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CATALOG OF RESIDENTIAL DEPTH-DAMAGE FUNCTIONS

Used by the Army Corps of Engineers in Flood Damage Estimation

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A depth-damage function is a mathematical relationship between the depth of flood water above or below the first floor of a building and the amount of damage that can be attributed to that water. The depth-damage relationship is the most important tool in the cost-benefit analysis of flood damage reduction projects. This reports presents a comprehensive catalog of residentail depth-damage functions used by Corps of Engineers district offices. These damage functions include those computed from National data of flood damage records as well as those originally computed on a project-specific basis and now in general use. This catalog should help analysts who perform flood damage estimates to carefully consider existing local damage functions, and has the functions compare with depth-damage functions used by other Corps of Engineers districts.

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CATALOG OF RESIDENTIAL DEPTH-DAMAGE FUNCTIONS USED BY THE ARMY CORPS OF ENGINEERS IN FLOOD DAMAGE ESTIMATIONS

by

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PREFACE

This report was completed under the Flood Mitigation, Formulation, Planning, and Analysis research work unit at the Corps of Engineers, Institute for Water Resources (IWR). Mr. Stuart A. Davis is the principal investigator for the research unit. The Flood Mitigation work unit is part of the Planning Methodologies research program, which is under the direction of Mr. Michael R. Krouse, Chief of the Technical Analysis and Research Division at IWR. Mr. Steven R. Cone is the technical monitor of the Flood Mitigation work unit, under the direction of Mr. Robert M. Daniel, Chief of Economics and Social Analysis Branch at the Office of the Chief of Engineers.

The authors wish to acknowledge the contribution of Mr. Ridgley K. Robinson who is responsible for designing the format for and preparing most of the tables, graphs, and figures in this report. Ms. Katherine McCleese also prepared several of the tables in the report. Mr. Robert Norton provided the technical editing of the document. Ms. Arlene Nurthen was responsible for the document preparation and publication. Too numerous to list are the individuals in district and division offices who provided the depth-damage tables used by their offices, responded to the detailed survey questions, which are the basis for this catalog, and answered many follow-up inquires. Mr. Howard Leiken, Special Assistant to Administrator of the Federal Insurance Administration (FIA) patiently answered many questions regarding the FIA's damage functions.

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CHAPTER ONE

INTRODUCTION

"Let's not make the wrong mistakes."

- Yogi Berra

PURPOSE

The depth-damage relationship is the most important tool in cost-benefit analysis of flood damage reduction projects. Even so, the use of depth-damage functions is frequently a routine process that may involve little thought of how applicable a set of damage functions is to a particular situation. Sometimes depth-damage functions are embedded in computer programs which calculate expected annual damages, and the analyst is not necessarily aware of what the depth-damage functions look like or what assumptions support them. Depth-damage functions can vary tremendously in the magnitude of expected damage at given levels of flooding. Consequently, the selection of an appropriate depth-damage function can often make the difference of whether or not a project is economically justified.

This report is intended to be a comprehensive catalog of residential depth-damage functions used by Corps of Engineer field offices. It includes damage functions that were computed from National data of flood damage records, and damage functions originally computed on a project-specific basis and now in general use. It is hoped that this catalog will provide the stimulus for analysts who perform flood damage estimates to carefully consider their own damage functions, the history and assumptions behind those functions and how the functions compare with depth-damage functions used by other Corps of Engineer districts.

The Corps of Engineers has never sanctioned any particular set of depth-damage functions, nor is any endorsement implied here. Corps field offices have been encouraged to collect local flood information and use depth-damage information that reflects the type of flooding and the style of building found in the region, and the project area in particular. Since depth-damage functions should be valid for the area in question, the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (Paragraph 2.4.6) encourages the use of "area depth-damage" relationships. However, National depth-damage functions issued by the Federal Insurance Administration (FIA) have been accepted for years for use in Corps feasibility studies, and the Army Audit Agency (AAA) has used the FIA depth-damage functions as a standard of reasonableness (Army Audit Agency, 1989, p. 15).

WHAT DEPTH-DAMAGE FUNCTIONS ARE AND HOW THEY ARE USED

A depth-damage function is a mathematical relationship between the depth of flood water above or below the first floor of a building and the amount of damage that can be attributed to that water. In tables illustrating damage as a function of water depth, the first floor elevation is equivalent to 0 water height; negative numbers indicate heights below the first floor threshold. Depth-damage relationships are computed separately for structure and contents.

"Depth-damage relationships are based on the premise that water height, and its relationship to structure height (elevation), is the most important variable in determining the expected value of damage to buildings. Similar properties, constructed, furnished, and maintained alike, and exposed to the same flood stages and forces, may be assumed to incur damages in similar magnitudes or proportion to actual values" (Davis, et al., 1988, p. V-35).

Depth-damage relationships are generally expressed with content damage as a percentage of content value, and structure damage as a percentage of structure value, for each foot of inundation. Depth-damage functions can also be expressed in a specific dollar amount of damage for each depth; this, however, is only useful when applied to particular buildings at one point in time.

Many factors affect the amount of damages arising from a flood. The variable aspects of floods that impact on the damages include depth of flooding, time of year of flooding, velocity of floodwater, duration of flooding, sediment load, and warning time. Although all these factors may be relevant to the flood damages incurred, most historical assessment procedures have focused on only one explanatory variable, depth of flooding.

Because the depth-damage function is the primary relationship used in flood damage estimation work, various depth-damage curves have been developed. These can be specific to certain structures, such as an individual home, or averaged for a number of similar buildings, such as one story residential dwellings with basements.

Details on calculating depth-damage functions are given in Chapter Two.

STRUCTURE DEFINITION AND VALUE DETERMINATION

Structure is usually defined as a permanent building and everything that is permanently attached to it. According to Engineering Regulation 1105-2-100 (paragraph 6-167), building values should be evaluated as an estimate of depreciated replacement value of the structure. Outside building values and land values are usually considered separately.

Sources used by several districts for making appraisals include the Marshall Valuation Service and the Marshall-Swift Residential Estimator Program, released by Marshall and Swift of Los Angeles, California, and the Boeckh Building Cost Guides, released by the E.H. Boeckh of Milwaukee, Wisconsin. These documents can be used for obtaining replacement costs for building construction in various parts of the country, using local construction cost multipliers by type of construction material and building size. These replacement values should be limited to depreciated conditions, however, or structural values will be overestimated.

CONTENT DEFINITION AND VALUE DETERMINATION

Household contents are usually defined as everything within the house, not permanently installed, such as rugs, portable dishwashers, and freestanding bookshelves.

The standard depth-damage relationships applied to residential property often incorporate content-to-structure value ratios. While property insurance companies often estimate the ratio of content value to structure value at 50 or 55 percent, ratios used by Corps districts have ranged from 25 to 75 percent. The ratio is now limited to 50 percent, unless supported by a local survey (ibid., paragraph 6-180). Several factors can influence the content-to-structure value ratio. The affluence factor is based on the principle that the ratio should increase with household income. It can also be assumed that basic necessities, such as clothing and appliances, and modest luxuries such as televisions and stereos, make the ratio above 50 percent for very poor households. Apartment and small condominium dwellers can also be expected to have higher valued items, when space becomes a limiting factor.

Appraisal of content values generally requires far more detailed work than structural appraisal because there is no easy way to approximate depreciated value for contents in the same way market value approaches depreciated replacement value for structures. By inventorying the contents of a sample of residences from the study area, pricing those contents using local store prices, and deducting an average percent of value for depreciation, the assumed content-to-structure value ratios can be corroborated or adjusted.

SCOPE OF THIS REPORT

This catalog is a basic introduction to depth-damage analysis. It is not a comprehensive guide to calculating depth-damage functions nor does it give extensive details on the various sets of depth-damage functions used within the Corps. The catalog does give a brief explanation of the concepts, procedures, and sources for depth-damage information, and it presents the damage functions used by Corps districts. The organization of the remainder of the catalog is described below.

Chapter Two offers a look at the methods for calculating depth-damage functions. The basic procedures and the advantages and disadvantages of each method are described.

Chapter Three describes the National Flood Insurance Program and the background and assumptions behind the damage functions which are the most widely used in the Corps.

All other damage functions are presented in Chapter Four. Chapter Four includes all the damage functions in a tabular format and all the assumptions or conditions on which the functions are based. The damage functions and assumptions are presented to enable a Corps field office to compare its own damage functions with those used by others. This will enable each field office to reassess the appropriateness of its own damage functions and to help determine if another set of damage functions might be considered for any particular building type.

Chapter Five presents a matter-of-fact, non-judgmental comparison of these damage functions. Chapter Six concludes with recommended policies on the development and application of depth-damage functions.

CHAPTER TWO
CONSTRUCTION OF DEPTH-DAMAGE FUNCTIONS

When estimating flood damages, an analyst may either use generalized depth-damage relationships, computed for the Nation, region, district, state, or project; or develop new depth-damage relationships. In computing new depth-damage functions, there are three basic approaches to determine the extent of damage occurring at various flood heights. These include post-flood surveys, synthetic damage estimates, and the adaptation of other damage functions to a specific region or locality.

Generalized depth-damage relationships were established for several types of residential buildings in 1970 and 1973 and updated annually by the Federal Insurance Administration (FIA); in 1979 by the Tennessee Valley Authority; and over the years by several Corps district offices. Standard relationships are common for residential structures because residential property is considered to be fairly homogeneous in susceptibility and layout of contents, and in types of building materials used.

BASIC CONSIDERATIONS

No matter what approach is used to estimate depth-damage relationships, a well-founded understanding of the effect of flooding and the type of damage that occurs at various depths of flooding is essential for judging the reasonableness of any estimates. A starting point would be to identify the susceptibility of contents, structure, and outside property to damage from immersion. Table 1 identifies the general effects of flooding on contents, structure, and outside property. The next step would be to determine what these effects mean in terms of percent damage.

TABLE 1

PHYSICAL EFFECTS OF FLOODS ON RESIDENTIAL PROPERTY											
	Effects of Flooding										
Element of Property Affected	Wetting	Dampness, Mildew, Rusting	Soiling or Staining	Eroding or Undermining	Silting	Contamination	Warping & Swelling	Shrinkage	Breakage	Overturning or Collapse	Sweeping away or drowning
CONTENTS											
Furniture	X	X	X	X	X	X	X	X	X	X	
Clothing	X	X	X		X	X		X			
Glass									X		
Small tools	X	X			X		X	X	X		
Appliances	X	X	X		X	X			X	X	
Toys and play equipment	X	X	X		X	X	X	X	X	X	
Pets											X
Books and records	X	X	X		X	X					
Food stuffs	X	X			X	X			X		
House maintenance supplies	X	X	X		X	X	X	X	X		
STRUCTURAL											
Foundations and walls	X			X	X				X	X	
Basement floors	X		X	X	X		X		X		
Heating, ventilating, air	X	X							X	X	
conditioning equipment	X				X						
Electric equipment	X	X							X	X	
Electric wiring	X				X				X		
Plumbing and equipment	X	X	X	X	X	X			X	X	
House insulation	X	X			X	X					
Floors, stairs, partitions	X	X	X				X	X	X	X	
Doors, windows, woodwork	X	X	X				X	X	X		
Plaster and lath	X	X	X		X				X		
Painting, decorations	X	X	X			X		X	X		
Hardware	X	X				X					
OUTSIDE PROPERTY											
Land and soil	X			X	X						
Landscaping	X			X	X				X		
Utility connections				X	X						
Cars, motors, mowers, etc.	X	X	X		X	X					X
Driveway, walks, etc.	X			X	X				X	X	
Gardens, trees and produce	X	X		X	X						
Fences, gates, etc.	X	X	X	X	X		X			X	
Sheds, garages	X	X	X	X	X		X		X	X	
Wells, water supply				X	X	X					

One approach to estimating percent damage is in the construction of susceptibility tables, such as those constructed in Great Britain by Penning-Rowsell and Chatterton for residential contents (Penning-Rowsell and Chatterton, p. 30-31). These tables indicate the percent of remaining value of each item after being immersed in water.

For structural damage, Penning-Rowsell and Chatterton also included a detailed narrative of the effects of immersion on various types of construction. They then assembled a table that lists the item-by-item cost for repair of structural components, given five levels of inundation and short and long durations (less than or greater than 12 hours). Similar tables (which do not account for the effect of warning time) were used by New York District in making synthetic estimates of flood damage on the Green Brook Sub-Basin Damage Study (URS Consultants, Flood Damage Evaluation Guidelines for the Green Brook Sub-Basin Damage Study, 1988). This New York District work is illustrated below in the section on synthetic damage estimates.

The level of background detail considered by Penning-Rowsell and Chatterton is desirable, but not required, for an adequate evaluation of depth-damage functions. However, to assess potential damage there is a great deal to be gained from the simple exercise of identifying what is immersed at each foot of inundation and what specific damages might occur. Table 2 gives such a summary. This table is included only for illustration. Field offices are encouraged to create their own tables.

POST-FLOOD INTERVIEWS

The most precise method of gathering residential depth-damage information is through interviews of recent flood victims. During the interviews, damages are also estimated for elevations above and below the first floor level of a structure.

Development of depth-damage functions through post-flood interviews should include the following steps, which closely follow the procedures found in the National Economic Development Procedures Manual - Urban Flood Damage, Volume II: Primer for Surveying Flood Damage for Residential Structures and Contents, (Mill, et. al., 1991).

TABLE 2
Typical Residential Depth-Damage Function
($100,000 Structure, with $50,000 Contents)

Water Height	Structure Damage	% Damage to Structure	Content Damage	% Damage to Contents	Typical Damage
-8	0	0	0	0	Basement floor wet
-7*	$1,000	1	$1,500	3	Clean up, stopped drain
-6	$2,000	2	$3,000	6	Equipment affected, basement furniture damaged
-5	$2,800	3	$4,000	8	Appliances, stairs, dampness in house
-4	$3,200	3	$5,000	10	Basement furniture covered equipment damaged
-3	$3,700	4	$5,500	11	
-2	$4,200	4	$5,800	12	
-1	$6,200	6	$6,000	12	Basement ceiling, wiring affected
0	$8,000	8	$6,200	12	First floor-framing, floor wet
1	$11,000	11	$10,000	20	Furniture, insulation, walls, electric outlets damaged
2	$17,000	17	$14,000	28	Woodwork, doors damaged
3	$22,000	22	$17,000	34	Redecorating, windows, clothes, electronic equipment
4	$28,000	28	$21,000	42	Water comes over counter tops - appliances damaged
5	$33,000	33	$23,000	46	Second layer of drywall and paintings damaged
6	$35,000	35	$23,400	47	Replastering
7	$38,000	38	$23,700	47	
8	$40,000	40	$24,000	48	Ceiling lighting
9	$45,000	45	$26,000	52	Second floor framing, rugs
10	$50,000	50	$28,000	56	Similar to first floor
11	$52,000	52	$30,000	60	
12	$54,000	54	$32,500	65	

*** Beginning damage elevation may depend on basement openings, foundation material, soil type, and velocity and duration of flooding.**

1. **Identify the Predominant Structure Types Within the Study Area.** For purposes of floodplain inventory, categories of property are defined by similar susceptibility to flood damage. Both structural use and physical characteristics can be practical areas for categorization. Classification should be established based on the number of stories, the presence of a basement, and, possibly, building material. Separate categories can also be established for mobile homes, houses built on piers, various types of multi-family dwellings, and for different styles of housing, such as ranch, colonial, and Cape Cod.

2. **Design the Questionnaire.** A questionnaire should be designed to cover all the information needed to estimate content and structure values and to cover all damages intended to be included in the depth-damage functions.

3. **Pre-test the Questionnaire.** It is imperative that questionnaires be pre-tested, to ensure that the interviewers and respondents understand the questions and that there are no great difficulties in executing the survey. A survey is best pre-tested among a small sample of the population to be surveyed.

4. **Draw Sample.** A stratified random sample should be drawn, reflecting the structure categories determined in step 1.

5. **Select and Train Interviewers.** It is useful, although not imperative, to have interviewers with survey experience and some knowledge of structure and content value and damage determination.

6. **Conduct Interviews.** These interviews should occur soon enough after the event for the damages to be remembered and records to still be available, but long enough after the event for the great proportion of damage to occur and be discovered. The ideal time period would be between one to three months after the flood, although damage to items such as electrical appliances and insulation may not show up that quickly.

The interviewers should help clarify any questions that the interviewee may not understand, and possibly act as a resource regarding questions about value and damage when the interviewee is unable to answer a question. However, to the extent possible, the interviewer should allow the respondent to answer the questions as they are written and not bias the responses by giving opinions. Adequate supervision should be provided throughout the course of the interviews, to insure proper sampling, completeness of survey forms, and to handle any public relations problems that arise.

7. **Assess Non-Responses.** Determine if there is a systematic bias among those not answering the questionnaire. If there is a major group under-represented in the sample, their responses might be given added weight in the analysis.

8. **Code and Edit Data.** Screen the questionnaires for completeness, enter, and clean the data to be analyzed.

9. **Analyze the Data.** Tabulate the data to determine the total content value and damage, and the total structure value and damage. This information can be used along with water height to determine depth-damage functions. Depth-damage functions can be calculated to various degrees of precision. Two alternative methods are described below.

Cross-Tabulation Procedure. The cross-tabulation procedure is the simplest way to establish depth-damage relationships. At the simplest level, it involves taking the average of all the percent damage-to-structure and percent damage-to-contents observations for each one foot level of flooding. The actual analysis generally requires considerable data clean-up, including the elimination of incomplete records and outliers (extreme values). This approach is used because water height is commonly viewed as having the most influence on physical damage and because this method is relatively easy and quick. However, there are also problems with this procedure. Percent damages are expressed in relation to only one variable: water height; and there is no parameter to show the strength of the one independent variable in explaining variation in the dependent variable, percent damage. Further, there is limited information on distribution of the sample.

Regression Analysis. The best method of measuring the effects of several variables on percent damage is regression analysis. The strength of any one variable can be estimated along with the strength of the entire model in explaining the variance of percent damage. Regression analysis with depth-damage data is difficult, however, because of the problems in obtaining good measurements for all the important variables that influence percent damage. There may be a multitude of variables that effect the amount of damage, and very often the amount of variance in damage or percent damage that can be explained by a regression equation is low. The analyst also needs to be aware of errors in specifying regression equations, such as using explanatory variables that are too highly correlated with one another. In any case, only statistical packages that are adequately equipped to give interpretative statistics and diagnose errors should be used in regression analysis for calculation of depth-damage functions.

10. Document the Damage Functions. Although it is commonplace for depth-damage functions to be documented solely on a spreadsheet, it is far preferable to have a report which documents the development of the damage functions, the type of flooding, description of the population surveyed, housing characteristics, methods used to perform the survey, a copy of the survey form, and results of the analysis.

Advantages and Disadvantages of Post-Flood Damage Analysis

Post-Flood damage analysis is the only way for the analyst to get first-hand knowledge of what actually occurs under a specific set of flood conditions, and the only way that the analyst is certain of all the assumptions that go into the depth-damage calculations.

While this method of estimating elevation-damage curves is preferred, it can be time-consuming and expensive. The major limitation of the post-flood survey, however, is its dependence on a recent flood occurrence. Without recent flooding, it is necessary to make synthetic estimates or adapt other damage functions, as described below. When a flood does occur, it is often difficult to acquire the financial resources or personnel in time for a complete survey of a very large sample.

As mentioned above, post-flood damage surveys can be the most accurate method of calculating residential depth-damage relationships for several reasons. First, the analyst can determine firsthand the damages that actually occur for a particular level of flooding and for a particular type of flood occurrence. Second, the analyst can determine the age and pre-flood condition of all belongings and depreciate contents based on a pre-determined depreciation schedule. Third, the analyst can determine whether to include clean-up costs, and damage to outside property or any other particular type of damage. After these damage functions have been developed, there can be a thorough documentation of any information pertinent to a future user.

The major difficulty with post-flood surveys is the heavy investment in time and money that must be committed to do an adequate job. Second, when the resources and the inclination to do an adequate job do exist, there is no guarantee of any recent flooding. Conversely, if there has been major flooding, there is never a guarantee of resources to survey an adequate sample of properties. A further problem is that post-flood surveys generally only apply to a single flood event, and, therefore, damage estimates are only available at one elevation for each structure. However, if enough structures with similar characteristics are located at different elevations a representative depth-damage curve can be developed.

SYNTHETIC DAMAGE ESTIMATES

Synthetic flood damage functions are constructed from estimates of what damages would be for several hypothetical levels of flooding. It is possible to identify "typical" floor plans and layouts for a "typical" quantity of household contents. The steps in synthetic flood damage analysis are exactly the same as those used in post-flood surveys. The questions, of course, relate to what would be flooded at various levels of inundation and what damages would occur at these levels. Because damage estimates are more difficult in hypothetical situations, it would be helpful to have experienced interviewers, who also have some knowledge of making damage estimates.

Guidelines for making synthetic damage estimates were created for the New York District's Green Brook Sub-Basin Study, ("Green Brook Flood Evaluation Guidelines"). The Green Brook Guidelines document the procedures and per unit costs for estimating damage to both structure and contents of residential and non-residential property. The synthetic method was used where no recent damage information was available, and it represented the average susceptibility and costs of repair and replacement of structural components and household contents. Eleven sources were identified as being used in making these damage estimates. These included building costs indexes, consumer product catalogs, contacts with retailers, and the contractor's personal experience with flood damage estimates.

One of the tables included in the Green Brook Flood Evaluation Guidelines gave a percent damage by structural item. Table 3, which follows, gives examples of data from that table.

TABLE 3
PERCENT DAMAGE BY WATER DEPTH

	Depth (Referred to First Floor Elevation)			
Item	1.0'	2.0'	5.0'	9.0'
Sub Floors	100%	100%	100%	100%
Plaster Wall	12.5%	25%	62.5%	100%
Cabinets (lower)	20%	20%	100%	100%
Redwood Tongue & Groove Paneling	4%	8%	19%	30%

(URS, p. 7)

This information was combined with repair cost information in another table which gives the unit costs of repair and remodeling. An example is provided below in Table 4.

TABLE 4
REPAIR AND REMODELING COSTS

(January 1988 Dollars)

Item	Total Cost	Unit	Depth to Total*
Sub Floors	$ 1.35	sq. ft.	1.0 ft.
Plaster Wall	$ 2.15	sq. ft.	8.0 ft.
Cabinets (lower)	$90.00	linear ft.	3.0 ft.
Redwood Tongue & Groove Paneling	$ 5.25	sq. ft.	3.3 ft.

(URS, p. 6)

* Depth to total refers to the depth of water required before item has 100 percent damage.

Other tables in the Green Brook Flood Damage Evaluation Guidelines give a range in values and percent damage by depth of flooding above the first floor for content items.

There is also information on estimating commercial, industrial, and public damage, as well as damage to outside property.

The major value of synthetic damage estimation guidelines, such as those used by New York District, is to serve as a quick reference so that an interviewer need only determine the size of a building and the layout of the structure and its contents to estimate the amount of damage and a depth-damage function for the structure.

Advantages and Disadvantages of Synthetic Damage Analysis

The major advantage of the synthetic damage estimate method is that it does not require a flood event. Damages for up to four or five levels of flooding can be estimated, subject to the amount of patience of the interviewee. This method is generally quicker and less expensive than post-flood surveys.

The major disadvantage is the hypothetical nature of the assumptions. Synthetic damage estimates may require a good deal of skill from the analyst and more cooperation and acceptance from the residents being surveyed. Synthetic damage estimates require an understanding of the types of damages that might result from various levels of inundation and the costs of repair. Synthetic estimates also require an understanding of how the specific flood circumstances and type of building will affect the extent of damages. However, guidelines that provide susceptibility and unit costs of repair and replacement are an invaluable tool in making synthetic damage estimates.

ADAPTATION OF EXISTING CURVES

Several Corps districts have adapted either the FIA depth-damage functions or curves from other districts to their own flood situations. Although damage function adaptation is a common practice, there is little guidance on how it should be done, nor documentation of how it has been done.

Adaptation of existing depth-damage functions can be accomplished by the following steps:

1. Identify the predominate structure types.

2. Identify the flood conditions of the study area, district, or region. The flooding problem should be characterized as much as possible by identifying typical velocities, durations, warning lead time, and identifying whatever factors may complicate flood damage, such as ice jams, debris load, wave actions, or salt content.

3. Review other flood damage functions. Determine whether other depth-damage functions have compatible structure categories and similar type of flood hazards.

4. Determine adjustment factors for each curve. After finding a compatible set of depth-damage functions, examine the beginning damage water height, the shape of the damage functions, the inflection points, and the magnitude of damage. Scrutinize these observations for reasonableness and make adjustments in the damage functions to reflect differences in flood conditions and architecture.

Advantages and Disadvantages of Existing Curves

Adaptation of existing depth-damage functions is the least expensive and least time consuming method of establishing depth-damage functions. It does not require a complete survey, nor does it require any recent flooding. It allows the flexibility of using any well-documented source and using reasonable judgement to make adjustments to fit the curves to the situation in the region of interest.

Adaptation of existing depth-damage functions also has the potential to be the most precarious of the methods for deriving depth-damage functions. If the original damage functions are not well documented, if they do not closely parallel the target region, or if poor judgement is used in their adaptation, an inappropriate set of damage functions may result. At the very least, a sampling of local depth-damage relationships is highly recommended. Otherwise, using the FIA damage functions, which represent averages for the country, should be sufficient.

CHAPTER THREE

FEDERAL INSURANCE ADMINISTRATION DEPTH-DAMAGE FUNCTIONS

The FIA depth-damage functions are extremely popular among Corps district offices. Twenty-four of the thirty-eight offices surveyed use some form of FIA depth-damage functions. For that reason, this report includes additional background on the National Flood Insurance Program (NFIP) and the FIA depth-damage functions. More detailed information can be found in a newly published IWR report, The Applicability of the Federal Insurance Administration's Standard Rate Tables for Corps of Engineers Depth-Damage Analysis.

NATIONAL FLOOD INSURANCE PROGRAM

The Federal Insurance Administration (FIA) is the U S. government agency responsible for flood insurance coverage. FIA is part of the Federal Emergency Management Agency (FEMA), an independent division of the Federal Executive Branch. As part of its role in providing adequate flood insurance coverage, FIA has developed nationwide depth-damage relationships. These depth-damage relationships are used in the actuarial rate setting process to determine flood insurance premiums sufficient to cover the expected loss, plus administrative expenses, for each non-subsidized policy.

FIA depth-damage functions were computed in 1970 and 1973, and new depth-damage functions are now published annually as part of the flood insurance rate review. The earlier depth-damage functions and the annual rate review are described briefly below.

1970 AND 1973 DEPTH-DAMAGE FUNCTIONS

Because they are the only set of National depth-damage functions, FIA's 1970 and 1973 depth-damage functions have been used extensively by Corps districts. Ironically, FIA depended on the Corps of Engineers for much of its initial depth-damage information. This is because the NFIP did not begin issuing policies until 1969, and participation in the program started off very slowly. Consequently, for the first several years of the program there were few claims on which to base any damage functions.

No written report is available that describes these initial depth-damage functions. The 1973 depth-damage functions are believed to be partly based on a series of post-flood surveys performed by the Buffalo District, Corps of Engineers. The Buffalo data and other information were reviewed by a rate review committee of individuals from private companies which sold flood insurance at the time.

FLOOD INSURANCE CLAIMS PROCESS AND RATE REVIEWS

FIA collects both indemnifications and total damage data from flood insurance claims. Indemnifications are cash payments paid to policy holders to settle a loss. The actual loss data, rather than indemnification information, are used by FIA in determining and modifying depth-damage percentages. Total damages are defined as all damages to the structure and contents, including both those covered by the NFIP and those in excess of policy coverage limits. The monetary value of total damages is based on the determination of actual cash value. The actual cash value is defined as the replacement cost of an item less its depreciation. Total damages represent all damages to the policyholder's structure and contents, not payments to the policyholder. Damages could actually far exceed the policyholder's flood insurance coverage.

FIA then computes the appropriate percent damage-to-value ratio from each policyholder's claim. Information regarding the replacement value of the structure and contents, less depreciation, is available from the policyholder's individual policy. Total damages information, as well as depth of inundation, is provided by the claims adjuster. Thousands of these claims are collected in the FIA database and used to adjust the 1973 theoretical base tables based on actual claims data. The resulting modifications to the FIA depth-damage relationships are released annually with the Flood Insurance Rate Review.

The initial FIA depth-damage functions were compiled from Corps damage information in 1970. These 1970 FIA relationships were adjusted in 1973 based upon further information from the Corps and from available flood insurance damage claims information. After reviewing the information, the NFIP actuarial committee selected depth-damage values that became the initial set of depth-damage relationships for structures and contents. These 1973 depth-damage relationships are referred to by FIA as theoretical base tables and are annually updated with the total damage information obtained during claims adjusting procedures, or "rate reviews." The statistical technique used to modify these 1973 theoretical base tables is known as "credibility" analysis.

Briefly, each "rate review" depth-damage report provides, by structure type and by foot of inundation, average damages expressed as a percentage of property value. The credibility of the actual claims data is tested by determining the number of claims in each cell that would be needed for full "credibility." A fully credible sample is one that meets predetermined conditions for estimating the true mean damage from sample mean damage in terms of confidence level and relative error. If there are enough claims in a cell for full credibility, then the average damage value from the claims data is used in the revised depth-damage table. If there are not enough claims for full credibility, then a value is determined for the revised tables based on a weighting between the actual claims data and the theoretical base table. This weighting procedure is subjective and a few different formulas have been used since annual NFIP rate reviews were initiated.

When an individual property owner covered by the NFIP suffers flood losses and files a claim with either NFIP or his insurance company, a claims adjuster calculates the monetary settlement for damages to the insured structure and contents. These "loss settlements" are equal to the replacement or repair costs for the structure and contents minus depreciation. (The NFIP definitions for structure and contents are identical to those used by the general insurance industry. Any item that is "an integral part of the building" is considered structure, while contents include those items that are not permanently installed.)

New damage functions are computed annually for the following residential structure categories: one floor, no basement; two or more floors, no basement; one floor, with basement (The tables call this two story, with basement, but the basement is considered one of the stories.), split-level, no basement; split-level, with basement; and mobile home. Content depth-damage functions are published annually for first floor only, first floor and above, and mobile home. Two or more floors, with basement structural functions and split-level, with and without basement content functions were calculated in 1970 or 1973, but have not been updated.

The basic assumptions behind the annual rate review table are described below:

1. Both structure and content values are estimated at the "actual cash value," which approximates the depreciated replacement value. There is a $185,000 limit on residential structure and a $60,000 limit on residential content coverage. However, the values and damages in the data base are unconstrained by these limits.

2. Items not covered by NFIP policies are not included in the database or the calculation of depth-damage functions. Items not covered include those articles stored outside the four walls of a house or garage; motorized vehicles; art work; coins; stamps; valuable papers; and for flood claims made after December 1983, anything stored in a basement, other than washer, dryer, or freezer.

3. Damages used in structural depth-damage functions are the total costs of structural repair, including the amount of damage beyond the limits of the policy.

4. Damages used in content depth-damage functions are the total costs of repair, including the amount of damage beyond the limits of the policy or the depreciated replacement value of the items, whichever is less.

5. Structural depth-damage functions are based on a combination of residential and non-residential claims. Close to 90 percent of these claims are residential. Consequently, there is no structural damage function exclusively for non-residential property. Content depth-damage functions are computed separately for residential or non-residential claims.

The 1970 and 1973 Flood Insurance depth-damage functions as well as the annual Flood Insurance Rate Review tables are included in Chapter Four and Appendix A.

CHAPTER FOUR
DISTRICT DEPTH-DAMAGE FUNCTIONS

This chapter, along with Appendix A, constitute the central components of this catalog. All depth-damage functions used by the Corps, except those which are adaptations of other curves, are presented in Appendix A; and it is here that the damage functions used by each Corps of Engineers field office are described. Table 3 summarizes what damage functions are used by each district and division office.

The depth-damage functions themselves would be far less valuable if they were not accompanied by information on the assumptions that went into them. Therefore, a detailed review of the background of the damage functions includes: 1) the derivation of the damage functions; 2) a description of the type of flooding that occurs in the region; 3) a list of the building categories for which damage functions have been defined; 4) the structure definition and method for structure value determination; 5) the content definition and method for content value determination; 6) the structure damage definition and method for structure value determination; and, 7) the content damage definition and method for content value determination.

Figure 1 illustrates some of the various structure type categories. It is included to help clarify what building is defined by each of these building categories.

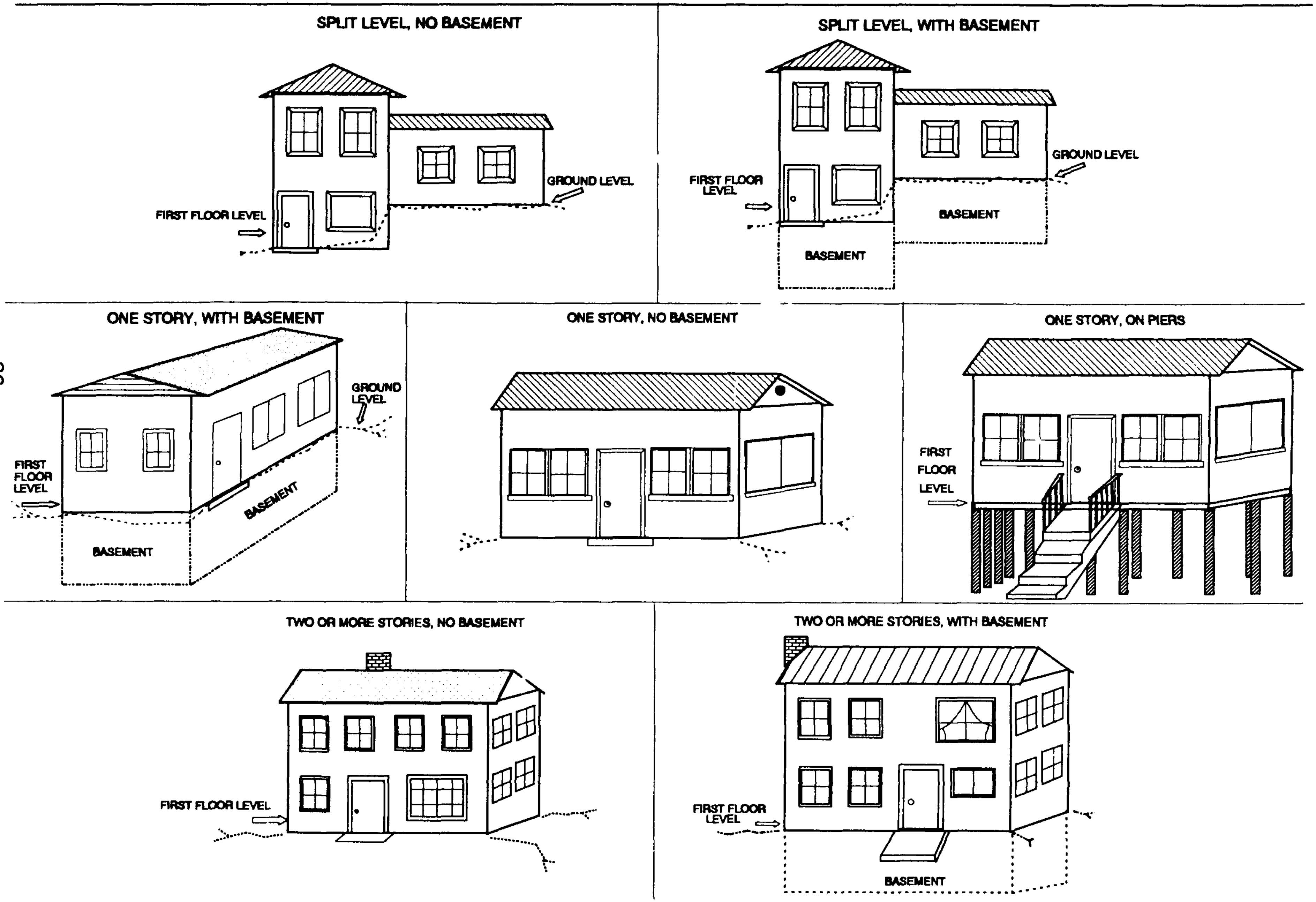
It should be noted that the damage function categories are entirely based on structure characteristics, with the exception of New Orleans District's freshwater and saltwater curves and Huntington District's mainstream and tributary curves.

TABLE 5
DERIVATION OF DEPTH-DAMAGE FUNCTIONS

DISTRICT OR DIVISION	DERIVATION
Alaska	1991 Flood Insurance Rate Review
Albuquerque	1991 Flood Insurance Rate Review, Surveys
Baltimore	1991 Flood Insurance Rate Review, St. Paul
Buffalo	1983 Survey
Charleston	1970 Survey
Chicago	1973 FIA, Various Surveys
Detroit	1973 FIA
Ft. Worth	Galveston
Galveston	1979 Survey, FIA Claims Data
Huntington	1975-1976 Survey
Jacksonville	FIA Claims Data, Various Surveys
Kansas City	1973 FIA, Adjusted
Little Rock	1968, 1981 Surveys
Los Angeles	1991 Flood Insurance Rate Review
Louisville	1991 Flood Insurance Rate Review, 1966 and 1978 Surveys
Memphis	1982 TVA
Mobile	1991 Flood Insurance Rate Review
Nashville	1970 FIA
New England Division	Various Surveys
New York	1973 FIA, 1981-85 Passaic River Survey

TABLE 5 DERIVATION OF DEPTH-DAMAGE FUNCTIONS	
DISTRICT OR DIVISION	DERIVATION
New Orleans	1978 Survey
Norfolk	1991 Flood Insurance Rate Review, Various Surveys
Omaha	1970 FIA
Pacific Ocean Division	1969-1970 Survey
Philadelphia	1973 FIA, Adjusted
Pittsburgh	Huntington
Portland	1991 Flood Insurance Rate Review
Rock Island	1973 FIA, Surveys
Sacramento	1991 Flood Insurance Rate Review
St. Louis	1973 FIA, Adjusted
St. Paul	Surveys, Synthetic Estimates
San Francisco	FIA Claims Data
Savannah	1991 Flood Insurance Rate Review
Seattle	1991 Flood Insurance Rate Review
Tulsa	Galveston
Vicksburg	New Orleans, 1982 TVA, Huntington
Walla Walla	1963 Study, Various Surveys
Wilmington	FIA Claims Data

FIGURE 1
ILLUSTRATIONS OF RESIDENTIAL STRUCTURE CLASSIFICATIONS USED BY CORPS OF ENGINEER DISTRICTS



LOWER MISSISSIPPI VALLEY DIVISION

Memphis

1. Derivation: Memphis' standardized depth-percent damage curves are taken directly from curves developed by the Tennessee Valley Authority (TVA) in 1982.

2. Type of Flooding: Flooding in the Memphis District may result from several meteorological phenomena (e.g., thunderstorms, tropical storms, frontal activity) and may be manifest as flash flooding along smaller streams, backwater flooding behind levees, and inadequate drainage or ponding drainage flooding in urban areas.

3. Type of Buildings: Depth-percent damage curves are differentiated for 15 residential building types: one story, no basement-slab (frame and masonry); one story, no basement (frame and masonry); one story, with basement (frame and masonry); two story, no basement-slab (frame and masonry); two story, no basement (frame and masonry), two story, with basement (frame and masonry); split-level (frame and masonry); and mobile homes. The depth-percent damage functions reflect the effects on damages of slab or wall-footing foundations and frame or masonry building material.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as replacement costs (new in kind and configuration), minus depreciation.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio used to estimate content value is 50 percent.

6. Structure Damage Definition and Determination: Structure damage is defined by the damage to a structure from a single flood event. A percentage is taken from the TVA depth-percent damage curves, based on the corresponding height attained by flood waters relative to the first floor level of the structure (-9' to +20'). This percentage is then multiplied by the replacement costs, minus depreciation, for that structure. This procedure is repeated for each structure in the flood zone.

7. Content Damage Definition and Determination: Content values are taken as the value of the contents within each structure. Procedures for computing damages to contents are the same as those used for structures.

New Orleans

1. Derivation: New Orleans District uses standardized depth-damage curves developed by the CH2M Hill, Inc. for the Lake Pontchartrain Hurricane Protection Study. Over 7,000 homes in New Orleans along the lake front were surveyed in 1978. The contractor visually inspected each structure and estimated expected damages from various levels of inundation. Curves were differentiated by structure type and type of flooding (i.e., fresh water versus salt water flooding).

2. Type of Flooding: Potentially severe flooding may occur in New Orleans District from periods of heavy rainfall associated with hurricanes, thunderstorms, or long duration frontal activity. Although flooding is generally of lower velocity, it may persist for long durations. In addition to damages caused by depth of inundation, the effects of salt water and tidal surge may also raise damages.

3. Type of Buildings: Depth-damage curves were derived for three residential building types (all with no basements): one story, two story, and mobile home. In addition, separate curves were developed for salt water and fresh water flooding. No determination was made of the effect of building material on the depth-damage functions.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as the depreciated replacement values, currently obtained from the Marshall and Swift Valuation Service residential estimating programs. Other potential sources of less detailed data would include census tract data from the Census of Housing and real estate values by neighborhood published annually by the University of New Orleans. For the Lake Pontchartrain study, however, depreciated replacement values were calculated by CH2M Hill from a statistical analysis using residential sales prices (obtained from the city's Central Appraisal Bureau) minus the cost of land.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio varies with the value of the structure. In the Lake Pontchartrain study, for example, contents averaged 60 percent of structure value, but ranged from 71 percent for homes under $30,000, 60 percent for homes between $30,000 and $50,000, and 48 percent for homes over $50,000.

6. Structure Damage Definition and Determination: Percent damages to structure value were determined for each one-half foot level of inundation in the New Orleans survey from -1' below first floor level to 15' above first floor level by taking the average of the total cost of repairs and clean-up to restore the structure to its pre-flood condition (i.e., less depreciation) and dividing by the average structure value for each structure type.

7. Content Damage Definition and Determination: Percent damages to contents value were determined for each one-half foot level of inundation in the New Orleans survey from -1' below first floor level to 15' above first floor level by taking the average cost of repair, clean-up, and replacement of damaged contents (less depreciation) and dividing by the average contents value for each structure type.

St. Louis

1. Derivation: The St. Louis District residential depth-damage curves are a modification of the 1973 FIA curves. The modifications are developed from actual damages observed during post-flood field surveys in urban areas. These modified curves thus reflect local flood damage conditions. Special curves are sometimes developed to fit unique buildings. Field surveys, real estate appraisers, consultants, and other sources are used to keep the curves current.

2. Type of Flooding: Flooding in the region may be caused by several meteorological phenomena. Riverine and stream flooding are most commonly caused by precipitation from intense thunderstorm activity and extended-duration frontal activity. Tributary flooding is usually of short duration.

3. Type of Buildings: Depth-damage curves are differentiated for eight standard residential building types: one story, no basement; one story, with basement; two or more stories, no basement; two or more stories, with basement; split-level, no basement; split-level, with basement; mobile home; and apartment.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and attached fixtures. Structure values are defined as replacement costs minus depreciation, which should approximate market values. Sources of data include professional real estate sales agents, appraisers, county sales records, and general cost references, such as the Marshall and Swift Valuation Service. Values for damage assessment purposes do not include land prices.

5. Content Definition and Value Determination. Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio used to estimate content values varies, but does not exceed 50 percent. Insurance companies generally assess content values at 50 percent of structure values as well. This practice tends to understate damage to wealthy areas, where the value of expensive contents may exceed structure values. Similarly, this bias may exist for low income areas, where the value of contents as a proportion of structure value rises.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see the FIA section above.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

Vicksburg

1. Derivation: Vicksburg District uses a computerized "Urban Flood Damage Program" which it developed to provide greater flexibility. It includes an option for selecting the appropriate depth-damage curves applicable to local flood conditions. The option currently includes standardized depth-damage curves from New Orleans District, Tennessee Valley Authority (TVA), and Huntington District. (For a description of the derivation of each of the curves, see the sections on New Orleans, Memphis TVA, and Huntington.)

2. Type of Flooding: Potentially severe flooding may occur in Vicksburg District from periods of heavy rainfall associated with tropical storms, thunderstorms, or long duration frontal activity. Although flooding is generally of low velocity, it may persist for long durations (e.g., ponding due to inadequate drainage, backwater flooding behind levees, etc.). Damages from this activity are mostly affected by depth of inundation. Flash floods are also prevalent in areas of intense development. These occur without warning and are shorter in duration, but occur with much greater velocity.

3. Type of Buildings: Depth-damage curves are derived for up to 15 residential building types and various categories of structure values. Structure types include one-, two-, and multi-story, with and without basement; split level; and mobile home. Curves are differentiated by building type (brick, frame, slab, pier, etc.) and type of flooding (e.g., freshwater versus saltwater flooding).

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as the market values, excluding the value of the land. This should approximate the depreciated replacement value of the structure. These values are obtained from professional appraisers within the Vicksburg District Real Estate Division.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio varies with the value of the structure and the affluence of the study area, but generally averages 50 percent in Vicksburg District.

6. Structure Damage Definition and Determination: Percent damages to structure were determined for each one-half foot level of inundation from -1 foot below first floor level to 15 feet above first floor level by taking the average of the total cost of repairs to restore the structure to its pre-flood condition (i.e., less depreciation) and dividing by the average structure value for each structure type.

7. Content Damage Definition and Determination: Percent damages to contents value were determined for each one-half foot level of inundation from -1 foot below first floor level to 15 feet above first floor level by taking the average cost of replacement of damaged contents "in kind" (less depreciation) and dividing by the average contents value for each structure type.

MISSOURI RIVER DIVISION

Kansas City

1. Derivation: Kansas City's standardized depth-damage curves are derived from 1973 FIA curves and adjusted using local post-flood survey data. (For a description of the derivation of FIA curves, see Chapter Three). The depth-damage relationships developed for apartments/duplexes use only locally obtained data.

2. Type of Flooding: Flooding in the region may be caused by several meteorological phenomena. Urban stream flooding is most commonly caused by precipitation from intense thunderstorm activity and extended-duration frontal activity. Floods are usually of short duration.

3. Type of Buildings: Depth-damage curves are differentiated for the seven standard residential building types defined by FIA in 1973, plus an apartment/duplex curve developed using local post-flood survey data.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as market values, obtained from recent sales prices and estimated values provided by real estate agents.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio used to estimate content value is 40 percent.

6. Structure and Contents Damage Definition and Determination: Percent damages to structure and contents are determined for each one-foot level of inundation from 1' to 4' (and every two feet for 4' to 12') by taking the average of the combined costs of structural repairs and contents replacement (less depreciation) and dividing by the combined average structure plus contents value for each structure type. The curves thus represent an aggregation of both structural and contents damages.

Omaha

1. Derivation: Omaha's standardized depth-damage curves are taken directly from 1970 FIA curves. (For a description of the derivation of FIA curves, see Chapter Three.)

2. Type of Flooding: Flooding in the region may be caused by several meteorological phenomena. In the eastern part of Omaha District, Missouri River floods of low velocity but long duration may result from snowmelt and extended-duration frontal activity. In the western part of the District, flash flooding may be caused by precipitation from intense thunderstorm activity.

3. Type of Buildings: Depth-damage curves are differentiated for the seven standard residential building types defined by FIA in 1970: one story, no basement; one story, with basement; two or more stories, no basement; two or more stories, with basement; split-level, no basement; split-level, with basement; and mobile home.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and attached fixtures. Structure values are defined as market values or depreciated replacement values, depending on the availability of data. Sources of data are real estate appraisals, recent sales prices, county tax assessments, and the Marshall and Swift Valuation Service.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio used to estimate content values varies from 35 to 50 percent (50 percent is used for reconnaissance studies).

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

NEW ENGLAND DIVISION

1. Derivation: New England Division does not employ standardized depth-damage curves. Rather, surveys are conducted for each study area, from which customized stage-damage relationships for various housing types and neighborhoods are developed. Corps interviewers gather information on actual damages experienced from past flooding, as well as synthetic flood damage estimates from area property owners. Division personnel construct stage-damage curves by expressing the resulting dollar damages at various depths of inundation.

2. Type of Flooding: Flooding in the region may be caused by several meteorological phenomena. Riverine and stream flooding are most commonly caused by precipitation from intense thunderstorm activity and extended-duration frontal activity. Coastal flooding may be caused by northeasters, tropical storms, or tidal actions.

3. Type of Buildings: Depth-damage curves are differentiated for each housing type characteristic of the study area. In addition to the standard categories defined by FIA, structures may also be characterized as colonial, cape cod, ranch, vacation or seasonal, and other styles.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined by market values. These values are obtained during surveys from recent sales data and local assessment offices. Assessed values may need to be inflated by an appropriate factor based on the sales-to-assessed value ratio maintained by many local government assessment offices.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. Content values are not expressed as a percent of structure value; rather, they are determined during actual interviews with property owners and by consulting published sources of cost information.

6. Structure Damage Definition and Determination: Typically, damages to structure are determined for each one-foot level of inundation from the start of damage to the Standard Project Flood (SPF) elevation by adding the average of the total cost of repairs to restore the structure to its pre-flood condition.

7. Content Damage Definition and Determination: Typically, damages to contents are determined for each one-foot level of inundation from the start of damage to the standard project flood (SPF) elevation by adding the total cost of replacing damaged contents "in kind."

NORTH ATLANTIC DIVISION

Baltimore

1. Derivation: Baltimore District employs standardized depth-damage curves taken directly from two sources. Baltimore has used St. Paul District's "Depth Damage System" (DDS) computer program for several flood control feasibility studies. The DDS program relates depth of flooding to actual dollar damages (not percent damages) for various structure values. Baltimore currently employs the Flood Insurance Rate Review curves updated annually by FIA. (For a description of the derivation of FIA curves, see Chapter Three.)

2. Type of Flooding: Flooding in the Baltimore District is generally of the flash flood type caused by overtopping of streambanks from heavy precipitation. Flooding is often both short duration and high velocity. Flooding in the St. Paul area, however, for which the DDS depth damage curves are assembled, is characterized by lower depths of inundation and longer duration.

3. Type of Buildings: DDS depth-damage curves are differentiated for only two structure types: one story, with and without basement. Separate depth-damage relationships are generated for basements, first floors without basements, and first floors with basements. No distinction is made between one and two story structures. No determination is made of the effect of building materials on the depth-damage functions.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as depreciated replacement values. For two recent feasibility studies, structure values were obtained from the West Virginia Department of Taxation. These appraised property values were calculated for the Department of Taxation using numbers from the Marshall and Swift Valuation Service as depreciated replacement values. Corps real estate appraisers then independently corroborated their validity. Recently, the District acquired residential valuation software from Marshall and Swift and is estimating depreciated replacement value based on square footage and age data from local taxing authorities and on type and condition of structures observed in the field.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. Content values are estimated as one-half of structure value. IWR conducted detailed surveys in 1988 in the flood plains of Petersburg and Moorefield, West Virginia, and Wilkes-Barre, Pennsylvania, and found the average ratios of contents to structure value were 50 and 72 percent, respectively.

6. Structure and Content Damage Definition and Determination: Synthetic damage estimates (in dollars) are determined by DDS for each one-tenth of a foot of inundation from 0' to 3' (and each half-foot of inundation from -7' to 0') for total residential values (structure plus contents) ranging from $1,000 to $50,000 in one-thousand dollar increments. Damages are also estimated for one- to three-foot intervals above 3' and up to 13.5'. Damages are assumed to be 60 percent structural and 40 percent contents.

New York

1. Derivation: New York District uses two sources of standardized depth-damage curves: 1973 FIA curves and those developed for the Passaic River Basin Study, New Jersey and New York. (For a description of the derivation of FIA curves, see Chapter Three.) The Passaic River curves were based on over 3,500 interviews and an inventory of over 50,000 structures in the floodplain. Property owners were interviewed regarding the amount of damage expected from various flood stages. Interview data was calibrated with post-flood data from 1981 through 1985 to verify the depth-damage functions. Additional surveys and updating and calibrating procedures are currently underway.

2. Type of Flooding: Flooding in the region is caused by several hydrological phenomena (e.g., intense thunderstorm activity, long duration frontal activity, snowmelt, ice jams) and may result in high velocity, short duration flash floods along streams and small rivers or low velocity, extended duration, low depth of inundation floods along larger rivers near the coast.

3. Type of Buildings: The depth-damage curves are differentiated for the seven standard residential building types defined by FIA in 1973. For the Passaic River curves, nine residential structure types are distinguished using local survey data (i.e., bungalow, bi-level, cape cod, colonial, mobile home, ranch, split-level, two-family, and a composite category including all other residential structure types). No distinct curves were derived for structures with or without basements because the damage surveys took into consideration the proportion of houses in each structure type category having basements. Except as incorporated in the characteristics of a particular structure type, the effect of building material on the depth-damage functions is not considered.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. For the FIA curves, the District defines structure values as replacement values, usually estimated from the "Means Construction Cost Guide." The replacement values per square foot provided by the Means Guide are then compared to market values supplied by real estate brokers for corroboration.
For the Passaic River curves, structure values are defined as market values (excluding land) obtained from recent sales prices and estimated values provided by real estate agents.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The District generally conducts a survey with property owners to estimate content damages as a percent of structure value. The ratio varies with the study, but averages 30-50 percent.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure values are determined by FIA, see Chapter Three. For the Passaic River curves, percent damages to structure value are determined for each one-foot level of inundation from -9' to 15' by taking the average value of damages to the structure and dividing by the average structure value for each structure type.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three. For the Passaic River curves, percent damages to contents value are determined for one-foot increments of inundation from -9' to 15' by taking the average cost of damaged contents and dividing by the average contents value for each structure type.

Norfolk

1. Derivation: Norfolk District employs both standardized depth-damage curves (taken directly from the most recent FIA Flood Insurance Rate Review, updated annually) and study-specific curves (obtained from conducting local floodplain surveys). Depending on the study, the District may also use curves constructed in-house from FIA claims data for a specific state or multi-state region.

2. Type of Flooding: Flooding in the region may be caused by several hydrological phenomena. Riverine and stream flooding are most commonly caused by precipitation from tropical storms, intense thunderstorm activity, and extended-duration frontal activity. Coastal flooding may be caused by northeasters, tropical storms, or tidal actions.

3. Type of Buildings: Depth-damage curves are differentiated for the six standard residential building types currently defined by FIA: one story, no basement; two or more stories, no basement; two or more stories, with basement; split-level, no basement; split-level, with basement; and mobile home.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as market values, obtained from tax assessments. Although assessed values should reflect 100 percent of market values (per State of Virginia requirements), assessed values frequently must be adjusted upward.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio used to estimate content values varies from 30-35 percent in the Norfolk-Virginia Beach urban area to 60 percent in the smaller towns.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

Philadelphia

1. Derivation: Philadelphia's standardized depth-damage curves are modified 1973 FIA curves. Based on observations from actual flood events, the District slightly increased the percent damages for flooding elevations of -2' and less.

2. Type of Flooding: Riverine and stream flooding are most commonly caused by precipitation from intense thunderstorm activity and are characterized by short duration, high velocity, and localized effects. Coastal storms may result in back bay flooding. A different set of damage relationships is used for coastal areas themselves because of the'effects of breaking waves and shore recession.

3. Type of Buildings: Depth-damage curves are differentiated for the seven standard residential building types defined by FIA in 1973.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as depreciated replacement values, estimated through the Marshall and Swift Valuation Service.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio used to estimate content value varies from community to community and depends on the level of detail of the study. For example, at the reconnaissance level, 40 percent is generally used for fluvial flood control studies, 25 percent for coastal studies. At the feasibility level, interviews conducted during surveys of the study area will determine the appropriate content-to-structure value ratio.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

NORTH CENTRAL DIVISION

Buffalo

1. Derivation: Buffalo District's standardized depth-damage curves are based on local post-flood survey data. The October 1983 survey covered several hundred residential structures in a suburb of Toledo, Ohio. Buffalo District is currently considering adopting the standardized Flood Insurance Rate Review curves updated annually by FIA. (For a description of the derivation of FIA curves, see Chapter Three.)

2. Type of Flooding: Flooding in the region may be riverine or stream flash flooding, resulting from thunderstorms or long duration frontal activity.

3. Type of Buildings: Depth-damage curves are derived for five residential building types: one story, no basement; one story, with basement; two story, no basement; two story, with basement; and split-level. No determination is made of the effect of building material on the depth-damage functions.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as market values, obtained from 1982 City of Toledo appraisals (minus land costs) and updated to current price levels. The accuracy of these prices is verified by comparing them to depreciated replacement values as estimated by the Boeckh Building Valuation Manual.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. Although the content-to-structure value ratio may vary, generally a 33 percent ratio is used to estimate content values. However, if the structure value exceeds $50,000, the content ratio is allowed to decrease to a minimum value of 25 percent.

6. Structure Damage Definition and Determination: Percent damages to structure value are determined for each 2/5-foot level of inundation from -8' to 8.8' by taking the average of the cost of repairs to restore the structure to its pre-flood condition (i.e., less depreciation) and dividing by the average structure value for each structure type.

7. Content Damage Definition and Determination: Percent damages to contents value are determined for each 2/5-foot level of inundation from -8' to 8.8' by taking the average cost of replacing damaged contents (less depreciation) and dividing by the average content value for each structure type.

Chicago

1. Derivation: Chicago District employs both standardized depth-damage curves (taken directly from 1973 FIA curves) and study-specific curves (obtained from conducting post-flood surveys). Depending on the study, the District may use either standard FIA curves or curves constructed from in-house surveys. Over the last ten years, the District has compiled a data base of residential depth-damage flood property information containing approximately 5,000 properties.

2. Type of Flooding: Flooding in the region may be caused by several hydrological phenomena. Riverine and stream flooding are most commonly caused by precipitation from intense thunderstorm activity and extended-duration frontal activity. Residential flooding may result from streambank overtopping, ponding from lack of adequate drainage, or sewer back-ups.

3. Type of Buildings: Depth-damage curves are differentiated for the seven standard residential building types defined by FIA in 1973.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined in conformity with the standardized curve applied to a particular study. For example, structure replacement costs less depreciation are used with FIA curves; market values, obtained from real estate appraisals and local tax assessments, may be used with locally derived depth-damage curves. At the reconnaissance level, estimates of structure values may be collected from census tract data.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. Content values are estimated using an algorithm relating structure value to household income. Shares of income expended for durable and non-durable goods are estimated. Content values are depreciated according to varying rates.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

Detroit

1. Derivation: Detroit's standardized depth-damage curves are taken directly from 1973 FIA curves. Although these curves were adjusted by Detroit District for some small commercial establishments, residential depth-damage relationships were not altered.

2. Type of Flooding: Flooding in the region may be caused by several hydrological phenomena, including high lake levels. Riverine and stream flooding are most commonly caused by precipitation from intense thunderstorm activity and extended-duration frontal activity.

3. Type of Buildings: Depth-damage curves are differentiated for the seven standard residential building types defined by FIA in 1973.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. For flood control studies started before the issuance of new guidance, structure values are defined as market values, obtained from city or county assessment offices or local real estate companies. For studies initiated since the distribution of new guidance, Detroit District plans to define structure values as depreciated replacement values.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio used to estimate content values varies from 30-35 percent for smaller communities to 50 percent for urban and suburban areas.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

Rock Island

1. Derivation: Rock Island's standardized depth-damage curves are derived from 1973 FIA curves and adjusted using local post-flood survey data. (For a description of the derivation of FIA curves, see Chapter Three.) The survey data was collected from flood damages in Liverpool, IL, during the years 1973 through 1979. The depth-damage relationships developed for split-foyer structures use only locally obtained data.

2. Type of Flooding: Flooding in the region may be caused by several hydrological phenomena (e.g., intense thunderstorm activity, long duration frontal activity, or snowmelt) and may result in high velocity, short duration flash floods along streams and small rivers or low velocity, extended-duration, low depth of inundation floods along the main stems of the Mississippi, Illinois, or Rock Rivers.

3. Type of Buildings: Depth-damage curves are differentiated for six of the seven standard residential building types defined by FIA in 1973 (i.e., one story, no basement; one story, with basement; two or more stories, no basement; two or more stories, with basement; split-level, with basement; and mobile home), plus a split-foyer, no basement developed using local post-flood survey data.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as market values, obtained from recent sales prices and estimated values provided by real estate agents.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio used to estimate content value is 35 percent.

6. Structure Damage Definition and Determination: Percent damages to structure value are determined for each half-foot level of inundation from -8' to 20' by taking the average of the cost of repairs to restore the structure to its pre-flood condition (i.e., less depreciation) and dividing by the average structure value for each structure type.

7. Content Damage Definition and Determination: Percent damages to contents value are determined for each half-foot level of inundation from -8' to 20' by taking the average of the cost of replacing damaged contents (less 40 percent depreciation) and dividing by the average contents value for each structure type.

St. Paul

1. Derivation: St. Paul District employs standardized depth-damage curves using the "Depth-Damage System" (DDS) computer program. The residential depth-damage relationships are based on post-flood surveys of real damages occurring in flooded communities in the St. Paul region. The program relates depth of flooding for actual or hypothetical flood events to dollar damages (not percent damages) for structures of various values and characteristics. Damage estimates are made on a structure-by-structure basis.

2. Type of Flooding: Flooding in the St. Paul region is generally characterized by lower depths of inundation (up to 8') of moderate duration (up to two weeks) and low velocity, often caused by snowmelt.

3. Type of Buildings: DDS residential depth-damage curves are differentiated for two structure types: one story, with and without basement. Separate depth-damage relationships are generated for basements, first floors without basements, and first floors with basements. No distinction is made between one and two story structures in the fixed database. This reflects the fact that most homes in the regional floodplains are one or one and one-half story construction. The applicability of the curves to structures of other types has not been tested. Structures with unique characteristics can be modelled independently by assigning unique depth-damage curves to each structure. (This procedure is typically used for commercial/ industrial/ public structures, but can be used for residential structures as well.)

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as market values, excluding all land-related values. Ideally, this should approximate the depreciated replacement value. Input values are determined through a combination of recent sales prices, tax assessments, and regional market conditions.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. Content values are estimated at one-third of structure value.

6. Structure and Content Damage Definition and Determination: Synthetic damage estimates (in dollars) are determined by DDS for each one-tenth of a foot of inundation from 0' to 3' (and each half-foot of inundation from -7' to 0') for total residential values (structure plus contents) ranging from $1,000 to $100,000 in one-thousand dollar increments. Damages are also estimated for one- to three-foot intervals above 3' and up to 13.5'. Damages are assumed to be 60 percent structural and 40 percent contents.

NORTH PACIFIC DIVISION

Alaska

1. Derivation: Although Alaska District has several sets of standardized depth-damage curves at its disposal, it most frequently uses the Flood Insurance Rate Review curves updated annually by FIA. Because of the small number of general investigation flood control studies undertaken by the District, it has not developed its own depth-damage curves.

2. Type of Flooding: Flooding in the region may be caused by several hydrological phenomena, including ice jam flooding along the interior rivers and coastal flooding from intense rainfall complicated by migrating channels.

3. Type of Buildings: Depth-damage curves are differentiated for the six standard residential building types currently defined by FIA.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as depreciated replacement values. However, this determination is a somewhat subjective process, as District real estate appraisers are asked to estimate the market values, taking into consideration physical depreciation and functional obsolescence.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed and that may be removed with the owner. The content-to-structure value ratio used to estimate content value has ranged from 25 to 50 percent.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

Portland

1. Derivation: Portland's standardized depth-damage curves are taken directly from the Flood Insurance Rate Review, updated annually by FIA.

2. Type of Flooding: Flooding in the region is generally caused by spring snowmelt or precipitation from extended-duration frontal activity. Although riverine flooding may occur along the Columbia or Willamette Rivers, smaller basins are more subject to flash floods and high velocity floods.

3. Type of Buildings: Depth-damage curves are differentiated for the six standard residential building types currently defined by FIA.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as market values, obtained from local tax assessment offices. Sampling is required to determine whether market values obtained from local tax assessment offices approximate the depreciated replacement values.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently attached. Currently, a 50 percent content-to-structure ratio is used.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

Seattle

1. Derivation: Seattle's standardized depth-damage curves are taken directly from the Flood Insurance Rate Review, updated annually by FIA.

2. Type of Flooding: Flooding in the region may be caused by several meteorological phenomena. Riverine and stream flooding are most commonly caused by snowmelt and intense precipitation from frontal activity and orographic effects.

3. Type of Buildings: Depth-damage curves are differentiated for the six standard residential building types currently defined by FIA.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as market values, obtained from local real estate companies and tax assessment offices. If the latter are used, the District constructs a sales-to-assessed value index and adjusts assessed values up or down by the appropriate factor to reflect market values.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio used to estimate content value is 50 percent.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

Walla Walla

1. Derivation: Walla Walla District employs standardized depth-damage curves derived from synthetic estimates, using a computer program originally developed at the District in 1963 for the study, "Boise River and Tributaries." Flood damage data from south central and eastern Idaho formed the basis of the original program. Beginning in 1968, an update of the program was undertaken incorporating relevant data from flood insurance studies in New Orleans District, residential flood damage appraisal systems in Omaha and Baltimore Districts, and additional post-flood damage surveys in Walla Walla District. The resulting damage versus depth data were expressed as percents of damage, separated for structures and contents. Several thousand actual flood-damaged structures are represented in the final standardized curves.

2. Type of Flooding: Flooding in Walla Walla District may result from riverine or groundwater flooding from heavy precipitation, snowmelt, or ice dams. Flooding may be characterized by high velocity and erosion damage.

3. Type of Buildings: Walla Walla's depth-damage curves are differentiated for 20 structure types: one story, with and without basement (frame and masonry); one and one-half story, with and without basement (frame and masonry); two story, with and without basement (frame and masonry); two-level, split-entry; three story, split-level; four story, split-level, five story, split-level; mobile home; and one and one-half, and two story log cabin. The effects of building materials on the depth-damage functions are incorporated in the curves

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as depreciated replacement values, as estimated by the W.F. Dodge Building Cost Calculator.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. Content values are estimated as a user-specified percent of structure value.

6. Structure Damage Definition and Determination: Percent damages to structure value were determined for each one-tenth foot level of inundation from 0' (first floor level) to 8' above first floor level by taking the average of the total cost of repairs (less depreciation) and dividing by the average structure value for each structure type.

7. Content Damage Definition and Determination: Percent damages to contents value were determined for each one-tenth foot level of inundation from 0' (first floor level) to 8' above first floor level by taking the average cost of replacement of damaged contents (less depreciation) and dividing by the average contents value for each structure type.

OHIO RIVER DIVISION

Huntington

1. Derivation: Huntington District uses standardized depth-damage curves developed by Stanley Consultants from an extensive survey of homes in the Huntington, WV/ Ashland, KY/ Portsmouth, OH area in 1975-1976. Curves are differentiated by structure type, ranges of housing values, and type of flooding (i.e., whether main stem or tributary flooding).

2. Type of Flooding: The flooding in Huntington District may be main stem river or tributary stream flooding, both resulting from periods of heavy rainfall. Main stem flooding is generally of longer duration, lower velocity, and provides more flood warning lead time. Damages caused by main stem flooding are overwhelmingly determined by depth of inundation. Tributary flooding on smaller rivers and streams can occur without warning and typically lasts a shorter duration but with greater flood velocity.

3. Type of Buildings: Depth-damage curves were derived for six residential building types: one story, no basement; one story, with basement; multi-story, no basement; multi-story, with basement; split-level; and mobile home. In addition, separate curves were developed for six categories of structure values for each structure type (i.e., $0-$12,699; $12,700-$21,099; $21,100-$31,599; $31,600-$52,699; $52,700-$105,399; and $105,400 and over). These structure value ranges are periodically updated to current price levels. No determination has been made of the effect of building material on the depth-damage functions because: 1) no significant coordination between building material and structural damage was identified during the studies; 2) use of building material as an added variable would have resulted in an unmanageable number of stage-damage curves; and, 3) the population of structures in the original study sample by building material is believed to adequately represent the overall population of the Huntington District.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are calculated as replacement costs less depreciation, using market values provided by local realtors' knowledge of recent sales prices and market conditions as tests to verify the applicability of valuation service data to the study area. If sampling indicates that the depreciated replacement and market values are inconsistent, additional validation procedures to ascertain the depreciated replacement value are employed.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratios used to estimate content values are determined as appropriate for each individual study area; no average or standard ratio is employed.

6. <u>Structure Damage Definition and Determination</u>: Percent damages to structure value were determined for each one-foot level of inundation in the Huntington survey from -8' below first floor level to 17' above first floor level (and from -8' to 25' for multi-story structures) by taking the average of the total cost of repairs to restore the structure to its pre-flood condition and dividing by the average structure value for each structure type.

7. <u>Content Damage Definition and Determination</u>: Percent damages to contents value were determined for each one-foot level of inundation in the Huntington survey from -8' below first floor level to 17' above first floor level (and from -8' to 25' for multi-story structures) by taking the average cost of repair and replacement of damaged contents (less depreciation) and dividing by the average contents value for each structure type and value range.

Louisville

1. Derivation: Louisville District uses several standardized depth-damage curves and selects the most appropriate set for a particular flood control study. The curves most frequently used by Louisville are the Flood Insurance Rate Review curves which are updated by FIA annually. (For a description of the derivation of FIA curves, see Chapter Three.) Other depth-damage relationships used for particular studies include the set of curves based on a post-flood survey in Frankfort, Kentucky, which was inundated in December 1978 by the maximum flood of record. Another set was derived from surveys conducted in the Louisville area in 1966 and from previous Corps records of flooding in Louisville going back to 1937. Louisville has also used the curves developed by Huntington District during an extensive survey of homes in the Huntington, WV/Ashland, KY area in 1975-1976. Because the Huntington curves will be discussed under the Huntington District section, the following explanations are specific to the Louisville and Frankfort post-flood surveys.

2. Type of Flooding: The flooding in Louisville District may be main stem river or stream flooding, both resulting from periods of heavy rainfall. Main stem flooding is generally of longer duration, lower velocity, and provides more flood warning lead time. Damages caused by main stem flooding are overwhelmingly determined by depth of inundation. Tributary flooding on smaller rivers and streams can occur with little warning and typically lasts a shorter duration, but with greater flood velocity. The Frankfort survey represents Kentucky River main stem flooding, while the Louisville survey represents Ohio River main stem flooding. Louisville District uses the FIA curves for small stream flooding.

3. Type of Buildings: Depth-damage curves were derived for four residential building types in the Frankfort survey: one story, no basement; one story, with basement; one and a half or two stories, no basement; one and a half or two stories, with basement; and for three building types in the Louisville survey (all with basements): one story, one and a half story, and two story. The effect of building material on the depth-damage functions was not determined.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as depreciated replacement values, obtained from the Marshall and Swift Valuation Service. Corps appraisers are trained by Marshall and Swift in methods of establishing depreciated replacement values for each structure in the floodplain inventory.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. A 50 percent content-to-structure value ratio is used to estimate content values.

6. Structure Damage Definition and Determination: Percent damages to structure were determined for each one-foot level of inundation in the Frankfort survey from -8' below first floor level to 20' above first floor level (and from -8' to 16' in the Louisville survey) by taking the average of the total cost of repairs (less depreciation) and clean-up of structure and dividing by the average structure value for each structure type.

7. Content Damage Definition and Determination: Percent damages to contents were determined for each one-foot level of inundation in the Frankfort survey from -8' below first floor level to 20' above first floor level (and from -8' to 16' in the Louisville survey) by taking the average of the cost of repair, clean-up, and replacement of damaged contents (less depreciation) and dividing by the average contents value for each structure type.

Nashville

1. Derivation: Nashville's standardized depth-damage curves are taken directly from 1970 FIA curves. (For a description of the derivation of FIA curves, see Chapter Three.)

2. Type of Flooding: Flooding in the region may be caused by several meteorological phenomena. Riverine and stream flooding are most commonly caused by precipitation from intense thunderstorm activity and extended-duration frontal activity. Flooding is usually of short duration.

3. Type of Buildings: Depth-damage curves are differentiated for the seven standard residential building types defined by FIA in 1970: one story, no basement; one story, with basement; two or more stories, no basement; two or more stories, with basement; split-level, no basement; split-level, with basement; and mobile home.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined, according to Corps real estate personnel, as "contributory/allocated" values, ascertained by qualified appraisers. The appraisers collect these market values from comparable sales data.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio used to estimate content values is 50 percent.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

Pittsburgh

1. Derivation: Pittsburgh District uses standardized depth-damage curves taken directly from Huntington District. (For a description of the derivation of Huntington District's curves, see the Huntington section above). Curves are differentiated by structure type, ranges of housing values, and type of flooding (i.e., whether main stem or tributary flooding).

2. Type of Flooding: The flooding in Pittsburgh District may be main stem river or tributary stream flooding, both resulting from periods of heavy rainfall. Main stem flooding is generally of longer duration, lower velocity, and provides more flood warning lead time. Damages caused by main stem flooding are overwhelmingly determined by depth of inundation. Tributary flooding on smaller rivers and streams can occur without warning and typically lasts a shorter duration but with greater flood velocity.

3. Type of Buildings: Depth-damage curves were derived for six residential building types: one story, no basement; one story, with basement; multi-story, no basement; multi-story, with basement; split-level; and mobile home. In addition, separate curves were developed for six categories of structure values for each structure type (i.e., $0-$12,699; $12,700-$21,099; $21,100-$31,599; $31,600-$52,699; $52,700-$105,399; and $105,400 and over). These ranges of structure values are periodically updated to current price levels. No determination is made of the effect of building material on the depth-damage functions because 1) no significant coordination between building material and structural damage was identified during the studies; and, 2) use of building material as an added variable would have resulted in an unmanageable number of stage-damage curves.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as market values, provided by local realtors' knowledge of recent sales prices and market conditions.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. Historically, a 50 percent content-to-structure value ratio has been used to estimate content values.

6. Structure Damage Definition and Determination: Percent damages to structure value were determined for each one-foot level of inundation in the Huntington survey from -8' below first floor level to 17' above first floor level (and from -8' to 25' for multi-story structures) by taking the average of the total cost of repairs and clean-up of the structure and dividing by the average structure value for each structure type.

7. Content Damage Definition and Determination: Percent content damages were determined for each one foot level of inundation in the Huntington survey from -8' below first floor level to 17' above first floor level (and from -8' to 25' for multi-story structures) by taking the average repair, clean-up, and replacement costs of damaged contents (less depreciation) and dividing by the average contents value for each structure type and value range.

PACIFIC OCEAN DIVISION

1. Derivation: Pacific Ocean Division's standardized depth-damage curves are taken directly from the Flood Insurance Rate Review, updated annually by FIA. (For a description of the derivation of FIA curves, see Chapter Three.) If local post-flood survey data are available, the FIA curves may be slightly modified as appropriate to reflect the local conditions.

2. Type of Flooding: Flooding in the region is often flash flooding of streams, resulting from thunderstorms or tropical storms. Floodplains are often small in area but steep in gradient, resulting in high velocity flows of short duration.

3. Type of Buildings: Depth-damage curves are differentiated for the six standard residential building types currently defined by FIA.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as depreciated replacement values, obtained from county tax assessment offices. The county assessors estimate structure replacement costs less depreciation, not market values. Property assessments are regularly reviewed and updated; properties not re-assessed during a given year are inflated at an annual rate of three percent.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. A survey of residences was performed in Hilo in 1977 to estimate the content-to-structure value ratio for homes of various value ranges. Survey results indicated that the relationship between structure and content values varies with the value of the structure. For homes having a depreciated replacement cost of under $10,000, contents are valued at 90 percent of structure value; for homes costing $10,000 - $20,000, 40 percent; for homes costing $20,001 - $30,000, 27 percent; for homes costing $30,001 - $40,000, 23 percent; for homes costing $40,001 - $60,000, 21 percent; and, for homes costing over $60,000, 20 percent. These depreciated replacement costs have not been updated for inflation.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

SOUTH ATLANTIC DIVISION

Charleston

1. Derivation: Charleston District employs standardized depth-damage curves taken directly from the 1970 FIA curves. The original FIA curves were partially based on actual post-flood surveys conducted by Charleston District in 1969 in two floodplains in Charlotte, NC. The survey included a representative sample of the various types of structures and contents located in the floodplains.

2. Type of Flooding: Flooding in the region may be caused by several meteorological phenomena. Riverine and stream flooding are most commonly caused by precipitation from intense thunderstorm activity and extended-duration frontal activity. Damages usually occur from inundation by short duration floods with little significant damage due to water velocities.

3. Type of Buildings: Depth-damage curves are differentiated for the seven standard residential building types defined by FIA in 1970.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as market values (which are expected to approximate depreciated replacement values), ascertained from tax roll assessments and corroborated by real estate professionals. If the depreciated replacement and market values are inconsistent, additional validation procedures to ascertain the depreciated replacement value are employed.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. Content values are estimated as a percentage of structure value for the reconnaissance phases of continuing authorities studies. For general investigation studies and feasibility phases, a field survey is conducted to determine content values.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

Jacksonville

1. Derivation: Jacksonville's standardized depth-damage curves are based on thousands of actual flood damage claims received by FIA in the state of Florida from 1978 through 1989. The District obtains claims data from FIA annually and uses samples of approximately 8,000 and 5,500 units, respectively, in estimating structural and contents depth-damage relationships. Separate curves were developed for flood damages in Puerto Rico and the Virgin Islands based on post-flood surveys conducted on the islands.

2. Type of Flooding: Flooding in Florida results from heavy precipitation associated with thunderstorm activity or tropical storms. Damages are mostly affected by depth of inundation. In the Caribbean, flash floods may occur in mountainous areas; therefore, flood velocity is also a damaging mechanism.

3. Type of Buildings: Depth-damage curves are differentiated for three residential building types: one story, no basement; mobile homes; and apartments/duplexes. No determination was made of the effect of building material on the depth-damage functions.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as market values or depreciated replacement values, depending on the availability of survey data. Both market and depreciated replacement values are obtained from professional appraisers within the District Real Estate Division.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio used to estimate content value varies with the study area, but averages 40 percent. The ratio may rise to 50 percent over the 50-year project life based on OBER's projections of rising economic affluence.

6. Structure Damage Definition and Determination: Percent damages to structure value are determined for each one-foot level of inundation from 0' to 10' by taking the average of the cost of repairs to restore the structure to its pre-flood condition (less depreciation) and dividing by the average structure value for each structure type.

7. Content Damage Definition and Determination: Percent damages to contents value are determined for each one-foot level of inundation from 0' to 10' by taking the average cost of replacing damaged contents (less depreciation) and dividing by the average contents value for each structure type.

Mobile

1. Derivation: Mobile's standardized depth-damage curves are currently taken directly from the Flood Insurance Rate Review, updated annually by FIA.

2. Type of Flooding: Flooding in the region may be caused by several meteorological phenomena. Riverine and stream flash floods are most commonly caused by precipitation from tropical storms, intense thunderstorm activity, and extended-duration frontal activity. Tidal flooding may occur in coastal areas. Extensive flooding along the Pearl River, MS, in 1979 and 1983, and along the Pea River in 1990, provided damage data against which to corroborate the depth-damage curves at all depths of inundation.

3. Type of Buildings: Depth-damage curves are differentiated for the six standard residential building types currently defined by FIA.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as market values, ascertained by certified Corps real estate appraisers. The District may employ "block appraisals" for whole subdivisions during the feasibility phase, while "individual unit appraisals" are estimated during the General Design Memorandum (GDM) Phase.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The District follows casualty insurance industry norms in estimating content-to-structure value ratios, ranging from 30 percent to a maximum of 50 percent.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

Savannah

1. Derivation: Savannah District employs standardized depth-damage curves taken directly from the Flood Insurance Rate Review, updated annually by FIA.

2. Type of Flooding: Flooding in the region may be caused by several meteorological phenomena. Riverine and stream flooding are most commonly caused by precipitation from tropical storms, intense thunderstorm activity, and long duration frontal activity. Tidal flooding may occur in coastal areas.

3. Type of Buildings: Depth-damage curves are derived for the six residential building types currently defined by FIA.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as replacement costs, less depreciation (using market values as an initial proxy, supplemented by additional validation procedures). Market values are obtained through field surveys or gross appraisals. They may also be computed by inflating assessed property values (obtained from county tax assessment offices) by the appropriate county-specific sales-to-assessed value factor. For example, surveys from a recent study indicated that properties were assessed at approximately 40 percent of their market values. In this case, the applicable sales value-to-assessed value multiplier would be 2.5.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. Generally, a 50 percent content-to-structure value ratio is used to estimate content values.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

Wilmington

1. Derivation: Although Wilmington's standardized depth-damage curves were originally acquired from Galveston District, the curves have subsequently been revised with FIA data. Wilmington District updates its depth-damage curves annually using national flood damage claims data received from FIA.

2. Type of Flooding: Flooding in the region may be riverine or coastal, caused by intense thunderstorm activity, long duration frontal activity, or tropical storms.

3. Type of Buildings: Depth-damage curves are differentiated for 16 residential building types: one story, no basement; one story, with basement; one story, high-raised; one story; high-raised, with half living area below; two stories, no basement; two stories, with basement; two stories, high-raised: two stories; high-raised, with half living area below; split-level, with all living space; split-level, with garage on lowest level; split-level, with half garage and half living space on lowest level; one and one-half story, no basement; one and one-half story with basement; one and one-half story, high-raised; one and one-half story; high-raised, with half living area below; and mobile home.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as replacement costs less depreciation. When market values approximate depreciated replacement values, market values are used as an initial proxy. If the depreciated replacement and market values are inconsistent, additional validation procedures to ascertain the depreciated replacement value are employed. Typically, the District obtains depreciated replacement values from county tax appraisal data, which usually incorporate the Marshall and Swift or a similar standardized valuation program in assessing real estate values.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio used to estimate content value varies from 40 to 50 percent, depending on the affluence of the study area. Generally, 40 percent is used for middle class areas, while 50 percent may be more appropriate for both high and low income neighborhoods.

6. Structure Damage Definition and Determination: Percent damages to structure value are determined for each foot of inundation (and interpolated between increments) from -15' to 24' by taking the average of the cost of repairs to restore the structure to its pre-flood condition (i.e., less depreciation) and dividing by the average structure value for each structure type.

7. Content Damage Definition and Determination: Percent damages to contents value are determined for each foot of inundation (and interpolated between increments) from -15' to 24' by taking the average cost of replacing damaged contents (less depreciation) and dividing by the average contents value for each structure type.

SOUTH PACIFIC DIVISION

Los Angeles

1. Derivation: Los Angeles' standardized depth-damage curves are taken directly from the Flood Insurance Rate Review, updated annually by FIA. (For a description of the derivation of FIA curves, see Chapter Three.)

2. Type of Flooding: Flooding in the region is infrequent. Damage that does occur usually results from thunderstorm-induced flash floods, which may carry large sediment loads at high velocities.

3. Type of Buildings: The District employs curves for five structure types: one story, no basement; two or more stories, no basement; split-level, no basement; mobile home; and multi-family residences.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Depreciated replacement values, as appraised using the Marshall and Swift valuation service, define structure values.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. Contents are valued at 50 percent of structure value.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

Sacramento

1. Derivation: Sacramento's standardized depth-damage curves are taken directly from the Flood Insurance Rate Review, updated by FIA annually. (For a description of the derivation of FIA curves, see Chapter Three.)

2. Type of Flooding: Riverine flooding in the region may be manifested as overtopping of banks or ponding in the delta region. The former is characterized by short duration (1-2 days) and shallower depth (1-4 feet); the latter by long duration (up to 60 days) and greater depth (6-20 feet).

3. Type of Buildings: Depth-damage curves are differentiated for the six standard residential building types currently defined by FIA: one story, no basement; two story, no basement; two story, with basement; split-level, no basement; split level, with basement; and mobile home.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as depreciated replacement values, obtained through consultations with local real estate professionals and county assessment offices. Verification is accomplished through estimates of replacement costs, less depreciation, on a square footage basis provided by the Marshall Valuation Service.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. Contents are valued at 50 percent of structure value.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

San Francisco

1. Derivation: San Francisco's standardized depth-damage curves are based on thousands of actual flood damage claims received by FIA nationwide through 1979. The District obtained the claims data from FIA and performed its own regression analysis in-house to estimate several depth-damage relationships. Reported damages at negative depths (i.e., below the first floor) were deleted from the regression analysis because they appeared to distort the regressed results. The resulting R^2s were generally over 90 percent.

2. Type of Flooding: Flooding in this heavily urbanized region is usually the result of short duration, high velocity flash floods caused by winter storms.

3. Type of Buildings: Depth-damage curves are differentiated for six standard residential building types: one story, no basement; one story, with basement; two or more stories, no basement; two or more stories, with basement; split-level, no basement; and mobile home.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as market values minus the cost of land. Market values are obtained from tax assessment records. They must be adjusted, however, based on the prevailing relationship between assessed and market values. The passage of Proposition 13 in California has led to property tax assessments that substantially underestimate their real market value.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. The content-to-structure value ratio used to estimate content value was historically 35 percent. However, after consultations with insurance appraisers, the District is contemplating increasing the ratio to 50 percent.

6. Structure Damage Definition and Determination: Percent damages to structure value are determined for each one-foot level of inundation from -4' to 10' based on the average of the cost of repairs to restore the structure to its pre-flood condition (less depreciation), compared with the average structure value for each structure type using regression analysis.

7. Content Damage Definition and Determination: Percent damages to contents value are determined for each one-foot level of inundation from -4' to 10' based on the average of the total cost of replacing damaged contents (less depreciation), compared with the average contents value for each structure type using regression analysis.

SOUTHWESTERN DIVISION

Albuquerque

1. Derivation: Albuquerque's standardized depth-damage curves are taken directly from the Flood Insurance Rate Review, updated by FIA annually. (For a description of the derivation of FIA curves, see Chapter Three.) An additional curve for adobe structures was derived from local post-flood surveys.

2. Type of Flooding: Flash flooding along arroyos (dry stream beds) may be caused by precipitation from intense thunderstorm activity. Longer duration, lower velocity flooding may occur along the Rio Grande Valley.

3. Type of Buildings: Depth-damage curves are differentiated for the six standard residential building types currently defined by FIA: one story, no basement; two or more stories, no basement; two or more stories, with basement; split-level, no basement; split-level, with basement; and mobile home. The District developed a seventh curve for one story, no basement adobe structures. Adobe buildings have dramatically higher damages for the same level of flooding.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and attached fixtures. Structure values are defined as depreciated replacement values, primarily obtained from use of the Marshall and Swift Valuation Service.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. Although a 50 percent content-to-structure value ratio is used by the District, some economists believe this may underestimate content damages. Insurance agents, contacted by the District, generally insure contents at 60 to 70 percent of structure value.

6. Structure Damage Definition and Determination: For a description of how percent damages to structure value are determined by FIA, see Chapter Three.

7. Content Damage Definition and Determination: For a description of how percent damages to contents value are determined by FIA, see Chapter Three.

Ft. Worth

1. Derivation: Ft. Worth's standardized depth-damage curves are taken directly from those established by the Galveston District. Those curves, in turn, represent a composite of post-flood survey data and FIA claims data. (For a description of the derivation of the Galveston curves, see the Galveston section below.)

2. Type of Flooding: Flooding in the region may be caused by several hydrological phenomena. Riverine and stream flooding are most commonly caused by precipitation from tropical storms, intense thunderstorm activity, and long duration frontal activity.

3. Type of Buildings: Depth-damage curves are derived for seven residential building types (all with no basements): one story; one and one-half story; two story, mobile home; high-raised structure; one level apartment; and two level condo/townhouse. No determination was made of the effect of building material on the depth-damage functions. Ft. Worth District uses a single, generalized depth-damage curve, weighted by the distribution of structure types in a given study area, for reconnaissance studies. More detailed breakdowns (seven structure types) are used at the feasibility phase.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as the depreciated replacement values, "which should approximate market value in a properly functioning market."

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. Generally, a 50 percent content-to-structure value ratio is used to estimate content values.

6. Structure Damage Definition and Determination: Percent damages to structure value are determined for each one-foot level of inundation from 0' to 24' by taking the average of the cost of repairs "to make the structure whole again", and dividing by the average structure value for each structure type. The cost of repairs is not depreciated.

7. Content Damage Definition and Determination: Percent damages to contents value are determined for each one-foot level of inundation from 0' to 24' by taking the average of the cost of replacing damaged contents (less depreciation) and dividing by the average contents value for each structure type.

Galveston

1. Derivation: Galveston District's standardized depth-damage curves are based on a composite of several post-flood surveys, the first of which took place in the mid-1970s at Mingo Creek, in Tulsa, OK. The most recent survey was conducted in the town of Alvin, TX, which was struck by Tropical Storm Claudette in 1979. Most residential structures were flooded with up to three feet of water. Because of the small sample size of structures that experienced higher levels of inundation, Galveston District had to rely on additional information from the FIA to derive damage percentages above three feet. Thus, the Galveston curves, which over the years have been used and modified by several other Corps districts, represent a combination of local post-flood surveys and FIA claims data.

2. Type of Flooding: The flooding in Alvin, TX resulted from intense rainfall, amounting to 42" in a 24-hour period and leading to the overflow of Mustang Bayou. Many towns in a wide area reported over 20" of rainfall during the same 24-hour period.

3. Type of Buildings: Depth-damage curves are derived for seven residential building types (all with no basements): one story; split-level; two story; mobile home; high-raised structure; one level apartment; and two level condo/townhouse. No determination was made of the effect of building material on the depth-damage functions.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as depreciated replacement values, ascertained from the Marshall and Swift's Residential Estimator Program.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. While a 50 percent content-to-structure value ratio is generally used to estimate content values, higher ratios have been employed. In the Cypress Creek, Texas study, for example, a 58 percent content-to-structure value ratio was employed based on sampling results from a universe of 6,000 residential structures in the study area.

6. Structure Damage Definition and Determination: Percent damages to structure value are determined for each one-foot level of inundation from 0' to 19' by taking the average of the cost of repairs "to make the structure whole again", and dividing by the average structure value for each structure type. The cost of repairs is not depreciated.

7. Content Damage Definition and Determination: Percent damages to contents value are determined for each one-foot level of inundation from 0' to 19' by taking the average of the [illegible] replacing damaged contents (less depreciation) and dividing by the average content value for each structure type.

Little Rock

1. Derivation: Little Rock District's standardized depth-damage curves are based on data compiled from two local surveys: a post-flood survey in Fourche Creek, AR, in 1968, and a survey of potentially flooded residences in Ft. Smith, AR in 1981. For the Ft. Smith study, questionnaires were sent to potentially affected residential properties and followed up by personal interviews by District personnel. Residents were asked to estimate damages for various depths of inundation. The curves were developed by averaging potential damages as a percent of structure value from over 400 observations.

2. Type of Flooding: Flooding in the region may be caused by several meteorological phenomena. Riverine and stream flooding are most commonly caused by precipitation from tropical storms, intense thunderstorm activity, and long duration frontal activity.

3. Type of Buildings: Depth-damage curves are derived for six residential building types (all without basements): one story slab foundation; one story block foundation; two story slab foundation; two story block foundation; one or two story frame on block foundation; and mobile home. Distinctions between foundation types and frame and masonry structures indicate that building material is a factor in the determination of depth-damage functions.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined by market or replacement values, obtained from county assessment offices.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed and that can be taken with the owner. The content-to-structure value ratio may vary from 20 to 50 percent depending on the affluence of the study area. Generally, a 50 percent ratio is used to estimate content values.

6. Structure Damage Definition and Determination: Percent damages to structure value are determined for each one-foot level of inundation from 0' to 10' by taking the average of the cost of repairs to restore the structure to its pre-flood condition (i.e., less depreciation) and dividing by the average structure value for each structure type.

7. Content Damage Definition and Determination: Percent damages to contents value are determined for each one-tenth foot level of inundation from 0' to 4.5' by taking the average cost of replacing damaged contents (less depreciation) and dividing by the average content value. Only one contents damage curve is used for all structure types.

Tulsa

1. Derivation: Tulsa District's standardized depth-damage curves are taken directly from those established by the Galveston District. Galveston District's curves, in turn, are based on a composite of several local post-flood surveys and claims data from the FIA. (For a description of the derivation of Galveston curves, see the Galveston section above.) Tulsa District's depth-damage curves for some commercial categories were developed from flood damage data collected by Tulsa District in the 1974 and 1976 post-flood damage surveys from floods on Mingo Creek.

2. Type of Flooding: Flooding in the region may be caused by several hydrological phenomena, but is often characterized by high velocity, short duration flash floods arising from intense thunderstorm activity.

3. Type of Buildings: Depth-damage curves are derived for nine residential building types: one story; split-level; two story; mobile home; high-raised structure; one level apartment; two level condo/ townhouse; one and two story, with basement; and one and one-half story, with basement. No determination has been made of the effect of building material on the depth-damage functions.

4. Structure Definition and Value Determination: Structures are defined as the residential buildings and everything permanently built into them. Structure values are defined as depreciated replacement values, obtained through the Marshall and Swift's Residential Estimator Program.

5. Content Definition and Value Determination: Household contents are defined as everything within the structure not permanently installed. A 50 percent content-to-structure value ratio is used to estimate content values.

6. Structure Damage Definition and Determination: Percent damages to structure value are determined for each one-foot level of inundation from 0' to 19' by taking the average of the cost of repairs to "make the structure whole again", and dividing by the average structure value for each structure type. The cost of repairs is not depreciated.

7. Content Damage Definition and Determination: Percent damages to contents value are determined for each one-foot level of inundation from 0' to 19' by taking the average cost of replacing damaged contents (less depreciation), and dividing by the average content value for each structure type.

CHAPTER FIVE

INTER-DISTRICT COMPARISONS OF DEPTH-DAMAGE FUNCTIONS

The principal differences between the depth-damage functions used throughout the Corps can easily be observed from the tables in Appendix A. An observer can quickly discover the differences in structure type definition, beginning damage water height, inflection points, and magnitude of damages. This chapter begins with a few observations on these differences and then graphically presents a selection of depth-damage functions for the various structure types. The graphs are not comprehensive; the number of damage functions presented on each graph is limited to avoid cluttering. However, the graphs do illustrate the range of damage functions found for various structure types. The narrative found in Chapter Four, and a knowledge of the differences in sources of flooding on which these damage function are based, can lead to an understanding of the diversity of the damage functions.

DIFFERENCES IN STRUCTURE TYPE DEFINITION

Categories of structures include the basic structure classes, used by nearly all districts to some extent. These include single story, one and a half, split-level, and two or more stories (all with or without basement), and mobile homes. New York District uses various styles of houses including cape cod, colonial, and ranch for the Passaic River Basin. Pacific Ocean Division has categories for high-raised structures and structures on piers, and Galveston District also has a high-raised category. Kansas City and Galveston have a town house/condo category. Charleston distinguishes between basements with living areas and basements used only for storage. Memphis, Walla Walla, Jacksonville Districts all have curves that distinguish between different building materials.

DIFFERENCES IN BEGINNING DAMAGE LEVEL

Damages begin for both mobile home structures and contents at one foot below the floor level and the floor level. For houses without basements, structural damage starts anywhere from -2 feet to the first floor level and content damage begins mostly at the first floor level. For houses with basements, structural and content damage starts anywhere from -8 to -4 feet, with the FIA curves showing damage starting at -4 feet.

DIFFERENCES IN INFLECTION POINTS

Inflection points occur where there is a significant change in the slope of a mathematical function. When applied to depth-damage relationships, they refer to a water height where there is a significant change in the rate of increase in percent damage. Understanding where inflection points are likely to occur can be useful in constructing reasonable depth-damage relationships.

Damage functions for mobile homes are very steep from one foot below the floor level to 3 feet above the floor. For one story homes, without basements, the percent damage-to-structure increases at an increasing rate at 0 and 4 feet, and at 0 and 2 feet for percent damage-to-contents. For one story homes, with basements, the rate of increase in percent damage-to-structure increases at 0 and 4 feet, while percent damage-to-contents increases at an increasing rate at 0 and 2 feet and slows considerably after 6 feet. Percent damages-to-structure for homes with two or more stories, with basements, increases at an increasing rate at 0, 4, and 8 feet. Percent damages-to-contents for homes with two or more stories, with basements increases at an increasing rate at 0 and 8 feet.

DIFFERENCES IN MAGNITUDE OF DAMAGES

Because of space limitations, depths of flooding for the tables in Appendix A and the graphs in this chapter stop at 10 feet. But 10 feet is still high enough to illustrate the percent damage at which most of the structure and content damage functions top out.

Structure and content damage functions for mobile homes generally top out in the 80 to 100 percent range at about 4 feet above the floor level.

One story, without basement curves increase to 10 feet, where damages reach the 40 to 60 percent range for structure damage and about 80 percent for content damage. One story, with basement damage functions increase to the 10 foot level where they reach the 50 percent level for structure and 50 to 85 percent level for contents.

Two story, no basement curves increase to the 10 foot level, where they reach the 30 to 40 percent range for structures. The percent damage-to-contents can range anywhere from 20 to 80 percent, but generally average about 60 percent damage. Two story, with basement curves increase to the 10 foot level, where they reach the 40 to 50 percent range for percent damage-to-structure and the 50 to 65 percent range for percent damage-to-contents.

Figures 2-31 graphically portray a range of structural and content damage functions used by FIA and Corps district and division offices.

GRAPHS OF RESIDENTIAL DAMAGE FUNCTIONS

FIGURES 2-31

Figure 2

Percent Damage to Structure Value
ONE STORY, NO BASEMENT

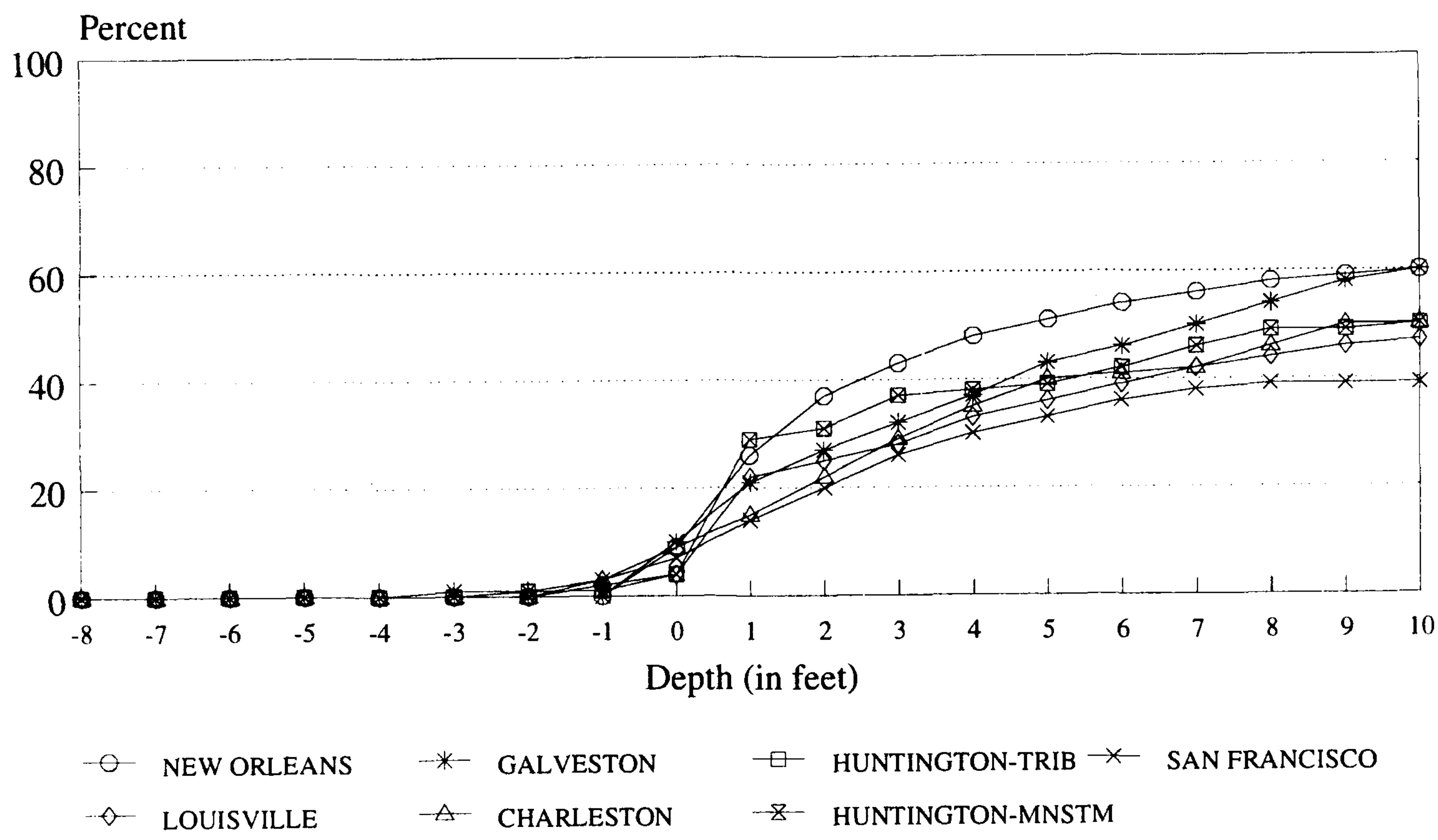


Figure 3

Percent Damage to Structure Value
ONE STORY, NO BASEMENT

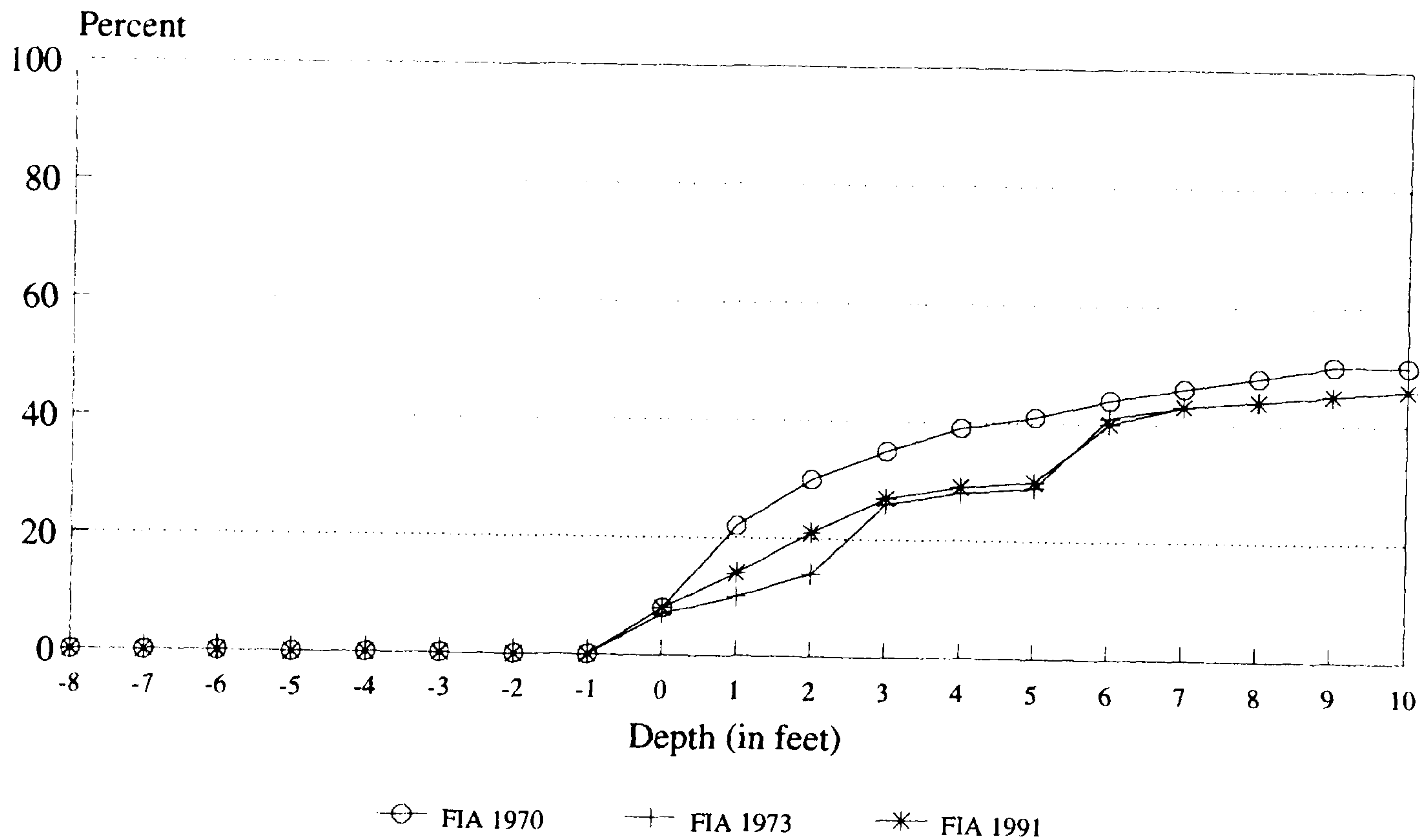


Figure 4

Percent Damage to Structure Value
ONE STORY, WITH BASEMENT

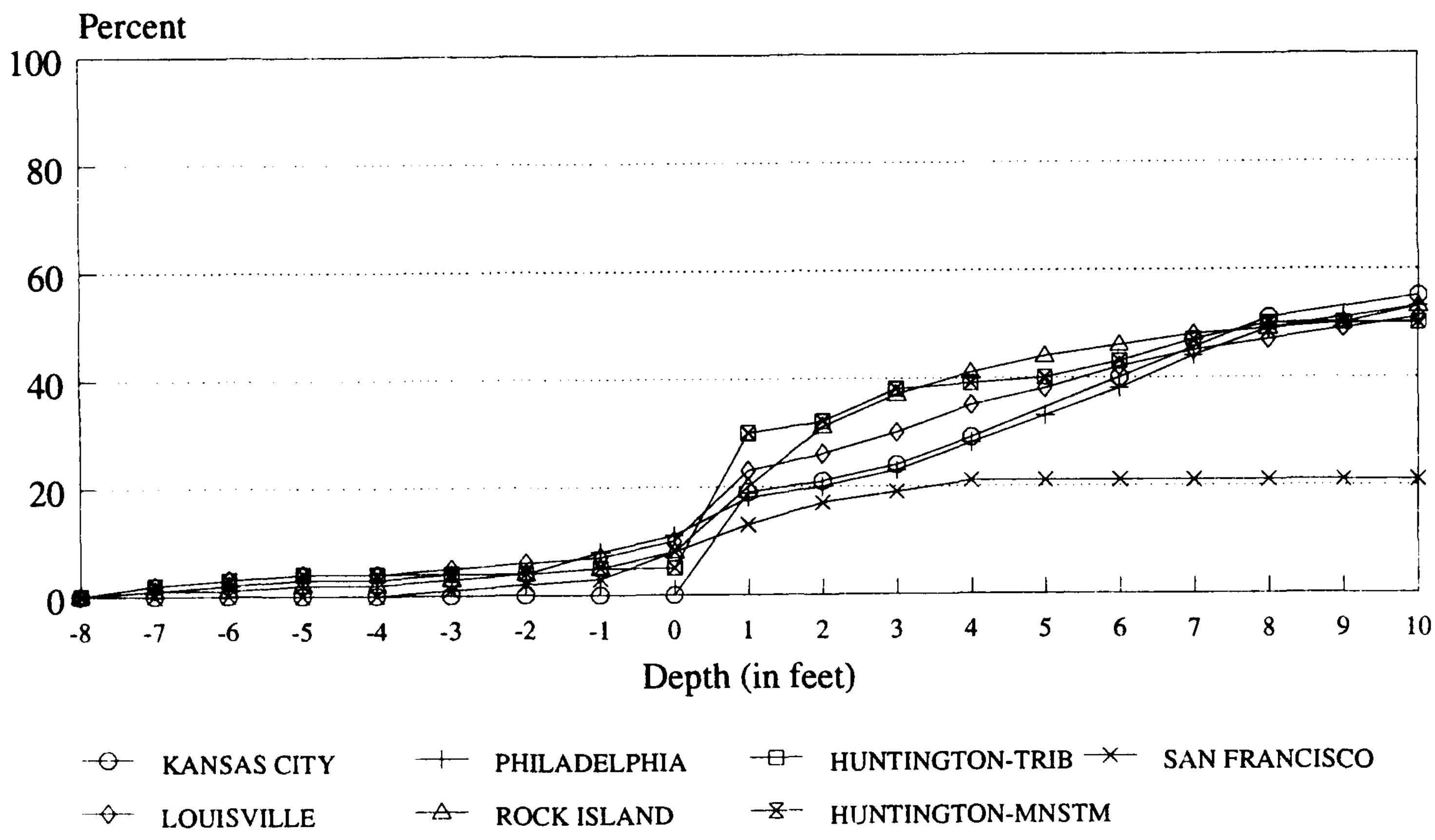


Figure 5

Percent Damage to Structure Value
ONE STORY, WITH BASEMENT

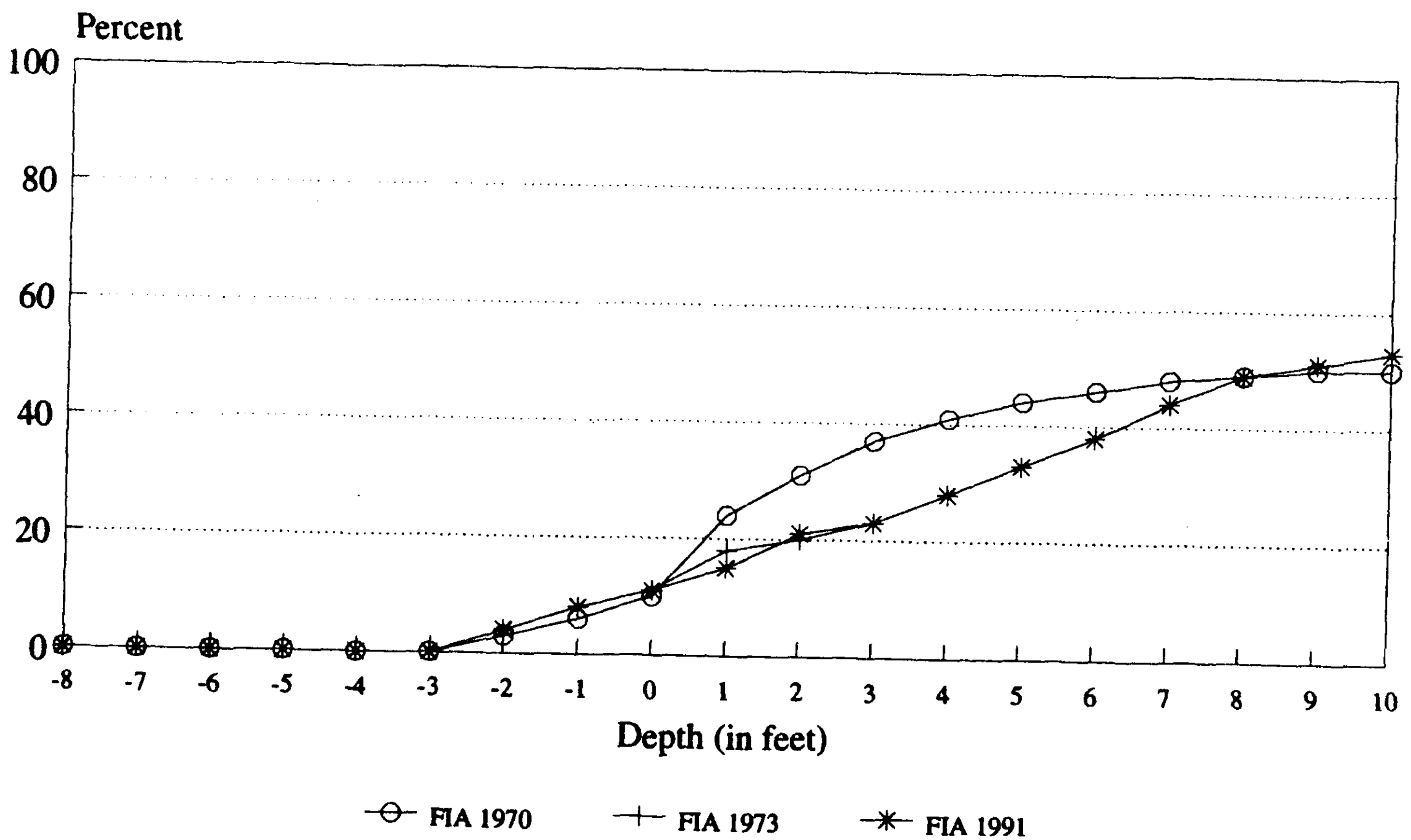


Figure 6

Percent Damage to Structure Value
SPLIT LEVEL, NO BASEMENT

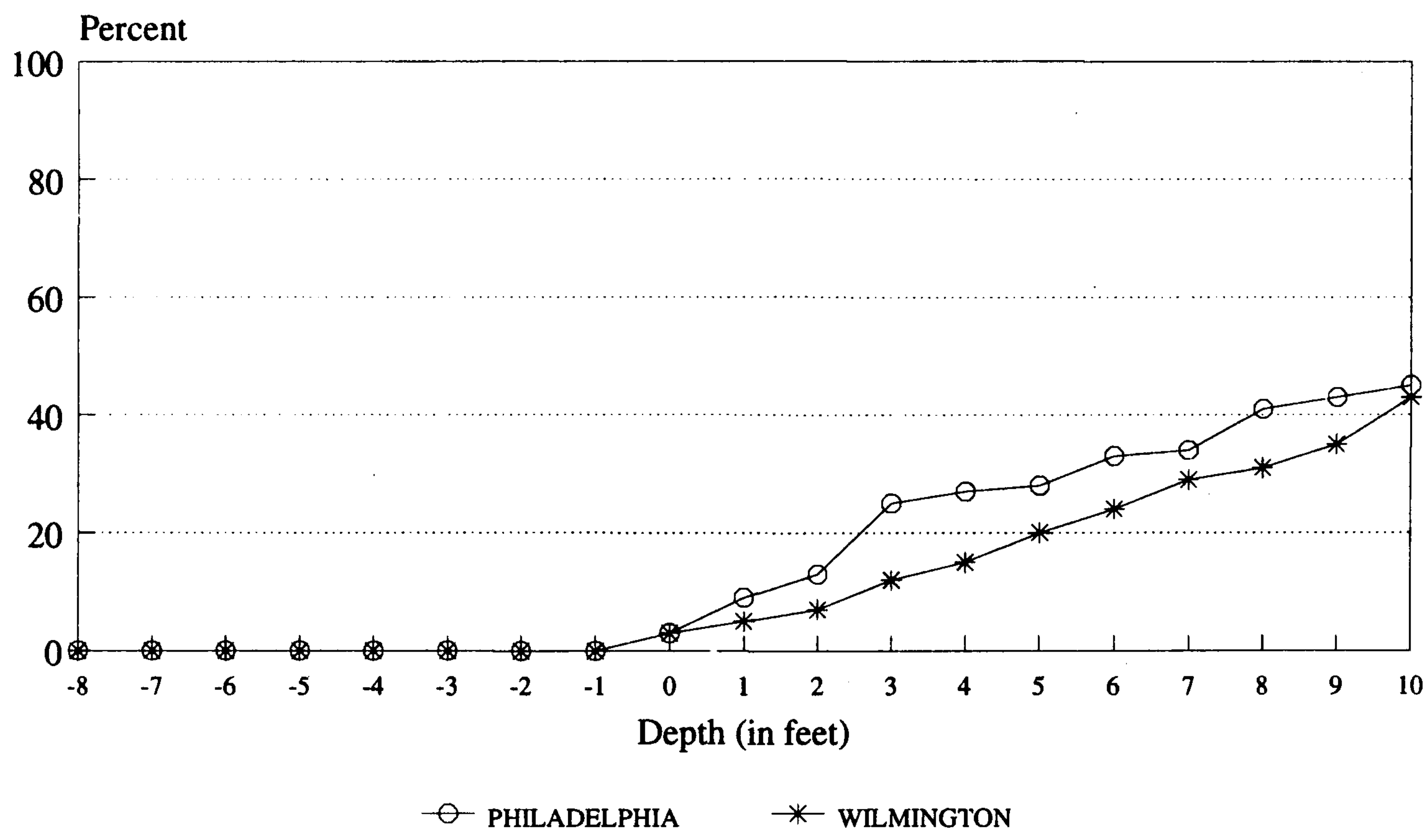


Figure 7

Percent Damage to Structure Value
SPLIT LEVEL, NO BASEMENT

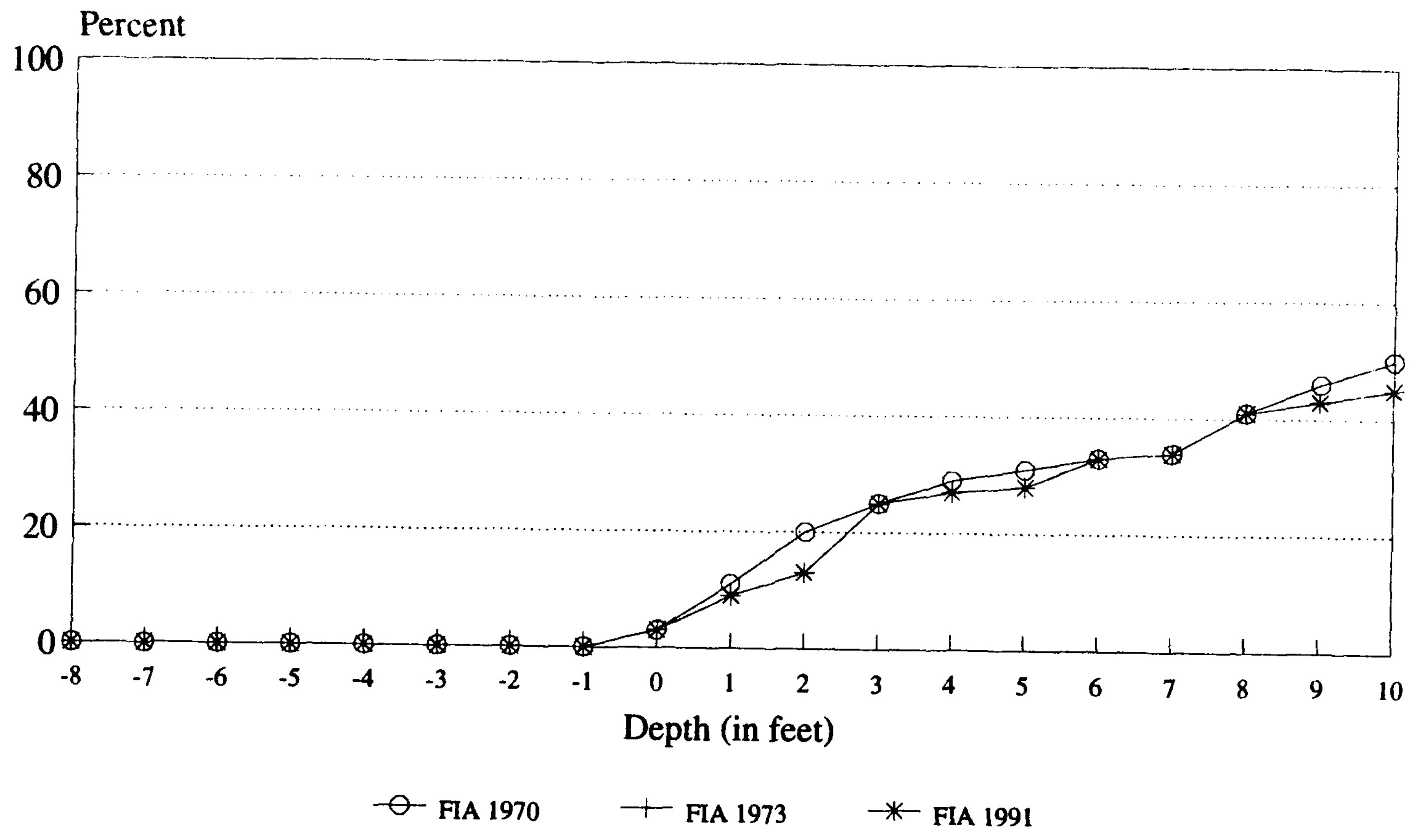


Figure 8

Percent Damage to Structure Value
SPLIT LEVEL, WITH BASEMENT

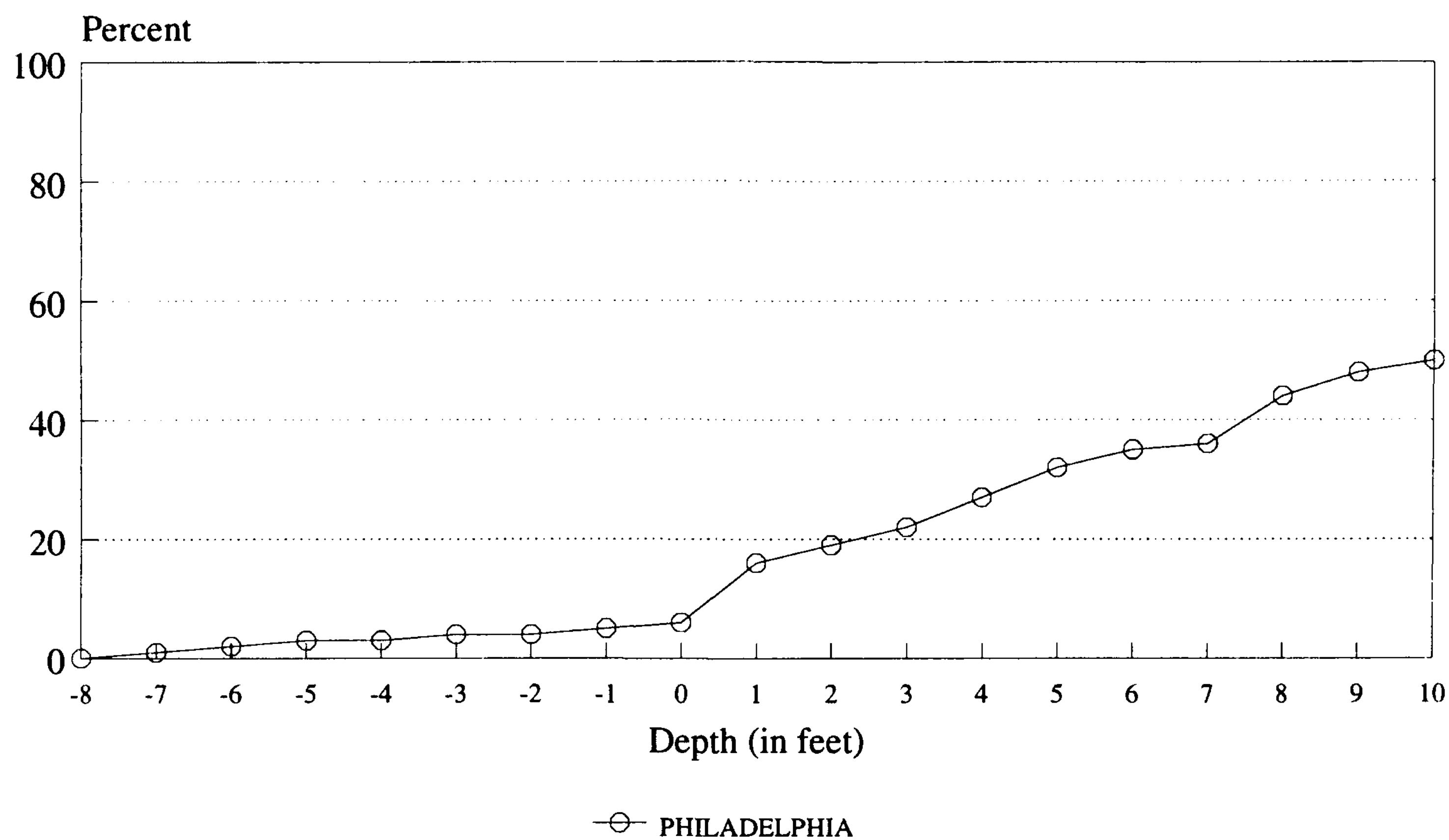


Figure 9

Percent Damage to Structure Value
SPLIT LEVEL, WITH BASEMENT

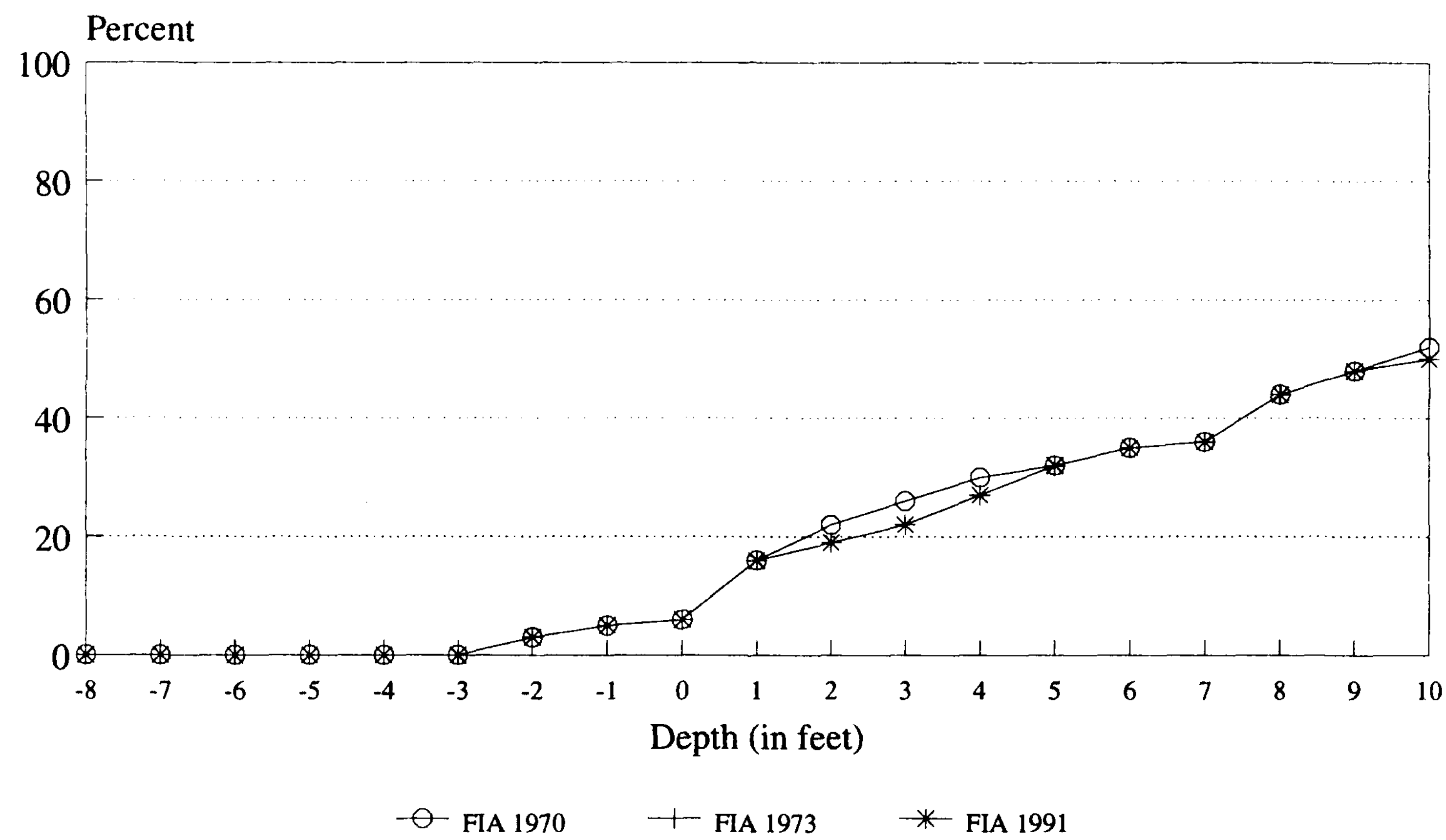


Figure 10

Percent Damage to Structure Value
SPLIT LEVEL

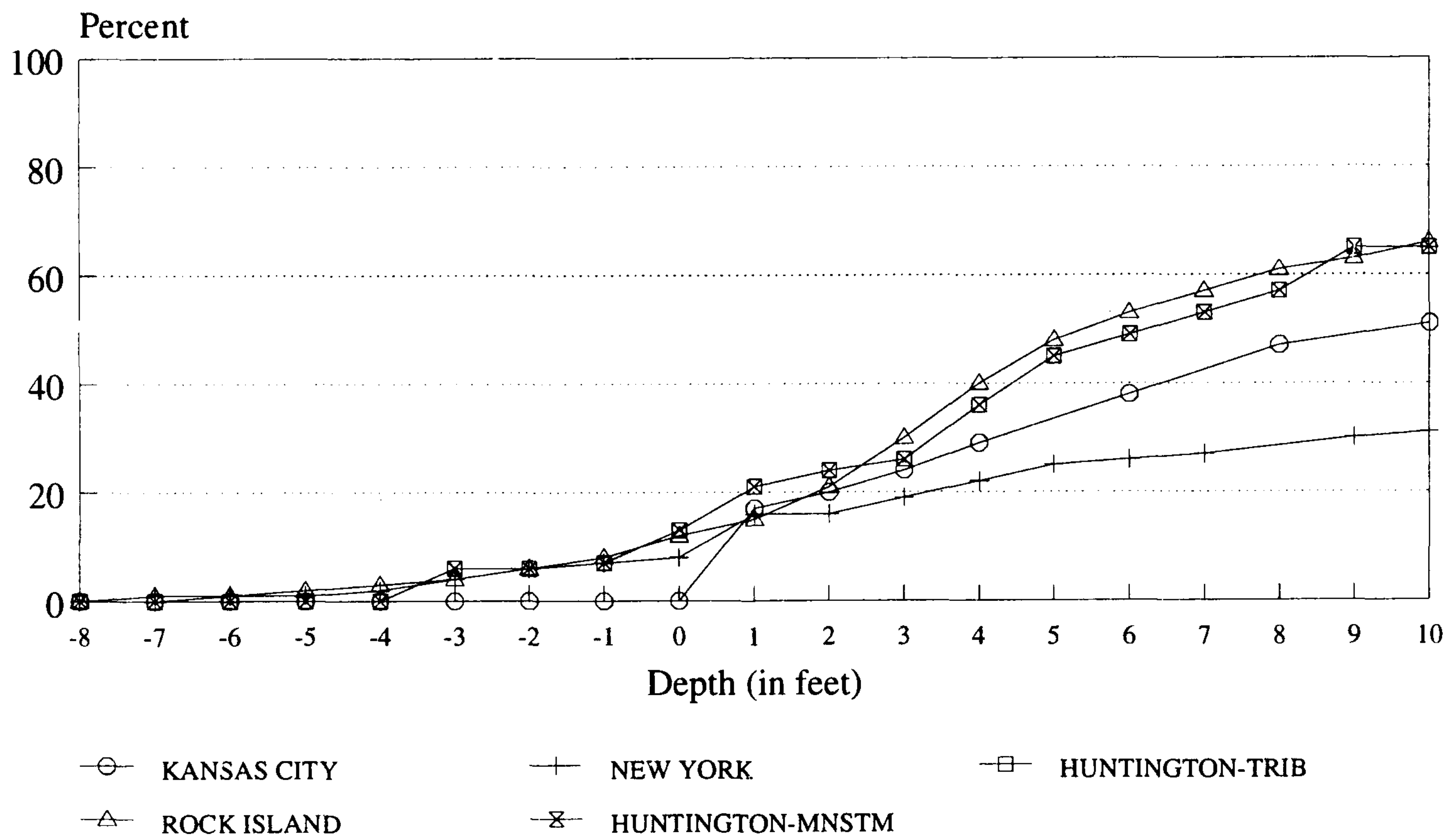


Figure 11

Percent Damage to Structure Value
TWO OR MORE STORIES, NO BASEMENT

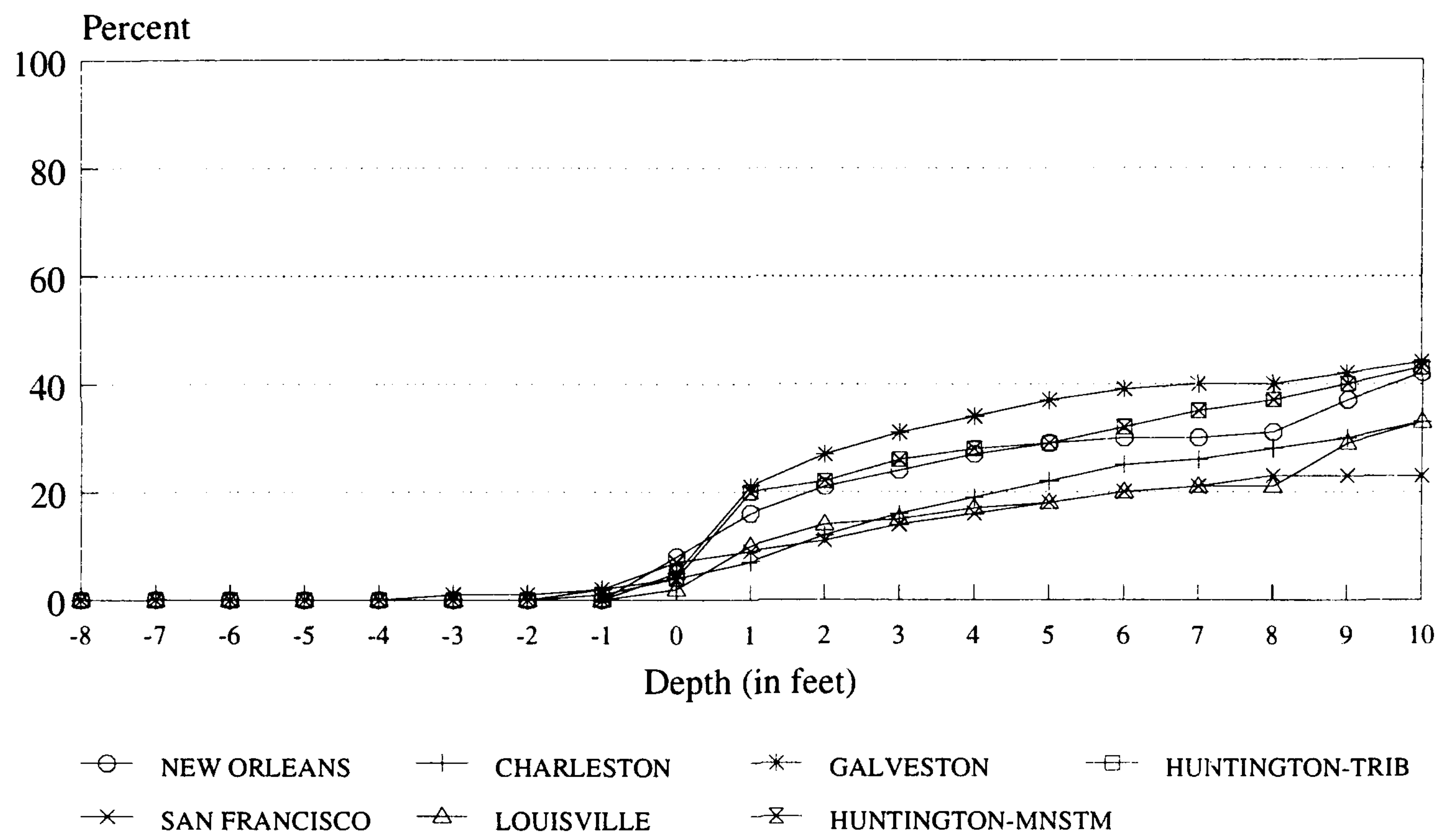


Figure 12

Percent Damage to Structure Value
TWO OR MORE STORIES, NO BASEMENT

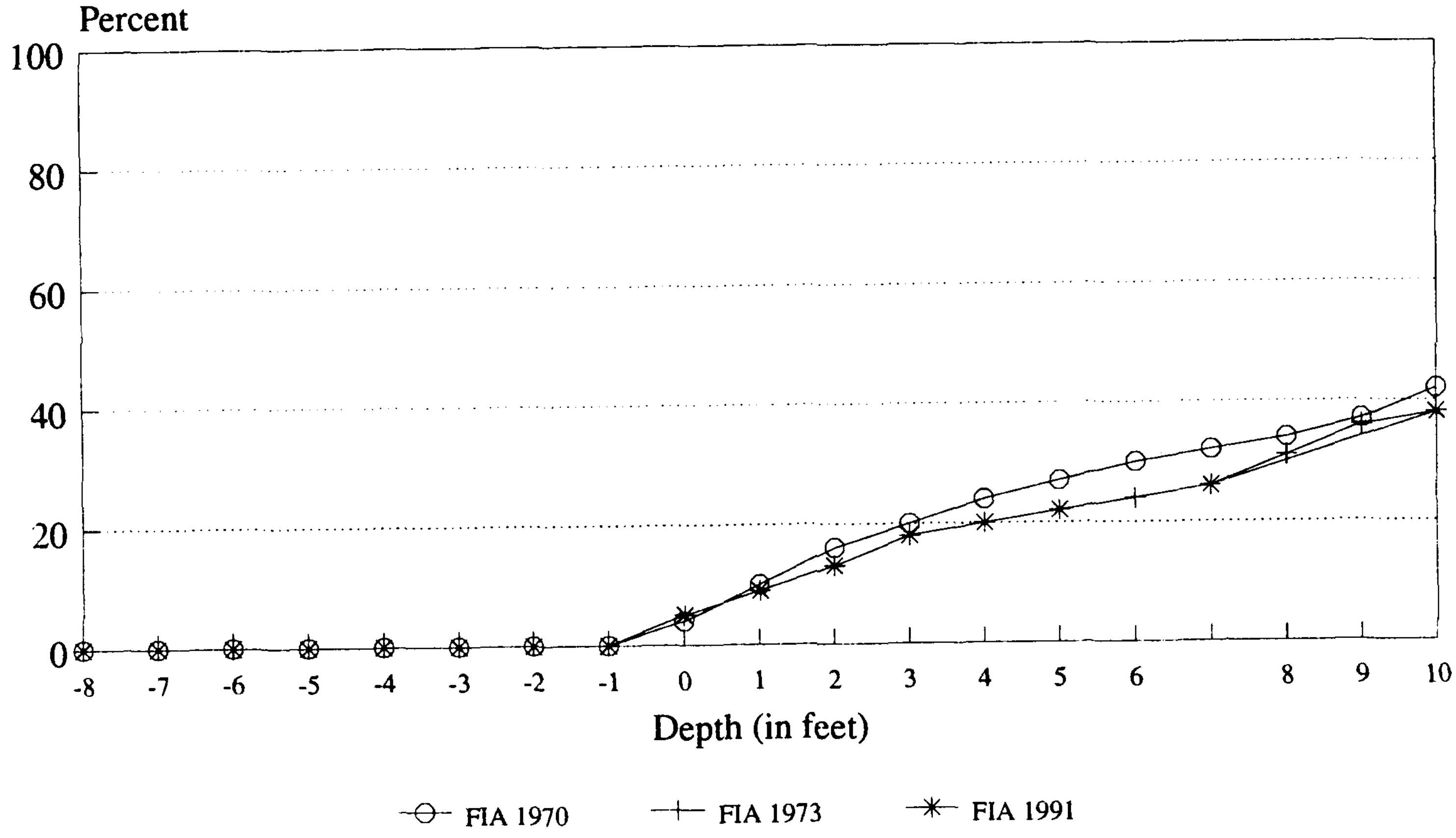


Figure 13

Percent Damage to Structure Value
TWO OR MORE STORIES WITH BASEMENT

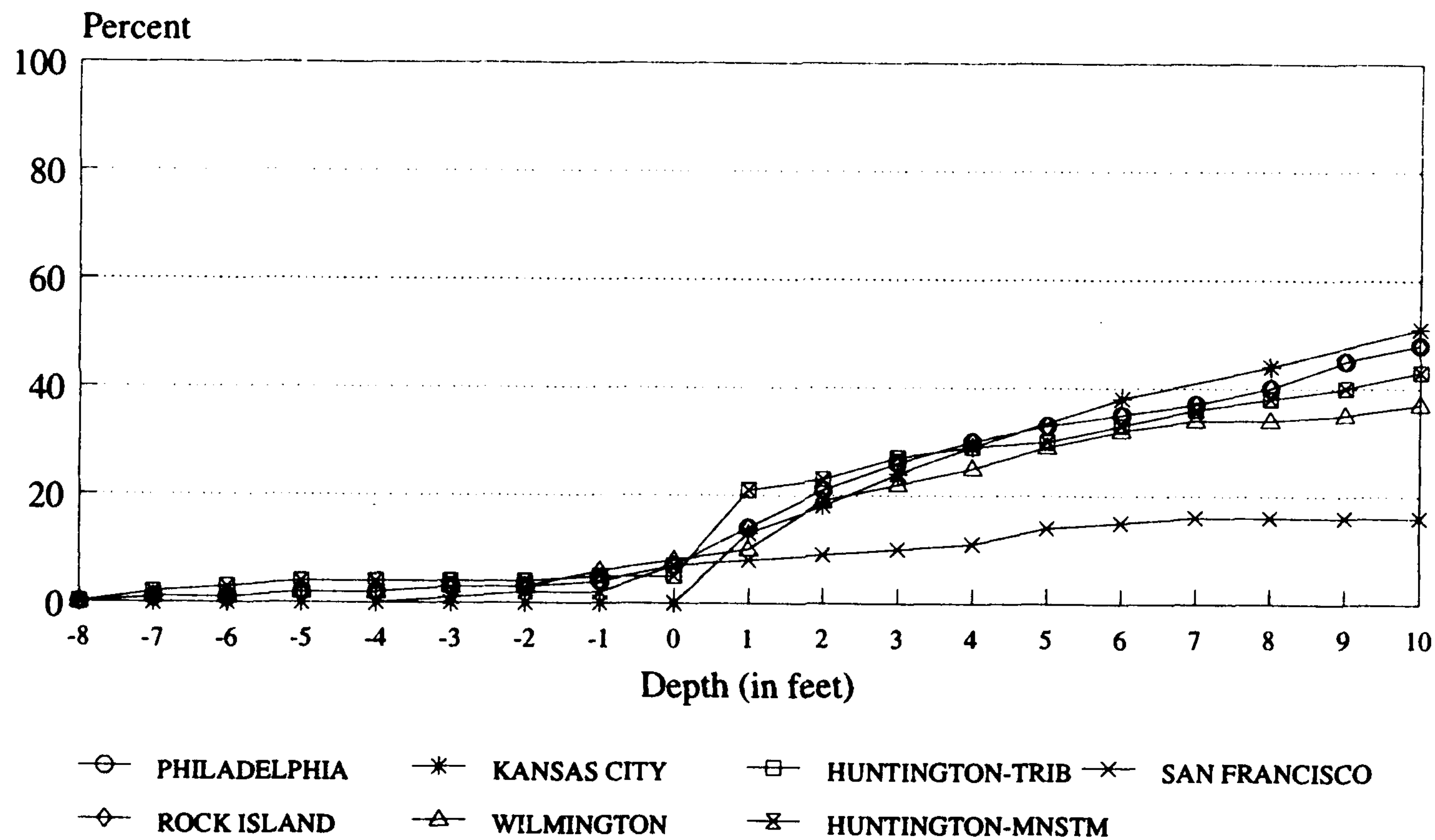


Figure 14

Percent Damage to Structure Value
TWO OR MORE STORIES, WITH BASEMENT

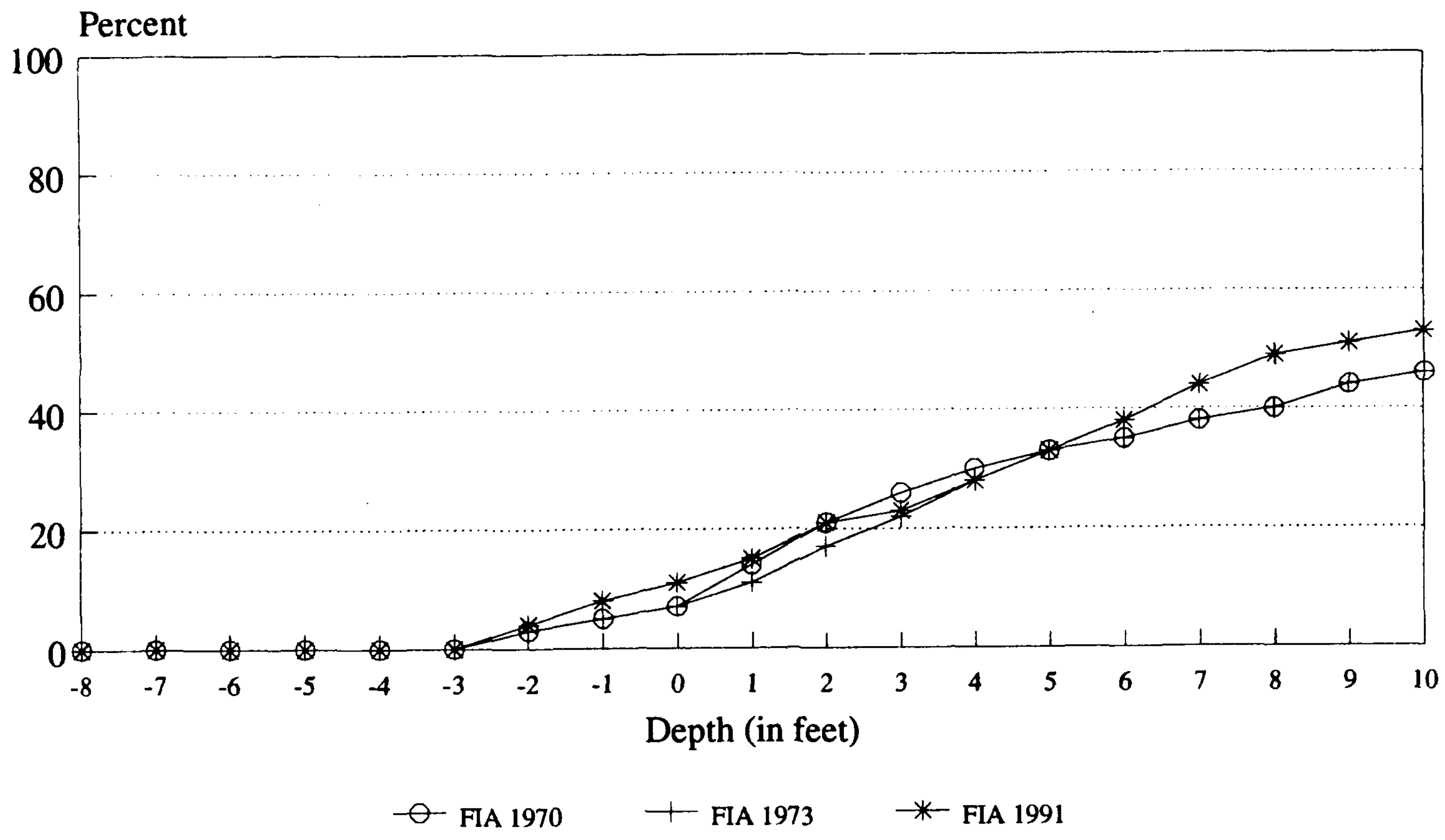


Figure 15

Percent Damage to Structure Value
MOBILE HOME

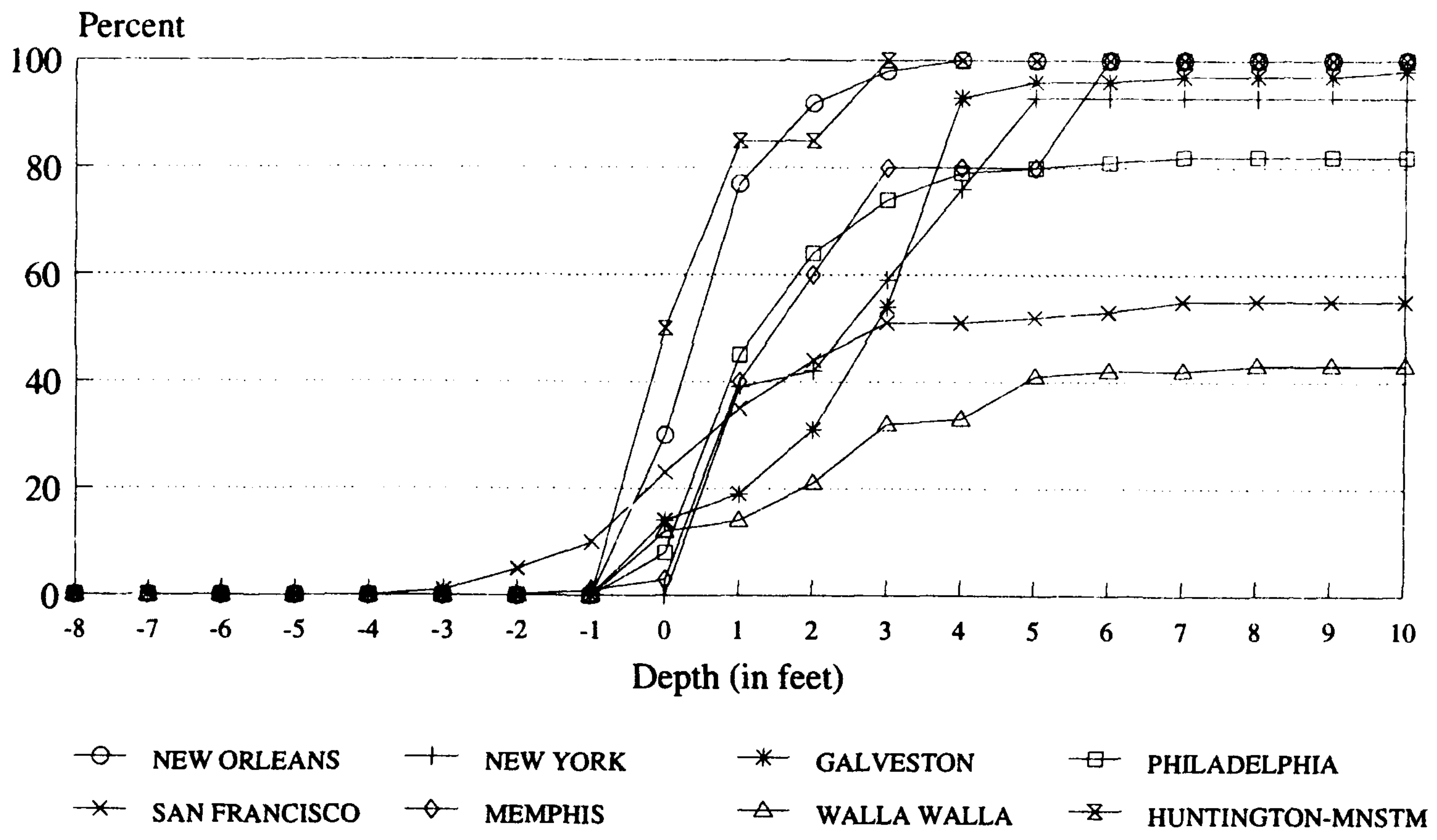


Figure 16

Percent Damage to Structure Value
MOBILE HOME

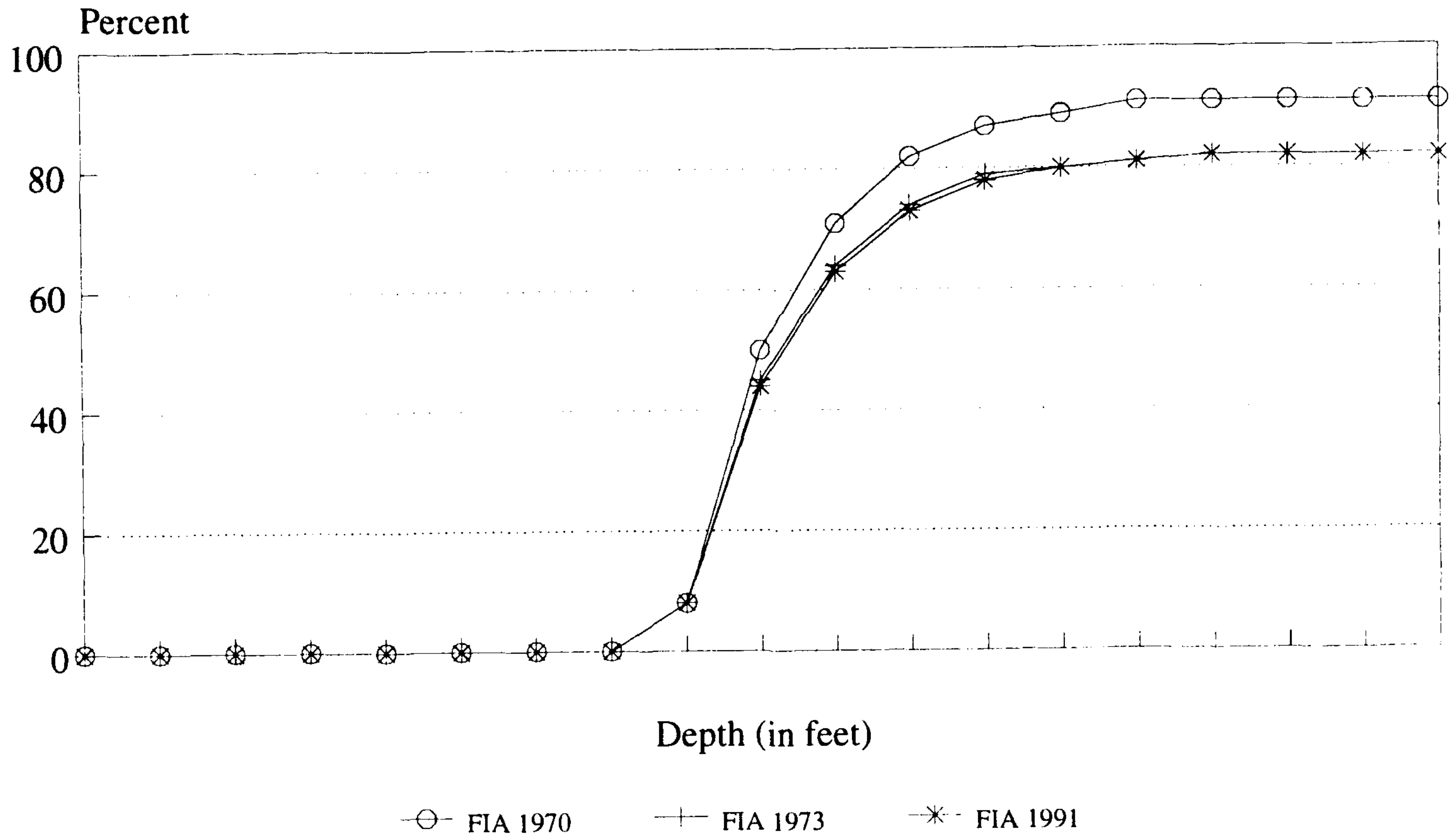


Figure 17

Percent Damage to Content Value
ONE STORY, NO BASEMENT

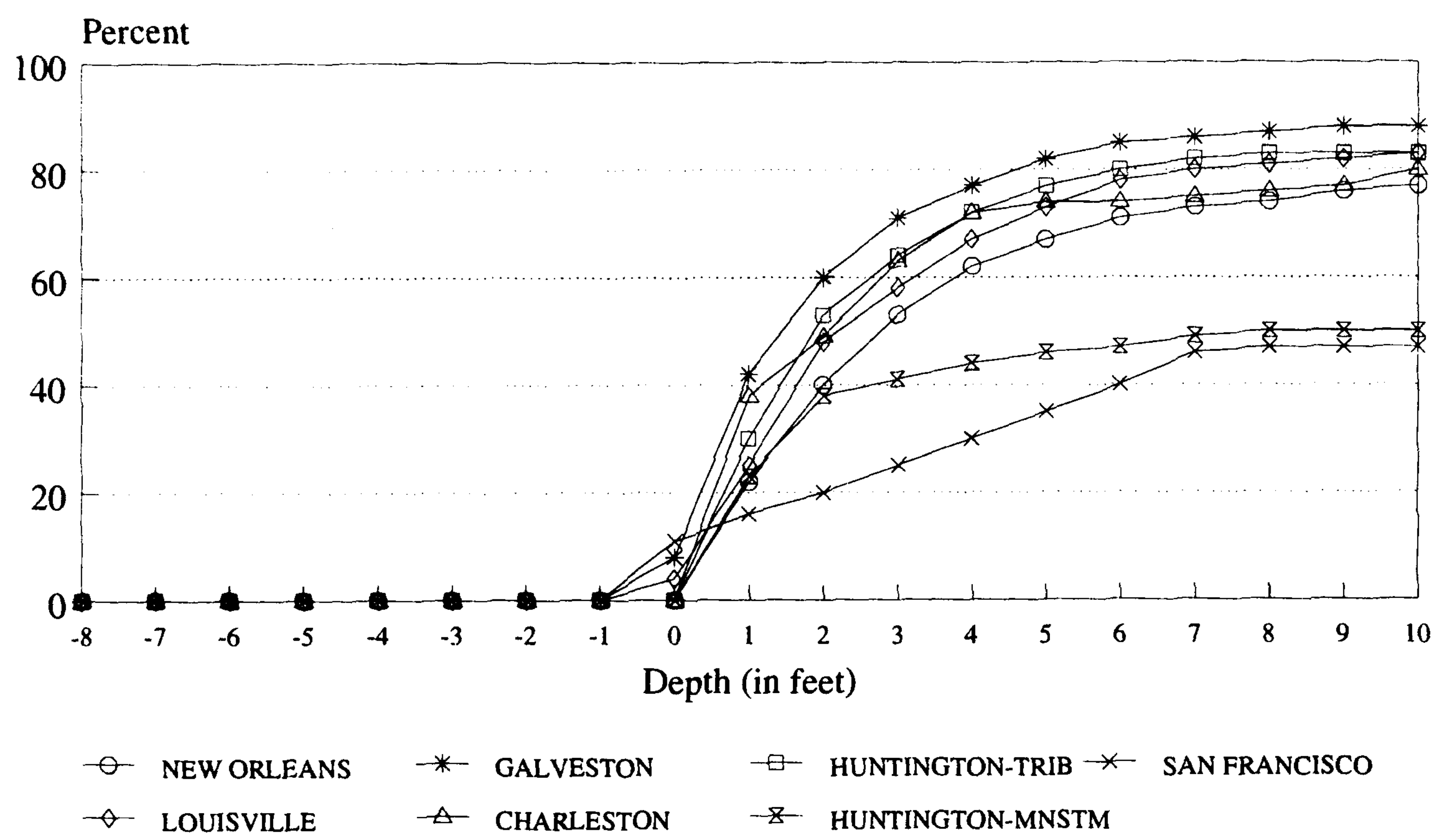


Figure 18

Percent Damage to Content Value
ONE STORY, NO BASEMENT

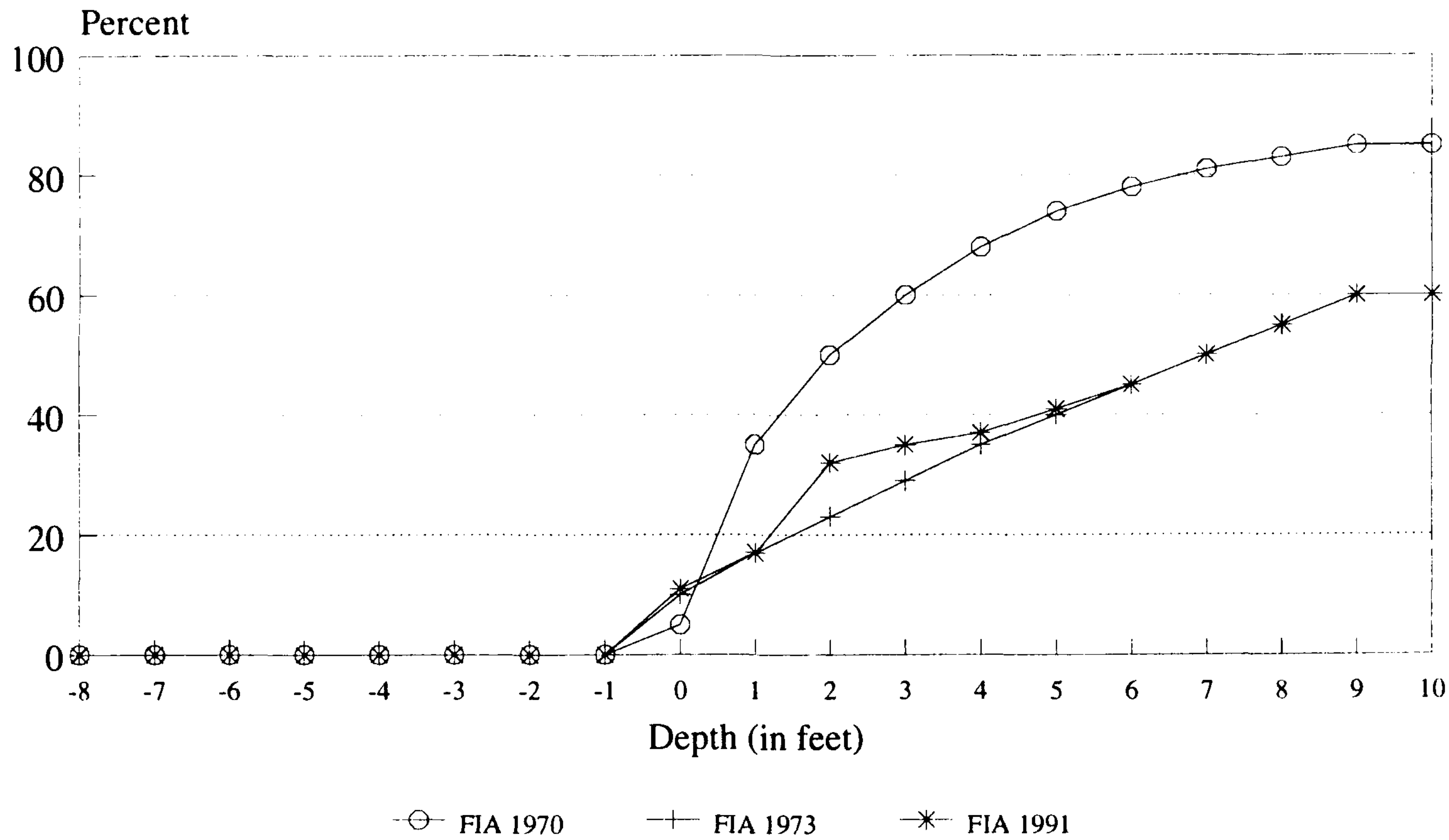


Figure 19

Percent Damage to Content Value
ONE STORY, WITH BASEMENT

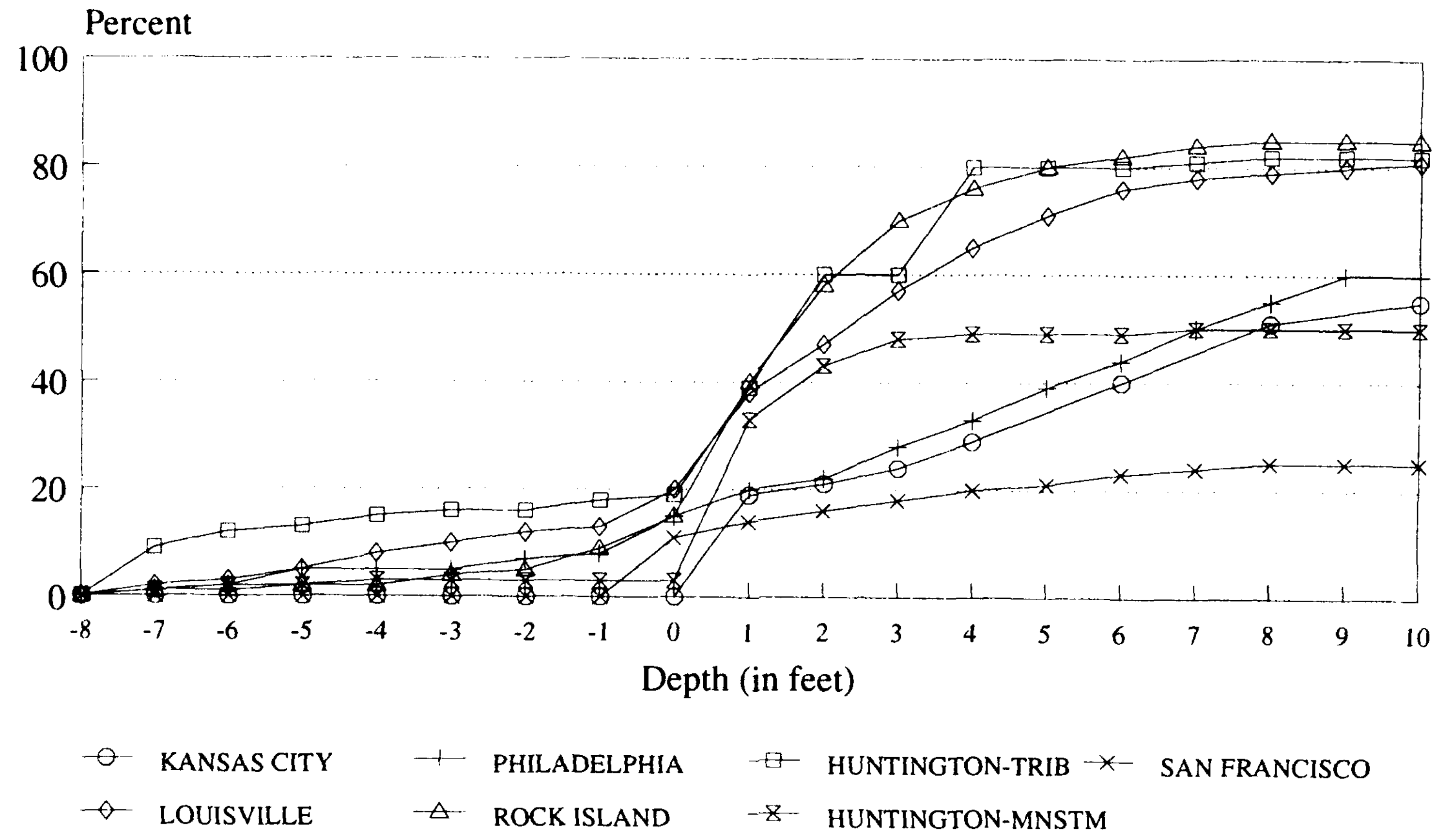


Figure 20

Percent Damage to Content Value
ONE STORY, WITH BASEMENT

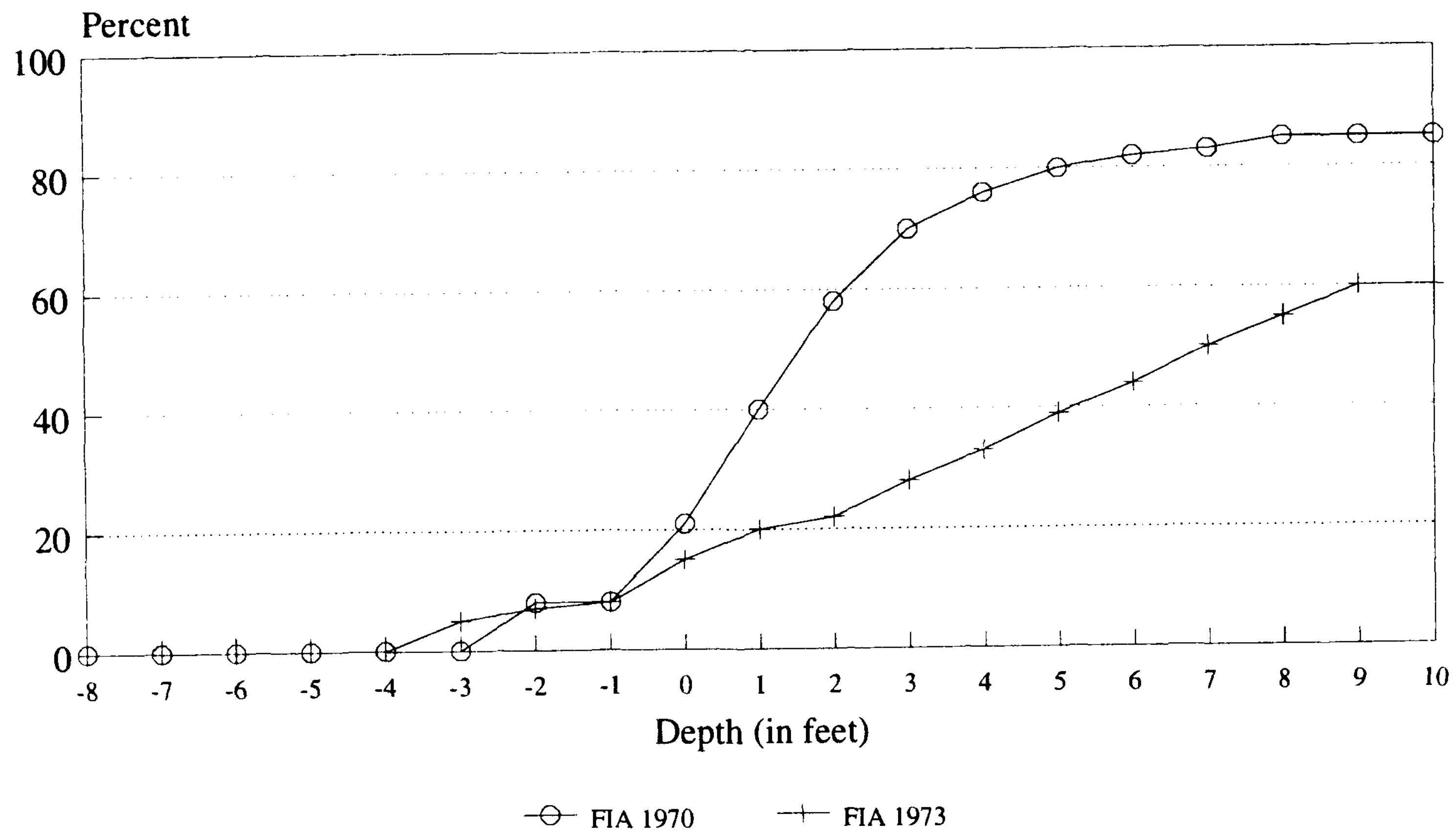


Figure 21

Percent Damage to Content Value
SPLIT LEVEL, NO BASEMENT

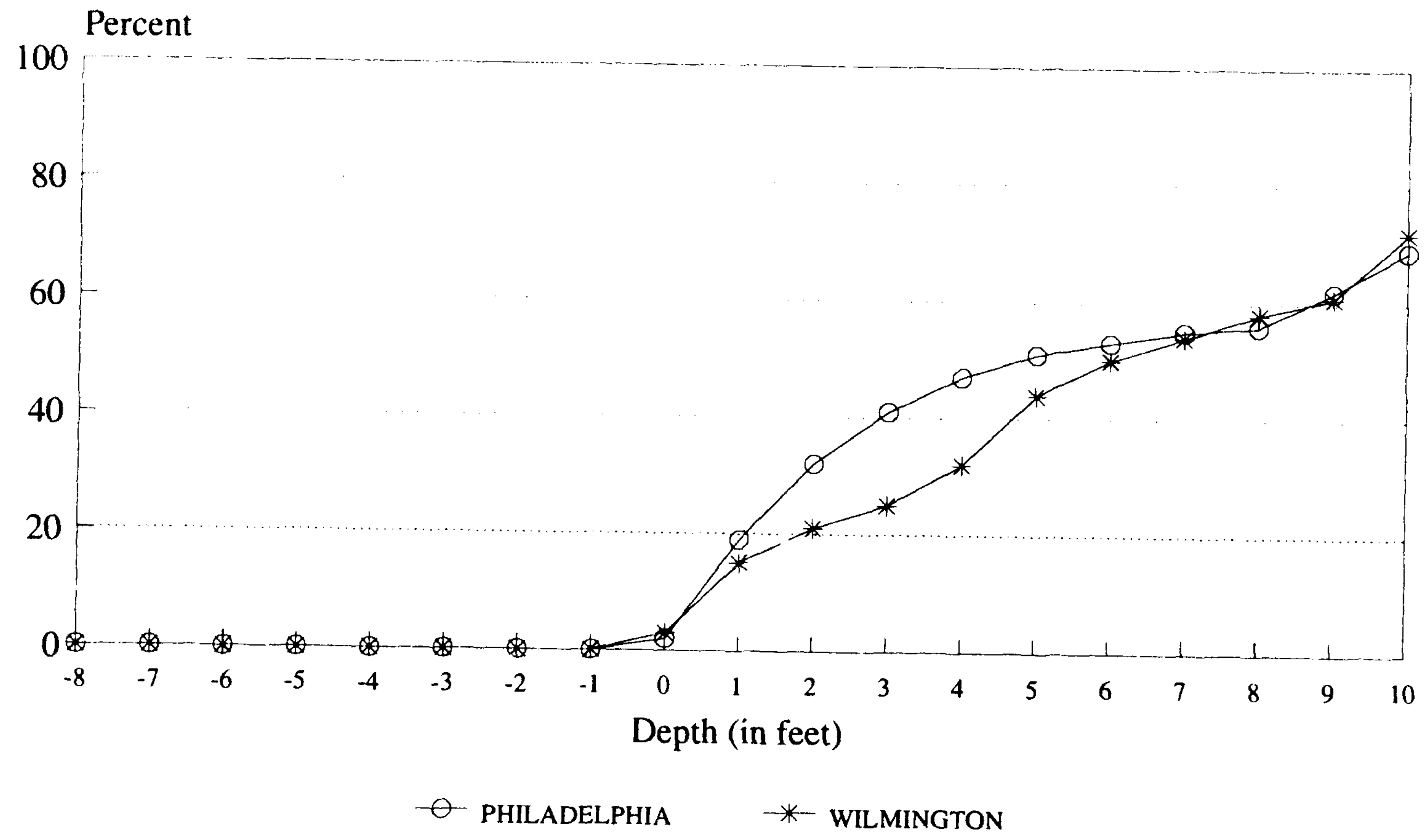


Figure 22

Percent Damage to Content Value
SPLIT LEVEL, NO BASEMENT

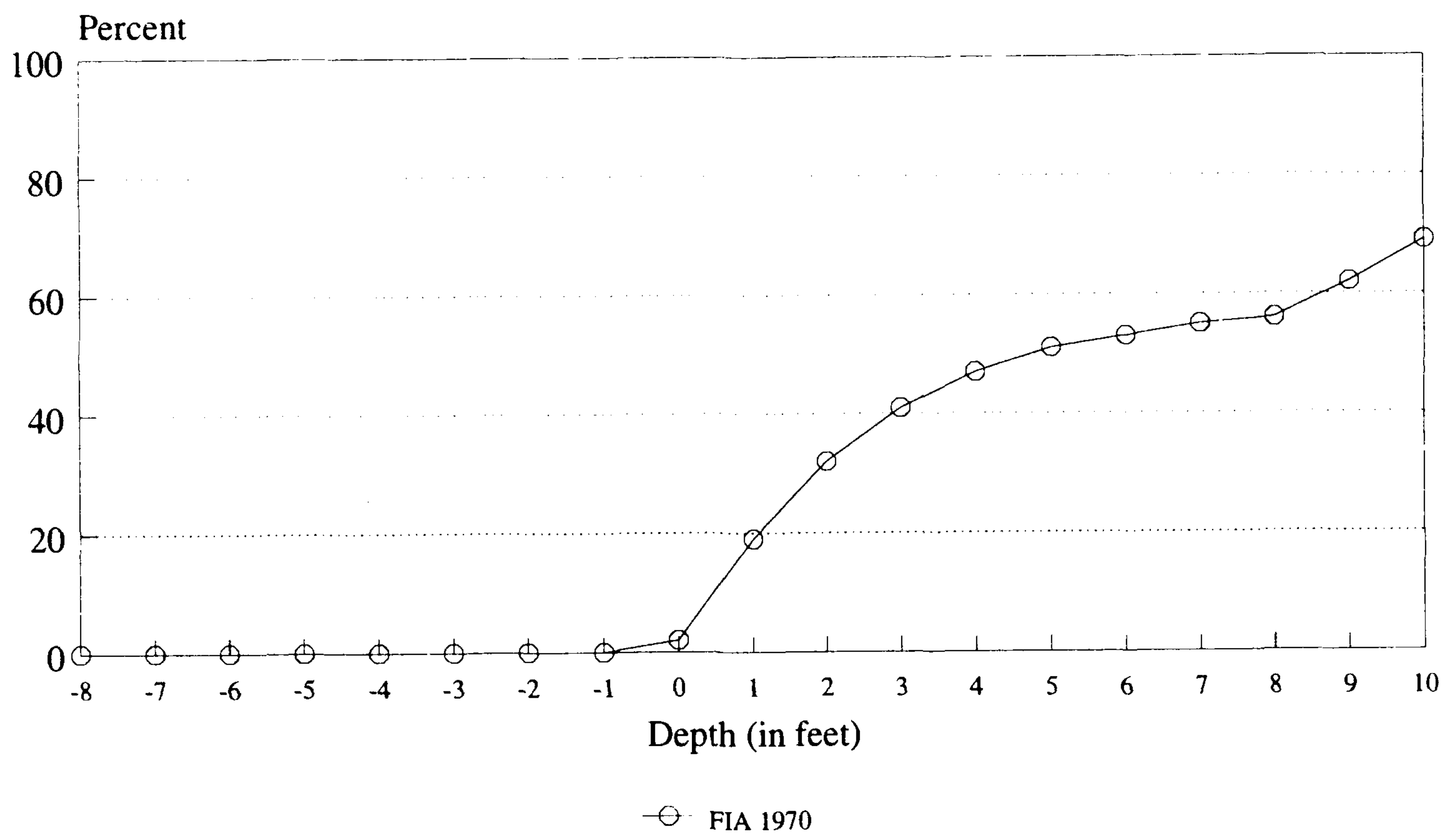


Figure 23

Percent Damage to Content Value
SPLIT LEVEL, WITH BASEMENT

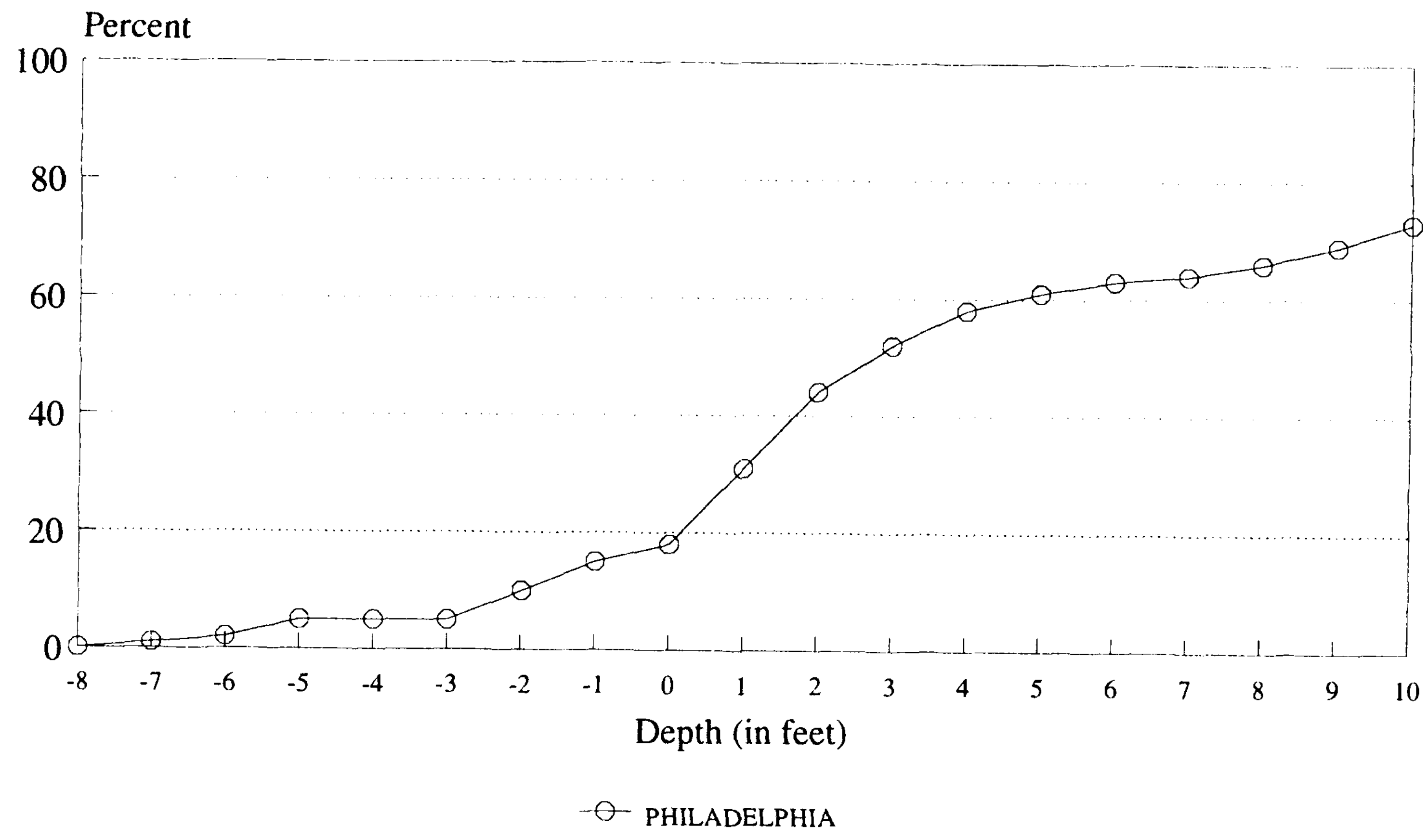


Figure 24

Percent Damage to Content Value
SPLIT LEVEL, WITH BASEMENT

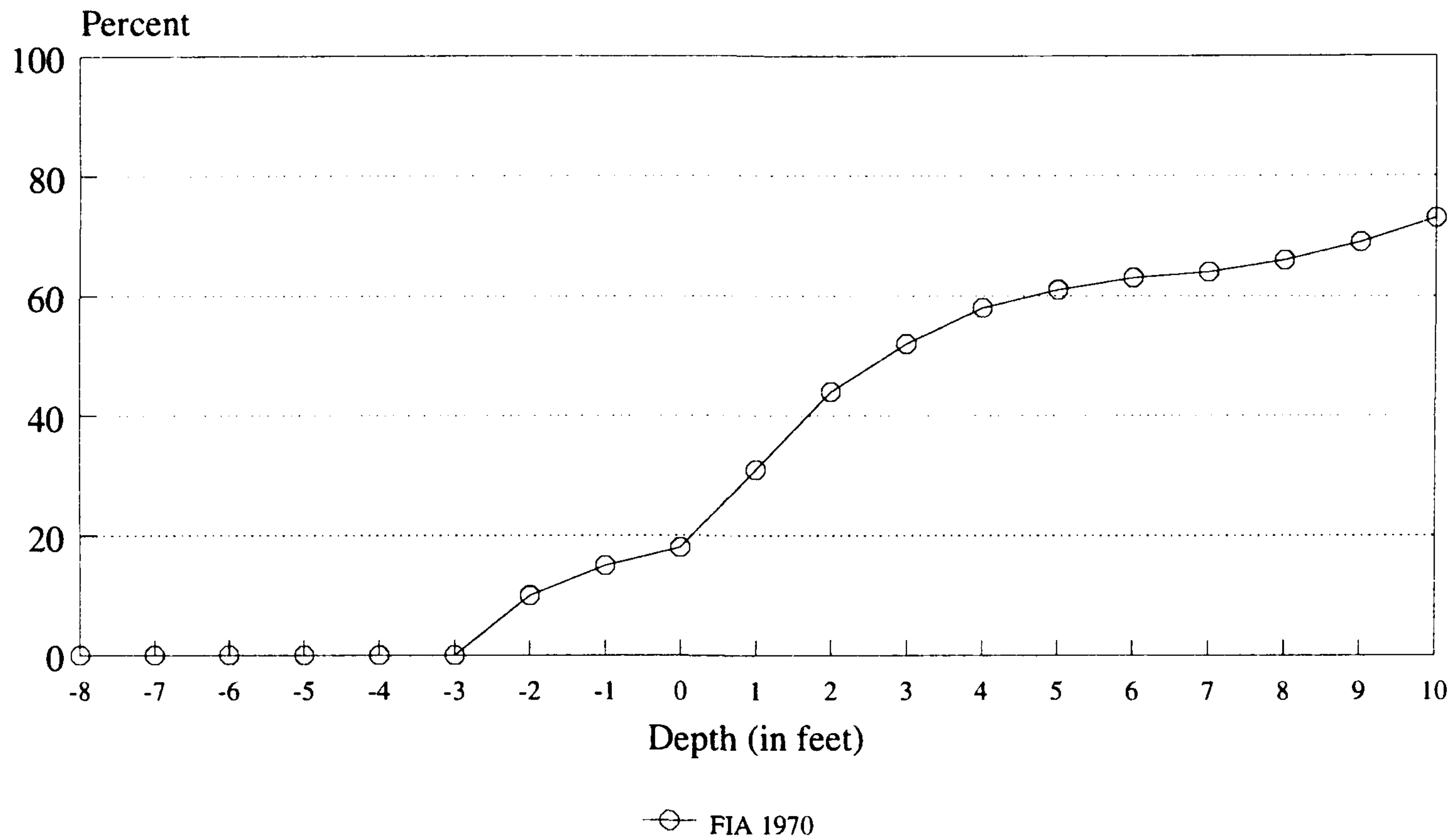


Figure 25

Percent Damage to Content Value
SPLIT LEVEL

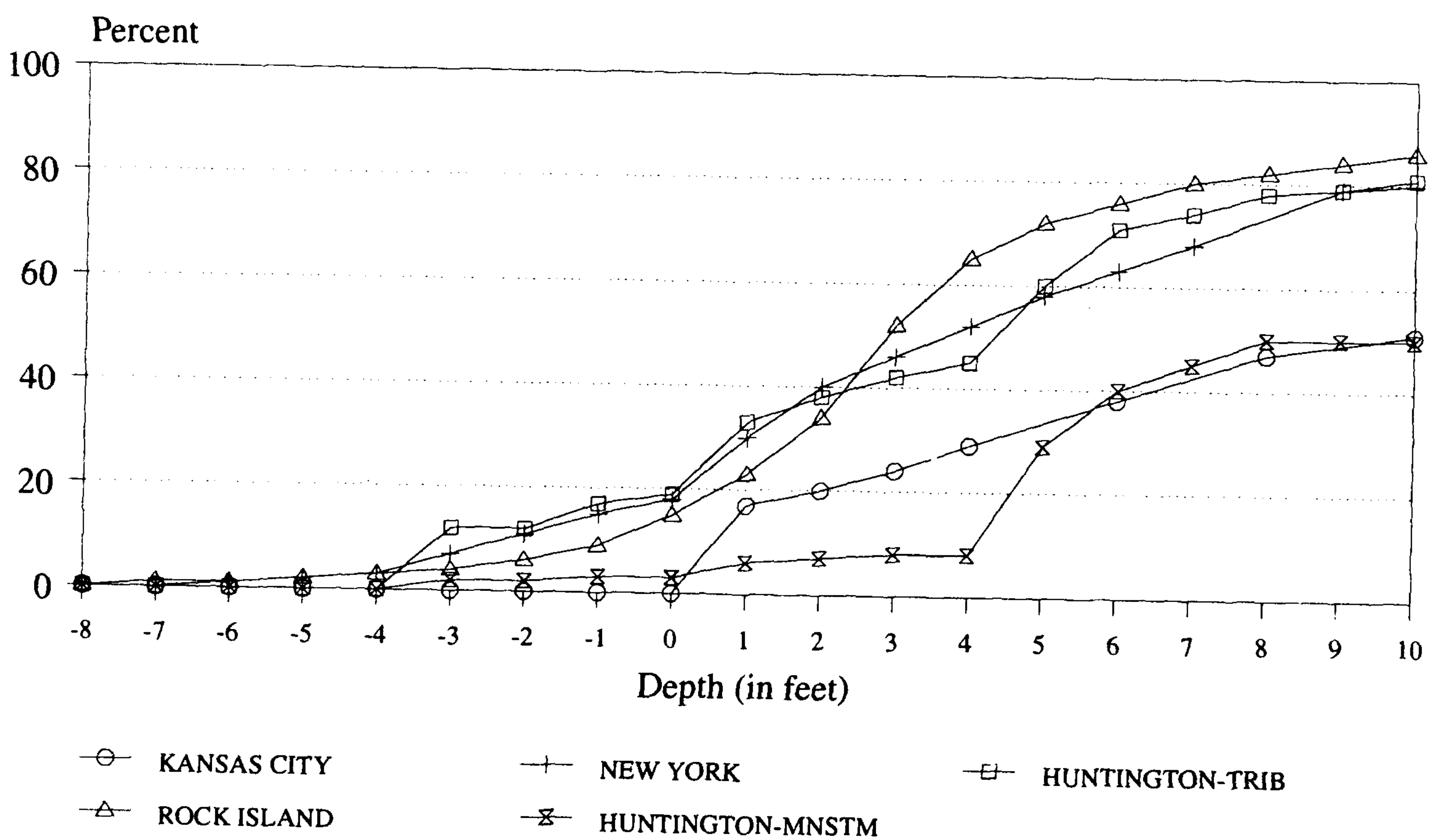


Figure 26

Percent Damage to Content Value
TWO OR MORE STORIES, NO BASEMENT

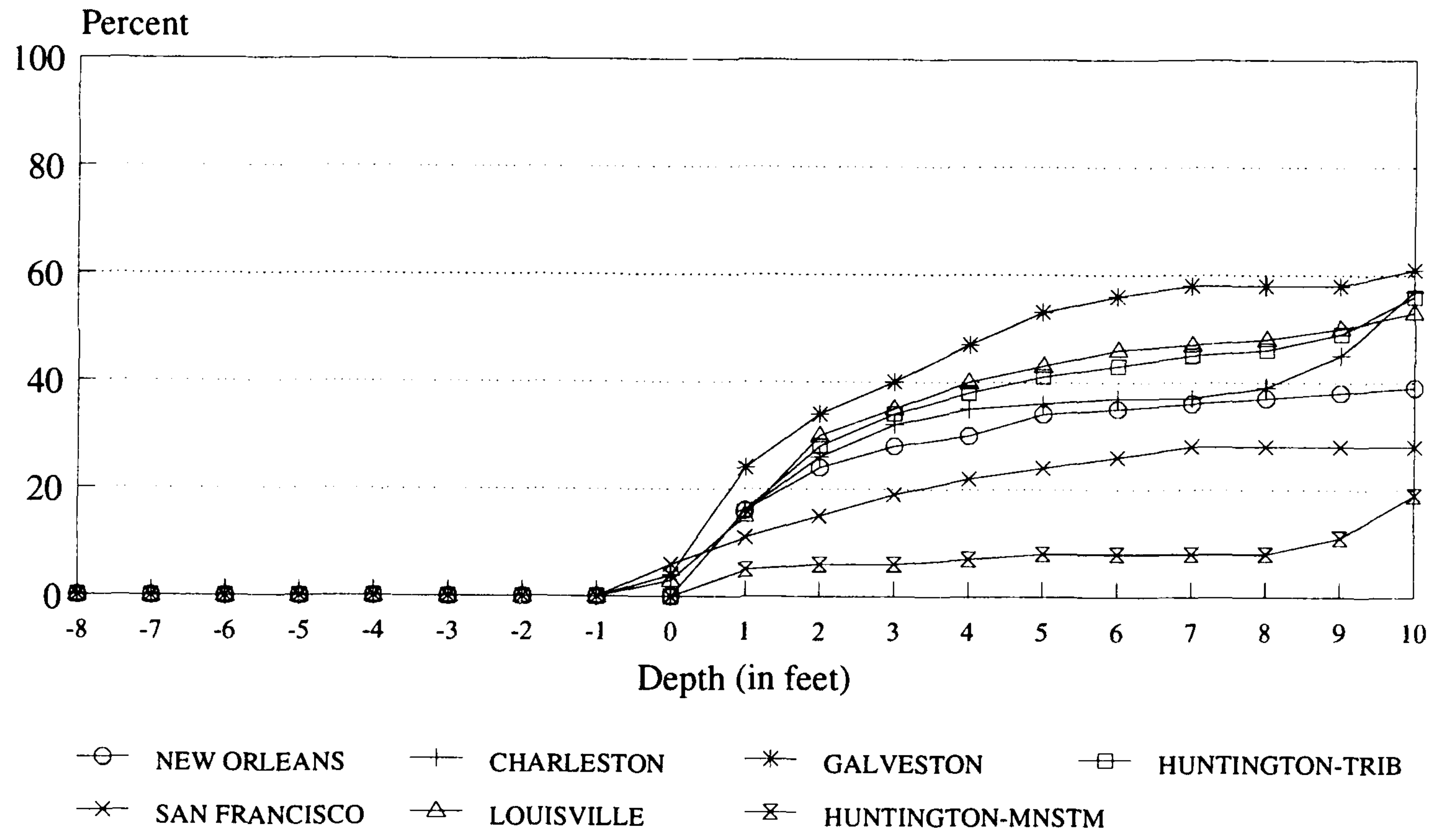


Figure 27

Percent Damage to Content Value
TWO OR MORE STORIES, NO BASEMENT

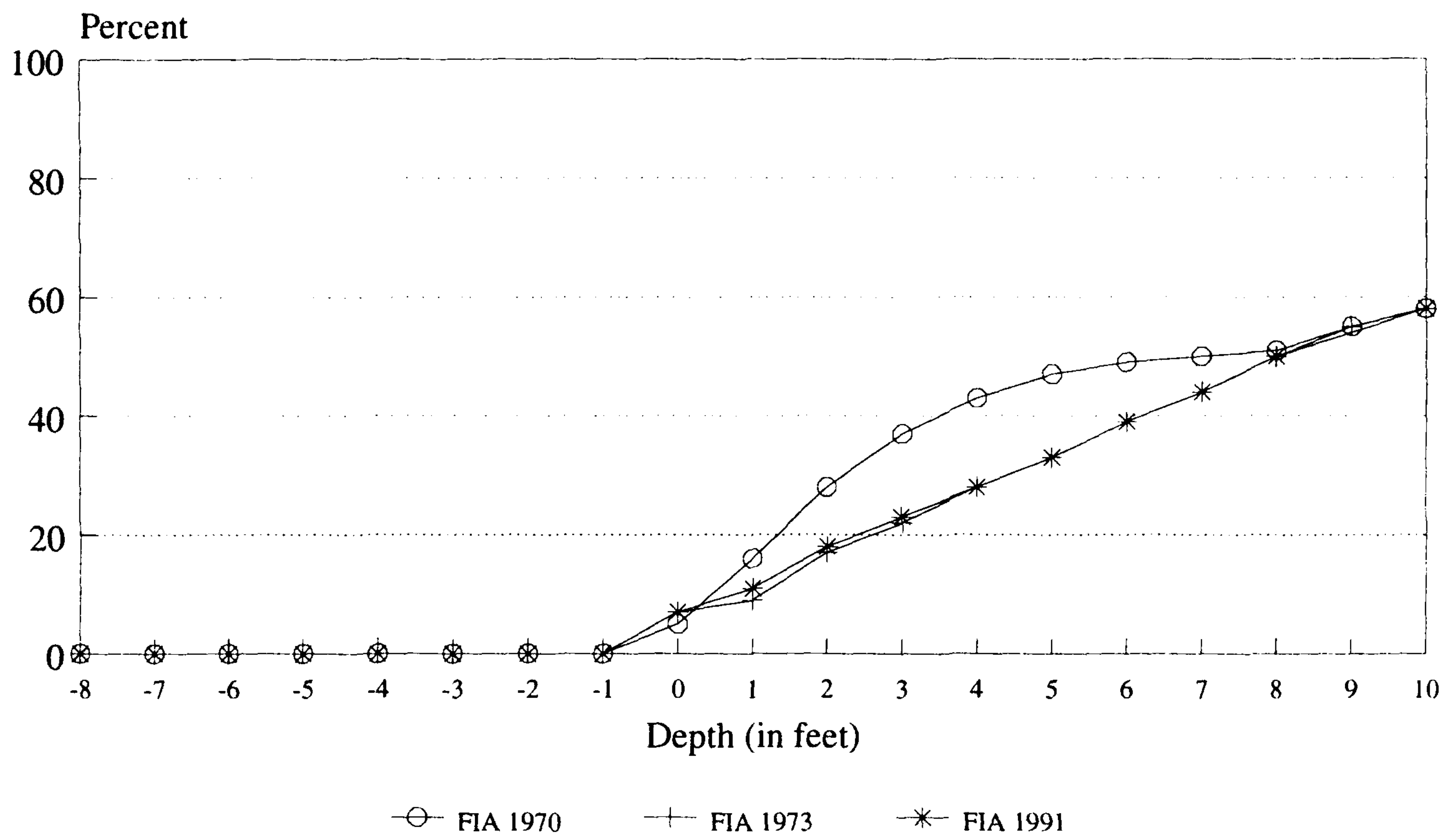


Figure 28

Percent Damage to Content Value
TWO OR MORE STORIES, WITH BASEMENT

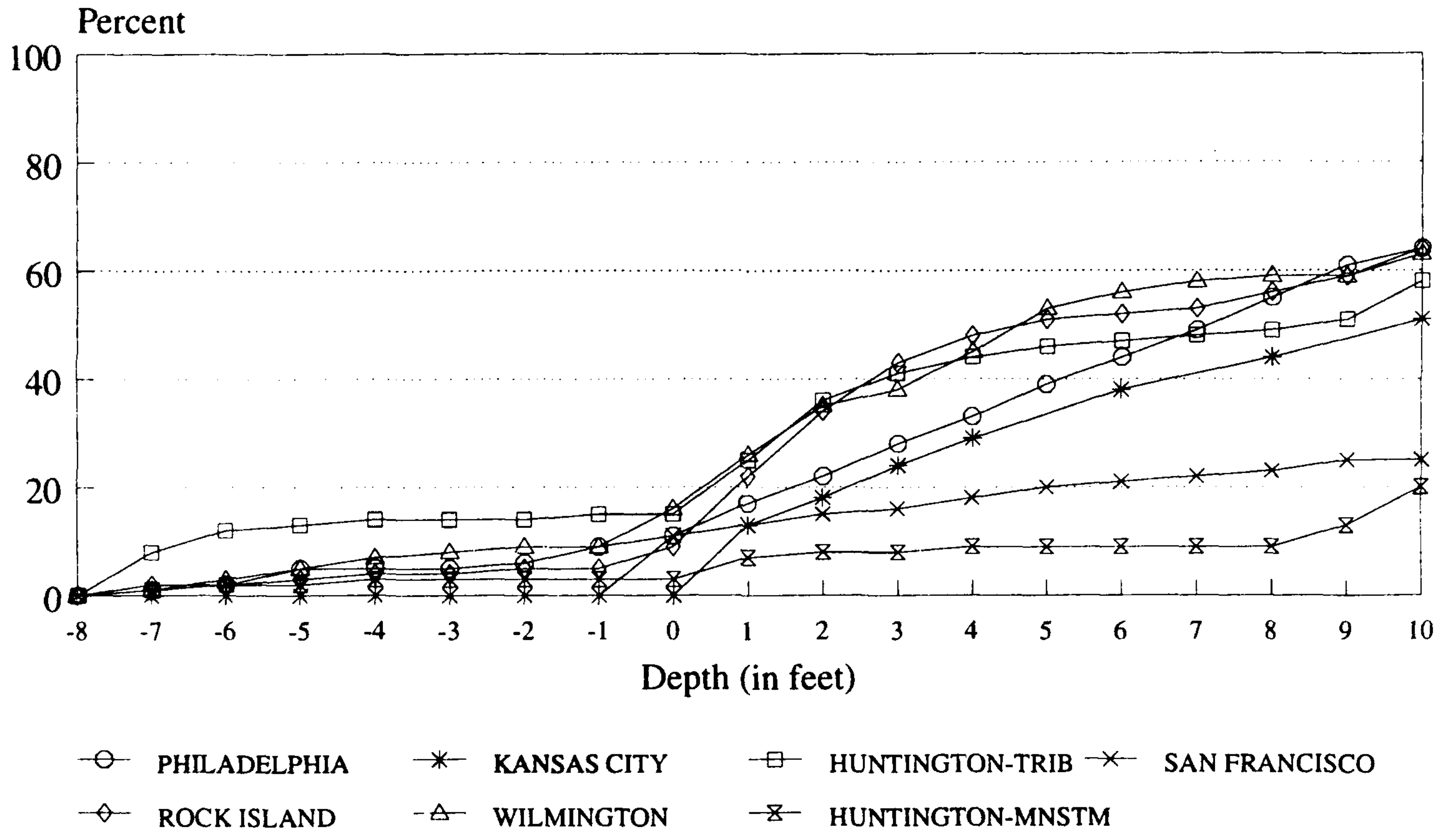


Figure 29

Percent Damage to Content Value
TWO OR MORE STORIES, WITH BASEMENT

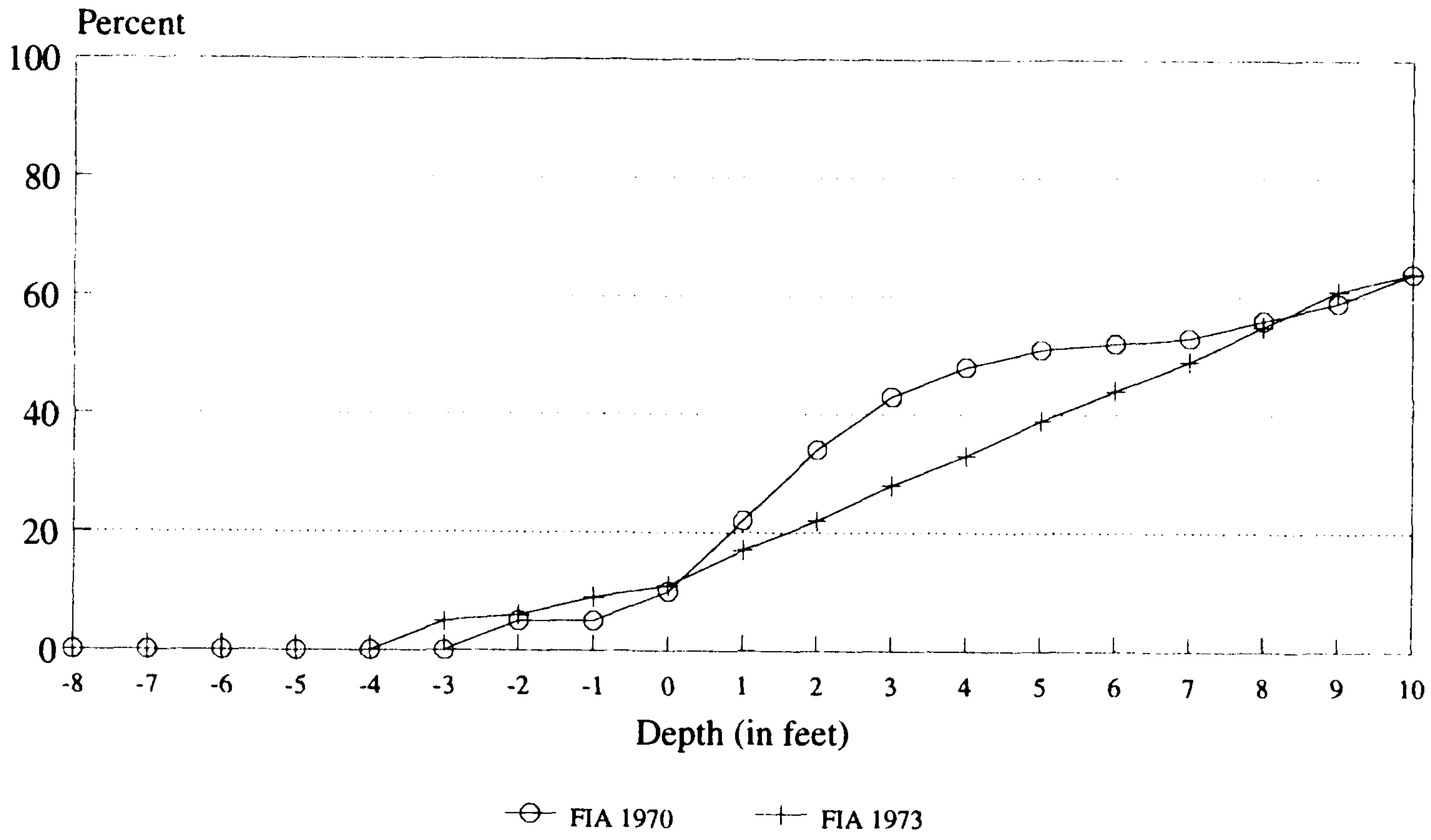


Figure 30

Percent Damage to Content Value
MOBILE HOME

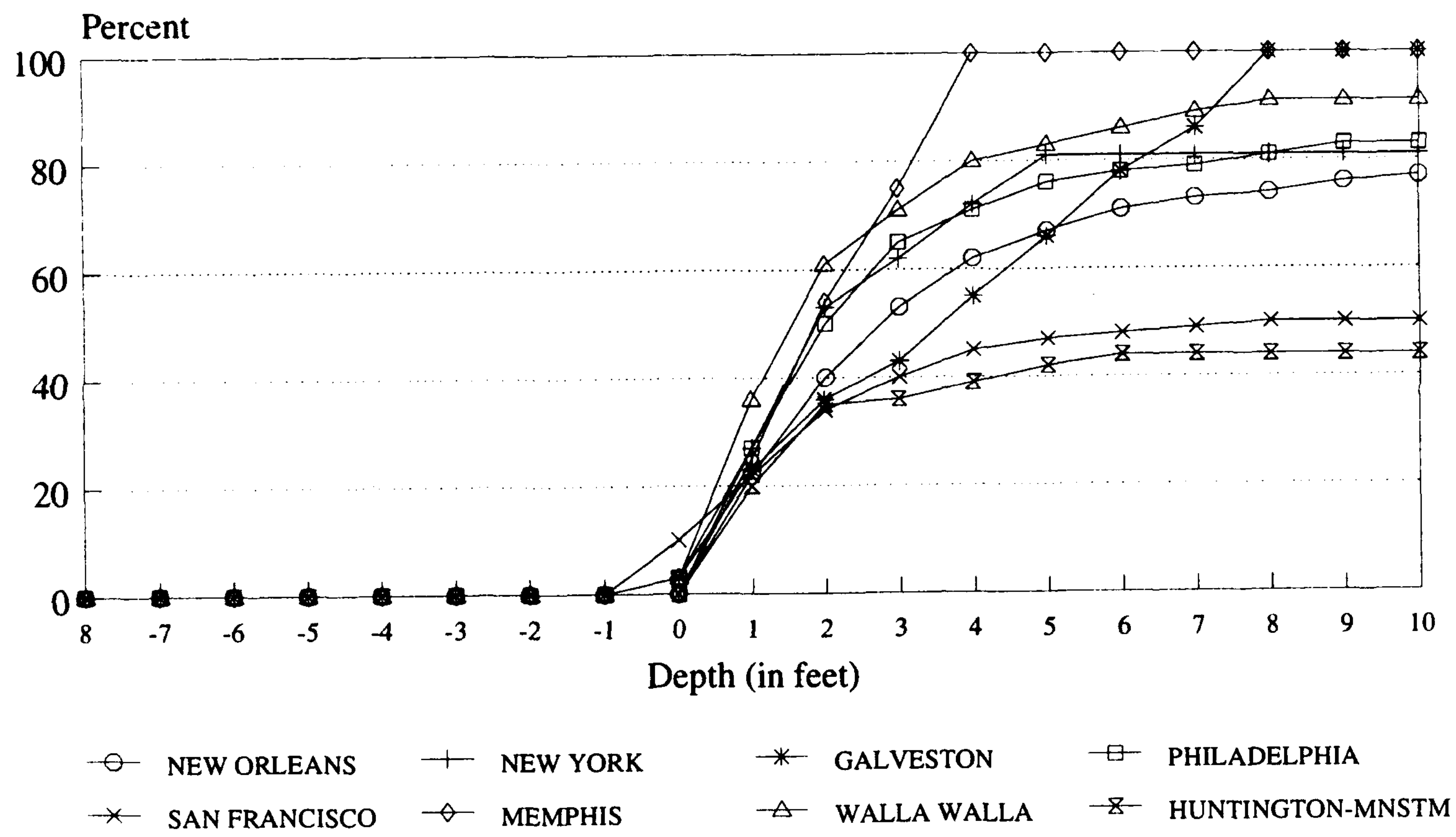
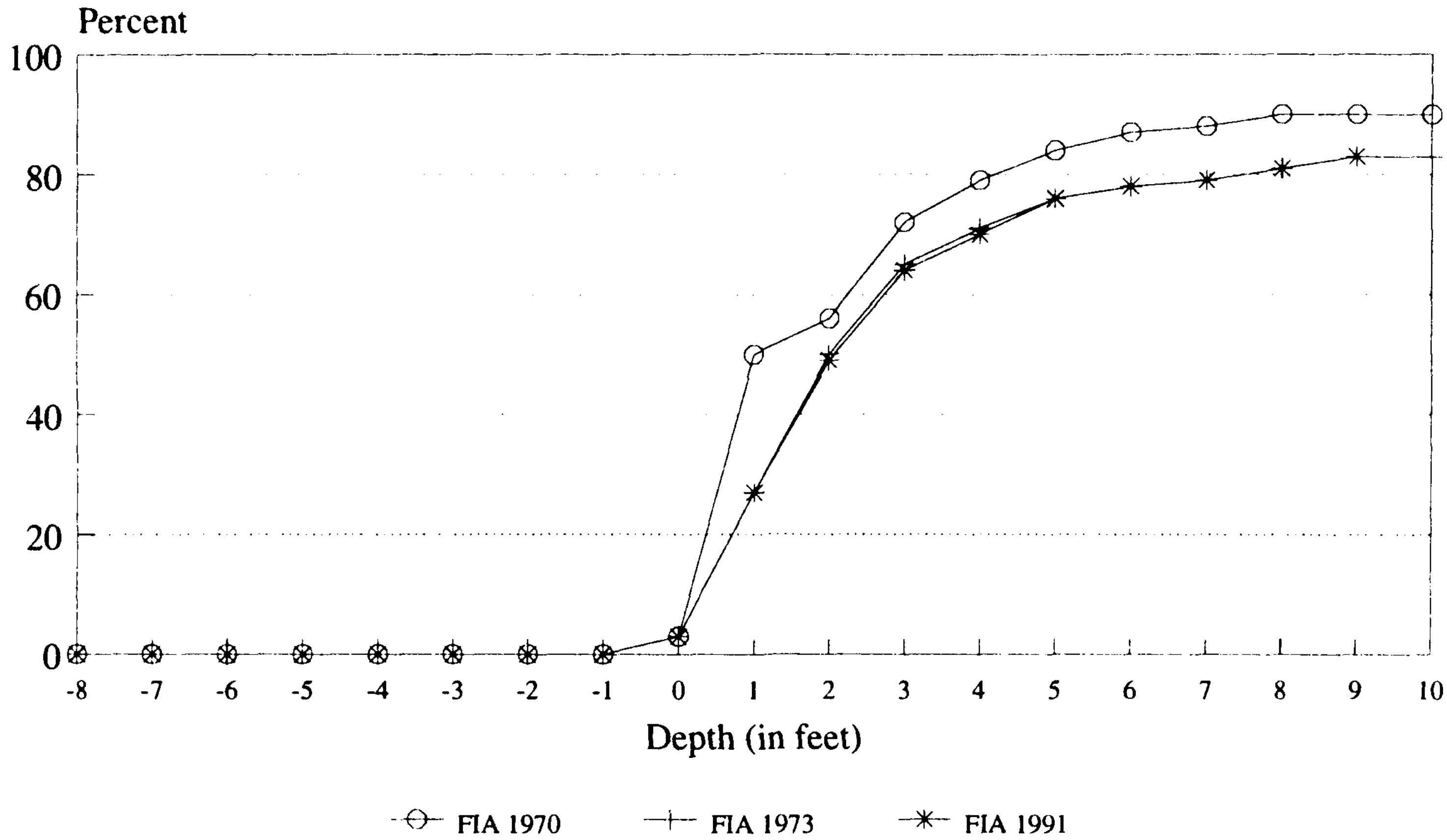


Figure 31

Percent Damage to Content Value
MOBILE HOME



CHAPTER SIX
CONCLUSIONS

This report emphasizes the importance and variability of depth-damage functions, and the many sources available to the analyst in developing, refining, adapting, or merely verifying the set of depth-damage functions. This catalog provides the first comprehensive review of the damage functions used by the Corps. All damage functions used by Corps field offices are presented, except those adapted from other sources.

The following conclusions are based on observations from this report and relate to the practice of depth-damage analysis.

1. No Establishment of Depth-Damage Functions

The Corps of Engineers has never officially established or required the use of a particular set of damage functions. The differences in magnitude of flood damages for various structure types and flooding sources, as illustrated in this catalog, are too pronounced to rely on any particular set of curves. It is recommended that selection of depth-damage functions remain the prerogative of each field office.

2. District and Division Responsibility

Exercising the prerogative of determining their own damage functions requires that the analysts involved in flood damage estimation be aware of the depth-damage functions used in their office. The analysts should be cognizant of structure types, beginning damage points, magnitude of damages, structure and content value definitions, and structure and content damage definitions implicit in the depth-damage functions.

3. Importance of Continual Verification

While each field office has the prerogative to compute its own depth-damage functions, this computation is often not done. This may result from lack of funding for an adequate survey, lack of recent flooding, lack of survey expertise, or lack of enthusiasm. But even when resources and enthusiasm are lacking, it is important to periodically conduct a small sampling of residences as a check on the validity of the functions. Over time, samples can build up to the point of generating new curves.

4. Value of Geographically Specific Damage Curves

While it is desirable for a Corps district to have district-wide damage functions, it is ideal to have either flood type or project-specific curves. Corps districts cover large geographic areas and sources of flooding are often quite diverse.

5. Insuring Sound Post-Flood Surveys

Post-flood studies are the ideal way to obtain accurate depth-damage information. But, in conducting post-flood surveys, the analyst should take care to insure proper questionnaire design, sampling procedures, and data analysis. It is also important to adequately document the results of the survey and analysis.

6. Insuring Sound Synthetic Damage Surveys

Synthetic flood damage surveys can be a valuable source of depth-damage information, especially when there is no recent flooding. Synthetic damage estimates can be greatly facilitated by the availability of: 1) susceptibility tables, which give the approximate extent of value loss when an item of building fabric or an item of contents is submerged; 2) repair cost indexes; 3) content depreciation tables; and, 4) a suggested value range for content items.

7. Insuring Sound Adaptations of Existing Damage Functions

As documented in Chapter Four, adaptation of existing depth-damage functions is a popular method for deriving new curves, but there are pitfalls in the adaptation option, which are described in Chapter Three. Adaptation can continue to be a valid source of depth-damage information as long as these pitfalls are avoided and sound judgement is used in the adaptation process.

8. Damage Function Documentation

The Corps of Engineers Washington Level Review Center (WLRC) is responsible for the detailed review of any Corps project that may be a candidate for Congressional authorization. This review includes examination of the reasonableness of any data that might affect the formulation of flood damage reduction activities. The WLRC makes no requirement to include depth-damage functions in reports. However, the reasonableness of the depth-damage relationship is determined by examining average annual damages per structure. If the average annual damages look unreasonable in relation to the value of property subject to flooding and frequency of flooding, the reviewer may reexamine the curves from the field office files. However, with little additional effort on the part of the analysts, reviewers and other readers would benefit from the inclusion of the depth-damage function in feasibility reports. After all, the depth-damage functions do influence a sizeable portion of the average annual benefits for most flood damage reduction projects.

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APPENDIX A

RESIDENTIAL DEPTH-DAMAGE TABLES[1]

TABLES A-1 - A-26

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1 In the following tables, note that 0 Water Height (In Feet) is equivalent to the first floor elevation.

Table A-1

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Structure Value)

Building Type: One Story, No Basement - Structural

Division:	District:	Set: *	Water Height (In Feet): -8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis																				
	New Orleans	Freshwater	0	0	0	0	0	0	0	0	9	26	37	43	48	51	54	56	58	59	60
		Saltwater	0	0	0	0	0	0	0	0	15	29	38	44	49	53	56	58	60	61	62
Missouri River	Kansas City		0	0	0	0	0	0	0	0	0	12	17	27	30		42		47		49
North Atlantic	New York	Passaic River																			
	Philadelphia		0	0	0	0	0	0	0	0	7	10	14	26	28	29	41	43	44	45	46
North Central	Buffalo		0	0	0	0	0	0	0	2	6	15	23	33	38	52	66	84	92	98	98
	Rock Island		0	0	0	1	1	1	2	4	10	22	30	35	39	43	45	47	49	50	51
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem	0	0	0	0	0	0	1	1	4	29	31	37	38	39	42	46	49	49	50
		Tributary	0	0	0	0	0	0	1	1	4	29	31	37	38	39	42	46	49	49	50
	Louisville	Frankfort	0	0	0	0	0	0	0	2	4	22	25	28	33	36	39	42	44	46	47
		Louisville	0	0	0	0	0	0	0	0	2	11	17	19	21	23	24	25	25	26	26
Pacific Ocean			0	0	0	0	0	0	0	0	23	43	62	81	100	100	100	100	100	100	100
South Atlantic	Charleston		0	0	0	0	0	0	0	0	3	6	10	13	16	18	22	25	25	25	25
	Jacksonville	Puerto Rico	0	0	0	0	0	0	0	0	3	6	10	13	16	18	22	25	25	25	25
		Florida	0	0	0	0	0	0	0	0	5	9	20	23	26	42	48		54		
	Wilmington		0	0	0	0	0	0	0	0	9	14	23	28	31	36	41	43	45	51	52
South Pacific	San Francisco		0	0	0	0	0	1	1	3	7	14	20	26	30	33	36	38	39	39	39
Southwestern	Galveston		0	0	0	0	0	0	0	0	10	21	27	32	37	43	46	50	54	58	60
	Little Rock	Slab Found.	0	0	0	0	0	0	0	0	0	20	26	37	42	44	45	45	46	51	56
		Block Found.	0	0	0	0	0	0	0	0	5	11	20	26	33	35	36	37	38	44	44
FIA 1970			0	0	0	0	0	0	0	0	8	22	30	35	39	41	44	46	48	50	50
FIA 1973			0	0	0	0	0	0	0	0	7	10	14	26	28	29	41	43	44	45	46
Flood Insurance Rate Review - 1991			0	0	0	0	0	0	0	0	8	14	21	27	29	30	40	43	44	45	46

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table. A-2

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Structure Value)

Building Type: One Story, With Basement - Structural

Division:	District:	Set: *	Water Height (In Feet): -8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis																				
	New Orleans	Freshwater																			
		Saltwater																			
Missouri River	Kansas City		0	0	0	0	0	0	0	0	0	19	21	24	29		40		51		55
North Atlantic	New York	Passaic River																			
	Philadelphia		0	1	2	3	3	4	4	8	11	18	20	23	28	33	38	44	49	51	53
North Central	Buffalo		0	2	3	5	5	6	7	7	10	18	22	28	39	68	78	89	94	99	99
	Rock Island		0	1	1	2	2	3	4	5	8	20	31	37	41	44	46	48	49	50	53
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem	0	2	3	4	4	4	4	5	5	30	32	38	39	40	43	47	50	50	50
		Tributary	0	2	3	4	4	4	4	5	5	30	32	38	39	40	43	47	50	50	50
	Louisville	Frankfort	0	2	3	4	4	5	6	7	10	23	26	30	35	38	42	45	47	49	51
		Louisville	3	3	3	3	4	4	4	4	2	13	19	21	23	24	25	26	26	27	27
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington		0	1	2	3	4	4	5	8	10	14	22	26	28	33	38	44	49	52	54
South Pacific	San Francisco		0	0	0	0	0	1	2	3	8	13	17	19	21	21	21	21	21	21	21
Southwestern	Galveston																				
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970			0	0	0	0	0	0	3	6	10	24	31	37	41	44	46	48	49	50	50
FIA 1973			0	0	0	0	0	0	4	8	11	18	20	23	28	33	38	44	49	51	53
Flood Insurance Rate Review - 1991																					

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-3

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Structure Value)

Building Type: One and One-Half Story, No Basement - Structural

Division:	District:	Set: *	Water Height (In Feet):																		
			-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis																				
	New Orleans	Freshwater																			
		Saltwater																			
Missouri River	Kansas City																				
North Atlantic	New York	Passaic River																			
	Philadelphia																				
North Central	Buffalo																				
	Rock Island																				
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem																			
		Tributary																			
	Louisville	Frankfort	0	0	0	0	0	0	0	1	4	13	15	18	22	25	27	30	34	37	38
		Louisville	0	0	0	0	0	0	0	0	2	10	15	17	19	21	22	24	24	27	31
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington		0	0	0	0	0	0	0	0	8	11	18	22	25	29	31	32	34	40	42
South Pacific	San Francisco																				
Southwestern	Galveston		0	0	0	0	0	0	0	0	10	28	35	41	43	46	48	49	50	50	50
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970																					
FIA 1973																					
Flood Insurance Rate Review - 1991																					

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-4

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Structure Value)

Building Type: One and One-Half Story, With Basement - Structural

Division:	District:	Set: *	Water Height (In Feet): -8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis																				
	New Orleans	Freshwater																			
		Saltwater																			
Missouri River	Kansas City																				
North Atlantic	New York	Passaic River																			
	Philadelphia																				
North Central	Buffalo																				
	Rock Island																				
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem																			
		Tributary																			
	Louisville	Frankfort	0	2	3	4	5	6	7	8	11	14	16	20	24	27	29	32	35	38	40
		Louisville	3	3	3	3	4	4	4	4	2	12	18	19	21	22	23	25	25	28	32
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington		0	1	1	2	3	3	4	4	9	12	20	24	27	31	35	38	39	41	43
South Pacific	San Francisco																				
Southwestern	Galveston																				
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970																					
FIA 1973																					
Flood Insurance Rate Review - 1991																					

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-5

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Structure Value)

Building Type: Split Level - Structural

Division:	District:	Set:	Water Height (In Feet):																		
			-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis																				
	New Orleans	Freshwater																			
		Saltwater																			
Missouri River	Kansas City		0	0	0	0	0	0	0	0	0	17	20	24	29		38		47		51
North Atlantic	New York	Passaic River	0	0	1	1	2	4	6	7	8	16	16	19	22	25	26	27	27	30	31
	Philadelphia																				
North Central	Buffalo		0	1	1	2	2	2	6	9	14	21	26	38	52	76	83	91	95	99	99
	Rock Island		0	1	1	2	3	4	6	8	12	15	21	30	40	48	53	57	61	63	66
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem	0	0	0	0	0	6	6	7	13	21	24	26	36	45	49	53	57	65	65
		Tributary	0	0	0	0	0	6	6	7	13	21	24	26	36	45	49	53	57	65	65
	Louisville	Frankfort																			
		Louisville																			
Pacific Ocean																			
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington																				
South Pacific	San Francisco																				
Southwestern	Galveston																				
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970																					
FIA 1973																					
Flood Insurance Rate Review - 1991																					

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or residential area.

Table A-6

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Structure Value)

Building Type: Split Level, No Basement - Structural

Division:	District:	Set: *	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
			Water Height (In Feet):																		
Lower Mississippi	Memphis																				
	New Orleans	Freshwater																			
		Saltwater																			
Missouri River	Kansas City																				
North Atlantic	New York	Passaic River																			
	Philadelphia		0	0	0	0	0	0	0	0	3	9	13	25	27	28	33	34	41	43	45
North Central	Buffalo																				
	Rock Island																				
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem																			
		Tributary																			
	Louisville	Frankfort																			
		Louisville																			
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington		0	0	0	0	0	0	0	0	3	5	7	12	15	20	24	29	31	35	43
South Pacific	San Francisco																				
Southwestern	Galveston																				
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970			0	0	0	0	0	0	0	0	3	11	20	25	29	31	33	34	41	46	50
FIA 1973			0	0	0	0	0	0	0	0	3	9	13	25	27	28	33	34	41	43	45
Flood Insurance Rate Review - 1991			0	0	0	0	0	0	0	0	3	9	13	25	27	28	33	34	41	43	45

* Some Districts use multiple sets of residential damge curves depending on type of flooding, structure, or geographic area.

Table A-7

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Structure Value)

Building Type: Split Level, With Basement - Structural

Division:	District:	Set: *	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
			Water Height (In Feet):																		
Lower Mississippi	Memphis																				
	New Orleans	Freshwater																			
		Saltwater																			
Missouri River	Kansas City																				
North Atlantic	New York	Passaic River	0	0	1	1	2	4	6	7	8	16	16	19	22	25	26	27		30	31
	Philadelphia		0	1	2	3	3	4	4	5	6	16	19	22	27	32	35	36	44	48	50
North Central	Buffalo																				
	Rock Island																				
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem																			
		Tributary																			
	Louisville	Frankfort																			
		Louisville																			
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington																				
South Pacific	San Francisco																				
Southwestern	Galveston																				
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970			0	0	0	0	0	0	3	5	6	16	22	26	30	32	35	36	44	48	52
FIA 1973			0	0	0	0	0	0	3	5	6	16	19	22	27	32	35	36	44	48	50
Flood Insurance Rate Review - 1991			0	0	0	0	0	0	3	5	6	16	19	22	27	32	35	36	44	48	50

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-8

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Structure Value)

Building Type: Two or More Stories, No Basement - Structural

Division:	District:	Set: *	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
			Water Height (In Feet):																		
Lower Mississippi	Memphis																				
	New Orleans	Freshwater	0	0	0	0	0	0	0	0	8	16	21	24	27	29	30	30	31	37	42
		Saltwater	0	0	0	0	0	0	0	0	8	16	21	24	27	29	30	30	31	37	42
Missouri River	Kansas City		0	0	0	0	0	0	0	0	0	9	14	19	22		28		36		44
North Atlantic	New York	Passaic River																			
	Philadelphia		0	0	0	0	0	0	0	0	5	9	13	18	20	22	24	26	31	36	38
North Central	Buffalo		0	0	0	0	0	0	0	2	5	10	15	23	28	41	58	81	91	98	98
	Rock Island		0	1	1	1	2	2	2	3	6	10	16	20	24	28	30	32	34	38	42
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem	0	0	0	0	0	0	0	1	4	20	22	26	28	29	32	35	37	40	43
		Tributary	0	0	0	0	0	0	0	1	4	20	22	26	28	29	32	35	37	40	43
	Louisville	Frankfort	0	0	0	0	0	0	0	1	4	13	15	18	22	25	27	30	34	37	38
		Louisville	0	0	0	0	0	0	0	0	2	10	14	15	17	18	20	21	21	29	33
Pacific Ocean																					
South Atlantic	Charleston		0	0	0	0	0	0	0	2	4	7	12	16	19	22	25	26	28	30	33
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington		0	0	0	0	0	0	0	0	7	9	15	18	21	25	28	29	30	32	36
South Pacific	San Francisco		0	0	0	0	0	1	1	2	7	9	11	14	16	18	20	21	23	23	23
Southwestern	Galveston		0	0	0	0	0	0	0	0	5	21	27	31	34	37	39	40	40	42	44
	Little Rock	Slab Found.	0	0	0	0	0	0	0	0	0	7	16	22	24	26	27	28	28	28	39
		Block Found.	0	0	0	0	0	0	0	0	6	20	26	37	42	44	45	45	46	51	56
FIA 1970			0	0	0	0	0	0	0	0	4	10	16	20	24	27	30	32	34	37	42
FIA 1973			0	0	0	0	0	0	0	0	5	9	13	18	20	22	24	26	31	36	38
Flood Insurance Rate Review - 1991			0	0	0	0	0	0	0	0	5	9	13	18	20	22		26			38

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-9

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Structure Value)

Building Type: Two or More Stories, With Basement - Structural

Division:	District:	Set: *	Water Height (In Feet):																		
			-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis																				
	New Orleans	Freshwater																			
		Saltwater																			
Missouri River	Kansas City		0	0	0	0	0	0	0	0	0	13	18	24	29		38		44		51
North Atlantic	New York	Passaic River																			
	Philadelphia		0	1	2	3	3	4	4	5	7	11	17	22	28	33	35	38	40	44	46
North Central	Buffalo		0	1	1	2	2	2	3	5	8	12	17	27	35	53	70	86	93	99	99
	Rock Island		0	1	1	2	2	3	3	4	7	14	21	26	30	33	35	37	40	45	48
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem	0	2	3	4	4	4	4	5	5	21	23	27	29	30	33	36	38	40	43
		Tributary	0	2	3	4	4	4	4	5	5	21	23	27	29	30	33	36	38	40	43
	Louisville	Frankfort	0	2	3	4	5	6	7	8	11	14	16	20	24	27	29	32	35	38	40
		Louisville	3	3	3	3	4	4	4	4	2	12	16	17	19	20	21	24	24	31	35
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington		0	1	1	2	2	3	3	6	8	10	19	22	25	29	32	34	34	35	37
South Pacific	San Francisco		0	0	0	0	0	1	2	2	7	8	9	10	11	14	15	16	16	16	16
Southwestern	Galveston																				
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970			0	0	0	0	0	0	3	5	7	14	21	26	30	33	35	38	40	44	46
FIA 1973			0	0	0	0	0	0	3	5	7	11	17	22	28	33	35	38	40	44	46
Flood Insurance Rate Review - 1991			0	0	0	0	0	0	4	8	11	15	21	23	28	33	38	44	49	51	53

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area

Table A-10

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Structure Value)

Building Type: Mobile Home - Structural

Division	District	Set: *	Water Height (In Feet) -8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis		0	0	0	0	0	0	0	1	3	40	60	80	80	80	100	100	100	100	100
	New Orleans	Freshwater	0	0	0	0	0	0	0	0	30	77	92	98	100	100	100	100	100	100	100
		Saltwater	0	0	0	0	0	0	0	0	30	77	92	98	100	100	100	100	100	100	100
Missouri River	Kansas City		0	0	0	0	0	0	0	0	0	40	60	71	77		80		90		95
North Atlantic	New York	Passaic River	0	0	0	0	0	0	0	0	0	39	42	59	76	93	93	93	93	93	93
	Philadelphia		0	0	0	0	0	0	0	0	8	45	64	74	79	80	81	82	82	82	82
North Central	Buffalo																				
	Rock Island		0	0	0	0	0	1	1	2	7	15	30	50	65	79	89	90	90	90	90
North Pacific	Walla Walla		0	0	0	0	0	0	0	0	12	14	21	32	33	41	42	42	43	43	43
Ohio River	Huntington	Mainstem	0	0	0	0	0	0	0	0	50	85	85	100	100	100	100	100	100	100	100
		Tributary	0	0	0	0	0	0	0	0	50	85	85	100	100	100	100	100	100	100	100
	Louisville	Frankfort																			
		Louisville																			
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida	0	0	0	0	0	0	0	0	14	19	35						97		
	Wilmington		0	0	0	0	0	0	0	0	8	27	42	60	93	96	97	97	97	97	98
South Pacific	San Francisco		0	0	0	0	0	1	5	10	23	35	44	51	51	52	53	55	55	55	55
Southwestern	Galveston		0	0	0	0	0	0	0	0	14	19	31	54	93	96	96	97	97	97	98
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970			0	0	0	0	0	0	0	0	8	50	71	82	87	89	91	91	91	91	91
FIA 1973			0	0	0	0	0	0	0	0	8	45	64	74	79	80	81	82	82	82	82
Flood Insurance Rate Review - 1991			0	0	0	0	0	0	0	0	8	44	63	73	78	80	81	82	82	82	82

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-11

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Structure Value)

Building Type: Miscellaneous Building Types for Kansas City, Galveston, Pacific Ocean, Memphis, and Jacksonville

Set: *	Water Height (In Feet):																		
	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Kansas City																			
Townhouse/Condo, Two Levels	0	0	0	0	0	0	0	0	0	20	26	29	31		35		41		46
Galveston																			
Townhouse/Condo, Two Levels	0	0	0	0	0	0	0	0	5	28	29	31	36	37	39	40	41	42	44
High-Raised Elevated	0	0	0	0	0	0	0	0	0	1	2	3	5	7	8	10	12	18	28
Pacific Ocean																			
One Story On Piers, No Basement	0	0	0	0	2	4	8	18	65	100	100	100	100	100	100	100	100	100	100
High-Raised Elevated	0	0	0	0	0	2	6	11	17	60	100	100	100	100	100	100	100	100	100
Memphis																			
One Story Frame, No Basement	0	0	0	0	0	0	0	0	0	10	18	27	31	35	39	43	54	57	61
One Story Frame, With Basement	0	1	1	1	2	2	2	3	6	15	23	31	35	38	42	46	55	58	61
Split Level Frame	0	0	0	0	0	0	0	0	0	7	12	17	22	31	33	37	42	45	47
Two Story Frame, No Basement	0	0	0	0	0	0	0	0	0	3	10	15	17	20	22	25	31	33	37
Two Story Frame, With Basement	0	1	1	2	2	2	3	3	4	9	14	19	21	23	25	27	33	35	39
One Story Masonry, No Basement	0	0	0	0	0	0	0	0	3	13	21	30	34	38	42	46	57	61	64
One Story Masonry, With Basement	0	1	1	1	2	2	2	3	6	15	23	31	35	38	42	46	55	58	61
Split Level Masonry	0	0	0	0	0	0	0	0	0	7	12	17	22	31	33	37	42	45	47
Two Story Masonry, No Basement	0	0	0	0	0	0	0	0	0	3	10	15	17	20	22	25	31	33	37
Two Story Masonry, With Basement	0	1	1	2	2	2	3	3	4	9	14	19	21	23	25	27	33	35	39
Jacksonville																			
Puerto Rico One Story Masonry, No Basement	0	0	0	0	0	0	0	0	3	6	10	13	16	18	22	25	25	25	25
Florida - One Story Masonry, No Basement	0	0	0	0	0	0	0	0	5	9	20	23	26	42	48		54		

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area

Table A-12

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Structure Value)

Building Type: Miscellaneous Building Types for Passaic River, Rock Island, and Charleston

Set: *	Water Height (In Feet):																		
	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Passaic River																			
Ranch	0	1	1	2	2	3	4	5	7	24	25	26	28	30	31	33	33	36	36
Cape	0	0	1	1	2	2	3	5	7	20	21	23	24	26	28	29	29	32	34
Colonial	0	0	1	1	1	1	3	4	5	17	18	20	21	23	24	26	26	29	31
Bi-Level	1	4	8	9	10	11	13	14	15	29	29	30	31	32	33	34	36	36	36
Two Family	0	0	1	1	2	2	4	5	6	17	18	20	22	23	25	27		30	32
Other	0	1	2	2	3	4	5	6	8	23	24	27	29	31	33	35	35	39	40
Rock Island																			
Split Foyer	0	2	4	5	5	6	8	11	15	23	29	33	36	39	41	42	43	44	46
Charleston																			
Tri-Level, No Basement	0	0	0	0	5	7	10	11	15	18	22	25	28	33	35	37	40	42	43
One Story, Basement Living Area	0	5	8	10	12	13	14	15	22	27	31	34	37	39	41	44	46	49	50
One Story, Basement Storage	0	2	4	6	7	8	9	10	17	23	28	31	34	38	41	44	46	48	50
Two Story, Basement Living Area	0	4	6	8	10	12	14	15	19	21	24	26	29	32	33	35	40	41	42
Two Story, Basement Storage	0	2	3	5	7	8	9	10	15	17	20	23	26	29	31	33	37	38	39

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-13

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Structure Value)

Building Type: Miscellaneous Building Types for Walla Walla

Set: *

Water Height (In Feet):

	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Walla Walla																			
One Story Frame, No Basement	0	0	0	0	0	0	0	0	12	14	21	32	33	41	42	42	43		
One Story Frame, With Basement	0	0	0	0	0	0	0	0	20	25	30	40	43	47	48	48	48		
One and One-Half Story Frame, No Basement	0	0	0	0	0	0	0	0	8	9	16	26	29	35	[illegible]	[illegible]	37		
One and One-Half Story Frame, With Basement	0	0	0	0	0	0	0	0	12	17	22	31	35	39	40	41	41		
Two Story Frame, No Basement	0	0	0	0	0	0	0	0	8	10	15	21	25	30	32	33	33		
Two Story Frame, With Basement	0	0	0	0	0	0	0	0	11	13	14	18	22	25	26	27	27		
One Story Masonry, No Basement	0	0	0	0	0	0	0	0	5	6	13	25	30	34	35	35	35		
One Story Masonry, With Basement	0	0	0	0	0	0	0	0	20	25	30	40	43	47	48	48	48		
One and One-Half Story Masonry, No Basement	0	0	0	0	0	0	0	0	1	2	8	18	22	27	29	29	29		
One and One-Half Story Masonry, With Basement	0	0	0	0	[illegible]	0	0	0	12	17	22	31	35	39	40	41	41		
Two Story Masonry, No Basement	0	0	0	0	0	0	0	0	2	3	8	14	18	23	25	26	26		
Two Story Masonry, With Basement	0	0	0	0	0	0	0	0	11	13	14	18	22	25	26	27	27		

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-14

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Contents Value)

Building Type: One Story, No Basement - Contents

Division:	District:	Set: *	Water Height (In Feet): -8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis																				
	New Orleans	Freshwater	0	0	0	0	0	0	0	0	0	22	40	53	62	67	71	73	74	76	77
		Saltwater	0	0	0	0	0	0	0	0	0	22	40	53	62	67	71	73	74	76	77
Missouri River	Kansas City		0	0	0	0	0	0	0	0	0	12	17	27	30		42		47		49
North Atlantic	New York	Passaic River																			
	Philadelphia		0	0	0	0	0	0	0	0	10	17	23	29	35	40	45	50	55	60	60
North Central	Buffalo		0	0	0	0	0	0	0	0	7	42	56	70	75	81	84	88	91	94	94
	Rock Island		0	0	0	0	0	0	0	0	3	32	50	60	68	73	78	81	83	85	87
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem	0	0	0	0	0	0	0	0	0	23	38	41	44	46	47	49	50	50	50
		Tributary	0	0	0	0	0	0	0	0	0	30	53	64	72	77	80	82	83	83	83
	Louisville	Frankfort	0	0	0	0	0	0	0	0	4	25	48	56	67	73	78	80	81	82	83
		Louisville	0	0	0	0	0	0	0	0	3	20	26	31	37	42	48	55	55	60	60
Pacific Ocean			0	0	0	0	0	0	0	0	11	40	85	100	100	100	100	100	100	100	100
South Atlantic	Charleston		0	0	0	0	0	0	0	0	0	38	49	63	72	74	74	75	76	77	80
	Jacksonville	Puerto Rico	0	0	0	0	0	0	0	0	0	15	29	44	60	70	79	87	90	95	95
		Florida	0	0	0	0	0	0	0	0	0	18	26	39	41				47		
	Wilmington		0	0	0	0	0	0	0	0	11	24	36	43	46	52	65	75	85	86	87
South Pacific	San Francisco		0	0	0	0	0	0	0	0	11	16	20	25	30	35	40	46	47	47	47
Southwestern	Galveston		0	0	0	0	0	0	0	0	8	42	60	71	77	82	85	86	87	88	88
	Little Rock	Slab Found.	0	0	0	0	0	0	0	0	4	31	53	68	86	89	89	89	89	89	89
		Block Found.	0	0	0	0	0	0	0	0	4	31	53	68	86	89	89	89	89	89	89
FIA 1970			0	0	0	0	0	0	0	0	5	35	50	60	68	74	78	81	83	85	85
FIA 1973			0	0	0	0	0	0	0	0	10	17	23	29	35	40	45	50	55	60	60
Flood Insurance Rate Review - 1991			0	0	0	0	0	0	0	0	11	17	32	35	37	41	45	50	55	60	60

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-15

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Contents Value)

Building Type: One Story, With Basement - Contents

Division:	District:	Set: *	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
			Water Height (In Feet):																		
Lower Mississippi	Memphis																				
	New Orleans	Freshwater																			
		Saltwater																			
Missouri River	Kansas City		0	0	0	0	0	0	0	0	0	19	21	24	29		40		51		55
North Atlantic	New York	Passaic River																			
	Philadelphia		0	1	2	5	5	5	7	8	15	20	22	28	33	39	44	50	55	60	60
North Central	Buffalo		0	4	8	10	13	14	15	16	23	38	50	63	68	73	79	85	89	94	94
	Rock Island		0	1	1	2	2	4	5	9	15	40	58	70	76	80	82	84	85	85	85
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem	0	1	2	2	3	3	3	3	3	33	43	48	49	49	49	50	50	50	50
		Tributary	0	9	12	13	15	16	16	18	19	39	60	69	80	80	80	81	82	82	82
	Louisville	Frankfort	0	2	3	5	8	10	12	13	20	38	47	57	65	71	76	78	79	80	81
		Louisville	3	3	3	3	4	4	4	4	3	21	27	32	37	43	49	56	56	60	60
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington		1	2	5	8	10	12	13	13	20	34	48	52	[illegible]	78	84	88	91	93	95
South Pacific	San Francisco		0	0	0	0	0	0	0	0	11	14	16	18	20	21	23	24	25	25	25
Southwestern	Galveston																				
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970			0	0	0	0	0	0	8	8	21	40	58	70	76	80	82	83	85	85	85
FIA 1973			0	0	0	0	0	5	7	8	15	20	22	28	33	39	44	50	55	60	60
Flood Insurance Rate Review - 1991																					

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-16

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Contents Value)

Building Type: One and One-Half Story, No Basement - Contents

Division:	District:	Set: *	Water Height (In Feet): -8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis																				
	New Orleans	Freshwater																			
		Saltwater																			
Missouri River	Kansas City																				
North Atlantic	New York	Passaic River																			
	Philadelphia																				
North Central	Buffalo																				
	Rock Island																				
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem																			
		Tributary																			
	Louisville	Frankfort	0	0	0	0	0	0	0	0	3	15	30	35	40	43	46	47	48	50	53
		Louisville	0	0	0	0	0	0	0	0	3	17	21	25	30	35	39	39	39	43	44
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington		0	0	0	0	0	0	0	0	9	21	31	37	43	51	60	68	75	78	80
South Pacific	San Francisco																				
Southwestern	Galveston		0	0	0	0	0	0	0	0	2	22	36	45	57	66	71	77	79	82	84
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970																					
FIA 1973																					
Flood Insurance Rate Review - 1991																					

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area

Table A-17

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Contents Value)

Building Type: One and One-Half Story, With Basement - Contents

Division:	District:	Set: *	Water Height (In Feet): -8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis																				
	New Orleans	Freshwater																			
		Saltwater																			
Missouri River	Kansas City																				
North Atlantic	New York	Passaic River																			
	Philadelphia																				
North Central	Buffalo																				
	Rock Island																				
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem																			
		Tributary																			
	Louisville	Frankfort	0	1	3	5	7	9	11	12	14	19	28	32	37	42	44	45	47	49	52
		Louisville	3	3	3	3	4	4	4	4	3	18	22	26	31	35	39	39	39	43	44
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington		0	1	3	5	6	8	8	9	18	30	41	43	54	67	72	77	80	80	81
South Pacific	San Francisco																				
Southwestern	Galveston																				
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970																					
FIA 1973																					
Flood Insurance Rate Review - 1991																					

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-18

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Contents Value)

Building Type: Split Level - Contents

Division:	District:	Set: *	Water Height (In Feet): -8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis																				
Valley	New Orleans	Freshwater																			
		Saltwater																			
Missouri River	Kansas City		0	0	0	0	0	0	0	0	0	17	20	24	29		38		47		51
North Atlantic	New York	Passaic River	0	0	1	2	3	7	11	15	18	30	40	46	52	58	63	68	68	79	80
	Philadelphia																				
North Central	Buffalo		0	1	2	3	5	7	11	14	19	26	31	38	44	53	58	67	73	79	79
	Rock Island		0	1	1	2	3	4	6	9	15	23	34	52	65	72	76	80	82	84	86
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem	0	0	0	0	0	2	2	3	3	6	7	8	8	29	40	45	50	50	50
		Tributary	0	0	0	0	0	12	12	17	19	33	38	42	45	60	71	74	78	79	81
	Louisville	Frankfort																			
		Louisville																			
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington																				
South Pacific	San Francisco																				
Southwestern	Galveston																				
	Little Rock	Slab Found.																			
		Block Found																			
FIA 1970																					
FIA 1973																					
Flood Insurance Rate Review - 1991																					

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area

Table A-19

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Contents Value)

Building Type: Split Level, No Basement - Contents

Division:	District:	Set: *	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis																				
	New Orleans	Freshwater																			
		Saltwater																			
Missouri River	Kansas City																				
North Atlantic	New York	Passaic River																			
	Philadelphia		0	0	0	0	0	0	0	0	2	19	32	41	47	51	53	55	56	62	69
North Central	Buffalo																				
	Rock Island																				
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem																			
		Tributary																			
	Louisville	Frankfort																			
		Louisville																			
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington		0	0	0	0	0	0	0	0	3	15	21	25	32	44	50	54	58	61	72
South Pacific	San Francisco																				
Southwestern	Galveston																				
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970			0	0	0	0	0	0	0	0	2	19	32	41	47	51	53	55	56	62	69
FIA 1973																					
Flood Insurance Rate Review - 1991																					

Water Height (In Feet)

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-20

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Contents Value)

Building Type: Split Level, With Basement - Contents

Division:	District:	Set: *	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis																				
	New Orleans	Freshwater																			
		Saltwater																			
Missouri River	Kansas City																				
North Atlantic	New York	Passaic River	0	0	1	2	3	7	11	15	18	30	40	46	52	58	63	68		79	80
	Philadelphia		0	1	2	5	5	5	10	15	18	31	44	52	58	61	63	64	66	69	73
North Central	Buffalo																				
	Rock Island																				
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem																			
		Tributary																			
	Louisville	Frankfort																			
		Louisville																			
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington																				
South Pacific	San Francisco																				
Southwestern	Galveston																				
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970			0	0	0	0	0	0	10	15	18	31	44	52	58	61	63	64	66	69	73
FIA 1973																					
Flood Insurance Rate Review - 1991																					

Water Height (In Feet): columns -8 through 10.

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-21

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Contents Value)

Building Type: Two or More Stories, No Basement - Contents

Division:	District:	Set: *	Water Height (In Feet): -8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis																				
	New Orleans	Freshwater	0	0	0	0	0	0	0	0	0	16	24	28	30	34	35	36	37	[illegible]	[illegible]
		Saltwater	0	0	0	0	0	0	0	0	0	16	24	28	30	34	35	36	37	[illegible]	[illegible]
Missouri River	Kansas City		0	0	0	0	0	0	0	0	0	9	14	19	22		28		36		[illegible]
North Atlantic	New York	Passaic River																			
	Philadelphia		0	0	0	0	0	0	0	0	7	9	17	22	28	33	39	44	50	55	58
North Central	Buffalo		0	0	0	0	0	0	0	0	6	17	29	39	44	51	58	66	72	79	79
	Rock Island		0	0	0	0	0	0	0	0	5	17	28	37	43	47	49	50	51	55	[illegible]
North Pacific	Walla Walla		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Ohio River	Huntington	Mainstem	0	0	0	0	0	0	0	0	0	5	6	6	7	8	8	8	8	11	19
		Tributary	0	0	0	0	0	0	0	0	0	16	28	34	38	41	43	35	46	49	56
	Louisville	Frankfort	0	0	0	0	0	0	0	0	3	15	30	35	40	43	46	47	48	50	53
		Louisville	0	0	0	0	0	0	0	0	3	15	19	23	26	30	34	34	34	39	41
Pacific Ocean																					
South Atlantic	Charleston		0	0	0	0	0	0	0	0	0	16	26	32	35	36	37	37	39	45	57
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington		0	0	0	0	0	0	0	0	8	18	26	30	40	50	53	55	55	55	58
South Pacific	San Francisco		0	0	0	0	0	0	0	0	6	11	15	19	22	24	26	28	28	28	28
Southwestern	Galveston		0	0	0	0	0	0	0	0	4	24	34	40	47	53	56	58	58	58	61
	Little Rock	Slab Found.	0	0	0	0	0	0	0	0	4	31	53	68	86	89	89	89	89	89	89
		Block Found.	0	0	0	0	0	0	0	0	4	31	53	68	86	89	89	89	89	89	89
FIA 1970			0	0	0	0	0	0	0	0	5	16	28	37	43	47	49	50	51	55	58
[illegible]			0	0	0	0	0	0	0	0	7	9	17	22	28	33	39	44	50	55	58
[illegible] Insurance Rate Review - 1991			0	0	0	0	0	0	0	0	7	11	18	23	28	33	39	44	50	50	58

* [illegible] Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-22

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Contents Value)

Building Type: Two or More Stories, With Basement - Contents

Division:	District:	Set: *	Water Height (In Feet):																		
			-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Lower Mississippi	Memphis																				
	New Orleans	Freshwater																			
		Saltwater																			
Missouri River	Kansas City		0	0	0	0	0	0	0	0	0	13	18	24	29		38		44		51
North Atlantic	New York	Passaic River																			
	Philadelphia		0	1	2	5	5	5	6	9	11	17	22	28	33	39	44	49	55	61	64
North Central	Buffalo		0	2	5	6	7	8	9	10	14	21	28	39	45	52	58	67	73	79	79
	Rock Island		0	2	2	3	4	4	5	5	9	22	34	43	48	51	52	53	56	59	64
North Pacific	Walla Walla																				
Ohio River	Huntington	Mainstem	0	1	2	2	3	3	3	3	3	7	8	8	9	9	9	9	9	13	20
		Tributary	0	8	12	13	14	14	14	15	15	25	36	41	44	46	47	48	49	51	58
	Louisville	Frankfort	0	1	3	5	7	9	11	12	14	19	28	32	37	42	44	45	47	49	52
		Louisville	3	3	3	3	4	4	4	4	3	16	19	23	27	30	34	34	34	39	41
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida																			
	Wilmington		0	1	3	5	7	8	9	9	16	26	35	38	45	53	56	58	59	59	63
South Pacific	San Francisco		0	0	0	0	0	0	0	0	11	13	15	16	18	20	21	22	23	25	25
Southwestern	Galveston																				
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970			0	0	0	0	0	0	5	5	10	22	34	43	48	51	52	53	56	59	64
FIA 1973			0	0	0	0	0	5	6	9	11	17	22	28	33	39	44	49	55	61	64
Flood Insurance Rate Review - 1991																					

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-23

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Contents Value)

Building Type: Mobile Home - Contents

Division:	District:	Set: *	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
			Water Height (In Feet):																		
Lower Mississippi	Memphis		0	0	0	0	0	0	0	0	0	25	54	75	100	100	100	100	100	100	100
	New Orleans	Freshwater	0	0	0	0	0	0	0	0	0	22	40	53	62	67	71	73	74	76	77
		Saltwater	0	0	0	0	0	0	0	0	0	22	40	53	62	67	71	73	74	76	77
Missouri River	Kansas City		0	0	0	0	0	0	0	0	0	40	60	71	77		80		90		95
North Atlantic	New York	Passaic River	0	0	0	0	0	0	0	0	0	27	53	62	72	81	81	81	81	81	81
	Philadelphia		0	0	0	0	0	0	0	0	3	27	50	65	71	76	78	79	81	83	83
North Central	Buffalo																				
	Rock Island		0	0	0	0	0	0	0	0	0	22	60	78	88	90	90	90	90	90	90
North Pacific	Walla Walla		0	0	0	0	0	0	0	0	3	36	61	71	80	83	86	89	91	91	91
Ohio River	Huntington	Mainstem	0	0	0	0	0	0	0	0	0	20	35	36	39	42	44	44	44	44	44
		Tributary	0	0	0	0	0	0	0	0	0	28	53	64	70	76	79	79	79	79	79
	Louisville	Frankfort																			
		Louisville																			
Pacific Ocean																					
South Atlantic	Charleston																				
	Jacksonville	Puerto Rico																			
		Florida	0	0	0	0	0	0	0	0	9	16	31	36		51	52		63		
	Wilmington		0	0	0	0	0	0	0	0	6	22	32	37	50	63	74	82	100	100	100
South Pacific	San Francisco		0	0	0	0	0	0	0	0	10	22	34	40	45	47	48	49	50	50	50
Southwestern	Galveston		0	0	0	0	0	0	0	0	3	23	36	43	55	66	78	86	100	100	100
	Little Rock	Slab Found.																			
		Block Found.																			
FIA 1970			0	0	0	0	0	0	0	0	3	50	56	72	79	84	87	88	90	90	90
FIA 1973			0	0	0	0	0	0	0	0	3	27	50	65	71	76	78	79	81	83	83
Flood Insurance Rate Review - 1991			0	0	0	0	0	0	0	0	3	27	49	64	70	76	78	79	81	83	83

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-24

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Contents Value)

Building Type: Miscellaneous Building Types for Kansas City, Galveston, Pacific Ocean, Memphis, and Jacksonville

Set: *	Water Height (In Feet):																		
	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Kansas City																			
Townhouse/Condo, Two Levels	0	0	0	0	0	0	0	0	0	20	26	29	31		35		41		46
Galveston																			
Townhouse/Condo, Two Levels	0	0	0	0	0	0	0	0	4	24	34	40	47	53	56	58	58	58	61
High-Raised Elevated	0	0	0	0	0	0	0	0	1	2	5	8	10	12	13	13	14	26	38
Pacific Ocean																			
One Story On Piers, No Basement	0	0	0	0	2	4	8	18	65	100	100	100	100	100	100	100	100	100	100
High-Raised Elevated	0	0	0	0	0	2	4	6	11	40	85	100	100	100	100	100	100	100	100
Memphis																			
One Story Frame, No Basement	0	0	0	0	0	0	0	0	0	21	46	72	78	83	83	83	83	83	83
One Story Frame, With Basement	1	1	2	3	4	4	4	4	7	22	47	71	77	82	82	82	82	82	82
Split Level Frame	0	0	0	0	0	0	0	0	0	14	31	47	51	55	56	64	72	80	82
Two Story Frame, No Basement	0	0	0	0	0	0	0	0	0	13	31	47	51	55	55	55	55	55	58
Two Story Frame, With Basement	1	1	2	3	4	4	4	4	4	15	32	48	52	55	55	55	55	56	63
One Story Masonry, No Basement	0	0	0	0	0	0	0	0	0	21	46	72	78	83	83	83	83	83	83
One Story Masonry, With Basement	1	1	2	3	4	4	4	4	7	22	47	71	77	82	82	82	82	82	82
Split Level Masonry	0	0	0	0	0	0	0	0	0	14	31	47	51	55	56	64	72	80	82
Two Story Masonry, No Basement	0	0	0	0	0	0	0	0	0	13	31	47	51	55	55	55	55	55	58
Two Story Masonry, With Basement	1	1	2	3	4	4	4	4	4	15	32	48	52	55	55	55	55	56	63
Jacksonville																			
Puerto Rico - On Story Masonry, No Basement	0	0	0	0	0	0	0	0	15	29	44	60	70	79	87	90	95	95	95
Florida - On Story Masonry, No Basement	0	0	0	0	0	0	0	0	18	26	39	41	36	40		47			59

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-25

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Contents Value)

Building Type: Miscellaneous Building Types for Passaic River, Rock Island, and Charleston

Set: *	Water Height (In Feet):																		
	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Passaic River																			
Ranch	0	1	2	3	4	4	6	9	10	32	53	63	73	82	83	83	83	83	85
Cape	0	1	2	3	3	4	7	10	12	29	45	52	59	65	66	66	66	66	70
Colonial	0	1	1	2	2	3	6	8	9	24	36	42	48	53	54	54	54	55	61
Bi Level	1	4	10	14	15	16	17	19	20	38	58	66	74	83	83	83	83	83	83
Two Family	0	0	2	2	3	3	5	6	7	20	33	39	46	52	53	54		56	61
Other	0	1	3	4	5	6	7	8	9	28	46	54	62	70	71	71	71	73	75
Rock Island																			
Split Foyer	0	1[illegible]	15	15	16	16	17	21	26	33	41	51	62	69	75	78	81	83	84
Charleston																			
Tri-Level, No Basement	0	0	0	0	8	12	15	18	20	27	30	32	34	36	46	56	66	75	78
One Story, Basement Living Area	0	9	14	17	20	22	22	23	23	23	53	56	65	74	76	77	77	78	80
One Story, Basement Storage	0	3	5	7	9	9	10	10	10	10	40	46	62	71	73	74	75	77	80
Two Story, Basement Living Area	0	8	12	16	18	20	21	21	21	21	31	34	42	45	46	46	47	47	53
Two Story, Basement, Storage	0	2	4	5	6	6	6	6	7	7	13	17	26	36	37	38	38	38	47

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.

Table A-26

RESIDENTIAL DEPTH-DAMAGE FUNCTIONS
(Percent Damages to Contents Value)

Building Type: Miscellaneous Building Types for Walla Walla

Set: *	Water Height (In Feet):																		
	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
Walla Walla																			
One Story Frame, No Basement	0	0	0	0	0	0	0	0	3	36	61	71	80	83	86	89	91		
One Story Frame, With Basement	0	0	0	0	0	0	0	0	9	39	65	73	81	84	86	89	91		
One and One-Half Story Frame,	0	0	0	0	0	0	0	0	2	26	42	49	56	57	59	60	61		
No Basement																			
One and One-Half Story Frame,	0	0	0	0	0	0	0	0	13	32	47	52	56	58	59	60	61		
With Basement																			
Two Story Frame, No Basement	0	0	0	0	0	0	0	0	2	17	24	29	34	34	34	35	35		
Two Story Frame, With Basement	0	0	0	0	0	0	0	0	15	33	48	53	57	59	60	61	62		
One Story Masonry, No Basement	0	0	0	0	0	0	0	0	3	36	61	71	80	83	86	89	91		
One Story Masonry, With Basement	0	0	0	0	0	0	0	0	9	39	65	73	81	84	86	89	91		
One and One-Half Story Masonry,	0	0	0	0	0	0	0	0	2	26	42	49	56	57	59	60	61		
No Basement																			
One and One-Half Story Masonry,	0	0	0	0	0	0	0	0	14	32	47	52	56	58	59	60	61		
With Basement																			
Two Story Masonry, No Basement	0	0	0	0	0	0	0	0	2	17	24	29	34	34	34	35	35		
Two Story Masonry, With Basement	0	0	0	0	0	0	0	0	15	33	48	53	57	59	60	61	61		

* Some Districts use multiple sets of residential damage curves depending on type of flooding, structure, or geographic area.