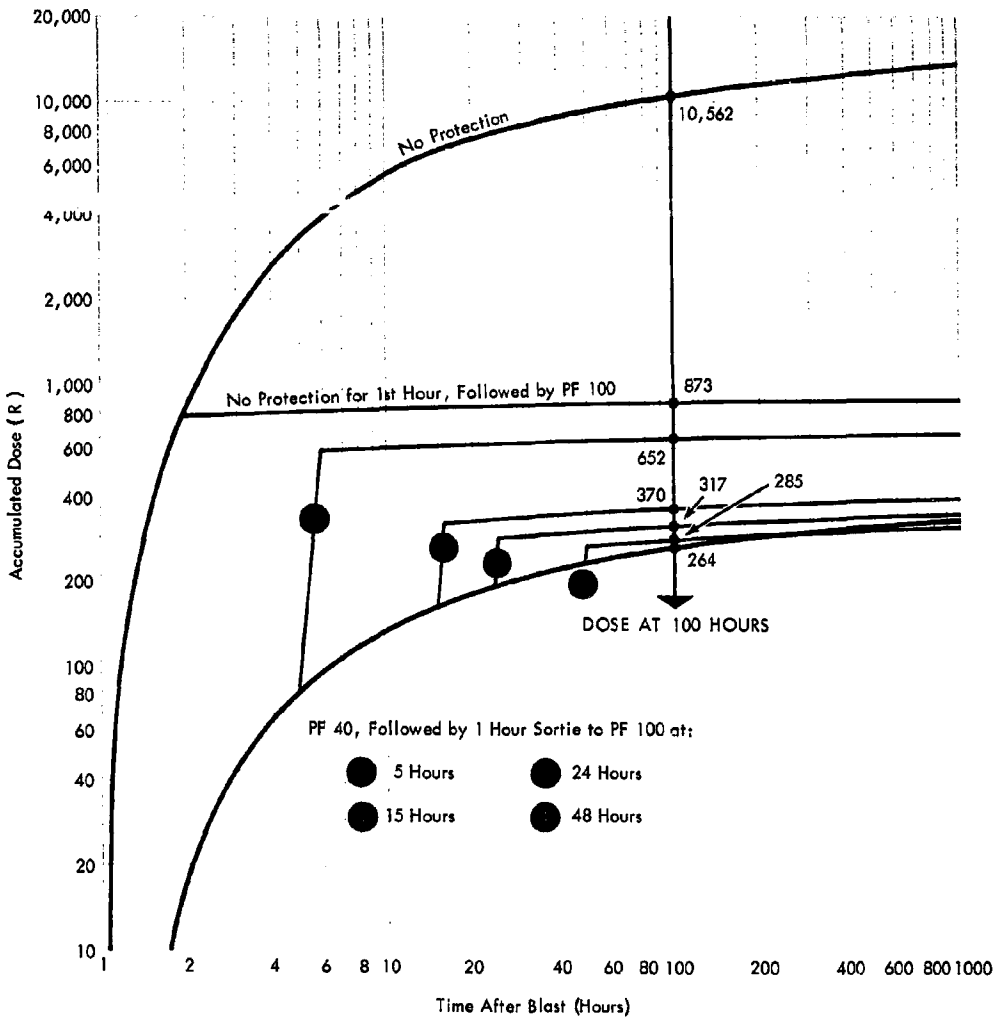
The time available for the movement of inadequately sheltered people to stocked shelter is determined to be about 1 hour at the most. Obviously the time should be kept as low as possible, since little protection from radiation will be available during movement and the projected accumulated dose should not be more than 250 to 300 rem. Greater doses begin to cause illness which requires medical attention and such attention may have to be devoted to more serious cases. Furthermore, the availability of facilities to care for people with radiation sickness will be limited.

The need for having 1 hour for movement of some people was determined by considering the distance to be traveled and the mode of travel to be used. The distance to be traveled will be up to 10 or 12 miles--the maximum distances from the outlying residential areas of Boston to the "downtown" area. The mode of travel must be a combination of walking and public transportation. Use of private automobiles will probably not be feasible, except perhaps to get to public transportation pickup points. Any greater use than this would be difficult to direct and control and would waste time, thus causing greater accumulated doses not only for the people being moved but also for personnel directing and controlling the movement. The railroad and rapid transit networks in Boston are extensive enough so that a 15- to 30-minute walk will place everyone at a point where he could board a train (see Figure 9). The use of trains will have to be well organized, but this arranging can be done in the time available preceding the actual movement. By using trains that have their own rights of way, the need for clearing streets of abandoned vehicles will be mostly eliminated. Furthermore, once these trains are filled, the trip to the downtown area can be made in a few minutes. People could be unloaded underground at their destinations and then directed to available shelter. Use of buses instead of trains would take more time to move people, and the problem of clearing routes for the buses might be insurmountable in a relatively short period of time, especially in areas where streets are narrow and buildings prevent pushing cars off the streets.

The last factor to be considered here is, how soon should the movement of people to improved shelter begin after the fallout has arrived. For this case the time selected would be about 2 days post-fallout for persons in unstocked refuges having a PF of about 40. This is based upon the time for movement, other planning factors discussed for this case, and the distribution of fallout and its radiation intensity. To make this determination, various relationships among PF's and accumulated doses were calculated--Figure 12. For this example it was assumed that the fallout arrived at $t_o$ + 1 hour (i.e., 1 hour after the blast); it stopped falling at $t_o$ + 3 hours; and the maximum radiation intensity (in areas of maximum fallout) at $t_o$ + 3 hours is 1,000 R/hr. Figure 12 shows that the dose received during the 1 hour of travel to improved shelter is such that it is better to remain in low protection refuge until about 2 days. (A uniform dose rate and no protection were assumed during the sortie--actually this would occur only under the worst circumstances and the average dose rate during the sortie would be something less than indicated in the figure for most people. The degree to which it is less may affect the time when the movement should occur.) Figure 12 also shows the importance of being in a refuge or shelter prior to the time fallout arrives. As indicated by this figure, a PF of 40 or more

FIGURE 12

CUMULATIVE DOSE UNDER VARIOUS CONDITIONS--Example 1




SOURCE: U.S. Dept. of Defense, Defense Atomic Support Agency, The Effects of Nuclear Weapons (prepared for the U.S. Atomic Energy Commission), April 1962.

is necessary to keep the accumulated dose down to 250-300 rem. Of course, not everyone will have even this protection, but the number of persons in this zone of maximum radiation intensity will be a small portion of the total. As a result, the number of persons receiving a total dose of over 300 rem would be relatively small. These people, however, are the ones whom it will be most urgent to move when the time comes and calculations must be made to determine the optimum time for this movement. Those who are injured, sick, or have the highest accumulated doses to date should be moved first.

As another example, calculations were made for persons being moved from unstocked PF 20 refuges to stocked PF 200 shelters, assuming slightly different radiation intensities; see Figure 13. It was assumed that fallout arrived at $t_o$ + 1 hour; it stopped falling at $t_o$ + 3 hours; and the maximum radiation intensity at $t_o$ + 3 hours is 400 R/hr. Further assuming a uniform dose rate and no protection during the 1 hour sortie, Figure 13 shows that the optimum time for movement to stocked shelter would be between 15 hours and 48 hours after the blast.

In moving people, the high intensity radiation zones should be avoided. This is obvious, but the zone determinations will have to be made.

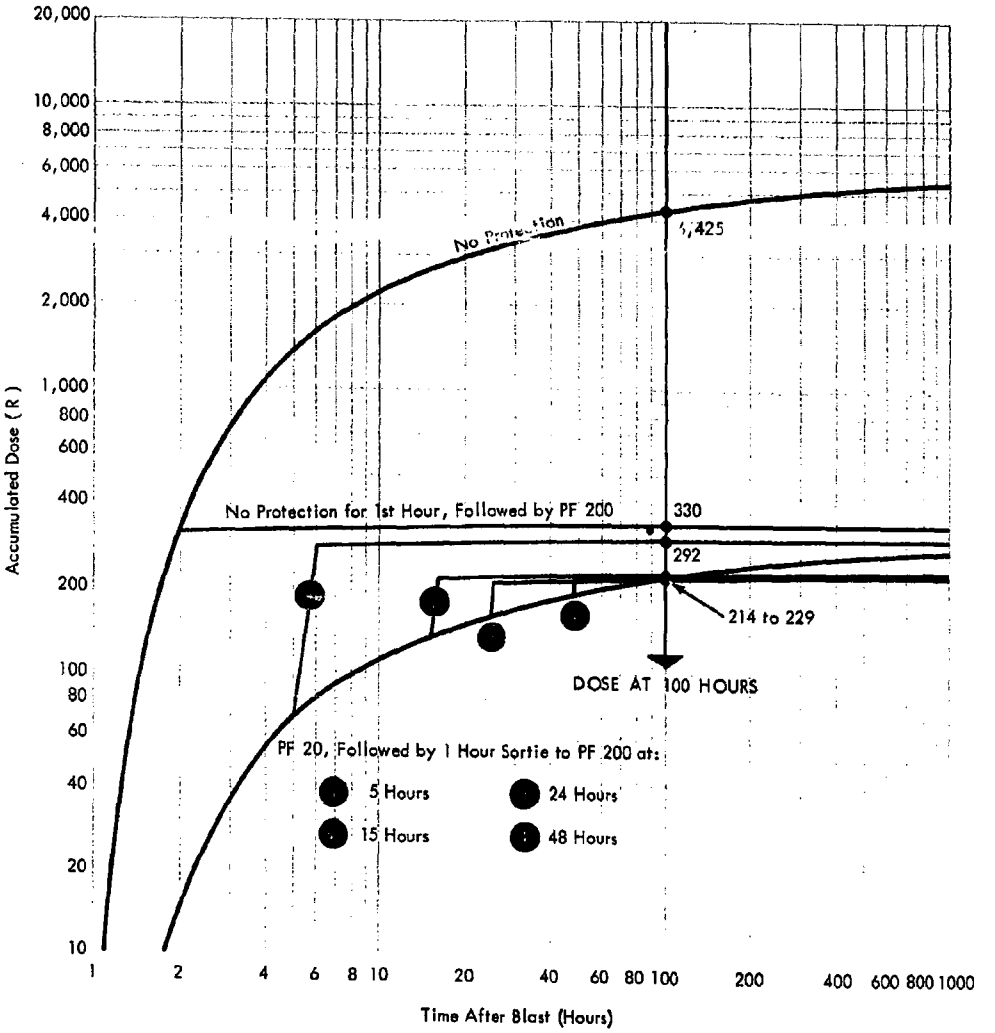
To summarize this case, people in inadequate shelter can be moved to adequate shelter beginning several hours after fallout has arrived. At that time they can be instructed to travel by foot to the nearest railroad or rapid transit line to board a train at a certain time so they can be moved in the least possible time.

Again, it should be stressed that the assumptions made in this case were purely hypothetical, to show the process of planning for the post-fallout movement of people. A number of different cases of this type, using different sets of assumptions, should be prepared if the "off-the-shelf" planning technique is to be used.

Actually, "on-the-spot" planning is probably more appropriate for post-fallout situations. The factors which affect this determination are PF of present shelter and accumulated dose to date, protection available during transit, variation in radiation intensity during transit, and the speed with which people can be moved. By determining these factors, an optimum time for movement can be calculated for any situation--the ones shown in Figures 12 and 13 are only two examples of the hundreds which could be developed.

FIGURE 13

CUMULATIVE DOSE UNDER VARIOUS CONDITIONS--Example 2




SOURCE: U.S. Dept. of Defense, Defense Atomic Support Agency, The Effects of Nuclear Weapons (prepared for the U.S. Atomic Energy Commission), April 1962.

## IV GENERAL ALLOCATION OF PEOPLE TO SHELTER

Once the preliminary analysis has been made and a shelter allocation plan has been formulated, the next step is to make a general allocation of people to shelter. This involves the determination, in general terms, of the people who will be able to reach different grades of shelters under the allocation plan and what shelter will be used by these people. The movement of people under the allocation plan discussed in Section III is analyzed and shelter collection areas are established. The assignment of individual people to specific shelters, which can only be accomplished after having first analyzed assignments in general terms, will be discussed in Section V.

The reasons for making a general allocation of people to shelters are several:

1. Data must be developed which can be used to prepare instructions informing the public what to do at the time of a CD alert.

2. Data on the status at the end of Stage One of the allocation plan form the basis for plans for Stage Two.

3. The real areas of adequate shelter are determined. (The preliminary analysis using SL boundaries did not take into account the specific locations of shelters and movement of people between SL boundaries.)

4. Which shelters and refuges will actually be used in the allocation plan is determined. As a result, which shelters should be marked and stocked and which refuges should be marked are known.

5. A basis is prepared for later specific assignments of people to shelters.

## General Allocation for Stage One of the Plan*

In making the general allocation for Stage One, the planning factors discussed in Section III were used. For Stage One these were that 30 minutes would be available to reach shelter, that approximately 1 mile could be traveled in this time, and that the primary mode of transportation would be walking. Several assumptions also had to be made. First of these was that of the shelters and refuges located by the A&E's in their surveys, those which would be needed would be licensed and could be used. The fact that this would probably not actually be the case does not affect the method used to make general allocations in this report. It was also assumed that people would not bypass nearby shelters to travel to some other area with a large amount of excess shelter, even though this might make space available to outlying areas which had inadequate shelter. People can be expected to follow their instincts for personal survival and will probably go to whatever shelter is nearest. Finally, it was assumed that, given a choice, people would choose shelter with a PF of 100 to 1,000 in preference to space with a PF of 40-99 which was marked as a refuge.

The allocation method utilizes a graphic approach in analyzing the problem and making assignments. Since the problem involves the various locations of shelter and the movement of people to these shelters, the use of maps was felt necessary.

The following informational inputs are required for the analysis:

1. The standard location and the shelter facility summary printouts from Phase II of the A&E survey.

2. The shelter location map previously developed and discussed in Section III.

3. The maps from Section III showing areas of excess shelter and unsheltered populations by standard location.

4. A U.S. Geological Survey map of the City of Boston, scale 1:24,000.

5. The land use map of Boston.

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* The approach discussed here is also appropriate to communities that choose a plan different from that suggested for Boston. Allocation is desirable for any plan similar to the one suggested in this report and the method used for Boston is applicable to almost all communities.

6. The base map of Boston showing city streets and major landmarks, discussed in Section III.

Allocation of Day Population to Shelter

The allocation of people to shelter is essentially a step-by-step process. Outlined below are the steps which were taken in the study of Boston.

1. The base map of Boston was attached to a drafting table with a sheet of tracing paper on top, so that the base map could be read through the tracing paper.

2. The city was divided into parts among which little or no cross-movement of people would occur during Stage One of the plan. Each part could then be analyzed separately. For the City of Boston, four different areas could be treated individually in a meaningful way: East Boston, Charlestown, Brighton, and Boston proper. The boundaries making Brighton a separate area are, of course, only "paper boundaries." Normally this area could not be analyzed by itself since the neighboring communities, particularly Brookline and Newton, would also have to be considered. However, under the basic assumption of this research study, problems resulting from communities adjacent to Boston were not considered.

3. Starting with one section of the city (the smallest section was chosen first to gain proficiency in the allocation process), allocation of people was made for shelters with a PF of 100 and over.

4. A line was drawn on the tracing paper representing 1 mile distance from areas of excess shelter as shown by the maps of excess shelters. This distance line was drawn on the basis of actual shelter locations within the standard location rather than on the basis of SL boundaries. Moreover, the distance was measured along actual travel routes through the streets rather than "as the crow flies."

5. The unsheltered people within the "distance line" were allocated to the shelters with excess or unused space. Where it was necessary to determine the number of unsheltered people for only a portion of a standard location, an estimate was made. The shelter location map, along with the shelter facility summary,

provides information as to the number of shelter spaces in the affected area; the land use map, street patterns, and knowledge of the city provide the basis for estimating the population within the particular section of the standard location. The allocation process also must take into account that those people closest to a shelter will fill that shelter first. As a result, people located 1 mile from excess shelter may actually be farther than 1 mile from shelter that has not already been filled. When this situation occurs, an approximation must be made as to which areas of people can actually reach unused shelters and a new line must be drawn on the map to indicate where this occurs.

6. If there is sufficient excess shelter to accommodate the number of unsheltered people within the area of the distance line, this line becomes the "shelter limit line" used to define the shelter drainage area. The shelter limit line is used as the basis for instructions to the public telling them what to do at the sounding of the CD alert. A record should be kept of the location and approximate amount of shelter space that remains unused after this allocation process because this information is necessary to planning assignments in Stage Two.

7. If there is insufficient excess shelter to accommodate the number of unsheltered people within the limits of the distance line, allocation is made by working outward from the area of excess capacity, adding unsheltered people until the shelter capacity is filled. A shelter limit line is drawn where the number of unsheltered people matches the amount of excess shelter space. Unsheltered population for parts of standard locations is estimated as in Step 5. The topographical map, street map, land use map, and estimates of human behavior are used in determining how people would move to shelters.

8. Steps 3 through 7 are repeated for the other sections of the city until allocation of shelters with a PF of 100 and over is completed.

9. Steps 3 through 8 are then repeated for the allocation of people still unsheltered to shelters with a PF of 40-99. In this case, the number of unsheltered people without PF 40-99 space is assigned to the total amount of space with PF 40-99 in those areas where the population has already been accommodated in PF 100 and over space.

10. Those people who in Stage One are still not allocated to shelter will be required to use whatever shelter or makeshift refuge is available in their own neighborhoods.

Results of the Allocation of Day Population to Shelter

The end result of the process outlined above is a map which shows the movement of people into different grades of shelters. The map developed to show the allocation of day population to shelters in Boston is shown in Figure 14. The dark green shapes indicate the location of large amounts of PF 100 and over shelter space to which people without shelter in their immediate neighborhoods would move. The green lines show the boundaries of the areas (light green) in which all the people would be able to reach PF 100 and over shelters within the 30 minutes allowed in Stage One. The yellow lines indicate the boundaries of the areas (light yellow) in which all of the people would be able to reach shelters with at least a PF of 40. Those people in areas (light red) outside the green and yellow lines would have to use makeshift refuge if there were no marked shelters or refuges in their immediate neighborhoods. The arrows indicate the general directions of the movement of people to shelters. The broken lines indicate where there is a distinct change in the direction of the movement to shelters.

A detailed explanation of the analysis and individual decisions made in developing the allocation map would be extensive. However, a brief statement of the analysis made in East Boston will serve as an example of how allocations were made throughout the City of Boston.

Almost all of the shelter space with a PF of 100 and over in East Boston is found at only two locations. The MTA subway tunnel under the Boston Harbor, which can be reached from the Maverick Street Station, has a capacity of 6,500. The Sumner and Callahan highway tunnels, whose eastern portals are located near the boundary between SL 7 and SL 8, have space for 24,825 people.* The 1-mile distance was measured from the

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* The space in Sumner and Callahan tunnels was assigned arbitrarily by the A&E's to the standard locations in which the western portals were located, SL 25 and SL 26. Because these standard locations are both in an area of downtown Boston which already has large amounts of excess space, it was decided to reassign the tunnel space to East Boston where a shortage of space exists. The tunnels are patrolled by guards on a 24-hour basis and, in time of alert, the western portals could easily be closed to make all of the space available to East Boston.

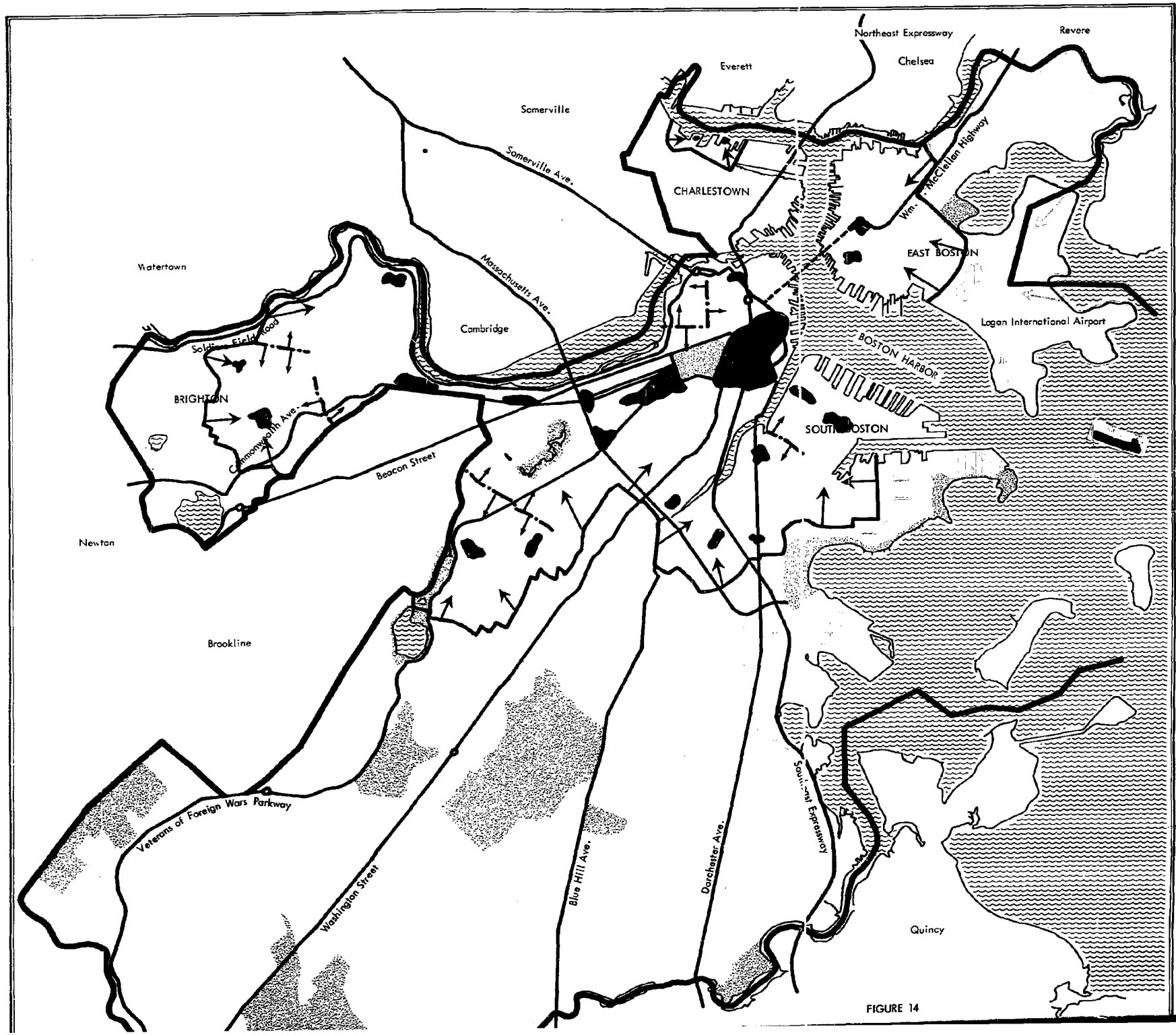
Northeast Expressway
Revere
Everett
Chelsea
Somerville
Somerville Ave.
CHARLESTOWN
Wm. F. McClellan Highway
Watertown
Massachusetts Ave.
EAST BOSTON
Cambridge
Logan International Airport
Soldiers Field Road
BOSTON HARBOR
BRIGHTON
SOUTH BOSTON
Commonwealth Ave.
Beacon Street
Newton
Brookline
Veterans of Foreign Wars Parkway
Washington Street
Blue Hill Ave.
Dorchester Ave.
Southeast Expressway
Quincy

FIGURE 14

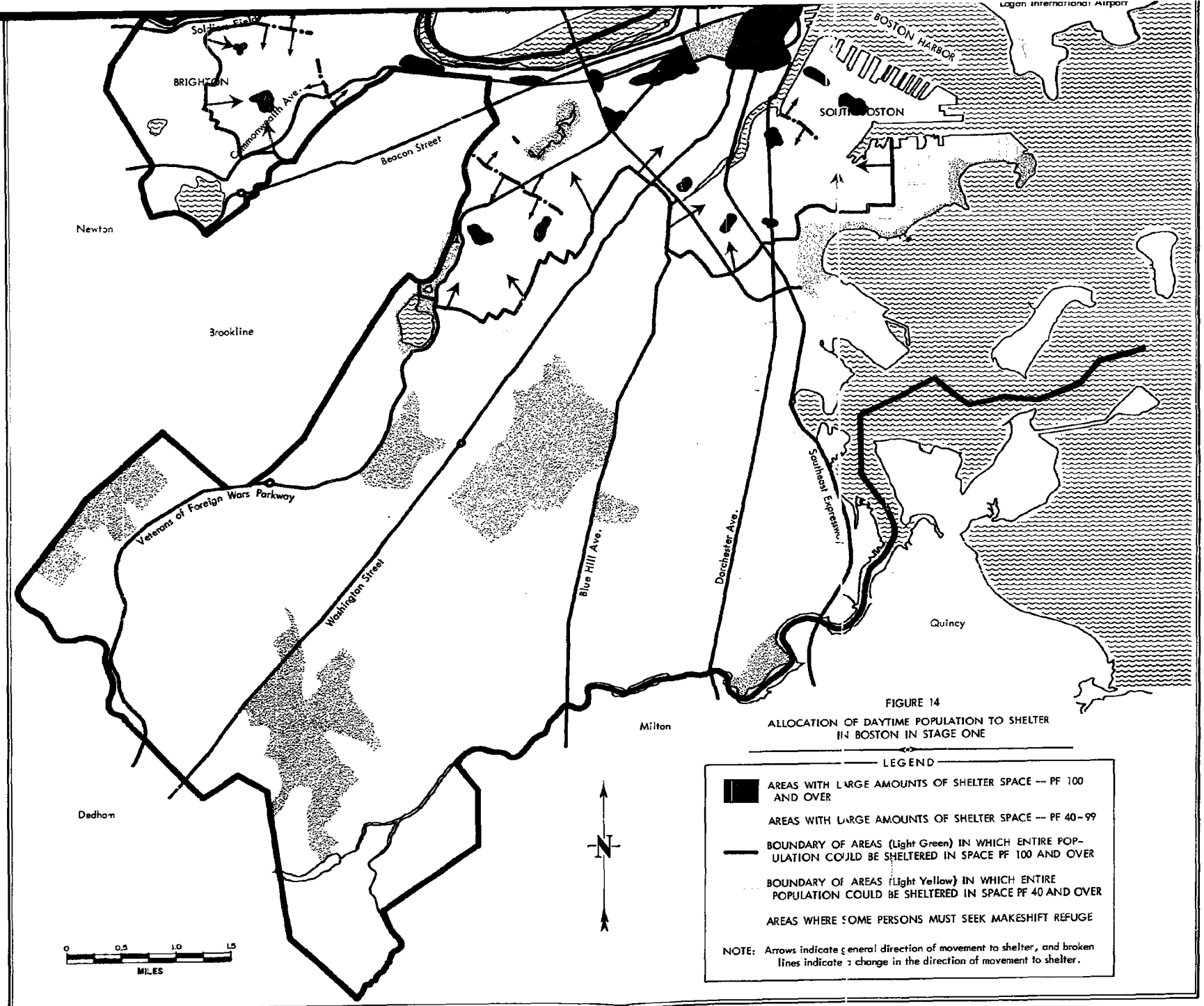


FIGURE 14

ALLOCATION OF DAYTIME POPULATION TO SHELTER IN BOSTON IN STAGE ONE

SOURCE: Stanford Research Institute.

entrances of these tunnels since the remaining shelters are too small to serve more than the people in their immediate neighborhoods. The southern and western boundaries of East Boston, which are formed by Boston Harbor, are within an easy 1-mile walk to the tunnels. A line 1 mile east of the MTA tunnel cuts through the Logan Airport property, about a third of a mile west of the passenger terminal building. To the north, the distance line was drawn 1/4 mile north of Eagle Square. Within the area of the distance lines, the number of unsheltered people is less than the amount of excess shelter space existing as a result of the highway and subway tunnels. However, the shelter limit line to the north was drawn slightly to the south of the distance line. There is a natural boundary formed by the railroads, expressway, and a change in land use which seemed to make greater sense as a shelter limit line used in instructions to the public than did the distance line. Most of the people to the north of the shelter limit line in East Boston will have to utilize marked shelter and makeshift refuge in their immediate neighborhoods. There is only a negligible amount of PF 40-99 space south of the shelter limit line which is close enough to be reached by those located in the northern portion of East Boston. As a result it was not felt desirable to establish a PF 40 and over limit line since it would be located only slightly north of the PF 100 and over limit line. In Figure 14 it has been shown coincident with the PF 100 and over limit line at this point.

The result of placing the limit lines as indicated is that, of the total 38,739 PF 100 and over spaces in SL's 3 through 12 (south and west of the limit line), 24,568 can be used during the day and 34,768 can be used during the night. None of the PF 40-99 unstocked refuge and, of course, no makeshift refuge will have to be used. Those people in the passenger terminal area at the airport (estimated to be 1,500 in the daytime and 500 at night), although not able to reach the space in the tunnels, will be able to find more than enough space with a PF of 70-99 in the various buildings at the airport. In that area there is no need to mark and use PF 40-69 space. All 2,068 spaces having PF 100 and over and all 1,413 spaces having PF 40-99, will be required both day and night in SL's 1 and 2. In addition, 29,519 people during the day and 8,219 people during the night will have to use makeshift refuge.

The analyses of the other sections of Boston were performed in a manner similar to that for East Boston and will not be commented upon further except to note that in Charlestown, as in the passenger terminal area at the airport, it was unnecessary to use any of the space which had a PF of 40-69. In the downtown areas of Boston proper it was not necessary to use any space with a PF of less than 100.

Figure 14 provides a graphic statement of the results of the assignment of the daytime population to shelters in Boston. By moving people to shelter during the 30-minute time period allowed during Stage One, the size of the areas where people are not all able to reach shelters with a PF of 40 and over has been reduced from that shown in Figure 7, where people were assigned space only by standard locations. However, a large area of the city must still make use of makeshift refuge. An analysis which only related the total number of available shelter spaces to the total population would not have revealed the existence of areas lacking shelter. The tabulation below shows numerical results of the general allocation of day population to shelter during Stage One of the plan:

| | Shelter Groups | | |
|---|---|---|---|
| | Stocked Shelter, PF 100 & Over | Unstocked Refuge, PF 40-99 | Makeshift Refuge |
| No. of persons--daytime | 773,672 | 149,312 | 291,711 |
| Percentage of daytime population | 64% | 12% | 24% |
| Percentage of total available space | 53% | 10% | Unknown |

Of the daytime population, 24 percent would have to use makeshift refuge during Stage One even though the total amount of shelter space with a PF of 40 or more is equal to 237 percent of the daytime population. The location of shelters in relation to the location of people is such that 53 percent of the space with a PF of 100 and over and only 10 percent of the space with a PF of 40-99 is used.

## Allocation of Night Population to Shelter

Since the number and distribution of people at night differs from the number and distribution during the daytime, a general allocation of the nighttime population to shelter must also be made. The same method of analysis was used for the night population as was used for the day population. The tabulation below shows the numerical results of the allocation of the nighttime population to shelter.

| | Shelter Groups | | |
|---|---|---|---|
| | Stocked Shelter, PF 100 & Over | Unstocked Refuge, PF 40-99 | Makeshift Refuge |
| No. of persons--nighttime | 478,988 | 155,293 | 304,095 |
| Percentage of nighttime population | 51% | 17% | 32% |
| Percentage of total available space | 33% | 11% | Unknown |

As a result of the increase at night in the number of people in the residential areas and a decrease at night in the population in the downtown areas, the percentage of the population which must use PF 40-99 space and makeshift shelters is greater at night than during the day. The areas in which all of the population can reach shelter with a PF of 100 and over or PF 40 and over also changes, as can be seen in Figure 15. The areas where people must use makeshift shelter have decreased somewhat in size but are still quite large.

## Translation of Graphic Allocations into Instructions to the Public

The general allocation of people to shelters is a purely academic process unless the allocations which have been made on paper can be issued as instructions to the public telling them what to do at the time of a CD alert. The general allocation maps form the basis for the development of such instructions. Since the shelter limit lines are drawn along actual streets and landmarks, the information on the maps can be easily translated into instructions for people in different sections of the city.

East Boston will be used again as an example area for the preparation of written instructions for the public based upon the analysis made during the general allocation. An outline of how the instructions might read is as follows:

1. From the first sounding of the alert signal, you have approximately 30 minutes in which to seek some sort of shelter. In this time you cannot expect to be able to walk more than 1 mile. The kind of shelter which can be reached within this time depends upon the part of East Boston in which you are located.

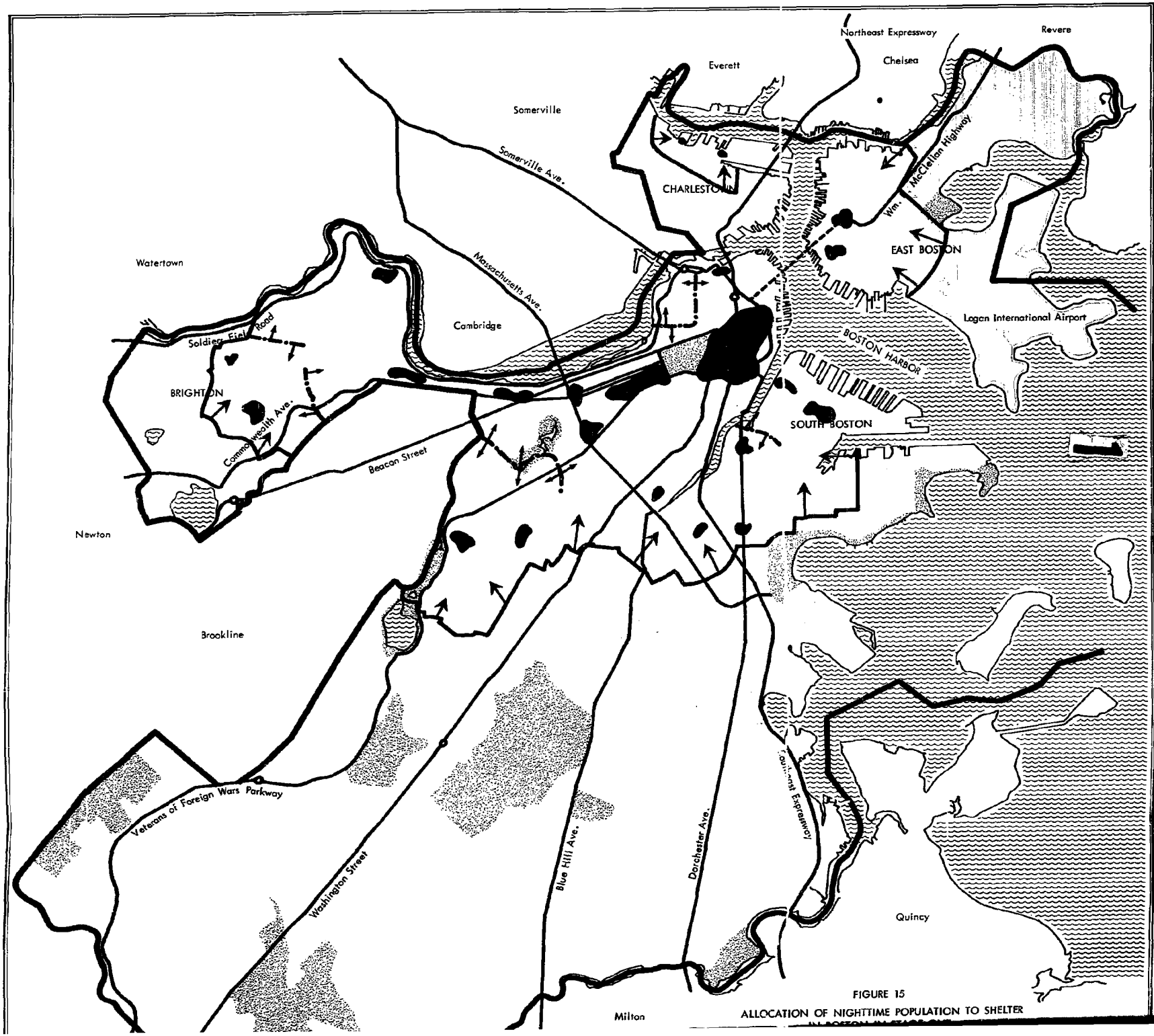


FIGURE 15
ALLOCATION OF NIGHTTIME POPULATION TO SHELTER

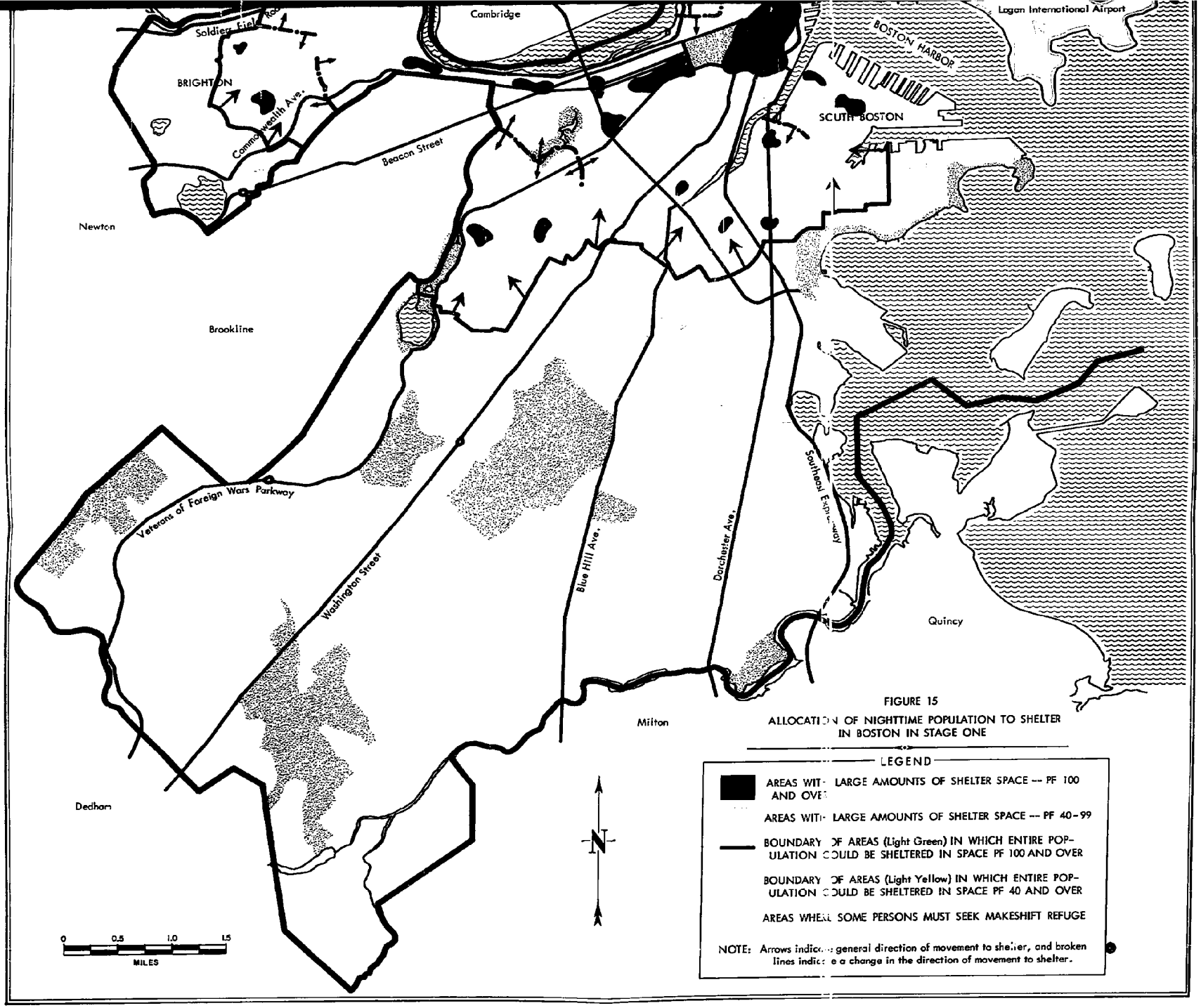


FIGURE 15

ALLOCATION OF NIGHTTIME POPULATION TO SHELTER IN BOSTON IN STAGE ONE

SOURCE: Stanford Research Institute.

2. Those people located in Area A* of East Boston should use the marked shelter in their immediate neighborhoods, if such shelter is available. If no shelter is available in your neighborhood or if it is already filled with other people, proceed to either the Maverick Street MTA Station or the portals of Callahan and Sumner tunnels located near Central Square, whichever is closest. Area A includes that portion of East Boston bounded by a line drawn one block north of Eagle Square to the Boston & Albany R.R. tracks, south along the tracks to Prescott Street, west along Prescott Street to the end of the street, south through the Logan Airport property just east of the passenger terminal area to Boston Harbor, and then west and north along the waterfront to one block north of Eagle Square.

3. Those people located in Area B** should follow the signs directing them to the refuge type shelter located in their immediate vicinities. Area B is the passenger terminal area of Logan Airport.

4. Those people in Area C*** should utilize the marked shelters or refuges located in their immediate vicinities. If there is no marked shelter or refuge within one or two blocks, immediately seek makeshift refuge. Area C is that portion of East Boston which is north of Memorial Park and east of the Boston & Albany R.R. tracks.

The instructions for East Boston are appropriate both day and night, since the shelter limit lines developed in the general allocation analysis are the same for day and night. In other parts of Boston, however, the shelter limit lines differ according to the time of day. As a result, there are basically four alternative kinds of instructions which can be issued to the public:

1. Issue one set of instructions for the daytime condition and another set for nighttime (the latter set also would be used on Sundays and holidays).

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* Light green in Figures 14 and 15.
** Light yellow in Figures 14 and 15.
*** Light red in Figures 14 and 15.

2. Issue only the day or the night instructions, according to which condition is thought to be most likely.

3. Issue instructions based upon the maximum population within each area of the city, expecting some shelters will not be used fully; or issue instructions based upon minimum population and expect overcrowding of shelters at certain times.

4. Issue instructions based upon a shelter limit line which is a compromise between the day and night conditions and which recognizes that a limited amount of overcrowding of shelters is perhaps permissible.

No one of the above alternatives is ideal. Alternative 1 brings about what is probably the optimum use of shelters but may lead to confusion in the public mind. The other alternatives either do not utilize shelter to the greatest possible extent or else risk the lives of people who are caught on the streets trying to get into shelters which are already full or who die from the overcrowded conditions within the shelter. Since each of the alternatives has inherent problems whose extent will depend upon the particular city and area within that city, this research report does not attempt to suggest the one right answer. Each local CD organization must make a policy decision after it has evaluated its own situation.

## General Allocation for Stage Two of the Plan

The general allocation for Stage Two follows the same basic methods as those used in Stage One. The only major differences are that different planning factors are used (time, distance, and mode of travel) and that the matching of people to shelters is done using the number of inadequately sheltered people (i.e. those in unstocked and makeshift refuges) and excess space still existing after the Stage One plan has been implemented. Whether the Stage Two allocations are made "on the spot" at the time of the alert or are made prior to an alert for later use as "off-the-shelf" plans does not change the method and approach used.

Before making the general allocations for Stage Two, the local CD organization must carefully assess its capabilities for carrying out a Stage Two plan and then incorporate its assessment with the planning factors and decision rules used in making the assignments to shelter. The ability to communicate instructions to the public after Stage One has actually been put into effect must be determined. Stage Two plans

which cannot be communicated to the public can never be carried out. The extent to which various transportation systems can be used to move people during Stage Two must also be established. Then steps must be taken to ensure that the transportation systems will be operational when actually needed.

In order to illustrate the allocation process in Stage Two through the use of the three cases discussed in Section III, it was assumed that the necessary instructions could be communicated to the public and that certain abilities to transport people would exist.

Case A

In Case A, fallout was not expected to arrive until 2 to 3 hours after Stage One had been implemented. Two hours were allowed for people who were in makeshift and PF 40-99 refuges at the end of Stage One to reach stocked shelter with a PF of 100 and over. Approximately 5 miles could be traveled in this time, using walking as the primary mode of transportation.

The results of the assignment of the nighttime population to shelters are shown in Figure 16. The green lines indicate the limits of the areas in which people would be able to reach better shelter. The arrows show the general direction of the movement to shelter. The dark green shapes indicate the location of PF 100 and over shelters with excess space at the end of Stage One and to which people would move in Stage Two.

In making the allocations, it was assumed that people already in space with a PF of 100 and over at the end of Stage One would not move even though this might make space available for inadequately sheltered people. As a result, the distances were measured only from the dark green shapes (Figure 16). It was assumed also that people in PF 40-99 space at the end of Stage One would not necessarily relocate in Stage Two even if they were told that such a movement would improve their protection. Therefore, no assignment of poorly sheltered people was made to PF 40-99 refuge space which had been used in Stage One.

In East Boston, all people in inadequate shelter would be able to reach the Callahan and Sumner tunnels. In order to make room for these people in Stage Two, the people in the tunnels at the end of Stage One would be directed to walk through the tunnels and obtain shelter in the financial district of downtown Boston. Such instructions are practical since adequate shelter management to carry out the orders exists for the tunnels because of their 24-hour guard system. Those people in the

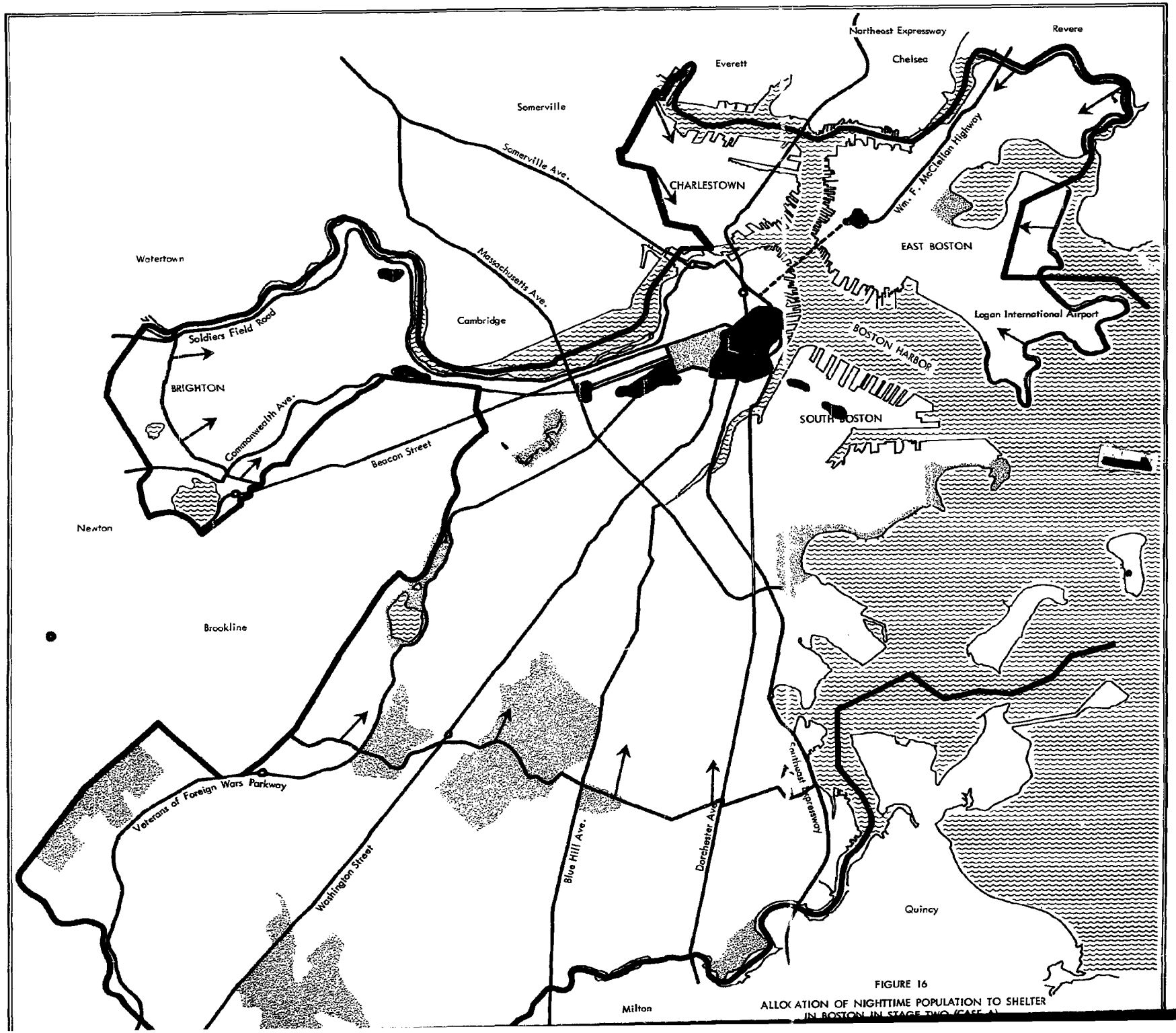


FIGURE 16

ALLOCATION OF NIGHTTIME POPULATION TO SHELTER IN BOSTON IN STAGE TWO (CASE A)

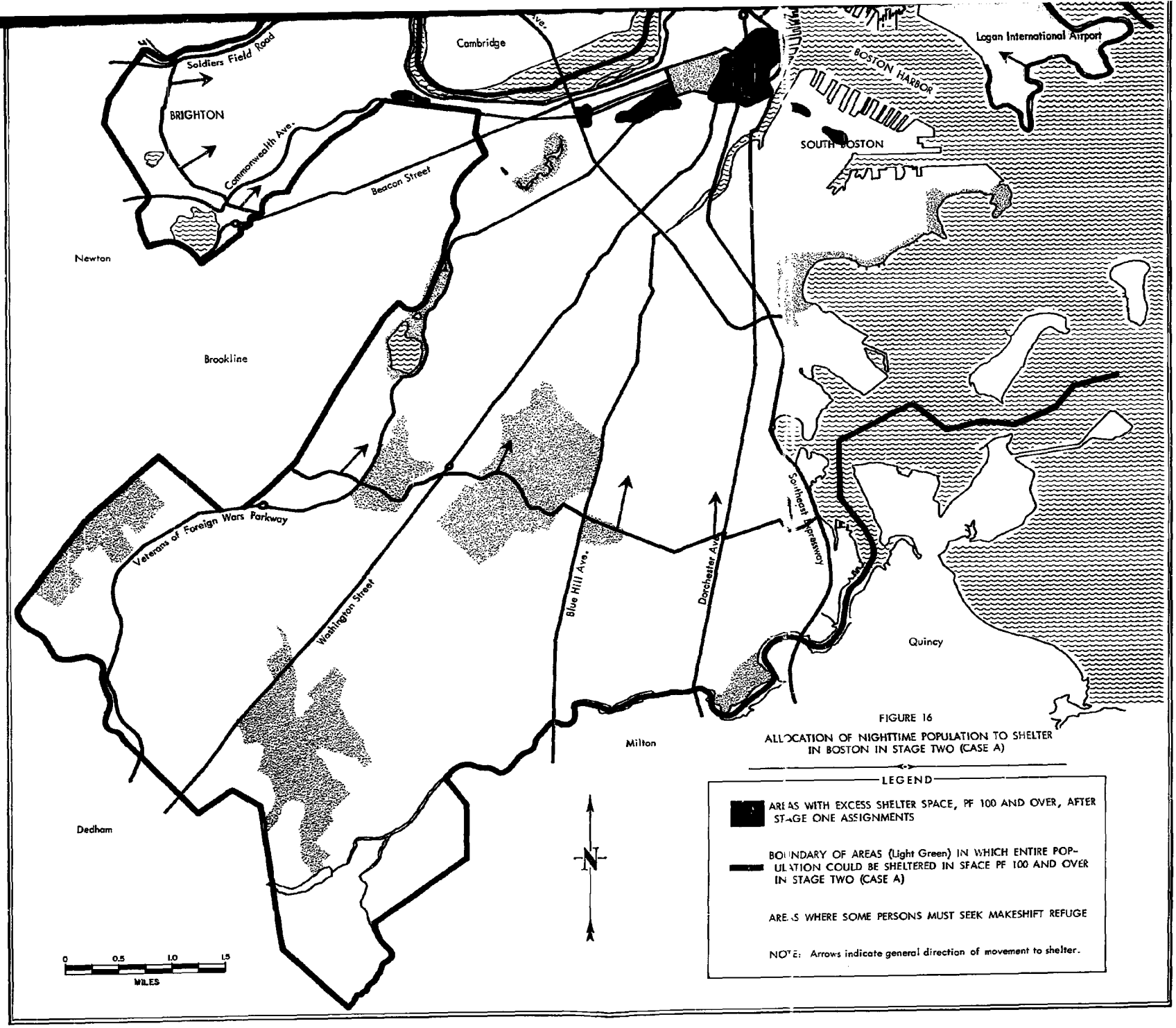


FIGURE 16
ALLOCATION OF NIGHTTIME POPULATION TO SHELTER IN BOSTON IN STAGE TWO (CASE A)

SOURCE: Stanford Research Institute.

Charlestown area who are poorly sheltered would be able to reach downtown Boston by way of the bridges over the Charles River. In Brighton, only a portion of the population would be able to reach the excess shelters in the institutions located along the Charles River because the amount of the shelter is limited and the distance to downtown Boston is too great. A large section of Boston proper would also not be able to reach better shelter because of the excessive distance from such shelter. As a result these people would be instructed to remain where they are.

The map showing the allocations for the daytime would be identical to Figure 16 with the exception of the Brighton area. Because of the decreased population during the day, all of the people would be able to reach shelter with a PF of 100 and over. The other shelter limit lines would not change because they are based upon distance to shelter rather than capacity of shelters. The numerical results of Stage Two shelter space allocations in Case A are shown below.

| | Shelter Groups | | |
|---|---|---|---|
| | Stocked Shelter, PF 100 & Over | Unstocked Refuge, PF 40-99 | Makeshift Refuge |
| Daytime | | | |
| No. of persons | 1,044,757 | 29,207 | 140,736 |
| Percentage of population | 86% | 2% | 12% |
| Percentage of space available | 72% | 2% | Unknown |
| Nighttime | | | |
| No. of persons | 726,468 | 38,730 | 173,178 |
| Percentage of population | 78% | 4% | 18% |
| Percentage of space available | 50% | 3% | Unknown |

Case B

In Case B fallout is postulated not to arrive until 10 hours after Stage One has been implemented. Within this 10-hour period, the entire population would be able to reach shelter with a PF of 100 and over. The longest distance traveled would be about 10 miles, which could be easily accomplished by walking and/or the use of some vehicular transportation. More than enough stocked shelter exists to accommodate the entire population, so this would not be a limiting factor in the movement of people.

Only 65 percent of the space with a PF of 100 and over would be used in the nighttime and 84 percent in the daytime.

The primary problem facing the local CD organization in a situation such as Case B would be whether to move people to the high protection shelters most of which are located in the downtown area. The risk that the downtown area will be closer to a possible target area would have to be assessed and weighed in relation to the expected radiation that would be received by people located in lower grade shelters. The problems of traffic control and such would be small in comparison with deciding in which direction to move people.

Case C

In Case C, fallout was postulated to arrive shortly after Stage One had been completed. Therefore, the movement of people would be made through sorties from areas of inadequate shelter or high radiation to stocked shelters where lower radiation intensities would be experienced. Because of the transportation network in Boston, it would be feasible to relocate people. The factors important in making shelter allocations have been discussed in Section III. The general allocation would be the sum of each of the individual sorties decided upon, using the criteria and considerations discussed in Section III. Because a great deal of flexibility is needed in the locations to which people can be moved, it would probably be desirable to license and stock all shelters with a PF of 100 and over in Boston even though there is a greater number of shelter spaces of this sort than there are people in the city.

# V SPECIFIC ASSIGNMENT OF PEOPLE TO SHELTER

Specific assignment means the assignment of people to space located in specific fallout shelters. In the general allocation of people to shelter discussed in Section IV, the direction of movement was performed on a general, over-all basis. In specific assignment, people will be told the exact location and name of the shelter to which they should go. Specific assignments can only be determined for the first stage of the allocation plan, however. They cannot be made for the second stage because the destination of people is dependent upon the actual attack situation and cannot be determined until that time.

Making specific shelter assignments is desirable for several reasons. First, each individual would know his own specific destination at the time of an alert; therefore, public confidence in the CD program would be increased and the confusion and potential for panic during the actual alert should be greatly reduced. Second, greater distance could be traveled during the time allowed for Stage One, since people would know exactly where they were going and would not waste time looking for shelters able to accommodate them. Third, utilization of the shelter space would be maximized because specific assignments obviate the problem of too many people going to one shelter and not enough to another. Shelter managers for each facility could be provided for in specific assignments and the management problem within each shelter would be simplified since the group using the space is predetermined. Fourth, planning and movement of people in Stage Two is made easier since the exact location of people after Stage One is implemented will be known--it will not have to be determined during the attack. Post-attack problems will also be simplified since locations of human resources will be known.

Considerable time and effort is involved in making specific assignments. As a result, the local CD organization should not wait until specific assignments have been made before publishing the general allocation and use plan. The general allocation discussed in Section IV forms the basis for the essential instructions to the public. Specific assignment should be treated as a second phase, in which more detailed instructions are issued the public.

A systematic planning approach is needed to accomplish specific assignment of people to shelters. Because many thousands of people (and in Boston several thousand shelter facilities) are involved, the magnitude

of the problem would be overwhelming unless a methodical approach were used. Since the total problem is essentially one of solving a great number of equations simultaneously,* it is necessary to develop an approach which allows working on parts manageable in size and able to be solved separately. It is also desirable to utilize a system easily understood and accomplished by clerical personnel.

The remainder of this section will discuss a suggested method for specific assignment, the information needed to use this approach, and related data handling considerations.

## Specific Assignment Method

Several general considerations are important to the process of making specific assignments. Assignments should be made by units of people (e.g., buildings, floors of buildings, apartments, residences, companies, and other organizational groups) rather than by individual names of people. Individual people in today's society are extremely mobile both in their places of work and in the location of their homes. Therefore, an assignment based upon individuals would be almost impossible to keep current. Units of people are much more static in their location and are reasonably stable in the number of people within each unit.

In performing specific assignments, no attempt should be made to match exactly the number of people assigned to the rated capacity of a shelter. The degree of accuracy in population and shelter data does not justify such precise matching. Moreover, in an actual alert, confusion will occur, which will result in some people not seeking shelter and others going to shelters to which they were not assigned. Furthermore, a limited amount of shelter overcrowding is probably acceptable. Finally, the problem of data manipulation is increased considerably by trying to assign people in the same number as the capacity of a shelter.

Specific assignments should be made in a manner which tries to recognize human behavior. Assignments which people would be unlikely to follow during the actual alert are of little value. Street patterns, land use,

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* The use of computer techniques for the assignment of people to shelter was investigated briefly during the study. It was soon determined that the problems of creating an adequate computer model were beyond the scope of the current study.

and various physical barriers must be analyzed when determining how people would move to shelter. Common sense must be used in deciding what assignments appear the most reasonable and practical.

The general criteria used in making assignments should be distance of people from the shelter. People closest to a shelter should be assigned first rather than using a criterion such as "women and children first." Such criteria are fraught with both practical and political problems.

## Policy Decisions Required before Making Specific Assignments

Two policy decisions are required before making specific assignments of people to shelter. First, will separate assignments be made for the daytime and for the nighttime or will some other approach be taken? The same problems and alternatives exist in this regard for specific assignments as they do for general allocation of shelter space. Reference is made, therefore, to the discussion concerning this issue in Section IV.

Second, how will the assignment of the refuge shelter space with a PF of 40-99 be handled? Since this space has a lower PF and is unstocked, it is less desirable shelter than the space in the PF 100 and over categories. Nevertheless, in some sections of the city it will be necessary to use all shelter space available even though some may be of lower grade. Either of two approaches could be used. The PF 100 and over space could be assigned first and the PF 40-99 space assigned afterwards. This method would recognize that a difference in the desirability of certain shelters exists and that people would not go to a lower grade shelter if they thought they could get to higher quality shelter. The other approach would be to assign PF 40-99 space and PF 100 and over space at the same time, as if they were the same. The latter method might be desirable because of the political implications.

## Steps in the Assignment Process

The method used in the actual making of specific assignments follows certain steps, as outlined below.

### A. General Analysis

1. Complete the analysis of general allocation outlined in Section IV before beginning specific assignments. General analysis

is necessary to determine the nature, magnitude, and location of the shelter problems for the entire city. This knowledge is required to break the city into meaningful parts so that specific assignments can be made.

2. Break the city into two basic parts--areas with insufficient shelter and areas of excess shelter. The assignment problems within these two areas are different and separate processes of specific assignment will be used in each. The shelter limit lines developed in Section IV and shown in Figures 14 and 15 provide the basis for this initial breakdown.

3. Subdivide the areas of insufficient and excess shelter into smaller parts. This further breakdown should be done on the bases of topography, natural and man-made barriers, voids of people, and voids of shelter.

B. Assignment in Areas of Excess Shelter

1. Assignment in areas of excess shelter should be performed before assignments are made in areas of insufficient shelter so that the line between these two areas can be defined more accurately than was possible in the general allocation process.

2. Make assignments first for the special problem situations in which the ability to move people is limited or in which an assignment to a particular shelter is important to the over-all CD program. Examples of these special situations are hospitals, mental institutions, convalescent homes, prisons, and groups such as fire departments, transportation companies, and communications organizations whose existence as operational units must be maintained. After the special assignments have been made, the data showing the numbers of people and shelter spaces must be changed to reflect these assignments.

3. Begin with one section of the area of excess shelter which had been defined in step A-3. A map at a scale considerably larger than that of the base map used in Section IV should be obtained for the area of the city being analyzed. The map should be as large as possible and still be physically manageable, because a large amount of detailed information must be placed on this map.

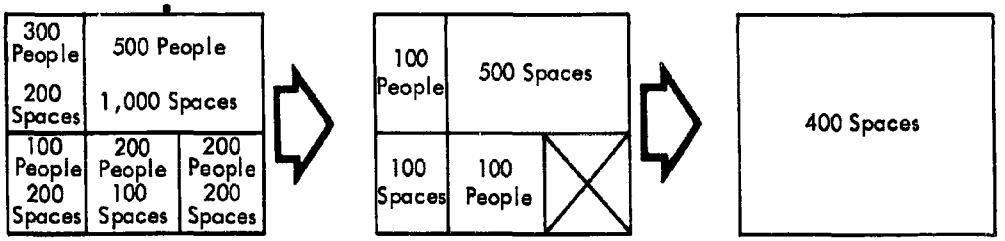
4. Draw in the SL boundaries on the map and number each block within each standard location using the U.S. Census block numbers obtained from U.S. Census of Housing: 1960, Vol. III, City Blocks. The tabular records which must be kept of the specific assignments as they are made will be keyed to the SL number and the city block number within the standard location. The records and their format will be discussed later in this section.

5. Assign the people within each building to the shelter within that particular building. The result for each building is excess shelter space, unsheltered people, or an approximate equality between shelter space and people. When the last situation exists, the specific assignment process has been completed for that building and the people in it.

6. Assign the unsheltered people within each block to excess shelter space within that particular block. The result will be one number for each block which indicates the condition of excess shelter space, unsheltered people, or an approximate equality between shelter space and people in the block. If this last situation exists, the specific assignment process for that particular block has been completed and can be so indicated on the map.

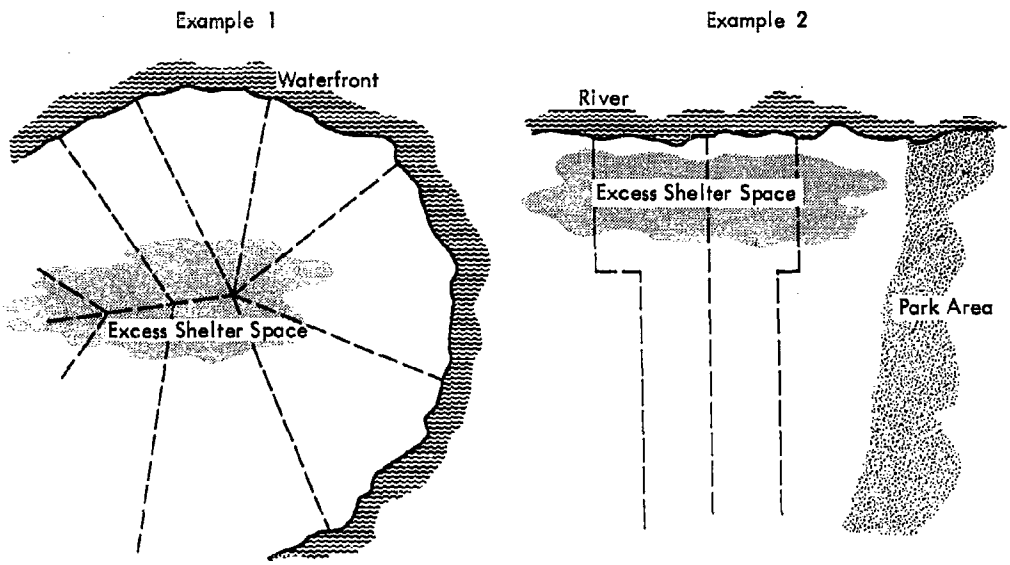
7. The results of the preceding two steps is a map showing: the city blocks for which an approximate equality between spaces and assignments has resulted; the blocks still having excess space and the amount of this space; and the blocks still having unsheltered people and the number of unsheltered people. Color coding can be used to show these conditions. The data are now in a form which is more manageable for the next steps involving the moving of people between city blocks. This process of data condensation is shown graphically below.

DATA CONDENSATION IN A CITY BLOCK



8. Group blocks together in a meaningful manner. The block groupings should not only make sense from the point of view of how people might move within the city but should also be arranged so that the unsheltered population is equal to or less than the shelter space within the block grouping. Two ways of grouping blocks which are appropriate to their particular situations are illustrated below.

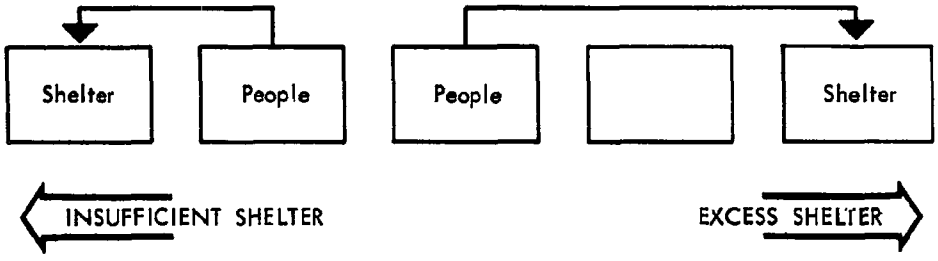
POSSIBLE BLOCK GROUPINGS




9. Within each block grouping, assign the unsheltered people to the excess shelter space. These assignments should be made by city blocks at this stage of the process. Assignments by buildings and parts of buildings within blocks will be made in a later step. When making the assignments by blocks, people should generally be moved to the nearest shelter when such a shelter exists nearby. Otherwise, or when there is a choice of several possible movements, people should be moved toward the

areas where there is a heavy concentration of excess shelter. In this way, a greater amount of space will be made available to the outlying areas of insufficient shelter. The time-distance limitation (30 minutes, 1 mile for Boston) should, of course, also be observed. These general criteria for movement of people are illustrated below.

MOVEMENT OF BLOCKS OF PEOPLE




10. Make the assignments for each of the block groupings until that particular section of the city is complete. Then make whatever adjustments are necessary among block groupings.

11. For each of the movements of unsheltered people in a block to a block (or blocks) with excess shelter space, assignments must now be made on a more specific basis. People in buildings or parts of buildings must be assigned to space in specific buildings in the block to which they have been moved. To the extent possible, assignments should be made in units or groups of people which can be easily described (e.g. floor of a building, part of a floor, or company).

12. Repeat steps B-3 through B-11 for other areas of excess capacity. The end result will be a newly defined limit line showing the limits of excess shelter; within the area so defined, assignments of people to specific shelter will have been made. The next step, in which people are informed of their shelter assignments, will be discussed later.

## C. Assignment in Areas of Insufficient Shelter

In areas of insufficient shelter space, shelters generally will be fewer in number, spaced farther apart, and smaller in capacity. Generally, these areas of insufficient shelter space will be predominantly residential in character.

1. Assignments should be made in areas of insufficient shelter space after assignments in areas of excess space. However, if for some reason it is felt necessary to solve both areas at the same time, assignment in areas of insufficient space should begin in those sections of the city which are farthest from the areas of excess space.

2. Solve the special problem situations as in step B-2.

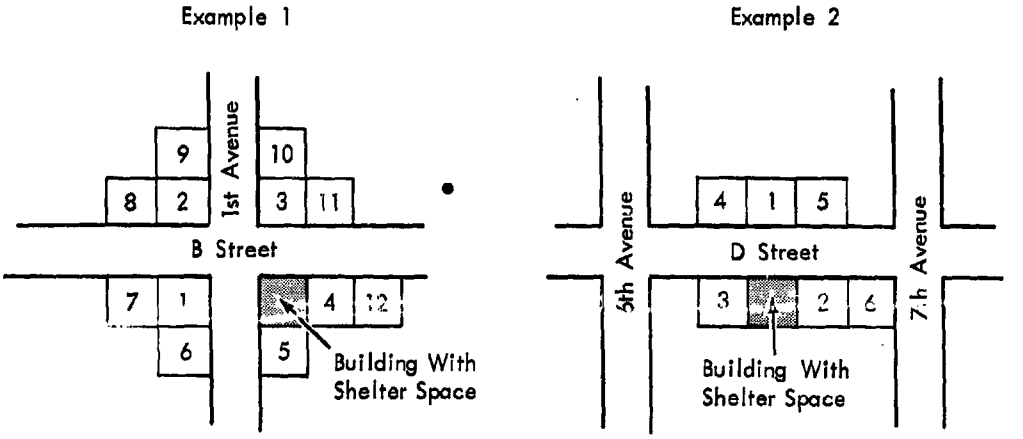
3. Obtain large-scale maps for those areas in which shelters are located. Maps are not needed where there is no shelter, since it is impossible to assign people in these cases. Draw in SL boundaries on the maps and number the blocks as done in step B-4. Locate shelters on the map and indicate the capacity of each shelter.

4. Start the specific assignment process in a section of the area with insufficient shelter as defined in step A-3.

5. Assign the people in a building to the shelter in that building.

6. When the remaining space in the shelter facility will not accommodate the population of at least two neighboring blocks, systematically assign people in adjacent buildings to the shelter until the capacity is reached. A set of assignment rules should be established to prevent accusations of partiality in making the specific assignments. In the two examples illustrated below, the assignments have been made on a clockwise basis.

## ASSIGNMENT OF PEOPLE TO SHELTERS WITH LIMITED CAPACITY




NOTE: Numbers indicate sequence in which buildings are assigned to the shelter space.

7. When the space remaining in the shelter after completion of step C-5 can accommodate the population of more than two neighboring blocks:

   a. Assign people in the block having the shelter to space in that shelter.

   b. Working outward in concentric circles or squares, assign additional blocks of people to the shelter until its capacity is almost reached.

   c. Assign the remaining spaces in the shelter in a systematic manner as done in step C-6.

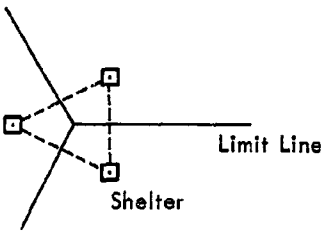
8. When several shelter facilities are located so they would drain the same population area:

   a. Consider the facilities as one shelter if located close enough together (e.g., one or two blocks). Then establish the population area to be served, as in step C-7. Assignment to specific shelters is made next by letting each facility serve one section of the drainage area.

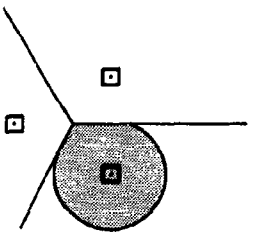
b. Where the facilities are not located so that they can be treated as one shelter, draw limit lines equidistant between the shelters. Then, beginning with the smallest shelter, assign space to the people located within the limit lines. Repeat the process for the next smallest shelter. In this manner, people are assigned to shelters until all shelters are filled. This process is illustrated below.

ASSIGNMENT WHEN SEVERAL SHELTERS DRAIN SAME AREA

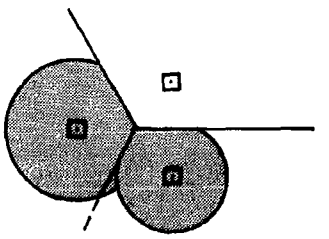
1. Draw lines equidistant from shelters



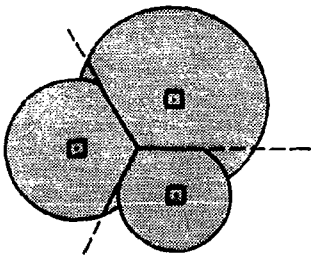

2. Assign smallest shelter



3. Assign next smallest shelter



4. Assign last shelter



9. Repeat steps C-4 through C-8 for other sections of the insufficient shelter area until all assignments have been made. In making the various assignments, the time-distance criteria and the factors affecting the movement of people must be taken into consideration.

## Information Required To Make Specific Assignments

A considerable amount of information is necessary to make specific assignments to shelter. At the present time, a great deal of the needed data must be obtained by the local CD organization.

### Shelter Information

The exact location of the various shelter facilities can be determined from the A&E facility maps of Phase I, the shelter location map developed in Section IV (Figure 5), and/or the street address of each shelter listed in the facility printouts. The capacity and protection factor for each shelter can be determined from the Phase II facility printouts. The local CD records should show which facilities have been licensed and are therefore usable.

### Population Information

The population data provided by the A&E's is not usable for specific assignments because the smallest breakdown made is by standard location. Information in much greater detail is necessary to be able to use the method suggested in this section. Both day and night population figures are needed by city blocks, buildings within blocks, and in some cases parts of buildings. Population statistics are not needed for those areas where only makeshift shelter will be used. The population data do not have to be extremely accurate, since only average figures are needed (i.e., the number of people who normally would be at a particular location during the day and at night). As a consequence, the use of estimates is acceptable where necessary. The information, however, must be quite specific as to the location of people.

In commercial and industrial areas, the population statistics can be generated fairly easily. Questionnaires can be sent to all companies and other organizations asking for the average number of employees and visitors or customers and the location of these people in their facilities by street address and floor of the building. The local real estate board and the local building owners and managers association can be helpful in providing lists of the tenants in office buildings. The Chamber of Commerce and the State Department of Commerce can provide lists of other companies to which questionnaires can be sent. Dun and Bradstreet listings and the city directory are other possible sources. Some of these sources may already have much of the needed information in a usable form. Their support may also be enlisted to obtain the

additional data required. After the questionnaires have been returned, a door-to-door census can be used for those buildings from which data have not been received.

In residential areas, the number of dwelling units per block can be determined through visual inspection. A sample of these dwelling units, by type of unit, can be taken in different sections of the city to determine the average number of people in each unit. To obtain the total population, the number of dwelling units in an area can then be multiplied by the average number of people expected in each unit. Aerial photographs and tax records can be helpful in locating dwelling units. Building inspectors' records may list the number of units in multifamily structures. U.S. Census statistics provide data by city block but must be adjusted where the residential census definitions would exclude important segments of the population. In some cities, special censuses are conducted by the police for other purposes which may also be adaptable to CD needs.

### City Characteristics

The topographical maps, land use maps, and street maps provide the information needed concerning the various city characteristics which must be considered in making specific assignments. The data and maps developed in Section IV provide the necessary basis for an over-all understanding of the shelter problem.

### Data Handling Considerations

A mass of data must be processed in order to make specific assignments for an entire community. Moreover, records must be kept of all the assignments made so that people can be told what shelter they have been assigned to. Notices must be sent to the occupants of each building which has been assigned a shelter, stating the name and address of the shelter facility to which building occupants have been assigned. Records are also necessary for the periodic updating of the shelter assignments.

It is essential, therefore, that a data handling and record system be established before making specific assignments. Each city probably will want to develop a system which is most appropriate to its own situation. However, the following could be used as the basis of the record system.

1. A file of 8-1/2 × 11-inch cards, one card for each city block, could be prepared. On each card a small drawing of the block would be made to show the location of the buildings in that block (Sanborn maps will show this information for the major portion of a city, particularly the commercial and industrial areas). Each building would be assigned a letter on the drawing which would key that building to a chart printed on the card. The chart would list name, address, and key letter for each building in the block. In addition, the population and number of shelter spaces, if any, would be listed for each building. Where excess space exists for a building, the names of the buildings (or other units of people) assigned to this space should be listed along with the number of unsheltered people in these buildings. Where unsheltered people exist, the facility number of the shelter to which they have been assigned is listed (plus the SL number and census block number where the shelter facility is located). Each block card would be assigned a number made up of its SL number and census block number. Additional information could be entered on these cards as desired.

2. The large-scale maps used in making specific assignments on which the SL and census block numbers are indicated could be part of the record system. Shelter locations would also be shown on these maps along with notations showing the major movements of people to shelter.

3. Form letters which are used to issue the specific assignment instructions can be incorporated in the records. These should contain the names and addresses of the people to whom the letter is sent along with the names and addresses of the shelters to which people have been assigned. These letters should be completed at the time specific assignments are being made and data should be entered on the 8-1/2 × 11-inch record cards.

# VI OTHER CONSIDERATIONS BEARING ON THE SHELTER USE PLAN

As indicated in the introduction to this report, a shelter use plan is a much broader and more encompassing plan than is a shelter allocation plan. Although the allocation plan is probably the most complex and most important part of the use plan, many other factors and problems must be considered. For example, how is the federal suggestion for semiannual inspection of the shelter supplies to be performed; in what manner should the public be informed; and how should the allocation part of the plan be coordinated with other communities? These factors must be considered by the local CD organization. In some cases policy decisions will have to be made, and the factors and decision must be integrated into the over-all plan for utilizing and maintaining the community shelter system. Only in this way will the system and shelters be ready for use if they are needed and only in this way can an efficient or maximum use of available protection be accomplished.

The "Boston team" did not study in detail or extensively all of the factors and problems that must be considered. Most of them have been studied by other members of the staff participating in the over-all task of studying community shelter systems. As stated earlier, the primary objective of the Boston team was to develop a shelter allocation plan. However, the secondary objective was to identify and evaluate factors or problems that are associated with the development and implementation of a city-wide shelter use plan. Most of the factors or problems that have been considered are related particularly to the allocation part of the use plan, but all of them, as presented in this section of the report, are relevant to placing the shelter use plan in operational readiness.

## Finalizing and Updating the Allocation Plan

### Licensing, Marking, and Stocking

Progress in licensing, marking, and stocking shelters has an important impact upon the shelter allocation and use plans. As noted earlier, in the development of a shelter allocation plan in this study it was assumed that all shelters identified during the Phase II survey as having a PF of 100 or more and accommodating 50 or more people eventually would be licensed, marked, and stocked. The degree to which this

has actually been accomplished has a direct effect upon the shelter allocation plan and on placing the shelter use plan into operational readiness.

During the early planning period when the shelter allocation plan is being developed, the extent to which licensing, marking, and stocking have occurred, the rate at which they are currently occurring, and the estimated ultimate success in completing this effort must be considered. The allocation plan should be based upon this estimate. At the time the plan has been completed and instructions are going to be made to the public, the plan may have to be modified slightly to reflect the actual numbers and locations of available shelter spaces. In some cities, perhaps only 50 percent of the spaces identified as meeting the criteria actually will be licensed, marked, and stocked. This determination must be made by the individual community. The allocation plan must be based upon this number rather than on the number that would have been available had all building owners agreed to sign licenses.

Once the initial licensing, marking, and stocking program has been completed, there will still need to be a continuing effort in this regard. Admittedly, the level of effort will be lowered considerably but the local CD organization in particular will need to update on a regular basis. New buildings will be constructed that may contain potential shelter--if the spaces are needed, licenses will have to be sought and the facility will have to be marked and stocked. Also, as international crises may develop, building owners originally reluctant to sign licenses may change their minds. On the other hand, buildings containing stocked shelter may be demolished (in Boston this is particularly true because of current redevelopment projects). Also, building owners who have signed licenses have the option of revoking the license at the end of 90 days, and some may take this option. For these reasons, a CD capability must be maintained for licensing, marking, and stocking that includes warehousing and equipment to handle the supplies. As new shelters are obtained and original shelters are lost, the impact on the shelter allocation plan must be evaluated. The plan must be modified to reflect these changes, and the public must be informed where the modifications affect previous instructions in seeking shelter.

The previous discussion also applies to "unstocked refuges" but to a much lesser extent because not as many refuges will actually be marked, and of course they will not be stocked.

## Upgrading Refuge and Shelter Spaces

In every community there probably will be some need to upgrade existing refuge and/or shelter space because some existing space is inadequate either in quality or quantity. In Phase II of the National Fallout Shelter Survey, the A&E survey teams determined which facilities could be upgraded, the extent to which they could be upgraded, and the estimated cost of the improvements. They used criteria (primarily cost) established by the federal government to make these determinations. The results of these determinations are contained in the data collection forms and Phase II printouts; copies of both are being distributed to local CD organizations.

Generally, two types of improvements can be made.* In shelters meeting the PF criteria for stocking, improvements in the ventilating system can allow significant increases in capacity (up to a factor of about five, because poorly ventilated facilities are rated at 1 person for each 500 cubic feet of air space and adequately ventilated facilities are rated at 1 person for each 10 square feet of floor area). In refuges not meeting PF criteria for stocking, improvements in shielding can increase the PF, thus allowing refuges to become stocked shelters. Shielding improvements can also increase the capacity in some cases.

Although present plans are not definite, the federal government may assist financially in making these improvements at some time in the future. It probably will be the responsibility of local CD organizations to decide which facilities and how many facilities should be improved. This determination will be relatively easy if the shelter allocation plan has been kept current. Obviously the first facilities that should be improved are those located in areas where "unsheltered people" exist--i.e., where makeshift refuges must be used in the first stage of the allocation plan. The degree to which facilities should be improved in areas where excess shelter spaces exist is dependent on how many persons will be able to use the upgraded space during the first stage or during early movements, such as those discussed in Case A of the second stage (Section III). In Boston, upgrading should not be performed in the "downtown" area because more than an adequate amount of high quality space is available now, if licensed. Of course, if a sufficient number of licenses are denied, it is conceivable that some upgrading even in this area might be warranted.

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* In the survey, a third type of improvement is calculated, based upon increased electrical capacity.

## Supplementing Federal Supplies

Although the problem of supplementing federal supplies was not a specific part of the Boston team's study, it will be mentioned briefly because it is so important. It is generally recognized by local CD organizations that federal supplies are barely minimum, but it is also important for the local government and people to recognize this fact. The local government might then authorize expenditures at least to supplement the supplies so they are above minimum subsistence, and the people can be informed as to which items to carry to shelter to suit their own particular needs. For example, the one quart of water per person per day (containers for which are supplied by the federal government but which must be filled locally) should be increased to at least two quarts. This can be done by buying and using additional containers or water may be retained in the plumbing of some facilities for use in an emergency. People with babies should be informed that no provisions have been supplied, and they should bring diapers, baby food, etc. if they are desired. There are many ways in which federal supplies need to be supplemented and this can be done to varying degrees by the local community.

## Internal Information Systems

### Needs of the Local CD Organization

Data and information required by the CD planning group to develop a shelter allocation plan, and sources of these data, have been discussed in Sections III, IV, and V. Primarily, numerical data required include day and night population estimates and potential shelter spaces available for each standard location within the city. In addition, the location, PF, and capacity of each shelter facility are needed. These data are supposed to be distributed to the local CD organization in the form of detailed facility listings (printouts) and in summary listings (printouts) by standard location. During the research team's field work in Boston, it was found that while the Civil Defense Department had received the detailed listings it had not received the summary listings, at least on Phase I data. Furthermore, the manner in which the detailed listing was distributed made the determination of whether the complete listing had been received an almost impossible task. Grouping of listings in a methodical and realistic fashion--e.g., by standard location--also would be an almost impossible task because data on individual facilities in the same standard locations were often spread throughout several books of listings. These observations by the research team are specifically mentioned to point out the importance of having the local CD organization

check carefully the data provided as a result of the Phase I and II surveys. If there are questions or problems in understanding or finding certain data, the Army Corps of Engineers or Navy Bureau of Ships and Docks which had contract administration responsibility over surveys performed in the community should be consulted. In addition, the A&E firms actually performing the survey can be consulted.

The specific data in the detailed and summary listings also should be checked carefully by the local CD organization for discrepancies. For example, the research team performing the study on Boston found that the daytime population indicated on the Phase I summary printout for one of the standard locations was incorrect. The printout showed a population figure of 99,999 for SL 29. Inasmuch as figures for other standard locations were not carried to this many significant figures (most were rounded to the nearest 100 persons) this figure was suspect. A check of the A&E written report proved this suspicion correct--the actual estimate of daytime population for this standard location was 151,250. One possible reason for this error is that the printer was not programmed for population figures of more than 5 digits. Another example of the type of error that can occur was the finding by the research team that some facilities not identified as suitable shelters by the A&E's should have been. Specifically, no data were found for the subway tunnels approximately between Andrew and Broadway stations in South Boston and between Fields Corner and Ashmont stations in Dorchester. There were appropriate data for the stations themselves. Therefore, the research team estimated the capacity for these tunnels, using a technique similar to that used by the A&E's for subway tunnels in other parts of Boston; cubic space was estimated from cross-section sketches and lengths of these tunnels provided by the MTA and the 500 cubic feet per person criterion was applied. This resulted in the addition of the following number of PF 100 and over spaces:

| Standard Location | Additional Spaces |
|---|---|
| 61 | 2,627 |
| 69 | 3,179 |
| 106 | 2,312 |
| 136 | 1,056 |

These examples show that other cities should be cautioned that similar errors may occur in their data.

For cities the size of Boston, where there are thousands of people and shelter spaces in dozens of standard locations, some type of systematic yet simple and practical method of handling large quantities of data must be employed. Not only should the system suit the needs of the CD planning group in analyzing and evaluating data to develop an allocation plan and in actually allocating or assigning people to shelter, but it should also allow for modifications and updating of data. Furthermore, it should be suitable for keeping account of building owners' names and addresses; shelter addresses (if different from the owners'); dates of licensing, marking, and stocking; dates of inspecting supplies; and so on. Also, the system should allow easy access to data; for example, when a person in a specific part of the city asks for information on the nearest shelter, this information should be readily available.

It is recommended, therefore, that some type of card system be developed. At a minimum there should be one card for each facility having stocked shelter, and these cards should be arranged by standard location. It would be desirable to have duplicate or triplicate cards on each facility so that other useful groupings of cards could be made, such as by PF. As an excellent example of the type and format of information that should be included on the cards, a copy of the Facility Control Card prepared by the State of California for use by cities and communities in the state is shown in Figure 17. Of course there are ways to improve even this card system; for example, "key sort" cards could be used, which make retrieval of cards according to different groupings an even simpler task.

In addition to the individual facility card system, it is also recommended that information be summarized by standard location and that a similar card file be maintained or at least that an SL summary card should head each group of facility cards in the facility card file.

## Suggested Improvements in the Information Sent to Local Levels

The success of the over-all CD program and plans ultimately depends upon the local CD organization. Therefore, the type and form of data and information developed must be tailored to the needs of the local level. They should not be tailored to needs of federal or state levels merely to make summary reports of an entire state or the entire nation more convenient unless the local level needs are also fulfilled. For example, the local level must have a copy of the Phases I and II summary printouts by standard location. In Boston, at least, it was found that

# FIGURE 17

## FACILITY CONTROL CARD

| | |
|---|---|
| County, City, S. L. No. | |
| Facility No. | |
| Spaces, Category 8 | |
| Spaces Categories 4 through 7 | |
| Spaces, Categories 2 and 3 | |
| Building | |
| Address | |
| Owner or Lessee | |
| Address | |
| Licensed (Date) | |
| Deleted or refused (date) | |
| Reason | |
| Marked Yes_____ | |
| Shelter Manager | |
| Management Plan Prepared Yes_____ | |
| Remarks | |

| FEDERAL STOCKS (COMPLETELY INSTALLED_____) | | | | |
|---|---|---|---|---|
| ITEM | REQUISITIONED | INSTALLED | INSPECTED | UNITS |
| Food | | | | |
| Water Drums | | | | |
| Medical | | | | |
| Sanitation | | | | |
| RADEF | | | | |
| Water Drums Filled | Date | | | |
| AUGMENTED STOCKS | | | | |
| Radio Receiver | | | | |
| Radio Transmitter | | | | |
| Water | | | | |
| Bunks | | | | |
| Aux. Power | | | | |
| Other | | | | |
| | | | | |

| FLOOR | PART | PF | SPACES | PART | PF | SPACES | PART | PF | SPACES | PART | PF | SPACES | MODIFICATION COSTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | | | | | |
| 1 | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | |

CDO 47 *Use Reverse Side for Continuation or Remarks* 68782 7-62 29.400 △ SPO

SOURCE: State of California Disaster Office.

sufficient copies for distribution had not been prepared for the groups desiring them.

It was mentioned earlier that the local CD department is not always able to determine when all data have been received and that organization of the information is poor in that it is dispersed throughout the books, at least in Phase I. It is suggested that some sort of checklist should accompany information being distributed so that the local level can determine whether it has all been received. It is also suggested that all information pertaining to a standard location be included in one book, even though there may be some delay in distributing the information. The local level will spend more time in trying to correlate different sources (books) of information than will be lost by a slight delay in distribution.

In regard to the format of the data sent to local levels, it is suggested that in addition to the Phase II facility printouts, the basic information on each facility should be printed on cards or adhesive-coated labels that could be placed on cards. A 5x8-inch card size probably would be adequate. At least three copies of each should be sent to the local level. This would save considerable time and money at the local level, at a relatively small expenditure in time and money at the federal level; it would provide the local level with a nearly ready-made card file of facilities, based on the Phase II survey. Summary printouts of information by standard location also could be prepared directly on cards. The data prepared in this fashion should include most of the information shown on the left-hand side and bottom of the Facility Control Card shown in Figure 17. It would be relatively easy for the federal government to perform this service because the data are already on computer tape or punched cards (used for preparing the regular printouts). Some rearrangement of data might be required to fit more nearly a desirable format for a card, but this should not be difficult.

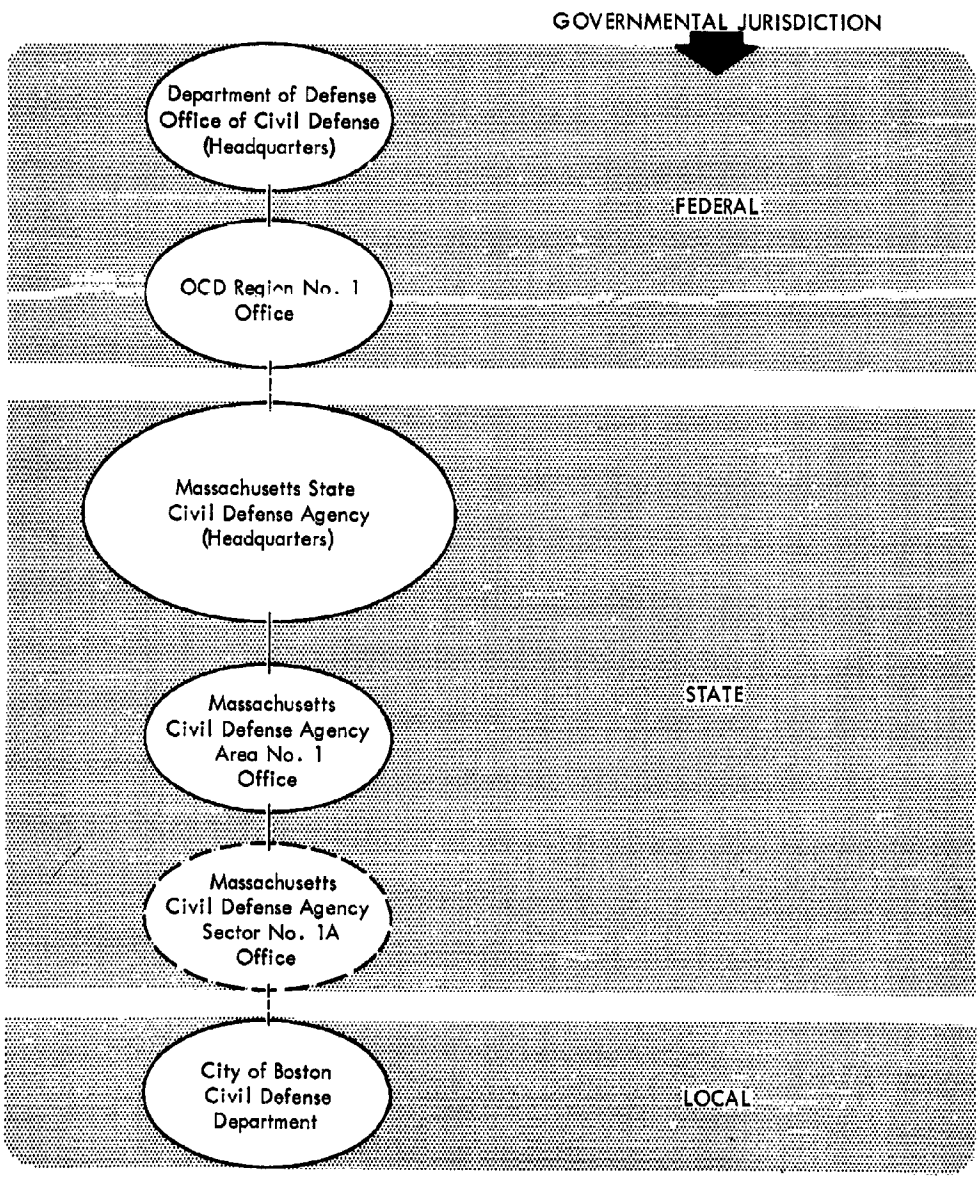
## Coordination between CD Organizations and Other Groups

### Relationship of the Various CD Levels

There is a strong requirement for coordination among CD levels. As an example, the position of Boston relative to other levels is shown in Figure 18. The Office of Civil Defense, acting through its regional offices, must coordinate with the various states. The State of Massachusetts, in this case, acting through its area offices and in turn through sector offices (although in this case the Boston CD Department is also the Sector 1A Office) must coordinate with the various local

FIGURE 18

CIVIL DEFENSE ORGANIZATION




SOURCE: Massachusetts Civil Defense Agency.

communities. The latter situation is not very different for most states. Also, it is seen in Figure 18 that there are up to four levels between the local CD organization and the Office of Civil Defense Headquarters. The combination of three governmental jurisdictions and up to three levels within each jurisdiction requires good coordination if strong ties are to be retained between OCD requests and local level performance of these requests.

## Relationship of Local CD Organizations

The need has already been described for having strong coordination among local CD organizations and thus among communities. Basically the need is derived from the fact that "paper" political boundaries do not affect the movement of people across these boundaries. Thus the shelter use plan for one community must be coordinated with that of another. Another example of needed coordination is in deciding how a tunnel between two communities should be used--if one decides to use "its half" for sheltering people and the other decides to use "its half" in the movement of emergency vehicles, the incompatibility of these two decisions is obvious. Such impasses can only be resolved through coordination and mutual agreements. The case used as an example here actually occurred between two communities in California and has probably occurred elsewhere.

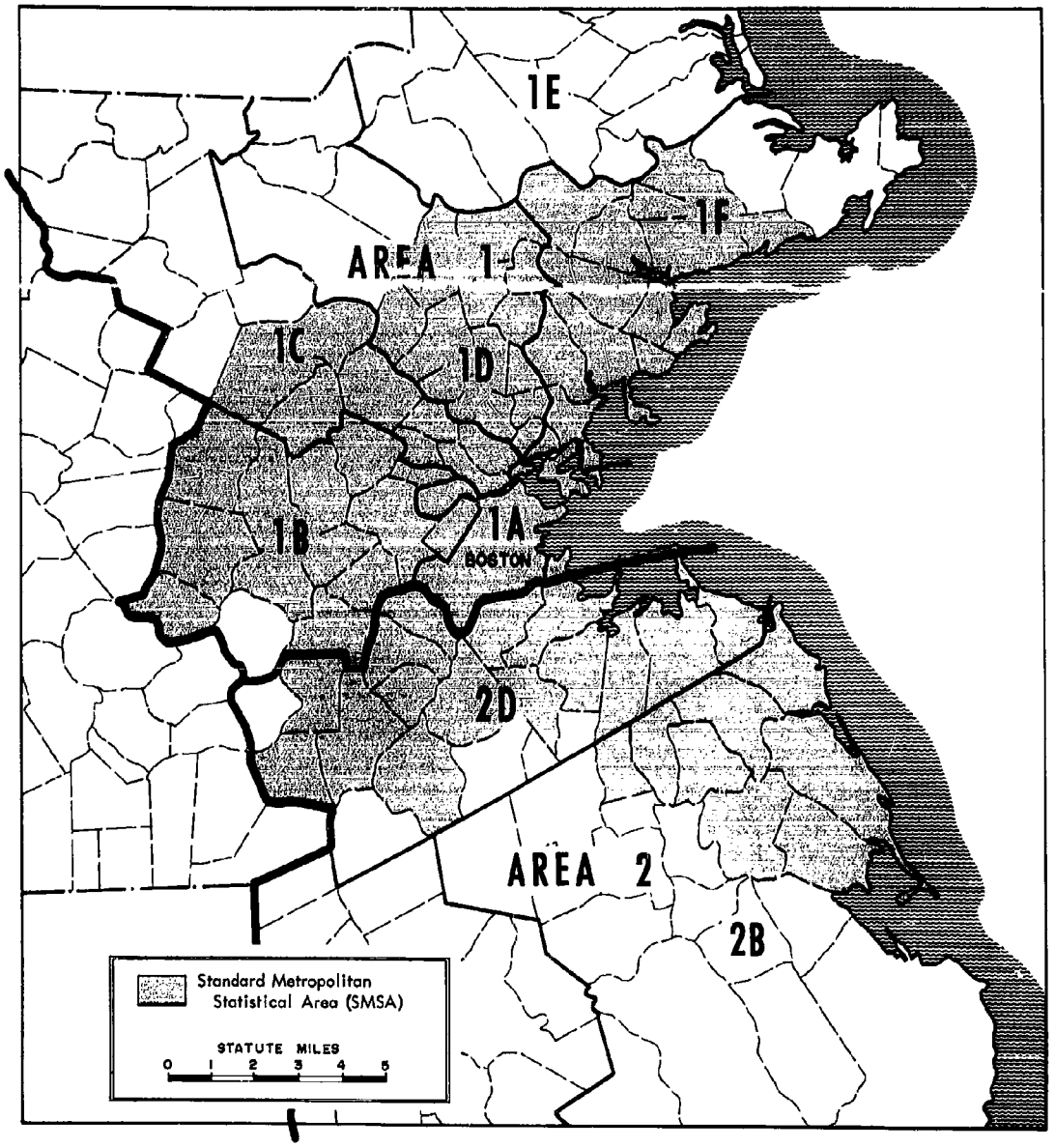
For a city the size of Boston, located in a large metropolitan area, CD plans should be compatible throughout the entire area. This can be a significant problem. In Boston, for example, the boundaries of the areas and sectors (Figure 19) are such that metropolitan Boston (Standard Metropolitan Statistical Area, SMSA, as defined in the 1960 Census) spans two state Civil Defense Agency areas, eight state Civil Defense Agency sectors, and 75 local CD departments or directors. The need for strong coordination is again emphasized.

## Relationship of the Local CD Organization and Special Political Subdivisions or Special Groups

The need for coordination also extends to special political subdivisions and special groups. For example, in Boston the transportation system is within the jurisdiction of the MTA. The MTA is separate from Boston and other cities that it serves--it is a political subdivision; furthermore, it has its own CD director. Because the subway system has several hundred thousand shelter spaces, not only in Boston but also in Cambridge, there must be coordination between MTA and these cities to

FIGURE 19

CIVIL DEFENSE AREAS AND SECTORS SPANNED
BY METROPOLITAN BOSTON




SOURCE: Developed by Stanford Research Institute from information provided by the Massachusetts Civil Defense Agency.

develop shelter use plans that take full advantage of these spaces. While this is perhaps the primary special political subdivision that Boston must work with, others that may have a relationship to civil defense include the Metropolitan District Commission, Metropolitan District Police, and the Tunnel Authority. An example of the need for coordination with the latter arises from the agreement the Department of the Army has made with the Tunnel Authority to take over the Sumner and Callahan tunnels under Boston Harbor for use in moving Army vehicles during an emergency. These tunnels will be needed by the Boston Civil Defense Department for sheltering people from East Boston. Probably the decision as to which use will take place will have to occur within DOD, between the Department of the Army and OCD. However, if the tunnels are to be used for sheltering people, their integration into the shelter allocation plan will have to be coordinated between Boston and the Tunnel Authority.

Almost every city and community will have groups, such as these mentioned for Boston, that will have important effects on the development of a shelter allocation and use plan.

## Informing the Public

Informing the public is one of the most important functions of the local CD organization. The extent to which the public is informed will directly affect the ability to successfully implement the shelter allocation plan and thus maximize the saving of lives. Furthermore, the building of an adequate CD organization in terms of personnel and equipment is in direct proportion to public recognition of this need and the expenditure of funds demanded by the public to satisfy this need. The success of the local CD organization's effort to inform the public will depend upon its ability to plan the distribution of information psychologically, both in terms of the timing of this distribution and in terms of the type and form of the information distributed. Every international crisis will provide the local CD organization with the opportunity to further the cause of civil defense, and such opportunities must be taken as a challenge. Eventually the public apathy that has existed will be reduced and civil defense will become a practical reality.

Four major types of information should be imparted to the public.

### General CD Background Information

The public needs to be given information answering general questions such as: What is civil defense? Why is it needed? How does it operate?

What are its various relationships, locally, state-wide, and nationwide? The public also needs general information on how to survive; primer-type information on radiation, fallout, blast damage, etc.; and life after a nuclear attack. Much of this type of information was made available to the general public a year ago by the federal government, in a booklet called "Fallout Protection--What to Know and Do about Nuclear Attack." Obtaining this booklet, however, was left up to the initiative of the individual, and probably over half the population has never heard of it. Every family or individual in the city or community should be sent a general background document such as this, and the importance of retaining the document should be stressed.

## Instructions on General Allocation of People to Shelter

The type of instructions that should be given to the public were discussed in Section IV. The general allocation plan should be explained to the public in a simple fashion. Then, simple but direct instructions should be given on how to use the plan. Every family and individual should receive this information and there should be no question by any individual as to what he should do if an alert is sounded. Publishing these instructions in successive issues of several newspapers, inclusion of a set of instructions in every issue of telephone directories, and distribution through schools, churches, and civic groups are methods that can be used to impart this knowledge to the public. It is important to realize that issuance of these instructions should be made as soon as possible after the plan is developed and adopted and the instructions are drafted. The local CD organization should not wait until a specific assignment plan is developed. The specific assignment plan may take many months to prepare, and in the interim, instructions on the general allocation plan will be far superior to anything available currently.

## Instructions on Specific Assignments of People to Shelter

The types of instructions to be given the public were discussed in Section V. The methods of distributing these instructions include the same methods used for distributing instructions on the general allocation plans. In addition, the posting of instructions on each building (or in the case of an apartment building, hotel, etc. in each room) showing the specific assignment of occupants is advisable. The use of this technique could be supported by a city ordnance requiring the posting, much as fire instructions are currently posted. Fire inspectors could be used to post the CD instructions initially and for periodic inspection to assure the instructions are still posted. Because the preparation of a complete

specific assignment plan may take many months, the public should be informed at the time general allocation instructions are given that work on specific assignments is under way. Then as specific assignments for specific areas of the city are completed, instructions on specific assignments can be given to the people in those areas. Other people should be kept informed as to the progress being made in preparing specific assignment plans for their areas.

## Updating Previous Instructions and Maintaining a Receptive Public

These two things work hand in hand. It will be necessary to update instructions on a periodic basis as new shelters are added and earlier shelters are taken away. Furthermore, as progress is made in upgrading the over-all CD program the public should be informed, particularly as it may affect them individually.

There are a number of techniques for maintaining a receptive public, but primarily this will derive from being able to issue new information or instructions at psychological times. Another technique is to have special telecasts, news articles, etc. pertaining to civil defense. Perhaps once a year there should be a "National Civil Defense Week" where the programs and plans are promulgated. Another technique is to work through schools, industry, churches, and civic groups such as Boy Scouts, women's clubs, Kiwanis, and so on. Eventually civil defense will be taken for granted, as it is today in many European countries (such as Sweden), but in the meantime the American public must be informed as to what they should do, where they should go, and what they should take with them if the need arises.

## In-Shelter Considerations

Although the Boston team did not include in the study any of these considerations in depth, certain factors which have a direct impact as a result of the shelter allocation plan will be mentioned briefly. The importance of developing and adopting a shelter allocation plan as the first step in preparing an over-all shelter use plan must be stressed. While in-shelter considerations are important, they may involve detailed study and perhaps months to finalize--in the meantime people still will need instructions for moving to shelter.

## Shelter Managers and Other Trained Individuals

To the extent feasible within the allocation plan, there should be an attempt to allocate, at least to the major shelters, trained shelter managers and other trained personnel such as doctors, nurses, and police. This will be most difficult to accomplish to any degree within the first stage of the plan, but in the second stage, depending upon time available for movement, allocation of specific individuals with these backgrounds should be possible. It is suggested that the local CD organization might wish to develop a specific assignment plan for trained people such as these, after the general allocation plan has been developed, adopted, and imparted to the public but prior to the development and adoption of a specific assignment plan for the general public. The advantages of having trained personnel in all shelters are obvious.

Many of the persons it will be desirable to mobilize and have available for assisting with in-shelter problems are already trained. They will only need to have instructions on what would be expected of them during an emergency. However, certain other individuals will not be trained; most important of these is the shelter manager. Full advantage should be taken of the federal courses in shelter management that are being offered. Perhaps the best way to train managers once they have been recruited is to send a nucleus of individuals to the federal courses so that they can in turn iustruct their fellow recruits, who in turn can instruct their fellow recruits, and so on. This technique would result in obtaining a large number of shelter managers in a relatively short time at a relatively low cost.

It is a decision for the local community as to what persons are recruited to act as shelter managers. One city (Sacramento, California) is already laying plans to use its policemen as shelter managers. It is planned that each police officer will be trained in shelter management and during his hours on duty will be assigned to a specific shelter on his beat which he could always reach in case of alert. During off-duty hours he would be assigned to a shelter near his home to act as shelter manager in cases where there are not enough police on duty to cover all shelters, or to act as backup to the police on duty.

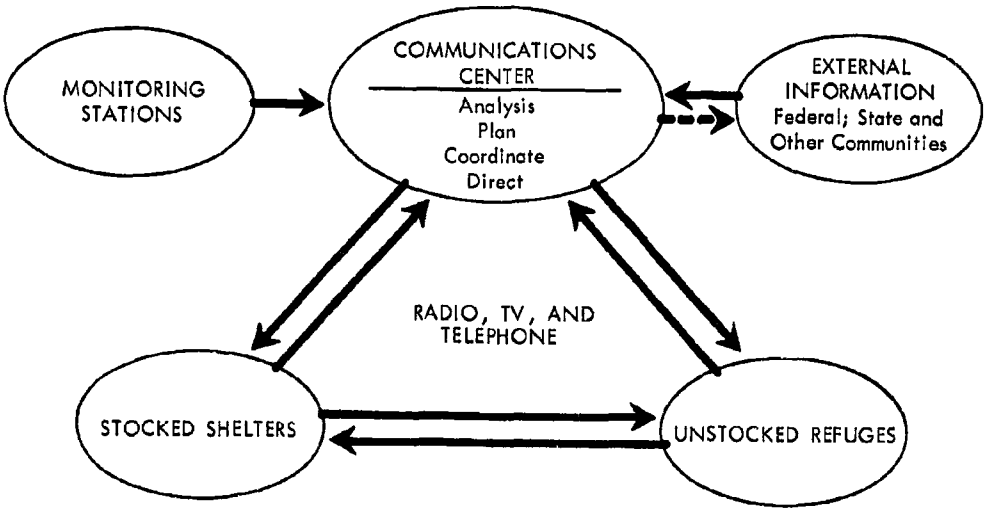
The advantages of using police forces for shelter managers are several. They are already accustomed to performing duties (often in potential panic situations) in an objective, unemotional manner. They are used to directing and controlling large groups of people, and the fact that they are uniformed demands a certain respect from the general public. Training police officers as shelter managers will be relatively

easy to accomplish because taking courses is a part of their regular police careers. Furthermore, many already have had training in the use of radiation monitoring and communications equipment and all are familiar with the writing and issuing of reports.

If a city does not find it desirable to follow the lead of Sacramento in using the policemen as shelter managers, other persons could be used. The city firemen could be used, for example; another possibility is use of the National Guard or local Reserve units. The one problem in using the latter groups is that they already may have been federalized or ordered to active duty at the time an attack occurs, if the emergency situation has developed over a period of several days or weeks. It should be pointed out that the argument that police and fire personnel could not be used as shelter managers because they would be out performing their usual emergency duties (putting out fires, directing traffic, quelling riots, etc.) is not a valid one. These personnel also must be sheltered from fallout if they are to survive, and in some respects it is even more important that shelter be assured for these personnel so that they can survive to handle the many complex problems of post-attack movements of people and ultimately of post-attack emergence from shelters.

## Communications

It has been stressed that communications are a mandatory requirement if the second stage of the shelter allocation plan is to function properly. The type of communications network that will be required is depicted below.



For directing movement of people, there must be two-way communications between the center and shelters and between shelters. Primary reports on radiation levels come from the monitoring stations, supplemented by monitoring performed within the shelters. Information concerning the magnitude and location of the attack comes from federal sources and from other states and communities.

For the next year or two, the local CD organization probably will have to rely on present means of communicating with shelters--radio and TV networks and the telephone system. For purely fallout situations these systems will probably be operative. As the CD program grows, less reliance will need to be placed on these systems if an independent two-way radio system is developed for use primarily by civil defense. Such systems already exist in some cities among monitoring stations, other emergency groups, and the CD communications center, but ultimately it may be desirable to have every shelter tied in to the center by an independent system. If vehicles are to be used efficiently in the movement of people in the second stage of the allocation plan, they also must be tied into the communications network.

## Decontamination

This consideration is mentioned specifically because in the type of allocation plan proposed, post-fallout movement of people is a very likely situation. Thus decontamination becomes much more important than if there were no movement of people outside shelters for two to three weeks post-fallout. The greatest difference that occurs in considering decontamination between very early and later times after the attack is in the need for speed with which decontamination is performed. During early movements of people to more adequate protection, radiation intensity from the fallout will be greater and it will be important to prevent contamination as much as possible and to decontaminate people as soon as possible. The use of plastic raingear outfits consisting of hat, coat, and shoes, which sell for $4 to $5, would be most useful. Mass production of gear specifically designed for this purpose (disposable, one-time use) would reduce this cost even farther. Such outfits could be donned just prior to leaving inadequate refuge and could be discarded upon entering vehicles transporting people to higher protection. Also, stocked shelters should be equipped so that peoples' clothes could be changed and their heads could be shaved, if necessary. No attempt will be made to discuss other techniques of decontamination here. That is a separate study in itself, not within the scope of the present study. The most important conclusions to be derived from this brief discussion are that prevention

of contamination and provision for decontamination are necessary within shelters and that they must become an integral part of the allocation plan.

## The Local CD Organization

This topic was not studied in detail by the Boston team, but it is discussed briefly to show that one of the most important functions of the CD organization is that of acting as a coordinating agency. If this coordination exists and able assistance is obtained from other city departments and special groups, then additional CD personnel requirements to develop, maintain, and implement a shelter allocation and use plan are relatively small.

### Relationship to Other City Departments

The most important coordination required is that between civil defense and other city departments. In most cities it will be the responsibility of the mayor or city manager to direct that this coordination occur. In San Francisco, for example, the mayor ordered into existence a CD operations plan that places specific responsibilities for civil defense upon each city department. To satisfy these responsibilities, each department developed an annex to the plan which prescribes the CD duties and functions of the department and assigns personnel and equipment to perform these functions. These responsibilities not only apply to the actual emergency but extend to developing and maintaining plans.

Insofar as the shelter use plan is concerned, many of the city departments could assist directly. Some of the ways in which specific departments could assist are shown below:

The Fire Department could assist in initial stocking of shelters with supplies. Inasmuch as it already performs fire inspections on buildings, it could also inspect shelter supplies to assure that they are in order. It has already been mentioned that shelter managers could be drawn from fire departments. In many cities, the fire department could also assist in training personnel in the use of radiation monitoring equipment.

The Police Department could assist in the collection of day and night population data by block so that a specific assignment plan could be developed. If appropriate forms and reporting techniques were employed,

it would be relatively easy for each officer to perform a building-by-building census of blocks within his "beat." The police department could also provide shelter managers, as indicated previously. It could also assist civil defense in planning for communications and solving problems related thereto.

The Public Works Department could assist in marking and stocking shelters not only by providing equipment but also by loaning personnel.

The City Planning Department (in Boston, the Redevelopment Agency) can be of significant assistance in the development of a shelter allocation plan and in performing the general allocation and specific assignments of people to shelters and refuges. This group should be more familiar with the layout of the city--land use, natural and man-made barriers, etc.--than any other single group. Furthermore it will also have knowledge of buildings (perhaps containing shelter) to be demolished and new buildings being constructed. It is also more familiar with the use of maps for city planning and the "planning approach" than any other group. Furthermore, it is perhaps better able to look at the over-all problem in a broad perspective--city planners won't get bogged down in the details of specific problems when this is not warranted. Therefore, they could be of great assistance to CD planning officers in developing movements of people and the use of transportation nets.

The Public Welfare Department could be extremely useful in considering in-shelter plans and problems and in handling different types of people.

No doubt there are other city departments from which civil defense should seek assistance. Those discussed above serve only as examples.

## Relationship to Special Groups

Other groups can be of assistance to civil defense in shelter use planning. In most cases, these groups cannot be directed by the mayor to provide assistance, but their cooperation can be elicited by the local CD director. It will be to the advantage of most of these groups to provide a reasonable amount of assistance and at least to coordinate with Civil Defense in their planning. Some that may be especially important in this regard are:

Schools, churches, and civic groups can assist in the distribution of CD information and instructions. Institutions of higher learning may have individuals who can be of direct assistance to civil defense, in planning or consulting.

Hospitals and other institutions should be contacted and cooperated with because they house people who may not be able to be moved any distance to shelter. Also, many of these institutions have large quantities of shelter spaces, useful to house not only their own inhabitants but also others. Such institutions should have their own CD and shelter plans but they must be compatible with the city's plans (or vice versa). These institutions may also be able to provide certain types of specialists useful to CD planning or useful for assisting in in-shelter and post-attack problems.

Industrial organizations and local businesses, as in the case of institutions, may have their own CD and shelter plans that should be coordinated with city plans. Also they can be useful in the distribution of CD information and instructions to their employees and employees' families. In some cases, they may be able to provide specialists to assist the city CD organization in solving special problems. There must be direct coordination with radio, television, and telephone companies if their means of communication are to be used by civil defense during emergencies. In the same way, if railroads are to be used for moving people to shelters, a coordinated plan with the railroads must be prepared. The same, of course, is true of other public transportation systems--for example, the MTA in Boston was mentioned earlier.

Volunteer groups, and there are a number in most cities, might be willing to volunteer time of their members. The use of volunteers should be considered only if it is feasible and necessary.

## Composition of CD Organization

### The Basic Organization

There will be need, of course, for a basic CD organization no matter how much assistance is received from other city departments and other groups. For a city the size of Boston, a basic CD organization (exclusive of shelter use considerations) might consist of one each of the following types of personnel (except that there should be three secretaries):

Director

Executive Assistant or Administrative Officer

| | |
|---|---|
| Planning Officer | Communications Officer |
| Training Officer | Radiological Officer |
| Public Affairs Officer | Accountant |

Clerk

Secretaries (stenographic and typist)

Justification of the need for these types and numbers of personnel is beyond the scope of this study and will vary considerably from one city to another.

## Additional Requirements for Personnel To Develop and Maintain a Shelter Use Plan

If a city the size of Boston has a basic CD organization such as the one above and if a high degree of cooperation and assistance is obtained from other city departments, then the additional personnel to plan, place in operational readiness, and maintain a shelter use plan might include:

1 Shelter officer (with a strong planning background)

1 Clerk typist

2 Materials handlers (or preferably 4, at half-time each)

The addition of these personnel to the basic CD organization might cost from $30,000 to $35,000 per year in operating expenses (including equipment and supplies). If there were no assistance from other city departments in the form of personnel and equipment, the cost might run two to three times this amount.

The personnel and costs indicated here are only for maintaining the plan--this does not include developing the plan, initial licensing, marking and stocking, and so on. The additional burden in terms of personnel and equipment for the latter can be absorbed by assistance obtained from other groups mentioned earlier. It was not within the scope

of this present study to determine in detail the expected cost in terms of dollars or man-hours. To provide one point of reference, it might be noted that the allocation plan developed by the Boston team, including derivation of the method of general allocation, consumed approximately four man-months, divided about equally among two professional researchers and one research assistant.

# VII GENERALIZING THE ALLOCATION PLAN FOR USE BY OTHER COMMUNITIES

The allocation plan developed in this study was tailored to the City of Boston and its needs. The method used in general allocation and specific assignment of people to shelter was also based upon Boston. Therefore, while this plan and these methods are believed appropriate for that city, they may be appropriate only to a degree in other communities. There is no one plan and method that is entirely appropriate for nationwide use. However, the planning approach used in developing an allocation plan and the general method suggested in this report are appropriate to all cities and communities. There are certain factors which must be considered, certain problems which must be evaluated and solved, and certain aspects of civil defense that must be integrated in order to formulate a proper plan and develop an appropriate method.

There are probably a few cities and communities which will approach the situation in Boston closely enough so that the plan and method used in this study will be directly applicable or applicable with slight modification. The impact of a continuing CD program is that this plan and method will become applicable to more and more cities and communities in the future. This is expected because the upgrading of low PF facilities to meet the criteria for federal stocking and the upgrading of existing shelters to hold more people, e.g., through increased ventilation, will result in more cities and communities having an adequate number of spaces to shelter their peak populations.

Some considerations regarding the generalization of the Boston allocation plan for use by other communities will be discussed in terms of: character and layout of the city, relationship to potential targets, and number and distribution of shelter spaces.

## Character and Layout of the City

In generalizing the plan developed for Boston, consideration must be given to the city's age, size, population density and distribution, topography, and so on. Boston is a high-density city with large fluctuations in population between day and night. The major natural barrier to the movement of people is water. The city's age and the type of construction allow for the use of home basements as shelter. Admittedly this is

a poor choice of shelter if better PF space is available, but it is better than no shelter. Many communities do not have home basements to fall back on--thus they cannot satisfy a major premise of the Boston plan, which is that every person should have a plan or destination that affords some degree of protection and therefore a reasonable chance of survival. The layout of the city and population density are such that the only feasible mode of traveling in the short time available is by walking. Communities with low population densities and many wide roads or highways might be able to move people by automobile. On the other hand, Boston's transportation net is extensive and its use makes it feasible to move people in post-fallout sorties to areas of higher protection. Many communities do not have any public transportation nets at all or else they are limited to buses. Boston is relatively flat in its topography and movement of people on foot is accomplished quite readily; other communities may be in mountainous terrain where the only feasible movement by foot is downhill. These considerations are only examples of how the general character and layout of a city must be considered if the Boston plan is to be used in other cities.

## Relationship to Potential Targets

In attempting to generalize the allocation plan developed for Boston, proximity to potential targets is probably one of the most important considerations. The plan for Boston is formulated to take into account the worst fallout situation (in the realization that Boston itself may be the target). Some communities are 100 miles or more away from the nearest target in all but the most unrealistic case, and the use of a two-stage plan would not be appropriate. Other communities may be situated so that protection from fallout would not even be required. If there is any question as to whether a city or a community is near a target, planning should be for the worst situation. This would include all major centers of population, centers of major defense or other industries, and communities adjacent to major military installations.

## Number and Distribution of Shelter Spaces

This is probably one of the first determinations to be made by any city or community in allocating or assigning people to fallout shelters. The relationship of population to shelter spaces must be determined and the general method used in this study can be employed. Obviously, if a community has only a dozen shelters or so, such a complex method is not warranted. If a city determines that it has an adequate number of spaces to shelter its entire population, then it is necessary to determine if

the distribution of spaces is such that a two-stage plan is warranted. If the distribution is uniform in relation to population of if the time-distance relationship is such that people can get to the spaces, even though the distribution is less than ideal, a two-stage plan is not warranted.

Currently, Boston is one of only a dozen or so cities that finds itself in the fortunate position of having enough shelter space meeting the criteria for stocking to accommodate its entire population. As mentioned earlier, more communities will reach this position through the upgrading of shelters in the continuing CD program. In the meantime, however, a community may decide to lower the criteria both in terms of PF and capacity to the point where the entire population will be sheltered in some fashion. In this case the distribution of this space in relation to population will still have to be performed and a decision will have to be made as to whether a two-stage shelter allocation plan should be used. It should be noted, however, that the present CD program does not allow for stocking these low PF or low-capacity shelters with federal supplies. The local community must arrange its own stocking if it is desired.

# Appendix A

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Appendix A

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## Appendix B

## LIST OF ORGANIZATIONS AND INDIVIDUALS CONTACTED IN THE BOSTON AREA

Appendix B

LIST OF ORGANIZATIONS AND INDIVIDUALS CONTACTED IN THE BOSTON AREA

Office of Civil Defense, Region One, Harvard, Massachusetts

Alexander A. Morrissette, Director
N. P. Fallon, Deputy Director
G. R. Thompson, Shelter Engineer
Allan B. Dick, Shelter Officer
John N. Levens, Field Representative for Massachusetts
Max W. Rote, Jr.
Mr. Black

U.S. Army Corps of Engineers, New England Division, Waltham

Joseph McManamin, Contracts Officer
Walter Donle, Contracts Officer

Massachusetts State Civil Defense Agency, Natick

Gen. John J. Maginnis, Director
George Burroughs, Deputy Director
Charles W. Smith, Shelter Officer
Basil Kontoyianes, Assistant Shelter Officer
Margaret M. Lanigan, Welfare Officer
Harold J. Magee, Commodity Supply Officer
T. P. Coates, Resources & Management Officer
Arthur Mackay, Transportation Officer
Stanley Ritter, Warden Service Officer
Leo M. Linehan, Economic Stabilization Officer
Leigh M. Nisbet, Intelligence Officer

Massachusetts State Civil Defense Agency, Area One Office, Topsfield

John Lovering, Director
Col. C. H. McLeod, Deputy Director

City of Boston

Department of the Mayor

Hon. John F. Collins, Mayor
William J. Devine, Assistant Secretary
Richard J. Sinnott, Director of Public Information

City of Boston (cont.)

Civil Defense Department

Gen. Charles W. Sweeney, Director
Waldo Pisco, Deputy Director
Thomas S. Maloney, Planning Officer
Samuel Risman, Warning Officer
Joseph Kelley, Assistant Radiological Officer

Fire Department

Thomas J. Griffin, Commissioner
John F. Howard, Chief of Staff
William A. Terrenzi, Chief
John E. Clougherty, Chief, Fire Prevention
Edward J. Gaughan, Deputy Fire Chief
Charles F. Freiberg, Fire Lieutenant
George R. Haines, Fire Lieutenant
George L. Rooney, Fire Lieutenant

Police Department

Edward L. McNamara, Commissioner
Capt. Hogan, Disaster & Emergency Planning
James Buchanan, Lieutenant

Redevelopment Authority

John McMorrow, Administrative Director
Henry Brinkers, Chief Planner

Building Department

J. F. Kelleher, Building Inspector

Traffic Department

Patrick F. Tierney, Primary Traffic Engineer

School Department

Louis Welch, Assistant Superintendent

Metropolitan Transit Authority

Col. William A. Whelton, Civil Defense Director

Massachusetts State Department of Commerce

Fred Fallon, Division of Planning

Greater Boston Chamber of Commerce

Daniel A. Ahern
Cy Minty

The Planning Services Group, Cambridge

Norman A. Abend

Anderson Nichols and Co., Inc.

Leroy Long

Fay, Spofford and Thorndike, Inc.

W. J. Hallahan

Gillette Safety Razor Co.

Steven Griffin, First Vice President
Walter Bowen, Civil Defense Officer
Mr. Brian, Operations Manager

John Hancock Mutual Life Insurance Co.

Gerhardt D. Bleicken, Executive Vice President
Col. Wood, Civil Defense Director
Arthur Driscoll, Shelter Officer

Appendix C

IMPLICATIONS OF OCD DECISION TO MARK PF 40-99 SPACE

## Appendix C

## IMPLICATIONS OF OCD DECISION TO MARK PF 40-99 SPACE

During November 1962, OCD changed its criteria for marking shelters from a minimum PF of 100 to a minimum PF of 40. The study of the City of Boston was almost completed before this change was made; therefore, this report was written on the assumption that only shelters with a minimum PF of 100 would be marked with the federal CD shelter sign. Where it was necessary to use shelter with a PF lower than 100, it was planned that the local CD organization would mark these shelters with a sign different from the regular shelter sign. The use of the term "unstocked refuge" to denote these lower grade shelters was proposed.

The decision of OCD to mark all shelter with a PF of 40 and over has many implications both for the City of Boston and for the shelter plan proposed in this report. In Boston the shelters in the PF 40-99 range are located primarily in the same places as are the PF 100 and over shelters. Eighty-nine percent of all the PF 100 and over space in Boston is located in only 29 standard locations. For each of these standard locations, the amount of PF 100 and over space is greater than its peak population. These same standard locations, however, also have 75 percent of all the PF 40-69 space and 69 percent of the PF 70-99 space. Moreover, the remainder of the PF 40-99 space is largely located in standard locations which are contiguous to standard locations with excess PF 100 and over space. Therefore, the addition of PF 40-99 facilities does not help to any great extent the problem of shelter space not being distributed properly in relation to the population. By the wholesale addition of PF 40-99 space, more space is added to those areas which already have adequate shelter and the areas of insufficient shelter are not helped significantly.

When people are given enough time to travel up to 1 mile in order to reach shelters, the utilization of space is as follows:

| | PF 100 and Over Space Used | PF 40-99 Space Used |
|---|---|---|
| Daytime | 53% | 10% |
| Nighttime | 33 | 11 |

As can be seen, only a very small portion of the space in the PF 40-99 range would be used. If time were available to travel a distance greater than 1 mile, the proportion of PF 40-99 space used would still be quite small. Generally, the location of the different grades of shelter is such that, if PF 40-99 shelters can be reached, space in PF 100 and over shelters can be reached also. Furthermore, in Boston there is enough space of PF 100 and over to accommodate the entire population.

It can be seen, therefore, that the marking of all shelters with a minimum PF of 40 is not appropriate for the City of Boston. Because the difference in the desirability of shelter would not be indicated under the new marking instructions, many people would go to poor shelter when they could just as easily have gone to shelter of a higher quality. Moreover, even though all the shelters would be marked the same, present plans are to stock only those shelters with a minimum PF of 100. This apparent discrimination as to which shelters will be stocked can be expected to result in confusion and an increase in the public misunderstanding of the CD program.

These problems can be alleviated somewhat if the local CD organization does not license and mark those shelters which it does not need nor want to be used. However, much of the PF 40-99 space is located in the same building or facility as the PF 100 and over space. Even though the local CD organization might want to use only the PF 100 and over space in a particular facility, present instructions to the Army Engineers when posting the signs are that the total number of spaces in the PF 40 and over range shall be listed as the shelter capacity on the sign.

In addition to the above problems, the OCD decision concerning marking also affects the two-stage shelter allocation plan proposed in this report. The proposed plan adopts the concept of using low-grade unstocked shelters as refuges or temporary shelters until such time as people can be relocated in stocked shelters or areas with a higher protection. In cases of pre-fallout movement, time may be relatively short; therefore it may be desirable to issue instructions to the people in a very simple fashion, for example "those persons in area x who are in refuges, proceed to stocked shelters in Area Y." The OCD decision complicates such a plan

since people would not know whether they were in a refuge and should move to better shelter. A similar problem could arise in post-fallout movements. The local CD organization can solve this particular problem by posting additional signs next to the federal shelter signs which add the word "refuge." If the differences in shelter desirability are not indicated in some manner, the methods used in this report to assign people to shelter will have to be revised slightly to reflect the changed criteria for marking shelters.

# Appendix D

## SRI DATA HANDLING

Appendix D

SRI DATA HANDLING

Treatment of Raw Data

At the time this study was undertaken, Phase II of the National Fallout Shelter Survey had not been completed. Discussions were held with the Army Corps of Engineers, New England Division, which has responsibility over the survey performed in Boston; it was concluded that utilization of Phase I survey data pertaining to shelter spaces might result in gross misconceptions--perhaps even in the development of an allocation plan that would not meet the true facts. Phase II shelter data should be employed if at all possible because of their relative superiority over similar data distributed from Phase I.

The only Phase II information available to the research team at the time data analysis began was the marking sketches. These sketches outline the shelter areas within facilities having shelters and give shelter spaces (capacities) of these areas. Sketches were prepared only for areas having a PF of 100 or more. Some facilities have only one shelter area but most facilities in Boston have several--some have as many as 25. The facility number in which the shelter area exists and the SL number in which the facility exists were also included on each marking sketch. An early decision, therefore, was that marking sketches should be used as the basic source of Phase II shelter data. However, they would only provide data on PF 100 and over space. To obtain data on space of lower PF and to obtain data on peak daytime and nighttime population estimates, the Phase I summary printouts would have to be used. It was therefore decided also to take the data on PF 100 and over space to compare with the Phase II data. Because Phase I data were developed only for building facilities (i.e., only potential shelters in buildings were surveyed in Phase I), and because Phase II data also included special facilities (i.e., tunnels, subway stations, underground garages), the marking sketches were also used to differentiate between building facilities and special facilities. The volume of data and extent to which they would be handled led to the decision to use punched cards for accumulating and summarizing the data. It was recognized that most local CD organizations probably could not use this technique, but they would not have to--the same data SRI developed by use of punched cards will be available on Phase II printouts to local

CD organizations. The raw data put into punched cards and the summarization of these data are indicated in Figure 20. This figure is self-explanatory and provides a nearly complete description of the task performed.

## Analyses

Four general types of analyses were performed using the punched cards. In the first analysis, the shelter facility deck was sorted and printed with appropriate subtotals being made to determine the characteristics of number and size of shelter facilities. The net result of this analysis was discussed in the main text of the report (Section III and Figures 2 and 3). Knowledge of the distribution of shelter facilities by size was helpful in understanding the over-all shelter situation in Boston.

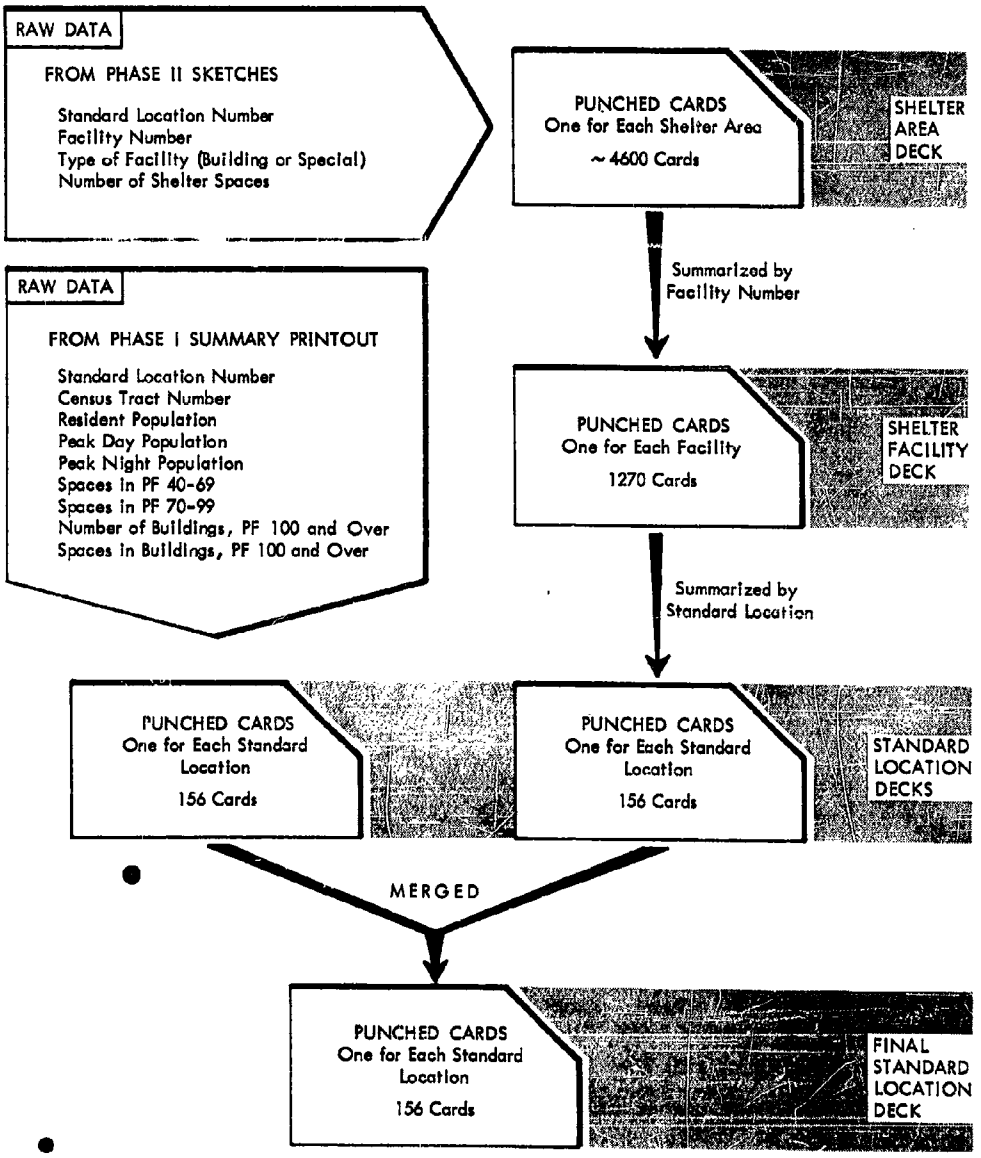
The second analysis also involved the shelter facility deck and was also discussed in Section III. The listing of shelter facilities in sequence by facility number was the basis (combined with the Phase I shelter location maps prepared by the A&E's) for developing a shelter location map in Phase II (Figure 5) and for showing the size range of these facilities.

The third analysis performed and the most important one to this study was the calculation of differences between population and shelter spaces for each standard location. This calculation was performed and printed automatically from the final standard location punched card deck. Although this calculation was performed automatically on the punched card printer, it must be emphasized again that this could have been accomplished without much more difficulty manually, had the Phase II standard location summaries been available at the time. The use of these different calculations (excess shelter spaces or unsheltered people) has been discussed in Section III and results were shown in Table II.

The fourth analysis performed was a comparison of Phase I and Phase II data. It was desirable to perform this analysis to determine how serious the discrepancy might be between Phase I and Phase II data, especially because utilization of space with a PF less than 100 would be required in the allocation plan. The final SL deck, containing data from both phases, was used to perform this analysis. Data preparation consisted of calculating and printing the subtracted difference between number of PF 100 and over building facility spaces derived in Phase I and those derived in Phase II for each standard location. The differences noted were very large and it was then decided to calculate ratios of the number of spaces found

FIGURE 20

INFORMATION CONTENT AND FLOW USED BY SRI
TO PERFORM THE STUDY




SOURCE: Stanford Research Institute.

in Phase I to those found in Phase II for each standard location. The average ratio for 153 standard locations was determined to be 0.86; i.e., on the average only 86 percent of the spaces found in Phase II had also been found in Phase I. (This ratio does not include three standard locations for which the discrepancy was so great that it biased the average ratio by more than 10 percent.) Next, the difference between this average ratio and the individual ratios for each standard location was calculated and squared. The square root of the sum of the squares divided by the number of squares was then calculated to determine the variance. This variance gives an indication of the reliability of the data. The result is that the true average ratio is $0.86 \pm 0.77$. This means that on the average the number of spaces for any standard location in Phase I would only be 86 percent of those determined in Phase II and the average error in this determination would be $\pm$ 77 percent. Indeed, the original statement by the Army Corps of Engineers that Phase I data would be grossly inaccurate compared to Phase II data is substantiated by fact.

A comparison of the number of facilities and number of spaces in various PF ranges between Phase I and Phase II is summarized in the following tabulations.

| | Phase I Data | | |
|---|---|---|---|
| | PF 40-69 | PF 70-99 | PF 100 & Over |
| No. of facilities | --* | --* | 2,057 |
| No. of spaces | 1,000,713 | 435,633 | 1,208,150 |

| | Phase II Data (PF 100 & Over Only) | | |
|---|---|---|---|
| | Buildings | Special | Total |
| No. of facilities | 1,199 | 175 | 1,274 |
| No. of spaces | 1,331,554 | 108,471 | 1,440,025 |

* Not available in the data on hand.

The differences between Phase I and Phase II data in the number of facilities and in number of spaces available (PF 100 and over) in building facilities, are readily observed in these tabulations. There are several reasons for this difference. Perhaps the major reason is that in Phase I the PF determinations were calculated on a central computer, which did not allow for "exceptions," whereas in Phase II the PF determinations from Phase I were adjusted as necessary by the A&E's at the time they were performing the survey. Also in Phase I, data were often estimated based on Sanborn maps and windshield surveys. In Phase II actual visits were made to every facility having potential shelter space. In several cases admittance to buildings was denied by the owner, and those buildings were therefore not included even though there was fair assurance that PF 100 and over shelters existed. Other reasons have also been offered as to why these differences arise.

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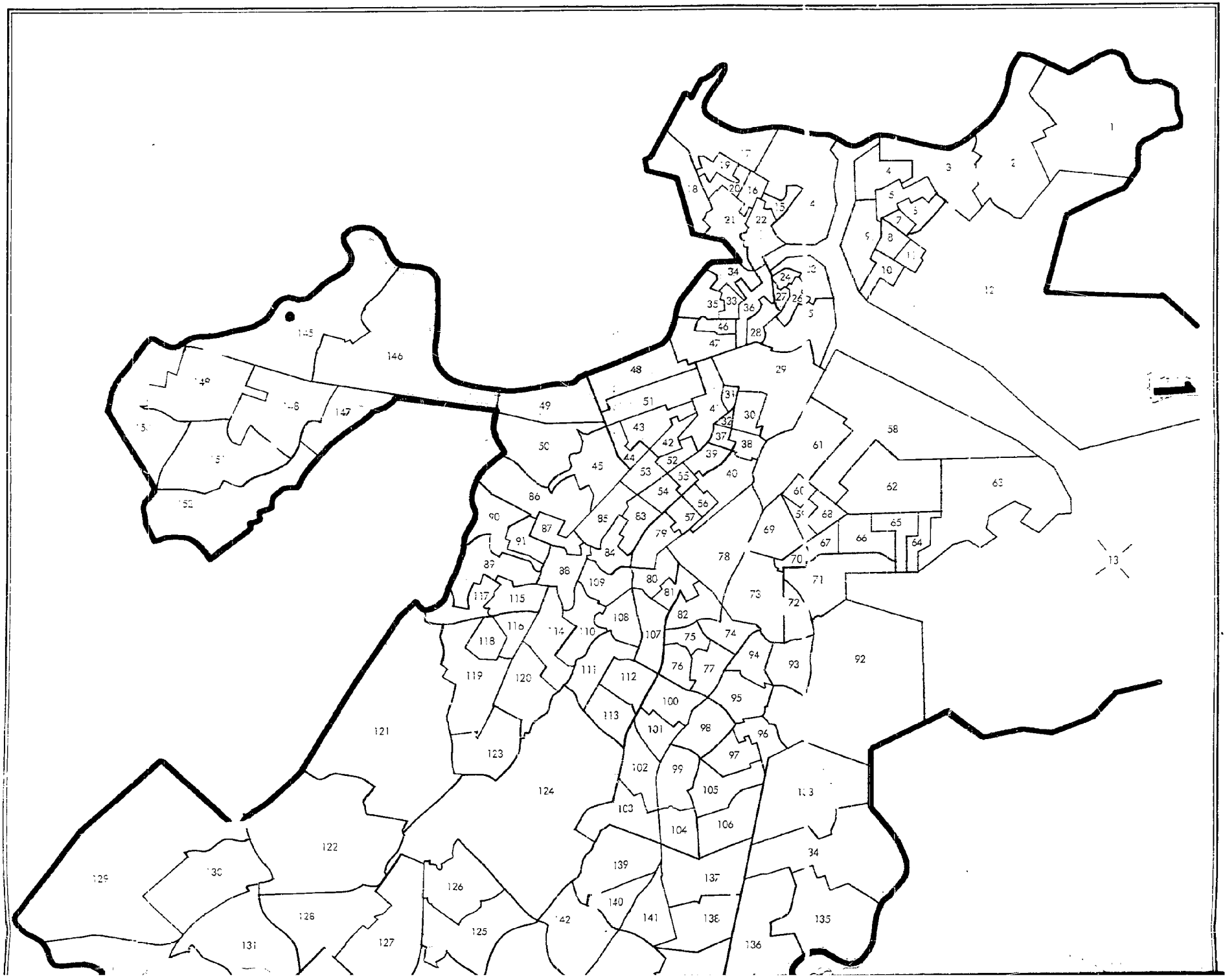

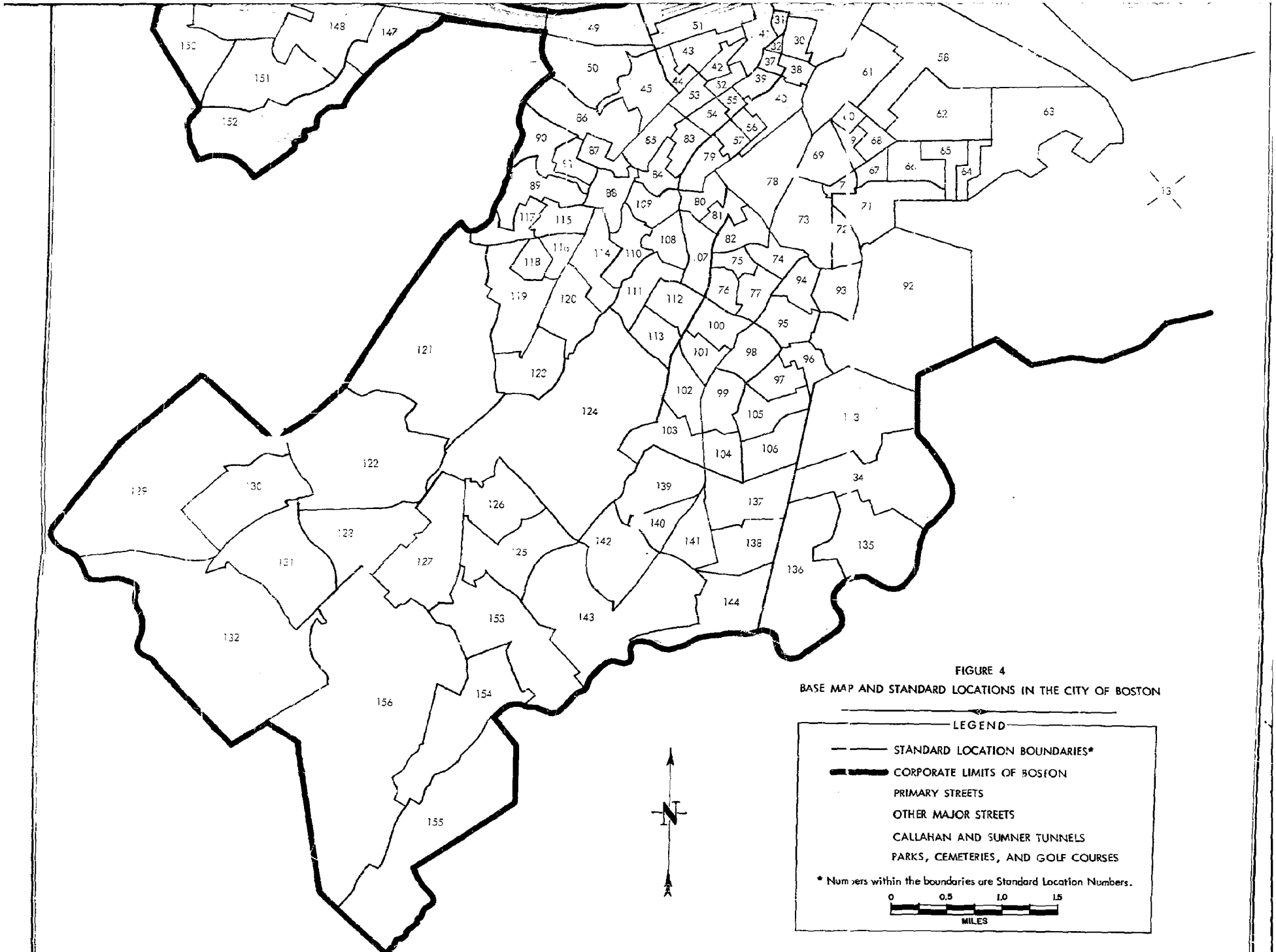


SOURCE: Developed by Stanford Research Institute from City Planning Board map of the City of Boston and A & E Phase I base maps.