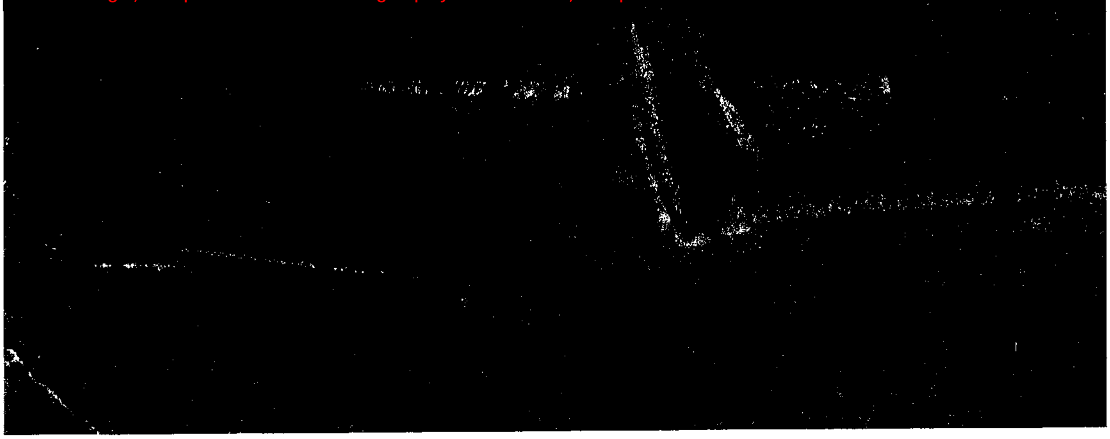
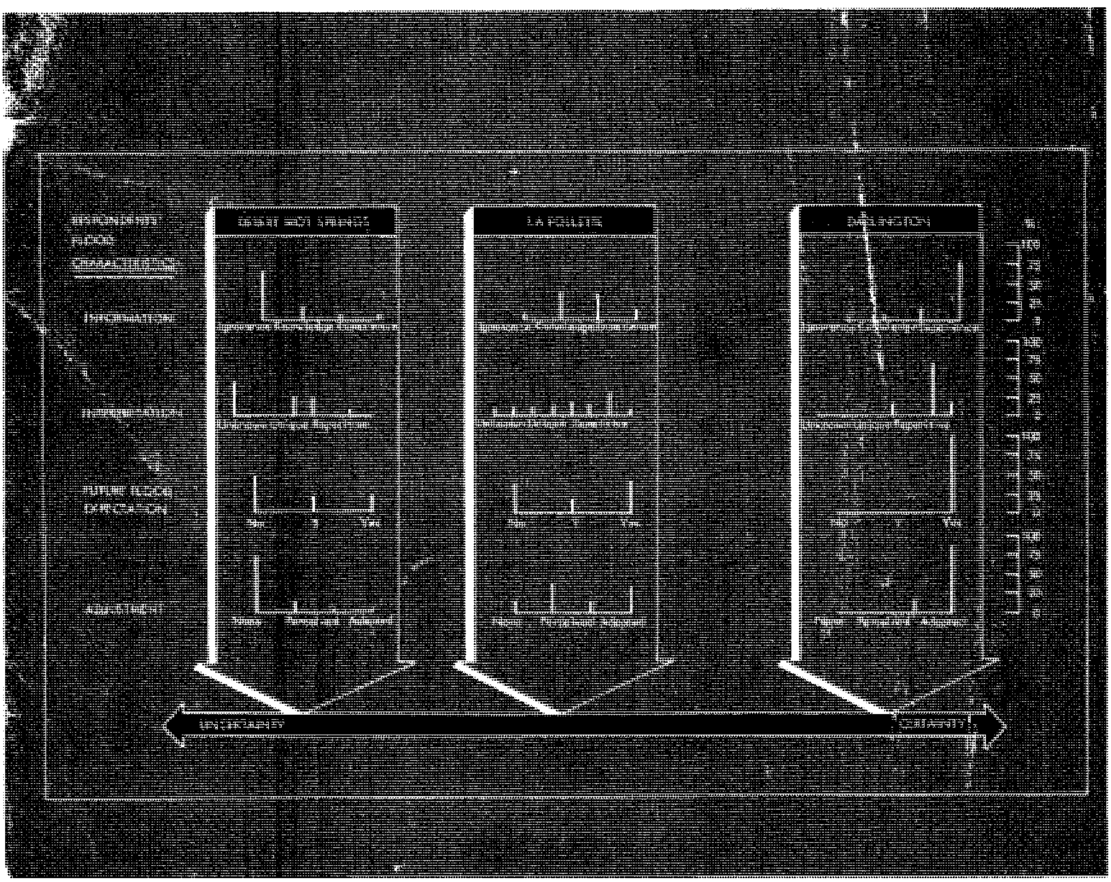


Hazard and Choice Perception in Flood Plain Management

BY ROBERT WILLIAM KATES



With affection — Bob

THE UNIVERSITY OF CHICAGO

HAZARD AND CHOICE PERCEPTION IN FLOOD PLAIN MANAGEMENT

DEPARTMENT OF GEOGRAPHY

RESEARCH PAPER NO. 78

By

ROBERT WILLIAM KATES

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CHAPTER I

GEOGRAPHIC RESEARCH AND FLOOD DAMAGE REDUCTION

The way men view the risks and opportunities of their uncertain environment plays a significant role in their decisions as to resource management. Urban flood situations well illustrate this relationship. The studies of hazard and choice perception reported in this volume throw new light on the conditions under which men occupy flood plains and, at the same time, yield empirical evidence on the decision-making process.

This dual aspect introduces a certain awkwardness and repetition of elementary material for readers familiar with either flood problems or decision-making theory. For this, the reader's indulgence is craved, and as in all such multi-purpose endeavors, it is hoped that the benefits will outweigh the costs.

To provide the perspective in which geographic research into the human occupance of flood plains may be viewed, much of this chapter is devoted to a restatement of the paradox of greater flood control and increasing flood damages, and the ensuing search for alternative measures of flood damage reduction. The next chapter presents a general discussion of the relevance of decision-making schema in resource management for understanding flood plain occupance.

Later chapters develop the empirical data from a detailed study of one flood-prone community and from reconnaissance examinations of five others differing markedly in flood hazard and geographic setting. Among and within these communities, there is great variability in perception of hazard and alternatives of flood damage reduction. The differences are large even where there is a sharing of common experience with floods, and they are significant among people acquainted with advanced technical knowledge as well as among those having only a rudimentary popular knowledge of the situation.

The certainty of flood occurrence, as it differs from place to place, appears to underlie this diversity of perception and to influence the way men attempt to order their activities to reduce the threat of natural hazard.

Twenty-Five Years of Flood Control Activity

On June 22, 1936, the Congress of the United States declared that:

> It is hereby recognized that destructive floods upon the rivers of the United States, upsetting orderly processes and causing loss of life and property, including the erosion of lands, and impairing and obstructing navigation, highways, railroads, and other channels of commerce between the States, constitute a menace to national welfare; that it is the sense of the Congress that flood control on navigable waters or their tributaries is a proper activity of the Federal Government. . . .[1]

In the twenty-five years that have elapsed since the passage of the Flood Control Act of 1936, over four billion dollars have been expended in pursuit of this "proper activity" and annual appropriations now average 300 million dollars.[2] Within the past eight years, there have appeared a series of appraisals of the efficacy of this expenditure and the massive activity so engendered.[3]

Appraisals of the flood control program.--All evaluations of the national flood control effort are obscured by serious defects in data collection and interpretation, particularly estimates of flood damage.[4] Flood damages recorded by the Weather Bureau are probably understated in toto and considerably exaggerated

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[1]49 U.S. Statutes 1570.

[2]U.S. Senate, Select Committee on National Water Resources, Floods and Flood Control, Committee Print No. 15, 86th Cong., 2d Sess., 1960, pp. 16-17.

[3]Appraisals and related information are included in the following: William G. Hoyt and Walter B. Langbein, Floods (Princeton: Princeton University Press, 1955), pp. 77-90; Gilbert F. White, Wesley C. Calef, James W. Hudson, Harold M. Mayer, John R. Sheaffer, and Donald J. Volk, Changes in Urban Occupance of Flood Plains in the United States (Chicago: University of Chicago, Department of Geography Research Paper No. 57, 1958), pp. 1-11, 203-227; U.S. Senate, Select Committee on National Water Resources, Floods and Flood Control, Committee Print No. 15, 86th Cong., 2d Sess., 1960, pp. 3-7, 27-28; U.S. Senate, Select Committee on National Water Resources, Flood Problems and Management in the Tennessee River Basin, Committee Print No. 16, 86th Cong., 2d Sess., 1960, p. 18; U.S. Senate, Select Committee on National Water Resources, River Forecasting and Hydrometeorological Analysis, Committee Print No. 25, 86th Cong., 2d Sess., 1960, p. 7; Walter B. Langbein, "An Assessment of Flood Control in the U.S.A.," Proceedings of Royal Geographic Society of Australasia, LXI (December, 1960), 9-12; Roland C. Holmes, "Composition and Size of Flood Losses," Papers on Flood Problems, ed. Gilbert F. White (Chicago: University of Chicago, Department of Geography Research Paper No. 70, 1960), pp. 11-18.

[4]See discussion in White et al., pp. 3-11.

in particular situations. Trends are obscured by the random effects of rare catastrophic floods and short-run increases in the amount of flooding. Despite these problems, most appraisals agree on the following relationships of flood control and flood damages:

1. The large investment in flood control works have not decreased the average annual flood damages. Data from Holmes would suggest that average annual flood damage doubled since the passage of the Flood Control Act of 1936 and now equals the average amount spent yearly in their prevention, $300 million.[1] Since the Weather Bureau series used by Holmes probably understates damage, a recent Corps of Engineers presentation attempted to estimate average damage potential which might be considered as the estimate of average long-run damages (including damages not actually recorded). The estimates for 1957 and a projection for the year 1980 are shown in Table 1.[2]

TABLE 1

CORPS OF ENGINEERS ESTIMATES OF DAMAGE POTENTIAL[a]
(MILLIONS OF DOLLARS)

Area	1957	1980
Downstream[b]	538	739
Upstream (total)[c]	417	574
Total	955	1,313

[a]Taken from U.S. Senate, Select Committee on National Water Resources, Floods and Flood Control, Committee Print No. 15, 86th Cong., 2d Sess., 1960, pp. 3-7, 27-28.

[b]Downstream damages occur at points along stream with drainage areas in excess of 390 square miles.

[c]Total upstream damages represents the enlargement of a partial upstream damage inventory by the application of some factor.

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[1]Holmes, p. 11, computed total damages for 34 years from 1903-1936 as $4.1 billion, and for a 22-year period, 1937-1958, at $6.6 billion in constant 1957 dollars. Average yearly damages are 2.5 times greater for the latter period.

[2]A comparison of the increase projected for 1980 of each component, downstream and upstream, suggest that they were projected at the same rate, an annual average growth of 1.4%. To the writer, this is an unjustified assumption.

2. Three factors have been suggested to account for the increases in estimated annual damages: (a) improvement in damage data collection, (b) a short-run increase in flooding, (c) the expanding investment in areas subject to flood.[1] After discounting the effects of data collection and the increase in flooding, the failure of the flood control program to reduce damages is primarily due to the steady pressure to occupy and develop flood plain land, particularly in urban and metropolitan areas. The Corps of Engineers' projection averages a 1.4 per cent annual increase in flood damage potential, and White has estimated the annual rate of increase at 2.7 per cent.

3. There is considerable evidence that flood control, while substantially reducing existing damages, actually encourages an increase in damage potential.[2] Almost all flood control works provide only partial flood protection, there being few known works protecting against the maximum probable flood. Partial protection eliminates damages from the more frequent floods, and in so doing, may intensify the ongoing trends to develop the flood plain regardless of protection. When some of the rare floods occur that are larger than the measure of protection provided for, catastrophic damages result. Furthermore, flood plain invasion has been triggered by the mere anticipation of future protection.

4. The trend of increasing protection being offset by increasing damage potential will continue into the future. At the present rate of federal investment in flood control, the United States is expected to expend some $10 billion by 1980, but the residual annual damage is estimated by the Corps to be only slightly under the 1957 damage potential of $698 million. With a 1970 level of protection expenditure of $500 million, the Corps of Engineers estimates that damage potential could be reduced to an annual average of $483 million.

5. The paradox of greater flood control and increasing damages strongly emphasizes the need to search for other alternatives that might be combined with engineering works to develop comprehensive programs of flood damage reduction. For over twenty years, a theoretical statement by White of possible alternatives

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[1]White *et al.*, pp. 5-11.

[2]The Corps of Engineers (Select Senate Committee, *Floods . . .*, pp. 27-28) estimates that since 1918 $9 billion (*current dollars*) of gross damages have been prevented by protection works. However, gross damages prevented includes damage to both the existing development at the time of the introduction of flood control works and the subsequent development of the flood plain, some of which were induced by the protective works themselves.

to engineering works has existed.[1] These included: Bearing the losses with or without public relief; permanent or emergency evacuation of life and property and the rescheduling of production; elevating land and making structures flood resistant; insurance; and the regulation and change of land use. However, it is only within the last decade that there has been developed a widespread interest in searching among such a theoretical array of alternatives for those that most practicably might supplement engineering works in a flood damage reduction program.

A Future Flood Damage Reduction Program

The individual and community components of a flood damage reduction program.--The elements of a flood damage reduction program are still unclear, but might well involve a range of actions as has been summarized in Table 2.

The first column of the Table presents the theoretical range of choice. In the second column, subsumed under each theoretical choice, are the individual actions presently available. The third column suggests ways in which municipal, state, and federal authority might be judiciously used to either encourage, reinforce, or mandate the individual action.

Table 2 attempts to identify those components of a flood damage reduction program that can be carried out by individual land users. In this format community action, be it on the federal, state, or municipal level, can either encourage, reinforce or mandate individual actions. To illustrate, an individual might locate a structure on a parcel of flood plain land to minimize his hazard. This action can be encouraged by the availability of flood hazard information provided by a federal organization, reinforced by regulations making home loan assistance contingent upon such structure location, or mandated by a zoning regulation requiring a set back from the stream channel or elevation above a given flood height.

In practice, the actual elements of a comprehensive flood damage reduction program will emerge from the interaction of the alternatives described in Table 2, the need perceived by the

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[1]Gilbert F. White, Human Adjustment to Floods (Chicago: University of Chicago, Department of Geography Research Paper No. 29, 1945), pp. 128-202. Recently developments of this theme may also be found in Gilbert F. White, "The Choice of Use in Resource Management," Natural Resource Journal, I (March, 1961), 30-36; and Gilbert F. White, "Strategic Aspects of Urban Flood Plain Occupance," Journal of the Hydraulic Division, Proceedings of the American Society of Civil Engineers, LXXXIII (February, 1960), 99-100.

TABLE 2

ELEMENTS IN A FUTURE FLOOD DAMAGE REDUCTION PROGRAM

Theoretical Choice of Actions	Possible Individual Actions	Public Actions to Encourage, Reinforce, or Mandate Individual Actions	
		State-County-Municipal	Federal
Bearing the loss	Bear an unexpected loss** Bear an expected loss* Set aside funds for future loss*	Provide flood hazard information* Provide relief to ease suffering and distress but in such manner as to reduce future flood damages	
Emergency flood fighting, evacuation, and re-scheduling	Maintain stand-by preparations for flood fighting* Prepare advance plans for temporary evacuation of life and property and the re-scheduling of production*	Provide men and materials for emergency flood-fighting** Organize community warning and evacuation assistance plans*	Provide federal warning assistance and expanded radar network** Encourage local disaster plans to provide for flood-damage reduction*
Structural change and land elevation	Use wide variety of structural adjustments presently available for old and new buildings* Land elevation above flood level for new buildings*	Use building codes to make mandatory structural changes and/or land elevation Use channel encroachment laws to prevent increased damage to others as a result of land elevation (fill)*	Provide hazard information on which to design structural changes and land elevation* Require structural changes and/or land elevation in flood-prone areas as requirement for HHFA and other loan assistance

TABLE 2--Continued

Changing land use	Locate structures so as to minimize damage** Change land to open use, such as: parks, playgrounds, parking lots, etc.* Abandon high hazard areas*	Mandate patterns of land use by flood plain regulations* Encourage open uses** Prohibit uses subject to high damage or loss of life** Use condemnation power and/or urban renewal to change land use	Provide hazard information for design of regulations* Require flood plain regulations as a provision for flood control, urban renewal, and similar assistance Use HHFA and other federal loan assistance powers to discourage improper flood plain use* Provide federal aid to permanently evacuate flood plain*
Controlling floods	Construct levees or walls, channel improvements, detention reservoirs* Request and promote local, state, and federal flood control projects** Share in costs of local, state, and federal projects*	Construct flood control projects* Request and promote state and federal flood control projects** Share in costs of federal projects*	Provide flood control in the form of levees, walls, channel improvement, land treatment, detention reservoirs**
Flood insurance	Obtain a policy* (Available under one of the following conditions: a) High premium b) Pooled risk with off-flood plain structures in comprehensive policies c) Structural adjustments reduce more frequent flood damage)	Provide standardized flood hazard information on which to base rate structure State supervision of insurance companies to encourage commercial policies that promote minimization of flood damages Subsidize a state-federal insurance program	Subsidize a federal or federal-state insurance program (Administered to promote minimization of flood damages)

*Present application limited

**Present application widespread

program executors for governmental action, and the prevailing trends of political organization.

The role of research.--The shape of a future flood damage reduction program could be substantially altered if the potential effectiveness of various damage reduction alternatives could be predicted. The appraisals of the effectiveness of engineering works, which helped create a receptiveness for a broader program, awaited many years of actual experience with protective works in order to be heeded. Hopefully, the development of a more predictive, though far from accurate, social science provides the basis for identifying some of the more fruitful elements of a flood damage reduction program.

To make effective predictions requires a deeper understanding of the complex process of flood plain invasion and occupance than presently available. Twenty years of geographic research has striven for such an understanding, and the concluding portion of this chapter will present a description of that research.

Flood Hazard Information: The Foundation of a Flood Damage Reduction Program

A research question with a vital but more limited import relates to flood hazard information. A recurring theme throughout Table 2 is the provision of accurate flood hazard information as a necessary if not sufficient condition for the installation of many of the alternative measures of flood damage reduction.

The federal information program.--The federal scientific and engineering agencies have always made their data on floods available to any who desired it.[1] Unfortunately, data on flood hazard were seldom in a form usable by laymen, and often required engineering interpretation. With the search for alternative flood damage reduction measures, the need became apparent for flood hazard data that could be used and understood by intelligent laymen with a minimum of technical assistance.

The pioneering effort was made by the Tennessee Valley Authority which had completed, by mid-1962, 97 flood hazard reports

[1]Among the federal agencies that collect data on floods are the U.S. Army, Corps of Engineers; U.S. Department of Agriculture, Forest Service and Soil Conservation Service; U.S. Department of Interior, Bureau of Reclamation and Geological Survey; U.S. Department of Commerce, Weather Bureau, Tennessee Valley Authority and the International Boundary and Water Commission. For types of data, see Walter B. Langbein and William G. Hoyt, Water Facts for the Nation's Future (New York: Ronald Press, 1959), pp. 253-258.

for valley communities.[1] The U.S. Geological Survey has moved in two significant directions. Flood hazard mapping (overprints of topographic sheets) is underway in 21 communities.[2] A number of maps have been completed including the first 6 of 43 sheets partially defining flood hazard in the Chicago Metropolitan Area. Simultaneous with its own mapping program, the Survey is issuing a series of regional flood studies, which combined with a recent handbook makes flood plain mapping possible on a self-help basis for many communities.[3] Finally, and probably most significant, has been the authorization by Congress under which the Corps of Engineers is providing communities information concerning floods, flood damages, and engineering advice for the amelioration of flood effects.[4] As of this writing implementation of the program has been somewhat slowed.

The expanding information program raises a number of questions. What is the relevance of various types of flood hazard information to flood plain managers? Should information concerning flood hazard be extended to include information on alternative adjustments to flood hazard? How may flood hazard information be presented in order to be most useful for managers?

The value of basic research applicable to these questions made the study seem particularly timely.

Twenty Years of Geographical Research into Human Occupance of Flood Plains

Research and policy.--In the previous discussion, the ongoing shift from a policy of flood control to a policy which includes controlling floods and land use has been chronicled. This shift in emphasis has been influenced by over 20 years of research,

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[1]See Select Senate Committee, Flood Problems . . . Tennessee River Basin, pp. 18-20 for general discussion of program. Present status of program taken from a personal communication from the Flood Relations Branch, Tennessee Valley Authority, July, 1962.

[2]Ian Burton, "Education in the Human Use of Flood Plains," Journal of Geography, LX (November, 1961), 366.

[3]For an example of a map see: United States Geological Survey, Floods near Chicago Heights, Illinois, Hydrological Investigation Atlas HA. 39 (Washington: U.S. Geological Survey, 1960), (map with description). For the methodology of regional studies, see: Tate Dalrymple, Flood Frequency Analysis (Washington: U.S. Geological Survey Water Supply Paper 1543-A, 1960), pp. 25-48. For methods of defining the flood plain, see: Sulo W. Wiitala, Karl R. Jetter, and Alan J. Sommerville, Hydraulic and Hydrological Aspects of Flood Plain Planning (Washington: U.S. Geological Survey Water-Supply Paper 1526, 1961).

[4]Section 206, Flood Control Act of 1960.

primarily geographical, into the nature of the human occupance of flood plains. Although foreshadowing the shift in policy, the research also has evolved, moving from an earlier preoccupation with physical factors of land and flood, towards a synthesis of human behavior that might describe the occupance of flood plains.

The shift in emphasis in geographical study.--In 1942, in Human Adjustment to Floods, White was preoccupied with factors affecting human adjustment, primarily, but not exclusively, physical variables of land and water. Fifteen years later White was concerned with factors that enter into decisions as to flood-plain adjustment. The focus of research had moved from a somewhat deterministic geography of the physical milieu of flood plains, to an inquiry into man's choice in the complex social, economic and physical world that surrounds him. The change in emphasis has been accompanied by a series of recent studies.

Studies of changes in urban and rural occupance of flood plains.--A study of rural flood-plain occupance confirmed the value of the change in emphasis by finding that the particular manner in which flood plain utility is perceived depends in large measure on the matrix of economic factors and agricultural organization in which the flood plain is found rather than on primarily physical factors such as the frequency of flood.[1]

The urban study noted:

> This process of continued invasion (of the flood plains) was not everywhere of the same magnitude, it varied with conditions of site and of gross urban growth, it unfolded in different patterns of land use, and it involved a wide range of managerial decisions as to the use of flood-plain resources in the face of flood hazard.[2]

To better explain the variability in flood plain use noted, as well as lay the basis for measuring the impact of flood hazard maps, two related investigations were conducted of the attitudes of flood plain dwellers.[3]

The attitude studies.--Roder in Topeka, Kansas, sought to formulate the first descriptive statement of the relationship between attitudes towards flooding, socio-economic class, and levels

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[1]Ian Burton, Types of Agricultural Occupance of Flood Plains in the U.S. (Chicago: University of Chicago, Department of Geography Research Paper No. 75), pp. 42, 150.

[2]White et al., p. 203.

[3]Wolf Roder, "Attitude and Knowledge on the Topeka Flood Plain"; Ian Burton, "Invasion and Escape on the Little Calumet," Papers on Flood Problems, pp. 62-92.

of flood hazard and protection information. He classified his respondents as optimistic, pessimistic, or neutral, depending on whether the respondent's future flood expectancy underestimated, overestimated or coincided with a prevalent scientific expectancy of future floods. Burton then conducted a similar study in the Hammond-Munster area of the Little Calumet flood plain in Indiana. In general, they found no associations between attitudes towards future flooding and socio-economic class or knowledge of protective structures.

The disaster studies.--In the course of seeking analogs to the catastrophic disaster of nuclear attack, a group of behavioral scientists have carried out a series of studies into natural disasters, including floods, or the "behavior of people in extreme situations."[1] The utility of such studies for explanatory models of the human occupance of flood plains is limited because of differing emphasis. Disaster studies of floods have focused on the threat, warning, and impact of the disaster, and the subsequent recovery of individuals and community. Geographic research, in contrast, has centered on the long-term adjustment to a recurring hazard, in which disasters may or may not occur, and are of limited import in most situations.

Decision-making studies.--Still another body of theory which behavioral scientists, among others, have helped formulate, that of decision-making, contains much that may be useful in developing an increased understanding of the processes of flood plain occupance. The continual invasion of the flood plain is generally a summation of the many individual decisions to locate there. The selection of alternative measures of flood-damage reduction by an individual or even the nation is also a process of choice or decision. These and similar questions may be fruitfully explored within a framework of decision theory.

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[1]Anthony F. C. Wallace, Human Behavior in Extreme Situations: A Survey of the Literature and Suggestions for Further Research (Washington: National Academy of Sciences-National Research Council Pub. No. 390, 1956); Roy A. Clifford, The Rio Grande Flood: A Comparative Study of Border Communities in Disaster (Washington: National Academy of Sciences, National Research Council Pub. No. 458, 1956).

Kates, R. W., 1962, Hazard and Choice Perception in Flood Plain Management, University of Chicago, Department of Geography Research, Paper No. 78.

CHAPTER II

DECISION-MAKING AND RESOURCES MANAGEMENT

Against the background of national flood policy and a sequence of geographical research which includes study of the choice available to occupants of flood plains, it is useful to examine decision theory and decision-making schema. How relevant are they to resource management study in general, and flood plains in particular? Do they assist in arriving at more refined understanding of why people do or do not occupy flood hazard areas?

Some Underlying Assumptions of Decision-Making Schema

Decision-making, in a broad sense, is the selection of alternate courses of human behavior, and decision-making schema are descriptions or prescriptions of this process. The study of decision-making is a burgeoning, inter-disciplinary, and somewhat confusing, area of research.[1]

Decision-making schema hold an intrinsic attraction for students of resources management. The concept of the multiple purpose use of resources, the variability of the perception of resources from culture to culture, the differences in resulting choices in similar environments, all offer grist for the mills of decision theory.

The writer has found it helpful to identify four of the underlying assumptions found in almost all decision-making schema and in their applications to resource problems. These are: (1) the underlying view of man's rationality; (2) the types of decision

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[1]In a recent review article, John W. Dyckman, "Planning and Decision Theory," Journal of the American Institute of Planners, XXVII (November, 1961), 335-345, are listed 110 works dealing with decision-making including works by economists, statisticians, operations researchers, psychologists, political scientists, planners, and sociologists. Ward Edwards' review article, "The Theory of Decision-Making," Psychological Bulletin, V (1954), 380-417 lists some 218 items. Paul Wasserman and Fred S. Silander in Decision Making: An Annotated Bibliography (Ithaca, N.Y.: Cornell University, Graduate School of Business and Public Administration, 1958) annotated over 400 references. The bibliography contains a topical listing of decision studies found to be useful as an introduction to this vast literature. Only studies actually cited in this chapter appear in footnotes.

processes involved; (3) the conditions of knowledge under which choice is made; (4) the criteria that are used to guide such choice.

Man's Rationality

The underlying view of man's rationality.--Rationality may be used to simply describe that ability to choose clearly and consistently those alternate courses of human behavior that are most appropriate towards attaining some end or goal. Among the difficulties in comparing inter-disciplinary research in decision-making are the conflicting assumptions as to man's rationality. These have been sharply defined by Simon in the following manner:

> The social sciences suffer from an acute case of schizophrenia in their treatment of rationality. At one extreme we have the economists, who attribute to economic man a preposterously omniscient rationality. Economic man has a complete and consistent system of preferences that allows him always to choose among the alternatives open to him; he is always completely aware of what the alternatives are; there are no limits to the complexity of the computations he can perform in order to determine which alternatives are best; probability calculations are neither frightening or mysterious to him. Within the past decade, in its extension to competitive game situations, and to decision-making under uncertainty, this body of theory has reached a state of Thomistic refinement that possesses considerable normative interest, but little discernible relation to the actual or possible behavior of flesh-and-blood human beings.
>
> At the other extreme, we have had tendencies in social psychology traceable to Freud that try to reduce all cognition to affect. Thus, we show that coins look larger to poor children than to rich (Bruner and Postman), that the pressure of a social group can persuade a man to see spots that aren't there (Asch), that the process of group problem solving involves the accumulation and discharge of tensions (Bales), and so on. The past generation of behavioral scientists have been busy, following Freud, showing that people aren't nearly as rational as they thought themselves to be. Perhaps the next generation is going to have to show that they are far more rational than we now describe them as being--but with a rationality less grandiose than that proclaimed by economics.[1]

Simon goes on to offer his own alternative:

> The alternative approach . . . is based on what I shall call the principle of bounded rationality:
>
> The capacity of the human mind for formulating and solving complex problems is very small compared with the size of the problems whose solution is required for objectively rational behavior in the real world--or even for a reasonable approximation to such objective rationality.
>
> If the principle is correct, then the goal of classical economic theory--to predict the behavior of rational man without

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[1] H. A. Simon, Administrative Behavior (2d ed.; New York: Macmillan, 1957), p. xxiii.

> making an empirical investigation of his psychological properties--is unattainable. For the first consequence of the principle of bounded rationality is that the intended rationality of an actor requires him to construct a simplified model of the real situation in order to deal with it. He behaves rationally with respect to this model, and such behavior is not even approximately optimal with respect to the real world. To predict his behavior we must understand the way in which this simplified model is constructed, and its construction will certainly be related to his psychological properties as a perceiving, thinking, and learning animal.[1]

Thus does Simon construct a trichotomy, fraught with perils of over-simplification. By utilizing the extremes of economic or psychological man, some scholars may insist that Simon has caricaturized the mainstreams of economic or psychological thought. Be this as it may, the writer in his review of the decision-making literature of the social sciences has found few exceptions to Simon's description of the prevalent underlying assumptions of rationality. If one acknowledges the descriptive aptness of Simon's trichotomy, what of its prescriptive value? Restated in another way: granted that decision-making analysts, consciously or unconsciously, formulate an underlying assumption as to man's rationality, is there one of these assumptions that is more useful for formulating decision-making schema?

To the writer, the stance, or assumptions as to man's rationality, from which the decision-making analyst prepares to discuss the process of decision-making has utility only in terms of the analyst's objectives and study matter.

One such objective is the intent of the analyst in terms of the normative-behavioral dichotomy or, as the writer prefers, those models of man that aspire to describe and predict his behavior as opposed to those that aspire to prescribe what his behavior ought to be. If the intention of the analyst is to describe correctly human behavior in decision-making situations and to predict future behavior, then it is clear to the writer that an assumption of omniscient rationality for economic man is at variance with both the potential and actual behavior of men.

It must be recognized that there are many who have wearied of the failure of behavioral theory to provide generalized descriptions of human action. Stimulated by computer technology, they are constructing a closer approximation of the rational economic man by prescribing rules and routines to help men become more nearly rational. These research workers appear ready to leap-frog the question: How does man perceive choice and act upon

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[1] H. A. Simon, Models of Man: Social and Rational (New York: John Wiley & Sons, 1957), p. 198.

it? and replace it with the question: How can he make his choices and choice mechanisms better? For some the horizon is endless and their ultimate goal might well be the following:

> We assert that it is possible to describe analytically any human function which can be reasonably defined in objective terms--and we specifically include in such functions "thinking" insofar as the term is definable. If by "thinking" one means being able to do arithmetic, or play a good game of chess, or learn from experience, or make optimal decisions in exceedingly complex situations, then we assert that thinking can be described analytically, and there are two important corollaries: if it can be described analytically, it can be simulated; and if it can be simulated, it can be performed mechanically.[1]

Omniscient, rational economic man, is a viable model for describing the behavior of a select group of human beings, though this group may be limited to the very proponents of the model. With an objective of prescribing rules for making better choices, surely one cannot argue that men ought not aspire to the very heights of rationality. What makes this view so vulnerable to Simon's attack is that its proponents do not restrict themselves to a prescriptive role, and often take the either/or position of Marschak that:

> The theory of rational behavior is a set of propositions that can be regarded either as an idealized approximation of the actual behavior of men or as a recommendation to be followed.[2]

The writer would suggest Marschak's set of propositions are indeed recommendations to be followed, but at best could be an idealized approximation of the actions of very few, if any, men.

If the intention of the analyst is to devise descriptive-predictive models of human behavior, his attention might be directed to either Simon's stance of bounded rationality or that of psychological man dominated by affect.[3] The choice between these

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[1]R. E. Machol (ed.), Information and Decision Processes (New York: McGraw Hill, 1960), pp. viii-ix.

[2]Jacob Marschak, "Rational Behavior, Uncertain Prospects, and Measurable Utility," Econometrica, XVIII (1950), 111.

[3]John Krutilla and Leslie Curry have pointed out, quite correctly, that many useful studies of a descriptive-predictive nature have been carried out within the framework of traditional economic man or more commonly, a rational man subject to a variety of constraints including the costs of obtaining additional information, human fallibility and lack of clairvoyance, chance, and the like.

The more constraints placed on the omniscience of the rational man, the closer such a model moves to that of bounded two assumptions as to man's rationality is influenced by the subject matter under study. In the writer's view, bounded rationality appears most appropriate for those situations in which one can hypothesize substantial conscious choices and an underlying view of psychological man lends itself to areas of decision in which there is evidence that less conscious, or instinctive choice processes are involved.

A model of man's rationality for resource managers.--Resources by definition are culturally determined, that is, a resource is a thing that becomes a resource when perceived as useful to man. To understand, describe, and predict from the varieties of ways that men manage resources implies a certain model of man. In this model, men bounded by inherent computational disabilities, products of their time and place, seek to wrest from their environment those elements that might make a more satisfactory life for themselves and their fellows. Simon's concept of bounded rationality is a suitable framework for such a model.

On the other hand, there is the same pressure in resource management as well as in other avenues of human affairs to leapfrog the need for patient understanding of complex activities and prescribe efficient resource allocation systems. As has been previously stated, the assumption of the maximum rationality on the part of man cum computer is almost inescapable in this field of research.

In explaining man's behavior in the face of an urban flood hazard the underlying assumption of man's rationality will be that of bounded rationality and a prime purpose will be the consideration of what the specific bounds might be.

Types of Choice Processes

Conscious decision-making provides but a fraction of the welter of decisions that men make every day. The existential concept of free and conscious choice is not only a "dreadful freedom" but time-consuming as well. The bulk of man's daily decisions are either habitual or so trivial as to take on a random aspect; men thus protect themselves from the burden of consciously choosing amidst the minutiae of life. The important decisions in life,

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rationality until such time as the difference might be more semantic than real.

Essentially a matter of focus, the espousal of bounded rationality found in this volume, is not intended as a denial of the utility of other formulations but rather to assert the utility of focusing on the limitations in decision-making rather than on an ideal from which men deviate.

while relatively few in number, do involve conscious elements in choice and often tend to be unique. In general three types of choice processes might be distinguished:

The conscious choice process.--There is a general acceptance that conscious choice processes involve some reflection on the part of the chooser, a consideration of ends, and alternative means of securing those ends. Churchman would distinguish between free choice or how one would choose on the basis of their own values; and a more restricted choice; the choices men make when their own values are bound up with extraneous or irrelevant external factors.[1] Existential philosophers would deny for the most part the distinction claiming that, in the last analysis, all men are free to choose among some alternatives.[2] The more psychologically oriented analyst might emphasize the impact of the unconscious on even the apparently conscious choice.[3] In any event, many of the important unique decisions men make involve considerable amounts of reflection.

The habitual choice process.--Habitual choice, or the recourse to traditional or repetitive behavior, has a profound influence on the ordering of men's activities. Geographers are quick to note how many responses to man's environment take on aspects of habitual choice. The writer would suggest that most habitual actions, be they trivial or important, result originally from more or less conscious decisions, made by some individuals singly or collectively interacting with society. Certain analysts like Firey, think that long-term habitual response systems like open-field farming represent not a habitual response to the environment as such, but "willing conformity" implying even in long-established traditional systems some conscious choice.[4]

Unconscious and trivial choice.--A detailed discussion of unconscious choice is beyond the ken, training, or inclination of the writer. Most readers might confirm that choices of love, marriage, and the like, are poorly suited for description by a rational conscious choice process. Fortunately, resources

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[1]C. West Churchman, Prediction and Optimal Decision: Philosophical Issues of a Science of Values (Englewood Cliffs, N.J.: Prentice Hall, 1961), p. 18.

[2]Jean-Paul Sartre, Existentialism (New York: Philosophical Library, 1947), pp. 38-40.

[3]Gardner Lindzey (ed.), The Assessment of Human Motives (New York: Grove Press, 1960), p. 19.

[4]Walter Firey, Man, Mind & Land: A Theory of Resource Use (Glencoe: The Free Press, 1960), pp. 111-130.

management appears to involve little unconscious choice, that is, choice governed by ends and means that are perceived dimly, if at all, by the chooser. On the other hand, certain questions like the propensity to gamble with nature, be it drought, flood, or a home on Fire Island, might conceivably be described by unconscious choice processes. This theme will be returned to in later sections.[1]

Another type of choice recognized by the writer (but denied by certain schools of psychology) is that of trivial choice. Many unique choices (non-habitual) are so trivial (either unimportant or the chooser is indifferent) that the choice takes on a random aspect. Indifference curves attempt to identify a point at which a choice between alternatives may be trivial, even though the alternatives themselves may have considerable significance.

The process of choice in resources management.--Elements of all three choice processes enter into the decisions made in the management of resources, but conscious elements appear to dominate. A mine is opened because there is a need for metal; a hillside site is selected for a home because it overlooks the ocean; water is added to a field because it has not rained. In others, one finds habitual response as well; stockpiling or purchasing silver persists after the original need has been filled; a house designed for a level lot is placed on a hillside; fields in an arid area are watered on schedule whether it rains or not. Some decisions perplex the analyst and one tends to ascribe to them unconscious or random influence. The shrewd small-town merchant is enticed into investing in a fraudulent mining stock; a particular hillside development takes place because the developer once had a flat tire there; irrigation is encouraged because a people raised in a humid clime associate green fields and flowing water with the good, fertile, and beautiful as opposed to a perceived ugliness of arid grass lands or desert.

In a broad over view, choice in resource management is primarily conscious choice and habitual choice which has been routinized after a series of initial conscious choices. What are

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[1]L. Wundheiler, a psychologist friend, suggests that the distinction between unconscious and conscious decision processes is best made not as a function of some class of activity, but rather as a function of the amount of desire or motivation for a certain goal. As such desire or motivation increases, so would irrational behavior regardless of type of activity.

Nevertheless, the writer would maintain that there are classes of human activity in which most, but not all, behavior can be explained in a rational, conscious framework, and others in which such explanation appears much weaker.

the bounds of such conscious choices? Firey likes to consider them as choices coming from three sets; a set of physically possible alternatives, a set of culturally adoptable alternatives, and a set of economically gainful alternatives.[1] White orders his thinking by defining a set of theoretical choices and a set of practical choices. These practical choices are controlled by two principal factors of awareness and restraint.[2] This study will attempt to identify empirically a range of choice of flood reduction measures as individually perceived. This discussion will be found in the fifth chapter.

Conditions of Knowledge

Risk and uncertainty.--Choice, however it is made, is made under a variety of conditions of knowledge as to alternatives and outcomes. The best available information may only suggest a range of outcomes, some with a known probability distribution and others with an uncertain one. The first case, outcomes with a known probability distribution, has been distinguished as risk, the second case as uncertainty.[3]

Dispersion of knowledge.--In the complex world, seldom is the best knowledge ever able to be completely brought together, or when this is done, assimilated. There is wide dispersion of such knowledge in any community of men. Thus, a descriptive theory of choice must deal with the well-informed and the poorly-informed and the choices that men make under certainty, risk or uncertainty. To complicate the matter further, such a theory must deal with the eventuality that not only do the conditions of knowledge vary, but the personal perception of the same information differs. Thus, for an objective standard of knowledge there may be a substantially different subjective interpretation of the same.

The conditions of knowledge under which resource decisions are made.--Natural resource management involves a great deal of uncertainty. It is first of all an economic activity, with uncertainty similar to other economic activities. Secondly, it is a field of human endeavor particularly sensitive to the great natural

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[1]Firey, p. 37.

[2]White, Natural Resource Journal, pp. 26-27.

[3]Since F. H. Knight in 1921 (Risk, Uncertainty & Profit [Boston: Houghton Mifflin, 1921], p. 233) coined these distinctions, numerous writers have suggested that the division between risk and uncertainty is at best hazy, a view concurred in by the writer. However, while the division may be hazy, the distinction between the extreme cases of certainty, risk, and uncertainty is useful.

uncertainties of drought and flood, fire and disease, and the like. Thirdly, uncertainty increases rapidly with time. Resource managers frequently plan for far longer periods (50-100 years) than the managers of other economic activities. Lastly, its technology is not only subject to the uncertainty of premature obsolescence, but of uncertain disbenefits, frequently of a serious nature. There are few experts, either here or in the Soviet Union, prepared to forecast with assurance the disbenefits of the proposed shift from grassland rotation to intensive farming in the Soviet Union, or for that matter even the long-term benefits. How do resource managers deal with such uncertainty? Ciriacy-Wantrup describes a series of measures for dealing with risk and uncertainty primarily economic devices of discounts, hedging, pooling, shifting risk, or greater flexibility in the management of resources. He then suggests that in the face of great uncertainty, managers abandon a calculative approach and fall back on custom or tradition as "habit patterns."[1]

The dispersion of knowledge in a community of resource managers is related both to variation in the quality and completeness of the available knowledge and to differences in its perception and interpretation.

One might distinguish between the <u>common knowledge</u> distributed more or less normally among a community of resource users and a distribution of <u>technical knowledge</u>. Common knowledge among Illinois corn farmers would have a smaller variance than a less homogenous group, for example, the world-wide community of mining investors. The technical knowledge of corn farming is diffused among a complex of individuals who range from experts on hybrid seed corn to the entomology of the corn borer.

Given these dispersions of knowledge or in White's terms, its awareness,[2] the subjective interpretation varies considerably: Two farmers read the directions on a fertilizer bag, then apply it differently. Two motorists drive the Logan Canyon road in Utah; for one the sinuous curves following the river are a pleasurable drive, for the other accident-prone obstacles interfering with his desired speed.

A recent series of studies of the Iowa Agricultural and

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[1]S. V. Ciriacy-Wantrup, <u>Resource Conservation: Economics & Policies</u> (Berkeley: University of California Press, 1952), pp. 111-128.

[2]White, <u>Natural Resource Journal</u>, p. 27.

Home Economics Station are relevant.[1] One hundred and forty-four farms in western Iowa were studied since 1949 for their progress in reaching a public goal of soil conservation measured by a maximum of five tons of soil loss per acre annually. This goal was decided on by Soil Conservation Service technicians who prepared individual farm plans for each farm, designed to attain the goal but without regard to economic analysis. In Firey's construct these practices designed to effect such a goal are the set of the physically possible.

The actual soil loss was measured several times and the results for 1949 and 1957 are shown in Figure 1. Farmers were interviewed at the same time as to those practices that they thought were desirable to install. If such practices were installed the Iowa study estimated that the soil loss distribution would appear as shown by the two other curves on Figure 1. Thus the curves of actual soil loss can be taken to represent two levels of adjustment to the soil resource; the curves of desirable practices represent two levels of rising aspiration; and the technicians' goal represents an arbitrary and economically unrelated set of physically possible adjustments. In this limited sense, the curves contrast one type of technical knowledge, and the distribution of perceived common or average knowledge at two states of time.

A consideration of the conditions of knowledge under which flood-plain decisions are made comprises much of what follows, occupying the greater portions of Chapters Four and Five.

Evaluation Criteria

Given men with certain powers, these being ascribed to them by the assumption made by the analyst as to their rationality, and given a choice process functioning under certain conditions of knowledge, how do or should men go about making decisions?

For certain choice processes or assumptions as to man's rationality the criteria used to evaluate choice are inextricably bound up with the process. In habitual choice the criterion is

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[1]John C. Frey, Some Obstacles to Soil Erosion Control in Western Iowa (Ames: Iowa State College Agricultural Experiment Station Research Bulletin No. 391, 1952); R. Burnell Held and John F. Timmons, Soil Erosion Control in Process in Western Iowa (Ames: Iowa State College Agricultural and Home Economics Experiment Station Research Bulletin No. 460, 1958); Melvin G. Blase and John F. Timmons, "Soil Erosion Control--Problems and Progress," Journal of Soil and Water Conservation, XVI (July-August, 1961), 157-162.

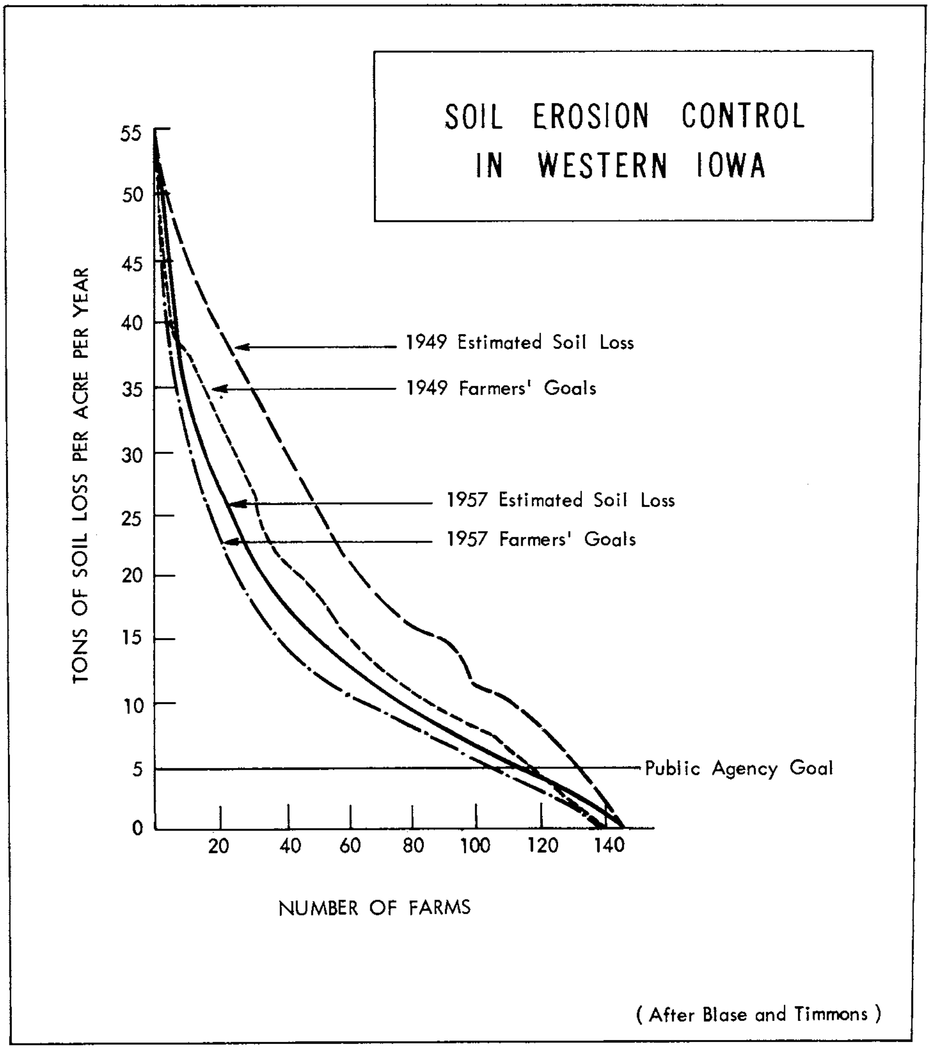
SOIL EROSION CONTROL
IN WESTERN IOWA
TONS OF SOIL LOSS PER ACRE PER YEAR
55
50
45
40
35
30
25
20
15
10
5
0
20
40
60
80
100
120
140
NUMBER OF FARMS
1949 Estimated Soil Loss
1949 Farmers' Goals
1957 Estimated Soil Loss
1957 Farmers' Goals
Public Agency Goal
(After Blase and Timmons)

Fig. 1

to do as one did formerly in a similar situation. The criteria for psychological man dominated by affect would presumably be such affect. It is for the conscious process of choice that one might inquire as to criteria for decision making.

Prescriptive criteria.--The prescriptive studies flower in this effort. To those who desire them, simple and complex rules are available to guide choices, to advise when to secure more information, to include hunches, and the like.[1] The writer finds himself tempted to summarize the rules as: the optimists' rules, those designed to maximize good fortune (money, best expectation, utility, or satisfaction); the pessimists' rules designed to minimize ill-fortune (worst expectation, regret, irreversible trends); and the neutralist rule of when uncertain assume equal probability for all outcomes.

Descriptive criteria.--Most decision-making studies are either prescriptive or theoretical, few being based on observations of group or individual behavior. To these studies, one might add the growing literature of experimental choice situations developed mainly by psychologists and sociologists.

Taken overall, such studies seem inconclusive. They yield mainly negative insights by suggesting that decision makers do not adhere to many of the assumptions made in prescriptive or theoretical works.[2]

Among other things, there is some evidence that certain probability distributions are intrinsically valued in excess of their mathematical expectation. Disturbing for game theory constructs is the finding that some men play not to win but because they like the game or they ignore outcomes that appear threatening to them.

Many analysts adhere to "maximizing" rules, not only as prescriptive criteria but as approximations of behavior. They assert that despite their descriptive imperfections such rules best approximate and explain many types of behavior.

Seeking a descriptive rule, Simon suggests that human behavior frequently satisfies a rule that he calls "satisficing."[3] In this construct individuals simplify the choice of outcomes into two or three classes: satisfactory or unsatisfactory; win,

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[1]See bibliography.

[2]Edwards, pp. 409-411; Herbert Simon, "Theories of Decision-Making in Economics and Behavioral Science," American Economic Review, XLIX (June, 1959), 253-274.

[3]Simon, Models of Man, pp. 241-260.

lose, or draw, and the like. Given such outcomes, Simon has people seeking or evaluating alternatives until they find one matching a broad class of satisfactory outcomes. In general, such an alternative is not the optimal one in the sense that it maximizes some esteemed objective. Simon also introduces a dynamic quality to the construct: if alternative solutions are not easily found, then the boundary between what is satisfactory or not might shift downward, and conversely, if a minimum solution is found with ease, the boundary might shift upward in a fashion analogous to the psychological concept of levels of aspiration.

Evaluation criteria for resource managers.--Resource management contains a body of evaluation criteria, many of which conflict. First there are the economic criteria of the market; markets that frequently conform closer to the ideal competitive situation than the oligopolistic markets of industrial society. These are followed by a host of legislative prescriptions, such as "that the benefits . . . shall be in excess of the costs" or to manage for "multiple use" or "first in time, first in right," and the like.[1] Overlaying this structure are the profound problems of measuring intangible or opposed values: scenic vistas vs. water skiing, salmon fishing vs. power generation, sand dune recreation vs. steel mills, and the like.

A study by the University of Tennessee Agricultural Experiment Station into the organizational problems of small watersheds, attempted to explore the criteria used by farmers in three sites of proposed P.L. 566 watershed protection projects, in accepting or rejecting such programs. They found that:

> The results indicated that landowners did not consider monetary costs and benefits alone when forming opinions about the watershed program. A landowner's attitude towards the program frequently was based on one or more of the following considerations:
>
> 1. Degree of confidence in the individuals or agencies supporting the program.
>
> 2. A belief that the program would cause a personal monetary loss . . . that the money they would have to pay into the program could be invested more profitably in other uses.
>
> 3. A fear that individual rights might be infringed upon. . . .
>
> 4. A fear that some friends and neighbors would be adversely affected by the program. . . .

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[1]A neo-classic view of the conflict between criteria is the subject of a number of studies at the University of Chicago including: Richard S. Ablin, "Misallocation of Electric Power in the Pacific Northwest" (Unpublished Ph.D. dissertation, Department of Economics, University of Chicago, 1960); B. Delworth Gardner, "Misallocation of Resources of Federal Range Land" (Unpublished Ph.D. dissertation, Department of Economics, University of Chicago, 1960).

> Many landowners had formed attitudes for or against the program on the basis of incomplete or inaccurate information about it.[1]

Crane, in a recent study of the replacement of small private dams breached in the 1955 flood in Massachusetts found primarily non-monetary benefit criteria used to decide on replacement.[2] The decisions were influenced by the rigidity of the state laws on dams and respect, or lack of respect, for their enforcement. Where partial ponds survived the breaching, these proved satisfactory, a finding relevant to the use of satisficing criteria.

To the writer, some form of satisficing best describes the variety of evaluation criteria used in reaching resource-management decisions. However, this is at best a weak observation. Evaluation criteria range from complex computer routines to the "off-the-cuff" decision and considerably more studies of an empirical nature will have to be made before reaching more useful generalizations.

Unfortunately this study does not contribute greatly to that task. Its substantive findings, discussed briefly in Chapters Five and Six, are inconclusive on this point and subject to differences of interpretation.

Decision Studies in Resources Management: A Comparative Table of Underlying Assumptions

To illustrate the use of decision-making schema in resources management and the variety of underlying assumptions found in such studies, Table 3 has been prepared. Six works have been chosen, representing that of a political scientist, a sociologist, two economists, and two geographers. Chronologically by publication date,[3] these are: S. V. Ciriacy-Wantrup's Resource Conservation, a pioneer study of the economics of conservation; J. Blaut's study of micro-economic geography, entitled "The Economic Geography of a One Acre Farm on Singapore Island"; Lee's Optimum Water Resources Development, which tentatively sets forth a methodology for optimal water development in

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[1]David W. Brown and Joseph E. Winsett, Organizational Problems of Small Watersheds (Knoxville: University of Tennessee Agricultural Experiment Station Bulletin No. 310, 1960), pp. 2-3.

[2]Donald Crane, "Small Dam Replacement in South-Central Massachusetts" (Unpublished Master's thesis, Department of Geography, University of Chicago, 1962), pp. 47-48.

[3]See bibliography for complete description of publication.

TABLE 3

COMPARISON OF DECISION-MAKING STUDIES IN RESOURCES MANAGEMENT

Study (1)	Intent of Study (2)	Decision Area (3)	Examples or Empirical Studies (4)	Rationality Assumption (5)
S.V. Ciriacy-Wantrup Resource Conservation	Descriptive-predictive Prescriptive	Flow resources	Diverse and minor	Bounded rationality
J. Blaut "The Economic Geography of a One-Acre Farm on Singapore Island"	Descriptive-predictive	Land use	Vegetable farming in Singapore	Bounded rationality with emphasis on motivation
I. Lee Optimum Water Resources Development	Prescriptive	Water resources in California	Water use in California	Economic rational man
E. Banfield The Moral Basis of a Backward Society	Descriptive-predictive	Social and economic activity	Village in Southern Italy	Bounded rationality
W. Firey Man, Mind and Land	Descriptive-predictive	Resources	Folk, feudal and industrial societies	Bounded rationality with strong unconscious psychological undercurrents
G.F. White "The Choice of Use in Resource Management"	Descriptive-predictive	Resource use	Flood plains	Bounded rationality

Choice Process (6)	Conditions of Knowledge (7)	Evaluation Criteria (8)
Conscious and habitual	"Best knowledge" available in given social group at a given time. This knowledge operates under risk and uncertainty grouped together	Satisficing: A safe minimum standard of conservation by preventing irreversability of depletion
Conscious	Good knowledge of resource, inputs, etc. No distinction between risk and uncertainty. Short-term uncertainties estimated and allowed for and secular trends and long-term uncertainties ignored because of inability to deal with them	Maximize net family income subject to non-economic value constraints
Conscious	Requires data as to physical relations and time trends not yet available. Suggests devices for dealing with risk and uncertainty	Maximize dollar measures of net economic product forthcoming from alternative lines of water development
Primarily conscious with habitual and unconscious elements	A shared knowledge common to the socio-economic group within the village. A clear preference for certainty and short-term horizons, risk and uncertainty is equated with calamity: a state that cannot be planned for or dealt with but only feared	"Maximize the material, short-run advantage of the nuclear family, assume that others will do likewise." Those whose behavior is consistent with this rule are called amoral familists
Conscious, habitual, unconscious	A spectrum of knowledge but concentrated in some culturally determined norm. Uncertainty dealt with in part by "likelihood" estimate	Satisficing; meeting criteria of possible, adoptable, gainful, and likely to be done by others
Conscious, habitual, unconscious	A broad spectrum of knowledge ranging from the best scientific to almost total ignorance. Risk with discrete probabilities described as sensitivity points	Some maximizing of net present value of gains over losses but ranging from "intuitive acceptance to highly sophisticated computations"

California; E. Banfield's study of a southern Italian village, The Moral Basis of a Backward Society; W. Firey's Man, Mind and Land, an overall theory of resource use; and G. F. White's "The Choice of Use in Resource Management" which accounts for some of the elements in decision-making as applied to resource use.

For each study certain key features are shown in tabular form. These, in most cases, were deduced by the writer as a judgment of the work in question and may vary considerably from the authors' own intentions, conceptions, and methods.

The features shown in the Table are: (column 1) a judgment as to the intent of the study, that is, whether it was intended to be descriptive-predictive or prescriptive; (column 2) the area of human activity in which the decisions under consideration are made; (column 3) whether examples or empirical findings are included; (columns 4-7) the four underlying assumptions; man's rationality, type of decision processes being discussed, the conditions of knowledge under which the decisions are made, and finally the evaluation criteria used to decide choice.

The six studies were chosen, not to convey their substantive findings for Table 3 ill-serves such a purpose, but to illustrate the richness and variety of authorship, intent and assumptions found in resource management decision studies.

The intent of this volume is narrower in scope and purpose. Although it comments on various aspects of the decision process, its focus is on the conditions of knowledge under which flood plain resource decisions are made. What is the nature of flood hazard information available to flood-plain occupants? What kind of choices of adjustment do flood-plain users perceive? What is the relationship between the perception of hazard and the choice of action to reduce flood damage?

Kates, R. W., 1962, Hazard and Choice Perception in Flood Plain Management, University of Chicago, Department of Geography Research, Paper No. 78.

CHAPTER III

THE STUDY: STRATEGY, SITES, AND METHODS

In this chapter, the analysis moves from the general to the particular. It shifts from a consideration of national flood problems to the floods of Big Creek at LaFollette, Tennessee. It moves from hypothetical decision makers to the actual decisions of 110 persons residing or working in LaFollette.

The research strategy called for a major study at LaFollette, supplemented by a series of reconnaissance studies at Aurora, Indiana; Darlington, Wisconsin; Desert Hot Springs and El Cerrito, California; and Watkins Glen, New York. Descriptions of some relevant geographic, social, and economic factors for each area follows, along with details of study method including the extended, intensive, interview.

The Strategy of the Study

As originally conceived, the study was viewed as complementary to a series of related studies undertaken by the Department of Geography of the University of Chicago to examine the practicability of various alternative adjustments to flood hazard. It would continue the probe of attitudes, knowledge, and experience begun in the Roder and Burton studies, and it would attempt to compare these attitudes with those held by technicians and scientists better informed as to flood hazard.

The strategy of these combined investigations called for two sets of simultaneous field observations. Establishments[1] in the flood plain would have potential flood damages assessed under a variety of assumptions. At the same time intensive interviewing

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[1]The terms establishment and managers follow the scheme of White, Natural Resource Journal, p. 25. In this study an establishment is a ground floor, functional land-use unit such as a residential, business or public and quasi-public structure and its surrounding lot. Structures occupied by a number of separate functional units are designated as a separate establishment for each use and the lot is pro-rated among the establishments. Businesses that occupy several structures form only one establishment. The set of flood plain establishments forms the universe of the companion study cited in n. 2, page 30.

of the managers[1] of flood-plain land would help establish measures of their knowledge, experience, attitudes, and responses towards flood hazard. The damage data provide the core material of the companion study;[2] the interviews the core of this study.

The area for the major study site was chosen on the basis of the following criteria: (1) hydrologic, topographic, and engineering data had already been developed for the site; (2) the number of establishments on the flood plain was small enough to permit a complete damage inventory to be made as well as to provide a variety of land use; (3) the site had little prospect of receiving protection from a flood control project;[3] (4) responsible local leaders in the study area were willing to provide needed cooperation.

The net effect of these criteria was to center the choice of site on the Tennessee Valley where the Tennessee Valley Authority had already developed the extensive supplementary technical data required. Further application of the criteria, particularly variety of land use and the negative prospect for protection

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[1]The managers in this study are, for residential establishments, the actual residents, be they owners or renters; and for commercial establishments, the owner or manager of the business occupying that structure. (Managers of public or quasi-public establishments have been grouped with commercial managers throughout the study.) The set of flood plain managers forms the universe of the respondents for the interviews conducted for this study.

[2]The companion study is that study that was designed by Gilbert F. White to examine the practicality of various alternative adjustments to flood hazard. The data of that study including its compilations of the best technical and scientific knowledge relevant to flood hazard at each site as well as its detailed expert judgments provide in part the standard against which the knowledge and judgments of the interviewed managers are measured. In turn, the writer will subject the "expert" standards to abstract tests of the reasonableness and reliability of its assumptions.

By being part of the study group, the writer had the unique (albeit occasionally schizophrenic) experience of observing and making "expert" technical judgments and at the same time comparing these decisions to those made by managers interviewed in the field.

The companion study will appear as a University of Chicago Department of Geography Research Paper tentatively entitled Choice of Adjustment to Floods.

[3]The thinking behind these criteria is fairly self-evident except for the requirement of a site not having protection in prospect. The reasoning in this case went something like this: It has been long observed that flood prone communities have a great deal of difficulty in giving serious attention to alternative measures of flood damage reduction when either awaiting or requesting federal flood protection works. Further, some alternatives are most applicable only where conventional engineering works cannot satisfy a test of economic feasibility. Since the focus of the study is primarily on alternative measures, it was felt that more might be learned in a situation where engineering works were not likely to be installed.

narrowed the study site to LaFollette, Tennessee.

The reconnaissance sites were chosen to provide a wide range of situations of climate, land use, flood hazard, and adjustment in which to compare the damage and attitude data from LaFollette.

Study Sites: The LaFollette Area

Geographic and economic characteristics.--LaFollette, Tennessee (est. 1961 pop. 7,200)[1] lies at the base of the Cumberland Plateau some forty miles north of Knoxville. Cumberland Mountain towers 800 feet above the town, pierced only by the gap of the Big Creek, whose flood plain is the focus of this study. The Big Creek drainage basin (26.2 square miles) is "T" shaped, with the horizontal member formed by the junction of Big Creek and Ollis Creek just above the gap. The combined stream then turns sharply right and emerges through the gap to flow across the grain[2] of LaFollette to its junction with Norris Reservoir just below the town. Its flood plain is the major area of level land in a town marked by the low parallel ridges, so characteristic of the area.

LaFollette was laid out in 1892 by Harvey M. LaFollette, whose foundry was a principal source of income until its closing in 1923.[3] With an economy intimately related to the declining coal industry, the city has been the center of a depressed area for many years. Since the early 1950's unemployment has been chronic (11.2% in 1960)[4] and the present opportunities are mainly limited to shirt-making plants (primarily employing women) and the trade activities of LaFollette as the major town in Campbell County. Although the center of a county of out-migration (net loss of population 18.7% in the 1950-60 decade),[5] LaFollette

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[1]Estimated by writer and includes area annexed after 1960 census.

[2]The predominant trend in this section of the ridge and valley province is northeast-southwest.

[3]LaFollette Municipal Planning Commission, LaFollette Land Use Survey and Analysis (Knoxville: Tennessee State Planning Commission, 1961), pp. 5-6.

[4]U.S. Bureau of the Census, U.S. Census of Population: 1960 General Social and Economic Characteristics, Tennessee, Final Report PC (1)-44c (Washington: Government Printing Office, 1961), p. 202.

[5]U.S. Bureau of the Census, U.S. Census of Population: 1960 General Population Characteristics, Tennessee, Final Report PC (1)-44b (Washington: Government Printing Office, 1961), p. 28.

itself showed a large increase in population due to rural in-migration from farms and mining camps and a recent annexation which added an estimated 926 persons to the population.[1]

Social characteristics.--One outstanding characteristic of the population of LaFollette appears to be homogeneity. (Comparative data on age, education, income, and employment status can be found in Table 4.) The impression formed by the study group who worked in LaFollette was that this white, Anglo-Saxon, Baptist community was as homogeneous a community for its size as one might find in the United States.

Compared to the national population, the people of LaFollette are, on the average, substantially older, poorer (and unemployed), and less educated than the mean of their fellow Americans.

LaFollette is governed by a five-member City Commission, one of whom serves as Mayor. Other governmental agencies potentially involved in aspects of water management are the LaFollette Municipal Planning Commission which works in conjunction with the Tennessee State Planning Commission, the Board of Public Utilities which manages the municipally owned water and electric systems, and the Campbell-Claiborne Counties Area Redevelopment Committee which is the designated agency working with the Federal Area Redevelopment Administration.

The future prospects for LaFollette.--The future of LaFollette, considered in the light of historical trends, is not particularly bright. One of the first areas to qualify under the Area Redevelopment Act, the net impact of federal aid is uncertain.[2] Population in-migration has probably reached its peak, the fertility ratio is low,[3] and the experience in attracting industry is not encouraging. Present efforts at industrial development have brought low wage, female labor-oriented industry and this trend will probably continue. LaFollette can provide a satisfactory future for its present ageing population, but with its poor schools and lack of amenities, it has not been able to retain its young people, whose infusion of vigor is a necessary if not sufficient condition for growth.

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[1]Estimated by East Tennessee Office, Tennessee State Planning Commission.

[2]At present 110 area workers are being retrained in vocational trades and federal aid for water supply and sewage projects has been granted. To the writer, it is dubious if measures of this type can solve any of the area's basic problems, but they can make LaFollette a more pleasant place in which to live.

[3]U.S. Bureau of Census, PC (1)-44b, p. 27.

TABLE 4

SELECTED POPULATION CHARACTERISTICS OF LAFOLLETTE AND UNITED STATES[a]

Characteristic	U.S.	LaFollette		
		Total	Commercial Respondents	Residential Respondents
Age:				
% Heads of household:				
Age 45 or greater	53.9	n.a.[b]	65.1	76.3
Age 65 or greater	16.7	n.a.	10.1	28.9
Education:				
% Heads of household:				
0-8 years school completed	41.2	67.8	14.7	70.2
9-12 years school completed	41.1	19.5	43.0	24.4
13 or more years school completed	16.5	12.3	41.2	5.4
Income:				
% Families with:				
Less than $2,500	26.1	33.7	3.2	72.1
Less than $4,000	41.1	56.6	17.4	83.1
Less than $6,000	63.8	74.6	31.6	97.0
Less than $10,000	89.5	95.1	70.8	100.0
Employment:				
% Heads of household:				
Retired from labor force.	n.a.	43.1	....	47.4
Unemployed	n.a.		....	13.2
Employed	n.a.	56.8	100.0	39.5
Household size:				
Mean number of persons ..	3.35	3.44	....	3.25

[a]Data are not strictly comparable as they include time periods ranging from 1957-61 and are derived from a variety of sources including: Donald J. Bogue, The Population of the United States (Glencoe: The Free Press, 1959); U.S. Bureau of the Census, U.S. Census of Population: 1960 (Washington: Government Printing Office, 1961); LaFollette interview data by author and associates.

[b]N.a.--not available.

Flood problems of LaFollette.--The city limits of LaFollette are located a stone's throw from a major reservoir, Norris Lake, of one of the more regulated rivers in the world. It is thus grimly ironic that LaFollette is plagued with the whole gamut of water management problems including floods, drought, and the continuous pollution of Big Creek.

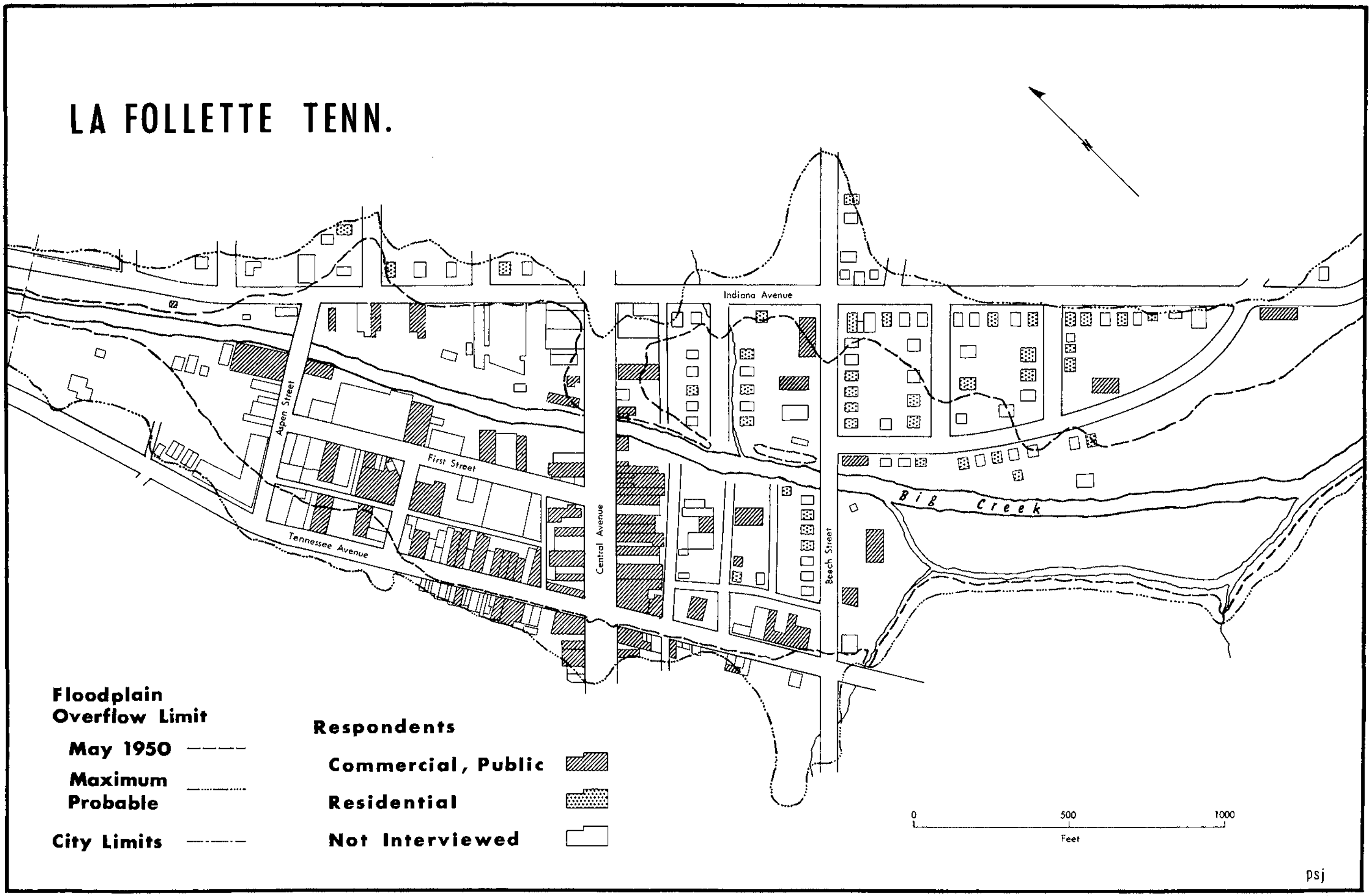
LA FOLLETTE TENN.
N
Indiana Avenue
Aspen Street
First Street
Tennessee Avenue
Central Avenue
Beach Street
Big Creek
Floodplain
Overflow Limit
May 1950
Maximum
Probable
City Limits
Respondents
Commercial, Public
Residential
Not Interviewed
0
500
1000
Feet
psj

Fig. 2

In the last ninety years for which some record is available, Big Creek has severely flooded twice; March 23, 1929 and May 11, 1950.[1] The flood of 1929 was the higher, but increased development of the flood plain caused the flood of 1950 to be the more damaging. The TVA estimated damages at the time to be $97,000. The constricted arch bridge on Central Avenue increases the natural effects of floods, causing an estimated 5.5 feet of heading in 1950. Floods rise rapidly off the steep slopes of Cumberland Mountain with the rate of rise in 1950 estimated to have been three feet in forty-five minutes at the upper end of town.

In addition to the flood plain inundated by the 1929 and 1950 flood, the TVA has defined overflow areas for floods that have not occurred but might be reasonably expected to occur in the future. The method used to calculate such floods will be described in the following chapter.

The largest of such future floods is called the maximum probable flood. It is defined as that flood that might be reasonably expected to occur as the result of storms that have occurred previously in the LaFollette region or might be expected to occur in the region.

The area subject to such an overflow is the working definition of flood plain[2] in this study, and is shown on Figure 2.

Land use in the flood plain.--On the Big Creek flood plain is found the greater portion of LaFollette's commercial and industrial establishments, but only a fraction of its residential establishments (see Table 5).

Most of the 87 residential structures are small frame buildings without basements. Three-fourths of these are owned outright by the residents; a fifth are without bath facilities, and two-fifths were classified by the study group as deteriorated or deteriorating. There is no statistically significant difference between the quality and variety of housing available on and off the flood plain, although there is a complete absence of high income housing on the flood plain.

Three-fourths of the business structures are over twenty years old. Brick buildings with basements predominate. There has

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[1]Flood data are from Tennessee Valley Authority, Division of Water Control Planning, Floods on Big Creek at LaFollette, Tennessee (Knoxville: Tennessee Valley Authority, 1958).

[2]For discussion of other possible flood plains, see Robert W. Kates and Gilbert F. White, "Flood Hazard Evaluation" in Papers on Flood Problems, pp. 138-142.

been some remodeling in the business district, and if it does not present an outward appearance of overall prosperity, neither does it have the shabby decaying look that one might associate with a chronic depressed area.

TABLE 5

LAFOLLETTE ESTABLISHMENTS, BY TYPE AND FLOOD HAZARD

Type	Subject to Hazard of				Total in City
	1950 Flood		Maximum Probable Flood[a]		
	Number	Per Cent of City	Number	Per Cent of City	Number
Commercial, industrial, public, and quasi-public	82	31.2	150	57.0	263
Residential	11	0.6	87	4.4	2,000[b]

[a]Includes establishments subject to 1950 flood.

[b]Estimated, other figures enumerated.

<u>The residential establishment managers</u>.--The residential flood plain area, primarily below the Beach Street Bridge, is home for some 320 persons. They are older, poorer, and less educated than their fellow LaFollette citizens. (See Table 4.) Consistent with the age of its head, the average household is considerably smaller than for LaFollette as a whole.

To the outsider, the flood plain area is not particularly attractive. The area is damp and the creek, an open sewer, is odoriferous. However, it would appear from the interviews that to its inhabitants, by and large, it is a satisfactory place in which to live.

The total shelter bill for over 75 per cent of the households in the flood plain was under $50 a month and flood plain location provides quick access for the aged population to the central business district and the doctor's office. Living anywhere else in LaFollette would involve some hill climbing and several of the older respondents cited the advantage of residing on level land.

For a dissatisfied minority the flood plain, with its odors and dampness, proved quite unattractive. For the dissatisfied whose outlook for the future was optimistic, residence on the flood plain was temporary, until something better came along.

For those few, who because of unemployment or inertia saw themselves without alternatives, continued flood plain residence augered a noxious and bitter future.

The commercial establishment managers.--The managers of the commercial establishments in LaFollette represent the elite of the town. From their ranks come all the city officials and members of the various boards, the pillars of the churches, and the organized leadership of all types. They are wealthier and better educated than their fellow citizens and somewhat younger than the residential managers. (See Table 4.)

These commercial managers engage in a range of business types consistent with those that are generally found in a town of LaFollette's size and trade area.[1] Three distinctive local features of doing business that were observed are: (1) Higher rates of inventory turnover than the average for towns of the size of LaFollette were found in a number of businesses. (2) Quite distinctive to LaFollette, and not to nearby towns, were the Saturday merchandising practices of street displays and sidewalk greeting of potential customers. (3) A grocery row of five establishments is clustered along one block of Tennessee Street.

Despite the chronic unemployment, businessmen were by-and-large optimistic. Since 75 per cent of them had been in business over ten years, and given the lower failure rates for that class of business,[2] their optimism would appear to be confirmed by their experience.

The interviews also indicated a strong desire (30 per cent) for relocation, preferably along the main highway south of town. In all cases, such desire was associated with space needs, parking problems, and the like, rather than response to flood hazards.

Contrast between commercial and residential managers.--The commercial and residential managers represent opposite poles of a localized continuum.[3] As an impression of the study group, the two groups of managers might be placed on opposite ends of the power

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[1]The expectation of business types given a size of town and trade area is from Brian J. L. Berry et al., "Retail Location and Consumer Behavior" to be published in Papers and Proceedings, Regional Science Association, Vol. VIII (1962).

[2]In 1960, of 7,386 retail business failures in the U.S. only 16.3% were firms in business over ten years. U.S. Bureau of the Census, Statistical Abstract of the United States: 1961 (Washington: Government Printing Office, 1961), p. 497.

[3]In terms of absolute difference, the length of such a continuum would be considerably less than that of the average of towns of this size.

structure, and of another imaginary continuum labeled social energy. If there are latent well-springs of social energy in LaFollette, it is monopolized by the business community. On the other extreme, old and retired, or prematurely retired by the vicissitudes of an ailing industry, are the flood-plain residents. They appear to be content to bestir themselves little, and to last out their days in a resigned, but quietly dignified manner.

Study Methods in LaFollette

Two sets of observations were made in LaFollette; the damage measurements and the intensive interviews.

The damage observations will be described in detail in the companion study, and the interviews will be described here.

The pre-interview data.--By the time one of the interviewers entered an establishment in LaFollette, a number of things had already occurred. The prospective respondent had been informed by letter of the interviewer's coming and this had been reinforced by local publicity in the LaFollette Press. The reason given for the interview was that it was to aid "a study in urban geography . . . in order to learn more about the ways in which land and buildings are used particularly in areas adjoining Big Creek." There was no mention of floods or the flood plain as such, as a test of flood hazard concern was included at the beginning of each interview.[1]

If the manager of an establishment was particularly busy, an appointment had been secured in advance. The study group had no difficulty securing responses and there were only two cases of antagonism preventing completion of interviews.

The interviewer was also prepared with pre-calculated elevations for every establishment giving the floor level and the heights of various size floods. In some cases, preliminary estimates of the size of inventory had been made as well as an assessment of the value of the house and furnishings. Finally, the interviewer had a sixteen-page questionnaire whose content varied depending on whether a commercial or residential manager was being interviewed.

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[1]At the outset, ten of the commercial managers learned the full purpose of the study in their roles as local officials. The study group had been quite candid with them in order to secure the needed local cooperation. As the study progressed, it became more widely known that the study was related to floods. Questionnaires were checked against increasing knowledge of the study's purpose and there appeared to be little difference in the answers received. There were few respondents evidencing a high "flood hazard concern" and these showed little sign of inflating their concern in response to some interest that they might have attributed to the interviewers.

The interview.--The questionnaire was loosely structured. The emphasis in the interview was placed on probing and understanding the respondent's answers rather than the uniform administration of interview schedules.

However, certain tests such as those dealing with concern for flood hazard and with flood frequency computation ability were administered in comparable fashion. A few questions were given priority and others were left to the interviewer's judgment during those interviews where time or the respondent's patience appeared limited.

The substantive material of the questionnaire is outlined in Table 6, and the complete interview for commercial managers is shown in the Appendix. Questions used in the supplementary reconnaissance studies are also indicated and their use is described in the following section.

The interview ranged from thirty minutes to an hour and a half, with the median interview taking forty-five minutes. Another thirty minutes were spent in inspecting the premises for the damage measurements. Including the damage calculations and interviewer's notes, an average of three hours were expended on each interview. Interviewers averaged three interviews per day. In all, 241 damage observations and 110 interviews were obtained by the five-person study group in eight weeks (see Fig. 2).

Preparations for the interviewing included pre-testing the questionnaire in the flood plain of the Little Calumet River in northwestern Indiana; jointly conducted interviews in LaFollette followed by comparative evaluations; and constant comparative discussion throughout the study. While there was evident the traditional bugaboo of comparability, exacerbated by the nature of a loosely structured interview, the findings do not rest solely upon the statistical testing of uniformly obtained answers. They depend heavily upon the understanding of behavior obtained by the interviewers as the day-to-day responses to the questionnaires were discussed and analyzed.

The Reconnaissance Studies: Strategy, Sites and Methods

Strategy and methods.--The reconnaissance studies extended the insights developed at LaFollette to a variety of situations in other parts of the country. The reconnaissance studies provided a range of flood hazard in areas with differing socio-economic characteristics. At each site answers were sought to the following questions: (1) Are the damage estimation methods developed in LaFollette applicable elsewhere? (2) How does information and attitudes towards flood hazard vary from those held by the managers in LaFollette?

TABLE 6

TYPES OF DATA COLLECTED IN THE INTERVIEWS

Type of Data	Type of Interview		
	Commercial	Residential	Reconnaissance[a]
Structure			
Description of structure	x	x	x
Tenure, rent, mortgage	x	x	x
Attitudes to structure	x	x	..
Location			
Description of location	x	x	x
Attitudes to location	x	x	..
Business			
Type and size of business	x	..	x
Time horizon for business	x	..	x
Attitudes to business	x	..	..
Respondents			
Family data	..	x	..
Head of household data	x	x	x
Attitude towards fate and planning	x	x	..
Personal time horizons of respondent	x	x	..
Church and club membership	x	..	..
Communication and discussion channels	x	x	..
Socio-economic data	x	x	x
Floods known about or experienced.	x	x	x
Attitudes towards floods and flood hazard	x	x	x
Alternative adjustments to floods			
Adjustments installed and perceived	x	x	x
Evaluation of alternative adjustments	x	x	x

[a]Partial data only.

The first question is the property of the companion study. To answer the second question flood plain managers at each site were sampled and interviewed with a series of questions abstracted from the standard questionnaire (see Table 6). These were so designed to provide the needed comparability on certain key questions of attitudes, socio-economic, and structure data.

The reconnaissance sites.--The location and general appearance of the reconnaissance sites is shown in Figure 3. A brief description of each site will conclude this chapter.[1]

Aurora, Indiana.--Aurora (1960 pop. 4,119) provides the opportunity of observing in a town with a long history of flooding (73 floods in 129 years) and an absence of protective works the types of adjustments made to a well-known hazard.

It is built on a small terrace of the Ohio River and Hogan Creek, some 26 miles below Cincinnati, Ohio. Aurora is an old river town, whose industries no longer require riverine access. Her population has been declining although neighboring areas, as part of the Cincinnati metropolitan area, have seen considerable industrial expansion.

Within the flood plain inundated by the 1937 flood of record (with depths of up to thirty feet) are the bulk of Aurora's industrial and commercial establishments and a considerable number of residences.

Darlington, Wisconsin.--Darlington (1960 pop. 2,347) like Aurora has frequent flooding, but with modest growth providing pressure to expand into an undeveloped portion of the flood plain. Attitudes to flood hazard are complicated by the existence of a P.L. 566 watershed protection project that includes the town.

Darlington lies in a bend of the Pecatonica River in southwestern Wisconsin. The flood plain narrows through the city averaging not more than six hundred feet in width.

It is the county seat of a prosperous farming area. About half of its business section and a dozen residences lie in the flood plain.

Floods are frequent from the 275 square mile drainage area, the most recent being in 1961. The 1950 flood of record inundated some of the business establishments to depths of 8-9 feet.

Desert Hot Springs, California.--Desert Hot Springs (estimated pop. 3,800) combines the situation of a rapidly expanding residential community and the highly erratic flooding of an arid area.

The town is located on an alluvial fan on the slopes of the Coachella valley, 10 miles north of Palm Springs. There is no manufacturing industry in this resort town and community for retired "senior citizens." The average yearly rainfall is four inches a year. Floods are flash floods, products of intensive highly localized rainfalls that produce in minutes heavy masses of

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[1]More detailed descriptions will be found in the companion study.

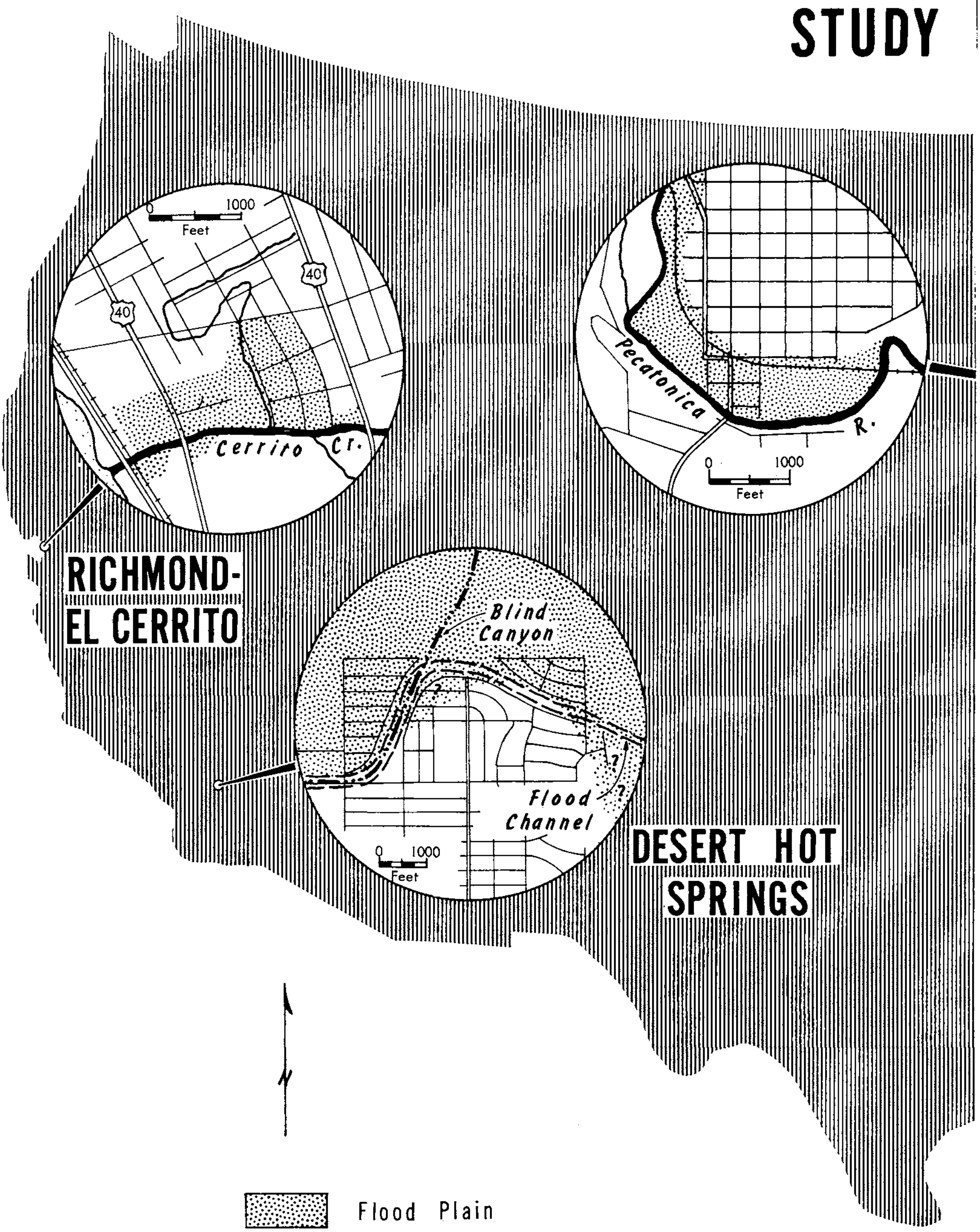
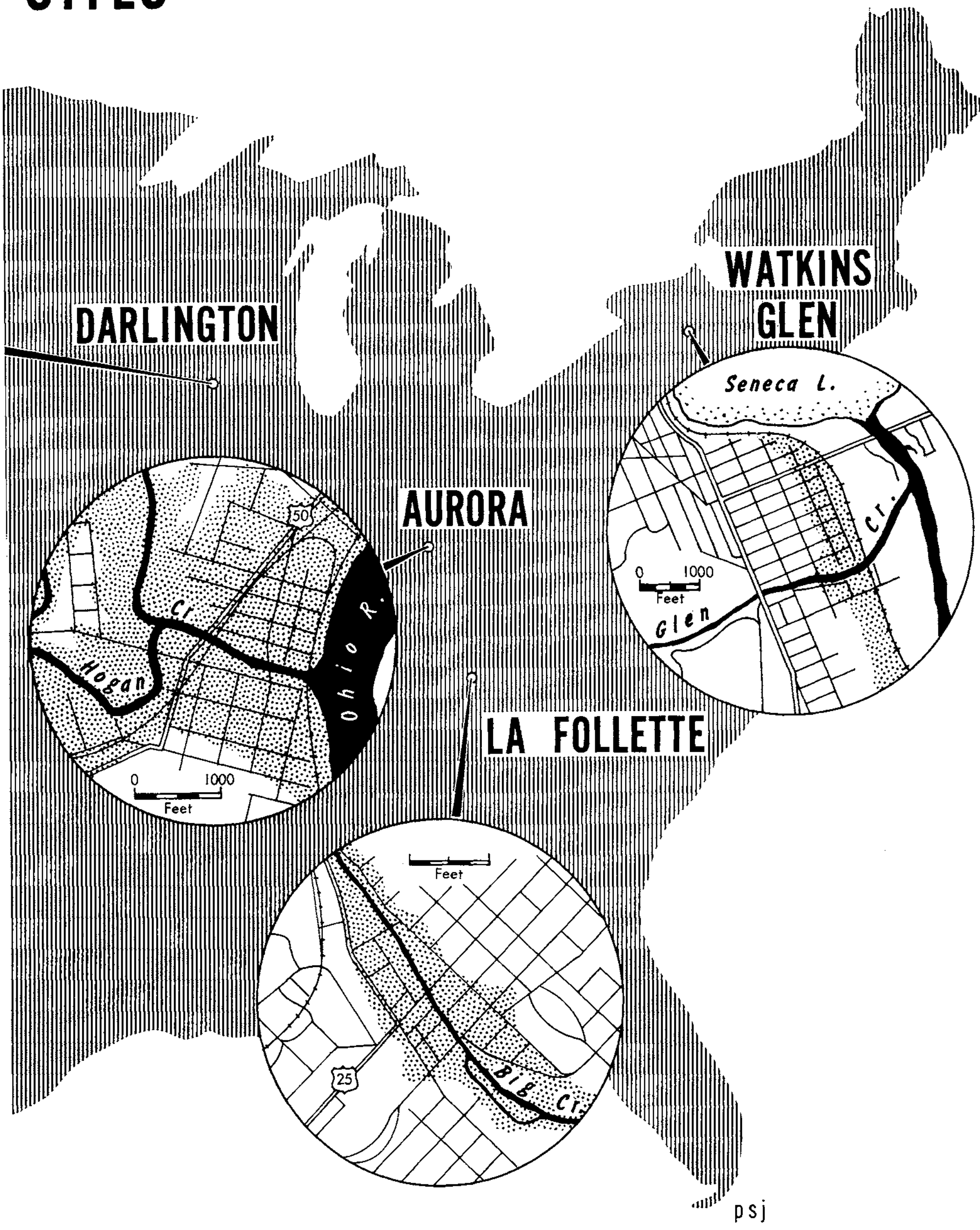

STUDY
0 1000
Feet
40
40
Cerrito Cr.
RICHMOND-
EL CERRITO
Pecatonica R.
0 1000
Feet
Blind
Canyon
Flood
Channel
?
?
0 1000
Feet
DESERT HOT
SPRINGS
Flood Plain

Fig. 3

SITES


DARLINGTON
AURORA
WATKINS GLEN
LA FOLLETTE
Seneca L.
Glen Cr.
0 1000
Feet
50
Hogan Cr.
Ohio R.
0 1000
Feet
Feet
25
Big Cr.
psj

sediment pouring down the steep ravines and out onto the alluvial fan. These floods are extremely erratic, and vary in intensity, location, and time of year, although they often occur in the summer.

Desert Hot Springs is expanding at a heady pace from its original square mile. Partial protection exists in the form of a flood channel to pass flows from the mouth of Blind Canyon, but development is placing a growing number of residences in the path of potential floods from other dry washes.

Cerrito Creek, California.--Cerrito Creek presents a familiar flood situation of a small watershed in a suburb of a major metropolitan area subjected to moderate but steady pressure of flood plain utilization.

The Creek rises in a three-square mile drainage area in the Berkeley hills on the east shore of San Francisco Bay. Its lower 3,000 feet overflows onto a 55-acre plot which is divided into an industrial area in the city of Richmond (1960 pop. 71,854) and El Cerrito (1960 pop. 25,437).

The flood plain includes three large industrial sites, four smaller industrial plants, some 17 apartment buildings (14 of recent vintage), and a 10-acre vacant tract. The 1958 flood of record placed two feet of water in the industrial area. A preliminary Corps of Engineers benefit-cost study rejected a program of protective works for the Creek. There has been some local channel clearing and diking, the efficacy of which is doubtful, and in any case limited.

Watkins Glen, New York.--Watkins Glen (1960 pop. 2,813) provides a complicated flood hazard picture, having experienced a flood greater than the maximum probable flood and ostensibly protected by channel improvements likely to fail but at an uncertain time and place.

Located at the head of Seneca Lake, largest of the finger lakes of western New York State, Watkins Glen is traversed by Glen Creek which emerges from a magnificent canyon site of a state park.

The 1935 flood of record covered most of the town but was the product of an unusual impoundment and surge and is not likely to be repeated. A definition of the flood plain is further complicated by the existence of protective works in the form of an artificial channel works, however, that, in the considered opinion of the Corps of Engineers, are subject to partial or complete failure. In the flood plain that might be inundated by a total failure of protective works are some 73 structures, all but one being residential or residential structures converted to commercial use.

The population is steadily declining and needed improvements on the channel fail to show a favorable benefit-cost ratio.

Kates, R. W., 1962, Hazard and Choice Perception in Flood Plain Management, University of Chicago, Department of Geography Research, Paper No. 78.

CHAPTER IV

PROBABILITY AND HAZARD EVALUATION

In each of the towns it is possible to discern the current information on flood hazard and how it is evaluated or, in the framework of decision theory, the conditions of flood knowledge.

The flood hazard information of each manager is compounded of experience and knowledge, and such information, or the lack of it, is known to be related to some perceived probability distribution of flood hazard. This relation, however, does not appear to be a simple one. In each town the possession by individuals of what appears to be similar information does not result in either similar perceptions of hazard or of desirable behavior.

To help account for the variation in perception and behavior, it is hypothesized that individuals behave as if they possess some underlying perception of the state of nature and that this perception aids in an interpretive process through which information is transformed into a personal evaluation of flood hazard.

Concretely, this chapter will examine for the six study sites, the quantity and quality of information available in both the common and technical variants of knowledge, the perceived distributions of future flood hazard, and the implications of such information for choosing between alternative measures of flood damage reduction.

Information and Flood Hazard Evaluations in LaFollette

The elements that are subsumed under the title of *information* can be described in a variety of ways. This study will specify two such elements, *knowledge* and *experience*, and in such broad terms as to include all the variety of information available to respondents.

Common knowledge and experience.--A *knowledge* of floods in LaFollette describes that part of the spectrum of *information* ranging from a rudimentary awareness of flood events to a detailed knowledge of LaFollette's flood history. In acquiring such knowledge, a respondent might have been exposed to a variety of channels and messages ranging from an informative neighbor to a detailed exposition of flood problems presented to members of the Planning Commission.

Experience is that element of information that describes the presence of the manager's establishment on the flood plain during the passage of a major flood. It implies physical presence only and not that the manager's establishment was necessarily damaged or even inundated.[1]

The range of information in LaFollette.--The existence of floods as natural phenomena is widely known, with only 8 of 109 respondents not sharing in such common knowledge (see Table 7). Almost half the respondents had personally experienced the flood of May 1950, and for these at least, such experience implied knowledge, that is, no respondent who experienced a flood in LaFollette (by the presence of his establishment on the flood plain) failed to display at least a rudimentary awareness of the passage of a flood event.

The expectation of a future flood.--However widely flood hazard information is distributed in LaFollette, its possession does not imply a personal awareness of flood hazard in the sense of a danger to person or property, or even the expectancy of a flood in the future.

The simplest and most reliable estimate of hazard evaluation obtained from respondents, the expectancy of a future flood, was in reply to the following question: "Do you think that you will have, or there will be, another flood while you are (in business) (living) here?"

The answers to the question, classified as yes, no, and uncertain, are shown in Table 7. A substantial reluctance to make even a simple dichotomous estimate of flood expectation might be noted. With considerable probing, the uncertain category had been reduced to twenty-four respondents, who represent two types of uncertainty. The first type of uncertainty, verbalized as "I just don't know," reflects a genuine puzzlement as to the future. The second type of uncertainty, verbalized by "You just can't tell what's going to happen," reflects not merely puzzlement, but doubt as to the predictability of the future.

Table 7 suggests that the expectation of a flood in the future is associated with a higher order of information and, as an individual moves up a knowledge-experience scale, his likelihood

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[1]A further distinction is made between experience onsite at the present location of an establishment and experience elsewhere at locations outside the LaFollette flood plain or at locations on the flood plain not comparable to the present site, but subject to flooding.

TABLE 7

INFORMATION AND FUTURE FLOOD EXPECTANCY IN PERCENTAGE OF COMMERCIAL AND RESIDENTIAL RESPONDENTS

Information	Commercial (71 Respondents)				Residential (38 Respondents)				Total (109 Respondents)			
	% Future Flood Expectancy				% Future Flood Expectancy				% Future Flood Expectancy			
	Yes	No	Uncer-tain	Total	Yes	No	Uncer-tain	Total	Yes	No	Uncer-tain	Total
No knowledge No experience	....	5.6	1.4	7.0	....	2.6	....	2.6	....	4.5	0.9	5.4
No knowledge Experience elsewhere	....	....	....	....	....	2.6	2.6	5.2	....	0.9	0.9	1.8
Knowledge No experience	8.4	11.2	9.8	29.4	5.2	18.4	2.6	26.2	7.3	13.7	7.3	28.3
Knowledge Experience elsewhere	5.6	8.4	1.4	15.4	7.8	....	5.2	13.0	6.4	5.5	2.7	14.6
One experience Onsite	22.5	5.6	5.6	33.7	10.5	21.0	10.5	42.0	18.3	11.0	7.3	36.6
Two or more experi-ences onsite	11.2	1.4	1.4	14.0	5.2	....	5.2	10.4	9.1	0.9	2.7	12.7
Total	47.7	32.2	19.6	99.5	28.7	44.6	26.1	99.4	41.1	36.5	21.8	99.4

for an affirmative future flood expectation increases. However, such association, while statistically significant for the commercial and total group of respondents, is relatively weak when measured by a variety of appropriate correlation measures, and is apparently lacking in the residential group.[1]

The differential measure of association between information and future flood expectancy for the commercial and residential respondents can be ascribed in part to their qualitative differences in experience. Though the number of individuals in each group who recalled having suffered any damage in the 1950 flood was roughly proportional to the respective group size, the eleven individuals suffering substantial damage (in excess of $150) were all commercial respondents. Ten of these eleven had affirmative future flood expectations. Other commercial respondents, who may not have suffered monetary damage, expended considerable effort in flood fighting during the 1950 flood and this action might have added to the impact of their experience. The differences in socio-economic status between the groups that were discussed in the previous chapter would appear to little influence contrasts in future flood expectancy; the various measures of socio-economic status including age, income, and education showing no apparent association with future flood expectancy.

In considering the total response, it is clear that despite the widespread minimum level of knowledge displayed in

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[1]In this volume, a statement that an association is statistically significant implies that such association (when measured by chi-square, representing the sum of the differences between the observed distribution and one that might be expected if there was no association between the variables in question) had but one chance in twenty or less of arising purely by sampling variability or chance (.05 level of significance).

In the example being considered, a condensation of Table 8 into a 3 x 3 contingency table results in a measure of association significant at a level that allows but one chance in a hundred (.01 level of significance) that the apparent association between information and future flood expectancy for the commercial and total respondent groups arose as a result of sampling variability or chance. For the residential group the chance is in excess of one chance in twenty and not significant.

A statistical test of significance is primarily a measure of the presence or absence of a relationship. The strength of such relationships can be measured by correlation statistics based on chi-square, such as Tschuprow's T in the case of 3 x 3 tables, and Ø for a 2 x 2 condensation of Table 7. The values of these measures range from .24 to .40, the largest value being the value of Ø for the 2 x 2 table associating onsite flood experience and affirmative expectations. It should be noted that while these measures are analogous to more common correlation measures, taking on the values of 1.0 for a perfect relationship and 0.0 for the absence of any relationship, the interpretation of the non-extreme values leaves something to be desired.

LaFollette, almost 60 per cent of the respondents either fail to perceive a personal flood hazard or are uncertain. It would further appear that, although the propensity to perceive such hazard is heightened by flood experience and particularly either repetitive experiences or those entailing personal loss or effort on the part of the respondents, some 24 of the 54 managers experiencing a flood fail to anticipate another experience or are uncertain. A precise understanding of the way managers evaluate flood hazard requires more than the simple specification of their knowledge and experience.

It seems likely that between the common knowledge (or even experience) of a flood event and the expectation of other such events in the future a process that might be conveniently called interpretation takes place. Interpretation describes that process whereby information is referred to an individual's underlying perception of the state of nature, and is assimilated in a unique personal way.

While interpretation may help explain the relationship between flood information and flood hazard evaluation, it is not suggested that the writer really knows that such a process takes place, but only that the verbalizations and actions of the respondents are those that one might logically infer as being consistent with it.

The variety of interpretations that might follow from several perceptions of the state of nature and how these are related to hazard evaluation will occupy much of this chapter. However an examination of the interpretation of the respondents in LaFollette might be enhanced by the prior consideration of the perception of the state of nature held by the possessors of technical knowledge and the kinds of hazard evaluation they might make.

A Technical Perception of the State of Nature

One kind of hypothetical perception of the state of nature can be illustrated by reference to a favored model for probability illustration and experiment; the balls of varying color or size in the well-mixed urn. It is hypothesized that nature has filled the urn with a large number of balls representing future annual floods and the volume of each ball is proportional to the peak discharge of such floods.[1] The exact distribution of the

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[1]A peak discharge is the largest momentary volume of water passing a point along a stream and is generally expressed as cubic feet per second, abbreviated cfs. An annual flood is the largest peak discharge in a water year. A water year is the twelve-month period commencing on October 1st of each calendar year.

balls is unknown, but one is conscious that a niggardly or capricious nature has filled the urn with a great many more smaller balls than larger ones.

The contents of the urn are not immutably fixed and may be changed by the actions of men, the size of the balls being altered, but the process is viewed either as uncertain or requiring great effort. In this analogy, the annual flood for any given year is found by reaching into the well-mixed urn and drawing a ball, the choice being random and independent of any other. A sequence of such draws might be conceived as a sample of the urn or the historical record of floods at a point, similar to the records presently available from some 7,000 sites in the United States.

Given this simplified perception of nature, three general problems may be distinguished that have caught the imaginations of engineers, hydrologists, meteorologists, statisticians, and mathematicians. They are:

1. Given a very large urn, and the relatively short life of man, what may be safely inferred from the small samples that represent his prior experience as to the contents of both the urn and future samples to be drawn from it?

2. Is it feasible to define the volume of the largest and smallest balls in the urn?

3. Can a basic underlying mathematical distribution that would describe the contents of the urn be hypothesized on an *a priori* theoretical basis?

The three questions are not unrelated and for some researchers reflect only differences in emphasis. At the risk of doing considerable violence to hydrology's hard won body of knowledge, as well as to the many divergent views in the field, some answers might be suggested by a brief survey of the present state of the art.

The sampling inference problem.--The record of past occurrences of floods is the best guide to the shape of the total distribution and predicting the composition of future samples. However, extrapolation beyond the predictive power of small samples is fraught with uncertainty. A recent study by M. A. Benson provides some measure of that uncertainty. Benson found that it would take at least a 39-year record to define the magnitude of a fifty-year flood (probability of occurrence in any year .02) within ± 25 per cent accuracy, 95 per cent of the time. To increase such accuracy to within ± 10 per cent accuracy, 95 per cent of the time, would take a record of 110 years.[1]

A number of techniques have been designed to reduce the uncertainty connected with flood magnitude-frequency analysis. Many of these are found in the current practice of the U.S. Geological Survey, which includes the following:[2]

1. Extending records backwards in time by historical research.

2. Utilizing the mathematical distribution of extreme values as developed by Gumbel as a framework in which to place small samples. However, the USGS relies on its actual observations where they do not plot according to the theory of extreme values.

3. Improving the estimating power of small samples by the pooling of records in homogeneous regions.

4. Limiting extrapolations to probabilities of .02 or .01.

5. Using graphical rather than arithmetical procedures to minimize the effect of extreme events in short records.

The application of sampling-inference techniques to the LaFollette flood data.--In the brief discussion of LaFollette flooding contained in the previous chapter, it was noted that Big Creek had flooded severely twice within the memory of local residents and that there was no provision for the systematic recording of streamflow. This poses one of the more difficult examples of the sampling inference problem; the need to make inferences without an actual sample.

While LaFollette lacks a stream gage, there are some 26 gages operated on the Cumberland Plateau, an area whose edge forms LaFollette's watershed. It is from the pooled relationships of these gages that a prediction of the discharge-frequency relationship of Big Creek can be made. The rationale for doing so is the following: Over fairly extensive areas, physiographic variables and drainage area size can be related empirically to a measure of the central tendency of flood flows, the mean annual flood.[3] The mean annual flood serves as an index flood related,

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[1]M. A. Benson, "Characteristics of Frequency Curves Based on a Theoretical 1,000 Year Record," Flood-Frequency Analysis (Washington: U.S. Geological Survey Water Supply Paper 1543-A, 1960), p. 64.

[2]Dalrymple, Flood-Frequency Analysis, pp. 1-48; M. A. Benson, Evolution of Methods for Evaluating the Occurrence of Floods (Washington: U.S. Geological Survey Water Supply Paper 1580-A, 1962), pp. 16-23.

[3]The mean annual flood is the arithmetical average of annual floods or the graphic average represented by a flood with

by dimensionless ratios, to a whole series of floods of varying magnitude and frequency. The relationship of magnitude (expressed as a ratio to the mean annual flood) to frequency (expressed as a return period or recurrence interval in years) is also constant for large areas. For Tennessee, one such curvilinear relationship for all small streams in the state has been derived.

The discharge-frequency curve plotted on extreme value probability paper and labelled USGS on Figure 4 was derived in this way. From the 26 gaging stations the mean annual flood was defined as:

$$\text{Mean annual flood} = 170\ \text{Drainage Area}^{.77}$$

For LaFollette the USGS calculates its value at 1,950 cfs. The relationship of magnitude (expressed as a ratio to mean annual flood) to frequency (recurrence interval) completes the data for the plot.[1]

The plot illustrates well the USGS policy for minimizing uncertainty. The discharge-frequency curve is laid out on extreme value paper, but curvilinear and more in keeping with the data than the theory. The curve represents the pooling of homogeneous records but is projected only to fifty years, even though the discharge of the fifty-year flood so determined is actually considerably less than the two observed LaFollette floods.

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a return period of 2.33 years when plotted on extreme value probability paper, that being the return period for the mean of the distribution. The <u>return period</u> or <u>recurrence interval</u> is a measure of <u>frequency and is the long-run average interval</u> of time <u>within which a flood</u> of a given magnitude will be equalled or exceeded once. It is thus the reciprocal of the <u>probability</u> of equalling or exceeding such a flood in any year.

An important assumption of annual flood methods might be noted here. By definition annual floods are derived using only the largest peak in any year and infrequently omit second and third largest peaks that are actually larger than many of the annual peaks.

This objection might be overcome by the use of a *partial duration series in which all floods greater than some base are listed.* This method also provides problems particularly in defining the independence of consecutive flood events.

A relationship between the two methods has been shown to exist by Walter B. Langbein in "Annual Floods and the Partial-Duration Series," *Transactions of the American Geophysical Union*, XXX (1949), 879-881; where the differences in recurrence interval appears to diminish for large floods.

[2]The actual plot of frequency-discharge was received by personal communication from the Tennessee District of the U.S. Geological Survey. The methods used in its computation are fully described in Clifford T. Jenkins, *Floods in Tennessee, Magnitude and Frequency* (Nashville: State of Tennessee, Department of Highways, 1960), pp. 26-35.

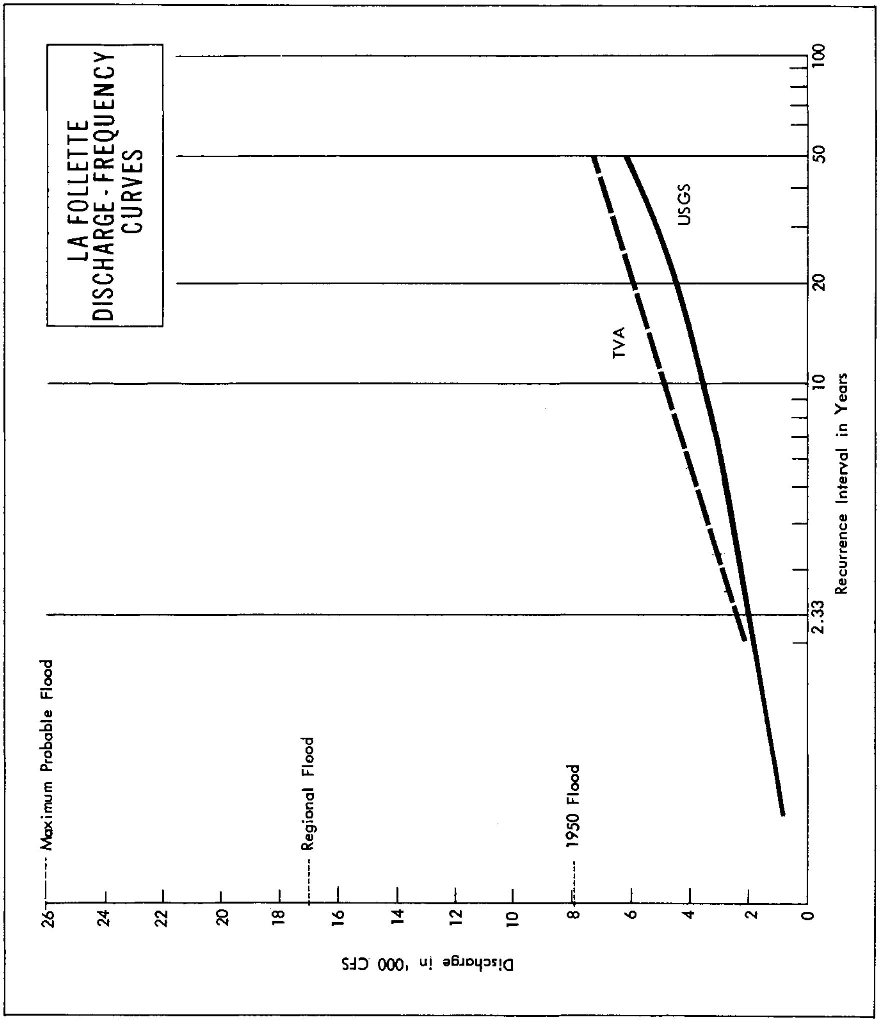
LA FOLLETTE
DISCHARGE-FREQUENCY
CURVES
Maximum Probable Flood
Regional Flood
1950 Flood
TVA
USGS
Recurrence Interval in Years
2.33
10
20
50
100
Discharge in '000 CFS
0
2
4
6
8
10
12
14
16
18
20
22
24
26

Fig. 4

The problem of defining the extreme of extremes.--There have been three main approaches developed for the problem of defining the extreme of the extremes, or more practically defining a maximum probable or possible flood. They are:

1. Assume that the magnitude of the largest possible flood is finite and bounded by some theoretical limit of the energy exchange of earth and atmosphere over the watershed.[1]

2. Assume that the magnitude of floods is infinite, but asymptotically so, and that operationally the magnitude is limited by the shape of the asymptotic distribution.

3. Ignore the question of the finite vs. infinite assumption and try to define a maximum probable flood by the pooling of analogous records, transposition of storms, and the like.

The application of extreme of the extreme techniques to the flood data at LaFollette.--The floods that the Tennessee Valley Authority suggests might be reasonably expected at LaFollette even though they have not as yet occurred are illustrative of the third approach to defining the extreme of the extremes. The TVA identifies in its flood reports two such floods; a regional flood and a maximum probable flood.[2] The regional flood is ostensibly derived from a study of extreme floods that have occurred in a region similar to LaFollette. The floods used to estimate the regional flood for Big Creek are shown on Figure 5 by drainage area size and discharge. All are from observations within 110 miles of LaFollette and drain the Cumberland Mountains. A set of floods and storms for a larger area is considered in estimating the maximum probable flood and this includes "floods that have occurred elsewhere but could have occurred in the LaFollette area." These too are shown on Figure 5. (The discharge of the estimated regional and maximum probable flood is also shown without frequency on Fig. 4 for comparative purposes.)

Considerable engineering judgment appears to have been employed in the actual estimation of the regional and maximum probable floods. An envelope curve, called by the TVA the "regional experience line" is identified on Figure 5. The actual estimated regional flood is some 4,200 cfs. below such a line (17,000 cfs.) and the estimated maximum probable flood is some 4,200 cfs. above the line (26,000 cfs.). It might be noted also that the regional

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[1]Herbert Riehl and Horace R. Byers, "Computing a Design Flood in the Absence of Historical Records," Geofisica Pura E. Applicata, XLV (1960), 3-14.

[2]All of the following flood data are from TVA, Floods on Big Creek, pp. 24-33.

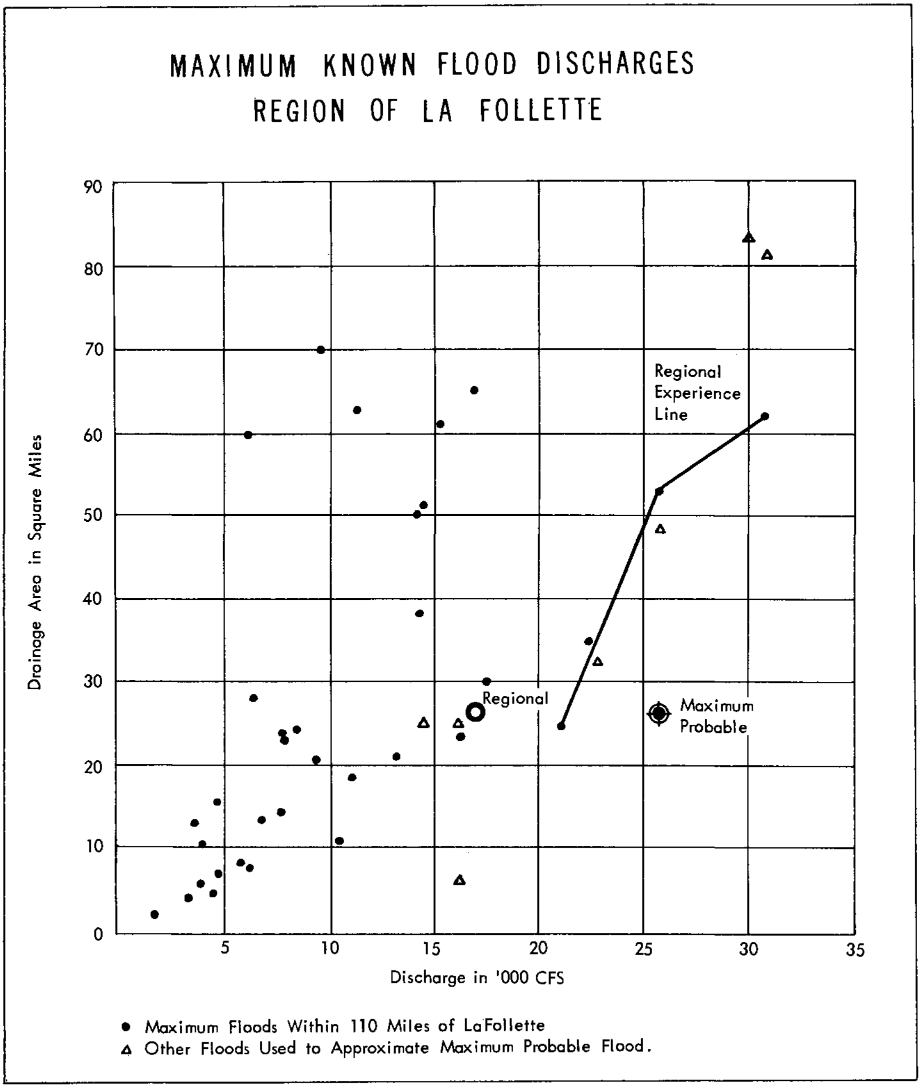
MAXIMUM KNOWN FLOOD DISCHARGES
REGION OF LA FOLLETTE
Drainage Area in Square Miles
Discharge in '000 CFS
Regional Experience Line
Regional
Maximum Probable
● Maximum Floods Within 110 Miles of LaFollette
Δ Other Floods Used to Approximate Maximum Probable Flood.

Fig. 5

experience line would give a good fit to all the non-regional floods ostensibly considered in defining the maximum probable flood except for the truly outstanding flood at Moorehead, Kentucky in 1939 (not shown on Fig. 5).

The problem of identifying an underlying distribution.--For many streams, an array of observed annual flood peaks closely corresponds to those predicted by the theory of extreme values.[1] When such an array is plotted on the special probability paper constructed on the basis of the theoretical distribution of extreme values, it tends to plot as a straight line relation between magnitude and frequency and the extrapolation of such a line enables one to predict the magnitude and frequency of floods greater than have been previously recorded.[2]

For many streams a straight line plot of observed floods may be at best an approximation and at worst a distortion of what is essentially a curvilinear plot. One can either ascribe such variance to the inadequacy of the theory or the violation of the independence of events assumption, error of measurement, random sampling variability, and the like.[3]

While confidence bands can be constructed around a straightline plot of magnitude and frequency, the range of magnitude for floods of rare frequency becomes so great as to render such a range worthless for predictive purposes.

The application of an extreme value distribution to the LaFollette flood data.--By personal request, and not as common practice of its flood information program, TVA prepared a discharge-frequency plot for Big Creek. The result is quite similar to the USGS plot.[4] (See Fig. 4.) The TVA mean annual flood is some 500 cfs. greater, but there is reason to think that a drainage area 2.3 square miles larger measured downstream from LaFollette was used in the TVA calculation. The major difference is

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[1]An introductory discussion of extreme value theory may be found in E. J. Gumbel, Statistical Theory of Extreme Values and Some Practical Applications (Washington: U.S. National Bureau of Standards Applied Mathematics Series No. 33, 1954).

[2]Figs. 4 and 6 are examples of extreme value probability paper with an arithmetic ordinate of discharge and an abscissa of probabilities derived from an extreme value function and expressing flood frequency either as an average recurrence interval (return period) or annual probabilities of a flood of given magnitude being equalled or exceeded.

[3]Benson, Evolution of Methods . . . , p. 9.

[4]Personal communication from the Tennessee Valley Authority, Local Flood Relations Branch, July 25, 1961.

the TVA use of a straight line plot, an assumption implying that in the limited range of frequency shown (50 years) the extreme value distribution is the best guide to the discharge-frequency relationship.

Accompanying the TVA and USGS plots come cautions that they are not to be extrapolated further. If for reasons to be discussed in the following section, one must throw caution to the wind, the minor differences observable in this range between straight and curvilinear plots take on considerable significance.

Technical Flood Hazard Evaluations

In the previous section, it was shown that technical and scientific personnel seem to share a common perception of nature, but often choose somewhat different techniques in seeking to reduce the uncertainty related to probability distributions of flood hazard.

The problems of sampling and inference, defining the extremes of the extremes, and the underlying distribution of flood events are challenging as abstract scientific questions. Solutions to these problems also bear directly on practical matters. In the work-a-day world a narrow but existent line is crossed between scientific enquiry into the nature of probability distributions of flood events and the evaluation of flood hazard with special constraints of time, money, and penalty for error. In short, hazard evaluation, while resting strongly on the shared perception of nature, and mathematical and hydrologic theory, introduces another series of factors related to the perceived hazards arising from floods and the skills and purposes of the organization or individuals evaluating such hazard.

The use of flood hazard evaluation data.--Two general types of flood hazard evaluation are commonly made:

1. Flood hazard evaluations to be used as basic data and not oriented to some specific application. Such data are most frequently supplied by the USGS and in its region, the TVA, and then reinterpreted for a variety of purposes. However, even basic data are designed with a probable set of users in mind.

2. Flood hazard evaluations designed for specific applications, including engineering works, the planning and regulation of land use, economic analysis, flood warning, architectural flood-proofing, insurance, and the like.

Flood hazard evaluations cannot be separated from their purpose. The design of a spillway for a great dam engenders a more careful hazard evaluation than that of a highway underpass.

The penalty for error is also considered greater in spillway design, but mainly in the direction of failure, and the charge of "overdesign" is common.[1]

Basic data, with great potential for abuse, are cautiously presented. Where magnitudes of floods are estimated, magnitudes that appear to be greater than the 50-100 year frequency range, seldom is the frequency associated with such magnitudes stated in print or even estimated. In general, the range of measurement error and the degree of uncertainty vary considerably with the projected application of a hazard evaluation.

A field of research, as yet little explored, involves the real and perceived costs of error in flood hazard evaluation. The application of organization theory to research into the social and organizational pressures that influence hazard evaluation might prove useful. A case study of a flood forecast might provide a start for such inquiry.

Though there may be a multitude of sins concealed beneath the pat phrase "engineering judgment," a glaring one is the obscuring of the probabilistic framework of flood hazard evaluation. Such evaluations are derived from probability distributions, but somewhere in the process of flood hazard evaluation the concept of "engineering judgment" is often substituted for estimates of sampling variability, ranges of measurement error, or even the high-median-low format that has become common in other types of projection and extrapolation in the face of uncertainty.[2]

To be sure, faced with the great uncertainties inherent in flood hazard evaluation, the statement of ranges of error or the quantification of uncertainty is a difficult task. However, the general reluctance of engineering organizations to even attempt to specify their doubt has led to scepticism on the part of water management _cognoscenti_ as to the reliability of flood hazard evaluations, a scepticism that might be reinforced by examining some of the flood hazard evaluations of Big Creek.

The evaluations of the flood hazard of Big Creek.--Evaluations of the flood hazard of Big Creek have been made over the

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[1]Luna B. Leopold and Thomas Maddock, Jr., _The Flood Control Controversy_ (New York: The Ronald Press, 1954), pp. 147-148.

[2]When compared with other fields in which such formulations are common, one is struck by the relative conservatism of the engineering fraternity. Two reasons might be offered to account for their reluctance; the first deals with the origins of much of civil engineering in a mechanical, deterministic physics of the early 19th century, and the second, by a type of professionalism that fears the misunderstanding of the client if the engineer were to voice his real doubts, a fear which might have considerable basis in fact.

years by a number of organizations for a variety of purposes. Table 8 presents a comparative summary of such evaluations, and a brief discussion of their origins might be in order.

The evaluations of the USGS and the TVA were discussed in the previous section as illustrative of varied approaches for inferring the probability distribution of flood hazard (Table 8, lines 1 through 6, 12, 13 and 19). The estimate of the Corps of Engineers for the frequency of what is described as "damaging floods" is derived from a Letter Report of 1954 (Table 8, line 7).[1] The estimate of the Schmidt Engineering Company is from the most recent of two investigations into water supply needs for LaFollette (Table 8, lines 24 and 25).[2] The estimate of the LaFollette Planning Commission used for its floodway proposal is derived from the TVA estimate of the regional flood (Table 8, line 14).[3]

The final set of estimates of frequency and magnitude, those developed by White for the companion study's comparative economic analysis of alternative measures of flood damage reduction, deserve further elaboration.

In general these estimates were derived by using the magnitudes of three levels of floods distinguished by the TVA: the experienced 1950 flood, the regional flood, and the maximum probable flood. Frequencies were then attached to each of these discharges on the basis of four different assumptions shown in Figure 6.

The "A" assumption or "common advice" is a graphic representation of the impression of flood frequency that a LaFollette citizen might glean from published sources and conversations with interested officials. As a technical estimate it probably severely overestimates the actual flood hazard. However in its estimate of the recurrence interval of the 1950 flood (20 years) and in its approximation of the frequencies which zealous officials concerned with arousing flood awareness might attach to the larger floods, it approaches the kind of flood hazard evaluation which

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[1]Letter Report on Flood Conditions on Big Creek by Col. G. M. Dorland, District Engineer of the Nashville District, Corps of Engineers, n.d.

[2]Report on the Water Supply of the City of LaFollette, Tennessee to the LaFollette Board of Public Utilities prepared by the Schmidt Engineering Company, Inc. of Chattanooga, Tennessee, February, 1960, p. 13.

[3]LaFollette Planning Commission, "Proposals for Adjusting to Flood Conditions at LaFollette, Tennessee," October, 1959, p. 5 (processed).

TABLE 8

ESTIMATES OF MAGNITUDE AND FREQUENCY OF FLOODS USED IN EVALUATIONS OF THE FLOOD HAZARD OF BIG CREEK

No.	Magnitude			Frequency	Flood Description	Source	Purpose of Evaluation
	Discharge (Cfs.)	Drainage Area Miles^2	Discharge (Cfs./Mile^2)	Recurrence Interval (Yrs.)			
1	1,950	23.9	81.6	2.33	Mean annual flood	USGS	Basic data
2	2,500	26.2	95.4	2.33	.....	TVA	By request
3	4,780	23.9	200.0	25.	.....	USGS	Basic data
4	6,000	23.9	251.0	50.	.....	USGS	Basic data
5	6,500	26.2	248.0	25.	.....	TVA	By request
6	7,550	26.2	288.2	50.	.....	TVA	By request
7	.....	23.9	.....	20.	"Damaging flood"	Corps of Engineers	Preliminary benefit-cost analysis
8	7,900	23.9	330.5	20.	1950 A	G. F. White	Comparative economic analysis
9	7,900	23.9	330.5	30.	1950 B	G. F. White	Comparative economic analysis
10	7,900	23.9	330.5	80.	1950 C	G. F. White	Comparative economic analysis
11	7,900	23.9	330.5	80.	1950 D	G. F. White	Comparative economic analysis
12	8,000	23.9	334.7	.....	Maximum known flood	TVA	Planning & flood damage reduction

TABLE 8--Continued

13	17,000	26.2	648.8	.....	Regional flood	TVA	Planning & flood damage reduction
14	17,000	26.2	648.8	.....	Regional flood	LaFollette Planning Commission	Floodway design
15	17,000	26.2	648.8	50.	Regional A	G. F. White	Comparative economic analysis
16	17,000	26.2	648.8	200.	Regional B	G. F. White	Comparative economic analysis
17	17,000	26.2	648.8	500.	Regional C	G. F. White	Comparative economic analysis
18	17,000	26.2	648.8	30,000.	Regional D	G. F. White	Comparative economic analysis
19	26,200	26.2	1,000.0	.....	Maximum probable flood	TVA	Planning & flood damage reduction
20	26,200	26.2	1,000.0	80.	Maximum A	G. F. White	Comparative economic analysis
21	26,200	26.2	1,000.0	2,000.	Maximum B	G. F. White	Comparative economic analysis
22	26,200	26.2	1,000.0	20,000.	Maximum C	G. F. White	Comparative economic analysis
23	26,200	26.2	1,000.0	10,000,000.	Maximum D	G. F. White	Comparative economic analysis
24	14,000	13.1	1,068.7	100.	"100 year flood"	Schmidt Engineering	Spillway design
25	22,000	13.1	1,679.4	1,000.	"1,000 year flood"	Schmidt Engineering	Spillway design

Sources: Various; see text.

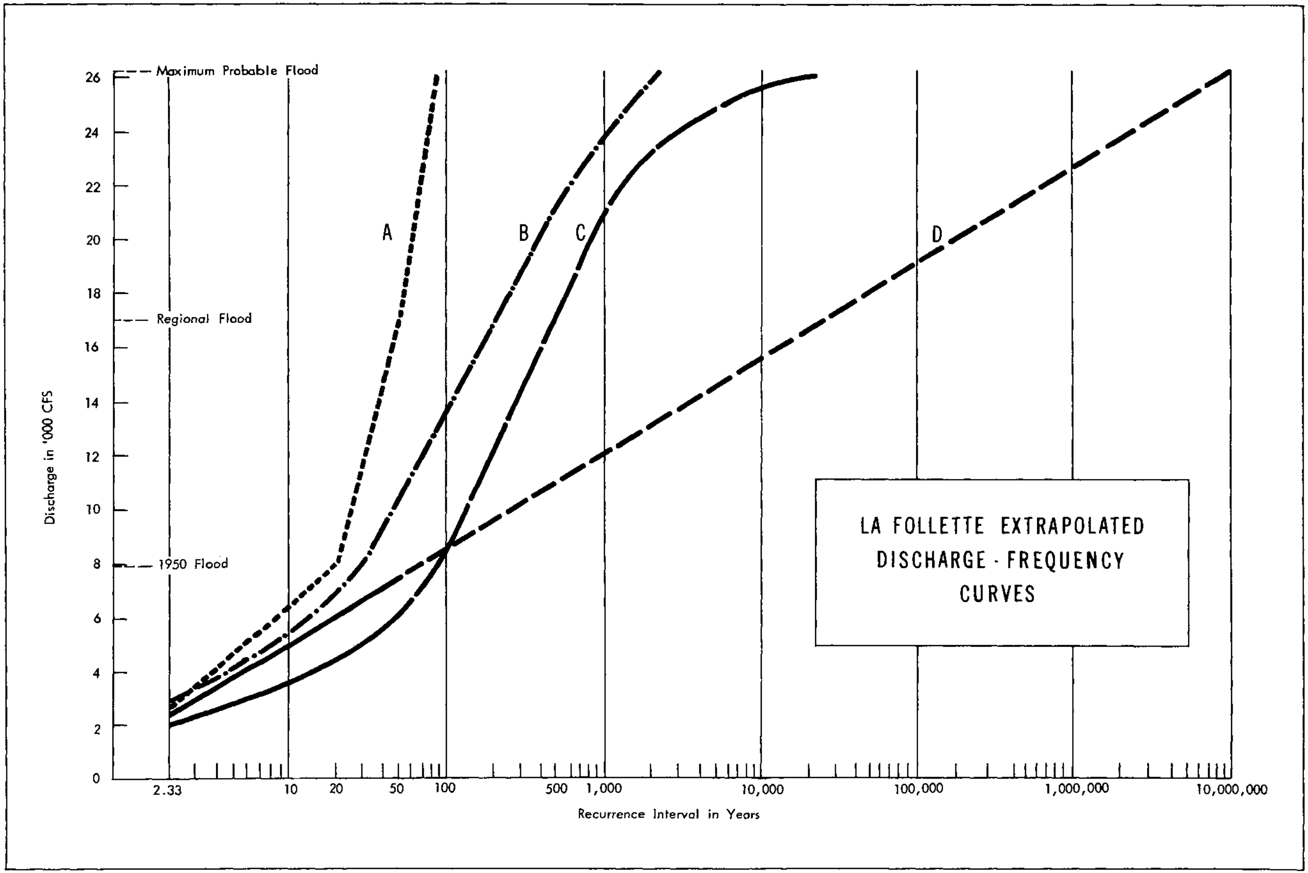
LA FOLLETTE EXTRAPOLATED
DISCHARGE - FREQUENCY
CURVES
Maximum Probable Flood
Regional Flood
1950 Flood
A
B
C
D
Discharge in '000 CFS
26
24
22
20
18
16
14
12
10
8
6
4
2
0
2.33
10
20
50
100
500
1,000
10,000
100,000
1,000,000
10,000,000
Recurrence Interval in Years

Fig. 6

might actually be used for decision-making, despite its obvious technical error (Table 8, lines 8, 15, and 20).

The "B" and "C" assumptions are derived by extrapolating curvilinear plots.

The "B" is an extrapolation of a curve constructed in a manner similar to that of the USGS in Figure 4. However it uses a larger valued constant in equation 1, which in the engineering judgment of TVA personnel, appears more suitable for Big Creek hydrology (Table 8, lines 9, 16, and 21).

The "C" is an extrapolation of the USGS curve shown in Figure 4 as an ogive or "s" shaped curve (Table 8, lines 10, 17, and 22).

The "D" assumption based on extreme value theory is to extend the TVA plot in Figure 4 as a straight line on extreme value probability paper (Table 8, lines 11, 18, and 23).

It might be recalled in connection with the last three assumptions that both the TVA and USGS warn against extrapolating their curves in such a manner. A realistic economic analysis, that would take into consideration all floods weighted by their probabilities of occurrence, requires frequencies to be attached to large floods despite the hazards of such a procedure. Though the agencies rightly caution against extrapolation, they would probably do the same or some variant thereof if called upon to make a similar economic analysis.

<u>A comparison of flood hazard evaluations of Big Creek</u>.--The series of flood hazard evaluations presented in Table 8 might be best compared as points in Figure 7.

Agencies and individuals using defensible logical methods arrive at estimates of greatly varying frequency for the same magnitude flood. When one considers the great uncertainty involved, such results are understandable. Generally such uncertainty is understated and what is in effect a "guesstimate" or in terms of probability theory a "degree of belief" is often stated as a fact.[1] An extreme example is the following quotation from the report of the Schmidt Engineering Company:

> Ollis Creek runs in rugged terrain with reasonably fast runoff and approximately 50 inches of rain per year. A record month of 14.51 inches of rain occurred at the LaFollette gaging station in May 1950. Because the valley channel is narrow, one of the physical problems to overcome in constructing a dam is to provide adequate spillway capacity. For a

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[1]For a discussion of the kinds of probability, see I. J. Good, "Kinds of Probability," <u>Science</u>, CXXIX (February, 1959), 443-447.

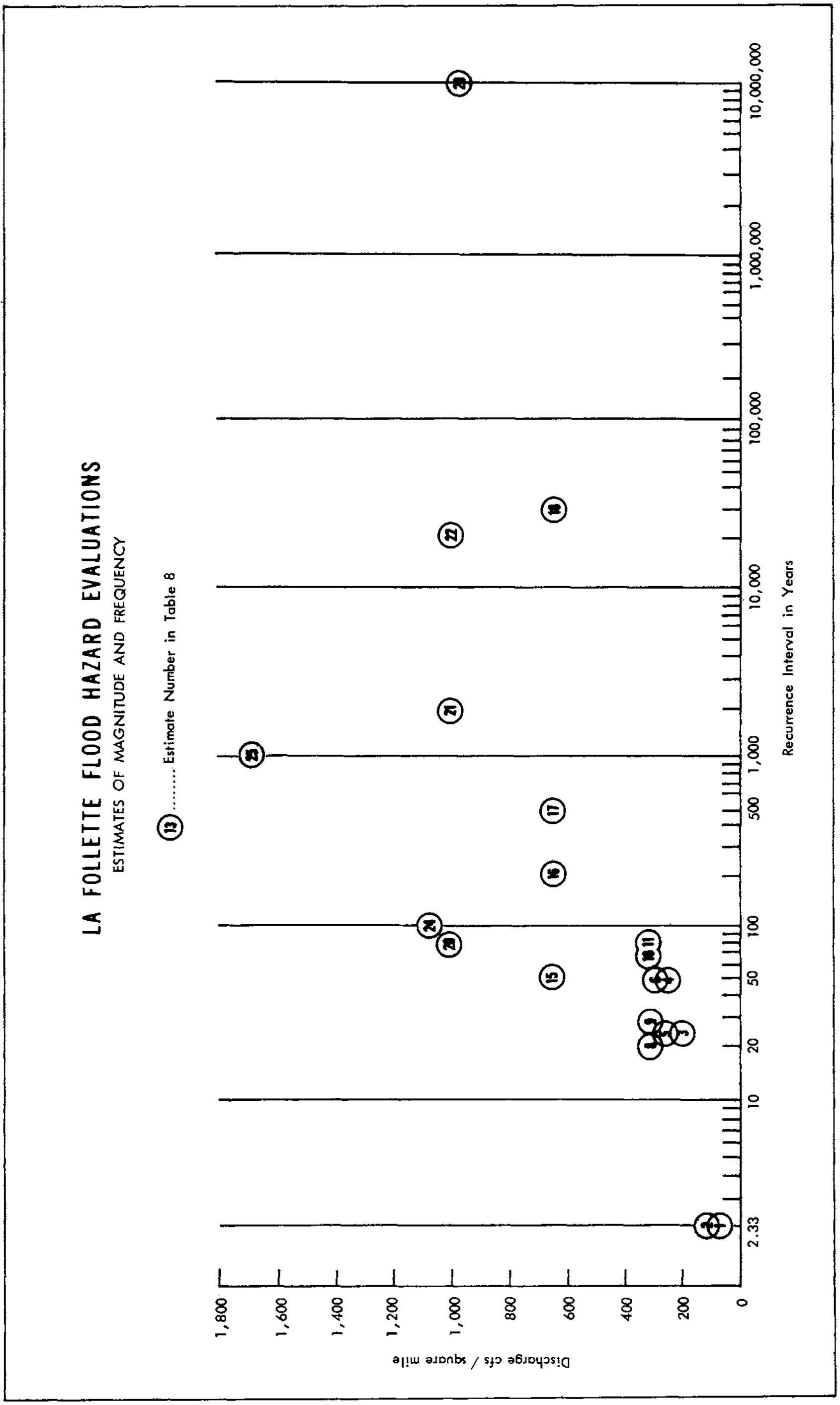
LA FOLLETTE FLOOD HAZARD EVALUATIONS
ESTIMATES OF MAGNITUDE AND FREQUENCY
13 .... Estimate Number in Table 8
Discharge cfs / square mile
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
Recurrence Interval in Years
2.33
10
20
50
100
500
1,000
10,000
100,000
1,000,000
10,000,000

Fig. 7

> concrete dam it is possible to construct the spillway to accommodate a 100 year flood. This would be 14,000 cfs. at Site A. For earth fill or Nantahala rock fill dams it would be necessary to design the spillway for a 1,000 year flood because this type of structure must not be overtopped under any circumstances. Therefore, the spillway for earth fill, conventional or Nantahala type rock fill dams would have to be designed to pass a flood of 22,000 cfs.

By comparison with the other estimates, the unqualified estimate of the 1,000-year flood is one and one-half times as large as the maximum probable flood in cfs./sq. mile of drainage area. While it is human to play it safe and overbuild, a more precise statement of such humanity might be desired.

How good are the estimates of flood hazard made by possessors of technical knowledge?--A judgment as to the value of the varying estimates of flood hazard might be formed on the basis of the following considerations:

1. Big Creek places a special burden on any analytic hydrology. It is a small drainage area, and much less is generally known about flood characteristics of small drainage areas; it has no gaging station, and only a short and spotty history of flood occurrence.

2. Relatively small amounts of time, money, and effort have been expended in deriving estimates of flood hazard for LaFollette. Conceivably a greater investment, including stream gaging might have improved such estimates, but with limited success.

3. For floods within the range of the fifty-year flood, the estimates correspond fairly well, while beyond such a range they diverge greatly. An attempt to estimate magnitude only, without frequency, while reflecting the genuine uncertainty of the analyst, might generate considerable ambiguity for a potential user of such estimates.

4. The method of stating magnitude in terms of discharge (volume flow) rather than stage (depth of water) exaggerated the practical aspects of the divergence of estimates of rare flood events. In many valleys, sizable increases in discharge yield only slight increases in stage particularly for the magnitudes of rare events. Thus while estimates might diverge greatly, practically such differences might result in only a slight fluctuation in stage for a given establishment on the flood plain.

5. Though the estimates of rare flood events diverge considerably, for many purposes greater accuracy might be unnecessary. If present value discounting is being used in economic analysis, the value of flood benefits from rare events quickly

approaches zero. At the other extreme, highways and sewer structures are often designed for frequencies with high probability and more certain magnitudes.

6. Nevertheless, the large divergence of the frequencies of floods of great magnitude engenders considerable confusion. From a theoretical point of view, such confusion arises from what is in effect a shift from one kind of probability formulation to another, a shift from "relative frequency" probability to "degrees of belief" probability. Floods of frequent occurrence can have their probability of occurrence approximated by their relative frequency or counting the number of floods of a given magnitude or greater that occur in n years. Beyond this range of frequent and actual occurrence, estimates as to probability are actually "degrees of belief" held by the estimator as to what the objective probability in the long run might actually be and are consequently subject to wide variation.

7. On balance, the estimates of more frequent events might prove quite useful. Even these, however, should be viewed in terms of a range and recalling Benson's data should not be expected to have much greater accuracy than ± 25 per cent. Beyond the range of the 50- or 100-year recurrence interval lies a realm of great uncertainty and the value of any estimate may be questioned.

The Interpretation of Flood Hazard Information at LaFollette

In the previous section, a single perception of nature described as a classic urn was sufficient to account for the several ways that possessors of technical knowledge interpret flood information and make hazard evaluations. This section returns to the problem of the interpretation of the common knowledge and experience, to attempt to make more precise the link between flood information and hazard evaluation.

Here, the actions and verbal assertions of the LaFollette respondents suggest that information is interpreted with reference to both a deterministic and indeterministic perception of the state of nature.

The perception of a deterministic nature.--In this generalization a less capricious and more deterministic nature has provided a track, rather than an urn, from the end of which is derived an annual flood. The mix of balls on the track is somewhat repetitious, albeit imperfectly so. The magnitude of the largest ball is not much beyond the community's shared experience. Although tending to supply floods in cycles, the track is particularly sensitive to the action of men, and in contrast to the previous state of nature alterations in the mix are obtained with relative ease.[1]

For those who act as if they perceive nature in this manner, the perception has no intrinsic value as an intellectual exercise and they do not share in the scientist's preoccupation with probing the nature of the distribution. For these, the majority of respondents in LaFollette, this perception, compounded out of folklore, experience and intuition, made reasonable by a strong motivation to simplify the uncertainty surrounding human existence, serves as a personal framework with which to interpret new incoming items of experience and knowledge.

Beyond the apparent need to assess the impact of man's tinkering with nature, the concern of the LaFollette respondent, of such concern is at all indicated, is to assess his personal time path relative to the next cycle of events.

The perception of an indeterministic nature.--For these managers, a distinct but relative minority, nature is indeterministic, and they perceive neither urn nor track.

For some, either by ignorance or the denial of the common shared experience, floods do not exist at all. For others, floods do not occur as repetitive events but as true acts of God and are not subject to the ken of man. If an urn does exist, it would be beyond their power to understand or control it. If they have pondered their future personal relationship to a potential hazard, it is only then to shrug it off. They have but pondered one more of life's many imponderables.

Interpretation and the determinate perception of the state of nature.--A determinate perception of nature which implies a track with cyclical or patterned flood events insures that for these respondents the 1950 flood is interpreted within a framework of repetitive events. The fact that the 1950 flood was practically the same size as the 1929 flood tends to reinforce such notions (see Class I-A, Table 9.)

Within the group of respondents who seem to interpret the 1950 flood as a repetitive event, two other assessments add variety to such interpretations. The first is an assessment of a

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[1]It is not entirely clear why a deterministic perception should allow for such considerable influence on the part of man. A likely explanation might lie in the fact that the largest ball conceived of is quite small compared to the magnitude of some of the balls in the urn of the more probabilistic perception. Therefore since timing is approximately known and magnitudes are small, it is well within the powers of men in this case to do something about it.

TABLE 9

INTERPRETATION OF THE FLOOD OF MAY, 1950 BY COMMERCIAL AND RESIDENTIAL RESPONDENTS

Interpretation Class	Commercial		Residential		Total	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
I. Respondent shares in common knowledge of 1950 flood:						
A. Tends to think of flood as one of a series of repetitive events:						
1. Decreasing in time	9	12.7	9	23.7	18	16.5
2. Constant in time	21	29.6	9	23.7	30	27.5
3. Increasing in time	7	9.8	....	....	7	6.4
4. Expectation of trend in time, not ascertained	11	15.5	3	7.9	14	12.8
5. Personally excluded by virtue of present or future location and/or time horizon	8	11.3	2	5.3	10	9.2
B. Tends to think of flood as unique	6	8.4	3	7.9	9	8.2
C. Denies to 1950 flood image of "real flood"	1	1.4	8	21.0	9	8.2
II. Respondent does not share in common knowledge of 1950 flood	4	5.6	3	7.9	7	6.4
III. Not ascertained	4	5.6	1	2.6	5	4.6
Total	71	99.9	38	100.0	109	99.8

secular trend for repetitive events, closely linked to an appraisal of the effect of human action on the pattern of floods. The second is an assessment of personal time path relative to the perceived pattern of repetitive events.

Repetitive events constant in time.--A majority of respondents interpreting the 1950 flood as one of a series of repetitive events foresee no secular change in time. Phrases used to verbalize such interpretations included: "It seems to be a pattern" and "Floods come in cycles" (see Class I-A-2, Table 9).

Repetitive events decreasing in time.--Eighteen respondents while acknowledging the repetitive nature of flood events appeared much impressed with the efficacy of a small creek dredging effort undertaken by the city of LaFollette in 1956. They believed that the effort to dredge the creek had resulted in either the complete (or partial) elimination of future floods. Residential respondents appeared more prone to this line of reasoning[1] (see Class I-A-1, Table 9).

Repetitive events increasing in time.--Seven respondents, including some of the best-informed perceived floods as repetitive with an increasing secular trend due to human intervention in the form of strip mining, timber cutting, and channel encroachment (see Class I-A-3, Table 9).

Repetitive events with little indication as to expectancy in time.--Fourteen respondents whose interviews suggested that they interpreted the 1950 flood in a framework of repetitive events gave little indication of an assessment of secular trend (see Class I-A-4, Table 9).

Personal exclusion.--The interview attempted to focus the respondent on his personal relationship to flood hazard and omit the broader social role as a member of the community. With leading members of the community, who possessed well-defined social roles, this was difficult; with others it was successful to an unforeseen degree.

Such respondents, while indicating a general notion of floods as repetitive events, appear completely dominated by the idea that they are personally excluded and cannot make other assessments. The basis for believing that while the community is subject to flood hazard, one is personally excluded, varied. For some it was their short-time horizon, because of plans to move or

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[1]Of the 49 commercial respondents and 13 residential respondents familiar with the creek dredging, 18 per cent of the commercial as opposed to 69 per cent of the residential respondents appeared to conclude that such dredging had a substantial effect on future floods.

retire from the management of an establishment. Others felt that their particular location on the flood plain obviated any need to think of floods (see Class I-A-5, Table 9).

An outstanding example of such thinking was the management of the local shirt factory, the major employer in town, and subject to the highest potential damage. (The shirt factory, with its absentee corporate ownership and its completely different scale of operation, has been omitted from the respondent data as it is part of a separate population of managers.)

The shirt factory is in the midst of plans and negotiations with its present landlord, the City of LaFollette, to move to a new location, which among other things would not be subject to flood. Between the press of day-to-day production and the anticipated move, the local management, while generally quite well-informed, was unable to focus on some of the estimates and information requested of them relative to flood hazard. With the anticipated move, such hazard had apparently ceased to exist.

Interpretation and the indeterminate perception of nature.--The occurrence of the 1950 flood is consistent with a determinate perception of nature. For those who act as if they possessed an indeterminate perception considerable stress is generated.[1] To return to the analogy, if no urn or track exists, a flood must either not be acknowledged or so acknowledged as to deny either its replication or the predictability of its replication. The LaFollette respondents do both; some by viewing the 1950 flood as a unique case and others by denying it the image and quality of being a "real flood" (see Classes I-B and I-C, Table 9).

The unique characteristic of a flood.--A persistent theme in many interviews attributes the 1950 flood to some freak occurrence that turns a heavy rain or "normal high water" into a flood.

A variety of causes are cited by such respondents as freak occurrences. The most common one is to attribute the flood to a surge of water caused by the rupturing of a slate dam upstream, the slate having been dumped into the river as a by-product of strip-mining operations. The second most popular explanation is to ascribe the flood to the damming of the Central Avenue Viaduct by debris, whose precise nature varies from respondent to respondent but includes bus bodies, beer cases, lumber and the like. Other suggestions were the clogging of sewers along Central Avenue and the rupture of a water supply dam (see Class I-B, Table 9).

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[1]Such stress is akin to what Festinger calls dissonance. See Leon Festinger, "The Motivating Effect of Cognitive Dissonance," Assessment of Human Motives, pp. 65-86.

Was the 1950 flood a product of some freak occurrence and in some sense unique?

It might be first noted that every flood is unique, that is, a given pattern of damage and overland flow, product of many random factors, is not duplicated even by floods of equal magnitude.

If the exact pattern of a flood in time and space is not predictable, the character of the flood and its damage is not particularly baffling. The effects of such constrictions as the Central Avenue Viaduct and their potential for temporary damming are well recognized in hydrologic literature.

To account for the observed flooding upstream of the viaduct, one does not have to hypothesize debris damming; the constricted channel alone accounts for the five feet of heading on the upstream side.

As for a surge, there was no suggestion from observed reports that one took place, and certainly the one permanent upstream dam did not rupture. The final "cause," clogged sewers, are effects, not causes of riverine floods.

<u>The denial of flood characteristics.</u>--An alternative of ascribing the 1950 flood to some freak occurrence was to exclude it and others in the region from some common image of floods. These "real floods" are modeled on the characteristics of the Mississippi and its main tributaries. Their characteristics include rising waters presaging the arrival of floods that commit great damage and do not run off quickly.

Respondents who desired to exclude the May 1950 flood from such an image would either minimize it by calling it a "flash flood" or a "cloudburst," or completely explain it away by saying: "The creek gets up once in a while" or "It was just water coming up." By calling the 1950 flood a flash flood, respondents imply that flash floods as opposed to "real floods" come quickly, are indeterminate, and run off quickly, doing little damage. The second type of phrase denies to the 1950 flood any quality of flood and implies that the water was just a little higher than usual (see Class I-C, Table 9).

What merit lies behind this denial of flood characteristics? In a technical sense, floods on Big Creek have different characteristics than those of the large streams. They are flashy; that is, they have a short flood-to-peak interval, they are less predictable (but this is rapidly being improved upon by new techniques), and their quick rate of runoff lessens the type of damage ascribed to prolonged inundation.[1] It is not the characterization of such floods as flashy that is inaccurate, but the implication in the words of one respondent that "towns can live with flash floods." To the contrary, there have been increasing signs that damage has been increasing faster along the tributary streams than along the main stems.[2] As for the complete denial of any characteristics of flood, such action can be best explained in terms of "wishing it away," but with one qualification: respondents dwelling on the edge of the flood plain might well consider a flood as "just water coming up" even though some of their less fortunate neighbors had a foot of water on their floors.

The two tendencies: to see the 1950 flood as unique or to deny it the characteristics of a real flood, were found in varying degrees among one-third of the respondents. However, only 18 of them were considered to have their interpretative process dominated by such tendencies. The distribution is not even, with residential respondents more inclined to an indeterminate perception of nature.

This would appear to be consistent with the variation in attitude towards fate and planning noted between respondent groups; 50 per cent of the residential group displaying a skepticism towards planning and a strong belief in fatalism as measured by a fatalism test (Appendix, Questions 34, 36, and 38) in contrast with 4.3 per cent of the commercial respondents displaying similar tendencies.

<u>Interpretation and future flood expectation</u>.--Given the widespread common knowledge having been interpreted in a variety of ways, how do such interpretations relate to the simple hazard evaluation measured by future flood expectancy? Table 10 presents a cross-classification of interpretations by future flood expectation, indicating an extremely high consistency between the two characteristics.

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[1]The <u>flood-to-peak interval</u> is that time interval between the rise of a stream to the elevation at which damage ensues and its peak crest.

The predictability of streams is more a function of their observation than of their characteristics. Improved use of radar holds out the prospect of providing warning systems for the small tributaries comparable to those of large streams in accuracy but not in time period between warning and flood.

[2]The shift in damage potential from the main stem of the tributary valleys has not been studied comprehensively. It would appear to come about through the increased levels of protection along the main stems of the larger rivers and the growing attractiveness of tributary valleys as residential sites in rapidly expanding urban areas.

TABLE 10

INTERPRETATION OF THE FLOOD OF MAY, 1950 BY EXPECTATION OF FUTURE FLOODS

Interpretation Class	Expectation of Future Floods					
	Yes		No		Uncertain	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
Interpretations related to affirmative expectations:						
I. A. Respondent shares in common knowledge, tends to think of floods as repetitive:						
2. Constant in time	28	93.3	1	3.3	1	3.3
3. Increasing in time	7	100.0	....	....	....	....
Interpretations related to negative expectations:						
I. A. Respondent shares in common knowledge, tends to think of floods as repetitive:						
1. Decreasing in time	2	11.1	16	88.9	....	....
5. Personally excluded	....	....	10	100.0	....	....
II. Does not share in common knowledge	....	....	6	85.7	1	14.3
Interpretations related to uncertain expectations:						
I. A. Respondent shares in common knowledge, tends to think of floods as repetitive:						
4. Expectation of trend in time, not ascertained	5	35.7	1	7.1	8	57.1
B. Tends to think of flood as unique	2	22.2	2	22.2	5	55.6
C. Denies to 1950 flood image of "real flood"	1	11.1	4	44.4	4	44.4
Total	45	43.3	40	38.5	19	18.3

With but two exceptions, those respondents who interpret past knowledge and experience in such manner as to imply a pattern of constant or increasing repetitive events also indicate a personal expectation of a future flood. Conversely, with three exceptions, those respondents who interpret floods as decreasing in time, exclude themselves, or are unaware of the common knowledge, do not expect a flood in the future.

The tendencies to see floods as unique events leads to uncertainty, and the denial of the characteristics of a real flood leads either to a negative future expectation or uncertainty. The large number of uncertain expectations associated with respondents whose interviews lack a secular trend suggests that such failure may reflect the respondents own uncertainty rather than an omission in the interview procedure.

Besides indicating the strong association between interpretation and the expectation of a future flood, Table 10 also probes the diversity of understanding that is concealed by even the simplest of hazard evaluations.

In terms of their studies, Roder and Burton would probably have classified a negative reply to the question: "Do you think your house will be flooded in the future?" as unduly optimistic.[1] In LaFollette there might be four types of replies, none of which could be described as optimistic:

1. No, they have cleaned the creek out.
2. No, I won't live here next year.
3. No, we don't have floods here.
4. No, we only have cloudbursts here.

The association of interpretation and future flood expectancy expressed as a condensation of Table 10 into a 3 x 3 contingency table is quite high, with a correlation measure of Tschuprow's T of .72 in contrast with the association of knowledge and experience in a similar 3 x 3 table that yielded a T value of .24.

It should be emphasized, though, that interpretation has not been presented for predictive purposes. The allocation of respondents to various classes of interpretation is based on an analysis of their entire questionnaire, interviewer's notes, careful study of their verbal assertions, and the specific answers to nine questions. (The future flood expectation of an individual respondent was not considered in allocating individuals to interpretative classes and to the extent possible in an admittedly

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[1]Roder, p. 68.

TABLE 11

INTERPRETATION OF FLOOD OF MAY, 1950 BY FREQUENCY ESTIMATES OF COMMERCIAL AND RESIDENTIAL RESPONDENTS

Interpretation Class	Commercial			Residential		
	Number in Class	Number Making Estimate	Mean Estimate Floods Per 100 Years	Number in Class	Number Making Estimate	Mean Estimate Floods Per 100 Years
I. Respondent shares in common knowledge of 1950 flood:						
A. Tends to think of flood as one of a series of repetitive events:						
1. Decreasing in time	9	6	2.9	9	6	1.9
2. Constant in time	21	18	7.9	9	5	55.1
3. Increasing in time	7	6	7.3	...	...	...
4. Expectation of trend in time, not ascertained	11	3	4.6	3	1	1.5
5. Personally excluded by virtue of present or future location and/or time horizon	8	5	3.4	2	2	15.0
B. Tends to think of flood as unique	6	1	2.0	3	1	12.0
C. Denies to 1950 flood image of "real flood"	1	1	4.0	8	3	50.0
II. Respondent does not share in common knowledge of 1950 flood	4	3	0.0	3	1	1.5
Total	67	43	5.63	37	19	25.38

subjective process, a respondent's interpretation class <u>assignment</u> is independent of his future flood expectancy.) The classification of respondents by interpretative class, depending as it does on intensive interviewing and analysis, is not replicated with sufficient ease to be useful as a predictor of an individual's future flood expectancy in other studies. It would be far simpler to inquire of managers directly regarding their expectations.

The high association of interpretation class and future flood expectation is most useful for its instruction as to the variety of ways information is assimilated and for the range of reasons that underlie even the simplest of hazard evaluations.

<u>A more refined hazard evaluation, estimates of frequency</u>.--The study posed an additional question dealing with hazard evaluation to respondents.

> If you were to live one hundred years, how many floods would you expect to have here?

Respondents resisted making such an estimate, a finding interesting in itself considering the ease with which some decision-making analysts assume the ability or willingness of individuals to make complex probability computations. Some respondents termed the question "silly" and only with considerable encouragement from the interviewers were 57 per cent of the respondents induced to make a "guesstimate."

These frequency estimates have been grouped by interpretation class in Table 11 and future flood expectancy in Table 12, and for each group the mean estimate has been computed. The usefulness of the data is limited because of the respondents' reluctance to make the estimates, the varied interpretations given "floods" in response to the question, and the fact that some respondents seemed to discount perceived temporal trends and others ignored them. This was especially true for the residential group, over half of which made extreme estimates (either 0 or $\geq$ 100 floods per 100 years) leading to erratic mean estimates.

Despite these limitations the frequency estimates provide several insights. The mean estimates shown in the tables do not appear to be generally inconsistent with interpretation and future flood expectancy. The overall mean estimate for the commercial respondents of 5.6 floods per 100 years closely approximates the actual experienced flood frequency in LaFollette, that is, a return period of twenty years. Finally the estimates indicate that for those willing to make them, floods of the order of the 1950 flood are considered to recur more frequently than possessors of technical knowledge would estimate.

TABLE 12

EXPECTATION OF A FUTURE FLOOD BY FREQUENCY ESTIMATES OF COMMERCIAL AND RESIDENTIAL RESPONDENTS

Future Flood Expectation	Commercial			Residential		
	Number	Number Giving Estimate	Mean Estimate Floods Per 100 Years	Number	Number Giving Estimate	Mean Estimate Floods Per 100 Years
Yes	34	27	7.2	11	6	47.9
No	23	13	3.1	17	10	4.2
Uncertain ..	12	3	2.7	10	3	51.0
Total ..	69	43	5.6	38	19	25.4

Factors affecting flood hazard evaluation.--A variety of variables thought to bear on flood hazard evaluation were tested for association with future flood expectancy. The results for sixteen of the variables are shown in Table 13.

An interesting finding is the lack of association between the expectation of a flood in the future and such diverse variables as: (1) a high score on a test of abstract flood knowledge, (2) education, (3) the length of time that a manager has been on-site, (4) a knowledge of floods at the time of the original decision to locate on the flood plain.

As to the demonstrable associations, a number of these have already been mentioned. These include: (1) the association between the yes-no-uncertain hazard estimates and the frequency estimates; (2) the association between awareness of the creek dredging effort and a negative flood expectancy for the residential respondents; (3) the association of experience and relative location on the flood plain, to an affirmative flood expectancy for commercial respondents.

Associated with an affirmative flood expectancy and not previously cited are: (1) the nine commercial respondents who recalled having seen the TVA Flood Report, (2) the thirty-five commercial respondents who recalled having discussed floods in the past two years, (3) the seventeen commercial and residential respondents who evidenced a heightened concern for floods in a flood concern test.

Even where significant relationships are found, the strength of the relationship is low, yielding values of less than .40 for the correlation measure ϕ of 2 x 2 contingency tables.

Interpretation and Hazard Evaluation at the Reconnaissance Sites

The details of interpretation and hazard evaluation that form the substance of this chapter have, in the main, provided a portrait of complexity and diversity in a single flood plain situation. The variation has been within-group variance, of interpretation and hazard evaluation for a single group of flood plain managers. The reconnaissance studies were designed to provide measures of between group variance, comparing the set of flood plain managers in LaFollette to managers in other situations.

TABLE 13

ASSOCIATION OF SELECTED VARIABLES WITH EXPECTATION OF A FUTURE FLOOD

Variables	Commercial Interview Question Number[a]	Expectation of a Future Flood	
		Residential	Commercial
Flood knowledge and experience			
Abstract flood knowledge	33, 35, 37, 39	-	-
Knowledge of floods	13	-	-
Floods experienced elsewhere..	18	-	-
Floods experienced on site ...	14	-	+
Discussion of floods in past 2 years	24	-	+
Flood knowledge at time of original decision to locate.	27	0	-
Flood concern	4 - 14	+	+
Awareness of channel dredging.	20	+	-
Knowledge of TVA flood report.	23	0	+
Flood frequency estimate	26	+	+
Estimated height of serious flood	50	-	-
Respondent			
Education	85	-	-
Personal time horizon	93 - 94	-	-
Time in residence, business on site	1	-	-
Structure			
Flood plain location	-	-	+
Value of house and furnishings	...	-	0

[a]See Appendix for commercial questionnaire.

+ Association significant at .05 level.
- Association not significant at .05 level.
0 Not tested.

The classifications of experience, knowledge, interpretation and future flood expectancy have been fitted to the more limited data of the reconnaissance sites and are summarized in Tables 14, 15, and 16.[1]

The six sites, essentially chosen to provide diversity, appear to group themselves into three distinct pairs of towns, with the members of each pair presenting contrasts of physical setting and social milieu, but strong similarities of flooding and human response.

Darlington, Wisconsin and Aurora, Indiana, flood sites of high certainty.--In both Darlington and Aurora, with their long history of flooding, managers are presented with a flood hazard of high certainty. Most managers have had two or more flood experiences, and have evolved elaborate and widespread adjustments to flood hazard.

In such a setting, most respondents expect a future flood. This expectation is not diminished by the widespread knowledge of imagined, installed, or expected protective works, as in Darlington. In fact, both communities exhibit a strange, somewhat defensive antagonism to protective works.[2] The most striking feature of all is the similarity of experience and outlook on the part of managers, with little important variation.

LaFollette, Tennessee and El Cerrito-Richmond, California, flood sites of intermediate certainty.--In LaFollette and El Cerrito-Richmond, flood plain managers are presented with a flood hazard of intermediate certainty. LaFollette has had two major floods in 94 years and minor ones at an average interval of about 5 years; El Cerrito-Richmond has had one major flood in at least 25 years, and minor floods somewhat more frequently than LaFollette. Cleaning and dredging of the creek bed has been carried out at both sites, but the efficacy from a technical point of view is negligible and as perceived by managers, varied and speculative.

In this type of setting, human response becomes more variable. El Cerrito-Richmond is the site of the Jacuzzi Pump Plant, the most flood-proofed establishment found in the entire study.

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[1]The reader is cautioned against making absolute comparisons between sites as the specification of characteristics such as knowledge, experience, protective works, and the like varies considerably from place to place.

[2]The attitude towards protective works is better considered in the setting of the following chapter which will also include detailed discussion of adjustments to flood hazard developed in each community.

TABLE 14

SELECTED CHARACTERISTICS OF INTERVIEWED MANAGERS, LAFOLLETTE AND RECONNAISSANCE SITES

Characteristics	Desert Hot Springs, California	Watkins Glen, New York	LaFollette, Tennessee	El Cerrito-Richmond, California	Aurora, Indiana	Darlington, Wisconsin
Respondent characteristics:						
Number interviewed: Commercial	6	3	71	.....	7	13
Residential	10	7	38	11	8	.....
Median age class, in years	45-64	45-64	45-64	25-44	45-64	25-44
Median education class, by grade	11-12	9-10	11-12	11-12	11-12	11-12
Median income class	$6-10,000	$4- 6,000	$4- 6,000	$4- 6,000	$4- 6,000	$6-10,000
Mean number of years on site	5.1	21.9	13.0	10.2	11.6	13.1
Establishment characteristics:						
Mean structure size: Commercial	1,620	1,050	4,330	.....	3,660	4,330
(In square feet) Residential	1,290	880	918	1,020	1,120	.....
Mean value of residence and furnishings.	$22,050	$ 9,400	$ 7,410	$35,590[a]	$ 8,590	.....
Respondents flood knowledge and experience:						
No knowledge of floods	11	.....	8	1	.....	.....
Knowledge, no experience	3	6	47	2	1	1
One on-site experience	1	2	40	2	5	2
Two or more on-site experiences	1	2	14	6	9	10

[a]These are multi-family dwellings in contrast to other residences that are primarily single-family units.

TABLE 15

INTERPRETATION OF FLOOD EVENTS BY THE EXPECTATION OF A FUTURE FLOOD AND KNOWLEDGE OF PROTECTIVE WORKS, LAFOLLETTE AND RECONNAISSANCE SITES

Interpretation of Flood Event	Desert Hot Springs, California				Watkins Glen, New York				LaFollette, Tennessee				El Cerrito-Richmond, California				Aurora, Indiana				Darlington, Wisconsin			
	Expect Future Flood			Knowledge of Prot. Works	Expect Future Flood			Knowledge of Prot. Works	Expect Future Flood			Knowledge of Prot. Works	Expect Future Flood			Knowledge of Prot. Works	Expect Future Flood			Knowledge of Prot. Works	Expect Future Flood			Knowledge of Prot. Works
	Yes	No	Uncertain		Yes	No	Uncertain		Yes	No	Uncertain		No	Yes	Uncertain		Yes	No	Uncertain		Yes	No	Uncertain	
Respondent shares in common knowledge, and:																								
Floods are repetitive events:																								
Decreasing in time	2	2	.	4	.	3	.	3	2	16	.	17	.	3	1	4	.	1	1	2	2	.	.	2
Constant in time	1	.	.	1	1	.	.	1	28	1	1	16	2	.	.	2	13	.	.	.	9	.	.	9
Increasing in time	.	.	.	.	.	.	.	.	7	.	.	4	1	.	.	1	.	.	.	.	2	.	.	1
Insufficient data to detect time trend expectation	.	.	.	.	.	.	.	.	5	1	8	10	2	.	.	2	.	.	.	.	.	.	.	.
Personal exclusion	1	3	.	3	.	2	.	1	.	10	.	4	.	.	.	.	.	.	.	.	.	.	.	.
Floods are unique events .	.	.	.	.	.	1	.	.	2	2	5	6	.	.	.	.	.	.	.	.	.	.	.	.
Denies common image of "real" flood	.	.	.	.	.	.	.	.	1	4	4	3	.	.	.	.	.	.	.	.	.	.	.	.
Respondent does not share in common knowledge	.	3	4	1	.	.	.	.	.	6	1	2	.	1	.	.	.	.	.	.	.	.	.	.
Not ascertained	.	.	.	.	.	2	1	3	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Total	4	8	4	9	1	8	1	8	45	40	19	62	5	5	1	9	13	1	1	2	13	.	.	12

At the same time, it has been the site of newly constructed unprotected multi-apartment buildings.

TABLE 16

RANK ORDER OF STUDY SITES BY PERCENTAGE OF RESPONDENTS DISPLAYING FLOOD KNOWLEDGE, EXPERIENCE, KNOWLEDGE OF PROTECTIVE WORKS, AND EXPECTATION OF A FUTURE FLOOD

Study Site	Expectation of Future Flood		Flood Knowledge		Flood Experience		Knowledge of Protective Works	
	Per Cent	Rank	Per Cent	Rank	Per Cent	Rank	Per Cent	Rank
Darlington .	100.0	1	100.0	1	92.3	2	92.3	1
Aurora	86.7	2	100.0	1	93.3	1	13.3	6
El Cerrito-Richmond .	45.4	3	90.9	4	72.7	3	81.8	2
LaFollette .	43.3	4	92.7	5	49.5	5	59.6	4
Desert Hot Springs ..	25.0	5	31.2	6	12.5	6	56.2	5
Watkins Glen	10.0	6	100.0	1	40.0	4	80.0	3

Future flood expectancy divides almost evenly between affirmative and negative expectation with a substantial minority uncertain. The lessened certainty also seems to encourage sentiments that would credit protective works with substantial reduction of future flooding. An outstanding feature of such sites is the relative diversity of interpretation and evaluation engendered.

Desert Hot Springs, California and Watkins Glen, New York, flood sites of uncertainty.--Desert Hot Springs and Watkins Glen pose to their flood plain managers situations of great uncertainty. In the former, such uncertainty is generated by the climate (4 in. annual average rainfall), the physiography (alluvial fans at the base of dry washes), and the relatively short experience of its flood plain managers (average time on site, 5.1 years). The latter generates uncertainty by the paradox of almost universal knowledge of a flood whose replication seems beyond the pale of probability, and almost total ignorance of the ambiguous but realistic threat of the failure of works that appear to protect against floods of lesser magnitude.

In such a setting, negative future flood expectations are common. Adjustments are seldom found, either because of ignorance of hazard or its perceived catastrophic nature, in the face of which most adjustments would seem valueless.

In both communities, there is fairly widespread knowledge of protective works, and these seem to reinforce the negative flood expectations. However, so strong are the negative estimates of hazard, that they appear to be independent of a perceived efficacy of protective works. In Desert Hot Springs, such negative expectations are displayed by both respondents partially protected by a flood channel and those outside the flood channel.

As in the situation of great certainty, one is struck by the reduced variance of interpretation and evaluation, and the high predictability of respondents' attitudes.

A Certainty-Uncertainty Scale

The six study sites, although too few in number to adequately test a hypothesis, do suggest the following idea:

The certainty-uncertainty scale hypothesis.--The most significant differentiating characteristic of urban flood plain sites is their location on a scale that might be labeled as the certainty-uncertainty continuum. Such a continuum is related to the frequency of flood events, but only partly so. It is in a sense the perceived frequency of flood events.[1] Such perceptions might vary considerably from the best technical estimates, being influenced by experience, catastrophic events, the perceived effectiveness of flood control works, and the like. Along such a continuum, urban places or portions thereof might be located as illustrated by Desert Hot Springs, LaFollette and Darlington in Figure 8. (The actual location and spacing of sites along such a continuum is of course unknown.)

As one shifts along such a continuum a series of observable changes takes place in certain characteristics studied in this volume. Some of these are shown in Figure 8.

With high certainty, as at Darlington, there is wide knowledge of floods reinforced with many experiences. Most managers expect a future flood and have developed elaborate adjustments to meet this threat. Because of the greater certainty, differences of personality and personal interpretation exert little influence and the awareness of installed or prospective

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[1]Although somewhat akin to subjective probability, the implied contrast, that is, if there is a subjective probability there is some real, knowable objective probability, does not fit flood frequency data too well. Given the short span of man, climatic change and the like, all flood frequencies are subjective probabilities beyond the range of the more frequent flows.

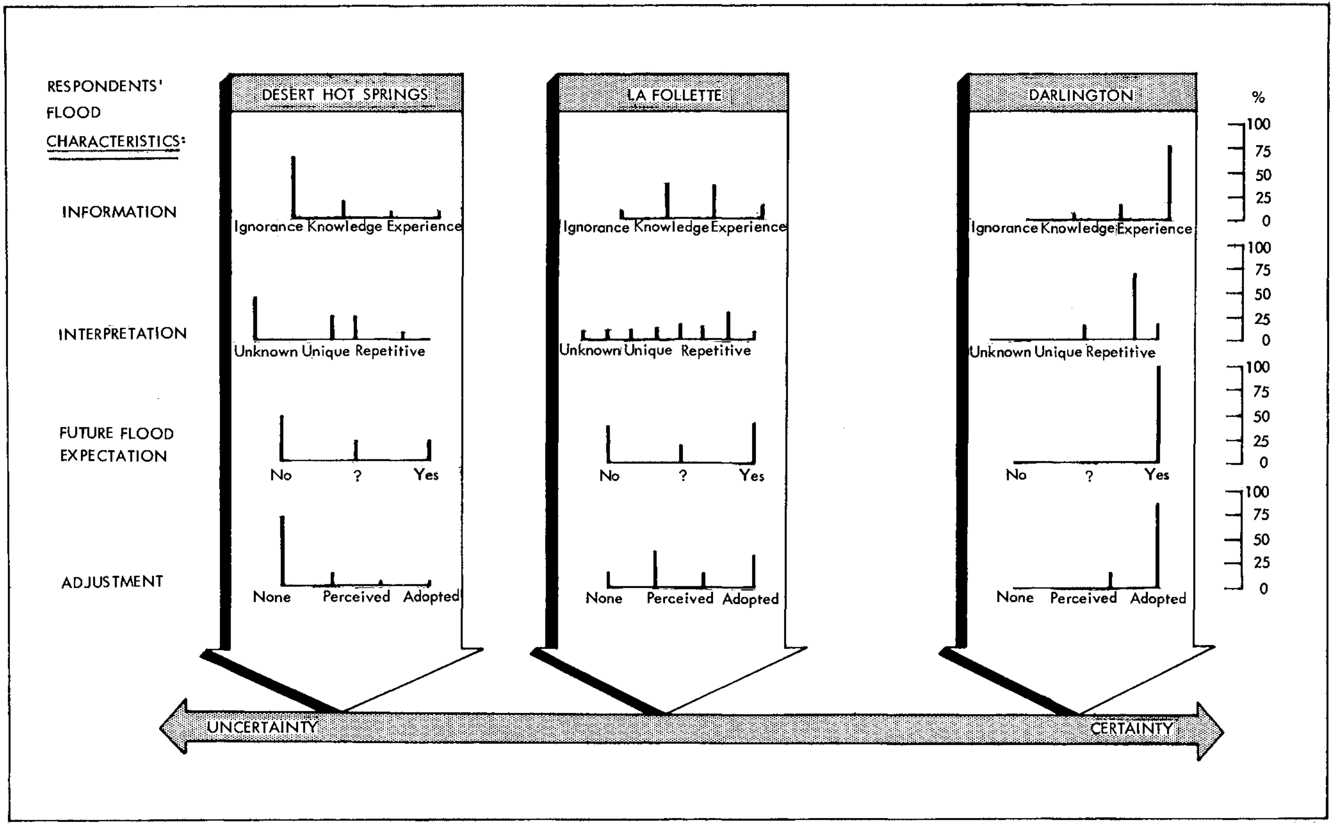

Fig. 8.--Variation in Respondents' Flood Characteristics in Towns Located on a Certainty-Uncertainty Scale.

protective works does not distort hazard evaluations. Finally, the dispersion of all characteristics is quite small.

Moving along such a scale towards uncertainty, as at LaFollette, the dispersion increases rapidly. Managers divide more evenly as to their future flood expectancy and a larger number are uncertain. Extremes of concern and ignorance are observed and establishments can exist side by side, some with elaborate adjustments and others with none at all.

In this area of intermediate certainty, the influences of personality or the perceived effectiveness of protective works increases. While individuals themselves may be quite firm as to their response to flood hazard, the community itself presents a portrait of ambivalence.

In the region of great uncertainty, as at Desert Hot Springs, the dispersion of characteristics again shrinks, but is oriented about negative or uncertain future flood expectations. Adjustment to hazard is non-existent and concern, if it exists at all, is directed towards the catastrophic event.

If this hypothesis is valid, then it suggests that the inconclusiveness of previous studies in assessing the impact of personal interpretation, personality, and awareness of protective works arises in part from a need to observe these characteristics in some framework of a certainty-uncertainty scale. It implies that, depending on the location of a site on such a scale, the observable impact of these factors would vary considerably.

It also offers an explanation for the high variation in LaFollette. While some of the variation is a function of sample size, the hypothesis suggests that it is also a function of lesser certainty. In a town at either end of the scale, such variability would diminish.

Finally, the hypothesis suggests the independence of flood response from socio-economic factors. Each pair of sites provides a wide contrast of socio-economic factors, while sharing a common dispersion of flood characteristics. Darlington is a prosperous regional farming center and Aurora is a fading river town; El Cerrito-Richmond are industrial-residential suburbs of a cosmopolitan city, LaFollette the commercial center of a depressed area; Watkins Glen is also a poor, population-losing community and Desert Hot Springs a burgeoning senior citizen retirement site.

Support for the hypothesis from an analysis of flood frequency at urban places.--Support for the certainty-uncertainty scale hypothesis and promise for its conversion into an interval scale is furnished by an analysis of unpublished frequency data obtained in an earlier study.[1]

In this earlier study of 1,020 urban places with flood problems, frequency data, expressed as the number of *recorded* floods per ten years, were obtained for 496 urban places with populations exceeding 1,000 persons in 1950.

TABLE 17

NUMBER OF FLOODS RECORDED PER TEN YEARS FOR 496 URBAN PLACES

Number of Floods Per Ten Years	Number of Urban Places
$<.9$	48
0.9-1.9	95
2.0-2.9	105
3.0-3.9	57
4.0-4.9	29
5.0-5.9	33
6.0-6.9	20
7.0-7.9	20
8.0-8.9	24
>9.0	65
Total	496

A plot on log-normal probability paper reveals that the frequency distribution of the 496 urban places is approximately normal with respect to the log of recorded floods per ten years. The distribution approximates the curve shown in Figure 9. In itself, this is a finding highly suggestive for future research. While lacking any theoretical explanation for the log-normal distribution of cities on a physical variate, flood frequency, the empirical implications are important. The well-known characteristics of the normal distribution may now be related to a population of urban places with flood problems whose actual size is unknown.

More relevant to the present discussion is the use of the log of flood frequency as an approximation of the certainty-uncertainty scale. It can only serve as an approximation for two important reasons. As noted previously, the certainty-uncertainty

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[1]The unpublished data are in the files of the Department of Geography at the University of Chicago. A description of the method of obtaining the information concerning the 1,020 places may be found in White *et al.*, pp. 33-35.

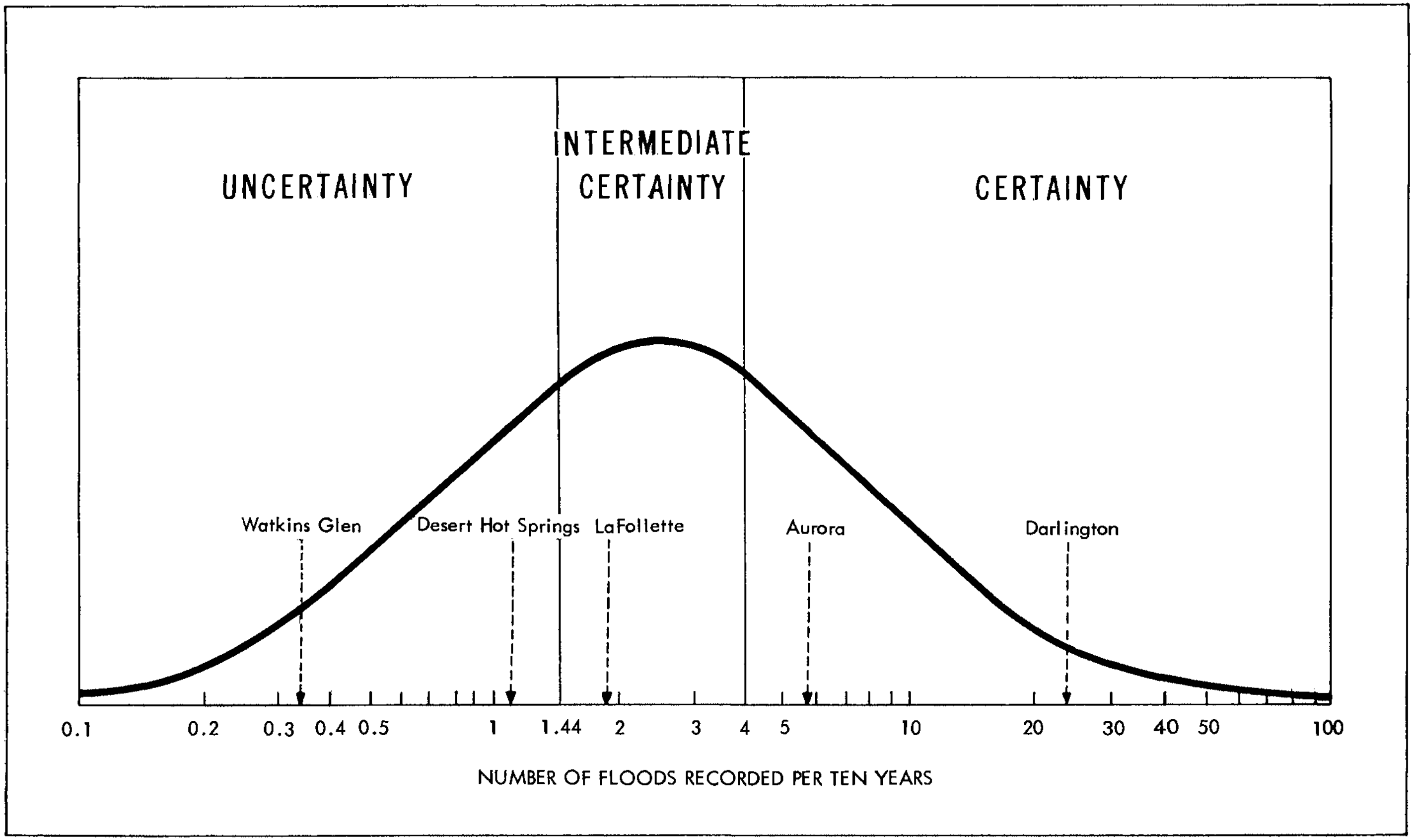

Fig. 9.--Log-Normal Distribution of 496 Urban Places by Flood Frequency

scale is hypothesized as measuring the perceived flood frequency which should vary at times considerably with the recorded number of floods per ten years. Moreover, the findings of the study indicate the importance of major floods as opposed to minor or just over-bankfull floods. The data for the 496 places records all floods and does not distinguish between major and minor floods.

Despite these drawbacks the use of the normal curve drawn in Figure 9 gives striking support to the hypothesis. The area under the curve has been arbitrarily divided into three equal parts and labeled according to the distinctions in the hypothesis; certainty, intermediate certainty, and uncertainty. The available flood frequency data for LaFollette and the reconnaissance sites were transformed into an equivalent expression with the urban place data and located on the scale.[1] In all cases the five sites fall into place within the areas for which they have been previously classified.

Perception, Hazard Evaluation, and Choice: A Commentary on Flood Hazard Information

In exploring the nature of probability distributions held by possessors of technical and common knowledge, it has been suggested that the shape of such distributions arise from underlying perceptions of the state of nature, which might be thought of as determinate, probabilistic, and indeterminate, with the parameters of such distributions dependent on the observation of the past and its extrapolation into the future.

In the case of LaFollette, the evidence of past floods is meagre and even technical extrapolations into the future show wide divergence. The possessors of the common knowledge are strongly conditioned by their immediate past and limit their extrapolation to simplified constructs, seeing the future as a mirror of that past, subject to the discounting of the perceived effect of man's work. By contrast with technical estimates, the hazard perceived in LaFollette is generally of greater frequency but of lesser magnitude.

Figure 10 attempts to present these ideas graphically, with each perception shown on an abscissa of past and future time, and an ordinate of magnitude. The probabilities of floods occurring in the past for all three perceptions are either 1.0 or 0.0, derived from the observation that floods either occur or do not occur. For the future of the indeterminate perception there is

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[1]The data for El Cerrito-Richmond were incomplete and could not be transformed.

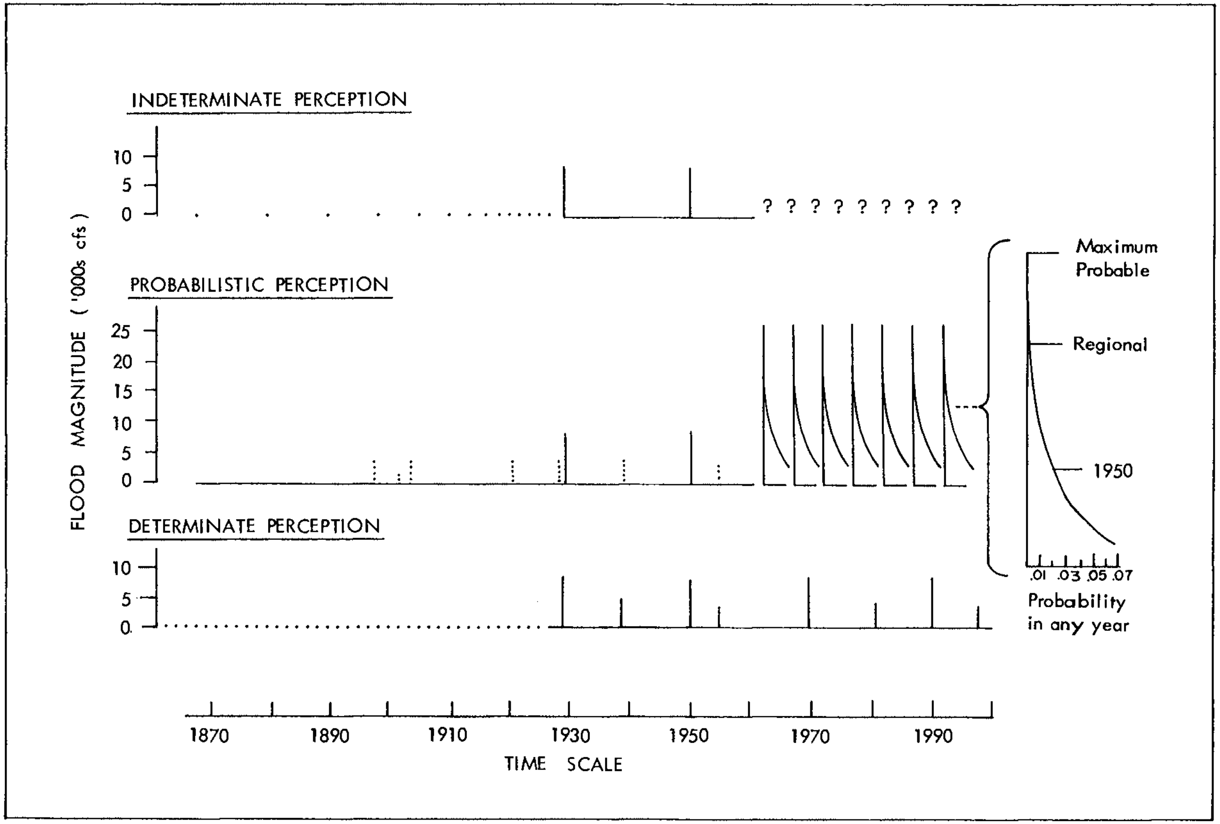

Fig. 10.--A Graphic Hypothesis of Probability Distributions and Perceptions of the State of Nature

only the unknown; and for the determinate position, a mirror of the past, with some flexibility as to year of occurrence. The future of the probabilistic perception is an infinite series of annual probability distributions of magnitude.

If this presentation is a fair exposition of the probability distributions believed in by the possessors of the common and technical knowledge in LaFollette, how well might they serve the needs of decision-making relative to flood damage reduction?

Three criteria can be suggested for guides to such judgments: (1) scientific accuracy, (2) comprehensibility for managers, (3) utility for choice.

Scientific accuracy.--The indeterminate perception would deny to man the opportunity to fathom the natural phenomena of floods and the deterministic perception would obscure the uncertainty such a process involves. Despite its general probabilistic orientation, the technician's perception also wears a determinate face concealed beneath engineering judgment, and an indeterminate face represented by the cautious scientist's retreat from the frequency calculation of extremely rare events.

The hydrologic literature is replete with new methods being developed to extract from the available data the last full measure of information. Nevertheless, no amount of improved statistical technique can fully overcome the limitations that small sample sizes of annual flood observations impose. They cannot substitute for a well-designed program of observation and the continued passage of time.

Equally disturbing is the suggestion that even an extended record has limited utility considering the artificial changes that are occurring in the regimen of many streams.[1] These changes introduce considerable bias into stream-flow records and impair their interpretation although with lessened effect on the analysis of extreme events.

The comprehensibility for managers of technical flood hazard evaluations.--It appears that not only are there severe bounds to the ability of managers to comprehend technical hazard evaluations but that there are limitations on their motivations to do so as well.

The experience in LaFollette with the TVA report entitled Floods on Big Creek suggests these limits of motivation. The report, typical of the genre of such reports, represents the best and

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[1]Walter B. Langbein and G. N. Alexander, "How to Figure Odds on a River Project," Engineering News Record, August 28, 1958, p. 36.

most comprehensive effort to date to combine scientific accuracy, attractive format, and non-technical presentation.

While precise records were not kept, the TVA estimates that 28 reports were distributed in LaFollette.[1] Based on the interviews in which respondents were confronted with a copy of the report, and considering the sample's bias towards including prospective report recipients, the penetration was slight and the recall even less (see Table 18).

TABLE 18

RESPONDENTS' KNOWLEDGE OF THE TVA REPORT

Never saw report		95
Evidenced no interest in report	35	
Evidenced some interest in report	52	
Interest not ascertained	8	
Claimed knowledge of report		11
Could not remember contents	1	
Evidenced vague knowledge of contents	3	
Evidenced fair knowledge of contents	3	
Knowledge of contents not ascertained	3	
Not ascertained		3
Total		109

One-third of the respondents showed no interest in the report, a finding in keeping with the lack of interest in the flood hazard map of Topeka.[2] Thus any evaluation of flood hazard information must grapple with evidence from two locales suggesting that there is a sizable portion of managers who lack sufficient motivation to even expose themselves to the informational materials presently available.

For the flood plain manager who is willing to at least expose himself to such information, there is a further set of obstacles. Limitations of vocabulary and inability to read graphs are blocks to comprehension. The reluctance to make computations of frequency may also apply towards trying to understand the computations of others.

Two other substantial blocks might be suggested. The first is the inability of individuals to conceptualize floods

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[1]Personal interview with John W. Weathers, Local Flood Relations Branch, TVA, July 16, 1961.

[2]Roder, p. 80.

that have never occurred.[1]

The second major block is the difficulty individuals have in grasping the independence assumption of random events. As an indicator of belief or disbelief in the independence of flood events, the following statement was read without comment to respondents who were polled as to their agreement with it:

> If you have a flood this year, chances are that you would not have another for some time.

Only 14 of the 109 respondents disagreed with it. To disagree would fly in the face of both intuitive and experiential perception. LaFollette, when it did have a flood, did not have another for some time. Yet agreement with the statement denies the independence of flood events for that assumption asserts the absence of relation between a flood this year and any other occurrence. The difficulty of intuitively accepting the independence of flood events is widespread, for example, the following quotations from a public administration-sociological study:

"Floods occur in cycles," the author asserts. But immediately following, a perfectly clear but obviously misunderstood statement: "As Hoyt and Langbein explained, 'We speak of a ten-year flood or a hundred-year flood, measuring in each case a flood of such magnitude that it occurs once in ten years or a hundred years on the average.'"[2]

While the evidence suggests that such notions as to interest, ability to conceptualize floods that have never occurred, and the acceptance of the independence of events should be reconsidered, little is known about the effectiveness of different presentations. In LaFollette, the penetration of the flood report was limited, and in Topeka, no one recalled seeing the flood hazard map prior to the time Roder interviewed them.[3] A fresh opportunity for practically testing the impact of flood hazard information is the program of flood hazard mapping in the Northeastern Illinois Metropolitan Area. The mapping program is being accompanied by an aggressive program of introduction to the public and an impact

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[1]The TVA, having long recognized this difficulty, goes to considerable length to try to bring home the graphic reality of potential floods. It draws analogs from regional experience, plots potential floods on easily read maps, and shows flood heights on photographs of familiar buildings. A well-designed study might usefully test the effectiveness of such measures.

[2]S. Weisman, Case Study of Flood Stricken City (New York: by author, 1958), p. 3.

[3]Roder, p. 80.

study of such hazard information is being planned.[1]

Despite the effectiveness of presentation designed to circumvent limitations of managers to comprehend hazard evaluations, it appears that a genuine conflict exists between scientific accuracy and comprehensibility of evaluations. There is a great gulf between the language of science and lay language. The scientist learns to live with uncertainty, the layman appears to have need to eliminate or ignore it.

Because this gulf is real, and technicians sense it, there is generated a powerful pressure to simplify statements, eliminate probabilistic constructs, and in general provide a more limited range of choice for managers to choose from.

The utility of hazard evaluations for choice.--Given the comprehensibility of a flood hazard evaluation, can it readily be used as a basis for choice in flood damage reduction?

For this discussion it would be best to consider but one common form of hazard evaluation, the magnitude-frequency plot. Immediately three problems present themselves, whose inadequate solution severely restricts the utility of such plots as a basis for choice.

The choice posed by a continuous function.--The first such problem is that of the continuous function that such plots present. For many resource management students it has been an article of faith that broadening the range of choice is desirable.[2] However, a range of choice broadened to a continuous function faces one with the paradox of the infinite range of choice potentially reducing one to impotency. In the face of a continuous function of alternatives, decision-makers, be they possessors of technical or common knowledge, shrink from the task and reduce such functions to a few discrete choices.

Acceptability of risk.--Related to the problem of continuous functions, but applicable to discrete situations, is the problem of deciding upon an acceptable risk level. Given some manageable range of choice, what kind of an acceptable level of risk should an individual decision-maker tolerate? Three approaches to the problem may be examined in search of guides.

Acceptability of risk, rules of thumb.--For some readers a discussion of risk levels immediately conjures up images of the

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[1]Personal conversation with John R. Sheaffer, Northeastern Illinois Metropolitan Area Planning Commission, July 18, 1962.

[2]G. White, "Broader Bases for Choice: The Next Key Move," Perspectives on Conservation (Baltimore: Johns Hopkins University Press, 1958), pp. 205-226.

statisticians' conventions of significance levels of .05, .01 and .001, and their wide adoption in science. For much of the world of science, risk is not a continuous function, but depending on the perceived seriousness of rejecting a null hypothesis when it is actually true, seems to move in discrete jumps from 1 in 20 to 1 in 100 and in rare cases 1 in 1,000, when one wants to be "really sure." If flood plain managers might be induced, as their more technical brethren do, to accept such conventions it would simplify the risk problem considerably.[1]

Acceptability of risk, minimum costs and maximum benefits.--A more sophisticated economist's and statistician's approach would seek to identify some point along a continuous risk function which maximizes, in some fashion, the benefits from a reduction of a given risk level of hazard.[2] Such processes while providing useful information for managers of establishments with long planning horizons or at an aggregate level in benefit-cost analysis, still depend on long-run averages to maximize such benefits. The variability of technical estimates of magnitude and frequency, the uncertainty of damage data particularly on an individual basis, and the potentially prohibitive cost of securing adequate information, further limits such an approach as an operational solution for the small individual decision-maker.

Acceptability of risk, behavioral analogs.--The first two approaches are essentially normative, suggestions of rules for selection of acceptable risk levels. Are there behavioral guides to acceptable risk levels, that is, regularities of acceptable risk for floods or other hazards that can be detected in the behavior of individuals?

Previous flood studies fail to provide clear guides. In both urban and rural situations, given some perceived reason for locating on a flood plain, the tolerance for risk levels varies considerably above some threshold. In Burton's agricultural flood plain studies, fields were found to be planted regularly subject to flood hazard with recurrence intervals ranging from 3-6 years

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[1]It is curious that the writer who chose a .05 level of significance for this volume would balk at adopting a standard for a floodway that had one chance in twenty of proving inadequate.

[2]Essentially this is a more sophisticated version of benefit-cost analysis where the risk level that maximizes the net benefits discounted to the present might prove acceptable or that risk level that provided the highest return per unit of capital invested to obtain such hazard reduction.

The companion study will attempt to identify frequency points at which net benefits discounted to present value are maximized for a variety of alternative flood damage reduction measures.

to extremely rare and such frequencies are best understood when considered in a matrix of other factors.[1]

In seeking elsewhere for analogs that would suggest behavioral guides for risk levels, fire or accident hazards might be considered. However the statistics for the occurrence of such events are not easily interpreted as frequencies of hazard partly because of the exposure frequency problem. For example, from statistics of fire in residential buildings by class of city, one might estimate that the relative frequency of fires in towns of LaFollette's class are of the order of 1 in 100.[2] However, this is not the probability of a fire in any year in a house in LaFollette, for surely few would argue that the probability is the same in a home with good safety habits as opposed to one without such preventive measures. The problem of determining the frequency of exposure has led a leading hazard investigator to declare:

> How does one measure exposure? That is, how does one define the conditions that characterize a class of risk situations? How does one measure the frequency of occurrence of risk situations? . . . Failure to recognize and deal with this problem has resulted in an unfortunate research situation. Analytical results which possess no more than speculative value are being constantly generated. Despite the seeming simplicity of these research problems, we still do not know whether men are safer drivers than women, whether it is more dangerous to cross the street with the light or against it, whether girls are stronger swimmers than boys, or whether aspirin is a more deadly accident hazard than lye. We do not know whether excessive speed is a factor common to turnpike accidents or common to turnpike driving. Despite the fact that turnpikes tend to have fewer fatalities per vehicle mile than ordinary roads, we really do not know whether turnpikes contribute fatalities or prevent them. In short, there is a major problem in separating those circumstances that are associated with the occurrence of an accident in a given risk situation from those that are associated with the occurrence of risk situations.[3]

Hazard research is also plagued by the differential perception of culturally allowable risk, succinctly described as follows:

> A report of a few cases of polio will empty the beaches, but reports of many more deaths by automobile accidents on the roads to the beaches will have little effect. The mother

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[1]Burton, <u>Types of Agricultural Occupance . . .</u>, pp. 42-138.

[2]Insurance Information Institute, 1960 Property Insurance Fact Book (New York: by author, 1960), p. 6.

[3]Herbert Jacobs, "Conceptual and Methodological Problems in Accident Research," Behavioral Approaches to Accident Research (New York: Association for the Aid of Crippled Children, 1961), p. 9.

who would not think of exposing her family to the risk of a polio "accident" does not apply the same logic to the risk of automobile accidents.[1]

The idea that there are culturally allowable levels of risk would further limit analog-seeking that might describe generalized risk tolerances, for even should such be found, there would always be a serious question as to their cultural comparability with flood hazard.

Long-run averages.--All expressions of frequency are subject to the law of large numbers, implying long-run averages, and one can note with I. J. Good, quoting J. M. Keynes' grim reminder, that "in the long run we shall all be dead."[2] What can long-run averages mean to a manager of a flood plain establishment?

A manager knows that people experience floods or they don't. He has never seen an average annual flood, received average annual benefits, or suffered average annual damage. Floods arrive in discrete packages, levy immediate discrete damages; and benefits in the conventional terms of damages averted, appear somewhat ludicrous. To the individual such a definition of damage provides the shallow consolation that some ill happening expected over a period of years did not happen to him this year.

From the broad view of nation or community the long-run average frequency has definite meaning. For an individual it may only serve as a source of bewilderment. Thus while the concept of the "100 year flood" represents a marked advance compared to such phrases as "Who knows?" or "Floods come in cycles," ways still need to be sought to make flood hazard evaluation suitable for individual choice. One such approach that might be explored follows.

A Probability Construct for the Individual Decision-Maker

What would be an effective method of presenting flood hazard information to the individual private decision-maker with a limited time horizon? It should be designed to make maximum use of technical hazard evaluations. It should seek to overcome the difficulty individual decision-makers have in using long-run statistics and to satisfy the need for simplifying continuous choice functions into discrete choices.

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[1]Edward A. Suchman, "A Conceptual Analysis of the Accident Phenomenon," Behavioral Approaches . . . , p. 40.

[2]Good, p. 445.

A simplified probabilistic perception of the state of nature.--A return to the analogy of the perceptions of nature will best illustrate such a method. In this perception, there is still an urn, but a friendlier nature, aware of human computational bounds, has thoughtfully colored the balls with three colors, green, yellow and red. Each flood plain manager has a personal urn in which the mix varies slightly from manager to manager. The green balls are those floods whose volume is smaller than that required to just inundate the manager's establishment, given his location on the flood plain. The yellow balls represent floods that would inundate his establishment but not cause, by some defined standard, a serious flood. The red balls, quite few in number, represent flood flows that would cause a serious flood or greater, possibly a catastrophe.

All managers are human beings with limited life spans and are spatially quite mobile. They often change location, and each such change provides a new urn, which seldom contains a large number of red balls. Thus for each manager, for any location, the number of draws of red balls and possibly yellow balls as well, is not only finite but small in number. Each manager has only passing interest in the shape or parameters of the distribution. His interest, if it exists at all, is directed to the number of red and yellow balls that might be expected in his relatively short sequence of draws. He has observed that many managers on many flood plains never experience a serious flood in their short fluctuating periods onsite.

Information required to make hazard evaluations based on a simplified probabilistic perception of nature.--To move from the perception to hazard evaluation, four items of information are needed:

1. A stage-damage relationship for the establishment, that would provide dollar estimates of damage for each increment of higher water.

2. The identification of two elevations: that marking an establishment's flood (just being inundated--yellow balls) and that defining the elevation of at least a serious flood (red balls). In this study, the beginning of flooding has been defined as the first floor elevation of each structure. Defining serious flooding is far more complex and, since damage is measured in dollars, related to the difficulty of comparing the utility of money from one person to the next.

Two separate approaches were developed for this problem and both will be used in the illustrating case.

In the interview, managers were asked to identify in feet and inches, the height that water would have to reach in their establishments to cause a serious flood. The first approach takes the manager's own estimate of a serious flood and converts it into stage.[1]

For the second approach, a serious flood is defined as some dollar equivalent of rent for the establishment and this is converted into stage using the damage-stage relationship. The rationale for such a process rests on theoretical assumptions that a flood is a natural rent or surcharge extracted by nature for flood plain location and that if the disutility of a serious flood is to be compared, it might be compared by some multiple of the actual or estimated rent of an establishment. The differences of such rents would reflect the value of the land and structure to the manager and thus provide some measure of surcharge to be tolerated by each establishment before it becomes "serious."

In the illustration that follows, a serious flood is defined as that flood that could cause damage equivalent to a year's rent. For actual decision-making, a small range of such rents might be provided.

3. A frequency or probability of occurrence in any year for the two stages previously identified, that where flooding begins, and that where serious flooding begins. Note that an entire discharge frequency curve need not be developed, and in general the two points might lie in the area where technical estimates prove most accurate ($\geq .01$ probability).

4. A time horizon expressed in years or the number of draws. Such horizons might be the manager's planning horizon, an average length in residence or business, mortgage loan periods for commercial or residential structures, and the like. In the example that follows, 25 years is used, a substantial planning period for any commercial venture.

Given the above items of information, it is a relatively simple task to compute the cumulative probabilities of drawing various numbers of yellow and red balls during the manager's time horizon by referring to the cumulative binomial probability distribution.[2] Such calculation might best be illustrated by using

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[1]It might also be noted that some managers argue that "any flood is a serious flood," however, even managers who state this argument do not appear to behave as if they believe it.

[2]Presenting flood probabilities in terms of the cumulative chances of receiving various numbers of discrete events is not common practice in flood frequency analysis. Walter Langbein has suggested a number of papers that have used such presentations for

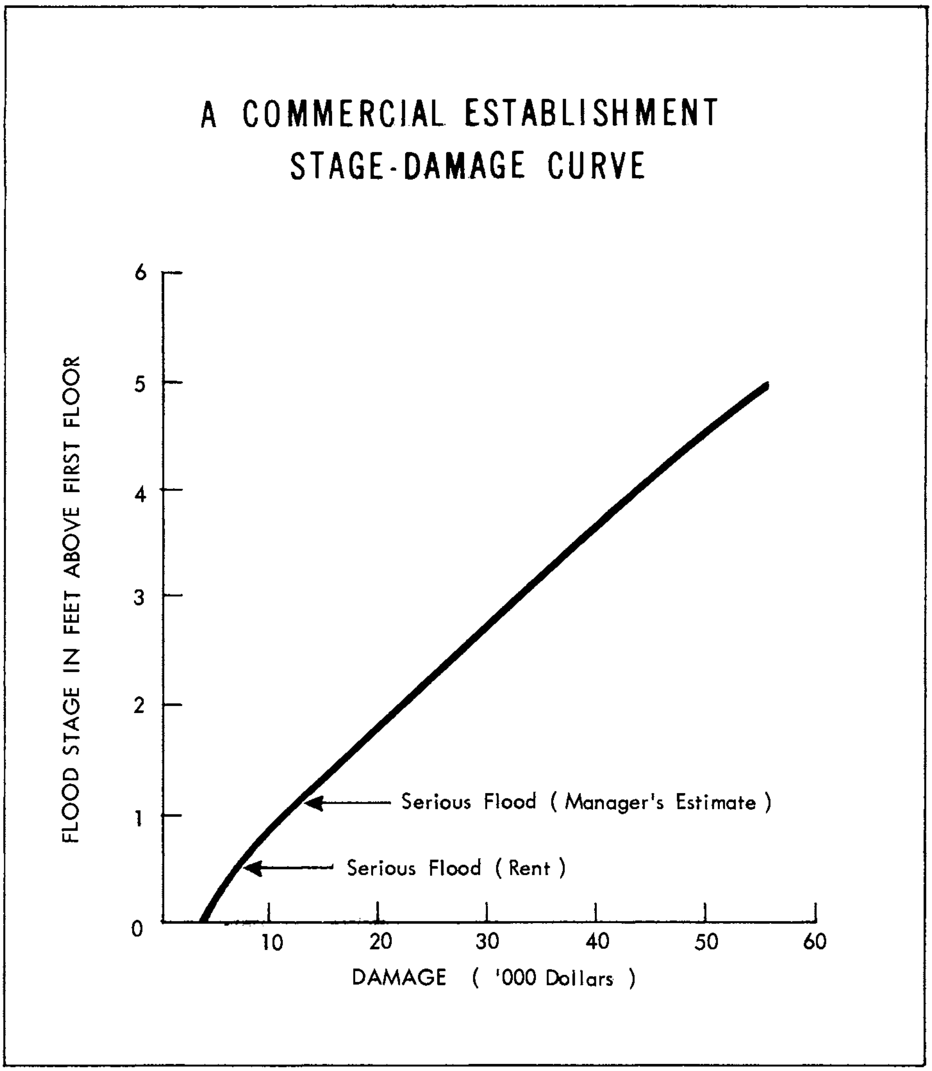
A COMMERCIAL ESTABLISHMENT
STAGE-DAMAGE CURVE
FLOOD STAGE IN FEET ABOVE FIRST FLOOR
0
1
2
3
4
5
6
10
20
30
40
50
60
DAMAGE ('000 Dollars)
Serious Flood (Manager's Estimate)
Serious Flood (Rent)

Fig. 11

an actual store in LaFollette in which the dollar expressions have been altered to preserve the confidential aspects of the data.

A flood hazard evaluation for a store in LaFollette.--The specifications of the needed information are as follows:

1. The stage-damage relationship based on a survey of the establishment is shown in Figure 11.

2. The two elevations, actually three, and their corresponding dollar damages are the following: Using increments of a tenth of an inch, flooding would begin at .10 foot above the first floor elevation. Such a flood would be equivalent to the 1950 flood and, at present, without any damage reduction measures, would cause an estimated $4,000 in damages, primarily to the basement and its contents. From a low of $4,000, damage might rise as high as $55,000 from the maximum probable flood. The damage required to equal one year's rent would be $7,200 or equivalent to that caused by .5 foot of stage. The damage equivalent of the manager's estimate in stage of a serious flood, 1.1 feet, would be $13,000. Both the rent and manager's estimates are used for defining a "serious flood."

3. The probabilities of .1, .5, and 1.1 feet of stage occurring in any year, or on any draw from the urn, are derived from the stage frequency plot of Figure 12, which presents the stage frequency relationship for the store in question based on the four assumptions used by White in the companion study. In the illustration, only the median assumption, the "C" curve is used and for the three stages give frequencies of .0125, .01 and .006 respectively of occurring in any year.

4. As stated previously the time horizon in this illustration is fixed at twenty-five years.

Given the above data and using the Poisson approximation of the cumulative binomial expression of the probability of having 0, 1, 2, and 3 or more floods of a given magnitude or greater during twenty-five years, Table 19 has been computed.

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discussion of various problems. See: American Society of Civil Engineers, Sub-Committee of the Joint Divisional Committee on Floods, "Review of Flood Frequency Methods," Transactions of the ASCE, CXVIII (1953), 1221; R. W. Davenport, "Discussion on Statistical Analysis by L. R. Beard," Transactions of the ASCE, CVIII (1943), 1139; W. Potter, Peak Rates of Runoff from Small Watersheds (Washington: Government Printing Office, 1961), p. 17; H. A. Riggs, "Frequency of Natural Events," Journal of the Hydraulics Division, ASCE, LXXXVII (January, 1961), 15-27; Harold Thomas, Jr., "Frequency of Minor Floods," Journal of the Boston Society of Civil Engineers, XXXV (October, 1948), 425-442.

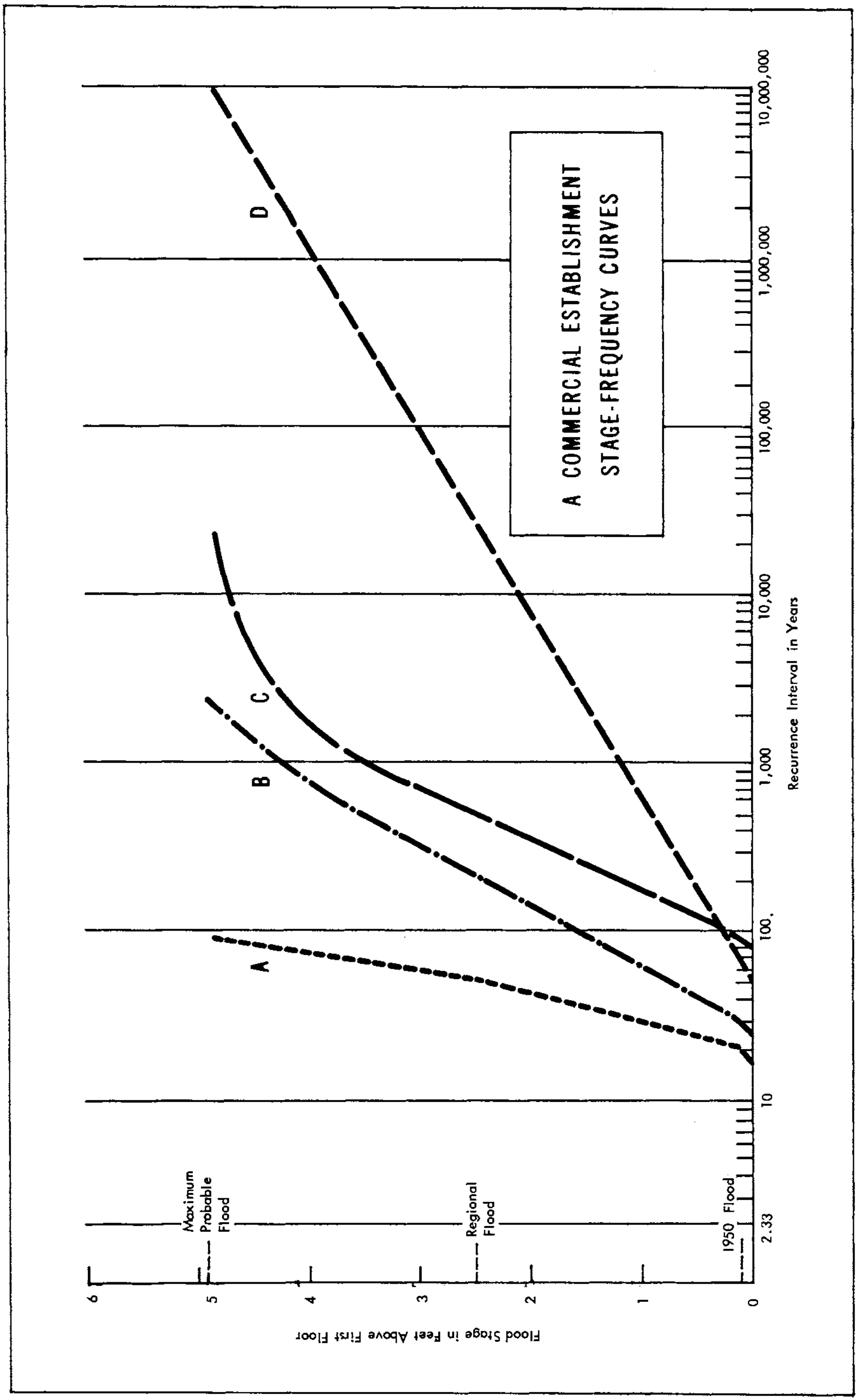
A COMMERCIAL ESTABLISHMENT
STAGE-FREQUENCY CURVES
A
B
C
D
Flood Stage in Feet Above First Floor
0
1
2
3
4
5
6
Recurrence Interval in Years
2.33
10
100
1,000
10,000
100,000
1,000,000
10,000,000
Maximum Probable Flood
Regional Flood
1950 Flood

Fig. 12

TABLE 19

EVALUATION OF FLOOD HAZARD AND SERIOUS FLOOD HAZARD FOR LAFOLLETTE COMMERCIAL ESTABLISHMENT DURING A TWENTY-FIVE YEAR PERIOD

Stage-damage data:

	Stage (Above 1st Floor)	Estimated Damage
Flood	0.1 feet	$ 4,000
Serious flood (1 yr. rent)	0.5 feet	7,200
Serious flood (manager's estimate)	1.1 feet	13,000

Frequency data: (Based on "C" curve)

Probability of a flood in any year	.0125
Probability of a serious flood (rent) in any year	.0100
Probability of a serious flood (manager) in any year .	.0060

Frequency-damage data:

Estimated average annual damage .... $ 196

Time period:

25 years

Flood hazard evaluation:

The probability of a manager having in the next 25 years:[a]

	Floods	Serious Floods (Rent)	Serious Floods (Man. Est.)
None	.7408	.7788	.8607
Exactly 1	.2222	.1947	.1291
Exactly 2	.0333	.0243	.0096
3 or more	.0035	.0021	.0005

[a]Computed by use of Poisson approximation of cumulative and individual binomial probability from E. Molina, Poisson's Exponential Binomial Limit (New York: Van Nostrand Co., Inc., 1942).

Included in Table 19 is the estimate of average annual damages of $196.00 derived by conventional benefit-cost analysis techniques. In a sense, this figure is the commonly used alternative presentation of flood hazard evaluations in economic terms.[1] It tells the manager, that if his present mode of business is projected infinitely into the future, the expected damages expressed as an annual figure would average $196.00.

In the writer's view, this type of presentation is ill-suited to individual decision-making. It implies a relatively

[1]This by no means exhausts alternative economic flood hazard evaluations. One such alternative, discounting a stream of average annual damages to its present value is used in the companion study.

small annual charge extracted by nature for the flood plain location of this establishment. In doing so, it disguises the fact that this charge results from the averaging of chances of about 3 out of 4 or not having any floods at all, and much smaller chances of having 1 or even several large floods.

The presentation of cumulative probabilities for several discrete levels comes closer to conforming to managers' intuition and experience and the bounds to their rationality that are posed by continuous functions, the absence of guides to acceptable risk levels, and long-term averages. The actual form of presentation would have to be substantially different than the technical format in Table 19 and is one for experimentation and research, there being little known about the best means of presenting probabilities to the general public. The meaningfulness of cumulative probabilities for individual decision-making as opposed to average annual damages and the presentation of flood magnitudes without frequency is also a matter that might await a future test specifically designed for that purpose.

However, regardless of its normative value for choice, the calculation of the cumulative probabilities displayed in Table 19 may be important in pointing out the high probability of never being flooded during limited time periods. This would imply that underlying the widely observed penchant for doing nothing about floods, which is often attributed to ignorance, foolhardiness, or other irrationality, lies a rational probability distribution of limited risk. It is a matter of speculation as to whether managers somehow intuitively recognize the large short-run probabilities that they may never be flooded, and the even larger ones that they may never had a serious flood. In any event, alongside other explanations for the widely observed failure of managers to react strongly to flood hazard, must be placed an explanation that is fully in accord with a theory of bounded rationality.

Kates, R. W., 1962, Hazard and Choice Perception in Flood Plain Management, University of Chicago, Department of Geography Research, Paper No. 78.

CHAPTER V

THE PERCEPTION AND ADOPTION OF ALTERNATIVE FLOOD DAMAGE REDUCTION MEASURES

It is illuminating to examine not only the way in which flood plain dwellers perceive the flood hazard but the ways in which they can deal with flood loss. The theoretical range of choice available for a flood damage reduction program was outlined in the opening pages. This chapter will examine in detail the portion of that theoretical range of choice perceived by either respondents or technical personnel as applicable to the conditions of LaFollette and the other study sites. These might be considered the practical range of choice.

These alternatives may be reviewed under six major groupings: bearing the loss, emergency actions, changes in structure or land elevation, changes in land use, flood control and abatement, and insurance. Many alternatives have both individual and community variants, often quite different, though not mutually exclusive, and in general distinguishing the major responsibility or capability for effectuating the alternative between the individual manager and community in its broadest sense.

Respondents and technical personnel may perceive alternatives, perception being the specific indication by word or deed of an awareness of some alternative action without interviewer's suggestion.[1] The array of perceived alternatives might be thought of as the perceived range of choice. Perceived alternatives can be adopted. Adoption is the partial or complete installation of any action. Figure 13 attempts to present schematically these relationships.

The Practical Range of Choice at LaFollette

Bearing the loss.--The most common human adjustment to flood hazard is for an individual to bear the loss when it occurs.

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[1] Reference might be made to the five-stage scheme used by rural sociologists and others to describe the adoption of new ideas and practices. Perception might be considered akin to the first three of these stages: awareness, interest and evaluation, while adoption describes the final stages of both trial and adoption. See Herbert F. Lionberger, Adoption of New Ideas and Practices (Ames: Iowa State University Press, 1960), pp. 22-23.

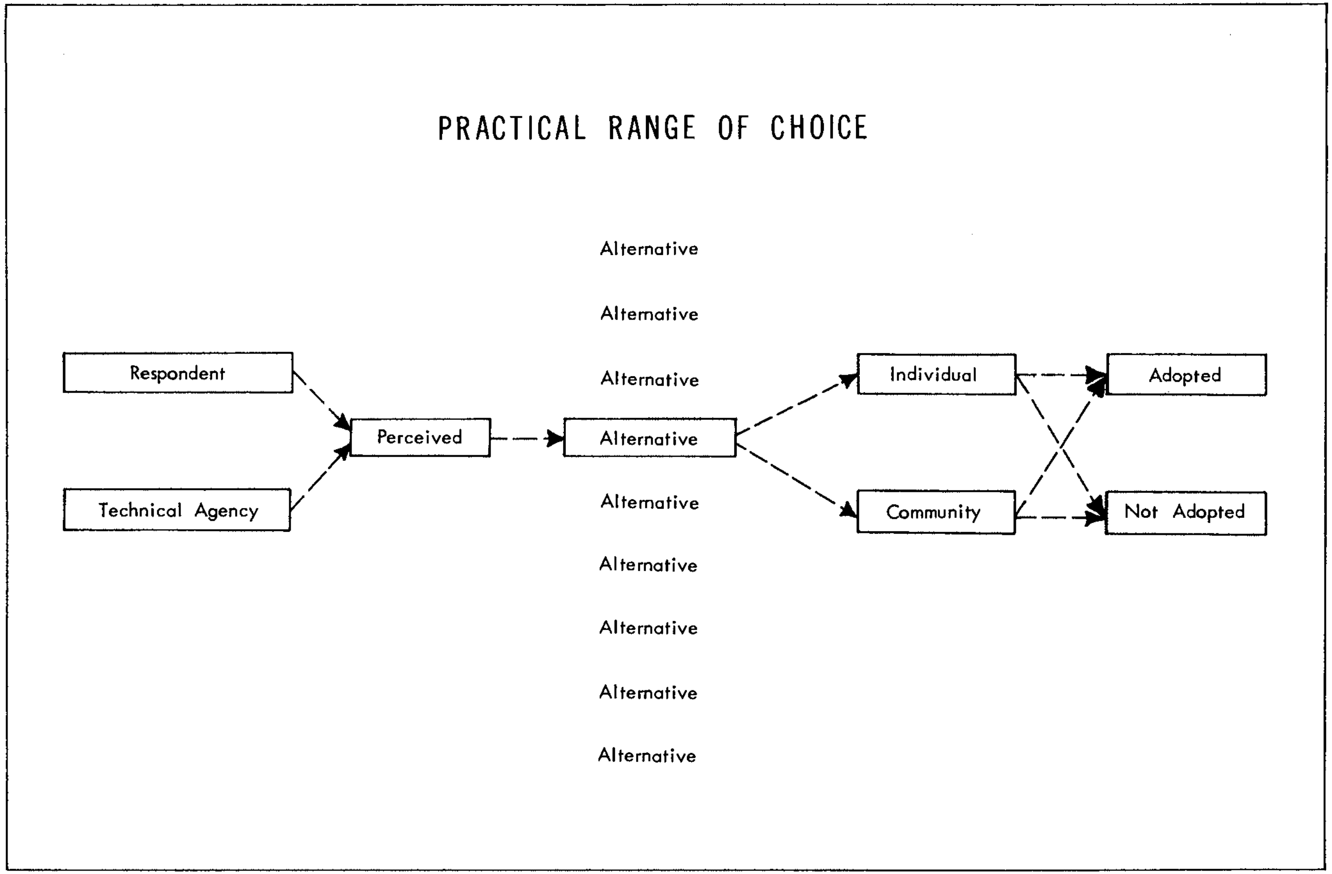

Fig. 13.--Variants of the Perception and Adoption of a Single Alternative

In general such losses may or may not have been expected, but even where some losses are expected, their frequency or magnitude is often underestimated.

The individual bearing of losses can result in reducing flood damages only from the broad view of the community. This is the case when the sum of the individual losses is less than the expenditures of the community on measures designed to prevent such losses.

Though the expectation of future losses does not reduce flood damages for the individual directly, it is a necessary condition that encourages the search for other alternatives.

Therefore, a comprehensive flood damage reduction program would attempt to insure that no manager suffered an unexpected loss. It would do this by providing information regarding the magnitude and frequency of such losses.[1] To date, the only authoritative effort at informing managers as to potential flood loss is the TVA volume, Floods on Big Creek, the limitations of which have already been discussed.

That a considerable effort to inform managers might be required is indicated by Table 20 which shows that both now and in the past a majority of LaFollette managers do not expect to bear losses by virtue of their failure to perceive a flood hazard.

While one might logically infer that if a respondent does not expect a flood, he does not expect a flood loss, the converse is not necessarily true for some managers do expect to avoid losses when a flood occurs. Since there were no questions asked of respondents that distinguished between the expectation of a flood and of bearing a loss, the 45 respondents who expect a future flood might include all those who expect to bear a loss as well as some who do not. Of these 45, 22 have adopted some minimum action designed to reduce flood damage, 15 others perceive such actions but have not adopted any, and 7 either fail to perceive any actions or have rejected them.

Presently, upwards of 45 managers expect to bear a loss and this might be compared with 46 who held a similar expectation when they made their original decision to locate on the flood plain. Since the two sets of data are statistically independent, they suggest an addition to the certainty-uncertainty hypothesis. This would say that the expectation of bearing a loss is a function

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[1]A comprehensive flood damage reduction program is presented in the companion study. As the final program depends heavily on still uncompleted economic analysis, reference to it is of a general rather than specific nature.

of the location of an urban place on the certainty-uncertainty scale, and if such location were approximately constant through time, then the number of persons expecting to bear a loss would also be constant through time.

TABLE 20

EXPECTATION OF BEARING A FUTURE FLOOD LOSS

Actions	At Time of Original Decision to Locate on Flood Plain		At Present Time	
	Number	Per Cent	Number	Per Cent
Bear unexpected loss	56	54.9	40	38.1
Uncertain	...	...	20	19.0
Might bear expected loss	46	45.1	45	42.8
Total	102	100.0	105	99.9
Might bear expected loss and:				
Adopted minimum action to reduce loss	...	...	22	48.9
Perceived minimum action to reduce loss	15	32.6	15	33.3
No action perceived or action rejected	23	50.0	7	15.6
Action not ascertained	8	17.4	1	2.2
Total	46	100.0	45	100.0

From the overall view, flood losses in LaFollette have been modest. A generous estimate of $97,000 accounts for the damage from the 1950 flood as estimated by TVA. From the interviews only one in five respondents recalled having any loss at all (compare with the 50 per cent who experienced the flood) and for only one in ten these losses exceeded $150.

Related to the alternative of bearing a loss are the relief activities of the community, for these activities make bearing the loss a more attractive alternative. They tend to mitigate some of the physical suffering and discomfort related to floods and their monetary assistance for rebuilding and refurbishing structures seems to place a ceiling on losses, particularly those of the lower income flood plain manager. The conscience of the community seldom permits any flood victim to be completely destitute. The net impact of relief activities on flood damage reduction is somewhat speculative, but from a community point of view they tend to increase the toll of flood losses.

The Red Cross, the major community organization charged with relief activities, has no specific plan for coping with disasters in LaFollette.[1] A minister serves as local representative and assistance in case of disaster would have to be improvised according to established national guides. No assistance was rendered after the 1950 flood, and in any event no respondent indicated that the prospect of obtaining relief consciously entered his decision-making.

Emergency actions.--Almost all floods involve a series of emergency responses. These generally are in three directions: (1) flood fighting involving either keeping the water out or hastening it through the establishment; (2) the temporary evacuation of men and material from the path of the flood; (3) the rescheduling of activities, mainly economic, to minimize disruptive and damaging flood effects.

The complexity of the responses varies considerably, depending on prior thought and preparation and the quality of the flood warning.

A comprehensive emergency plan for reducing flood damage in LaFollette might start with extending the warning period to provide the maximum of two hours that a year-round warning system with radar equipment might provide.[2] Given a two-hour warning prior to major floods, an organized community might first see to the evacuation of persons from the flood plain, the disconnection of utilities (a major source of damage), and other measures designed for the protection of equipment. Then, depending on the height of the flood and the location of an establishment, an attempt might be made to keep the water out of well-constructed brick buildings and to remove or elevate machinery and goods in others. Materials such as sand bags for flood fighting would be provided beforehand and individual establishments would have semi-formal plans for flood fighting and the removal or elevation of goods from the path of the flood.

Some emergency actions are widely perceived and acted upon, others dimly perceived and even rejected. A quotation from the TVA report might convey the quality of the emergency actions undertaken during the 1950 flood:

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[1]Interview with Mrs. Abbie Houston, Director of Home Services, Knoxville Chapter, American Red Cross.

[2]The Weather Bureau suggests that the maximum warning that might be provided would be between one and two hours for a flood of the size of the 1950 flood. (Personal communication to G. F. White from William E. Hiatt, U.S. Weather Bureau, Hydrologic Services Division, July 27, 1961.)

> Although the high stage of the creek flood occurred after closing time, many merchants had been alerted by the surface water flood accompanying the intense downpour. As a result they had been busily engaged in trying to block out the water with bags of flour, feed, fertilizer, old rags and other handy materials. Some closed their doors and stuffed cotton under them to keep out the water. These expedients were successful at a number of stores along the south side of Central Avenue where the water reached only the front of the stores. Here the water was one foot to eighteen inches deep on the street side of the stores but 5 to 6 feet lower under the buildings. Realizing this, the merchants simply tore out their wooden vestibules or cut holes in the floor near the front of their stores and let the water drain out as fast as it seeped in.
>
> On the north side of Central Avenue, on the east side of Tennessee Avenue and elsewhere in the business section the situation was more complicated. Water completely surrounded these buildings, entering not only through the front and back but in some cases coming up through the wooden floors. As a result sand bagging operations were of little value.[1]

The experience described in the previous paragraph weighs heavily on the perception of emergency actions today. The measures undertaken then were rudimentary, improvised, but effective for many establishments. Managers were quick to acquaint interviewers with their successful experiences in flood fighting pointing to an ever-ready supply of flour sacks in grocery stores or to holes that were drilled in the vestibule floors to drain water to the basements. Table 21 summarizes the perception of emergency actions to be employed in some future flood. In the case of emergency actions their perception implies adoption, for adoption in the formal sense must await a future flood.

Commercial and residential managers have markedly different perceptions of emergency action alternatives. Whereas 81.9 per cent of the commercial respondents perceived at least one emergency action that they might undertake, only 23.7 per cent of the residential managers did likewise.

This difference is in keeping with the differences between both structures and resources available to the two groups. The commercial respondents are housed mostly in brick buildings, and have available manpower and transport. In contrast, the residential managers reside in wooden structures and lack both manpower and transport to plan for the elevation or removal of their furnishings.

Thus it was not surprising to find that the most common action cited by the residential group (although of doubtful worth as a flood damage reduction measure) was to "get out."

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[1]TVA, Floods on Big Creek, pp. 16-17.

TABLE 21

PERCEPTION OF EMERGENCY ACTIONS

Actions	Commercial		Residential		Total	
	Number	Per Cent of Respondents	Number	Per Cent of Respondents	Number	Per Cent of Respondents
Actions perceived not requiring prior preparation:						
Elevation and removal of goods	35	53.9	2	5.3	37	36.0
Flood fighting	33	51.6	2	5.3	35	34.3
Protection of equipment ..	8	12.7	5	13.1	13	12.9
Actions perceived requiring prior preparation:						
Stock materials for flood fighting	12	18.8	..	..	12	11.5
Community warning system .	1	1.6	1	2.8	2	1.9
Total, at least one of the above	54	81.9	9	23.7	63	60.5

To help people "get out" was the role perceived by the LaFollette Rescue Squad, a recently organized group of volunteers equipped with boats, ambulances, and emergency equipment of all types, and whose headquarters is located on the flood plain. The Rescue Squad recently evacuated, during a minor flood, several residents who live right alongside the creek. The only other community organization with a perceived role in flood damage reduction was the Fire Department whose pumper had assisted merchants in clearing basements of water in 1950.

It would be quite possible for the combined forces of the Fire Department and Rescue Squad to provide considerable strength for an emergency flood plan that would go far beyond the evacuation of persons and would include the disconnection of utilities, elevation of furnishings, and assistance to the merchants in the elevation and removal of stock. Such plans, which have been instituted elsewhere in the nation, depend considerably on an adequate warning. A comprehensive radar system or a more limited program involving the cooperation of the fire control radio network of the State Forestry Division could provide such a warning.

The major obstacle to such a program is that not only do few persons perceive the need for an improved warning system but there is actually serious opposition to one. In part people feel they are protected, citing the fire department, the radio, and Rescue Squad as sources for early warning. Paradoxically, while some are convinced they have ample warning, others doubt the efficacy of any warning system on a stream whose rate of rise is as fast as that of Big Creek. When questioned as to the desirability of an improved warning system 28 respondents rejected it out of hand.

Another obstacle to more refined emergency actions lies in the progressive atrophy of any disaster preparations with time. A number of commercial respondents cited to interviewers their immediate post-flood stocking of sand bags, then gradually getting rid of the sand and saving the bags, until now they were even uncertain as to the location of the bags.

Structural change and land elevation.--One of the most ancient of man's responses to flood hazard is the design and construction of his structures to minimize damage or the elevation of his site above the flood. Somewhat paradoxically, the application of modern architectural and engineering skills to the design of such structural innovations has been quite limited. A revival of interest in this approach to flood hazard reduction is discussed comprehensively in a recent work by Sheaffer.[1]

A comprehensive flood damage reduction program in LaFollette would consider the elevation on block foundations of the older wooden homes in the flood plain as well as provide for the elevation of the sites of new buildings. If site elevation would not prove practicable for new buildings a considerable variety of architectural techniques would be available for virtually flood-proofing such buildings depending upon the magnitude and frequencies of floods to be encountered.

In the older commercial buildings minor openings can be bricked shut and temporary bulkheads placed across permanent openings. Backup valves, pumps, and tuckpointing would help control seepage. For almost all commercial ventures, some reorganization of contents can minimize damage. The comprehensive program would make available information as to sources of specialized equipment, their use, and installation.

Although the formal application of architectural and engineering skills has lagged, it would appear from the LaFollette data that managers do give thought to reducing flood damages by changes in the structure, organization of contents, and in the

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[1]J. Sheaffer, Flood-Proofing: An Element in a Flood Damage Reduction Program (Chicago: University of Chicago, Department of Geography Research Paper No. 65, 1960).

design of new structures or remodeling. Table 22 indicates the range and participation in the perception and adoption of such actions.

TABLE 22

PERCEPTION AND ADOPTION OF STRUCTURAL CHANGE AND LAND ELEVATION ACTIONS

Actions	Commercial		Residential		Total	
	Number	Per Cent of Respondents	Number	Per Cent of Respondents	Number	Per Cent of Respondents
Individual structural and elevation actions adopted:						
Brickwork and other measures to keep water out .	3	4.5	..	..	3	2.8
Sump pumps and water disposal	3	4.5	3	7.9	6	5.7
Reorganization of contents	4	6.0	..	..	4	3.8
Land elevation	5	7.5	1	2.6	6	5.7
Sub-total	15	22.5	4	10.5	19	18.1
Individual structural and elevation actions perceived:	Not ascertained					
Community structural and elevation actions adopted:						
Land elevation of municipal building	2	3.0	..	..	2	1.9
Sub-total	2	3.0	..	..	2	1.9
Community structural and elevation actions perceived:						
Miscellaneous actions	3	4.5	3	7.9	6	5.7
Sub-total	5	7.5	3	7.9	8	7.6
Total, at least one of the above actions ..	19	28.4	6	15.8	25	23.8

The actions themselves range from the minimum provision of a sump pump or bricking up a basement window, to such relatively complex actions as the installation of terrazzo flooring to facilitate cleanup or the replacement of subfloor wiring to prevent shortcircuits of key motor units in a millwork shop.

Any actions taken appear to be home grown with no evidence that they were inspired by or involved any considerable technical advice, although a few persons undertaking these minimal actions did possess some construction skills. The one exception was the construction of the variety store built over the creek on steel piles; this having been done on the basis of advice sought from TVA engineers.

The major tools that a program of flood damage reduction might use to effect structural and land elevation changes were not perceived at all by respondents. The elevation of existing houses by jacking them up and replacing their foundations was not considered by residential respondents who in the main perceived no possible structural changes that they might undertake. The commercial respondents also seemed totally unaware of the use of bulkheads in permanently installed frames as a major tool for keeping water out of solidly constructed buildings. This is not surprising considering the small number of such installations found in the entire country.

Six respondents perceived various minor changes that the community might install or pay for and two respondents claimed credit for the elevation of the municipal building (constructed in 1950) one foot higher than the projected grade.

As to the willingness to consider structural changes, the following question was posed to commercial respondents:

> If you found that at the cost of several hundred dollars you could make some small changes to the building that would protect your stock from most floods, would you make these alterations?

Almost half the respondents replying answered in the affirmative and seven others indicated that they would consider it but that they needed the approval of landlord, owner, or the like. An equal number felt they knew of sources where funds might be borrowed for such a purpose.

The question was not posed to residential respondents as there are no <u>small</u> changes that might protect them from flood hazard. Preliminary data from the companion study indicate that the question might prove unrealistic for many commercial managers as well. The cost of protecting stock would be considerably in excess of several hundred dollars. Thus the response is at best interpreted as providing a measure of the maximum number of managers that might be interested in flood proofing, being in this case no more than 50 per cent.

<u>Changing land use</u>.--A most effective, albeit costly, flood damage reduction alternative is a dramatic change in land use by

the permanent evacuation of the flood plain. In a somewhat less drastic fashion, a variety of regulatory means are at hand to encourage or mandate a shift in land use from high to low flood damage uses.

A comprehensive flood damage reduction program would utilize the regulatory powers of the LaFollette City Commission to amend the present zoning ordinance to provide a floodway zone for the unobstructed flow of water and a flood fringe zone in which new construction would be prohibited unless elevated above a given flood level. Non-conforming uses in these areas would be eliminated through time and new construction controlled by the issuance of building permits. These powers would be reinforced by the application of the loan activities of the FHA and VA in such manner as to inhibit an increase in damage potential. Finally, information would be available that would enable managers to evaluate the benefits of complete evacuation from the flood plain.

Since the 1950 flood there have been extensive changes in land use, but unfortunately not in the direction of reducing flood damage. In that time 15 new commercial structures or additions and at least 2 new homes have been built in the overflow area of the 1950 flood. There was also 1 case of a structure being demolished and the land shifted to an open use--a parking lot.

While it is relatively easy to measure the increase in encroachment upon the flood plain, it is difficult to obtain data on those who left the flood plain because of their assessment of flood hazard. Using the only 2 available city directories, 15 flood plain dwellers who had moved between 1955 and 1959 within LaFollette were identified.[1] Four of these moved to other locations on the flood plain, 5 could not be located, and of the remaining 6, none had considered floods in deciding to evacuate the flood plain.

In the course of the study, only 1 individual was found in the entire town who had moved off the flood plain because of a fear of floods. (She is actually on the fringe of the flood plain but does not know it.) Of the 11 respondents with concrete plans for moving off the flood plain, only 1, a residential respondent, indicated that flood problems had entered into the decision.

In summary, then, the decade following the 1950 flood has seen intensified use of the flood plain and no major compensatory movement towards reduction of damage potential by shifts in land use or voluntary evacuation.

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[1] LaFollette City Directory, 1956, 1960 (Chillicothe, Ohio: Mullin-Kille Company, 1956, 1960), *passim*.

At present, the governmental financing policies that would serve to reduce flood damage potential in other areas are not operative. Although both the FHA and VA have adopted policies in this area that would discourage an increase in construction of new residences in the flood plain, neither agency has had an opportunity in recent years to put such policies into practice.[1] What construction goes on, and there is a new residence now under construction along the creek, is financed by private capital, bank loans, or by the purchase of materials on credit. Much real estate that changes hands in LaFollette is by contract, and auction sales are common.

The major legal control in LaFollette on land use is the present zoning ordinance passed in 1947 and not revised since.[2] Using a common format it provides for residential, local and general business districts, light industry, and industry districts. Enforcement through the years has been spotty, there being no official Municipal Building Inspector as provided for in the ordinance, the chores being shared by the City Recorder and the Street Superintendent. Building permits are issued for only some of the new construction and only in cases of strong complaint or flagrant violation might they be denied. Non-confirming uses are commonly found even in new construction.

An amendment to the present zoning ordinance has been pending for a considerable time, having been passed on first and second reading in August of 1960, but still awaiting final action. The amendment, its purpose, and some of the considerations involved in its drafting can be best presented in the words used by the LaFollette Planning Commission itself:

> A study of the available flood data suggests that there is a need for maintaining at least a minimum "floodway" for Big Creek. The purpose of the floodway is to assure that flood waters which can be reasonably expected may be accommodated within the limits of the stream and its flood plain. This suggestion is based upon two major considerations. First, land fill, structures and other restrictions to the flow of water placed in the stream or on the flood plain could cause increased flood elevations upstream . . . .
>
> A second consideration on the need of a floodway is that areas subject to flood are hazardous to life and property. Authorities agree that the really dangerous flood areas are those covered by two or more feet of water and located in

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[1]Communication from Charles M. Johnson, Veterans' Administration, Nashville, Tennessee, and interview with Gray McCarroll, Federal Housing Administration, Knoxville, Tennessee, July 13, 1961.

[2]LaFollette City Commission, Zoning Ordinance of City of LaFollette (LaFollette: City of LaFollette, 1947).

> the main stream of the flood plain where water velocities are likely to be high . . . .
>
> To meet this problem it is recommended that the zoning ordinance designate a floodway sufficient to pass floods down Big Creek without unduly increasing flood heights upstream, and within which flooding is dangerous to life and property. Areas where flood waters tend to eddy and would not materially help the flow of water through the area would not be included in the floodway.
>
> The three categories of floods have been considered as to their applicability for this purpose. It is believed that the maximum probable flood is too large . . . the maximum flood of record is considered low . . . . The regional flood is considered a more reasonable basis for determining elevations and delimiting a floodway.
>
> . . . .
>
> . . . Assuming that structures and/or earth fills would be built to cover the entire fringe area just outside the floodway . . . the regional flood height for Big Creek would be increased about 2 feet . . . . It is not possible to have a reasonable floodway through LaFollette which would not increase the height of large floods unless the creek channel was widened.
>
> Within the floodway district subdivision of land would not be permitted and all buildings for human habitation would be prohibited. Agriculture, recreation, parking and other open-type uses not damaged by floods would be permitted . . . filling of land would be prohibited.
>
> Outside the floodway all legal uses would be permitted, provided that the first floor of structures is above the elevation subject to flood. Land could be filled or foundations of structures raised to these elevations.[1]

The initiative for the amendment comes from the joint program for flood damage prevention of the TVA and the Tennessee State Planning Commission which supplies professional planning services to LaFollette through the LaFollette Planning Commission. Out of 97 communities with completed TVA flood hazard studies some 25 have already adopted regulations based on these studies and numerous other regulations are in various stages of study or adoption.[2]

Since the floodway amendment is the major form of community action pending before LaFollette the circumstances surrounding the proposal might be examined with some care.

On the surface, it would appear that there is much that would favor its passage. A number of creekside managers expressed strong concern over the alleged encroachment activities of their neighbors. Figure 14 records their attitudes in a generalized diagram. Five of the 13 managers who perceived of the floodway as a flood loss reduction alternative are located at creekside, and include a number of civic-minded and influential men.

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[1]LaFollette Planning Commission, pp. 3-4.

[2]Communication from Local Flood Relations Branch, TVA, July, 1962.

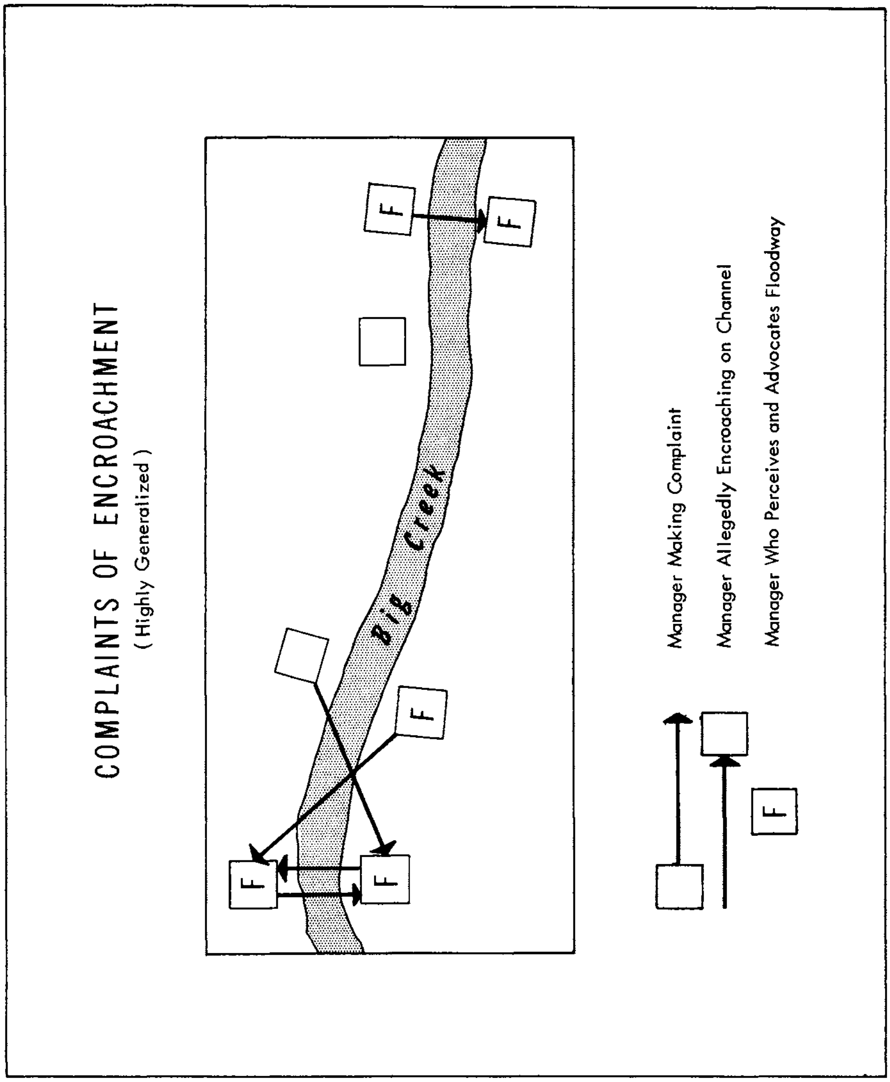
COMPLAINTS OF ENCROACHMENT
(Highly Generalized)
Big Creek
F
Manager Making Complaint
Manager Allegedly Encroaching on Channel
Manager Who Perceives and Advocates Floodway

Fig. 14

TABLE 23

FLOODWAY ATTITUDE AND STRUCTURE DATA

Item	Commercial		Residential		Total	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
Attitudes by floodway respondents:						
Perceive floodway	4	44.4	..	..	4	30.8
Approve floodway	1	11.1	2	50.0	3	23.1
Dubious about floodway ..	3	33.3	2	50.0	5	38.5
Attitude not ascertained.	1	11.1	..	..	1	7.7
Total	9	99.9	4	100.0	13	100.1
Attitudes by non-floodway respondents:						
Perceive floodway	9	14.5	..	..	9	9.4
Approve floodway	28	45.2	22	64.7	50	52.1
Dubious about floodway ..	17	27.4	10	29.4	27	28.1
Attitude not ascertained.	8	12.9	2	5.9	10	10.4
Total	62	100.0	34	100.0	96	100.0
Floodway structure data:						
Structures extending 50% or more into floodway:						
Constructed: Pre-1945 .	5		4		9	
1943-1950.	4		5		9	
Post-1950.	3		1		4	
Total	12		10		22	

The general attitude towards the floodway proposal is also favorable (see Table 23). Although a larger proportion of floodway respondents are dubious over the proposal compared with those whose establishments are out of the proposed floodway, given the small numbers, this proportion is not significant. More important, no substantial overt opposition to the proposal could be found in the entire town. The only case of heated verbal opposition was initiated by the study itself, when one respondent outspokenly in favor of the proposal was shown the map of the proposed floodway. When to his surprise he found that a vacant lot he owned was included in the proposal, he quickly reversed himself. However, despite the unanimous support for the proposal evidenced by influential managers, interviewers found managers alluding to the opposition of others. While ostensibly supporting the proposal himself, each of these managers would attribute opposition to some other, and particularly one who was suspected of having designs on the creek for further encroachment.

Therefore, while the overt opposition appears negligible, the perceived opposition appears large to certain of the decision-makers. Given the political balance outstanding in LaFollette at the time, a perceived opposition, even if not real, is enough to slow down any decision, especially when it concerns a proposal the fruits of which are only tenuous. The tenuous nature of the proposal lies not in its intrinsic merit, for there is strong feeling for preventing encroachment. The uncertainty lies in the previous experience experience with other regulation, in an unsureness whether passage of the ordinance would ever involve effective enforcement or be a paper gesture.

Another simpler explanation as to failure of passage of the proposal favored by some informed persons was that it was merely oversight. As support for this explanation, the study found that a number of officials and others actually thought that the ordinance had been passed. If this simpler explanation is valid, then an external nudge might be all that would be required to secure passage.

Leaving aside the decision-making aspects of the proposal and speculation as to whether its passage would lead to its enforcement, certain beneficial actions have already resulted from the discussion of the ordinance and the presentations of the TVA and the Tennessee State Planning Commission in this regard.

The interest generated at the time led to the temporary withholding of at least two building permits, leading in one case to negotiation that resulted in placing the variety store on piles rather than solid fill, and in the other case to the manager's plan for fill being held in abeyance. In another action, the LaFollette Housing Authority is using the proposed floodway line to guide its construction of a housing project for the aged that will overlook the creek. Thus, while formal passage of the ordinance has lagged and formal enforcement would always be in doubt, the flood hazard report and the floodway amendment proposal would appear to be informal inhibitors to encroachment.

As a final observation on land use in LaFollette it might be noted that, although there has been considerable flood plain expansion in the past decade, the continuance of such in the future would appear to be severely limited by non-flood related considerations. Highway-oriented sites are becoming increasingly attractive to local business men. The shirt factory has concrete plans to move off the flood plain and this would remove the major source of monetary damage potential. The future relative decline of LaFollette would inhibit any considerable economic expansion and the supply of attractive flood plain sites is quite limited.

Flood control and abatement.--The most prevalent method of flood damage reduction is the use of various engineering and land treatment works to restrain or control flood waters.

A comprehensive flood damage reduction program would subject to a variety of economic and engineering feasibility tests the potential of engineering works for reducing flood damages in LaFollette. Practically these would center around an upstream reservoir and a series of channel improvements including the elimination of the bottleneck created by the Central Avenue crossing.

The only actual flood control measures adopted in LaFollette have been the sporadic clearing of the channel. Channel clearing, consisting of bulldozing debris from the rock base, clearing brush, and building up the banks, has been done in 1948, 1951 and 1956. According to local reports $790 was spent on the 1951 work and $960 on the 1956 work. While townsfolk appear to be considerably impressed with the efficacy of such work, TVA data suggest that the effect of such clearing on the 1950 flood would be negligible. In addition to the community sponsored channel clearing, two riparian managers claim that they regularly keep their property free of brush and debris.

Levees have never been seriously considered by many in LaFollette. The old LaFollette Coal and Iron Company elevated right-of-way acts as a partial levee between Central Avenue and Beech Street. (See pattern of 1950 flood on Fig. 2.) The Corps of Engineers Report discusses both levees and channel improvements as follows:

> Channel rectification to the extent which would be necessary appears impractical due to the cost of rock excavation involved and the fact that a number of buildings for which flood protection is desired, would have to be demolished. Protection by means of a system of levees or walls is also considered impractical due to physical limitations of right-of-way. The most feasible method of control seems to be by means of a reservoir above the city.[1]

A reservoir above the city for water supply purposes has been considered in reports by two engineering firms, the present 28-foot dam having proved inadequate. The Corps Letter Report, using data from an early engineering study for water supply, estimated that (in 1961) a dam that might completely control the 1950 flood and pass safely a considerably larger one would cost $1,125,000. Assuming a twenty-year return period for the 1950

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[1]Letter Report on Flood Conditions . . . , p. 3.

flood, the Corps estimated that this project would return but 24 cents for every dollar of cost.

During the period of the study, there was lively interest in a flood control dam as an appendage to a water-supply dam that might be constructed with the help of the Area Redevelopment Administration. However, judging from local accounts since that time this has been dropped and a dam to be built with an A.R.A. grant will provide only water supply storage.[1]

One further action that might be considered to reduce flood damages is the replacement of the Central Avenue Viaduct, the constriction of which in 1950 raised flood heights behind it an estimated 5.5 feet. Although clearly recognized by the townspeople for its constricting effect, and despite major highway improvements in 1961 along Central Avenue, its replacement has never been considered by the State Highway Department which maintains Central Avenue as part of State Route 63. The resident engineer claimed that he had never seen a copy of the TVA Flood Report and showed little interest in its data regarding the viaduct's flood constricting effects, being only concerned with its vehicle-carrying function.

Despite the general reluctance of technical personnel to support flood control and abatement measures, on either engineering or economic grounds, these form the most common alternatives perceived by LaFollette residents. This finding is in keeping with experience across the country.

Table 24 summarizes this perception. One out of every five respondents has taken action, either individually or in a social role to encourage flood control activity. Two out of three respondents perceive the desirability of flood control measures.

The large number of individuals perceiving the desirability of channel improvements appear strongly influenced by what might be called the heightened reality of channel improvements.

Fifteen miles to the south of LaFollette, at Lake City, a recently completed channel improvement project of the Corps of Engineers bears continuous witness to the potential of channel improvement. The dredging of the creek on all three occasions created quite a stir in a town where nothing that stirs goes unnoticed. How impressive this is, was brought home to the study group in the following way. While the study was going on, a riparian manager hired a bulldozer to build up the banks and fill low spots in preparation for more <u>intensive</u> use of his land.

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[1]<u>The LaFollette Press</u>, August 24, 1961.

From that day on respondents cited the bulldozer's operations as a new creek dredging effort that would reduce the flood hazard, when actually the converse is more probable.

TABLE 24

PERCEPTION AND ADOPTION OF FLOOD CONTROL AND ABATEMENT ACTIONS

Actions	Commercial		Residential		Total	
	Number	Per Cent of Respondents	Number	Per Cent of Respondents	Number	Per Cent of Respondents
Individual actions adopted:						
Cleared and cleaned riparian channel	2	3.1	..	..	2	2.0
Contributed financially to channel clearing	2	3.1	..	..	2	2.0
Encouraged and promoted community action in:						
Role as public officials	11	17.2	..	..	11	10.8
Association with public officials	3	4.7	..	..	3	2.9
Urging action by public officials	4	6.2	2	5.3	6	5.8
Total, at least one of above ...	20	31.3	2	5.3	24	23.5
Community actions perceived:						
Channel improvement	46	70.7	14	38.9	60	59.4
Enlargement of Central Avenue Viaduct	15	24.8	1	2.8	16	16.0
Upstream reservoir	14	21.5	1	2.8	15	4.7
Levee	8	12.3	2	5.3	10	10.1
Total, at least one of above ...	52	81.4	16	42.1	68	67.5

Insurance.--From the individual point of view, insurance is an effective way of dealing with flood damages by spreading the risk in time and space. From a national point of view insurance adds to the toll of flood losses,[1] for in addition to the

[1] An exception might be an insurance scheme which was so administered as to encourage the reduction of flood damage potential to the extent that this reduction in damage exceeded the costs of administration.

total flood losses are the costs of management that in the case of fire insurance creates a ratio of premiums to paid losses of 2:1.[1]

Insurance is only obtainable under special conditions. Local insurance agents in LaFollette were ignorant of these conditions and advised clients that insurance was unobtainable. One agent had kept a file of newspaper discussions on flood insurance for several years.

A comprehensive flood damage reduction program might consider insurance for certain managers. Insurance might prove a viable alternative for an extremely large establishment such as the shirt factory or for branch establishments of regional or national firms who might secure comprehensive policies with ease for all branches. Insurance would probably be prohibitive for all other managers.

Despite the difficulty of securing insurance 21 respondents thought they were covered by insurance through their existing policies. Considering the number of managers who shared this misconception up until the 1950 flood, this is a very high figure. The net effect of managers believing they are covered by insurance when they are really not is to reduce the likelihood that such managers would adopt more realistic damage reduction alternatives.

The Perception and Adoption of Alternatives at LaFollette

Three questions should be raised concerning the alternatives perceived and adopted by technical personnel and LaFollette flood plain managers: (1) How does the practical range of choice of technical personnel compare with that of the flood plain managers? (2) Is there any discernible order in the perception and adoption of alternatives? (3) How does the perception and adoption of alternatives relate to the other flood characteristics studied?

The practical range of choice of technical personnel and flood plain managers.--A comparison of the range of choice of flood plain managers and technical personnel suggests important similarities and differences. The major similarity lies in the overlap of such ranges of choice when these are organized under

[1]National Academy of Sciences, National Research Council, Committee on Fire Research, A Study of Fire Problems (Washington: National Academy of Sciences-National Research Council Publication No. 949, 1961), p. 33.

major categories of action. Flood plain managers and technical personnel perceive some variant of alternative in every major class of damage reduction measures.

The main difference lies in the quantity and quality of these perceptions. Among flood plain managers, knowledge concerning alternatives that are perceived as most effective in reducing flood damages by some technical personnel is thinly diffused and its quality is at best sketchy. Thus only a minority of LaFollette managers would bear an expected loss, foresee the substantial gains that might be made by a community flood warning system, the stockpiling of sandbags, the use of the organized manpower and transport of the Rescue Squad, or the enlargement of the Central Avenue Viaduct. Conversely such measures deprecated by technical personnel, as the clearing of brush and debris from the channel, the mistaken belief in insurance coverage, and the efficacy of improvised flood-fighting are held in high esteem by many managers.

Both the perception of technical personnel and respondents are weighted heavily by experience and observation. Technical people draw on the experience of a hundred communities. LaFollette managers draw only on several at best. Professional flood-fighters have seen towns earnestly barricade their doorways with flour sacks and rags, only to be overwhelmed by an additional foot of water. In LaFollette, such action was successful in 1950, and for managers who perceive no larger flood than suffered in the past, these improvised measures are a sufficient solution to an occasional problem.

That flood problems are occasional is at times forgotten by technical personnel who are always preoccupied with some flood problem, somewhere. For many technical people, aspects of flood damage reduction have been the focus of much of their working life and they consistently bring to bear on them all their reasoning powers. In contrast, the flood plain manager only focuses a small portion of whatever bounded rationality he possesses on flood problems. Flood hazard, even when perceived, is but one of a host of problems requiring solution, and except for those moments of disaster, is quickly submerged beneath the requirements of paying the rent or hiring help. The flood of 1950 lasted for two weeks on the pages of the LaFollette Press, yet for technical personnel it is of a genre of concern that finds it the focus of several reports and provides source material for the greater portion of two books.

It is therefore not surprising to note the differences between alternatives perceived by technical personnel and by flood plain managers. Despite the casualness and improvisation employed by managers in searching and evaluating alternatives, one is nevertheless struck by the variety and ingenuity displayed in the process.

The ordering of perceived alternatives.--In reviewing the perception of alternatives, it appears that managers do not perceive a range of alternatives in a random manner, but rather as if such alternatives were spaced along a continuum ranging from no perception to adoption.

Using Guttman scaling techniques, the perception of alternatives appears to pass through a hierarchy of no perception, common perception, uncommon perception, and adoption. The perception or adoption of any one of the grouped alternatives in either its individual or community variants advances an individual's ranking on the scale. The path an individual respondent might choose to obtain such ranking is shown on Figure 15 along with the numbers of respondents that qualify at each stage.

A scale implies a hierarchy of values, that is, an individual who adopts an alternative also perceives at least one common and one uncommon individual or community alternative. It should be noted that within each group of common or uncommon alternatives, all are considered equal, that is, the perception of a channel improvement is neither higher nor lower on the perception scale than the perception of a levee. A further assumption is that individual and community variants are also equal and an individual might perceive, for example, a common individual variant and an uncommon community variant.

The test of a scale is the ability to reproduce the individual's characteristics from its final score or classification. In this scale an individual who is an adopter must possess at least one common or uncommon perception, and uncommon perceivers must have at least one common perception. If they do not, then in the practice of scaling they are in "error."[1] There are six

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[1] A few notes concerning scaling may be in order. Each classification of a respondent might be considered as a score ranging from 0,1,2,3--and 3 representing adoption. A score of 3 would then indicate or reproduce the other items leading to adoption--a common perception or an uncommon perception. The coefficient of reproducibility is a measure of the success one would obtain by reproducing the components of perception-adoption from the final score. For the LaFollette data it is 96.1%. This is quite high and should be interpreted in the light of two other considerations.

First is the construction of the scale itself. Anyone who had installed a structural change provided prima facie evidence of perceiving structural change. There are nine individuals who only qualified as adopters in this manner, and for these, they scale correctly by definition.

Secondly, all coefficients of reproducibility should be

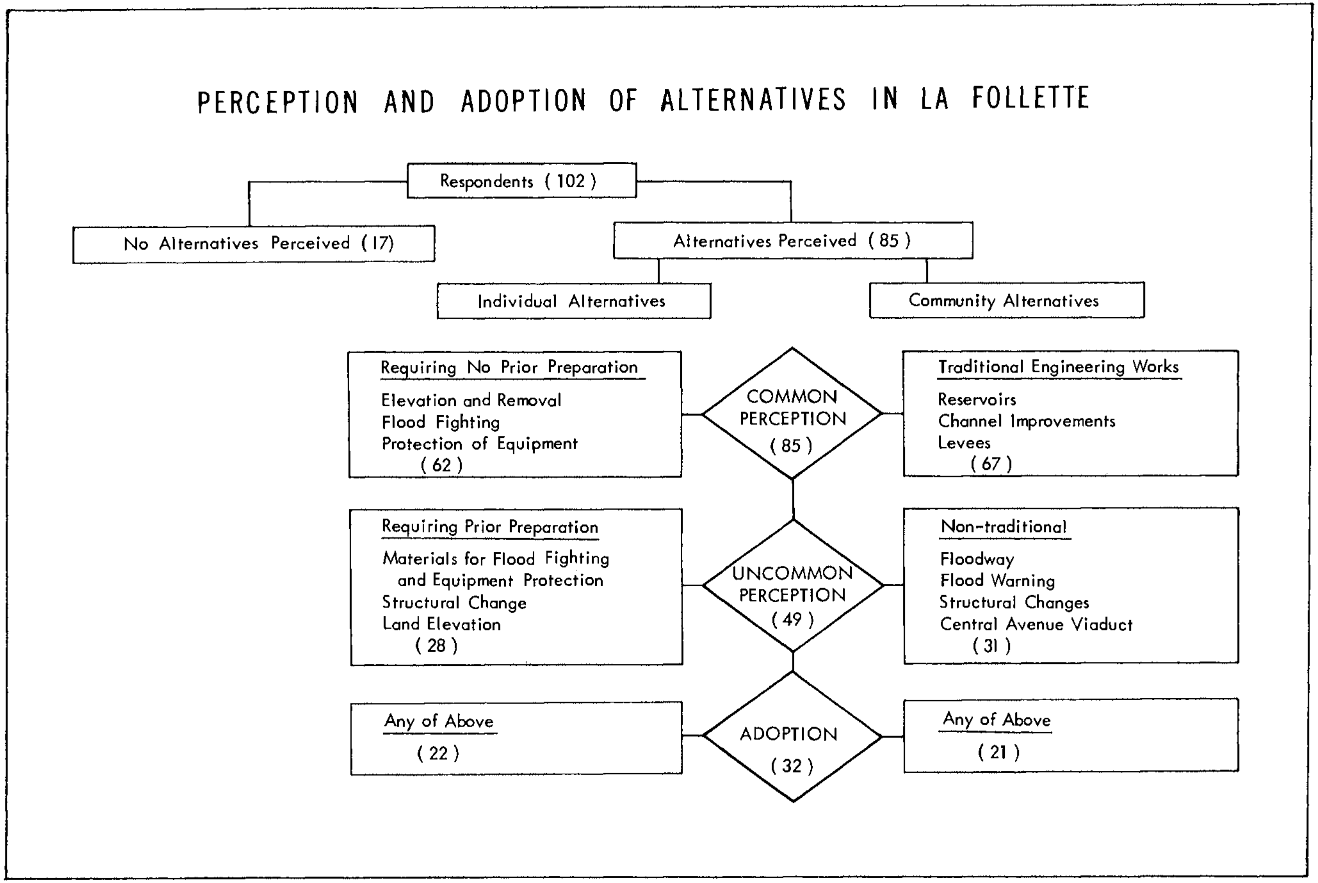
PERCEPTION AND ADOPTION OF ALTERNATIVES IN LA FOLLETTE
Respondents (102)
No Alternatives Perceived (17)
Alternatives Perceived (85)
Individual Alternatives
Community Alternatives
Requiring No Prior Preparation
Elevation and Removal
Flood Fighting
Protection of Equipment
(62)
COMMON PERCEPTION (85)
Traditional Engineering Works
Reservoirs
Channel Improvements
Levees
(67)
Requiring Prior Preparation
Materials for Flood Fighting and Equipment Protection
Structural Change
Land Elevation
(28)
UNCOMMON PERCEPTION (49)
Non-traditional
Floodway
Flood Warning
Structural Changes
Central Avenue Viaduct
(31)
Any of Above
(22)
ADOPTION (32)
Any of Above
(21)

Fig. 15

respondents with error, five of whom are residential respondents. This reflects the weakness of applying the scale to residential respondents. For example, unlike the commercial respondents, the elevation and removal of goods would be an uncommon perception for them.

It is not, however, the ranking of the alternatives themselves in a hierarchy that is important but the existence of the scale itself. It implies that managers who are adopters have not become so without a more intensive canvas or awareness of alternatives and that they possess a wider range of choice. Of the 46 respondents who perceived at least one uncommon alternative, 31 went on to become adopters. This may be compared with the 43 respondents who perceived only common alternatives, and only 3 of whom became adopters.

<u>The relationship of perception-adoption to previously studied flood characteristics</u>.--Adoption, which represents the higher end of the perception-adoption scale, is also associated with various flood characteristics that have been previously studied. These are summarized in Table 25.

The adoption of an alternative is associated with the expectation of a flood in the future, and its related variable of interpretation. The low values of Ø indicate that the relationship is weakened considerably by the substantial number of non-adopters who expect a flood and a much smaller number who don't expect a flood because of the perceived effectiveness of their adopted alternative. Adoption is not significantly associated with experience, although most adopters have had experience.

Adoption is associated with a number of minor variables, minor in the sense that only a small number possess these characteristics. Recalled knowledge of the TVA report and of $150 or more flood damage is associated with adoption but an above average score on the flood concern test is not.

<u>Perception and adoption in LaFollette, a summary</u>.--In LaFollette, while many managers might bear a loss, less than 40 per cent actually expect to bear future losses.

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compared with a measure called minimum marginal reproducibility which for this data is 67.6%. This means that if instead of the individual scores, only the modal frequency of yes or no for each class was used to predict the components for every individual, then this would insure 67.6% correctness. Thus the difference between the minimum reproducibility and the coefficient of reproducibility is a measure of the gain to be gotten by using an individual's score as a predictor, the gain coming in part because of the effect of the scale.

A more lucid discussion can be obtained from Allen L. Edwards, <u>Techniques of Attitude Scale Construction</u> (New York: Appleton-Century-Crofts, Inc., 1957), pp. 184-197.

TABLE 25

FLOOD CHARACTERISTICS ASSOCIATED WITH THE ADOPTION OF SOME FLOOD DAMAGE REDUCTION ALTERNATIVE
(2 x 2 Contingency Tables)

Characteristics	Significance Level	Value of Ø
Major characteristics:		
Affirmative future flood expectancy.	.001	.35
Flood interpretation of floods constant or increasing in time	.02	.25
Flood experience	Not significant	
Minor characteristics:		
Recall damage in excess of $150	.001	.33
Recall having seen TVA report	.001	.33
Evidence above-average flood concern	Not significant	

Many managers learned in the course of the 1950 flood that it was possible to keep water out of buildings by improvised emergency measures and that losses could be reduced in others by the elevation and removal of goods. However, with some exceptions, they have given little thought to the possibility of a future flood in which such measures might prove ineffectual. Residential managers have done even less, their prime concern being to leave the premises in case of flood. The potential for an organized warning and evacuation service in LaFollette is not perceived by respondents.

Similarly, while some managers have adopted a variety of minor measures designed to reduce flood damage by structural and land elevation changes in their establishments, none share with technicians the more recent sophisticated techniques of flood proofing.

In changing land use, the direction has been mainly towards increasing flood damage potential, although the first steps have been taken toward regulation.

The most popular alternative would be some community sponsored flood control activity. This feeling is not shared by technical personnel either on engineering or economic grounds or both. Insurance is actually non-existent, but the illusion of being covered by insurance is fairly widespread.

There is a clear order in the perception and adoption of alternatives. Managers who adopt some alternative would appear to possess a wider range of choice than the manager who does not. They are also more inclined to expect a future flood and to interpret floods in such manner as would lead them to that expectation.

The Perception and Adoption of Alternatives at the Reconnaissance Sites

The abbreviated interview used at the reconnaissance sites does not permit the delimitation of the entire range of choice. However, an attempt was made to classify those adopted and perceived alternatives that were recorded for each respondent on a fourfold scale as in LaFollette but in terms of the particular range of choice that would appear to be practicable for these areas. This is presented on Table 26 and has been shown graphically on Figure 8.

TABLE 26

DISTRIBUTION OF RESPONDENTS ON SCALE OF PERCEPTION-ADOPTION OF FLOOD REDUCTION MEASURES AT LAFOLLETTE AND RECONNAISSANCE SITES

Sites	None		Perceived				Adopted	
			Common		Uncommon			
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Darlington, Wisconsin	..	..	..	..	2	15.4	11	84.6
Aurora, Indiana	..	..	..	..	..	..	15	100.0
LaFollette, Tennessee	17	16.7	36	35.3	17	16.7	32	31.4
El Cerrito-Richmond, Cal..	5	50.0	3	30.0	1	10.0	1	10.0
Watkins Glen, N.Y.	1	12.5	5	62.5	1	12.5	1	12.5
Desert Hot Springs, Cal...	11	73.3	2	13.3	1	6.7	1	6.7

A survey of the kinds of alternatives adopted at the various sites, while lacking the detail of the LaFollette data, might prove useful.

Aurora, Indiana.--The outstanding and effective flood damage reduction alternative in Aurora is the widespread and elaborate elevation and removal of goods, furnishings, and the like. Respondents, when quizzed as to how high a serious flood would have to come, reply that they are more concerned with time than with height. Given enough time, they felt prepared to cope with any size flood below second floor elevation. The second floor elevation is crucial, for many managers commonly elevate to the second floor.

Structural changes observed include the raising of floor levels, use of water-resisting floor materials, sump pumps, and back-up valves.

Near Aurora is Lawrenceburg, a town protected with a ring levee. Aurora had been studied for a similar levee project but failed to pass the test of economic feasibility. While some younger respondents perceived levees as a viable community alternative, the memory of the levees that failed at Lawrenceburg in 1937 is still strong. The interviewers encountered a considerable skepticism as to the value of levees, bordering on a "leveephobia." Given the limited number of respondents, it is only speculation as to how widespread are such feelings. However, residents at Aurora might reasonably be willing to suffer the greater frequency of flooding rather than hazard the danger of a rare catastrophic event caused by the overtopping of a levee.

Darlington, Wisconsin.--Flood plain managers at Darlington also make common use of emergency measures of elevation and removal. However Darlington cannot avail itself of the developed Ohio River forecast system, as Aurora does, so it has with some pride developed a local warning system in conjunction with the Weather Bureau. Expected warning is 6 to 8 hours and local managers have informal plans for the elevation and removal of goods and furnishings. Tanks at the bulk oil plant are kept reasonably full and vats at the creamery are filled to prevent flotation.

Permanent structural changes in the form of floor and stock elevation are common. The local auto dealer maintains flood insurance on his stored vehicles; sump pumps and sewer valves are common. Considerable interest has been generated in flood control but a feasible levee plan of the Corps has met with only limited interest. The Soil Conservation Service has upstream work in progress and some managers see in this rather than in a levee, hope for reducing damages. Others do not want to see any part of the relatively narrow flood plain sacrificed for levees and still others may oppose the levee for reasons similar to those of respondents in Aurora.

El Cerrito-Richmond, California.--El Cerrito-Richmond presents the contrast of the widespread failure of residential respondents to adopt flood damage reduction alternatives and the complex system of adjustments installed by the leading industrial flood plain manager, appropriately a manufacturer of pumps. This complex of adjustments includes (1) a retaining wall, (2) sandbagging, (3) plant fabricated redwood bulkheads with rubber seals for all major doors, (4) permanent elevation of all materials subject to damage, (5) mobile and permanent sump pumps that can be operated under flood conditions to control any seepage, (6) outlets for all internal drainage elevated above flood levels, (7) annual inspection of all emergency and structural measures. The type of adjustments adopted for the plant represents a national policy, and the bulkheads were originally designed for the St. Louis plant, which was inundated at one time by 40 feet of water.

Having failed to qualify for protection by a federal project, the community has done a certain amount of work in clearing brush from the channel and building an intermittent foot-high asphalt embankment.

Watkins Glen, New York.--Except for one installed sump pump there were no alternatives adopted by the respondents in Watkins Glen.

Most of the community perceived itself protected by the levees and concrete cribbing along the creek. None of the managers appeared to be aware of the internal weakness of the earthen levees which are actually spoil heaps. The only respondent concerned with the conditions of the levees at all was bothered by their unsightliness as a background for her flower garden.

Desert Hot Springs, California.--Here, too, perception and adoption is almost non-existent. The only alternative adopted was the reported elevation and landscaping of a new home so as to facilitate drainage.

The main portion of the town is partially protected by a concrete lined flood control channel designed to bypass the town with the runoff from Blind Canyon. In addition, as a conscious process, the asphalt streets are constructed with high crowns, deep gutters and with slope conforming to the alluvial fan in order to facilitate runoff.

The perception-adoption scale and the certainty-uncertainty hypothesis.--The data in Table 26 and the descriptive material just presented indicate that levels of adoption appear to respond to greater certainty and to shrink as uncertainty increases. The only anomaly, the low number of adopters at El Cerrito-Richmond is the result of the failure to include the industrial plants in the formal interview. For towns of intermediate certainty such as LaFollette or El Cerrito-Richmond, the hypothesis would suggest that examples of adoption of elaborate alternatives for flood damage reduction would exist side by side with establishments whose managers perceive few, and adopt even less, alternatives. This is certainly the case at El Cerrito-Richmond.

Decision-Making and the Perception and Adoption of Alternative Flood Damage Reduction Actions

What generalizations about decision processes might be made from this review of perception and adoption at the six towns?

Rationality in flood plain management.--The evidence overwhelmingly bespeaks a boundedly rational decision-making process once the analyst frees himself from the assumption that common knowledge of past floods means expectation of future floods, and that the expectation of future floods implies the expectation of bearing a loss. It is only in areas of high certainty that there is widespread expectation of bearing a future loss and because flood plain managers are rational they do something about it. In areas of intermediate certainty probably no more than 40 per cent of the managers actually expect to bear a future loss (for all the involved reasons that have been presented), but these managers also appear to do something about it. Therefore, the first generalization that emerges from the study is that those managers who actually expect to bear a future loss try to do something about it.

The prison of experience.--However, the urge to do something about the flood may not be fully realized, being limited by the bounds of a manager's rationality. The outstanding limit to his rationality, that is, the choice of the best means of reducing his expected losses, is that he is a prisoner of his experience. (Here experience is being used in an expanded sense, including the experiencing of a flood as well as the events surrounding it.) First, his expected losses are products of his experiences, few managers showing any ability to visualize losses or floods greater than commonly experienced. Secondly, much of human response to flood hazard reflects a satisficing or learning process. If experience has shown that rags and flour sacks keep the water out, they will suffice again. It is only in areas of great certainty, where elaborate adjustments have evolved by repeated experiences, that one feels that experience has been not a prison, but a teacher. There, if engineering works are rejected, the choice lies in a risk preference for the more frequent but less ambiguous risk. Everywhere else the predominance of personal experience acts as a prison, denying to flood plain managers the accumulated experience of other managers in other places.

Latent opportunities and the atrophy of time.--Except for areas of high certainty, it is only at the moment of flood and shortly after that the full attention of the manager is brought to bear on the flood problem. The atrophy of interest in flood damage reduction alternatives with time from the last flood is a well known phenomenon to technical personnel and politicians. However, the data also suggest that despite the atrophy of intense interest, there is a considerable latent interest that is willing to seize opportunities long after a passage of a flood to reduce personal hazard, when those opportunities are either self-perceived or brought to the manager's attention.

Most of the structural changes appear to come about in that manner. An old building may not be elevated, but when a new addition is constructed another foot of fill is added. Normal remodeling provides new opportunities for flood damage reduction. An expansion provides the opportunity for a complete internal reorganization of stock.

It should also be noted that these latent opportunities in no way reflect optimal adjustments. One foot is a convenient number and three structures at different sites in LaFollette were elevated one foot despite the variation in hazard. The latent opportunity is seized upon, but in a casual manner almost as an afterthought.

<u>The use of economic criteria in the flood hazard evaluation process</u>.--An initial hope of the study was to provide further insight into the role economic criteria play in individual decision-making, in view of their important role in community decision-making through the benefit-cost ratio. The findings to date are mixed and inconclusive. No evidence was uncovered in the study that indicates a responsiveness in land values or rents toward flood hazard. In LaFollette rent might actually show an inverse trend increasing with flood hazard. Where expenditures for flood damage reduction have taken place these have been modest and with little sign of maximizing benefits in excess of cost.[1] Lastly, the decision to locate seems little affected by flood hazard information.

On the other hand, there is evidence that monetary damages do affect the adoption of flood loss reduction alternatives. Where <u>perceived</u> future losses or <u>experienced</u> past losses are great the

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[1]Here might be noted a question raised by a number of scholars. How does one tell <u>ex post</u> that a manager has not attempted to "maximize" albeit <u>ineffectually</u>, because he lacks skill, information, or foresight? In reply it may be stated that while the admittedly meagre findings do not preclude the judgment that less-than-optimal actions are really unsuccessful optimally-intended actions, neither do they encourage the view. Quite relevant are the instances where managers considering or having just considered flood loss reduction measures showed little interest in the improved flood hazard data proffered to them by interviewers.

motivation for expending money and effort in reducing future damage is stronger and there is an association between substantial past damage and flood damage reduction activity.

Kates, R. W., 1962, Hazard and Choice Perception in Flood Plain Management, University of Chicago, Department of Geography Research, Paper No. 78.

CHAPTER VI

INFORMATION AND DECISION-MAKING IN FLOOD DAMAGE REDUCTION

Having run its course of interviews, observations and miscellaneous data, this final chapter comes full circle, reconsidering in the light of the findings decision-making and the role of information in individual flood damage reduction. But first an attempt will be made to answer a basic question.

Why Do They Live There?

Almost anyone who has studied flood problems has been asked, usually informally, the perennial query, "But why do they live there?"

The question ought not to be taken at face value. People live and work in flood plains for a variety of locational reasons including certain intrinsic advantages to flood plain location. Therefore, the question might better be rephrased as follows: "Why do people persist in living and working in areas subject to repeated floods?"

This study has provided raw material with which to undertake an answer. It has found that people persist in areas subject to flood hazard for any of the following reasons:

1. They do not know about the flood hazard and are therefore not unduly concerned.

2. They know about the flood hazard, but personally do not expect a future flood, and therefore are not unduly concerned.

3. They expect a future flood, but do not expect to bear a loss, and are therefore not unduly concerned.

4. They expect to bear a loss, but not a serious one, and are therefore not unduly concerned.

5. They expect to bear a serious loss and they are concerned. Therefore they have undertaken or are planning to undertake some action to reduce such losses.

The first four states lead managers to ignore rationally flood hazard despite the opinions of technical personnel or even repeated flood experiences. The fifth state in which managers are found leads to their taking action to reduce the flood hazard.

However, such action may be casual, improvised, ineffective, and far from optimal.

This is a major finding of the study. In the face of community knowledge and experience, there is a variety of personal perceptions of hazard and potential loss that rationally leads managers to ignore flood hazard.

A second major finding is that there is strong evidence for an underlying orderliness in the proportions of managers that hold a particular perception in any small urban area. It seems likely that a certainty-uncertainty scale, measuring in part the perceived frequency of flooding at a place, accounts for this observed order.

In areas of high certainty, both the expectation of bearing future losses and the perception and adoption of alternatives to reduce such losses are widespread. In areas of lesser certainty, knowledge of a past flood might be widespread, but only a minority would expect to bear a future loss, and fewer still a serious loss. Finally in areas of great uncertainty, any knowledge of floods (and certainly the heightened sense of bearing a future loss) might be absent among managers.

Thus the answer to the original query, "Why do they live there?" will vary from place to place. In Darlington one could answer that people persist in living there because, having recognized the potential for serious loss from repeated flooding, they have evolved a satisfactory series of adjustments to reduce such losses. In Watkins Glen the answer might be that managers do not expect a future flood. In El Cerrito-Richmond a complex answer would be required. Some managers don't know about floods, others don't expect to bear a loss, and at least one who is quite concerned has effectively protected his establishment against most floods.

Decision-Making by Flood Plain Managers

The attitudes and behavior of flood plain managers now may be examined in the light of the major assumptions of decision-making analysis that were discussed in the second chapter.

The rationality of man.--Almost all the findings confirm the *a priori* assumption of a boundedly rational man. This rationality is not overly impressive, being contained by the limits of a manager's experience and leading to less than optimal behavior.

Rational behavior appears to be weakened according to the location of a place on the certainty-uncertainty scale. The tendencies for differences of personality to create behavioral differences is most pronounced in areas of intermediate certainty. An example might be those respondents who for a variety of motivations deny to a flood the characteristics of a real flood. In areas of high certainty, each new occurrence would make such a denial more difficult. In areas of uncertainty there may not be any known floods to which characteristics might be denied.

Processes of choice.--Following from the boundedly rational behavior observed in this study, the most common choice mechanisms appear to be conscious ones. However other processes are present. The response to frequent flooding in Aurora or Darlington almost appears habitual. There is also a minority whose reactions to flood hazard might result from an unconscious choice process related to a need to eliminate that which is uncomfortable and threatening from their world.

In ascribing such unconscious processes to a minority, the study does not ignore the many managers who share in a desire to bring order to their future and eliminate uncertainty. However, in most cases such desires are in accord with both the common experience and knowledge, and the conscious goals of the possessors of technical knowledge as well and does not lead to the denial of unpleasant facts.

The conditions of knowledge.--The conditions of knowledge under which resource management decisions are made are traditionally distinctions between known and unknown probability distributions described as certainty, risk, and uncertainty. For those familiar with these concepts flood hazard is usually considered a risk. It is a hazard with a known probability distribution. In the light of this study, the assumption is questionable. It would be better to think of flood hazard as lying somewhere between risk and uncertainty, that is, as having an ill-defined probability distribution best described within a range.

If on careful scrutiny flood hazard is closer to uncertainty than to risk, only a minority of managers appear to behave as if they operated under such a condition of knowledge. This minority finds flood hazard actually less risky, and closer to certainty, than the conventional assumption of the economic analyst. They do this by perceiving nature in a deterministic fashion, being oblivious to the independence of flood events, and failing to perceive the probability of floods occurring which are much greater than recent common experience.

Thus both engineers, economists and flood plain managers appear to ignore some of the uncertainties of flood hazard; the former for the practical needs of their analyses and the latter for what appears to be a conscious effort to order their environment in a deterministic and comprehensible way.

A second concern related to the conditions of knowledge might be recalled: the variation of information within a community of individual managers. Again, the findings in LaFollette and the other sites suggest the influence of the certainty-uncertainty scale, with the variation greatest in areas of intermediate certainty.

The improved quality of information is exemplified by possession of a broader range of choice that is loosely scaled and increases in complexity up to the adoption of some flood loss reduction alternative.

In terms of broad alternatives flood plain managers share between them as wide a range of choice as possessors of technical knowledge. However, no single manager would perceive all the possible alternatives and in general the quality of such perceived alternatives is of a lower order than the technical perception.

Evaluation criteria.--It has been difficult to define the evaluation criteria used by managers to choose between alternative loss reduction measures. There is no simple format or set of rules.

At best it might be said there are few signs of conscious optimizing or maximizing, and the consistent application of any economic criteria is in doubt. Alternatives adopted under the momentary stress of a flood can be described by Simon's satisficing. After repeated experiences, a stable habitual series of adjustments appear to be evolved.

Decision-making analysis in resources management.--All decision-making analyses suffer from the need to abstract the decision process from the context of daily life and being ends-means schemes tend to simplify real life situations. The ends of one endeavor are the means of another and frequently means become ends in themselves. For flood-loss-reduction decisions such problems make it extremely difficult to make meaningful analysis. Except for the short period in which a flood occurs this entire area of decision-making is relegated to minor status.

Many areas of decision-making in resources management are similar. Most resource activities might be broken up into components that would appear to be minor when considered individually and yet whose sum is a major livelihood activity.

In considering the utility of this type of analysis, it must be judged finally by its results--the degree to which it has helped illuminate the process of resource use. If new and valued insights have been derived then despite conceptual problems of application it is a useful approach, having focused on aspects of resources problems too frequently ignored in other types of analysis.

The types of perception described in the previous paragraphs are derived from a description of the behavior and attitudes of flood plain managers. But the world in which flood plain managers make decisions is not a static one. A host of factors change. The perceived frequency can change dramatically with the occurrence of a series of floods in rapid order. The perceived utility of flood plain land might change; witness the interest in evacuating the flood plain at LaFollette to secure a highway oriented location. The social rules with which decisions must conform might change, or the information upon which such decisions are based. It is to the last factor to which the following will be addressed.

Information and Human Adjustment to Floods

In the light of what has been learned of decision-making in urban flood plains it may be asked what effect improved information might have on managers' actions to reduce flood damages.

An improved information program would share with flood plain managers the best information that men possess concerning the flood hazard of the area in question and the possible adjustments to it. It is the writer's conclusion that the yield from such a program in terms of managers taking individual actions to reduce flood losses would be negligible in the face of the rapid increase of damage potential.[1] For on close scrutiny, it appears that the information would be least accurate in the area where the greatest opportunities for damage reduction exist and even foregoing accuracy, managers may not be able to use the information.

Flood frequencies.--This study has included a series of examples illustrating various approaches taken by technical personnel to flood frequency analysis. All such analyses suffer the limiting effects of small samples of extreme events. In the range of probabilities smaller than .02 or .01 these limitations become aggravated and the variance of probability estimates becomes so large as to cause great difficulty in interpretation. Yet floods having these probabilities are those that Holmes identified as

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[1]This conclusion refers to a program of improved flood hazard information. Most persons concerned with the rising toll of flood damages view improved hazard information as but one item in a comprehensive program of community and individual activity.

contributing some 50 per cent of all flood losses.[1]

Further, even if frequencies had a higher order of accuracy than they now possess, there is considerable doubt as to their utility in their present form given the fact that they are based on long-run averages, while individual short-run use of flood plains is the predominant occupance.

The prison of experience.--A major limitation to human ability to use improved flood hazard information is the basic reliance on experience. Men on flood plains appear to be very much prisoners of their experience, and the effect of such experience is not consistently in the direction of taking individual action to reduce flood damage.

Improved flood hazard information would include data on floods greater than those flood plain managers have experienced. The observations in LaFollette and elsewhere suggest that managers have a great deal of difficulty conceptualizing and acting upon this information.

Floods need to be experienced, not only in magnitude, but in frequency as well. Without repeated experiences, the process whereby managers evolve emergency measures of coping with floods does not take place. Without frequent experience, learned adjustments wither and atrophy with time.

Conversely, limited experience encourages some managers to feel that floods are not so bad after all and they lose their motivation to seek further for alternatives. With limited experience, other managers appear to decide that they have received the flood that nature has had in store for them and that they will not have another flood for some time.

Recently experienced floods appear to set an upper bound to the size of loss with which managers believe they ought to be concerned. Since much flood damage is caused by floods greater than have recently been experienced, this experience serves to negate the effect of improved information that seeks to expand the expectation of the flood plain manager.

The simplification of choice.--Compared to the kinds of information that managers presently use in LaFollette and elsewhere, improved information will be considerably more complex. Yet both managers and technical personnel share in the widely observed need to simplify choice processes. Whether such action is thought of as simplifying, abstracting or constructing models, it usually results in the boiling down of masses of information and the reduction of a large number of choices.

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[1]Holmes, p. 17.

This tendency works adversely on flood hazard information in several ways:

It may emasculate flood hazard information by so simplifying it that the very qualities that provide the improvement are removed. Complex data, when reduced to essentials, might provide little improvement over what was previously known.

More commonly it might cause managers to abdicate all individual decision-making and "leave it to the experts." Faced with a need to simplify for himself complex data that he feels unable to understand or that leaves him confused and uncertain, a manager might find himself unable to take any individual action based on such information.

Of course improved information does not have to imply more complex information. The process of simplification can be done by technical personnel. Continuous functions can be made into discrete choices. Arbitrary or intuitive risk levels can be chosen. An average of contrasting frequency estimates can be used. However, when this is done by technical personnel, and it is being done, a new element has been introduced into individual decision-making. Technical personnel of public agencies, unlike private consultants, are guided by what they perceive as broad community requirements. They interpose their judgment into the decision process. The judgment is related to the perceived long-range needs of the community and may not be in the best short-run interest of a particular individual decision-maker.

When the TVA offers communities data on three groups of floods, having distilled these from a mass of collected data, these levels might actually be quite unsuitable for use by an individual decision-maker planning to take action to reduce his flood losses.

The need to simplify the world in order to deal with it can also lead to distorting the content of information as well as removing detail. Flood plain managers are more prone to doing so than technical personnel who seem to have a higher tolerance for uncertainty. For some managers, a belief that floods come in cycles reduces an uncertain world into a more predictable one. They might be expected to develop interpretive mechanisms that would enable them to transform any hazard information by selective abstraction into a buttress for their existing belief. Managers in LaFollette appear to do this with their observed experience and might find it even easier to do so with information conveyed by maps or printed word.

<u>The effect of the certainty-uncertainty scale on information.</u>--All the previous tendencies that lessen the utility of

information are aggravated in areas other than those of certainty. But it is in areas of certainty like Darlington and Aurora that managers actually have a reduced need for additional or improved information to encourage them to take individual action to reduce flood damages. Such actions are already highly developed. In the other areas, where the opportunity to reduce flood damage is greatest, the inaccuracies of the data, the restraint of experience, and the need to simplify choice, all act to reduce the effectiveness of improved flood hazard information.

Improving the effectiveness of information for individual flood damage reduction activity.--Despite the general gloomy conclusion about the effect of improved information inducing individual flood damage reduction actions, a number of insights were obtained in the study that point to minor ways of increasing the effectiveness of such data.

A major consideration in the presentation of flood hazard data might be to ask how such data might enlarge the prison of experience and make more real the experience of others.

The approach that the TVA has evolved along these lines has much to recommend it although subject to criticism on other grounds. For the people of the Valley, many still with strong ties to the land, pointing out floods that have occurred on such and such a creek can be quite effective. For the new urbanite, with creeks buried beneath a maze of concrete, making real any flood experience other than his own becomes a difficult task.

This task is complicated by the lag between peoples' perception of a more real past and the realities of the present day. The great floods of the depression era still provide the basic reference for a flood perception which is perpetuated by the use of rural-oriented books and films in present-day conservation education or by such venerable and moving products of that era as the Pare Lorentz film, "The River." The complexity of water management problems posed by any metropolitan area is of a different qualitative order than the popular image of flood problems.

With its accent on forested uplands, great engineering works, and the like, the perception of the great river flood can only serve to discourage individual action to reduce flood damages.

Flood hazard information could seek to change this perception--to focus on the tributary streams of the nation where damage potential is being spurred by the suburbanization of both residence and industry and is very much the product of individual locational decisions.

The actions taken by managers in LaFollette to elevate sites or make structural changes long after the 1950 flood suggests that a neglected opportunity for flood hazard information might be to seek to exploit the latent opportunities for flood damage reduction that expansion and remodeling present.

On one level, detailed technical data might be channeled into professional architectural and construction activities. On another level, popular material can be made available to lumber and building supply dealers, the how-to-do-it magazines, newspaper columns and the like, introducing simple practices designed to reduce flood damages and to be undertaken when remodeling or new construction is being planned.

A further opportunity to make information more effective might be to help dispel the widely held illusion that comprehensive household policies insure against flood losses, while conversely making known the actual opportunities that do exist in obtaining insurance.

The three suggestions cannot result in any massive activity to reduce flood damages by individual action. The leadership, encouragement, and mandate to reduce flood damages must come primarily from the community and there is a considerable distinction between private and community decision-making.

This study has been preoccupied with individual decision-making. Individuals play a social role as well as having a private life and their social role in the community has been a part of this study. However the writer is convinced of a deep hiatus between individual and community interest. The calculus of individual decision-making when summed over all the individuals in the community does not equal the costs and benefits (in their broadest sense) of the community. In this case the whole is not equal to the sum of its parts.

Three reasons might be suggested for this state of affairs:

1. Spillover effects or social costs and benefits that cannot be allocated or captured by the market may not be reflected in individual decision-making.

2. Substantially different probability distributions of risk exist for communities and individuals. The mobility and short planning horizons of individuals provide for the lower probabilities of discrete flood events. An individual's probability is compounded of the probability of his being on the flood plain and the probability of there being a flood.

3. Communities are subject to a political process that creates demands on the community for flood protection on the basis of considerations that individuals making such demands would not employ themselves. Individuals demand flood protection that they

are unwilling to pay for directly, or even indirectly through their local community. Such demands are perfectly rational from the individual point of view as the cheapest means of protecting one's self from flood losses. For the citizens of the national community they might prove to be a costly and uneconomic means of dealing with the problem.

Therefore a community might be motivated to seek flood damage reduction alternatives, not because the toll of individual flood damages seriously places a burden on the community, but because they give rise to irrational demands on the part of the individual members to have the community provide protection all out of keeping with the magnitude of the losses.

There are other distinctions between the stance upon which community and individual decision-making rests, but these will suffice to warn the reader not to extend any conclusions derived from a study of individual decision-making to flood loss reduction for the community as a whole.

In the last analysis, there is a justification for better information not contingent upon the reduction of flood losses. It would follow from a philosophy of an open society that no citizen suffer an unexpected loss if the opportunity for informing him is available. It may be an act of faith to feel that information, even if not suitable for flood loss reduction, will in the long-run contribute to a more informed community decision-making. If it is an act of faith, it is one the writer feels little need to apologize for. Despite the limits of human ability to handle certain levels of information, as a society we should aspire to an ever-increasing ability for rational decision-making. However, information that frankly acknowledges some human limits and seeks to relate to this frailty would probably prove most effective.

And so full circle is reached. The paradox of rising damages with increased flood control with which this study began will probably exist for some time. It is not a major problem as problems go--the catastrophe of floods and the magnitude of flood control expenditures are dwarfed by the accepted realities of the nuclear age. Yet in the need for new approaches, insights, and actions, it is symptomatic of a variety of resource problems accompanying the increase of man's numbers and the spread of his works.

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APPENDIX

COMMERCIAL QUESTIONNAIRE

1. How long have you been connected with this business establishment? ________ years
2. What is your exact position in this business? Owner ____ Owner-Manager ____ Manager ____ Other ________ (specify)
3. Did (the owner) (you) start this business at this location ____ Move it from some other ____ Or (purchase) (rent) it already established here? ____
4. Why (did you) (do you think the owners) (start) (move) (buy) the business at this location?

   Accessibility to: customers ___ passers-by ___ delivery ___ linkage ___ economics ___ status ___ Other ________________
5. What do you think are the advantages in using the building or the store itself?

   Construction ___ appearance ___ in-out ___ Space: selling ___ storing ___ display ___ other space ___ economics ___ equipment ___ Other ________________
6. What do you think are the disadvantages to doing business at this location?

   Poor accessibility to: customers ___ passers-by ___ delivery ___ poor linkage ___ economics ___ low status ___ Other ________________
7. What do you think are the disadvantages in using the building or the store itself?

   Poor construction: ___ poor appearance ___ in-out ___ Lack of space: selling ___ storing ___ display ___ other space ___ Economic: Poor equipment ___ Other: ________________

(ALL QUESTIONS ARE ASKED UP TO THIS POINT)

(If floods are mentioned pass on to)

8. Do you have any special problems with your business location?

   ____

   (If floods are mentioned pass on to)

   What days of the week do you get your largest amount of business?

   What seasons of the year do you get your largest amount of business?
9. Does the weather interfere much with business?
10. Is this tornado country?
11. What about rain?
12. Do you have any floods?
13. Have you had any floods while you have been in business here?
14. What was the worst flood that you have experienced in the course of your (living here) (business experience here)?

Probe:

Key Items: Month _____ Year _____ Ht. in street _____ Ht. in basement _____ Duration _____ Hrs. Ht. 1st fl. _____ Damage description: _____

15. Have you experienced any other floods at this location?

Probe: (as in question)

16. Have you read, heard, or learned about any others in this neighborhood?

Probe: Year, description

17. Have you been through a flood elsewhere?

Probe: Year, location

18. Do you think that you will have, or there will be, another flood while you are (in this business) (living) here?

Probe: Why?

19. Do you know of anything being done to reduce flood damage?

Channel: _____
Reservoirs: _____
Levee: _____
Investigations and surveys: _____
Land regulations: _____
Local citizen or gov't. action: _____
Other: _____

20. Have you done anything about it? (averting danger or reducing damage)

Volunteer work (physical) _____ Structural changes _____ Discussion: _____ Leadership _____ Agitation _____

21. Do you know of anybody who has investigated the flood situation?

Army ___ TVA ___ State ___ City ___ County ___ Somebody ___ Other: _____

22. Have you seen a copy of this report?

Probe: If yes, what do you think the report said? ___
Probe: If no, does respondent show interest? ___

23. Do you remember hearing people discuss floods in the past two years? Probe: Who?

Family ___ Friends ___ Customers ___ Neighbors ___ Associates ___ Public officials ___ Others _____

Probe: What did they talk about?

24. Compared to others in this town, do you think that you talk about floods more often ___, less often ___, or just about the same ___, as others?

25. If you were to live one hundred years, how many floods would you expect to have here?

100 ___ 50 ___ 25 ___ 10 ___ 5 ___

Additional comments: _____

Probe: If discrepancy with question 19 then ask: you said before that you . . . .
yet now you say . . . . Why? _____

26. Try and remember back. Did you know anything about the flood problem, when (you) (the owners) decided to (do business) (move) here?

Probe: If yes: Do you remember how you felt about it at the time? What you felt you might do if a flood came? ____

27. Knowing what you now know, would you (buy) (start) (locate) (advise your employer to locate) here again?

NO: Then why don't you leave?

Never thought about it ___ No place else to go ___ Costs too much to move ___ Like it here ___ Other _______

YES: Have (you) (they) ever considered leaving in the past?

Probe: Then why didn't you? ____________________

28. If you had your choice, what city would you like to (live) (do business) in? ____________________

29. Where in LaFollette would you like to (live) (do business) in? ____________________

30. Would you like to be in some other business?

Probe: What kind? ____________________

Now, I would like to read to you several statements and ask your opinion as to whether you agree with the statement or disagree with it. The statements are all different and I would appreciate it if you listened to them carefully:

Probe for positive answer. Do you agree, disagree?

31. If you have a flood this year, chances are that you would not have another for sometime.

32. Planning only makes a person unhappy since your plans hardly ever work out anyhow.

33. The only sure thing that you can say about floods is that if you wait long enough, you will always get a bigger one.

34. When a man is born, the success he's going to have is already in the cards, so he might as well accept it and not fight against it.

35. Floods, like trouble, come in threes.

36. Nowadays, with world conditions the way they are, the wise person lives for today and lets tomorrow take care of itself.

37. A flood that will cover the handrail of Central Avenue Bridge would occur on the average, only at rather long intervals of time, but it could occur in any year.

Additional comments: ____________________

38. Now we have found that in asking questions, it is often very hard to remember things on the spur of the moment and that it often helps if you try to do it in the course of a little story. So, I am going to sketch some situations for you and I'll ask you to tell me what you would do if you were in the situation? OK?

Well, first I want to ask you if you usually listen to the evening weather report?

39. Suppose, about two months ago, you were listening to the weather report before going to bed, and the announcer says that heavy thundershowers are expected in the Cumberland Mountains. What do you do?

Go to bed ___ Stay up a while longer ___ Close windows ___ Other ____________________

40. Well, you decided to go to bed, and at 2:00 in the morning, you wake up because of the heavy thunder and lightning. Do you get up?

Probe: Why do you get up?

Personal ___ Look out window ___ Call someone ___ Get dressed and go downtown ___ Radio TV ___ Other _______

41. If you were worried about the possibility of Big Creek flooding, do you know anyone that you might call in the middle of the night for information?

Probe: Any other way to find out about it? ___________

42. Now, let's suppose that the same thing happened on a Saturday afternoon, when you are at the (store) (home). It begins raining again very heavily about noon and the sewers can't take it and the water begins backing up in the street. What do you do?

Note: If he suggests action, let him continue. If he does not, probe to find out what indications are needed to signify flood, note down, and then ask, that if that happened, what would he do?

Alternative Flood Indicator: ______________________________

Note: Classify all answers according to this chart, noting a brief description of all items suggested by respondent, then probe for missing items and classify responses.

Code: (1) Respondent suggested (2) Probable (3) Possible (4) Uncertain (5) Rejected

Do nothing: ___________________
Standby preparations: ___________________
Previous structural changes: ___________________
Keep water out: ___________________
Let water run through: ___________________
Utilities and motors: ___________________
Elevation or removal of possessions: ___________________
Others: ___________________

43. Well, the water keeps coming up until it reaches about as high as the 1950 flood. How high would that have been in your place?

____ feet, in basement ____ 1st floor ____ yard ____ street ____

44. If discrepancy from flood report:

Probe: I thought it was ___ feet? (Just note down answer. If asked for source, cite report).

45. Anyway, if it ___ feet, do you think that you would have more ____ less ____ or the same damage ____ as in 1950?

46. The water goes down in an hour or two, what do you do now? Cleanup: __________ Other action ______________

47. Would you be back in business the next day?

48. How much higher would the water have had to come to cause you serious trouble?

49. Do you have insurance on your property?

50. Does it cover flood damages?

51. Well, in 1956 Congress did pass a law to set up a Federal Insurance System but they must have had some second thoughts about it because they never got around to appropriating the money to get it started. But if they do get started some day and could offer you insurance for, let's say, your personal possessions and furniture, would you be interested?

52. Yes:
Would you be willing to pay $100 a year for a $1,000 protection? How about $25? How about $10?

53. Now that we have talked about what you would do before and after a flood, let's imagine that a (neighborhood) (businessmen) meeting is called to discuss ways of reducing flood damages and the chairman calls on you to speak. What would you say?

54. Now, if you were the mayor, what do you think you would do about the flood situation?

55. Note: Following is a checklist of possible adjustment for any items not volunteered in the previous two questions. The checklist should be used as a probe. Ex.--What do you think of a dam and a reservoir to store the flood waters? The answers should be coded with combinations of the following.

1. Respondent suggested 2. Probable 3. Possible 4. Uncertain 5. Rejected
Use additional blank space to quote interesting comments, if any.

56. On same checklist for coded items 1, 2 ask who installs adjustment?

57. Also ascertain willingness to pay increased taxes for 1, 2 coded purposes.

	Code	Who Installs	Willingness to Pay
Reservoir:			
Channel improvements:			
Central Ave. bridge openings:			
Levee:			
Structural change:			
Floodway:			
Better warning system:			
Other:			

58. What is the exact name of your business firm?

59. How would you describe, to somebody, the nature of your business?

60. How many full-time and part-time employees do you have?

61. How long has the business been located on this spot?

62. How long has the business been located in LaFollette?

63. Could you estimate what percentage of your customers come from LaFollette? ____ Out of town? ____

64. In which of the following classes would you put your average weekly gross receipts?

Under $1,000 ___ $1,000 - $2,000 ___ $2,000 - $3,000 ___
Over $3,000 ___

65. Do you think that your business will have increased ___, decreased ___ or stayed about the same ___, a year from now?

66. How about five years from now?

67. How many buildings do you occupy for business purposes and what are they used for?

68. Do you know the outside dimensions or the sq. footage of the main building here?

69. How much space do you use for selling and how much for storing?

70. Do you have a basement:

    Probe: What do you use it for?

    Utilities and heat only ____
    Storage space: High value ___ low value ___ other use ___

71. Do you own outright ___ own with mortgage ___ or rent ___ this building?

72. Renters: Who is your landlord?
    Name and address: ______________________________
    Do you have a lease? How long? ________ years
    What is your monthly rent? _____________

73. All owners:

74. What are the real estate taxes on this property?
    $ _____ Offhand, do you know the assessed valuation?
    $ _____

75. What do you think is a fair rent for the land and buildings (without fixtures, good will, etc.) $ _____ per month

76. Do you need more space for selling ___ storing ___?

77. If you had the money and/or the authority to improve your place of doing business, would you build a new store here ____, elsewhere ____, repair the present one ____ or just use what you have ____ ?

78. For all except last choice: What kind of improvements would you make? ______________________________

79. If you found at the cost of several hundred dollars you could make some small changes to the building that would protect your stock from most floods, could you make these alterations?

    Probe: Whose approval would you need? ____________________

80. Do you know of any agency that lends money for such a purpose?

81. For managers only: Name and address of supervisor:

82. What is your home address? ____________________

83. What is the grade of the last full year of school that you attended? _____ grade

84. What kind of previous business experience have you had? Where? ______________________________

85. What clubs do you belong to? ____________________

86. Are you a member of a church?

    Probe: Which one? ____________________

87. You mentioned before (such and such special problems). Who would you discuss such a matter with?

88. In which of the following groups would you place your total yearly family income?

    Under $2,500 ____ $2,500 - $4,000 ___ $4,000 - $6,000 ___
    $6,000 - $10,000 ___ Over $10,000 ___

89. In which of the following age groups would you place yourself?

    0 - 17 ___ 18 - 24 ___ 25 - 44 ___ 45 - 64 ___ 65 and over ___

90. If, for some reason or another, you had to get out of this business and you knew of a friend who was interested in it, would you advise him to (buy it, apply for the job)?

91. Do you think that it is likely ___ or unlikely ___ that you will be (owner) (manager) of this store one year from now?

92. What about five years from now? Likely ____ Unlikely ____

Probe: If unlikely: Do you know of anything now that might change your personal situation? _______________

93. Do you think that it is likely ___ or unlikely ___ for this business to be here five years from now?

94. 25 Years? Likely ___ Unlikely ___

Probe: If unlikely: Do you know now of anything that might affect the business in the future? ___