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PUBLIC PROTECTION STRATEGIES FOR
POTENTIAL NUCLEAR REACTOR ACCIDENTS:
SHELTERING CONCEPTS WITH EXISTING
PUBLIC AND PRIVATE STRUCTURES

MASTER

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NUCLEAR REACTOR ACCIDENTS: SHELTERING CONCEPTS
WITH EXISTING PUBLIC AND PRIVATE STRUCTURES**

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Abstract

Three generic sheltering/relocation strategies are identified and discussed. They are (1) population relocation only (no specific sheltering response initiated), (2) sheltering at location followed by relocation, and (3) preferential sheltering followed by relocation. Shielding factors representative of these strategies are calculated, and the adequacy of using average shielding factors for the calculation of public health effects is discussed.

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PUBLIC PROTECTION STRATEGIES FOR POTENTIAL NUCLEAR REACTOR
ACCIDENTS: SHELTERING CONCEPTS WITH EXISTING PUBLIC AND
PRIVATE STRUCTURES

I. INTRODUCTION

If an accident should occur at a nuclear power reactor resulting in inadequate cooling of the fuel and subsequent loss of clad integrity, there is a possibility of release to the atmosphere of significant quantities of radioactive material. As a result of such a release the public may receive early radiation doses* through three exposure modes. These include: (1) exposure to external penetrating radiation as the radioactive material cloud passes; (2) exposure to external penetrating radiation from radionuclides deposited on the ground and other surfaces during cloud passage; and, (3) exposure due to radionuclides inhaled during passage of the cloud. Because of the internal retention of inhaled radionuclides, this latter pathway also leads to a radiation dose delivered to the individual continually during the remaining years of his life.

Protection strategies to limit or mitigate the radiation exposure and therefore the consequences of such exposure, to the general public are of prime concern to those responsible for radiological emergency planning and response. Two important elements of any protection strategy are public acceptance of, and the ability to implement, the measures proposed. There has been considerable discussion of evacuation, which is an expeditious movement of people to avoid exposure to the passing cloud, as a possible

*Early radiation dose is that dose received within the first few days following the accident.

protective measure. A simple evacuation model was, in fact, included in the consequence model developed for the Reactor Safety Study [1]. Our studies support the view that it is desirable to consider alternative or supplemental strategies to evacuation that include population sheltering followed by the selective relocation of affected persons [2]. The shielding inherent in building structures can afford protection against exposure to the external sources of radiation cited above. Furthermore, the exclusion of a significant amount of airborne radioactive material from the interior of a structure, either by natural effects or by certain ventilation strategies, could reduce the amount of radionuclides inhaled as well [3]. Therefore, for the purposes of this report, sheltering is defined as a deliberate action by the public to take advantage of the inherent radiation shielding available in normally inhabited structures by remaining indoors, away from doors and windows, during and after the passage of the cloud of released radioactive material. Population relocation is a post-accident action designed to limit radiation exposure from ground contamination.

This report discusses the potential of sheltering and relocation strategies for limiting the dose from the two external radiation pathways described above. Estimates of shelter effectiveness are presented for specific building types. Three generic sheltering/relocation strategies are identified and average shielding factors representative of these strategies are calculated. These shielding factors reflect regional differences in the relative numbers of brick and wood homes and of homes with basements, as well as temporal differences in building occupancy. The effectiveness

of sheltering/relocation strategies in terms of limiting public health effects will be considered in subsequent papers.

II. BACKGROUND

The shielding from airborne and surface deposited radionuclides afforded by conventional building structures is well understood and discussed in the literature [1,4]. The shielding effectiveness of a structure is expressed in terms of a shielding factor (SF)* which is the ratio of the dose received inside the structure to the dose that would be received outside the structure. Burson and Profio [4] have made estimates of shielding for several distinct building types using currently available shielding technology. Their estimates of representative shielding factors for airborne radionuclides, assuming a semi-infinite cloud of gamma emitting material surrounding the structure, are summarized in Table 1. The energy of the gamma ray assumed in the calculations is characteristic of what might be expected from a reactor accident. A summary of the shielding factors that they suggest for radionuclides deposited on the ground and other surfaces (walls and roof of the structure), assuming uniform deposition around the structure, is presented in Table 2.

III. SHELTERING/RELOCATION STRATEGIES

The estimates of Burson and Profio [4] presented in Tables 1 and 2 indicate (1) the wide range of potential shielding factors afforded by normally inhabited structures, and (2) that basements of both homes and larger buildings offer very effective shielding against radiation. Therefore, the efficacy of a sheltering strategy depends to a large extent on the type of structures the public inhabits

*The shielding factor is often referred to in the literature as the reduction factor.

TABLE 1. REPRESENTATIVE SHIELDING FACTORS FROM GAMMA CLOUD SOURCE
(from Ref. 4)

Structure or Location	Shielding Factor ^(a)	Representative Range
Outside	1.0	--
Vehicles	1.0	--
Wood-frame house ^(b) (no basement)	0.9	--
Basement of wood house	0.6	0.1 to 0.7 ^(c)
Masonry house (no basement)	0.6	0.4 to 0.7 ^(c)
Basement of masonry house	0.4	0.1 to 0.5 ^(c)
Large office or industrial building	0.2	0.1 to 0.3 ^(c,d)

- (a) The ratio of the dose received inside the structure to the dose that would be received outside the structure.
- (b) A wood frame house with brick or stone veneer is approximately equivalent to a masonry house for shielding purposes.
- (c) This range is mainly due to different wall materials and different geometries.
- (d) The shielding factor depends on where the personnel are located within the building (e.g., the basement or an inside room).

TABLE 2. REPRESENTATIVE SHIELDING FACTORS FOR SURFACE DEPOSITED RADIONUCLIDES (from Ref. 4)

Structure or Location	Representative Shielding Factor	Representative (a) Range
1 m above an infinite smooth surface	1.00	---
1 m above ordinary ground	0.70	0.47-0.85
1 m above center of 50-ft roadways, 50% decontaminated	0.55	0.4-0.6
Cars on 50-ft road:		
Road fully contaminated	0.5	0.4-0.7
Road 50% decontaminated	0.5	0.4-0.6
Road fully decontaminated	0.25	0.2-0.5
Trains	0.40	0.3-0.5
One- and two-story wood-frame house (no basement)	0.4 ^(b)	0.2-0.5
One- and two-story block and brick house (no basement)	0.2 ^(b)	0.04-0.40
House basement, one or two walls fully exposed:	0.1 ^(b)	0.03-0.15
One story, less than 2 ft of basement, walls exposed	0.05 ^(b)	0.03-0.07
Two stories, less than 2 ft of basement, walls exposed	0.03 ^(b)	0.02-0.05
Three- or four-story structures, 5000 to 10,000 ft ² per floor:		
First and second floors	0.05 ^(b)	0.01-0.08
Basement	0.01 ^(b)	0.001-0.07
Multistory structures, > 10,000 ft ² per floor:		
Upper floors	0.01 ^(b)	0.001-0.02
Basement	0.005 ^(b)	0.001-0.015

(a) The ratio of dose received inside the structure to the dose that would be received outside the structure.

(b) Away from doors and windows.

as well as how long they remain there before being relocated away from ground contaminated by radioactive material. Three generic sheltering/relocation strategies are identified here and discussed below. They are (1) population relocation only (no specific sheltering response initiated), (2) sheltering at location followed by relocation, and (3) preferential sheltering followed by relocation.

Population relocation is an action taken sometime after passage of the cloud of radioactive material to limit radiation exposure from ground contamination. Before relocation, the exposure that individuals receive from airborne and surface deposited radionuclides depends on the radiation shielding available from the particular structure they are inhabiting. Because a large percentage of the public is located indoors most of the time [5] (see Appendix A), some radiation shielding will be afforded the public even if no specific sheltering response is initiated (i.e., the public continues its normal activities; strategy (1) above). This protection was recognized in the Reactor Safety Study [1] and was used there to calculate health effects for populations located at distances greater than that assumed for evacuation. Note, however, that this protection applies to the public only in an average sense; by virtue of their normal activities some persons will be outdoors during the radiation exposure incident and will receive little if any benefit from structural shielding.

Additional protection, beyond that automatically afforded as a result of normal activities, could be achieved by initiating a sheltering strategy. One such strategy is sheltering at location (strategy (2) above) in which persons are directed to remain

indoors at their present location, or to move indoors if they are outside, preferably occupying basements if they are available. Additional benefit might be derived from a strategy of employing preferential sheltering locations (strategy (3) above); for example, directing people to those neighboring homes with basements or to nearby large buildings such as schools, public office buildings or public fallout shelters.

The time required to implement a sheltering/relocation strategy significantly influences the effectiveness of each of the response strategies discussed here. Ideally, shelter-access by the public would be accomplished prior to the arrival of the cloud of radioactive material. If this cannot be accomplished, the effectiveness (dose reduction) diminishes almost linearly with increasing outside exposure time [6]. Radiation exposure from radionuclides deposited on the ground and other surfaces continues long after cloud passage and, in many instances, in a relatively short time results in a dose much greater than the dose from the other exposure pathways. Therefore, the time interval between the cloud passage and the public relocation is also very important and should be minimized.

IV. REPRESENTATIVE SHIELDING FACTORS

In order to evaluate the three sheltering/relocation strategies identified above, shielding factors representative of each strategy must be obtained. The Burson and Profio [4] shielding factors presented in Tables 1 and 2 above may be used to evaluate preferential sheltering in specific building types; (strategy (3)). However, the remaining two strategies require some knowledge or estimate of the frequency distribution of the occupancy for various types of buildings as well as the availability and occupancy of basements.

Average shielding factors for the strategy in which no specific sheltering response is initiated (i.e., the public continues its normal activities; strategy (1)) were established in the Reactor Safety Study [1]. In that study, data on the frequency of occupancy for different building types (Appendix A), the percentage of brick housing units (Appendix B), and the Burson and Profio shielding factors (Tables 1 and 2) were permuted to obtain average shielding factors for five geographic regions* within the U.S. The average shielding factors for airborne radionuclides obtained in this manner ranged from 0.66 to 0.83 over the five regions, while those for radionuclides deposited on the ground and other surfaces ranged from 0.26 to 0.38. Both of these ranges are quite small and average values of 0.75 and 0.33, respectively, are adequate regardless of geographic region. The occupancies of different building types assumed in these calculations were averaged over a 7-day week (see Appendix A). However, the occupancy of buildings at any particular time may vary substantially from the average values; for example, at night most people will be at home, during a weekday many people will be at school or work, etc... Calculations similar to those of the Reactor Safety Study were performed using a variety of assumptions for building occupancy. Here, the average regional shielding factors for airborne radionuclides ranged from 0.64 to 0.82, while those for radionuclides deposited on the ground and other surfaces ranged from 0.28 to 0.37. These ranges indicate that the computed average shielding factors are quite insensitive to building occupancy and that the values of 0.75 for airborne

*States were grouped into regions based on the percentage of brick housing units within the state.

radionuclides and 0.33 for ground contamination are sufficient for all instances in which no specific sheltering strategy is employed.

In order to represent the strategy of deliberately sheltering persons on location (strategy (2)), average shielding factors were calculated that reflect temporal differences in the occupancy of different building types and regional differences in the relative numbers of brick and wood homes and of homes with basements. For this strategy, persons are assumed to be sheltered in basements when available to take advantage of the increased shielding that they provide. Data from the 1970 Housing Census (Appendix C) was used to estimate the fraction of homes with basements for each state and seven geographic regions.* Since no correlation is available between the frequency of basements and the type of house construction, the frequency of basements within a region was assumed to be the same for wood and brick homes. Data on the percent of brick versus wood construction (Appendix B), basement frequency, and various assumed occupancies were permuted, as in the Reactor Safety Study, using the following selected shielding factors from Tables 1 and 2 above.

TABLE 3. SELECTED SHIELDING FACTORS FOR AIRBORNE RADIONUCLIDES

Wood house, no basement	0.9
Wood house, basement	0.6
Brick house, no basement	0.6
Brick house, basement	0.4
Large office or industrial building	0.2
Outside	1.0

*The seven geographic regions were chosen to correspond to the seven reactor sites selected in the Reactor Safety Study [1] as being representative of the variability in climatic and topographic features. They are; Northeast, Great Lakes, Southwest, Midwest, Pacific Coast, Atlantic Coast and Southeast.

TABLE 4. SELECTED SHIELDING FACTORS FOR SURFACE DEPOSITED RADIOISOTOPES

Wood house, no basement	0.4
Wood house, basement	0.05
Brick house, no basement	0.2
Brick house, basement	0.05
Large office or industrial building	0.02
Outside	0.7

Locations of individuals are categorized as either (1) home, (2) school or work, and (3) commuting or outdoors.* As in the Reactor Safety Study, for the school or work category it is assumed that one-third of the people are in large offices or similar structures, and that the remaining people are in buildings having a distribution of construction types similar to that of the local single-family dwellings, i.e., the same percentage of brick buildings and buildings with basements. This assumption is believed to be conservative since government agencies (federal, state, and municipal) employ about 30% of the work force, and public buildings are usually substantial structures. No additional protection due to basement occupation is assumed for the 30% in large office or industrial buildings. This assumption has minimal impact on the resulting average shielding factors. Table 5 presents the average shielding factors calculated in each geographic region for four representative assumptions of building occupancy. Column A (78% home, 22% school or work, 0% outside or commuting) is based on the weekly average data presented in Appendix A, assuming that all persons

*Commuting and outdoors, which were separate categories in the RSS, are combined here for simplification. Persons in this category receive shielding factors of 1.0 (cloud) and 0.7 (ground).

TABLE 5. REGIONALLY AVERAGED SHIELDING FACTORS FOR SHELTERING AT LOCATION

Region	A. "Weekly Average"		B. "Weekly Average w. 10% outside"		C. "Weekday"		D. "Night"	
	1		2					
	<u>Cloud</u>	<u>Ground</u>	<u>Cloud</u>	<u>Ground</u>	<u>Cloud</u>	<u>Ground</u>	<u>Cloud</u>	<u>Ground</u>
1. Northeast	0.5	0.08	0.6	0.1	0.5	0.08	0.5	0.08
2. Great Lakes	0.6	0.1	0.6	0.2	0.5	0.1	0.6	0.1
3. Southwest	0.7	0.3	0.7	0.3	0.6	0.2	0.7	0.3
4. Midwest	0.5	0.09	0.6	0.2	0.5	0.08	0.5	0.1
5. Pacific Coast	0.7	0.3	0.7	0.3	0.6	0.2	0.8	0.3
6. Atlantic Coast	0.6	0.2	0.6	0.2	0.5	0.1	0.6	0.2
7. Southeast	0.7	0.2	0.7	0.3	0.6	0.2	0.7	0.2

Assumed population locations:

	<u>Home</u>	<u>School or Work</u>	<u>Commuting or Outside</u>
A. 78%		22%	0%
B. 70%		20%	10%
C. 40%		60%	0%
D. 100%		0%	0%

1. Shielding factors for cloud of radioactive material.
2. Shielding factors for ground and other surface deposited radionuclides.

either commuting or outdoors are moved indoors (they are assumed to occupy various building types with the same frequency as those already inside). Column B (70% home, 20% school or work, 10% outside or commuting) is similar, but assumes that 10% of the public remains outside. Columns C (40% home, 60% school or work, 0% outside or commuting) and D (100% home) employ estimates of population location for a weekday and for nighttime, respectively. Here, the average shielding factors for airborne radionuclides range from 0.5 to 0.8 and those for ground and other surface deposited radionuclides range from 0.08 to 0.3. Therefore, the range of protection offered by this sheltering strategy is well represented by two sets of "cloud" and "ground" shielding factors, (0.5, 0.08) and (0.75, 0.33), where the upper values are chosen to be the same as the "normal activity" values discussed earlier.

V. ADEQUACY OF USING AVERAGE SHIELDING FACTORS

Use of the average shielding factors described in the previous section for the assessment of radiological consequences results in the assignment of average doses to all individuals within a given area rather than the distribution of doses that would actually occur due to the variation in shielding protection afforded individuals. In other words, the average dose to the area population is calculated rather than the dose to individuals within the area. The adequacy of this simplification must be established.

The calculation of latent health effects is based on the population dose (integral of population times dose which is expressed as man-rem) rather than individual doses. Therefore,

latent health effects estimated using an average shielding factor would be identical to the results calculated using the appropriate distribution of shielding factors if a linear dose response model is assumed.^a However, early fatalities and early injuries are threshold effects and are calculated based on the dose to individuals. It is possible that dose values calculated using an average shielding factor may fall below a threshold level while, in fact, some members of the population have received doses in excess of this value (due to differences in the inherent shielding afforded by different building types, being outside, etc.). For this reason, the use of average shielding factors may introduce some error in the calculation of early health effects.

To estimate the potential error introduced by the assumption of average shielding factors, early health effects were calculated using several assumed shielding factor distributions (for example, 40% of population with cloud and ground SF's (0.9, 0.4), 40% with (0.6, 0.2), 10% with (0.2, 0.02) and 10% with (1.0, 0.7)) and compared to the early health effects calculated using the corresponding average shielding factors ((0.72, 0.31) in this example).^b Calculations were performed for a PWR2 release [1] using a stratified sample of 91 accident start times for the selection of weather during the release, meteorological data for a single reactor site, and an assumed uniform population density of 100 persons per square mile. Over the range of potential

^a Latent health effects estimated using an average shielding factor are nearly identical to the results calculated using the appropriate distribution of shielding factors when nonlinear dose response models are assumed.

^b Previous work has indicated that potential errors in the calculation of early effects due to the assumption of average shielding factors are more pronounced for the large release categories (PWR1 and PWR2).

shielding factors, the mean number of early fatalities calculated using the average shielding factors was 0-25% lower than the number obtained using the corresponding (and more appropriate) shielding factor distribution. The estimated peak number of early fatalities ranged from 4% higher to 20% lower when using average shielding factors. Both the mean and peak number of early injuries were only from 1-3% lower with average shielding factors.

The ranges of potential error presented above apply only for the specific release and assumptions noted, i.e., for mean values of early fatalities and injuries from 91 different accident start times. Potential errors in calculations for any specific meteorological sequence may fall outside this range. For population distributions other than uniform, e.g., a distribution peaked at a distance for which calculated doses are close to a threshold value, the discrepancy could be very much larger than is indicated above.

In conclusion, it appears that in most instances the use of average shielding factors will contribute only small errors compared to the overall uncertainties determined by all the other factors required in the consequence assessment, and therefore their use should be adequate in most situations. Nevertheless, under particular circumstances the errors introduced in the consequence assessment could be extremely large. Therefore, this possibility should be kept in mind whenever using average shielding factors, and care should be taken in interpreting results calculated using them.

VI. SUMMARY

Three generic sheltering/relocation strategies have been identified and discussed. They are (1) population relocation only (no specific sheltering response initiated), (2) sheltering at location followed by relocation, and (3) preferential sheltering followed by relocation. Shielding factors representative of these strategies have been calculated. The Burson and Profio [4] shielding factors presented in Tables 1 and 2 above may be used to calculate preferential sheltering in specific building types; (strategy (3)). Average shielding factors of 0.75 for airborne radionuclides and 0.33 for ground contamination were shown to be sufficient for instances in which no specific sheltering strategy is employed; (strategy (1)). The range of protection offered by the strategy of sheltering at location (strategy (2)) was shown to be well represented by two sets of "cloud" and "ground" shielding factors; (0.5, 0.08) and (0.75, 0.33). The range reflects regional differences in the numbers of brick and wood homes and of homes with basements, as well as temporal differences in building occupancy. The adequacy of using average shielding factors for the calculation of public health effects was discussed in section V.

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APPENDIX A

Time-Use Study

The Robinson and Converse time-use study* estimated the fraction of time the public spends in various activities. Because the study selectively sampled only the adult population below 65 years of age, retired and student populations are not fully represented. However, data from the time-use study was used in the Reactor Safety Study [1] to estimate the fraction of time the population spends in various locations since (1) it gives actual measured data and (2) the student population (28% of the total population), though it might be expected to have more outdoor activity than the adult population, should be somewhat balanced by infants and retired persons (about 18% of the population), who presumably have less outside activity. Activities reported by the time-use study were categorized into four general locations; home, school or work, commuting, and outdoors. The hours per day spent at each location, or activity, averaged over a 7-day week are presented below.

DAILY HOURS AT PRINCIPAL LOCATIONS OR ACTIVITIES, AVERAGED
OVER A 7-DAY WEEK

Location or Activity	Hours per day	Fraction of Total Time (%)
Home	16.6	69.2
School or work	4.7	19.6
Commuting	1.2	5.0
Outdoors	1.5	6.2

*Robinson, J. P., and P. E. Converse, 1966, Summary of U.S. Time Use Survey, Institute for Social Research, University of Michigan, Ann Arbor, Michigan.

APPENDIX B

Brick/Wood Housing Units

Data concerning the percentage of brick housing units within each state was presented in the Reactor Safety Study [1] and is repeated here. Figure B1 indicates graphically the percentages of family housing units that are brick for different parts of the country; the wide variation is conveniently categorized within five regions. Data for this figure were derived from the 1970 Census of Housing* and the 1971 FHA Homes, Data for States and Selected Areas** data book published by the Department of Housing and Urban Development (HUD). The HUD book gives statistics by state for existing single-family homes sold under the Federal Housing Administration (FHA) Section 203 program. These data show percentages of those existing (used) houses sold that have brick, stone, or concrete-block exteriors. These percentages have been assumed to be typical of all single-family houses within the state. The data were then adjusted to account for multifamily structures, which were assumed to be of heavy construction (i.e., brick). By using the housing census data on multifamily structures, the percentage of brick or equivalent housing units was estimated as follows:

$(\% \text{ multifamily units}) + (\% \text{ single-family homes}) (\text{fraction that are brick})$

As for the basement data in Appendix C, representative percentages of housing units that are brick were estimated for seven geographic regions; Northeast, Great Lakes, Southwest, Midwest, Pacific Coast, Atlantic Coast and Southeast. The states comprising these regions are listed in Appendix C. The

*U.S. Department of Commerce, 1972, 1970 Census of Housing, Detailed Housing Characteristics, United States, Washington, D.C.

**U.S. Department of Housing and Urban Development, 1972, 1971 FHA Homes, Data for States and Selected Areas.

FIGURE B1. Percentage of Brick Housing Units by Region (from Ref. 1)

percentages for each state included within a region (mid-values were assumed for the ranges in Figure B1), weighted by the number of housing units in that state, were averaged to obtain the following regional percentages of brick housing units.

<u>Region</u>	<u>% brick housing units</u>
Northeast	47
Great Lakes	36
Southwest	40
Midwest	35
Pacific Coast	27
Atlantic Coast	45
Southeast	59

APPENDIX C

Basement Data

Basement data from the 1970 U.S. Housing Census* is presented for each state in Table C1. The total number of basements in each state was divided by the number of year-round housing units to estimate the percentage of homes with basements for that state. As indicated, over 50% of U.S. homes have a basement. Also note that there is no correlation available between basements and type of house construction.

The percentages of homes with basements are typically similar for states within the same geographic area. Basement data for individual states were combined to estimate representative percentages for seven geographic regions: Northeast, Great Lakes, Southwest, Midwest, Pacific Coast, Atlantic Coast, and Southeast. The total number of basements in each region (i.e., the sum of the numbers for each state in the region) was divided by the total number of year-round housing units to estimate the percentage of homes with basements for that region. The states comprising each region, and the basement percentages calculated are listed below.

*U.S. Department of Commerce, 1972, 1970 Census of Housing, Detailed Housing Characteristics, United States, Washington, D.C.

<u>Region</u>	<u>% homes with basements</u>
Northeast	87
(Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Pennsylvania, Rhode Island, Vermont and West Virginia)	
Great Lakes	77
(Illinois, Indiana, Michigan, Minnesota, Ohio and Wisconsin)	
Southwest	13
(Arizona, California, Nevada, New Mexico, Oklahoma, Texas, Utah and Wyoming)	
Midwest	71
(Colorado, Illinois, Indiana, Iowa, Kansas, Montana, Nebraska, North Dakota, South Dakota and Idaho)	
Pacific Coast	23
(California, Oregon and Washington)	
Atlantic Coast	51
(Connecticut, Delaware, Florida, Georgia, Maine, Maryland, Massachusetts, New Jersey, North Carolina, Rhode Island, South Carolina and Virginia)	
Southeast	16
(Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina and Tennessee)	

TABLE C1. BASEMENT DATA FROM 1970 U.S. HOUSING CENSUS

	Year-round housing units	Basements	% homes w. basements		Year-round housing units	Basements	% homes w. basement
Alabama	1,114,845	160,677	14	Montana	240,755	155,521	65
Alaska	88,555	39,259	44	Nebraska	511,473	405,688	79
Arizona	578,771	25,116	4	Nevada	171,658	23,432	14
Arkansas	672,967	52,260	8	New Hampshire	248,799	213,815	86
California	6,976,261	1,170,214	17	New Jersey	2,305,293	1,915,056	83
Colorado	742,858	443,118	60	New Mexico	322,294	31,084	10
Connecticut	968,815	881,224	91	New York	6,159,314	5,522,331	90
Delaware	174,990	112,713	64	North Carolina	1,619,548	387,055	24
Dist. of Columbia	278,390	233,146	84	North Dakota	200,465	168,555	84
Florida	2,490,838	82,237	3	Ohio	3,447,860	2,621,202	76
Georgia	1,466,687	304,813	21	Oklahoma	937,815	102,872	11
Hawaii	215,892	29,149	14	Oregon	735,631	265,237	36
Idaho	238,293	130,456	55	Pennsylvania	3,880,102	3,466,494	89
Illinois	3,692,447	2,854,269	77	Rhode Island	307,309	283,784	92
Indiana	1,711,896	999,320	58	South Carolina	804,858	88,438	11
Iowa	954,975	828,370	87	South Dakota	221,636	170,302	77
Kansas	787,508	435,365	55	Tennessee	1,297,000	368,753	28
Kentucky	1,060,689	440,674	42	Texas	3,809,086	131,486	4
Louisiana	1,146,105	34,701	3	Utah	311,982	213,172	68
Maine	339,440	280,264	83	Vermont	149,762	127,767	85
Maryland	1,234,680	930,067	75	Virginia	1,484,952	629,401	42
Massachusetts	1,839,028	1,708,242	93	Washington	1,204,902	570,500	47
Michigan	2,845,448	2,204,469	78	West Virginia	592,845	313,501	53
Minnesota	1,219,591	1,069,946	88	Wisconsin	1,416,427	1,272,087	90
Mississippi	697,271	35,103	5	Wyoming	114,572	67,224	59
Missouri	1,665,506	1,094,080	66				
				U.S. Total	67,699,084	36,112,009	53