# Space between buildings as a means of preventing the spread of fire. Report B: survey of low-density subdivision on outskirts of metropolitan Vancouver

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CANADA

DIVISION OF BUILDING RESEARCH

# SPACE BETWEEN BUILDINGS AS A MEANS OF PREVENTING THE SPREAD OF FIRE

## Report B -- Survey of Low-Density Subdivision on Outskirts of Metropolitan Vancouver

by

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Vancouver, B.C.



A Joint Project of the School of Architecture
and the Graduate Program in Community and Regional Planning,
University of British Columbia
and the
Division of Building Research, National Research Council

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OTTAWA

November 1963

The late Professor Fred Lasserre, as Director of the School of Architecture at the University of British Columbia, was one of the original sponsors of this research project. His contribution is remembered appreciatively by all connected with this Report.

R. F. Legget

# PREFACE

This report is one of a series of four which are concerned with space between buildings as a means of preventing the spread of fire, which in turn forms part of a main research project "Performance Standards for Space and Site Planning for Residential Development."

This project has been undertaken for the Division by the School of Architecture at the University of British Columbia. Two reports have already been issued: An Annotated Bibliography on Performance Standards for Space and Site Planning for Residential Development (NRC 6442) and DBR Internal Report No. 273, "A Study of Performance Standards for Space and Site Planning for Residential Development." The latter contains a discussion of the factors that determine the spacing of residential buildings. This present series of four reports deals with one of these factors -- fire. The other factors, including daylight, noise and privacy, will be dealt with in subsequent reports. When all of these reports are issued, they will form a complete evaluation of the conditions that must be considered in the planning of residential areas in Canada.

The first two authors of this report are on the staff of the University of British Columbia. Professor Oberlander, besides his duties on the staff of the School of Architecture, is Head of the Graduate Program in Community and Regional Planning; Professor Gerson, at the time this report was written, was Acting Director of the School of Architecture. Mr. Goldsworthy, a graduate architect, was engaged as research assistant to the project. Professor Henry Elder is the present Head of the School of Architecture; the project was initiated under the direction of his predecessor, the late Professor Fred Lasserre.

This information is being issued in the Divisional series of internal reports so that those responsible for the work can have the benefit of informed comments prior to publishing in a more formal way. Comments will therefore be welcomed and should be sent either to Professor Oberlander at the University of British Columbia or to the writer at Ottawa.

Ottawa
November 1963

R. F. Legget
Director, DBR/NRC

# TABLE OF CONTENTS

Page No.

# SPACE BETWEEN BUILDINGS AS A MEANS OF PREVENTING THE SPREAD OF FIRE

## Report B -- Survey of Low-Density Subdivision on Outskirts of Metropolitan Vancouver

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## INTRODUCTION

The volume of post-war housing across Canada has revealed a great number of problems in the use of site planning standards as a basis for achieving a high quality of residential communities. This unprecedented volume, coupled with the concentration of new housing in the suburbs of Canadian cities, has made a rational layout of the many hundreds of units in relation to each other and to their communal facilities very difficult. Traditional space and location standards for large-scale housing have not been able to control resulting development adequately. In most instances, it has merely allowed housing to be built in a mechanically neat and orderly fashion. More flexible and imaginative standards of house grouping and layout seem essential if the next flood of housing in Canadian cities is to add more to urban Canada than merely further volume of accommodation.

Throughout the post-war decade Canadian cities and towns became aware of the value of community planning and of their respective responsibilities for controlling the individual's use of his land for the benefit of the community as a whole. Traditionally, town planning has been closely linked with rules and regulations laid down in bylaws, uniformly applied throughout the jurisdiction of a given city or town. These rules and regulations, usually contained in a zoning or subdivision control bylaw, restrict the way in which buildings may be sited on their respective lots and the amount of space on that lot that has to remain open and unobstructed by any construction. These regulations often include minimum front and rear yard dimensions as well as side yard limitations and related restrictions as to the height of buildings. It is usually contended that it is in the community's interest to set certain space standards between and around buildings to achieve safety, minimum health standards, amenity and aesthetic appearance. These space regulations as a rule are expressed in absolute measurements of distance, and result in monotonous and rigid spacing of buildings. This is particularly true of residential areas that have been built in large groups of single units; the typical post-war housing subdivision falls into this category.

The main purpose of the research project is to demonstrate that adequate space around and between buildings for functional and aesthetic purposes can be achieved with greater flexibility and without unduly restricting the siting of residential buildings. Such flexible standards are usually referred to as performance standards since they determine space between and around buildings by the variety of functions that they are to perform and in relation to the size and dimension of land and buildings in a given situation. In the post-war decade, performance standards were used in the siting and building of industrial and commercial structures. This experience demonstrated that performance standards provide a more flexible framework for the designer of individual buildings or groups of buildings and also enable government agencies to administer regulations effectively.

The present report forms a portion of this research. The research began with a survey of literature from which an annotated bibliography was prepared (2). This gave the initial direction to the work and was used extensively during the following studies. The factors which determine the spacing of residential buildings were then investigated (3). The full range of community objectives are fire, daylight, air, noise, privacy, view, traffic and outdoor space.

The general aim of this part of the investigation, now reported, is to study the application of the prevention of fire as a determinant of space between buildings in residential areas and to develop specific methods for the application of these standards. This particular field of investigation was chosen because of the critical nature of fire safety and because information was more readily available than for some of the other community objectives. The information which is here discussed is based on fire studies conducted by the Division of Building Research and similar bodies throughout the world.

The first part of this investigation consists of three field surveys of actual residential developments in Metropolitan Vancouver*. The information thus obtained provides the basis for formulating a technique for applying performance standards to the prevention of fire spread from building to building through the flexible use of the space between them (contained in DBR Internal Report No. 283 by H.P. Oberlander and R.S. Ferguson).

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* This report (DBR Internal Report 281), and DBR Internal Reports Nos. 280 and 282 by the same authors.

# PART 1

## THE ANALYTIC METHOD

It is the purpose of this stage to examine current conditions and standards; hence the investigation begins with a survey of existing residential areas of a varied nature in order to obtain as wide a view as possible of the total range of residential development in a typical Canadian metropolitan area.

These surveys consist of field questionnaires and measured drawings for each building. A summary of this information for all of the buildings within the area now reported on will be found in Appendix A. This method yields an adequate explanation of the construction and geometry of the buildings but does not fully show the relationship of a building to its neighbours. To demonstrate this a scale model of the area was constructed (Figures 1, 2 and 3).

The model indicates not only the relationships of buildings in the area but, more important, it indicates the types and qualities of the spaces between and around the buildings much more clearly than any other form of presentation. In addition to showing the existing spaces, the model also allowed graphical illustration of the spatial separations which would be required if the layout of the buildings on the site were to conform to certain standards other than those which were in effect at the time of construction. These standards will be more fully explained in the following pages and the analyses of the spaces will be found in Part 3 of this report.

Any study of existing conditions is incomplete without an investigation of the forces which shaped them. Among others, great influence is exercised by the building and zoning bylaws through which the public controls the siting and the form of individual buildings for purposes of public safety. Since this survey is restricted to the control of conflagrations by space separations, the extent to which these regulations are based on considerations of fire safety will become evident. This will allow demonstration of the effect of these regulations on the pattern of residential development.

Analyses of existing spaces consist of checking the spaces against three standards: Table IV of the Housing Standards, 1962 (7), Table VI contained in the Division of Building Research Internal Report No. 187 by J.H. McGuire (5), and a conversion of Table VI. For convenience, these tables shall be referred to as Tables 1, 2 and 3 respectively in this present report (see pages 9 to 11).

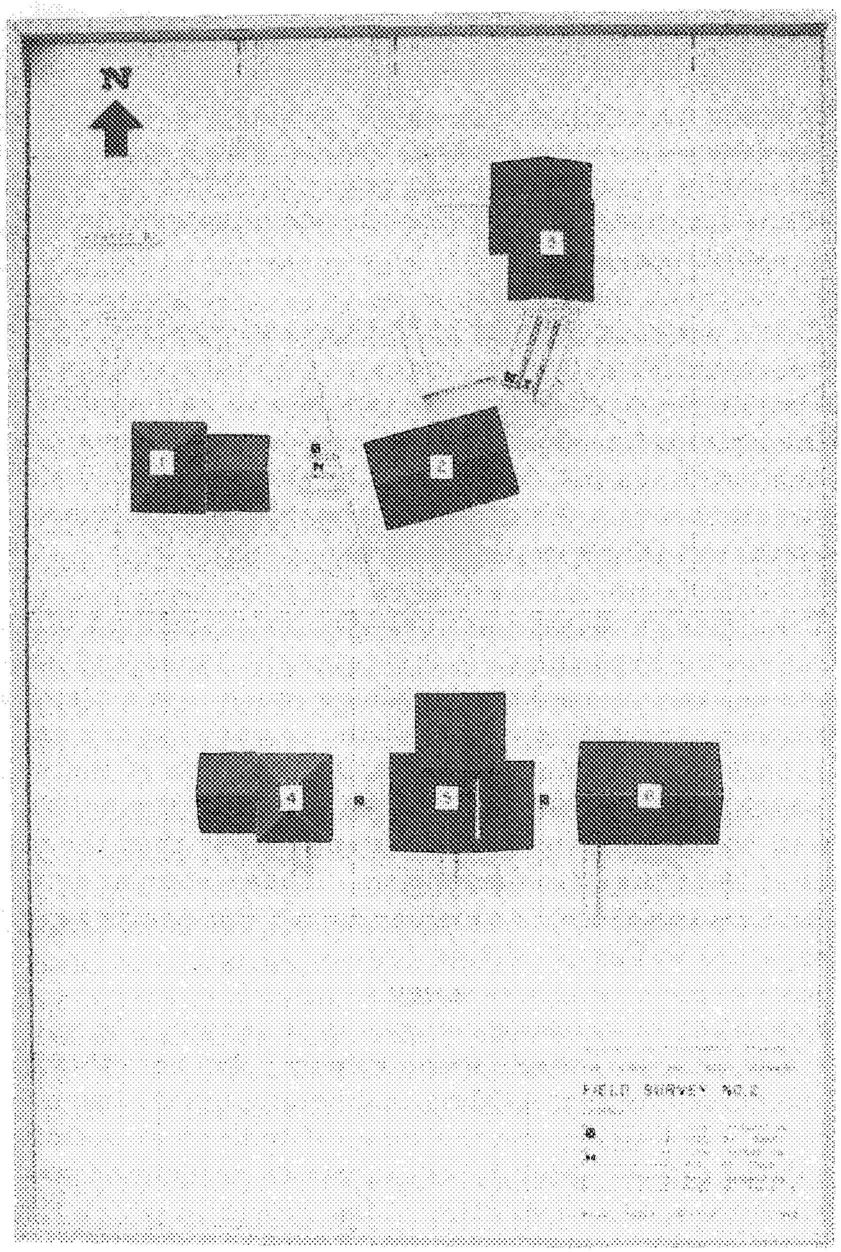


FIGURE I

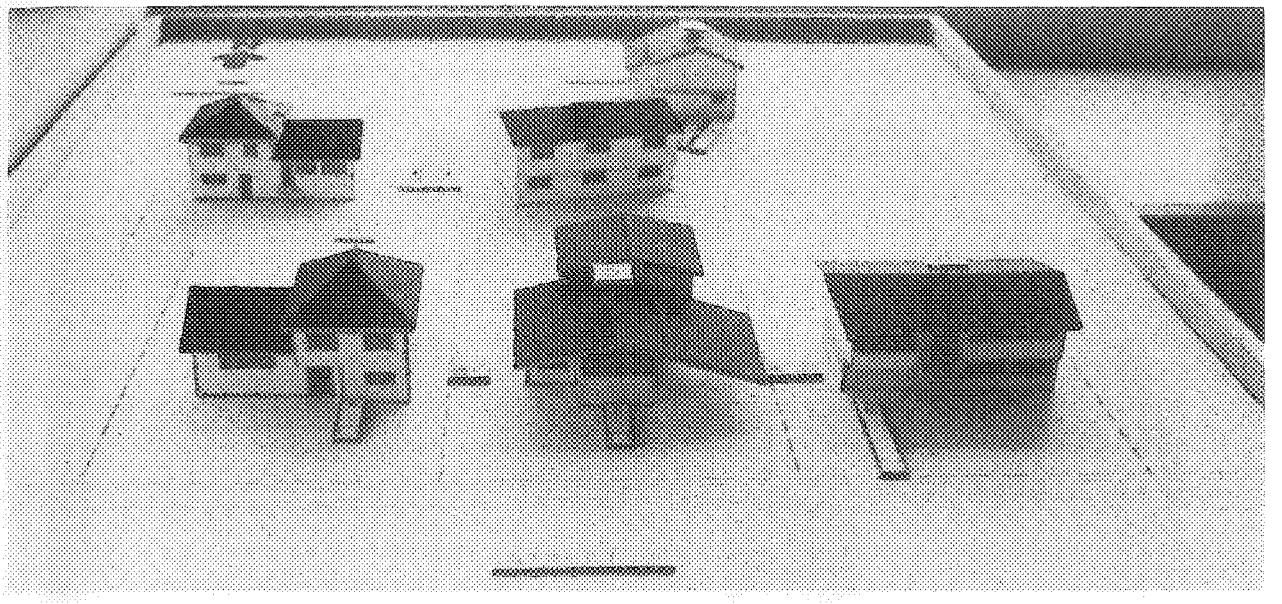

FIGURE 2

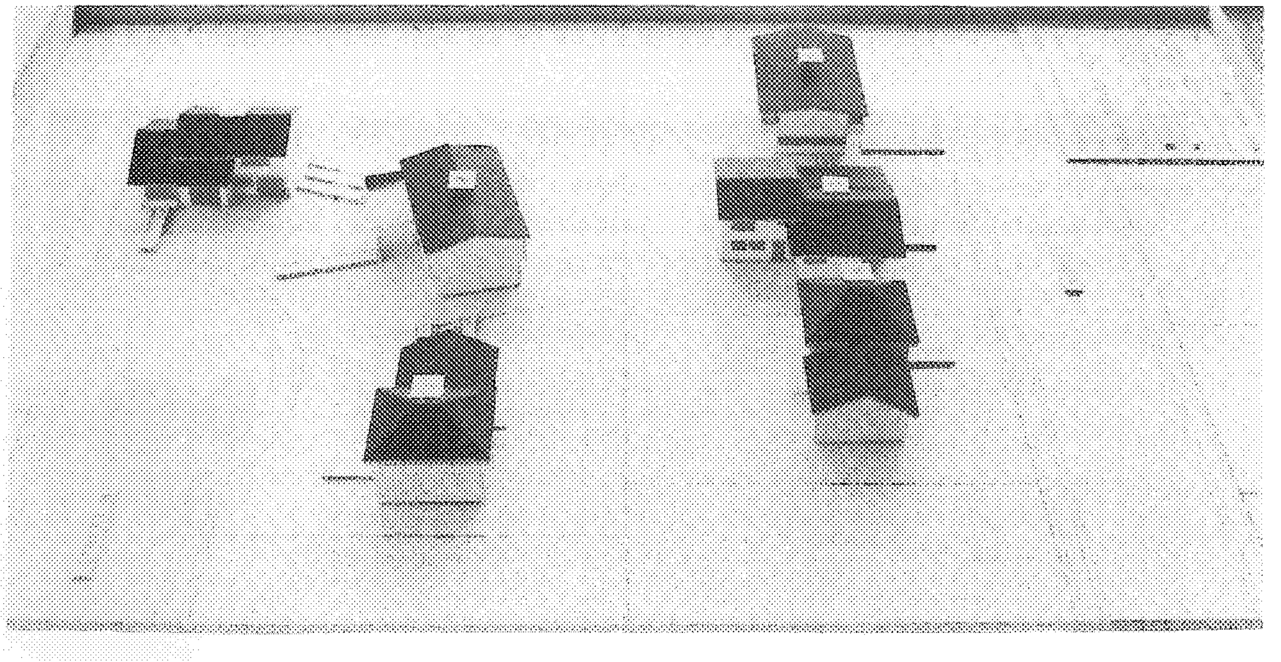

FIGURE 3

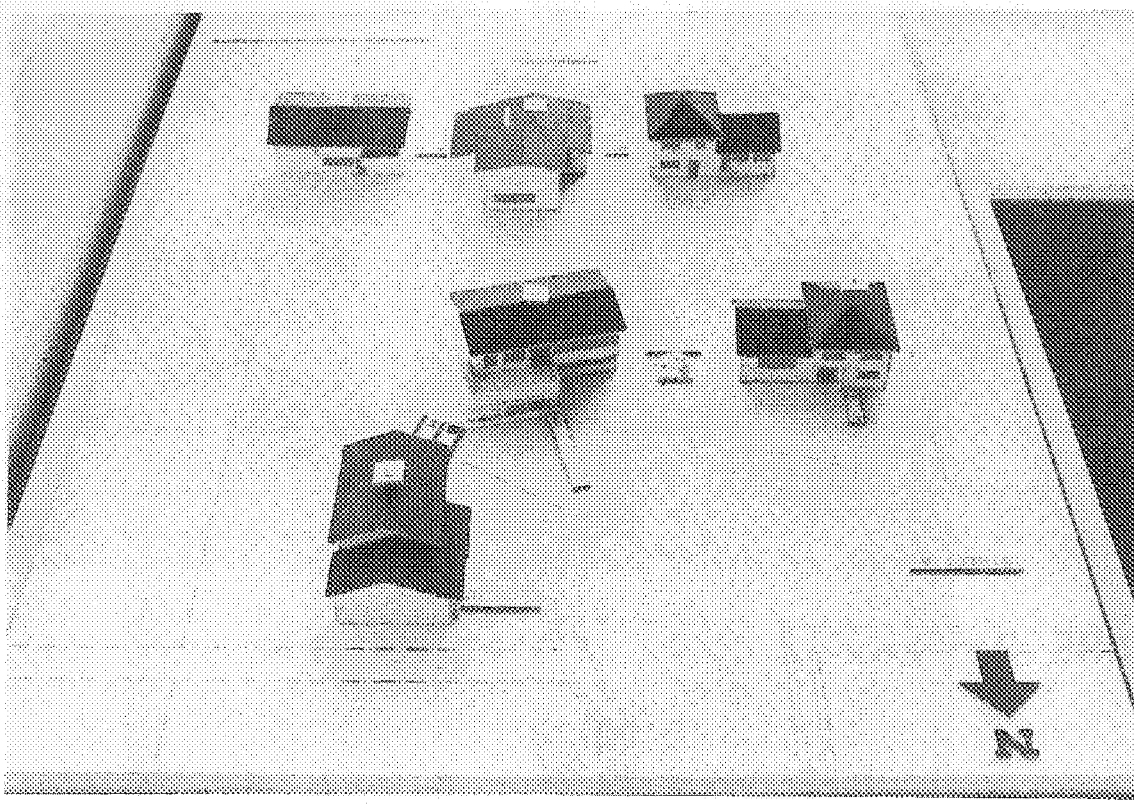


FIGURE 4

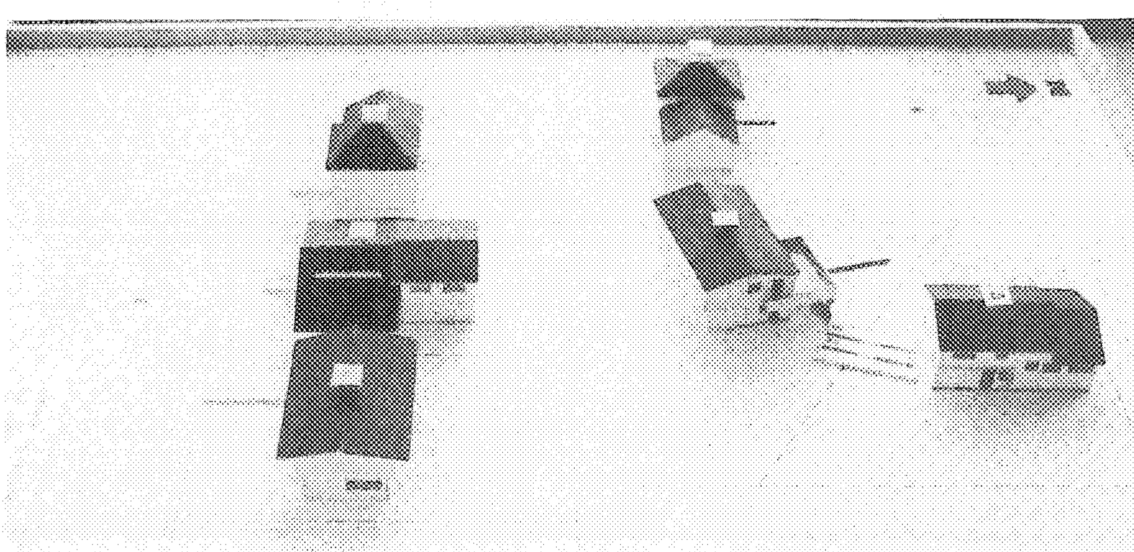

FIGURE 5

The reasons for choosing Table 1 were twofold. First, it allowed comparison between the municipal regulations concerning the use of spatial separations and those contained in the National Building Code. Also, the project could be used as a testing ground for the use of the table, as a basis for comment on its workability and discussion of its advantages and limitations under a variety of conditions. These comments will be found in Part 3 of this report. Table 2 was used because it formed the basis for Table 1. It was therefore of interest to compare the results of these two standards in order to assess the agreement between them and to comment on the workability of the two different forms of presentation.

Tables 1 and 2, however, give the required spatial separations in terms of distance from the building face to the lot line. This was done to simplify the application and to avoid administrative difficulties. In order to increase the flexibility of the standards and, incidentally, to make them more consistent with the results of original research conducted by the Division of Building Research, Table 2 was converted to give the separations in terms of space from building to building. The conversion is included in this report as Table 3.

It should be mentioned that the analyses are based on two assumptions: that all of the buildings studied have a fire load of 10 pounds per square foot and that the spread of fire takes place primarily by radiative heat transfer.

The fire load concept has been defined as follows:

> "If the . . . amount of the combustible contents of a building are divided by the floor area, a figure is obtained which allows comparison between different buildings, or different parts of the same building. Fire load is thus determined in B. Th. U's per sq. ft. by the formula:
>
> $$\frac{\text{cal. value of contents in B. Th. U's per lb.} \times \text{weight of contents in lb.}}{\text{Floor area in sq. ft.}}$$
>
> "Because most buildings are built for a specific occupancy, it is possible to predetermine fairly accurately their maximum fire loads in full use." (1, p. 47, 48).

From discussions with officials of the Division of Building Research, it was found that the value of 10 pounds per square foot is the one on which the table of separation in the National Building Code was based. This is also approximately the same as the values assumed in the St. Lawrence Burns experiments which were conducted by the Division in 1958 (11).

As for the assumption that the spread of fire from building to building takes place by radiation, it is stated in "Spatial Separation of Buildings" (5, p. 1) that:

> "The spread of fire between two buildings may result from:
>
> 1. Flying brands,
> 2. Convective heat transfer, and/or
> 3. Radiative heat transfer.
>
> "Flying brands may initiate secondary fires at substantial distances from the primary fire, e.g. a quarter of a mile, and thus it is not practical to consider spatial separation between buildings as a means of combatting this hazard. Fortunately other means are available.
>
> "Convective heat transfer will only cause ignition if the temperature of the gas stream is several hundred degrees Centigrade. Such high gas temperatures are only to be found in or very near to the flames emanating from the windows of burning buildings.
>
> "Since ignition by radiation from a burning building can occur at distances greater than those to which the flames generally extend it follows that radiative heat transfer is the factor of primary importance in producing spread of fire across a space separation between buildings . . . ."

# TABLE 1

## SEPARATION FROM LOT LINE

| Area of Exposed Building Face, sq ft | Ratio L/H or H/L* | LIMITING DISTANCE, ft | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4 | 6 | 10 | 15 | 20 | 30 | 50 | 70 | 100 | 140 |
| | | Permissible Area of Unprotected Openings in Exposed Building Face, per cent | | | | | | | | | |
| less than 300 | less than 3:1 | 5 | 7 | 15 | 32 | 57 | 100 | 100 | 100 | 100 | 100 |
| | 3:1 to 10:1 | 6 | 9 | 18 | 34 | 63 | 100 | 100 | 100 | 100 | 100 |
| | over 10:1 | 9 | 13 | 25 | 44 | 68 | 100 | 100 | 100 | 100 | 100 |
| 300 and over but less than 400 | less than 3:1 | 5 | 6 | 12 | 23 | 41 | 65 | 100 | 100 | 100 | 100 |
| | 3:1 to 10:1 | 6 | 8 | 15 | 27 | 45 | 80 | 100 | 100 | 100 | 100 |
| | over 10:1 | 8 | 11 | 20 | 35 | 55 | 100 | 100 | 100 | 100 | 100 |
| 400 and over but less than 500 | less than 3:1 | 4 | 6 | 11 | 21 | 34 | 73 | 100 | 100 | 100 | 100 |
| | 3:1 to 10:1 | 5 | 7 | 13 | 23 | 37 | 75 | 100 | 100 | 100 | 100 |
| | over 10:1 | 7 | 10 | 18 | 31 | 47 | 87 | 100 | 100 | 100 | 100 |
| 500 and over but less than 600 | less than 3:1 | 4 | 6 | 10 | 18 | 19 | 60 | 100 | 100 | 100 | 100 |
| | 3:1 to 10:1 | 5 | 7 | 11 | 19 | 32 | 70 | 100 | 100 | 100 | 100 |
| | over 10:1 | 7 | 10 | 17 | 28 | 41 | 80 | 100 | 100 | 100 | 100 |
| 600 and over but less than 800 | less than 3:1 | 4 | 5 | 8 | 15 | 23 | 50 | 100 | 100 | 100 | 100 |
| | 3:1 to 10:1 | 5 | 6 | 10 | 16 | 25 | 52 | 100 | 100 | 100 | 100 |
| | over 10:1 | 7 | 8 | 14 | 23 | 35 | 60 | 100 | 100 | 100 | 100 |
| 800 and over but less than 1000 | less than 3:1 | 4 | 5 | 7 | 12 | 19 | 40 | 100 | 100 | 100 | 100 |
| | 3:1 to 10:1 | 5 | 5 | 9 | 14 | 22 | 44 | 100 | 100 | 100 | 100 |
| | over 10:1 | 6 | 8 | 13 | 21 | 30 | 50 | 100 | 100 | 100 | 100 |
| 1000 and over but less than 1500 | less than 3:1 | 3 | 4 | 6 | 9 | 14 | 28 | 73 | 100 | 100 | 100 |
| | 3:1 to 10:1 | 4 | 5 | 8 | 11 | 16 | 31 | 75 | 100 | 100 | 100 |
| | over 10:1 | 6 | 7 | 11 | 17 | 23 | 40 | 87 | 100 | 100 | 100 |
| 1500 and over but less than 2500 | less than 3:1 | 3 | 3 | 5 | 7 | 10 | 19 | 44 | 88 | 100 | 100 |
| | 3:1 to 10:1 | 3 | 4 | 6 | 9 | 12 | 21 | 48 | 90 | 100 | 100 |
| | over 10:1 | 5 | 7 | 9 | 13 | 17 | 34 | 50 | 100 | 100 | 100 |
| 2500 and over but less than 3500 | less than 3:1 | 3 | 3 | 4 | 6 | 8 | 14 | 34 | 62 | 100 | 100 |
| | 3:1 to 10:1 | 3 | 4 | 6 | 8 | 10 | 16 | 47 | 67 | 100 | 100 |
| | over 10:1 | 5 | 6 | 8 | 11 | 15 | 23 | 50 | 73 | 100 | 100 |
| 3500 and over but less than 5000 | less than 3:1 | 2 | 3 | 4 | 5 | 7 | 11 | 25 | 44 | 88 | 100 |
| | 3:1 to 10:1 | 3 | 3 | 5 | 7 | 8 | 13 | 35 | 48 | 90 | 100 |
| | over 10:1 | 5 | 6 | 7 | 10 | 12 | 19 | 38 | 50 | 100 | 100 |
| 5000 and over | less than 3:1 | 2 | 2 | 3 | 5 | 6 | 8 | 19 | 34 | 50 | 100 |
| | 3:1 to 10:1 | 2 | 2 | 4 | 6 | 7 | 10 | 22 | 37 | 55 | 100 |
| | over 10:1 | 4 | 5 | 7 | 9 | 10 | 15 | 30 | 47 | 60 | 100 |
| Column 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |

* L = length of building face; H = height of building face.

# TABLE 2

## SEPARATION FROM LOT LINE

| Width of Compartment (feet) | Percentage of Window Openings | Height of Compartment (feet) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| 30 | 100 | 19 | 26.5 | 33.5 | 38.0 | 41.5 | 45 | 48.5 | 51.5 | 54.5 | 57 |
| | 80 | 17 | 24.0 | 30 | 34 | 37.5 | 41 | 43.5 | 46 | 48.5 | 50 |
| | 60 | 14.5 | 21.0 | 25.5 | 29.5 | 32.5 | 35 | 37.5 | 39.5 | 41 | 42.5 |
| | 40 | 12 | 16.5 | 20 | 23 | 25.5 | 27.5 | 29.5 | 31 | 32.5 | 33.5 |
| | 20 | 8.5 | 11.5 | 14.5 | 16 | 17 | 18 | 19 | 19.5 | 20 | 20 |
| 40 | 100 | 21.5 | 30.5 | 38 | 43 | 48 | 52 | 56 | 59.5 | 63 | 66 |
| | 80 | 19.5 | 28 | 34 | 39 | 43.5 | 47.5 | 51 | 54 | 56.5 | 59 |
| | 60 | 16.5 | 24 | 29.5 | 33.5 | 37 | 40.5 | 43.5 | 46 | 48 | 50 |
| | 40 | 13 | 19 | 23 | 27 | 30 | 32.5 | 34.5 | 36.5 | 38 | 39.5 |
| | 20 | 9 | 12.5 | 16 | 18 | 19.5 | 21 | 22 | 23 | 24 | 24 |
| 50 | 100 | 24 | 33.5 | 41.5 | 48 | 53.5 | 59 | 63 | 67 | 71 | 74 |
| | 80 | 21 | 30 | 37.5 | 43.5 | 48 | 52.5 | 56.5 | 60 | 63.5 | 66.5 |
| | 60 | 17.5 | 26 | 32.5 | 37 | 41 | 45 | 48.5 | 51.5 | 54.5 | 56.5 |
| | 40 | 14 | 21 | 25.5 | 30 | 33 | 36 | 38.5 | 40.5 | 42.5 | 44 |
| | 20 | 9 | 13.5 | 17 | 19.5 | 21.5 | 23.5 | 25 | 26.5 | 27.5 | 28 |
| 60 | 100 | 26 | 37 | 45 | 52 | 59 | 64.5 | 69 | 73.5 | 78 | 82.5 |
| | 80 | 22.5 | 33 | 41 | 47.5 | 52.5 | 57.5 | 62 | 66 | 69.5 | 73 |
| | 60 | 19 | 28 | 35 | 40.5 | 45 | 49.5 | 53 | 56 | 59 | 62 |
| | 40 | 14.5 | 22.5 | 27.5 | 32.5 | 36 | 39 | 42 | 45 | 47 | 48.5 |
| | 20 | 9 | 14 | 18 | 21 | 23.5 | 25.5 | 27.5 | 29 | 30 | 31 |
| 70 | 100 | 28 | 39 | 48.5 | 56 | 63 | 69 | 75 | 80 | 84.5 | 89 |
| | 80 | 24 | 35 | 43.5 | 51 | 56.5 | 62 | 66.5 | 71 | 75.5 | 79.5 |
| | 60 | 20 | 30 | 37.5 | 43.5 | 48.5 | 53 | 56.5 | 60.5 | 63.5 | 67 |
| | 40 | 15 | 24 | 29.5 | 34.5 | 38.5 | 42 | 46 | 48.5 | 51 | 53 |
| | 20 | 9 | 14.5 | 19 | 22 | 25 | 27.5 | 29 | 31 | 32.5 | 34 |
| 80 | 100 | 29 | 41 | 51.5 | 59.5 | 67 | 75.5 | 80 | 85.5 | 90.5 | 95 |
| | 80 | 25 | 37 | 46 | 54 | 60 | 66 | 71 | 76 | 80.5 | 84.5 |
| | 60 | 21 | 32 | 39.5 | 46 | 51.5 | 56 | 60.5 | 64.5 | 68 | 71.5 |
| | 40 | 15.5 | 25 | 31 | 36.5 | 40.5 | 45 | 48.5 | 51 | 54 | 56.5 |
| | 20 | 9 | 14.5 | 19.5 | 23 | 26.5 | 29 | 31 | 33 | 35 | 36.5 |
| 90 | 100 | 30 | 43.5 | 54.5 | 63 | 71 | 78 | 84.5 | 90.5 | 95.5 | 100.5 |
| | 80 | 26 | 39 | 48.5 | 56.5 | 63.5 | 69.5 | 75.5 | 80.5 | 85 | 89.5 |
| | 60 | 22 | 32.5 | 41 | 48 | 54.5 | 59 | 63.5 | 68 | 72 | 75.5 |
| | 40 | 16 | 25.5 | 32 | 38 | 42.5 | 47 | 51 | 54 | 57 | 60 |
| | 20 | 9 | 15 | 20 | 24 | 27.5 | 30 | 32.5 | 35 | 37 | 38.5 |
| 100 | 100 | 30.5 | 45.5 | 57 | 66 | 74 | 82.5 | 89 | 95 | 100.5 | 106 |
| | 80 | 26.5 | 40 | 50 | 59 | 66.5 | 73 | 79.5 | 84.5 | 89.5 | 94 |
| | 60 | 22.5 | 33 | 42.5 | 50 | 56.5 | 62 | 67 | 71.5 | 75.5 | 79.5 |
| | 40 | 16 | 26 | 33.5 | 39.5 | 44 | 48.5 | 53 | 56.5 | 60 | 63.5 |
| | 20 | 9 | 15 | 20 | 24 | 28 | 31 | 34 | 36.5 | 38.5 | 40.5 |
| 120 | 100 | 32 | 48.5 | 61.5 | 71.5 | 81 | 89.5 | 97 | 103.5 | 109.5 | 115 |
| | 80 | 28 | 42 | 54.5 | 64 | 72 | 79 | 86 | 92 | 97.5 | 103 |
| | 60 | 22.5 | 34.5 | 45.5 | 53.5 | 61.5 | 67.5 | 73 | 78 | 83 | 87 |
| | 40 | 16 | 27 | 36 | 42 | 47.5 | 53 | 57.5 | 61.5 | 65.5 | 69.5 |
| | 20 | 9 | 15 | 20 | 25 | 29 | 32 | 35 | 38 | 41 | 44 |
| 150 | 100 | 33.5 | 53.5 | 67 | 78.5 | 89 | 99 | 107.5 | 114.5 | 121.5 | 128 |
| | 80 | 29 | 46.5 | 59.5 | 69.5 | 79 | 86.5 | 94.5 | 101 | 107.5 | 114 |
| | 60 | 23 | 37 | 49.5 | 58.5 | 67 | 73.5 | 80 | 86 | 92 | 97 |
| | 40 | 16.5 | 28 | 38 | 45.5 | 52 | 58 | 63 | 67.5 | 72 | 76.5 |
| | 20 | 9 | 15 | 21 | 26 | 31 | 34.5 | 38 | 41.5 | 44.5 | 47.5 |
| 200 | 100 | 34 | 57.5 | 74 | 88 | 100.5 | 111 | 120.5 | 129 | 137 | 145 |
| | 80 | 29 | 50.5 | 65 | 77 | 87.5 | 97.5 | 106.5 | 114.5 | 122.5 | 130.5 |
| | 60 | 24 | 40.5 | 53.5 | 64 | 73.5 | 82.5 | 90.5 | 97.5 | 104.5 | 111.5 |
| | 40 | 17 | 29.5 | 40.5 | 49.5 | 57 | 64 | 70 | 76 | 81.5 | 86 |
| | 20 | 9 | 16 | 22.5 | 28 | 33.5 | 38 | 42.5 | 46.5 | 50 | 53.5 |

TABLE 3

SEPARATION FROM BUILDING TO BUILDING

| Width of Compartment (feet) | % of window openings | Height of compartment (feet) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| 30 | 100 | 33 | 48 | 62 | 71 | 78 | 85 | 92 | 98 | 104 | 109 |
| | 80 | 29 | 43 | 55 | 63 | 70 | 77 | 82 | 87 | 92 | 95 |
| | 60 | 24 | 37 | 46 | 54 | 60 | 65 | 70 | 74 | 77 | 80 |
| | 40 | 19 | 28 | 35 | 41 | 46 | 50 | 54 | 57 | 60 | 62 |
| | 20 | 12 | 18 | 24 | 27 | 29 | 31 | 33 | 34 | 35 | 35 |
| 40 | 100 | 38 | 56 | 71 | 81 | 91 | 99 | 107 | 114 | 121 | 127 |
| | 80 | 34 | 51 | 63 | 73 | 82 | 90 | 97 | 103 | 108 | 113 |
| | 60 | 28 | 43 | 54 | 62 | 69 | 76 | 82 | 87 | 91 | 95 |
| | 40 | 21 | 33 | 41 | 49 | 55 | 60 | 64 | 68 | 71 | 74 |
| | 20 | 13 | 20 | 27 | 31 | 34 | 37 | 39 | 41 | 43 | 43 |
| 50 | 100 | 43 | 62 | 78 | 91 | 102 | 113 | 121 | 129 | 137 | 143 |
| | 80 | 37 | 55 | 70 | 82 | 91 | 100 | 108 | 115 | 122 | 128 |
| | 60 | 30 | 47 | 60 | 69 | 77 | 85 | 92 | 98 | 104 | 108 |
| | 40 | 23 | 37 | 46 | 55 | 61 | 67 | 72 | 76 | 80 | 83 |
| | 20 | 13 | 22 | 29 | 34 | 38 | 42 | 45 | 48 | 50 | 51 |
| 60 | 100 | 47 | 69 | 85 | 99 | 113 | 124 | 133 | 142 | 151 | 160 |
| | 80 | 40 | 61 | 77 | 90 | 100 | 110 | 119 | 127 | 134 | 141 |
| | 60 | 33 | 51 | 65 | 76 | 85 | 94 | 101 | 107 | 113 | 119 |
| | 40 | 24 | 40 | 50 | 60 | 67 | 73 | 79 | 85 | 89 | 92 |
| | 20 | 13 | 23 | 31 | 37 | 42 | 46 | 50 | 53 | 55 | 57 |
| 70 | 100 | 51 | 73 | 92 | 107 | 121 | 133 | 145 | 155 | 164 | 173 |
| | 80 | 43 | 65 | 77 | 97 | 108 | 119 | 128 | 137 | 146 | 154 |
| | 60 | 35 | 55 | 70 | 82 | 92 | 101 | 108 | 116 | 122 | 129 |
| | 40 | 25 | 43 | 54 | 64 | 72 | 79 | 87 | 92 | 97 | 101 |
| | 20 | 13 | 24 | 33 | 39 | 45 | 50 | 53 | 57 | 60 | 63 |
| 80 | 100 | 53 | 77 | 98 | 114 | 129 | 142 | 155 | 166 | 176 | 185 |
| | 80 | 45 | 69 | 87 | 103 | 115 | 127 | 137 | 147 | 156 | 164 |
| | 60 | 37 | 59 | 74 | 87 | 98 | 107 | 116 | 124 | 131 | 138 |
| | 40 | 26 | 45 | 57 | 68 | 76 | 85 | 92 | 97 | 103 | 108 |
| | 20 | 13 | 24 | 34 | 41 | 48 | 53 | 57 | 61 | 65 | 68 |
| 90 | 100 | 55 | 82 | 104 | 121 | 137 | 151 | 164 | 176 | 186 | 196 |
| | 80 | 47 | 73 | 92 | 108 | 122 | 134 | 146 | 154 | 165 | 169 |
| | 60 | 39 | 60 | 77 | 91 | 104 | 113 | 122 | 131 | 139 | 146 |
| | 40 | 27 | 46 | 59 | 71 | 80 | 89 | 97 | 103 | 109 | 115 |
| | 20 | 13 | 25 | 35 | 43 | 50 | 55 | 60 | 65 | 69 | 72 |
| 100 | 100 | 56 | 86 | 109 | 127 | 143 | 160 | 173 | 185 | 196 | 207 |
| | 80 | 48 | 75 | 95 | 113 | 128 | 141 | 154 | 164 | 169 | 183 |
| | 60 | 40 | 61 | 80 | 95 | 108 | 119 | 129 | 138 | 146 | 154 |
| | 40 | 27 | 47 | 62 | 74 | 83 | 92 | 101 | 108 | 115 | 121 |
| | 20 | 13 | 25 | 35 | 43 | 51 | 57 | 63 | 68 | 72 | 76 |
| 120 | 100 | 59 | 92 | 118 | 138 | 157 | 174 | 189 | 202 | 214 | 225 |
| | 80 | 51 | 79 | 104 | 123 | 139 | 153 | 167 | 179 | 190 | 201 |
| | 60 | 40 | 64 | 86 | 102 | 118 | 130 | 141 | 151 | 161 | 169 |
| | 40 | 27 | 49 | 67 | 79 | 90 | 101 | 110 | 118 | 126 | 134 |
| | 20 | 13 | 25 | 35 | 45 | 53 | 59 | 65 | 71 | 77 | 83 |

# PART 2

## DESCRIPTION OF THE AREA

It was mentioned in Part 1 of this report that the investigations were to consist of surveys of existing residential areas of a varied nature in order to obtain as wide a view as possible of the total range of residential development in a typical Canadian metropolitan area. The site for the second study was chosen with this in mind. The selected site differs significantly from the other areas being investigated.

The site is in a typical low density subdivision on the outskirts of Metropolitan Vancouver. Density of the area can be indicated by comparison of the floor-space ratios of this study area and the area which has previously been investigated. The standard of comparison used is the ratio of the total habitable floor area to the total area of the site. The floor-space ratio for this area is 0.2, whereas the ratio for the site in the fully developed residential area adjacent to Vancouver's Downtown is 1.4.

Another difference between the residential developments chosen for the field surveys lies in the types of housing they contain. The area which forms the basis for this report consists entirely of single-family houses; the preceding report dealt with an area composed of apartment houses and rooming houses.

It is also to be expected that there will be a difference in the types of occupancy between this area and the others, e.g. there will be many more families with young children here than in the apartment area. It might also be assumed that the family incomes would generally be less here than for the third study area, which is currently being investigated, since the low price of land plus N.H.A. financing of the home are the factors which attract residents to the area.

As a further contrast, this area is quite new. All of the buildings were constructed after World War II as compared with the other areas that contain dwellings dating, in some cases, to the turn of the century.

## FACTORS THAT SHAPED THE AREA

### Building and Zoning Bylaws

The historical method of urban development has been to exploit every piece of land within the lot lines as far as structural considerations allow. The congestion of cities, however, caused by the rapid industrial expansion in the nineteenth and early twentieth centuries led to a reaction.

Two methods have been used in the past to control the development of private property. The first, such as the regulations governing the materials of construction incorporated into the Redevelopment of London Act, intended to achieve the community value by requiring minimum standards of materials and building construction. The second, also based on structural considerations, achieved its purpose by imposing a dimensional limitation on the interior space.

The attitude today is still the same; yet in an attempt to safeguard the general welfare of the public, residential building regulations enforce standards of spatial separation as well as structural standards. Although both forms of control are exercised in modern building regulations, it is the effect of spatial separation that is important in this study. It is controls on the dimensions of space which are involved in space and site regulations.

Contemporary space and site controls appear to have evolved from these early efforts of communities to protect themselves against hazards to safety and health which might otherwise arise if development by the individual land owner was uncontrolled. Structural safety and protection from fire spread and health hazards still provide the basis for all bylaws in Canada dealing with the construction and use of buildings.

The history of regulations governing the materials and methods of construction has progressed through three stages of development; "primitive standards," specification standards and performance standards (8). To date it is still the accepted practice to formulate space and site regulations with reference to a specification standard. Such a standard gives quantitative meaning to the regulation and defines the extent to which a community can control the right to develop the land. Providing the developer complies with the minimum standard specified in the regulation when erecting a structure on his property, it is assumed that the community interest has been satisfied insofar as the community value basic to the regulation is concerned. For reasons already stated, however, it is the contention of the authors that performance standards should also form the basis for space and site planning.

In Canada, where timber construction is still prevalent, space separations are utilized as barriers to the spread of fire in place of fire resistive construction. Setback regulations in building codes and zoning ordinances in North America appear to have originated as devices to prevent the spread of fire.

The variety of minimum setbacks quoted in various building and zoning bylaws in Canada for similar circumstances suggests that; first, other functions are now critical in establishing setback requirements in certain cities, or second, some cities have given no recognition to technological improvements in fire-resisting materials of construction, hence are out-of-date with respect to current building practice.

## Subdivision of Land

Because of the traditions of home ownership in Canada, subdivision of large parcels of land into individual lots has normally preceded the construction of housing units. The R. A. I. C. Committee of Inquiry noted the following practice common in current residential development.

> "The developer decides what plot dimensions he can sell to prospective dwelling owners. He shows the tract of land to technical advisers: salaried or consultant surveyors, site planners, utility engineers. About a third of his land will have to be dedicated for thoroughfares and public open space. The remainder of his tract he will ask to be divided for the optimum sale of plots of the chosen size. It is possible, and not uncommon, for a whole township to be reduced to little pieces of identical dimensions; on each plot only one sort and size of house can be built." (10, p. 191).

To meet these conditions, regulations which were intended to control the spacing of structures in relation to one another were related to the legal lot lines to permit spatial control despite the absence of structures on the adjacent lots. This form of regulation still exists today. It is sufficient to state here that this approach opposes variety in site development.

## Results of These Factors

The Committee of Inquiry also emphasized the adverse effect that existing site and space regulations are having upon residential development.

> "Where municipal codes governing physical development are demonstrably linked to such future contingencies, their clauses must be respected. But this sensible linkage is hard to discover in many of the by-law restraints put upon residential area design. For instance it is commonly laid down that an access road allowance must be 66 feet wide, with all buildings set back another 25 or 30 feet

> from that road line. These provisions sterilize 1000 square feet of land that some family should be allowed to enjoy. They also separate opposite house fronts by something like ten times their height, thus making illegal the grouping of houses for best effect at lowest cost. There are many other examples of this unreason." (10, p. 191).

The community values generally accepted as underlying current site and space controls are related to safety, health and welfare. Urban areas and particularly urban residential areas are now, in comparison with those of the last century, safe and healthy places in which to live.

It is the continuing purpose of residential building regulations to improve the existing environment. While progress has certainly been made in the past, the process must continue.

The space and site planning regulations for the study area are contained in the zoning bylaw of that municipality (9, p. 1). This document commences with the following statement of purpose:

> "A by-law to make provision whereby the natural growth of the Municipality may proceed in a systematic and orderly way . . . ."

These regulations attempted to achieve this aim by enforcing the following specification standards, among others:

Width of Lot:

A minimum of 66 ft for one-family dwellings.

Area of Lot:

A minimum of 7920 square feet for one-family dwellings.

Lot Coverage:

The buildings shall not cover more than 33% of the total area of each lot.

Front Yard:

Not closer to the front street line than 25 ft.

Rear Yard:

Not closer to the rear lot line than a distance equal to 25% of the average length of the lot, but in no event less than 25 ft from the lot line.

Side Yards:

One side yard to be 10 ft wide and the other to be a distance equal to 10% of the average width of the lot (for interior lots).

Height of Dwellings:

No dwelling shall exceed 35 ft in height.

Windows in Side Walls:

No window on the first storey of a building shall be constructed in any side wall unless there is an open space having a width of not less than eight feet between such wall and the side lot line. While this regulation is intended to ensure adequate daylighting for the interiors, it also has a great effect on reducing the possibilities of fire spread from building to building.

A point worth consideration is that regulations that control the dimensions of residential space for the purpose of safeguarding health and safety have significantly, although unintentionally, influenced the visual appearance of residential environment. The problem in urban residential development is the growing concern about the absence of satisfactory design in the spatial arrangement of housing. The model furnishes graphic proof of the rigid and monotonous spacing of the buildings in the study area.

In situations where housing is being constructed for sale or rent, the economic return from a residential lot within the same neighbourhood is roughly proportional to the space enclosed by the structure. Under these circumstances, the building envelope defined by the site and space regulations and which establishes the maximum permissible enclosed space, effectively shapes the structure. In cases where economy is secondary to design the specific nature of the standards permits no substitution which might equally well achieve the purpose basic to the regulation, hence they exert a confining effect on imaginative layout design. It is the main purpose of the research project to demonstrate that adequate space around and between buildings for functional and aesthetic purposes can be achieved with greater flexibility and without further restricting the individual's choice in siting and building his dwelling units.

# PART 3

All buildings in the area have been numbered to allow reference to a space and its surrounding buildings with ease. For example, Buildings 1 and 2 define Space 1-2. The numbering system and the relationship of the buildings may be seen in the photographs of the model (Figs. 1, 2, 3, 4 and 5 on pages 4 to 6).

The procedure to be followed is to analyze each building to determine the space required around it to prevent the spread of fire to the neighbouring buildings. Based on this, the total requirements for the space according to a number of standards will be given.

## DEFINITIONS

### Compartment

This refers to a fire-resistive compartment. A compartment may be considered fire-resistive if its bounding walls, ceiling and floor meet the requirements for fire safety given in the National Building Code. It has been assumed that if the containing elements resist the passage of fire for three-quarters of an hour they may be considered as fire resistive. When the "enclosing rectangle" concept (defined below) is used, however, the compartment is considered to be the rectangle shown on the sketches which accompany the analyses, whether or not it is bounded by fire-resistive elements.

### Enclosing Rectangle

This is the rectangle which, drawn on the façade of a building, will enclose all the openings in the area of maximum exposure hazard. This rectangle is referred to as a compartment in the analyses although it is not necessarily bounded by fire-resistive elements.

### Opening

It is of utmost importance to realize that it is the openings that are considered to be the radiating areas. An opening can be defined as any portion of the wall that does not have the required fire resistance. This is usually a window or a door since, for our purposes, it has been assumed that the exterior walls will resist the passage of fire for a period of time sufficient to allow the Fire Department to arrive and combat the fire. Some authorities believe that combustible cladding increases the hazard; results from the St. Lawrence Burns however, indicate otherwise (11). "It would therefore seem that the use of clapboard exterior cladding on a house does not appreciably increase the hazard it presents to its neighbours." (5, p. 5).

Distribution of Openings

The tables of fire separation prepared by the Division of Building Research are based on the assumption that the openings in the wall are infinitely small and are distributed uniformly across the wall. In many cases this approach is not applicable as, for example, where the openings are concentrated in one portion of the façade only. Here it is more accurate to deal only with the local area having the high concentration.

Plane of Reference

The plane of reference is usually the plane of the major wall surface but this may not be the case if the wall surface has projections or setbacks. If the setbacks are not more than 5 ft from the face of the building it can be assumed, for purposes of calculation, that they lie in the same plane as the face of the building (12). Generally speaking, the plane of reference is that plane which contains the openings, either in fact or projected onto the plane from a wall surface behind the plane. It is from this point that the separations are measured.

Separation

There are two types of spatial separation referred to in this report: total separation and separation to the boundary (lot line). Total separation refers to the space between buildings; separation to the boundary refers to the space between the building and the lot line. It is important to remember that separation means open and unobstructed space. Roof overhangs of approximately 2 ft 6 in. or less need not be considered, but other projections, such as carports, which are liable to ignite and aid in the transfer of the fire, should be considered. One method of dealing with these elements is to assume that the required separation should be measured from the extremity of the projections.

Open and Enclosed Interior Stairs

An enclosed stair is one which is contained within suitably fire-resistive walls so that it will not permit a fire, having its origin in one storey of the structure, to spread to the other storeys. An open stair is one which will permit the spread of fire vertically through the structure. All buildings in the study area are assumed to have open interior stairs.

## ANALYSES OF SPACES

Numerous illustrations of the buildings have been included in Part 3 to give more meaning to, and to clarify, the analyses of the spaces. The openings which are considered to be emitting radiative heat, the compartment under investigation and the barriers which resist the spread of fire through the building are all superimposed on the façades. These are shown in Figure 3/1. The emitting windows are shaded, the compartment boundaries are indicated by the heavy broken line and the fire-resistive walls, floors and ceilings, by the light broken lines.

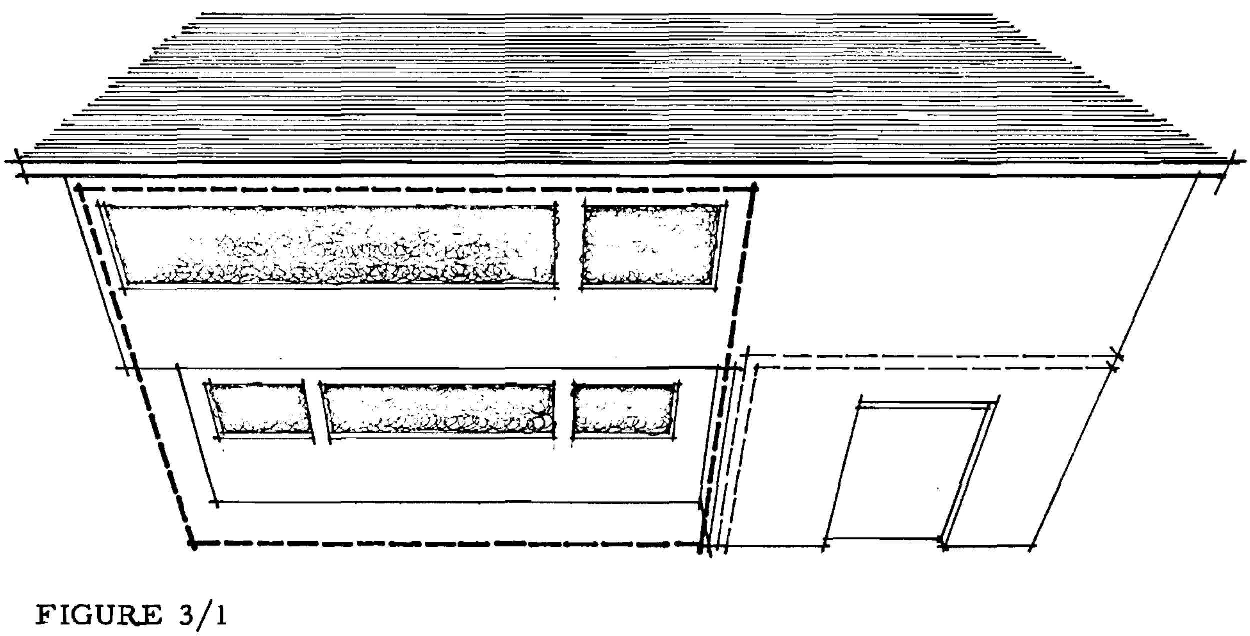

FIGURE 3/1

## ANALYSIS OF SPACE 1 - 2

### BUILDING 1

Note 1 : The East elevation of Building 1 has no openings and hence presents no danger. However, there may be some hazard to Building 2 from the extension of radiation of the North and South elevations of Building 1 around the corners.(5)

CONSIDER THE NORTH ELEVATION

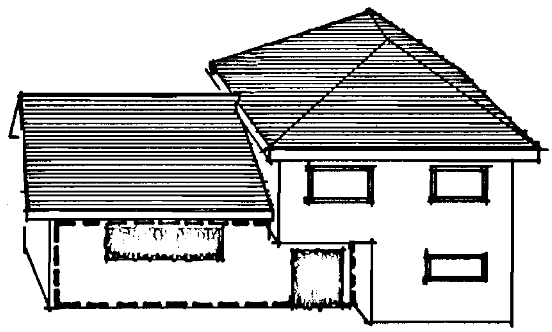

FIGURE 3/2

Width of compartment .......................................... 28.'

Height of compartment .......................................... 10.'

Area of compartment .......................................... 280.'

Total area of openings .......................................... 88. sq. ft.

Percentage of openings $\left(\frac{88.}{280.} \times 100.\%\right)$ .......................... 31.4%

Separation required by Table 1 .............................. 10.' to boundary

Separation required by Table 2 .............................. 10.' to boundary

Separation required by Table 3 .............................. 15.' total

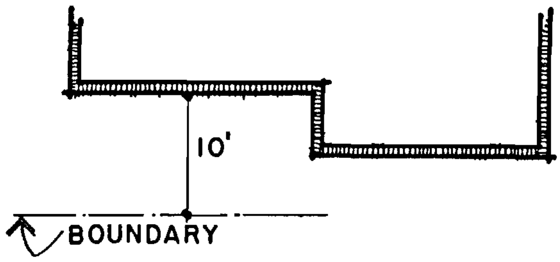


FIGURE 3/3

Note 2: It is permissible to reduce the separation requirements at the corners of buildings since fire fighting is easier at these points. From D.B.R. Internal Report No. 187,(5) we find that the separation at the corners need only be 80% of that required at the centre of the compartment.

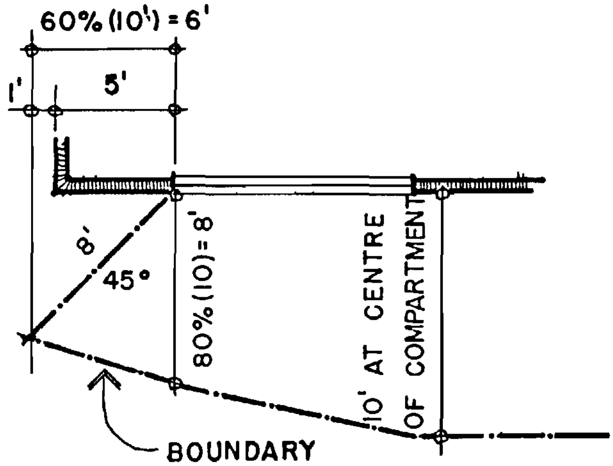


FIGURE 3/4

CONSIDER THE SOUTH ELEVATION

METHOD 1

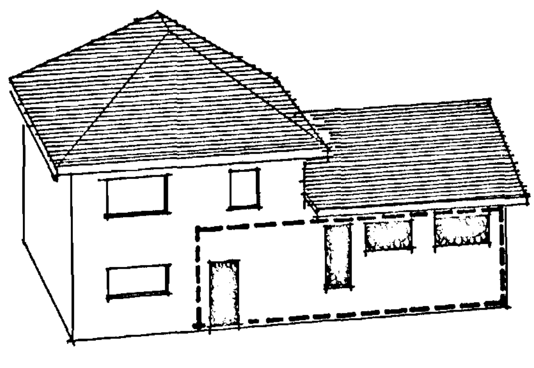

FIGURE 3/5

| | |
|---|---|
| Width of compartment .......................................... | 29.' |
| Height of compartment .......................................... | 10.' |
| Area of compartment .......................................... | 290. sq.ft. |
| Total area of openings .......................................... | 81.4 sq. ft. |
| Percentage of openings .......................................... | 28.% |

| | |
|---|---|
| Separation required by Table 1 .............................. | 10.' to boundary |
| Separation required by Table 2 .............................. | 10.' to boundary |
| Separation required by Table 3 .............................. | 15.' total |

METHOD 2

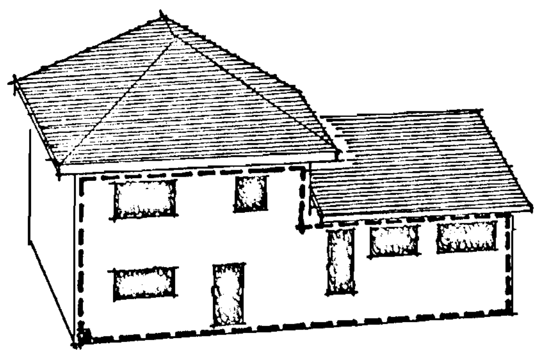

FIGURE 3/6

| | |
|---|---|
| Area of compartment .......................................... | 626. sq. ft. |
| Total area of openings .......................................... | 128. sq. ft. |
| Percentage of openings .......................................... | 20.4% |

| | |
|---|---|
| Separation required by Table 1 .............................. | 12.' to boundary |
| Separation required by Table 2 .............................. | 11.' to boundary |
| Separation required by Table 3 .............................. | 17.' total |

Note 3: Using the same method as was used in the analysis of the North elevation, we get :

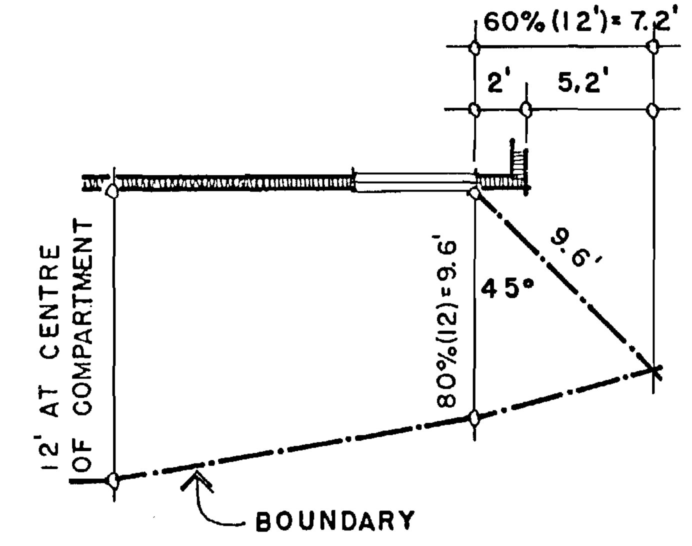


FIGURE 3/7

## BUILDING 2

Note 4: The West elevation of Building 2 has no openings.

## CONSIDER THE NORTH ELEVATION

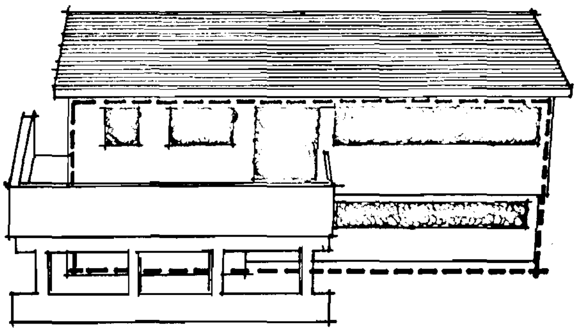

FIGURE 3/8

| | |
|---|---|
| Width of compartment ........................................ | 43.' |
| Height of compartment ........................................ | 17.' |
| Area of compartment ........................................ | 730. sq. ft. |
| Total area of openings ........................................ | 272. sq. ft. |
| Percentage of openings ........................................ | 37.% |

| | |
|---|---|
| Separation required by Table 1 ........................... | 17.5' to boundary |
| Separation required by Table 2 ........................... | 17.5' to boundary |
| Separation required by Table 3 ........................... | 30.6' total |

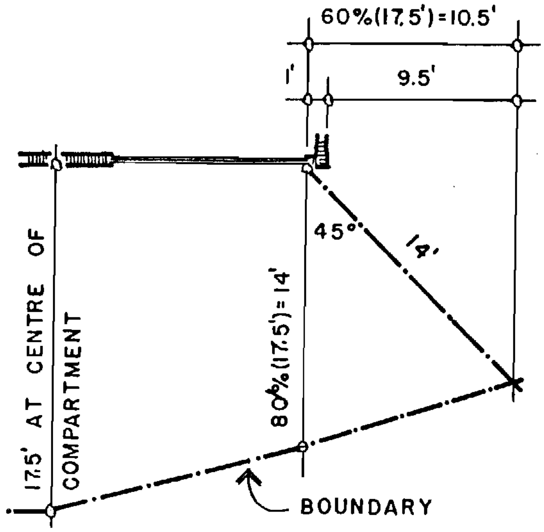


FIGURE 3/9

CONSIDER THE SOUTH ELEVATION

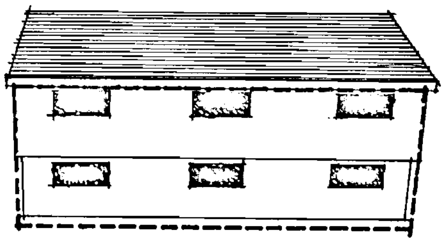

FIGURE 3/10

| | |
|---|---|
| Width of compartment ................................ | 43.' |
| Height of compartment ................................ | 17.' |
| Area of compartment ................................ | 730. sq. ft. |
| Total area of openings ................................ | 126. sq. ft. |
| Percentage of openings ................................ | 17.3% |
| Separation required by Table 1 ........................ | 10.7' to boundary |

Note 5: Tables 2 and 3 are not applicable in this case since they do not consider percentages of openings of less than 20.%.

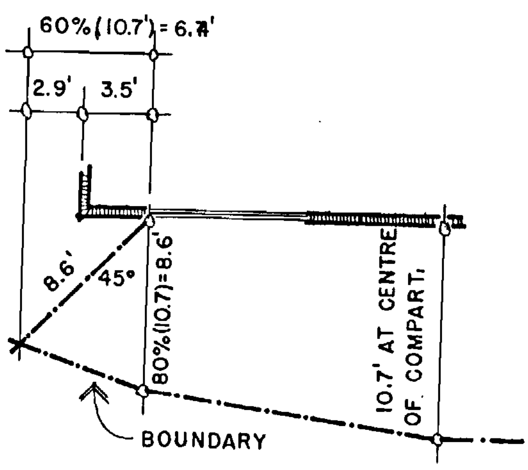


FIGURE 3/11

## SUMMARY OF SEPARATIONS

### TABLE 1

Building 1: From the north-east corner, the maximum value is 1.' to the boundary.

From the south-east corner, the maximum value is 5.2' to the boundary.

Building 2: From the north-west corner, the maximum value is 9.5' to the boundary.

From the south-west corner, the maximum value is 2.9' to the boundary.

The total separation required between northern corners is 10.5'.

The total separation required between southern corners is 8.1'.

### TABLE 2

Building 1: From the north-east corner, the maximum value is 1.' to the boundary.

From the south-east corner, the maximum value is 4.6' to the boundary.

Building 2: From the north-west corner, the maximum value is 9.5' to the boundary.

No value from south-west corner since Table 2 was not applicable.

The total separation required between northern corners is 10.5' .

TABLE 3

Building 1: From the north-east corner, the maximum value is 4.' total.

From the south-east corner, the maximum value is 8.2' total.

Building 2: From the north-west corner, the maximum value is 17.3' total.

No value from south-west corner since Table 3 was not applicable.

The total separation required between northern corners is 17.3' .

## ANALYSIS OF SPACE 2 - 3

## BUILDING 2

### METHOD 1

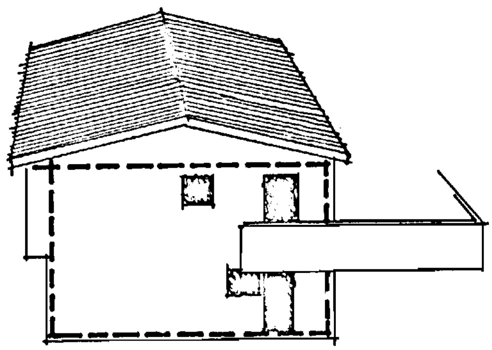

FIGURE 3/12

| | |
|---|---|
| Width of compartment .............................................. | 26.' |
| Height of compartment .............................................. | 17.' |
| Area of compartment .............................................. | 440. sq. ft. |
| Total area of openings .............................................. | 60. sq. ft. |
| Percentage of openings .............................................. | 13.6% |

Separation required by Table 1 ............................. 7.' to boundary.

Note 1: Tables 2 and 3 are not applicable in this case since they do not consider percentages of less than 20.% .

Note 2: The tables of separation are based on the assumption that the openings are distributed uniformly over the facade. Such is not the case in this instance. We will, therefore, deal only with the localized area which contains the openings.

METHOD 2

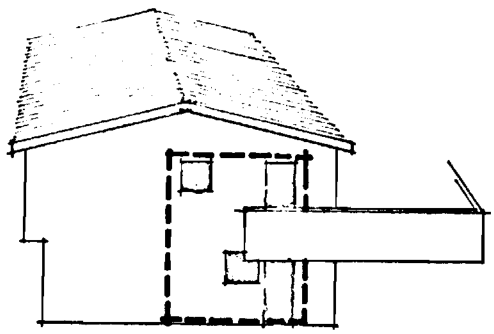

FIGURE 3/13

| | |
|---|---|
| Width of compartment .......................................... | 11.' |
| Height of compartment .......................................... | 17.' |
| Area of compartment .......................................... | 187. sq. ft. |
| Total area of openings .......................................... | 60. sq. ft. |
| Percentage of openings .......................................... | 32.% |
| Separation required by Table 1 .............................. | 10.' to boundary |

Note 3: The area of the compartment is considerably less than the minimum figure in Table 1. This would tend to make our figures inaccurate since the separations required by the table are, in this instance, based on an area of close to 300 square feet.

METHOD 3

| | |
|---|---|
| Width of compartment .......................................... | 17.' |
| Height of compartment .......................................... | 17.' |
| Area of compartment .......................................... | 290. sq. ft. |
| Total area of openings .......................................... | 60. sq. ft. |
| Percentage of openings .......................................... | 20.7% |

Separation required by Table 1 ............................. 8.' to boundary

Separation required by Table 2 ............................. 8.5' to boundary

Separation required by Table 3 ............................. 12.' total

Note 4: It would appear, however, that the North facade might have more effect in determining the separation requirements.

From previous calculations (page 23) the separations are:

Separation required by Table 1 ............................. 17.5' to boundary

Separation required by Table 2 ............................. 17.5' to boundary

Separation required by Table 3 ............................. 30.6' total

Note 5: The tables are based on an <u>open</u> space between the buildings. In this case, we have a carport/sundeck projecting into the space. This element increases the hazard by facilitating the transfer of the fire from building 2 to building 3. One solution to the problem could be to assume that the separation must be from the face of the projection. If, on the other hand, the projecting element were of fire-resistive construction - such as a concrete balcony on an apartment building - there might not be any need to consider it as contributing to the hazard.

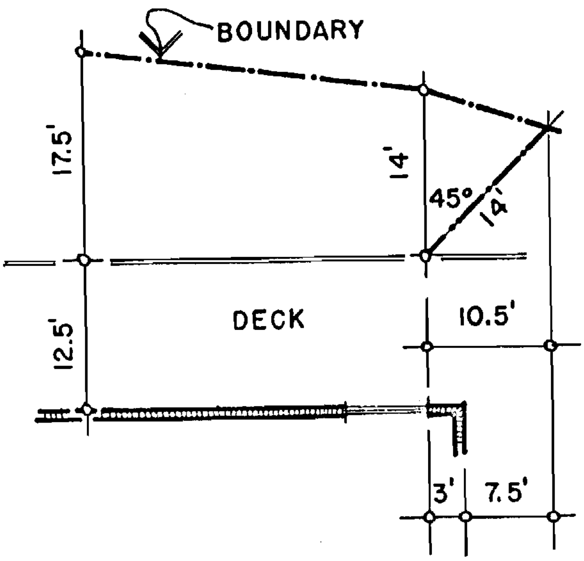


FIGURE 3/14

## BUILDING 3

Note 6: We will assume here that a garage creates the same amount of hazard as do the other portions of the building.

### CONSIDER THE SOUTH ELEVATION

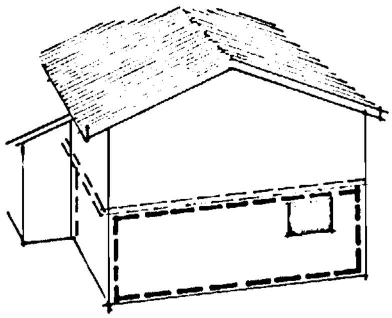

FIGURE 3/15

| | |
|---|---|
| Width of compartment .................................... | 24.' |
| Height of compartment .................................... | 8.' |
| Area of compartment .................................... | 192. sq. ft. |

Note 7: This is considerably less than 300 square feet. It would be more accurate to increase the area, maintaining the same proportions of the wall and the same area of window openings.

| | |
|---|---|
| Area of compartment .................................... | 299. sq. ft. |
| Total area of openings .................................... | 15.8 sq. ft. |
| Percentage of openings .................................... | 5.26% |

| | |
|---|---|
| Separation required by Table 1 ............................ | 4.' to the boundary. |
| Separation required by Table 2 ............................ | N.A. |
| Separation required by Table 3 ............................ | N.A. |

Note 8: This is the minimum value allowed by Table 1.

CONSIDER THE WEST ELEVATION

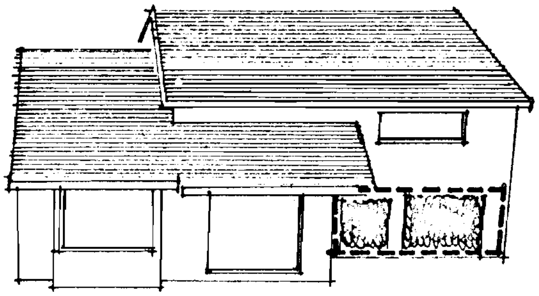

FIGURE 3/16

Width of compartment .................................... 17.'

Height of compartment .................................... 8.'

Area of compartment .................................... 136. sq. ft.

Note 9: We will use the same procedure as on page 30.

Area of compartment .................................... 299. sq. ft.

Total area of openings .................................... 77. sq. ft.

Percentage of openings .................................... 26.%

Separation required by Table 1 .................................... 9.' to boundary

Separation required by Table 2 .................................... 9.' to boundary

Separation required by Table 3 .................................... 14.2' total

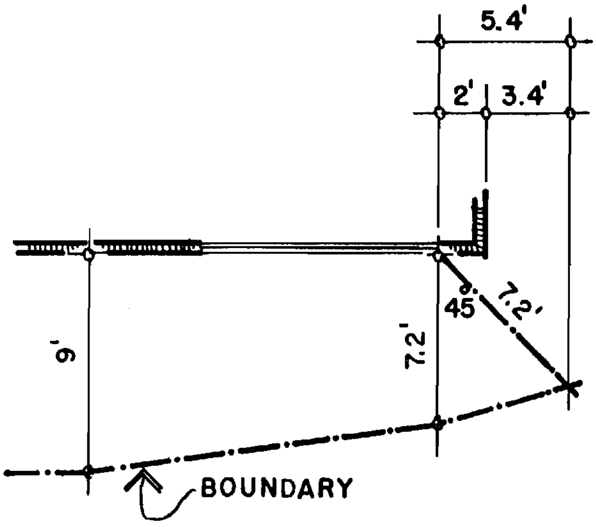


FIGURE 3/17

## SUMMARY OF SEPARATIONS

Note 10: It is unnecessary to give the separations from all corners because of the angle between the buildings.

TABLE 1

Building 2: From the north-east corner, the maximum value is 23.' to the boundary.

Building 3: From the south-west corner, the maximum value is 3.4' to the boundary.

Total separation required is 26.4' .

TABLE 2

Building 2: From the north-east corner, the maximum value is 23.' to the boundary.

Building 3: From the south-west corner, the maximum value is 3.8' to the boundary.

Total separation required is 26.8'.

TABLE 3

Building 2: From the north-east corner, the maximum value is 30.8' total.

Building 3: From the south-west corner, the maximum value is 6.5' total.

Total separation required is 30.8' .

## ANALYSIS OF SPACE 4-5

## BUILDING 4

Note 1: The East elevation of Building 4 has no openings and hence presents no hazard to Building 5. We will use the same procedure as before.

### CONSIDER THE NORTH ELEVATION

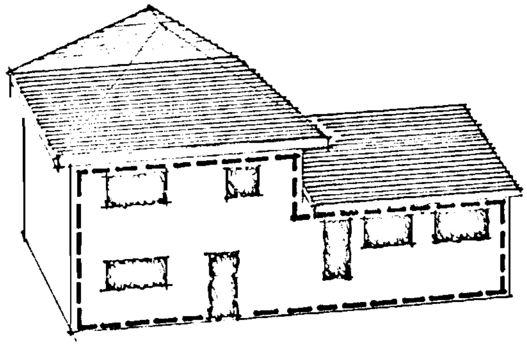

FIGURE 3/18

| | |
|---|---|
| Area of compartment ........................ | 626. sq. ft. |
| Total area of openings ........................ | 128. sq. ft. |
| Percentage of openings ........................ | 20.4% |

| | |
|---|---|
| Separation required by Table 1 ........................ | 12.' to boundary |
| Separation required by Table 2 ........................ | 11.' to boundary |
| Separation required by Table 3 ........................ | 17.' total |

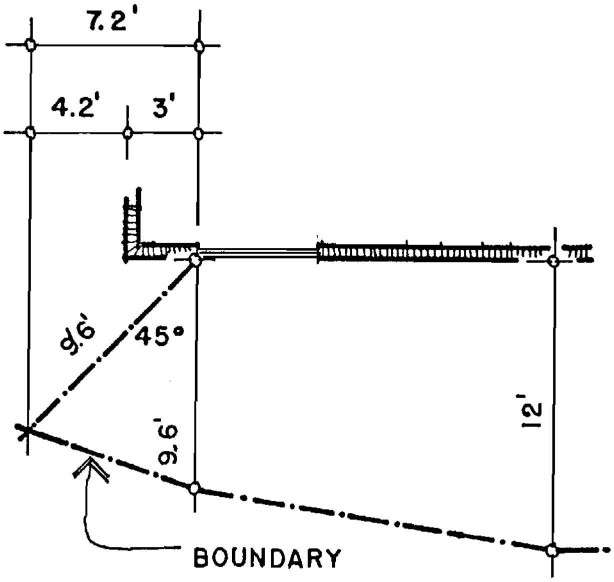


FIGURE 3/19

## CONSIDER THE SOUTH ELEVATION

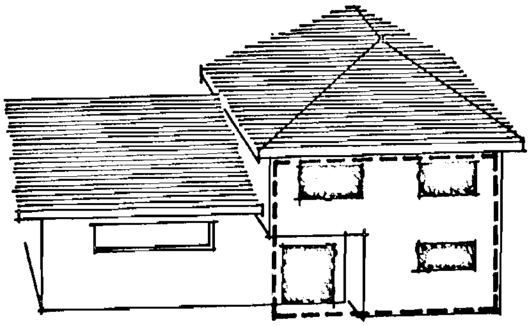

FIGURE 3/20

| | |
|---|---|
| Width of compartment ........................................ | 22.' |
| Height of comparment ........................................ | 16.' |
| Area of compartment ........................................ | 352. sq. ft. |
| Total area of openings ........................................ | 84.6 sq. ft. |
| Percentage of openings ........................................ | 24.% |
| Separation required by Table 1 ............................ | 10.' to boundary |
| Separation required by Table 2 ............................ | 10.' to boundary |
| Separation required by Table 3 ............................ | 15.' total |

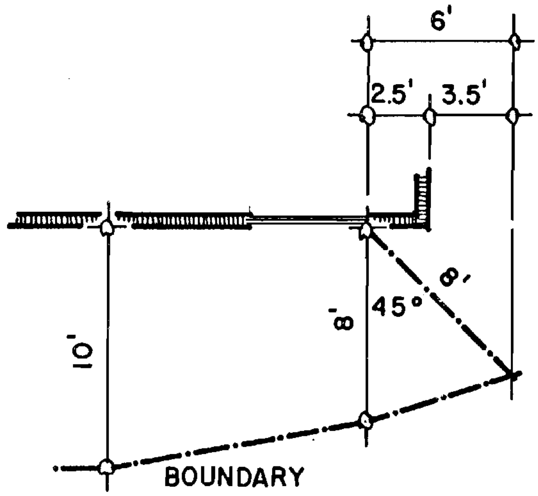


FIGURE 3/21

## B U I L D I N G 5

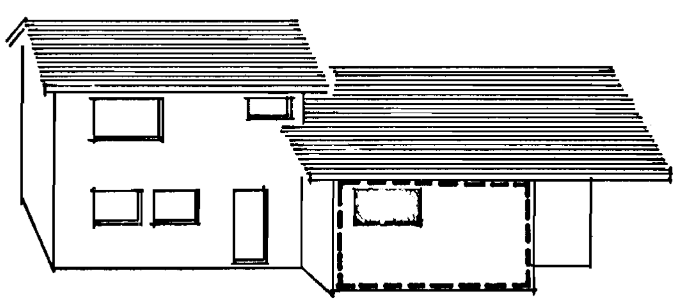

FIGURE 3/22

| | |
|---|---|
| Width of compartment ........................................ | 18.' |
| Height of compartment ........................................ | 11.' |
| Area of compartment ........................................ | 200. sq. ft. |
| Total area of openings ........................................ | 24, sq. ft |

Note 2: The area of the compartment is considerably less than 300 square feet. It would be more accurate to expand the area arbitrarily.

| | |
|---|---|
| Area of compartment ........................................ | 290. sq. ft. |
| Total area of openings ........................................ | 24. sq. ft. |
| Percentage of openings ........................................ | 8.3% |

| | |
|---|---|
| Separation required by Table 1 .............................. | 4.' to boundary |
| Separation required by Table 2 .............................. | N.A. |
| Separation required by Table 3 .............................. | N.A. |

## SUMMARY OF SEPARATIONS

### TABLE 1

Building 4: From the north-east corner, the maximum value is 4.2' to the boundary.

From the south-east corner, the maximum value is 3.5' to the boundary.

Building 5: The maximum value is 4.' to the boundary.

The total separation required is 8.2'.

TABLE 2

Building 4: From the north-east corner, the maximum value is 3.6' to the boundary.

From the south-east corner, the maximum value is 3.5' to the boundary.

TABLE 3

Building 4: From the north-east corner, the maximum value is 7.2' total.

From the south-east corner, the maximum value is 6.5' total.

## ANALYSIS OF SPACE 5 - 6

### BUILDING 5

Note 1: It is evident that the northern portion of the east facade, due to its offset, will present no great hazard to the adjoining building. We will, therefore, only consider the southern portion of this wall.

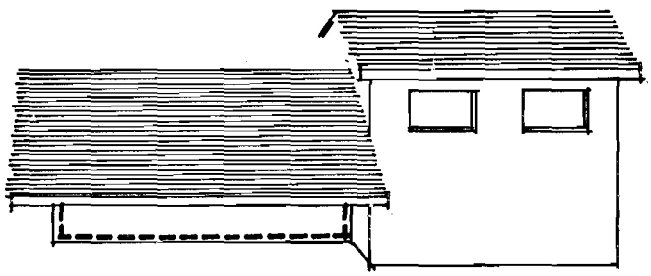

FIGURE 3/23

| | |
|---|---|
| Width of compartment ........................................ | 27.' |
| Height of compartment ........................................ | 11.' |
| Area of compartment ........................................ | 297. sq. ft. |
| Total area of openings ........................................ | 30. sq. ft. |
| Percentage of openings ........................................ | 10.% |

| | |
|---|---|
| Separation required by Table 1 ............................ | 4.' to the boundary |
| Separation required by Table 2 ............................ | N.A. |
| Separation required by Table 3 ............................ | N.A. |

Note 2: Because the 4.' must constitute open and unobstructed space, the separation must be measured from the edge of the roof.

BUILDING 6

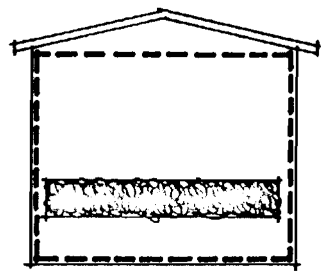

FIGURE 3/24

| | |
|---|---|
| Width of compartment .......................................... | 22.' |
| Height of compartment .......................................... | 17.' |
| Area of compartment .......................................... | 374. sq. ft. |
| Total area of openings .......................................... | 63. sq. ft. |
| Percentage of openings .......................................... | 17.% |

| | |
|---|---|
| Separation required by Table 1 .............................. | 8.' to boundary |
| Separation required by Table 2 .............................. | N.A. |
| Separation required by Table 3 .............................. | N.A. |

METHOD 2

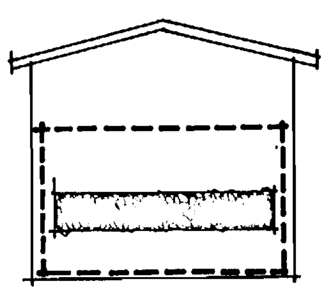

FIGURE 3/25

| | |
|---|---|
| Width of compartment .................................... | 21.' |
| Height of compartment .................................... | 14.' |
| Area of compartment .................................... | 295. sq. ft. |
| Total area of openings .................................... | 63. sq. ft. |
| Percentage of openings .................................... | 21.4% |

| | |
|---|---|
| Separation required by Table 1 ............................ | 8.3' to boundary |
| Separation required by Table 2 ............................ | 8.5' to boundary |
| Separation required by Table 3 ............................ | 12.' total |

## SUMMARY OF SEPARATIONS

### TABLE 1

Building 5: The maximum value is 4.' to the boundary (from the edge of the roof).

Building 6: The maximum value is 8.3' to the boundary.

Total separation required is 12.3'.

### TABLE 2

Building 6: The maximum value is 8.5' to the boundary.

### TABLE 3

Building 6: The maximum value is 12.' to the boundary.

## ANALYSIS OF SPACE 1-B

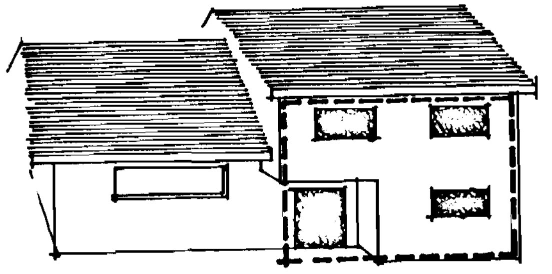

FIGURE 3/26

| | |
|---|---|
| Width of compartment ........................................ | 22.' |
| Height of compartment ........................................ | 16.' |
| Area of compartment ........................................ | 352. sq. ft. |
| Total area of openings ........................................ | 84.6 sq. ft. |
| Percentage of openings ........................................ | 24.% |
| Separation required by Table 1 ............................ | 10.' to boundary |
| Separation required by Table 2 ............................ | 10.' to boundary |
| Separation required by Table 3 ............................ | 15.' total |

## ANALYSIS OF SPACE 2-B

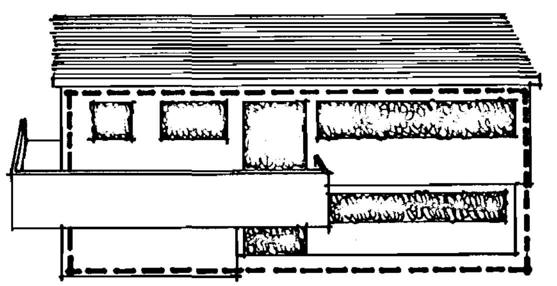

FIGURE 3/27

Width of compartment .................................... 43.'

Height of compartment ................................... 17.'

Area of compartment ..................................... 730. sq. ft.

Total area of openings .................................. 272. sq. ft.

Percentage of openings .................................. 37.%

Separation required by Table 1 .......................... 17.5' to boundary.

Separation required by Table 2 .......................... 17.5' to boundary.

Separation required by Table 3 .......................... 30.6' total.

Note: These separations are to be measured from the edge of the balcony.

## ANALYSIS OF SPACE 3 - B

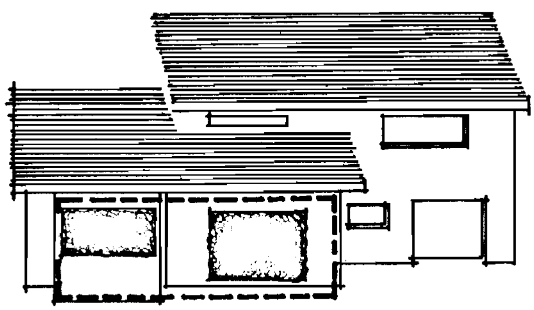

FIGURE 3/28

Width of compartment .................................... 27.'

Height of compartment ................................... 11.'

Area of compartment ..................................... 296. sq. ft.

Total area of openings .................................. 135. sq. ft.

Percentage of openings .................................. 45.6%

| | |
|---|---|
| Separation required by Table 1 ............................ | 12.4' to boundary. |
| Separation required by Table 2 ............................ | 12.7' to boundary. |
| Separation required by Table 3 ............................ | 20.4' total. |

## A N A L Y S I S   O F   S P A C E   4 - A

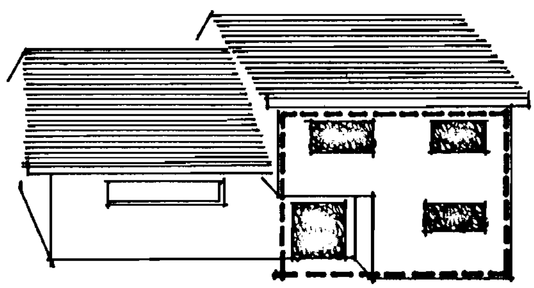

FIGURE 3/29

| | |
|---|---|
| Width of compartment ...................................... | 22.' |
| Height of compartment ..................................... | 16.' |
| Area of compartment ....................................... | 352. sq. ft. |
| Total area of openings .................................... | 84.6 sq. ft. |
| Percentage of openings .................................... | 24.% |

| | |
|---|---|
| Separation required by Table 1 ............................ | 10.' to boundary. |
| Separation required by Table 2 ............................ | 10.' to boundary. |
| Separation required by Table 3 ............................ | 15.' total. |

## ANALYSIS OF SPACE 5 - A

### METHOD 1

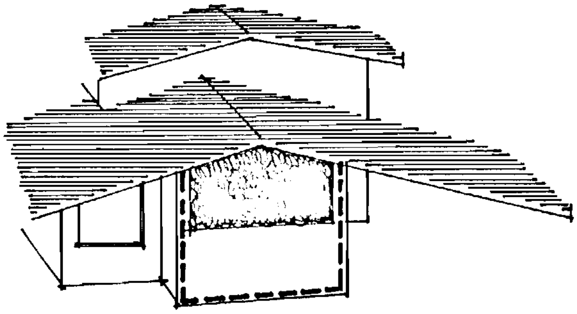

FIGURE 3/30

| | |
|---|---|
| Width of compartment ........................................ | 14.' |
| Height of compartment ........................................ | 12.' |
| Area of compartment ........................................ | 168. sq. ft. |
| Total area of openings ........................................ | 91. sq. ft. |
| Percentage of openings ........................................ | 54.% |

| | |
|---|---|
| Separation required by Table 1 ............................ | 13.6' to boundary. |
| Separation required by Table 2 ............................ | N.A. |
| Separation required by Table 3 ............................ | N.A. |

Note 1: The area of the compartment is considerably less than 300 square feet.

### METHOD 2

| | |
|---|---|
| Area of compartment ........................................ | 290. sq. ft. |
| Total area of openings ........................................ | 91. sq. ft. |
| Percentage of openings ........................................ | 31.4% |

Separation required by Table 1 .............................. 10.' to boundary.

Separation required by Table 2 .............................. 10.3' to boundary.

Separation required by Table 3 .............................. 15.6' total.

## ANALYSIS OF SPACE 6-A

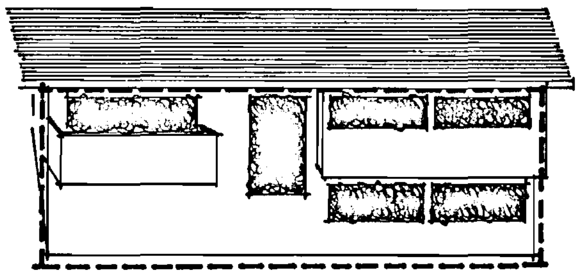

FIGURE 3/31

Width of compartment ........................................ 43.'

Height of compartment ....................................... 17.'

Area of compartment ......................................... 730. sq. ft.

Total area of openings ...................................... 260. sq. ft.

Percentage of openings ...................................... 35.6%

Separation required by Table 1 .............................. 17.' to boundary.

Separation required by Table 2 .............................. 16.4' to boundary.

Separation required by Table 3 .............................. 27.8' total.

GRAPHIC SUMMARY OF MAXIMUM SEPARATIONS REQUIRED FROM EACH BUILDING IN THE STUDY AREA TO THEIR BOUNDARIES

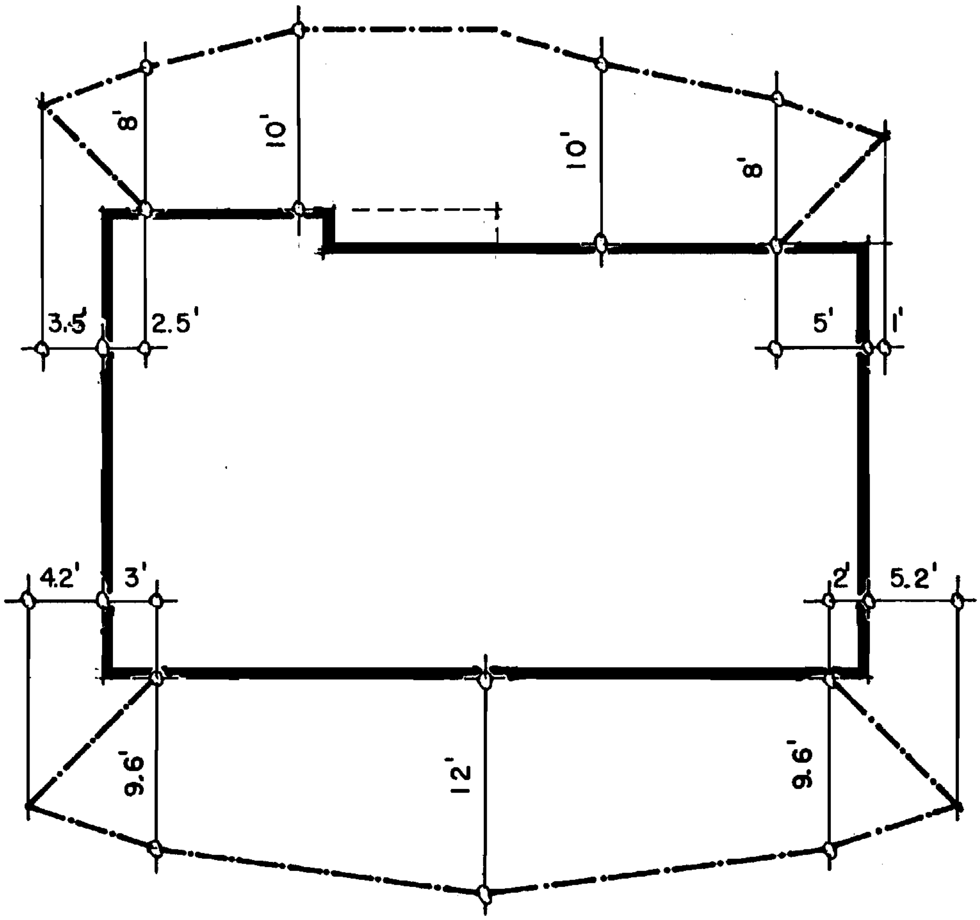


FIGURE 3/32 BUILDING 1

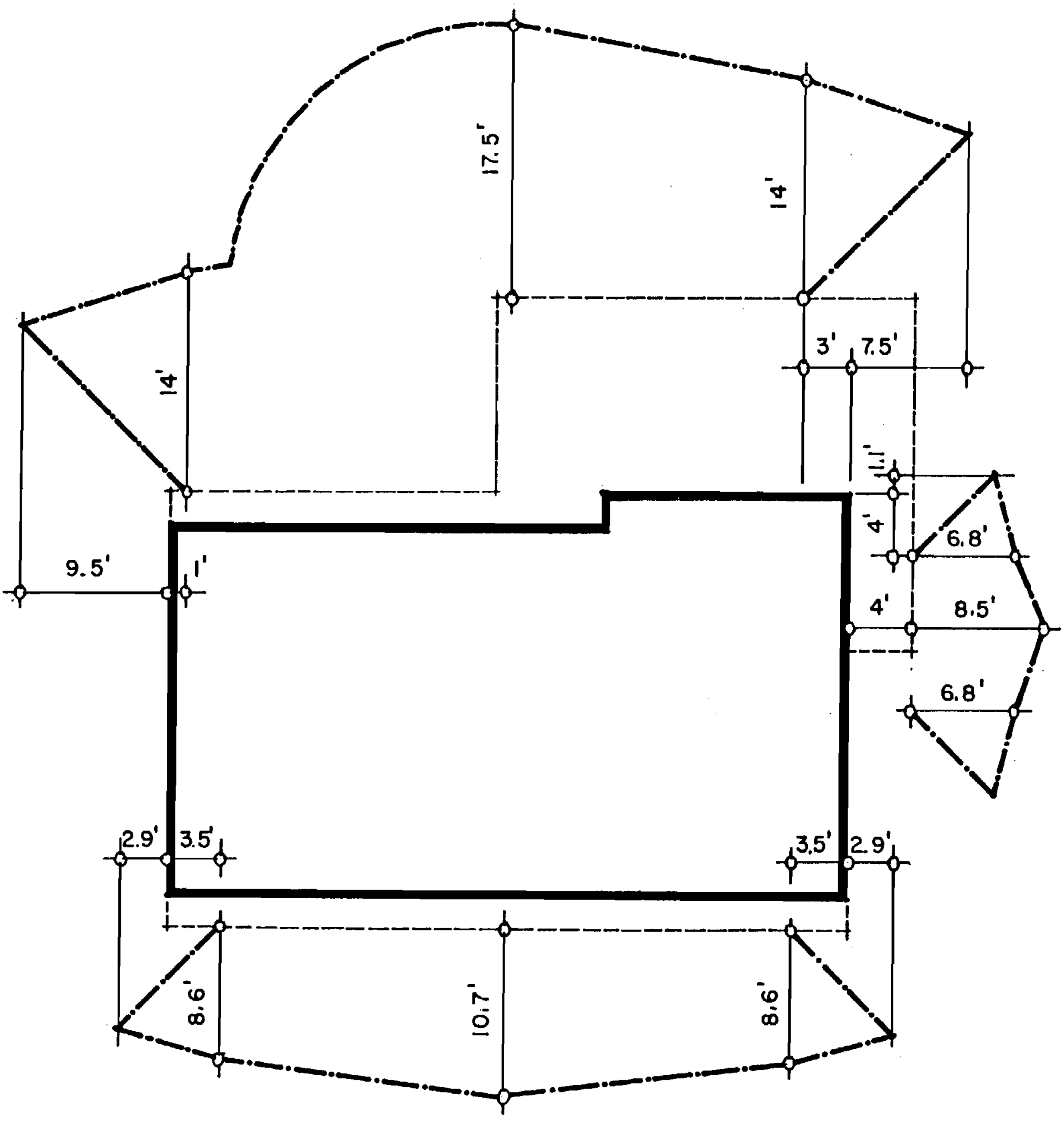


FIGURE 3/33 BUILDING 2

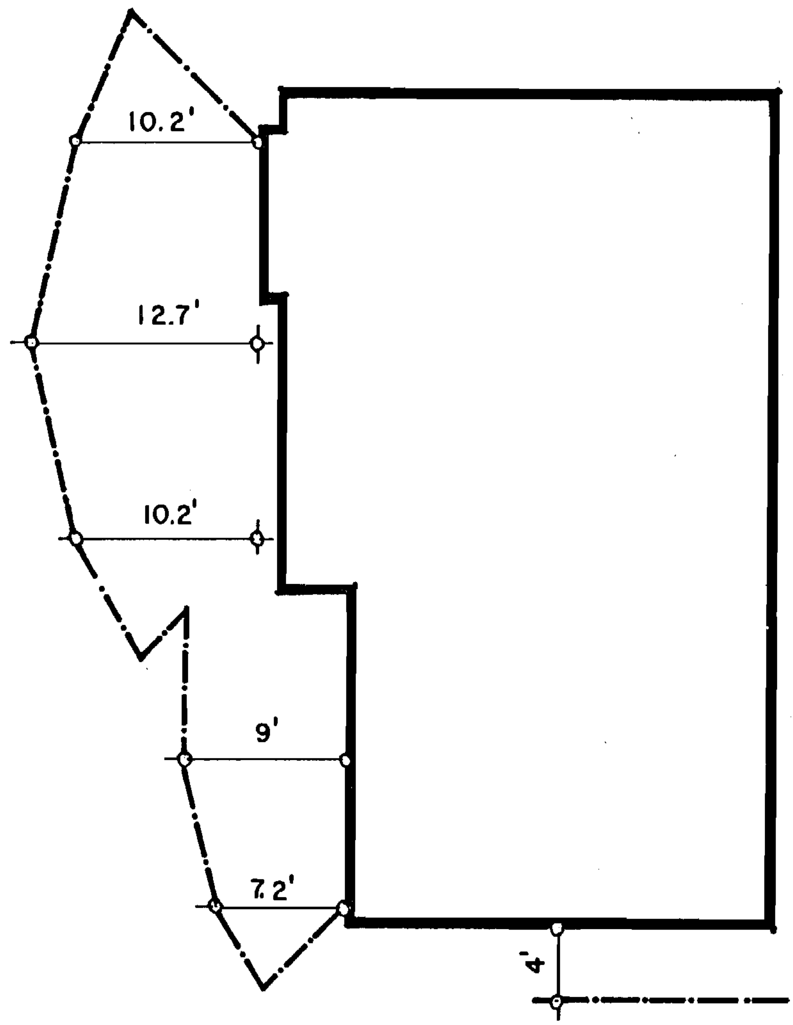


FIGURE 3/34 BUILDING 3

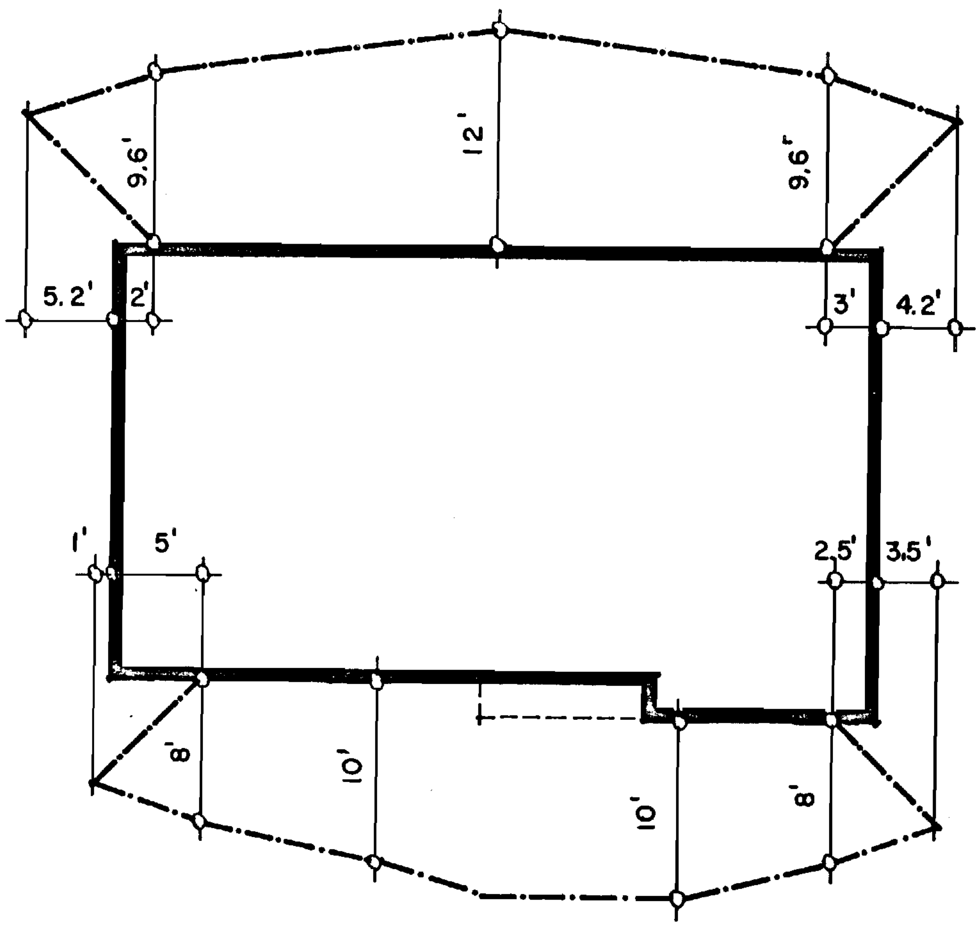


FIGURE 3/35 BUILDING 4

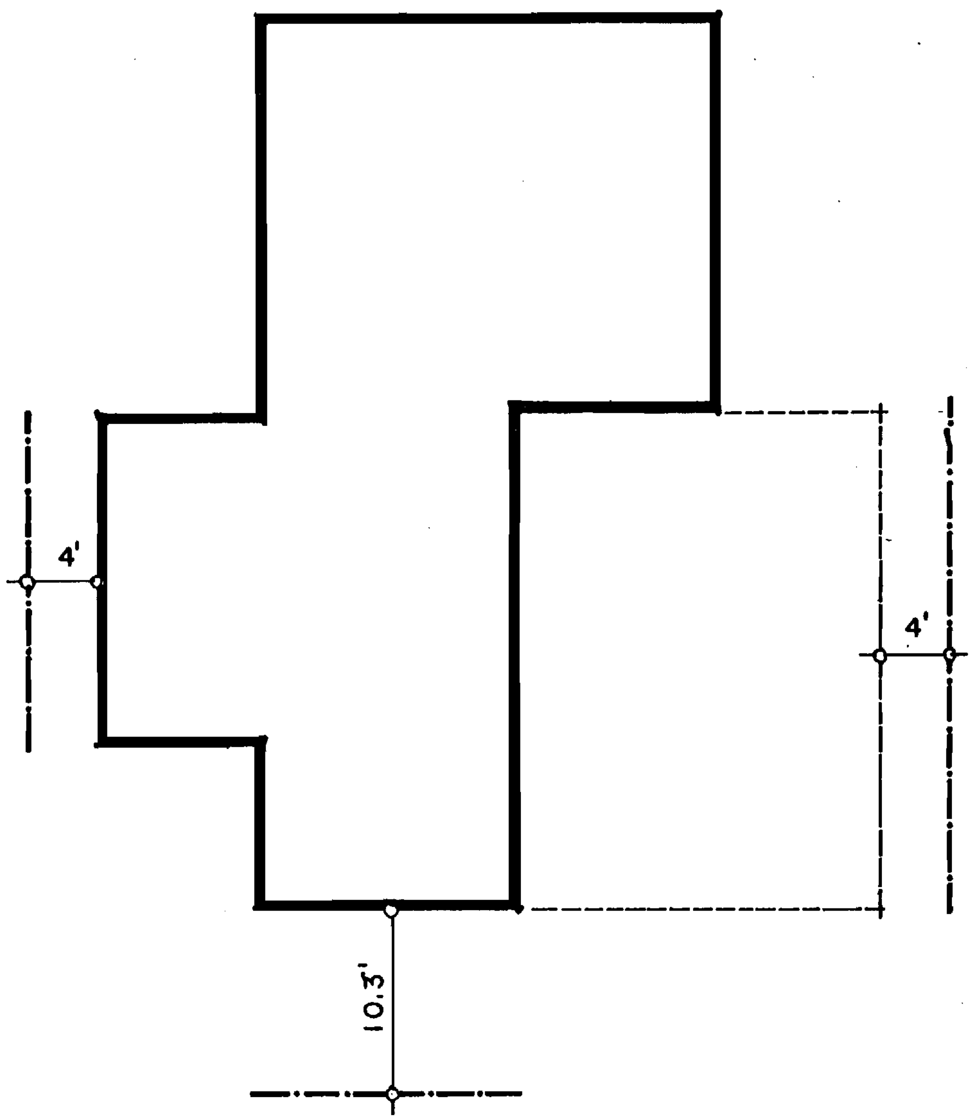


FIGURE 3/36 BUILDING 5

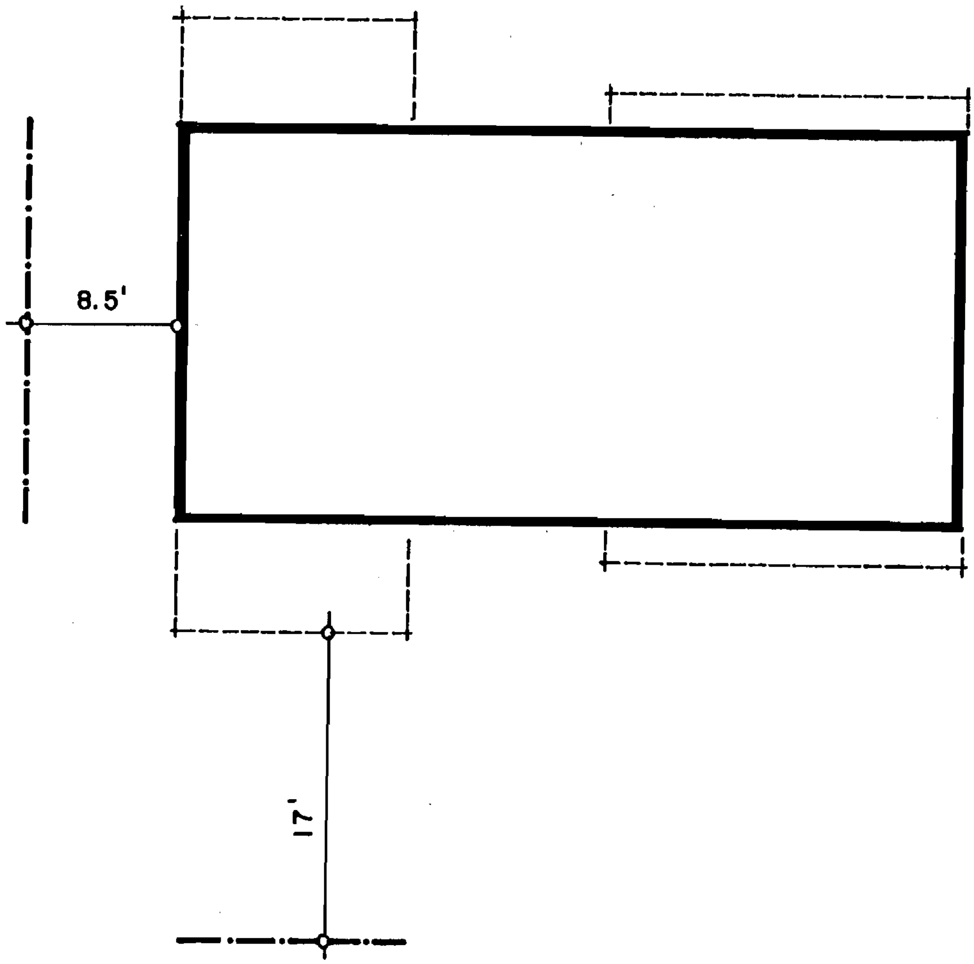


FIGURE 3/37 BUILDING 6

## COMMENTS ON ANALYSES

### LIMITATIONS OF TABLE 1

Table 1 does not apply to compartments of much less than 300 square feet. Although the first separation requirements shown in the table are for areas of "less than 300 sq. ft." the separations are, in fact, based on an area of something very close to this figure.

### LIMITATIONS OF TABLES 2 AND 3

Tables 2 and 3 do not apply to compartments having a width of less than 30.' and a height of less than 10.' . This may be overcome for a compartment having an area of 300 square feet if the ratio of the width to the height is less than 3:1. This assumption is similar to the one on which Table 1 was based. A greater limitation is the fact that the tables become inaccurate when the percentage of openings falls below 20 %.

### DISTRIBUTION OF OPENINGS

The tables of separation prepared by the Division of Building Research are based on the assumption that the openings in the wall are infinitely small and are distributed uniformly across the wall. However, there are many cases where the openings are concentrated in a localized area. In such instances the method of analysis tends to break down. It was shown that it is safer to use the enclosing rectangle concept in such cases; that is, to concentrate on the localized area which contains the openings.

### SEPARATION AS OPEN SPACE

It is important to remember that separation means open and unobstructed space.

In this study area we have cases of building elements, such as balconies, which project past the plane of reference. In order to deal with these elements it was assumed that the required separation should be measured from the extremity of the projections.

SEPARATION AT CORNERS

From the Division of Building Research Internal Report No. 187 (5) we have taken the assumption that there may be a reduction in the separation requirements at the corners of a building. This is possible since fire fighting is easier at these points. For the application of this principle see the analysis of Space 1 - 2. The assumptions dealing with the extension of the radiation around the corners was also taken from the same work.

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# APPENDIX A

## DESCRIPTION OF THE BUILDINGS IN THE STUDY AREA

## B U I L D I N G 1

Building Type ............................ Single family dwelling.

Split level.

Date .................................... Post-War.

Construction ............................ Wood frame.

Roofing Material ........................ Asphalt shingles.

Cladding ................................ Cedar siding and stucco.

Interior Stairs ......................... Open.

Roof overhang ........................... 2.'

## B U I L D I N G 2

Building Type ........... ................... Single family dwelling.

1 storey plus basement.

Date .................................... Post-War.

Construction ............................ Wood frame.

Roofing Material ........................ Tar and gravel.

Cladding ................................ Cedar siding and stucco.

Interior Stairs ......................... Open.

Roof overhang ........................... 2.'

Accessory Structures .................... Attached wooden carport / balcony.

## B U I L D I N G 3

Building Type ............................ Single family dwelling.

Split level.

| | |
|---|---|
| Date .................................... | Post-War. |
| Construction ................ ............ | Wood frame. |
| Roofing Material ......................... | Asphalt shingles. |
| Cladding ................................ | Cedar Siding on upper storey. |
| | Stucco on lower storey. |
| Interior Stairs .......................... | Open. |
| Roof Overhang ........................... | 2.' |

B U I L D I N G 4

| | |
|---|---|
| Building Type ............................ | Single family dwelling. |
| | Split level. |
| Date ............. ...................... | Post-War. |
| Construction ............................. | Wood frame. |
| Roofing Material ......................... | Asphalt shingles. |
| Cladding .. .............................. | Cedar Siding and stucco. |
| Interior Stairs .......................... | Open. |
| Roof Overhang ........................... | 2.' |

B U I L D I N G 5

| | |
|---|---|
| Building Type ............................ | Single family dwelling. |
| | Split level. |
| Date ..................................... | Post-War. |
| Construction ............................. | Wood frame. |
| Roofing Material ......................... | Tar and gravel. |

| | |
|---|---|
| Cladding .................................. | Cedar Siding on upper storey. |
| | Stucco on lower storey. |
| Interior Stairs .......................... | Open. |
| Roof Overhang ............................ | 2.' on upper storey. |
| | 22.' over carport. |
| Accessory Structures ..................... | Attached wooden carport. |

## B U I L D I N G 6

| | |
|---|---|
| Building Type ............................ | Single family dwelling. |
| | 1 storey plus basement. |
| Date ..................................... | Post-War. |
| Construction ............................. | Wood frame. |
| Roofing Material ......................... | Tar and gravel. |
| Cladding ................................. | Cedar Siding and stucco. |
| Interior Stairs .......................... | Open. |
| Roof Overhang ............................ | 2.' |
| Accessory Structures ..................... | Wooden balcony. |