NATURAL HAZARD MITIGATION SAVES: An Independent Study to Assess the Future Savings from Mitigation Activities

Volume 2 – Study Documentation

THE MULTIHAZARD MITIGATION COUNCIL

The ***Multihazard Mitigation Council (MMC)***, a council of the National Institute of Building Sciences (NIBS), was established in November 1997 to reduce the total losses associated with natural and other hazards by fostering and promoting consistent and improved multihazard risk mitigation strategies, guidelines, practices, and related efforts. The scope of the Council's interests is diverse and reflects the concerns and responsibilities of all those public and private sector entities involved with building and nonbuilding structure and lifeline facility research, planning, design, construction, regulation, management, and utilization/operation and the hazards that affect them. In recognition of this diversity, the Council believes that appropriate multihazard risk reduction measures and initiatives should be adopted by existing organizations and institutions and incorporated into their legislation, regulations, practices, rules, relief procedures, and loan and insurance requirements whenever possible so that these measures and initiatives become part of established activities rather than being superimposed as separate and additional. Further, the Council's activities are structured to provide for explicit consideration and assessment of the social, technical, administrative, political, legal, and economic implications of its deliberations and recommendations. To achieve its purpose, the Council conducts activities and provides the leadership needed to:

- Improve communication, coordination, and cooperation among all entities involved with mitigation;
- Promote deliberate consideration of multihazard risk reduction in all efforts that affect the planning, siting, design, construction, and operation of the buildings and lifelines systems that comprise the built environment; and
- Serve as a focal point for the dissemination of credible information and sage counsel on major policy issues involving multihazard risk mitigation.

*The Multihazard Mitigation Council,
a council of the National Institute of
Building Sciences*

NATURAL HAZARD MITIGATION SAVES: An Independent Study to Assess the Future Savings from Mitigation Activities

Volume 2 − Study Documentation

Prepared with funding from the Federal Emergency Management Agency of the U.S. Department of Homeland Security by the Multihazard Mitigation Council of the National Institute of Building Sciences with the assistance of the Applied Technology Council

National Institute of Building Sciences
Washington, D.C.
2005

This report was prepared under Contract EMW-2003-CO-0417 between the Federal Emergency Management Agency and the National Institute of Building Sciences. It is based on concept development and analytical work conducted under Contract EMW-1998 CO-0217. For further information, visit the Multihazard Mitigation Council website at http://nibs.org/MMC/mmchome.html or contact the Multihazard Mitigation Council, 1090 Vermont, Avenue, N.W., Suite 700, Washington, D.C. 20005; phone 202-289-7800; fax 202-289-1092; e-mail mmc@nibs.org.

In Memoriam

The Multihazard Mitigation Council wishes to acknowledge James M. Delahay, PE, for his contributions to the Applied Technology Council's research/analysis efforts and his significant contributions to the profession of structural engineering and the nation's codes and standards development efforts. The built environment and all those who use it have benefited tremendously from his work.

PREFACE

The National Institute of Building Sciences through its Multihazard Mitigation Council is pleased to submit this report to the Congress of the United States on behalf of Federal Emergency Management Agency (FEMA) and the Department of Homeland Security. This report presents the results of an independent study to assess the future savings from hazard mitigation activities.

This study shows that money spent on reducing the risk of natural hazards is a sound investment. On average, a dollar spent by FEMA on hazard mitigation (actions to reduce disaster losses) saves the nation about $4 in future benefits. In addition, FEMA grants to mitigate the effects of floods, hurricanes, tornados, and earthquakes between 1993 and 2003 are expected to save more than 220 lives and prevent almost 4,700 injuries over approximately 50 years. Hurricane Katrina painfully demonstrates the extent to which catastrophic damage affects all Americans and the federal treasury.

The MMC Board wishes to acknowledge the efforts of its subcontractor, the Applied Technology Council (ATC). Further, it applauds the innovative and painstaking work of the ATC research team under the guidance of Ronald T. Eguchi of ImageCat, Inc., the project technical director. The team members were: Adam Z. Rose of The Pennsylvania State University, leader of the benefit-cost analysis portion of the study; Keith Porter, Consultant, co-leader of that portion of the study; Elliott Mittler, Consultant, leader of the community research portion of the study; Craig Taylor of Natural Hazards Management Inc., co-leader of that portion of the study; Corey Barber of the University of California, Berkeley; Jawhar Bouabid of PBS&J; Linda B. Bourque of the University of California, Los Angeles; Stephanie Chang of the University of British Columbia; Nicole Dash of the University of North Texas; James Delahay of LBYD, Inc.; Charles Huyck, ImageCat, Inc.; Christopher Jones, Consultant; Megumi Kano of the University of California, Los Angeles; Karl Kappler of the University of California, Berkeley; Lukki Lam of the University of California, Berkeley; Rebecca C. Quinn, CFM, RCQuinn Consulting, Inc.; Archana More Sharma of the University of California, Los Angeles; Kenneth Strzepek of the University of Colorado; John Whitehead of Appalachian State University; Michele M. Wood of the University of California, Los Angeles; Kathryn Woodell of the University of California, Berkeley; and Bo Yang of The Pennsylvania State University. Thanks also go to the ATC Independent Project Review Team members William Petak of the University of Southern California, David Brookshire of the University of New Mexico, Stephanie King of Weidlinger Associates, Inc., Dennis Mileti of the University of Colorado, Doug Plasencia of AMEC Earth and Environmental, and Zan Turner of the City and County of San Francisco; to the ATC project staff including Thomas R. McLane and Christopher Rojahn; and to additional consultants engaged by ATC (James R. McDonald of McDonald-Mehta Engineers, Bruce Miya, and Douglass Shaw of Texas A&M University).

The MMC also offers its thanks to the Project Management Committee established to oversee the project on its behalf. The committee members have spent countless voluntary hours reviewing study materials and providing guidance to the MMC subcontractor conducting the data analysis effort, and the MMC Board thanks them very much for their extraordinary contribution of time and expertise. Serving on the committee were: Philip T. Ganderton, Ph.D., Professor and Chair, Department of Economics, University of New Mexico; David Godschalk, Ph.D., Stephen Baxter Professor, Department of City and Regional Planning, University of North Carolina, Chapel Hill; Anne S. Kiremidjian, Ph.D., Professor of Civil and Environmental Engineering, Department of Civil and Environmental Engineering, Stanford University, Palo Alto; Kathleen Tierney, Ph.D., Professor and Director, Natural Hazards Research and Applications Center, University of Colorado; and Carol Taylor West, Ph.D., Professor, Department of Economics, University of Florida.

The MMC also is grateful to L. Thomas Tobin of Tobin & Associates, who worked closely with the Project Management Committee and served as technical liaison with the ATC researchers, and to the superb MMC staff. Further, the MMC wishes to thank the FEMA personnel and state and local officials who provided data and other information for analysis in this study. The MMC also wishes to express its gratitude to FEMA for having the confidence in the Council to give it the independence needed to conduct the study and prepare this report and especially to Maria Vorel and Margaret Lawless of FEMA for their insight and support.

Brent Woodworth
Chair, Multihazard Mitigation Council

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

Chapter 1
INTRODUCTION

"An ounce of prevention is worth a pound of cure."

Natural hazards such as floods, hurricanes, tornadoes, and earthquakes can cause billions of dollars in damage when they happen. Much of the expense of this societal loss is borne by the federal government. But does "an ounce of prevention is worth a pound of cure" hold true when the federal government invests in natural hazard mitigation with the objective of reducing or eliminating losses from future natural disasters? To answer this question, the House Appropriations Committee, Subcommittee for the Veterans Administration, Department of Housing and Urban Development, and Independent Agencies of the 106th Congress mandated this study (House Report 106-161) stating:

> The Committee recognizes that investing in mitigation will yield reductions in future disaster losses, and that mitigation should be strongly promoted. However, an analytical assessment is needed to support the degree to which mitigation activities will result in future "savings." Therefore, the Committee directs FEMA to fund an independent study to assess the future savings from the various types of mitigation activities.

This document, *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities*, *Volume 2 – Supporting Documentation*, describes how the analytical assessment was performed, documents the methods used, and explains the results. Volume 1, Findings, Conclusions, and Recommendations, presents the MMC Board's synthesis of the study results.

1.1 Purpose and Background

The Federal Emergency Management Agency (FEMA) charged the Multihazard Mitigation Council (MMC) of the National Institute of Building Sciences (NIBS) with conduct of the mandated study. The MMC explored possible approaches and issued a report presenting the parameters for the independent assessment (MMC, 2002).

The parameters report called for:

> Two interrelated studies on representative mitigation activities and communities to allow nationwide generalizations regarding future savings from mitigation. One study will involve empirical research on the savings realized through the application of specific mitigation activities in varying risk contexts and will use a nationwide statistically representative sample of commonly used mitigation activities. The other study will involve empirical research on savings realized through mitigation activities carried out in specific community contexts and will use a sample of communities selected deliberately and in a systematic way that will maximize variations in hazards and mitigation measures considered.

In conducting the study, the MMC first issued a request for qualifications, received five responses, requested full proposals from two organizations deemed to have the best qualifications, and selected the research team organized by the Applied Technology Council to perform the research and analysis work needed for the independent assessment, the results of which are presented in this report. The research team included more than 30 experts in diverse fields including structural engineering, hazard loss estimation, regional economics, environmental economics, geographical information systems, sociology, health, and public policy (Appendix A).

1.2 Federal Mitigation Grant Programs

The Federal Emergency Management Agency (FEMA), the lead agency in providing federal disaster relief, has made natural hazard risk mitigation a primary goal in its efforts to reduce the long-term cost of disasters. During the period studied, FEMA conducted three programs in support of this goal: the post-disaster Hazard Mitigation Grant Program (HMGP) and two pre-disaster programs, Project Impact (PI) and the Flood Mitigation Assistance (FMA) Program. The Hazard Mitigation Grant Program, the oldest and largest of the three programs, was created in 1988 to assist states and communities in implementing long-term hazard mitigation measures following presidentially declared disasters. Between 1993 and 2003, FEMA obligated $3.5 billion for states and communities to invest in a variety of eligible mitigation activities selected as the most beneficial by local officials.

Project Impact was a program funded between fiscal years 1997 and 2001. Unlike the Hazard Mitigation Grant Program, which provides funding after disasters, Project Impact supported the development of pre-disaster mitigation programs. In total, 250 communities in every state and some U.S. territories received $77 million in grants ranging from $60,000 to $1,000,000 per community. The one-time Project Impact grants were considered seed money for building disaster-resistant communities and encouraged government to work in partnership with individuals, businesses, and private and nonprofit organizations to reduce the impact of likely future natural disasters.

The Flood Mitigation Assistance Program was created as part of the *National Flood Insurance Reform Act of 1994* with the specific purpose of reducing or eliminating claims under the National Flood Insurance Program (NFIP). The Flood Mitigation Assistance Program provides funding to assist states and communities in implementing measures to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the National Flood Insurance Program. Annual funding of $20 million from the National Flood Insurance Fund is allocated to states that, in turn, obligate it to communities. Like Project Impact, the Flood Mitigation Assistance Program supports pre-disaster mitigation.

Note that the present study does not estimate the benefits of all FEMA mitigation grant expenditures during the study period. Approximately $200 million in grants were not addressed for any of several reasons but primarily because they did not address one of the three hazards (earthquake, flood, and wind) examined in this study.

1.3 Study Objectives

The objective of the independent study was to quantify the expected benefits of avoided hazard-induced losses and the potential future savings for the three FEMA hazard mitigation programs described above. The study consisted of two major components.

The first component, a benefit-cost analysis of FEMA mitigation grants, estimated the future savings from FEMA mitigation activities based on past FEMA mitigation expenditures. This study component is quantitative and was performed on a statistical sample of FEMA-funded mitigation activities selected from the National Emergency Management Information System (NEMIS) database. The unit of analysis for the benefit-cost analysis of FEMA mitigation grants is the individual FEMA-funded grant.

The second study component, community studies, assessed the future value of mitigation activities through empirical research conducted on savings realized through mitigation activities carried out in community contexts. This study component is both quantitative and qualitative and examines mitigation activities previously funded by FEMA in a purposive sample of communities. The purposive selection procedure considered criteria such as hazard and community size and included a blind draw ─ in other words, communities were not "cherry-picked" or selected because of their mitigation reputation or any other special characteristic. The unit of analysis in the community studies is the individual community.

1.3.1 Benefit-Cost Analysis of FEMA Mitigation Grants

In the benefit-cost analysis of past FEMA mitigation grants, a variety of methods was used to estimate the benefits of a sample of past FEMA-funded grants. Grants for different types of mitigation activities (project and process) and hazards (earthquake, wind, and flood) were selected. This estimate was developed using established principles of benefit-cost analysis as codified by several federal government agencies. These principles were applied to several categories of avoided losses (benefits): property damage, business interruption, casualties, negative societal and environmental impacts, and destruction of historic buildings. These losses were measured in terms of real resources lost to the nation as a whole. The analysis of FEMA mitigation grants also evaluated how various federal tax revenues and transfer payments could potentially be affected by hazard mitigation. The analysis of FEMA mitigation grants was structured to answer three questions:

1. What are the net benefits of hazard mitigation to the nation?
2. Do these benefits vary across types of hazards and mitigation activities?
3. What are the potential savings to the federal treasury from hazard mitigation?

1.3.2 Community Studies

The community studies component assessed the broad benefits from FEMA mitigation activities using empirically collected data from eight purposively selected communities. In addition to FEMA-funded activities, the community studies investigated mitigation activities funded by non-FEMA federal and state agencies that were either associated with and/or independent of FEMA-funded activities. The purpose of this wide focus was to determine the context within which community hazard mitigation occurs. The community studies investigation was structured to answer the following questions:

1. What is the magnitude of the ratio of the benefits to costs of hazard mitigation activities funded by FEMA when evaluated within a community context?
2. What, if any, additional mitigation activities and benefits were stimulated by FEMA Hazard Mitigation Grant Program, Project Impact, and Flood Mitigation Assistance Program activities?

1.3.3 Types of Mitigation Activities

The study addresses two applications of grant funding referred to herein as project and process mitigation activities. Project activities include physical measures to avoid or reduce damage resulting from disasters. Typically they involve acquiring, elevating, or relocating buildings, lifelines or other structures threatened by floods; strengthening buildings and lifelines to resist earthquake or wind forces; and improving drainage and land conditions (MMC, 2002). Process activities lead to policies, practices, and other activities that reduce risk. These efforts typically focus on assessing hazards, vulnerability, and risk; conducting planning to identify mitigation efforts, policies, and practices and set priorities; educating decision-makers and building constituencies; and facilitating the selection, design, funding, and construction of projects (MMC, 2002).

1.4 Study Characteristics

This study was conducted independent of FEMA. Its assumptions were generally conservative — that is, where uncertainty was high, the parameters and methods chosen were those that produced lower estimates of benefits. Sensitivity analyses were conducted on key variables to determine whether the results are robust. The Multihazard Mitigation Council will maintain all data collected from FEMA regional offices and from FEMA databases for use by researchers who wish to test the results, in accordance with the confidentiality requirements of the Office of Management and Budget's Circular A-130 and the Institutional Review Board at the University of California at Los Angeles.

Independent review of this study was provided by the periodic review and input of an Internal Project Review Team (IPRT), six nationally recognized experts providing independent, broad, consensus-based input to the research team. (A letter of endorsement from the IPRT is included in Appendix A of this report.)

1.5 Organization of Report

This volume, *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities*, *Part 2 – Supporting Documentation*, is organized into seven chapters, including this introduction, plus a series of appendices.

Chapter 2, Principles and Definitions, provides a discussion of guiding principles of this study, an overview of key methodologies that define its scope and depth, and important definitions and delineations. The discussion lays the foundation for more detailed and complex summaries of the approach this study took to assess the benefits and costs of mitigation activities.

Chapter 3, Data Collection, Processing, and Analysis, introduces the primary datasets for both the benefit-cost analysis of FEMA mitigation grants and the community studies. These datasets are used to establish the costs of all FEMA mitigation activities, to help select the stratified sample for the benefit-cost analysis of FEMA mitigation grants and the communities evaluated in the community studies analysis, and to help support comparative analysis studies of community mitigation.

Chapter 4, Methodology, is critical to understanding the underlying methods used for both the benefit-cost analysis of FEMA mitigation grants and the community studies. In many cases, common methods are employed in both parts of the study, and HAZUS®MH (a loss estimation software) was used when possible. Estimating expected losses, impacts to buildings and infrastructure, and exposed populations from earthquake and hurricane wind used common methodologies. In some cases, the benefit-cost analysis of FEMA mitigation grants involved a more in-depth analysis of benefits by examining a wider range of impacts, especially to the environment and historic structures. At the same time, the community studies offered additional insights into mitigation effectiveness by exploring how FEMA-funded mitigation activities percolate throughout the community in the form of synergistic activities that would not have occurred had it not been for the original FEMA grant.

Chapter 5, Community Studies, contains the results of the community analysis. In total, eight communities were investigated based on the combination of FEMA-funded grants received since the start of the Hazard Mitigation Grant Program in 1988 (e.g., multiple hazard exposure), the hazard levels experienced, size of FEMA-funded grants, population of the community, and the FEMA region in which the community is located. The analysis is both quantitative and qualitative. To the extent possible, benefit-cost ratios were calculated for all "project" and "process" activities in the communities funded by FEMA grants. Project activities include physical measures to avoid or reduce damage resulting from disasters. Typically they involve elevating, acquiring, and/or relocating buildings, lifelines or other structures threatened by floods; strengthening buildings and lifelines to resist earthquake or wind forces; and improving drainage and land conditions (MMC, 2002). Process activities lead to policies, practices, and projects that reduce risk. These efforts typically focus on assessing hazards, vulnerability and risk; conducting planning to identify projects, policies, and practices and set priorities; educating decision-makers, and building constituencies and political will; and facilitating the selection, design, funding, and construction of projects (MMC, 2002). As part of the analysis, synergistic activities were also assessed.[1] Through the use of activity chronologies, variables and factors (e.g., institutionalization) that affect a community's ability to undertake and implement hazard mitigation activities are described.

[1] Synergistic activities are activities or effects that follow or accompany the award of FEMA grants for project mitigation or process mitigation activities, or the strong expectation that a grant would be awarded, that reduce risks (or increase benefits of risk-reduction activities) from floods, earthquakes, and severe winds. The synergistic activities identified were not funded by FEMA.

Chapter 6, Benefit-Cost Analysis of FEMA Mitigation Grants, contains the major findings of the grant analysis. The National Emergency Management Information Systems (NEMIS) database served as the starting point. A detailed summary of FEMA's mitigation activities ─ delineated by hazard, mitigation type, costs, etc., as documented by the NEMIS database ─ is provided. The study used a stratified sample to represent the entire population of mitigation activities funded by FEMA between 1993 and 2003. The major focus of this chapter is the analytical results. Benefit-cost ratios are calculated for six different strata: project activities for wind, flood, and earthquake and process activities for wind, flood and earthquake. In addition to delineating the net benefits of mitigation to society, this chapter also provides insights into impacts (or savings) to the federal treasury.

Chapter 7, Summary, identifies the key findings from the benefit-cost analysis of FEMA mitigation grants and the community studies. It also indicates how FEMA-funded mitigation activities have fared with respect to anticipated benefits and actual mitigation costs. From an analysis of eight communities that have received FEMA hazard mitigation funds, it is clear additional benefits accrue, in large part, as result from FEMA-funded mitigation activities. This chapter attempts to put into perspective the magnitude of these synergistic benefits and the types of linkages with FEMA-funded efforts.

A series of technical appendices contain benefit-cost analysis data collection forms, community studies field research documentation, explanations of the methods used to develop information on cost and benefits, a detailed listing of assumptions and limitations of this study, and other background information. Every attempt has been made to document assumptions, methodologies, and data to permit the reader to fully understand this study and perhaps undertake additional analyses.

A second document, *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities*, *Volume 1 – Findings, Conclusions*, *and Recommendations* includes a brief overview of the study findings and the MMC Board's conclusions and recommendations based on those findings.

Chapter 2
PRINCIPLES AND DEFINITIONS

This chapter discusses the guiding principles of this study, describes the key methods that define its scope and depth, and presents important definitions and delineations that help to connect its different parts. The discussion helps lay the foundation for more detailed and complex summaries of the approach to assessing mitigation benefits. The reader should note that, while the discussions are general, some parts may apply more to a particular study component. For example, the discussion on case study principles is designed to frame the approach used in the community studies. Similarly, the section on synergistic activities focuses on key concepts used in the community study analysis to define the extended benefits of mitigation. All other discussions apply to both study components.

2.1 Benefit-Cost Analysis

A benefit-cost analysis requires that hazard mitigation costs and hazard losses be measured in terms of the value of all resources used (or destroyed) and at prices that represent their efficient allocation ─ not necessarily at market prices, which often do not account for inefficiencies or may not even exist in cases such as environmental resources (Boardman et al., 1996). In addition, transfer payments (e.g., taxes and subsidies) should not be included because they do not represent the use of resources, but rather a shift of funds from one entity to another. This method avoids double-counting and covers all resources, including nonmarket resources (Ganderton, 2004). In practice, standard accounting categories, such as asset purchase cost and lost sales, represent proxies for the ideal resource valuation (efficiency prices) because of limitations of measurement.

To complete a benefit-cost analysis, it is necessary to estimate all costs and all benefits. The cost side is usually the straightforward assessment of capital expenditures, and operation and maintenance expenses (where applicable). Benefits, or avoided losses from hazards, are much more difficult to assess because they are not limited to a single structure or moment in time and are highly uncertain over the short term. Accordingly, elaborate methods (discussed in the following sections) have been developed to estimate these benefits by first estimating the various categories of losses from hazards in the absence of, and in the presence of, mitigation. Two complications arise in estimating the future benefits of hazard mitigation. First is the need to discount them to a present value so that benefits accruing at different times can be made comparable. (An exception is that it is considered inappropriate to discount the economic value of avoiding future statistical deaths and nonfatal injuries. See Section 4.2.2.3.) Second is the need to express them in probabilistic terms (the number of times something will probably occur over the range of possible occurrences) to capture their uncertain frequency of occurrence and magnitude.

Benefit-cost analysis is widely used by the federal government. It was first made a requirement in the Flood Control Act of 1936 where Congress stipulated that the U.S. Army Corps of Engineers could only undertake flood control projects if the benefits of the projects exceeded their costs. Today, a benefit-cost analysis is required before many public projects or initiatives can be approved, including FEMA hazard mitigation grants. Several government documents specify formal rules and procedures for undertaking benefit-cost analyses (U.S. Government Accountability Office, 2002; Office of Management and Budget, 1992). Benefit-cost analysis methodologies have been refined by economists, other social scientists, scientists, engineers, and ethicists for over 60 years. Contentious issues, such as discounting, have been resolved by National Academy of Science panels.

FEMA follows established benefit-cost analysis practices, including the publication of its own guideline documents and the circulation of illustrative examples (e.g., NIBS and FEMA, 2003a; 2003b). The FEMA mitigation grant application process requires completion of a benefit-cost analysis. Approval hinges to a great extent on demonstration of positive net benefits, which is equivalent to a benefit-cost ratio exceeding 1.

The benefit-cost analyses in FEMA grant application files provide important information. However, not all of it could be used in this study for a variety of reasons including the following:

1. Because this study is intended to be an independent assessment, benefit-cost ratios in FEMA grant files were not used or validated. However, the basic data from the grant application files on the characteristics of structures and mitigation projects were used to estimate benefits.
2. The benefit-cost analyses in the FEMA grant applications examined typically did not include a wide range of benefits, especially those difficult to quantify (e.g., avoidance of indirect business interruption, environmental damage, and societal impacts). This study develops new methods to quantify such additional benefits.

This study does, however, use mitigation cost data from FEMA files. The first approximation to cost is the FEMA grant allocation, a matter of public record and a definite expenditure. This must, however, be adjusted for any significant transfer payments (e.g., taxes). It also should include any matching funds from other government entities or the private sector used to carry out the mitigation activity.

One important issue was the selection of an appropriate discount rate. The real rate used for discounting is based on market interest rates. The base case real discount rate used is 2 percent, the same rate that is recommended by the Congressional Budget Office (CBO) (Congressional Budget Office, 1998). This rate is based on a CBO estimate of the long-term cost of borrowing for the federal government and is generally considered a conservative estimate of the long-term real market risk-free interest rate. The Office of Management and Budget (OMB) recommends that the real rate should be based on the rate of return to private investment (Office of Management and Budget, 1992). The sensitivity tests conducted for this study were performed using 0 percent as a lower bound and 7 percent as an upper bound. A 7 percent rate approximates the marginal pretax rate of return on an average investment in the private sector in recent years. This rate is generally considered to be an upper bound for federal projects because the rate of return to public-sector projects is typically assumed to be lower than private-sector projects.

Another important issue in the calculation of benefits is the selection of the effective life of a mitigation effort, which is used to calculate the present value of avoided future losses. Consistent with common practice in the new design or rehabilitation of ordinary (non-essential or hazardous) buildings, the present study applies a 50-year effective life to mitigation efforts for ordinary buildings; a 100-year effective life is assumed for lifeline facilities.

2.1.1 Measures of Costs

The costs of hazard mitigation are all the resources used — not just the explicit "out-of-pocket" expenditures on labor, capital, materials, and services but also more subtle categories. The latter include implicit, or "opportunity costs" that refer to the use of inputs (e.g., donation of labor time, the carrying cost of capital) which may not have been charged to the mitigation activity but could have been productive elsewhere. The value of the foregone opportunity represents a type of implicit cost. Examples are government administrative costs and the value of non-priced environmental services. Environmental impacts can be either positive or negative (e.g., whether a wetland was destroyed in the course of building a drainage project or created by rezoning land).

There are also indirect costs and spillover effects of mitigation. An example of the latter is a change in real estate values, again possibly either positive or negative. Because nearly all of the mitigation grants analyzed applied to individual structures or a small cluster of private residences, spillover effects are assumed to be negligible, at least in the benefit-cost analysis of FEMA mitigation grants. An additional consideration is "ripple effects" of mitigation activities. These represent the additional jobs and income generated because of backward and forward economic linkages of the construction or operation of a mitigation project or process. Because of the controversy over whether to treat this category as a cost or a benefit and because of an Office of Management and Budget (1992) stricture against including it in official federal government benefit-cost analyses, this category also is omitted from the benefit-cost analysis of FEMA mitigation grants. This effect, however, is addressed (to a certain extent) in the community studies (Section 2.5.2, Synergistic Activities).

Independent estimates of the costs of administering FEMA grants could not be obtained, nor could estimates of the savings of reduced costs of administering post-disaster recovery because of mitigation. The omission of these two administrative cost categories is unlikely to have a significant effect on the *net* benefit calculations.

The primary approach to cost estimation involved use of entries from the National Emergency Management Information System (NEMIS) database on basic project and process costs. These cost entries are entered into NEMIS from grant applications and were considered to be reliable primary data for this study. On the other hand, estimation of nonmarket costs is based on the data-transfer methods that involve applying empirical results from related contexts to individual project and process grants in the sample.

In summary, the following hazard mitigation cost categories addressed in this study are:

1. Cost of project mitigation activities (e.g., building retrofit, bridge improvement, equipment tie-down, buyouts);

2. Cost of process mitigation activities (e.g., education, community organization to deal with hazards, vulnerability analysis); and
3. Nonmarket costs (e.g., effects on wetlands or historic sites).

2.1.2 Measures of Benefits

The benefits of hazard mitigation are the avoided losses that would have occurred if the mitigation activity had not been implemented. It is important at the outset to note two key differences between mitigation costs and benefits. Mitigation costs are incurred primarily during a short period, such as during construction, and they are relatively certain. The only exception pertains to operating costs and maintenance costs, but these costs are usually relatively minor in comparison to construction costs. Mitigation benefits, however, accrue over the useful life of the project or process activity and are highly uncertain over the short termbecause they are usually realized only if natural hazard events occur. At best, the expected value of benefits of mitigation measures currently in place can only be approximated by multiplying the potential total benefits by the probability distribution of hazard events. In addition, benefits must be discounted to present value terms to account for the time value of money.

The various categories of hazard mitigation benefits addressed in this report are:

1. Reduced direct property damage (e.g., buildings, contents, bridges, pipelines);
2. Reduced direct business interruption loss (e.g., damaged industrial, commercial, and retail facilities);
3. Reduced indirect business interruption loss (e.g., ordinary economic “ripple” effects);
4. Reduced (nonmarket) environmental damage (e.g., wetlands, parks, wildlife);
5. Reduced other nonmarket damage (e.g., historic sites);
6. Reduced societal losses (casualties, homelessness); and
7. Reduced need for emergency response (e.g., ambulance service, fire protection).

The standard loss category, direct property damage, is almost always reported in the aftermath of a natural disaster. Some of the other categories, such as direct and indirect business interruption losses, have been estimated more frequently in recent years. However, other categories, such as environmental damage and societal losses, have rarely been estimated, with the exception of casualty losses. The absence of estimates is due not to lack of legitimacy but rather to lack of data.

2.2 Loss Estimation Modeling

Compared to benefit-cost analysis, loss estimation modeling is relatively new, especially with respect to natural hazard assessment. Although some studies were conducted in the 1960s, only in the 1990s did loss estimation methodologies became widely used. A major factor in this development was the emergence of geographic information systems (GIS) technology that allowed users of information technology to easily overlay hazard data or information onto maps of various systems (e.g., lifeline routes, building data, population information).

Loss estimation methodologies are now vital parts of many hazard mitigation studies. They are typically used to forecast the potential impacts of different hazard scenarios (typically used for planning), to project losses in an actual event (when used in conjunction with near real-time sensor systems, such as the ShakeMap system deployed by the U.S. Geological Survey), and to assess the benefits of a mitigation activity such as structural retrofit. A National Research Council (NRC) report, *Impacts of Natural Disasters* (NRC Committee on Assessing the Costs of Natural Disasters, 1999), also discusses the importance of relying on loss estimation modeling as a means of tracking and monitoring the costs of natural disasters. Because current government accounting systems are inadequate when it comes to totaling the costs of a disaster, the NRC report suggests that loss estimation modeling could provide surrogate means of tracking these costs.

FEMA has recognized the value of loss estimation modeling as a key hazard mitigation tool. In 1992, FEMA began a major effort (which continues today) to develop standardized loss estimation models that could be used by nontechnical hazard specialists. The resulting tool, the software program called HAZUS®MH, currently addresses earthquake, flood, and wind. It was used extensively in this study as discussed in Section 4.2.

2.2.1 Basic Components

To fully understand the loss estimation process, it is important to recognize the basic components of the mathematical model used to estimate loss (referred to here as the loss model). Regardless of the hazard being analyzed, a loss estimation model will consist of three basic components:

1. A hazard model that characterizes the likelihood and severity of the hazard;
2. An exposure model that quantifies the assets at risk in the area affected by the hazard; and
3. A vulnerability model that relates the damage potential of various assets to varying hazard levels.

Characterizing the hazard often involves the use of statistical or probabilistic models. Generally, an analyst is interested in two aspects of hazard: how frequently will the hazard occur over a designated period of time and what is the greatest intensity event that can be expected over a period of time. Probabilistic models that consider the relative frequency of past events are generally employed to determine frequency. For some hazards, this assessment may be easy; for hazards that occur only infrequently, this may be the most complex task of the entire loss estimation process.

Assessing the degree of exposure also is complex. Exposure applies to characterizing what is at risk ─ for example, the number of buildings, the amount of infrastructure within a region, or the number of people exposed to the hazard. In addition, quantification of exposed assets includes a characterization that often requires a definition or assignment of structural types and values.

Ironically, this component is often the most unsubstantiated part of the model. Although it has the potential for being 100 percent reliable, it generally relies on crude approximations because of the overwhelming resources needed to develop an accurate representation. In the present application, the nature of the facilities whose risk has been mitigated is crucial information, because costs and benefits are calculated largely based on specific projects, rather than on the nature of the general building stock.

The last major component is the vulnerability model. Often referred to as a fragility or damage function, this model directly relates the amount of damage or functionality expected to the level of hazard (or intensity) experienced. Significant research has been conducted in developing facility-specific functions for buildings and lifeline components. In many cases, the uncertainty or variability associated with these models is expressed in statistical (e.g., standard deviations) or probabilistic terms.

To complete a credible loss assessment, other modules or elements are needed. This procedure begins with translating physical property damage into dollar loss. Certainly, the value of the damaged facility is a key part of determining the eventual cost of repairs. For many facilities, however, the cost of downtime translated into lost production is also a major element of expected loss. The role of these other factors is discussed in the next section.

2.2.2 HAZUS®MH

HAZUS®MH is built on an integrated GIS platform that estimates losses due to earthquake, flood, and wind events. The software program is composed of seven major interdependent modules. The connectivity between the modules is conceptualized by the flow diagram in Figure 2-1. The following discussion provides a brief description of each module; detailed technical descriptions can be found in the HAZUS®MH Technical Manuals (NIBS and FEMA, 2003a, 2003b, 2003c).

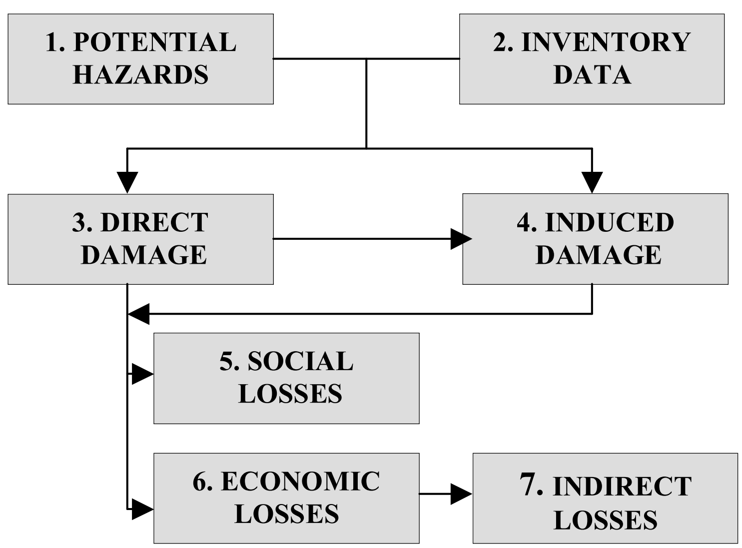


Figure 2-1 HAZUS®MH modules.

Potential Hazards (1) ─ The potential hazard module estimates the expected intensities or hazard severities for three hazards: earthquake, flood, and wind. For earthquake, this would entail the estimation of ground motions and ground failure potential from landslides, liquefaction, and surface fault rupture. For flood, this involves the estimation of flood heights or depths. For wind, this entails the estimation of wind speeds and wind-born debris. For a probabilistic analysis, the added element of frequency or probability of occurrence would be included.

Inventory Data (2) ─ A national-level exposure database of the built environment provided with HAZUS®MH allows the user to run a preliminary analysis without collecting additional local information or data. The default database includes information on the general building stock, essential facilities, transportation systems, and utilities. The general building stock data are classified by occupancy (residential, commercial, industrial, etc.) and by model building type (structural system, material of construction, roof type, and height). The provided mapping schemes are state-specific for single-family dwellings and region-specific for all other occupancy types. In all cases, they are age and building-height specific.

Direct Damage (3) ─ This module estimates property damage for each of the four inventory groups (general building stock, essential facilities, transportation, and utilities), based on the level of exposure and the vulnerability of structures at different hazard intensity levels.

Induced Damage (4) ─ Induced damage is defined as the secondary consequence of a disaster event on property. Fire following an earthquake and accumulation of debris are examples.

Social Losses (5) ─ Societal losses are estimated in terms of casualties, displaced households, and short-term shelter needs. The casualty model provides estimates for four levels of casualties (minor injuries to deaths), for three times of day (2:00 a.m., 2:00 p.m., and 5:00 p.m.), and for four population groups (residential, commercial, industrial, and commuting). The number of displaced households is estimated based on the number of structures that are uninhabitable, which is in turn estimated by combining damage to the residential building stock with utility service outage relationships.

Economic Losses (6) ─ Direct economic losses are estimated in terms of structural and nonstructural damage, contents damage, costs of relocation, losses to business inventory, capital-related losses, wage and salary income losses, and rental losses.

Indirect Economic Losses (7) ─ This module evaluates region-wide ("ripple") and longer-term effects on the regional economy from earthquake, flood, and wind losses. Estimates provided include changes in sales, income, and employment by sector (i.e., commercial, industrial, retail).

The various modules of the HAZUS®MH software have been calibrated using existing literature and damage data from past events. For earthquake, two pilot studies were conducted several years ago for Boston, Massachusetts, and Portland, Oregon, to further assess and validate the credibility of estimated losses. A similar testing and validation effort was conducted for flooding and hurricane wind.

2.3 Benefit Transfer Methods

Not all mitigation measures evaluated in this study can be analyzed using traditional evaluation methods. Thus, an alternative approach for assessing mitigation benefits was needed. For environmental and historic building benefits, a feasible approach for measuring the benefits of hazard mitigation is the benefit transfer approach (Brookshire and Neill, 1992; Bergstrom and DeCivita, 1999). The approach was developed for situations in which the time and/or money costs of primary data collection are prohibitive. In this approach, environmental benefit estimates from other case studies are spatially and/or temporally transferred to the policy case study.

The benefit transfer approach can be used to quickly adapt benefit estimates from one case study to another and to develop those estimates around the particular parameters of the case study of interest. Benefit transfer is also increasingly being applied to estimating many categories of public policy benefits (ranging from economic to societal), not just the environmental aspects. There are several types of benefit transfer. For decades, economists have used the benefit estimate transfer approach in which researchers obtain a benefit estimate from a similar study conducted elsewhere and use it for a current policy analysis case study (e.g., Luken, Johnson, and Kibler, 1992). This study relies predominately on standard applications of benefit estimate transfer. The application of this approach to estimating the benefits of grants for process mitigation activities, however, stretches this method to its limits because there are no studies that measure the benefits of process activities. Studies of the implementation of process activities in related areas (e.g., radon risk communication) were used instead. Hence, this modified application is referred to as a surrogate benefit approach.

More recently, benefit function transfer and meta-analysis function transfer have been developed in an attempt to transfer benefits more accurately. Benefit function transfer uses a statistical model of benefits developed at the original study site to estimate benefits at the subsequent policy site application (e.g., Loomis, 1992). Characteristics from the policy site are substituted into the model from the study site to tailor benefit estimates for the policy site. Benefit function transfer is generally preferred to benefit estimate transfer but was determined to be too cumbersome for use in this study.

Meta-analysis is a general term for any methodology that summarizes results from several studies. Benefit estimates gathered from several studies serve as the dependent variable in regression analysis, and characteristics of the individual studies (e.g., water quality, type of survey methodology) serve as the independent variables (e.g., Rosenberger and Loomis, 2000). Meta-analysis functions were used in this study when available.

2.4 Case Study Principles

Case studies were employed to explore more fully the impact of hazard mitigation activities in a single community. The methods employed in the community studies followed traditional case study principles best expressed in U.S. Government Accountability Office (1990) and Yin (2003). They were selected to meet the independent study's goals and to address four tests commonly used to establish the quality of empirical social research. The tests, according to Yin (2003), are:

1. Construct validity (to establish correct operational measures for the concepts being studied);
2. Internal validity (to establish a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships);
3. External validity (to establish the domain to which a study's findings can be generalized); and
4. Reliability (to demonstrate that the operations of a study (e.g., such as the data collection procedures) can be repeated with the same results.

To meet these tests and the study's goals, the following techniques were used:

1. Purposive sampling ─ Communities were selected because they had received numerous FEMA hazard mitigation grants and the sum of their grants exceeded $500,000. Other selection criteria included geographical disparity and instances of earthquake, flood, and wind grants; they were not chosen because they might be considered best or worse cases, typical communities, or have special characteristics.
2. Reliability ─ Use of a case study protocol; development of a case study database.
3. Measurement or construct validity ─ Multiple sources of evidence were used (document collection, structured telephone interviews, open-ended on-site interviews, archival research) and a chain of evidence was established.
4. Data analysis or internal validity ─ Triangulation (comparison of multiple, independent sources of evidence before reaching conclusions); ordering information chronologically for time series analysis, rival explanations (developing alternative interpretations of findings and testing through search of confirming and non-confirming information until one hypothesis is confirmed and the others ruled out); plausibility after completely considering all evidence.
5. Handling multiple-site data sets (internal and external validity) ─ Matrices of categories related to the evaluation questions; flow charts listing critical decisions to illustrate each site and to use for comparisons; use of nonquantitative time series analysis for explanation building.

2.5 Definitions

In the conduct of this study, there are several key concepts that help to establish the scope and depth of the analysis. These are discussed below.

2.5.1 Process and Project Activities

An important definitional distinction in this study refers to "project" mitigation and "process" mitigation. As indicated earlier, project activities include physical measures to avoid or reduce damage resulting from disasters. Typically they involve elevating, acquiring, and/or relocating buildings, lifelines or other structures threatened by floods; strengthening buildings and lifelines to resist earthquake or wind forces; and improving drainage and land conditions (MMC, 2002). Process activities lead to policies, practices, and projects that reduce risk. These efforts typically focus on assessing hazards, vulnerability and risk; conducting planning to identify projects, policies, and practices and set priorities; educating decision-makers, and building constituencies; and facilitating the selection, design, funding, and construction of projects (MMC, 2002).

Because of the wide disparity in the types of studies that fall under each category, different evaluation approaches were used in the assessment of benefits. For most project activities, it was possible to use some type of quantitative method or tool (e.g., HAZUS®MH) to determine benefits. For process activities, benefit transfer methods were a key component in the assessment of mitigation benefits. Chapter 4 discusses in detail the various methods used to quantify mitigation benefits for both project and process activities.

2.5.2 Synergistic Activities

One potential benefit of a FEMA grant is that a community may be able to use it as seed money or otherwise leverage the grant funds to expand existing and/or to develop new mitigation programs. A FEMA mitigation grant also may lead to increased economic activities. However, communities may develop mitigation programs without FEMA influence. During community studies, some activities were found that were heavily influenced by the FEMA-funded grants and others were not – they were the result of other community processes. Thus, a scheme to categorize community activities that follow FEMA project or process grants was developed.

Synergistic activities are activities or effects, which reduce risks (or increase benefits of risk-reduction activities) from floods, earthquakes, and severe winds that follow or accompany the award of FEMA grants for project or process mitigation activities or the strong expectation that a grant would be awarded. These activities are not funded by FEMA and can take the form of spin-off activities, collateral activities, or spillover effects.

Spin-off activities are synergistic mitigation activities that directly (an action that would not otherwise have taken place) or indirectly (accelerated timing of an action that would have taken place eventually) result from or are enabled by FEMA hazard mitigation grant support, but which were not directly funded by FEMA. Collateral risk-reduction activities are activities that are not spin-off activities because FEMA hazard mitigation grant support had no significant impact on their content or timing. Spillover effects of mitigation include direct and indirect increases in economic activity or value of assets in the more conventional use of the terms direct (i.e., increase in business activity of new or revitalized enterprises or increase in property value) and associated indirect (i.e., ripple effects).

To determine if a community activity was a spin-off activity, it was asked whether there was a high chance that the activity in question was financed or supported because FEMA provided support (or was strongly expected to provide support) for another process or project. If a preponderance of evidence from telephone interviewees, face-to-face interviewees, and contemporary documents indicated that the answer was "yes," then the activity in question was categorized as a spin-off activity. An example of a spin-off activity occurred in Jefferson County, Alabama, where following the implementation of a FEMA grant to buy out substantially damaged houses after a flood, the county council passed a regulation that mandates that the county set aside $2M annually for the specific purpose of removing houses from the floodplain. In this situation, the houses purchased from the FEMA grants funds were the first that the county removed, and both interviewees and documents indicated that the subsequent regulation was a direct result of the FEMA grant.

If the answer to the above question was “no,” it was asked whether the FEMA grant accelerated the activity in question. If the answer was “yes,” the activity in question was categorized as a spin-off activity. If the answer was “no,” the activity in question could not be a spin-off activity, but could still be a collateral activity.

Chapter 3
DATA COLLECTION, PROCESSING, AND ANALYSIS

This chapter introduces the primary datasets for both the benefit-cost analysis of FEMA mitigation grants and the community studies. These datasets were used to:

1. Establish the costs of all FEMA mitigation activities;
2. Help select a stratified sample for the benefit-cost analysis of FEMA mitigation grants and the communities evaluated in the community studies analysis; and
3. Help support comparative analysis studies of community mitigation.

These primary datasets, how information was developed using them, and the additional datasets developed during the course of this project are described below.

3.1 Existing Data Sources

3.1.1 FEMA NEMIS Database

The National Emergency Management Information System (NEMIS) database is used by FEMA to monitor the status of hazard mitigation grants. The NEMIS database was used to help select the stratified sample of grants for the benefit-cost analysis of FEMA mitigation grants and the communities for in-depth analysis. Key fields in this database are: FEMA region, disaster declaration number and project numbers, subgrantee name, project title, mitigation type, project status (void, withdrawn, denied, pending, approved, closed), total approved net eligible project cost, and Federal share obligated to date.

These data identify general location (city or county), cost of mitigation, and often (but not always) the type of risk being mitigated, and so were useful in selecting sample grants for detailed examination. However, the NEMIS database does not provide several pieces of information crucial to estimating mitigation benefits, most notably: precise location (latitude, longitude, and ground-floor elevation of affected properties for flood hazard mitigation projects); engineering and architectural information (structure type, number of stories, square footage, era of construction, roof configuration, etc.); values exposed to risk (building replacement cost, content replacement cost, number of occupants, economic consequences of business interruption, etc.); and, in many cases, detailed descriptions of the mitigation work performed.

The NEMIS database provides a current, cross-sectional snapshot of the status of FEMA-funded grants but provides complete data for only those projects that are "closed." Information for all other FEMA-funded grants either reflect the project descriptions and costs indicated in the original project application or, if changes have been approved, information from the last posted quarterly report.

In most cases, probably over 95 percent, information in the database proved to be accurate. There were, however, some recurrent problems that became apparent when grant files were reviewed or verified during community site visits. For example, sometimes the subgrantee name was too long to fit the allocated space in the database, and this resulted in an occasional misidentification. Also, mitigation types were often chosen to fit a list of very general, predetermined categories, and some projects were significantly different from what was expected. For example, in the list of flood-induced buyouts of private property in riverine areas, one buyout would have been more accurately caused by a landslide debris flow in an alluvial fan than by flooding.

In many cases, after funds were allocated for hazard mitigation projects, some projects were cancelled, not completed, or reduced in scope and unspent or "de-obligated" federal funds were often reallocated after subsequent disasters. The reallocations often were for large projects with many buyouts (in which properties are purchased, the buildings removed, and the land dedicated to open space) or elevations (in which buildings are physically raised and their foundations altered so that the first floor is above the 100-year flood elevation) that could be divided so that some could be funded from separate disaster declaration funds. In these situations, a total buyout of multiple properties in a community was funded by two or more disaster grants. Consequently, in a limited number of cases the number of NEMIS grants exaggerated the number of actual projects.

According to the NEMIS database (as of 5 June 2003), there were 9,719 project applications for all hazards since approximately 1989. The disposition or status of these applications is presented in Table 3-1. A little over 40 percent of these applications represented completed projects and about 30 percent were still active. All applications were funded by the following programs:

1. Various supplemental appropriations and appropriations to serve unmet post-disaster reconstruction needs,
2. Flood Mitigation Assistance,
3. Hazard Mitigation Grant Program, and
4. Project Impact.

Table 3-1 Status of applications in NEMIS database (as of 5 June 2003)

Current Project Status	Count
Closed	4,265
Approved	2,967
Denied	793
Withdrawn	783
Pending	527
Void	279
Null	104
2nd Appeal	1
Total	9,719

Of the 7,232 funded mitigation activities (i.e., approved and closed), 5,479 were associated with flood, wind (including hurricane and tornado), or earthquake. Because other hazards such as winter storm, fire, and terrorism were outside of the scope of this project, grants to reduce the risks from these hazards were excluded.

Table 3-2 presents the approximate number and cost of funded grants by hazard type. Approximately 64 percent of the funded projects dealt with the mitigation of flood hazards, while 29 percent addressed wind, and 7 percent addressed earthquake hazards. Flood grants represent 63 percent of costs, while wind and earthquake represent 11 percent and 27 percent, respectively. Earthquake mitigation efforts are generally more costly than flood or wind ─ $2.4 million for the average earthquake grant, compared with $630,000 and $240,000 for flood and wind, respectively.

Table 3-2 Number and cost of funded grants by hazard type

Hazard Type	Grants	Cost ($M)
Wind	1,572	374
Flood	3,512	2,217
Earthquake	395	947
Total	5,479	3,538

A breakdown of grant types indicates that 90 percent of the grant applications were for project mitigation activities and 10 percent were for process mitigation activities. In terms of cost, grant applications for process mitigation activities accounted for only 5 percent of total costs.

Figure 3-1 shows the distribution of grants by FEMA region. The largest number of grants (32 percent) is associated with Region IV, which includes Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee. The greatest grant amount (28 percent) is associated with Region IX, which includes California, Arizona, Nevada, and Hawaii.

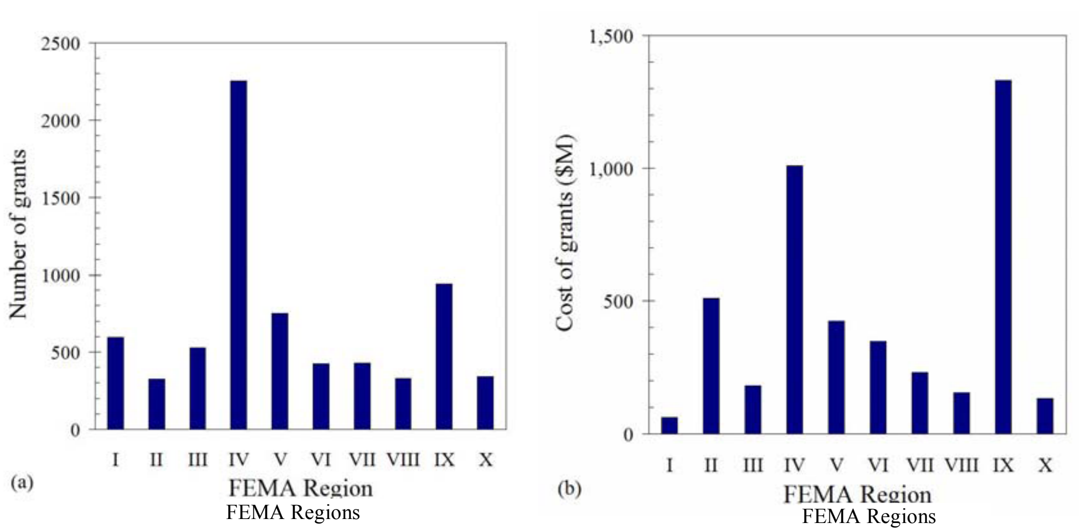


Figure 3-1 FEMA mitigation grants by region: (a) number and (b) total cost.

Figure 3-2 shows the distribution of FEMA grants by year of declaration (i.e., the year the disaster was officially declared by the federal government). Although the largest number of funded projects occurred in 1998, the highest costs were experienced in 1994, the year the Northridge, California, earthquake occurred.

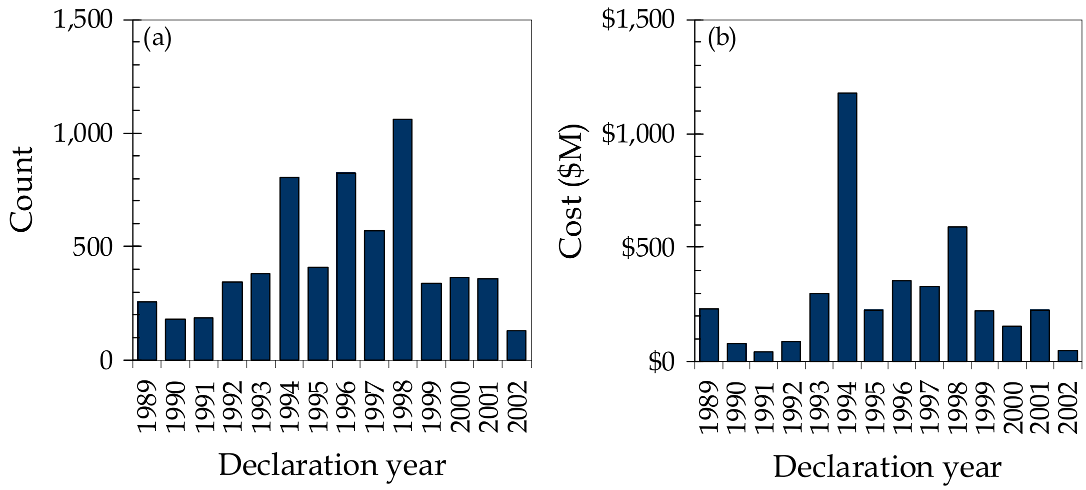


Figure 3-2 Mitigation grants by year of declaration.

3.1.2 Hazard Mitigation Grant Program and Flood Mitigation Assistance Grant Files

An examination of grant files was necessary to supplement the NEMIS data, particularly for precise location, engineering and architectural information, values exposed to risk, and in many cases, detailed descriptions of the mitigation work. Grant files generally were kept by the FEMA regional office overseeing the grant, the state emergency management office, and the local community or subgrantee. FEMA provided copies of files for review or the files were examined in FEMA offices. Files from the FEMA regional office and the state emergency management office were found to be nearly identical and were organized into similar folders that separated documents by topics such as financial, benefit-cost, environmental, project application, and correspondence. The only consistent differences were in correspondence and the retention of original notes that accompanied sent mail. Files exist at both locations for all grants listed in NEMIS.

Documents retained at the state and federal FEMA region were typically also found at the local community; however, they were not organized in the same way (e.g., in some communities, all documents were located together while in others documents were retained in the files of the staff or consultants who created them). Unlike the states and the FEMA regions, which broke up lengthy documents and filed different sections under the appropriate topic, the local communities kept their documents whole. Also, communities retained internal project analyses and consultant reports that seldom made their way into the state or federal files (e.g., the state and FEMA region files might contain a summary of a benefit-cost analysis while the community file would contain the lengthy analysis developed by a consultant that was used to create the summary).

Grant applications were the main source of information for the FEMA Hazard Mitigation Grant Program (HMGP) and Flood Mitigation Assistance (FMA) funded grants. The grant applications usually contained fairly detailed explanations of the proposed mitigation activity, justifications for funding, engineering back-up if needed, descriptions of structures affected by the proposed activity, financial statements, benefit-cost analyses, and project schedules. There were, however, often more than one grant application if the project scope had changed. The grant applications were available at the regional, state and community sites and provided the basis for technical analysis.

During field visits, the initial contact person in each community normally provided access to the written documents, set up interviews with key informants to discuss the projects, and led tours of the project sites. The field visits usually were sufficient to clear up misconceptions and uncover information not available at the FEMA regional and state emergency management offices. Following field visits, detailed analyses of the FEMA-funded grants were conducted. If questions arose, knowledgeable persons were contacted by telephone and e-mail for additional information.

3.1.3 Project Impact Report Files

Project Impact was initiated by FEMA in 1997 to provide federal seed money to communities (selected by states) willing to develop long-term public-private partnerships that would result in self-sustaining disaster mitigation programs.[2] FEMA's goals were to support the creation of "disaster-resistant communities" and to reduce future federal post-disaster payments to these communities. It was believed that, if successful, Project Impact communities would become examples for other communities to emulate. Because of the nature of Project Impact, these grants and the reporting requirements are not like those for the other two FEMA hazard mitigation grants programs considered.

Whereas HMGP and FMA grant files were retained in folders with similar headings, Project Impact files were not. FEMA gave the communities great latitude in running their programs. Project Impact grants typically funded multiple activities determined by locals to be good mitigation investments. However, after the start of Project Impact, many initially proposed activities were further evaluated and were either cancelled or modified during the life of the grant and different activities were often added. If partners in the community offered to pay for a project, federal funds were moved to another activity. The dynamic nature of the projects was reflected in the files. There often was no clear indication of what set of activities was actually completed until a final report was prepared and, because the program ended suddenly, some communities did not keep their files or write final reports.

On-site interviews with Project Impact managers and the collection of additional printed documents were necessary to accurately identify the activities conducted under Project Impact. Most of the printed documents found in the communities had not been submitted to FEMA as

[2] Project Impact ended in 2001; communities with existing grants were allowed to complete their activities.

part of their required financial quarterly reports. However, uncertainties concerning what activities were actually attempted and their status remained because key managers on several Project Impact grants had left and were unavailable for interviews.

3.1.4 Other Files

In the community studies, additional data were sought to describe and evaluate overall community hazard mitigation programs and to determine the effect of FEMA hazard mitigation grants on future community mitigation activities. Telephone and face-to-face interviews, field investigations, and email correspondence efforts were structured to cast a wide net to gather information concerning any hazard mitigation efforts that occurred before or after a community received FEMA grants, the sources of funding those efforts, any written documents describing the activities and their outcomes, and knowledgeable persons to contact to discuss the endeavors and locate the documents. Virtually all the documents identified through this process were collected during site visits although some were also located over the Internet.

Five types of written documents were found:

1. Local hazard mitigation plans;

2. Budgets, both annual and capital, that contained descriptions of mitigation activities carried out by local government agencies, spending amounts, and funding sources such as local revenues, dedicated property tax receipts, or bonds;

3. City and county council meeting minutes and resolutions related to mitigation activities;

4. Internal local government agency reports and studies done in-house or by contracted consultants describing proposed or existing mitigation activities, funding, and expected or actual results; and

5. Files, including project applications and supporting documents, for mitigation projects funded by state or non-FEMA federal agencies. Funding agencies included state emergency management offices and insurance departments, the U.S. Army Corps of Engineers, and the U.S. Department of Housing and Urban Development.

3.2 Other Primary Datasets

To supplement the databases above, several new datasets were developed during the course of this study. The discussion below presents data and information created as part of the community studies analysis; this is followed by a brief discussion on new data for the benefit-cost analysis of FEMA mitigation grants.

3.2.1 Community Studies

To supplement existing datasets and to provide more contextual information on community mitigation activities, additional data were collected through structured interviews with knowledgeable persons, field research, and limited archival record recovery. Figure 3-3 illustrates the data collection process. The process is comprised of four major phases: pre-interview activities; formal interviews; field visits; and data or information processing.

Pre-interview activities generally were conducted by field researchers. The main purpose of this activity was to collect from FEMA regional offices reports and data that would help in the conduct of any subsequent benefit-cost analysis and identify knowledgeable persons to interview. As part of the study protocol, FEMA Headquarters formally asked the regional offices to provide records to study personnel.

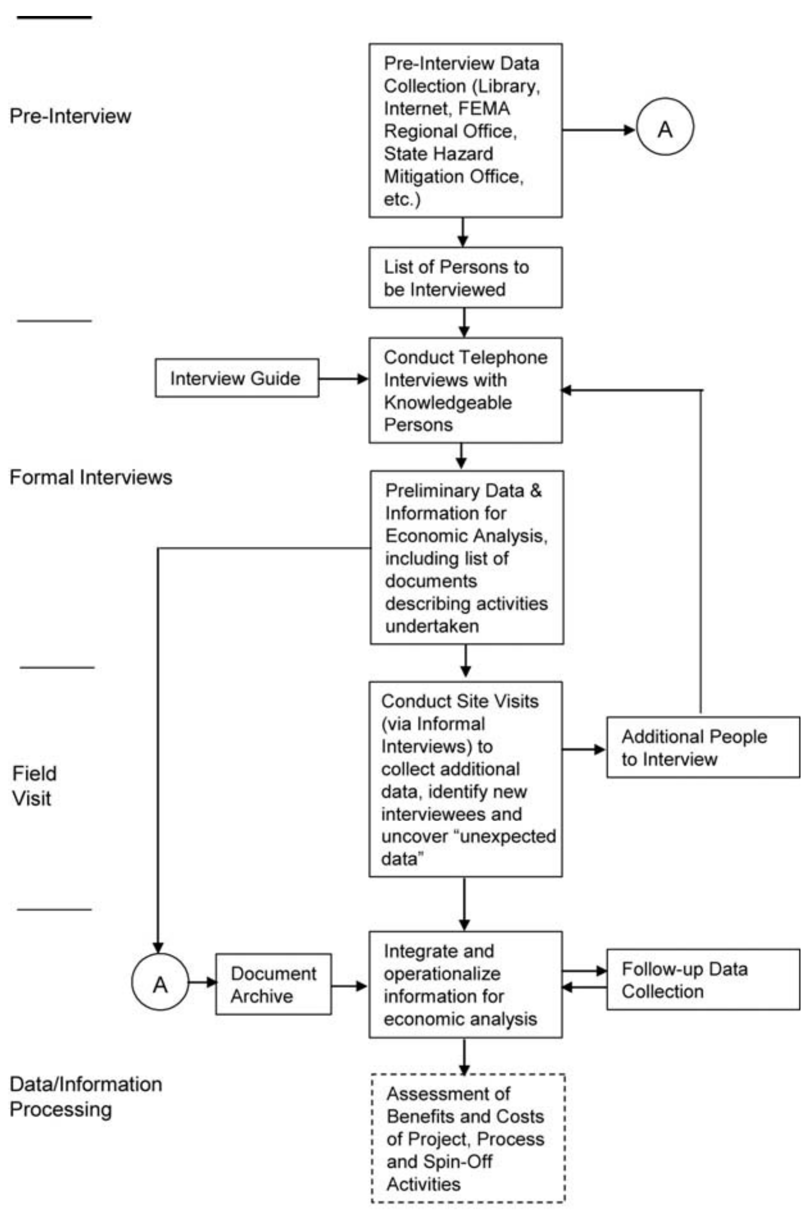


Figure 3-3 Data collection process for community studies; "A" denotes archive.

The next step involved telephone interviews with knowledgeable persons. These interviews provided an "insider's view" of hazard mitigation programs and projects that were being conducted within each of the communities investigated. As part of the data collection protocol, a detailed interview guide was created (see Appendix B) and tested during a pilot study involving Tulsa, Oklahoma.[3] Because the vetted guide was used in all subsequent interviews, the information gathered could be used as the basis for limited generalization. Some of the questions contained in the interview guide focused on the identification of possible synergistic activities that arose from FEMA hazard mitigation grants. These interviews also resulted in identification of additional people for face-to-face interviews.

Once telephone interviews were complete, face-to-face interviews were conducted with some of the knowledgeable people identified above and with others whose input was identified as valuable during field visits. In many communities, unexpected data and additional persons were found that led to further data analysis and telephone interviews. After the community site visit, any additional requests for data or clarifications were completed by telephone or by email.

3.2.2 FEMA Mitigation Grants

The FEMA regional office files were reviewed for all grants in the study sample. Electronic coding forms were created to extract data from the sample grant applications in a detailed and structured manner. The form for project mitigation activities contained 200 data fields for each property or location mentioned in the grant application. A coding database was compiled from the extracted data. Eventually 54,000 data items were entered into the coding database. The database addresses 1,546 properties in project mitigation activities and 387 distinct efforts in process mitigation activities.

Required data that appeared neither in the grant files at FEMA regional offices nor in the NEMIS database were acquired from the Internet or from other sources and inserted into the coding database. For example, square footage, number of employees, and precise street addresses for a number of mitigated buildings were acquired from the subgrantee's website or from the website of engineers or architects involved in the grant project. Latitude and longitude of most facilities were acquired using GIS software such as Microsoft Streets and Trips® (Microsoft Corp. 2004). Site soil classifications for earthquake projects were acquired using a geographic database created by the California Geological Survey (Wills et al., 2000).

[3] The above concepts were considered in development of the standardized questionnaire used in telephone interviews and when selecting variables to assess from the 2000 census. Included in the standardized questionnaire were questions about non-FEMA-funded hazard mitigation activities, the history of hazard mitigation in the community, the existence of relevant state and local mitigation laws, the existence of active partners, perceived risk of disaster, perceived efficacy of hazard mitigation programs, and similar questions. Drawn from the 2000 census were data on population size, population growth rate, median age, percent non-white, percent of households with children under 18 and members over 64, percent of female-headed households with children, percent of families below the poverty line, percent in the labor force, and median family and per capita income. A more complete discussion of the demographics of each community is contained in Appendix C.

Chapter 4
METHODS OF ANALYSIS

This chapter is key to understanding the underlying methods used for both the benefit-cost analysis of FEMA mitigation grants and the community studies. In many cases, the same methods were used in both parts of the study. This was especially true in estimating expected losses and impacts to buildings, infrastructure, and exposed populations from earthquake and hurricane wind. In some cases, the benefit-cost analysis of FEMA mitigation grants performed a broader analysis of benefits by examining a wider range of impacts, especially to the environment and to historic structures. At the same time, the community studies offered additional insights into mitigation effectiveness by exploring how FEMA-sponsored mitigation activities percolate throughout the community in the form of synergistic activities ─ mitigation efforts that would not have occurred had it not been for the original FEMA grant. These different aims, seemingly similar, but in many ways very different, at times required that unique methodologies be developed and employed in both parts of this study.

This chapter is organized into four major parts. The first (Section 4.1) discusses the rationale behind the parallel components of the benefit-cost analysis of FEMA mitigation grants and the community studies. As suggested above, each study component is designed to answer a different part of the mitigation effectiveness question. The second and third parts of this chapter (Sections 4.2 and 4.3) introduce methodologies that are common between both components. HAZUS®MH was used for many of the loss calculations for both study components. This was especially true for earthquake and hurricane wind studies. However, in many cases, either because HAZUS®MH does not address certain kinds of losses or because the versions of HAZUS®MH that were available at the time of this study were not yet fully refined, it was necessary to develop alternative methodologies for loss estimation. Several of these methodologies are discussed in detail in this chapter; others that were important, but not key, to completing a particular phase of this study are mentioned briefly in this chapter and discussed in detail in the appendices to this report. The final two parts of this chapter (Sections 4.4 and 4.5) deal with the *sampling methods* and the overall methodologies for both the community studies and the benefit-cost analysis of FEMA mitigation grants. Appendix D contains the assumptions and limitations used in this study.

4.1 Parallel Study Components

What are the future savings to the nation that result from FEMA-sponsored hazard mitigation programs?

To answer this key question, the project was structured to provide for empirical research using a statistically representative sample of commonly used FEMA-funded mitigation activities as well as for research on mitigation activities carried out in specific community contexts. Together, these two study components:

1. Provide a robust assessment of mitigation effectiveness by quantifying the benefits and costs of FEMA-funded mitigation activities at both the national and at the community levels;
2. Identify the scope and breadth of mitigation benefits by examining both direct and indirect effects (e.g., business interruption to suppliers and customers of directly damaged structures);
3. Quantify the cost-effectiveness (i.e., benefits equal to or exceeding costs) of mitigation at a very high level (for the nation) and corroborate this assessment with specific benefit-cost analyses performed at the community level; and
4. Describe the extent to which FEMA-sponsored activities led to synergistic efforts that amplified the effects of the initial FEMA grant.

To compile or create the required methods of analysis, it is valuable first to understand the nature of FEMA's grant activities. Table 4-1 summarizes the types and distribution of grants within the present scope of study. The upper portion of the table details grants for project-type activities; the lower portion details grants for process-type activities. It shows that the most common grant for project mitigation activities involves acquisition, relocation, elevation, or floodproofing of property to mitigate flood (project type codes 200.1-204.4; 47 percent by cost). Various other small flood management projects (300.1-405.1; 18 percent by cost) and seismic structural retrofit (205.5-205.6; 13 percent by cost) represent half the balance. Regarding grants for process activities, Project Impact represents one third of the total cost, with miscellaneous grants (800.1; 18 percent by cost) and public awareness and education (100.1; 11 percent by cost) represent half the balance.

4.2 HAZUS®MH and Other Loss Estimation Methodologies

The section begins with a brief summary of HAZUS®MH and how it was used in this study. The basic structure of HAZUS®MH was introduced in Section 2.2.2. The reader is referred to the HAZUS®MH Technical Manuals (NIBS and FEMA, 2003a, 2003b, 2003c) for details on the model and the databases provided databases. The discussion below describes how HAZUS®MH was used to calculate loss and benefits for earthquake and for hurricane wind.

4.2.1 Direct Property Damage (Stock Loss)

Direct property damage (or direct stock loss) from earthquake and hurricane wind was calculated using the standard version of HAZUS®MH (an alternate methodology was used for floods as described in Section 4.3.1 below). HAZUS®MH is constructed so that for each of several non-exceedance frequencies (hazard levels), an excitation or hazard load can be calculated at each location of interest (e.g., for each building having hazard mitigation). In the case of earthquake, this is the performance point at which the building's pushover curve (as constructed from parameters in HAZUS®MH and from information in the grant application) crosses the seismic shaking response spectrum. In the case of wind, the excitation is peak gust velocity, as determined using the HAZUS®MH database.

Table 4-1 Distribution of grants in the NEMIS database

	Project Type Code	Mitigation Activity Type Description	% by No.	% by Cost
Project Activities	200.1-204.4	Acquire, Relocate, Elevate, or Floodproof Property	46	47
	205.3-205.4	Nonstructural Retrofitting/Rehabilitating – Seismic	3	9
	205.5-205.6	Structural Retrofitting/Rehabilitating – Seismic	4	13
	205.7-205.8	Retrofitting Structures – Wind	6	3
	206.1-206.2	Safe Room (Tornado and Severe Wind Shelter)	1	1
	300.1-405.1	Shoreline, Wetlands, Utilities, Flood Mgt, Roads, Bridges	28	18
	500.1-501.1	Flood Control - Major Structural Projects	2	6
	600.1-602.1	Warning Systems, Generators, and Other Equipment	10	3
		Grants for Project Mitigation Activities Total	100%	100%
Process Activities	90.4, 91.1	Mitigation Plan – Local Multihazard Mitigation Plan	16	5
	90.6, 92.1	Mitigation Plan – State Multihazard Mitigation Plan	3	5
	100.1	Public Awareness and Education	12	11
	101.1	Professional Education (Inspectors, Architects, etc.)	2	1
	103.1	Feasibility, Engineering and Design Studies	10	7
	104.1	Codes, Standards, Ordinances and Regulations	5	9
	105.1	Applied R&D in the Building Sciences	1	6
	106.1	Other Non-Construction (Regular Project Only)	8	4
	106.2	Project Impact	29	33
	600.1	Warning Systems	1	1
	800.1	Miscellaneous	13	18
		Grants for Process Mitigation Activities Total	100%	100%

The physical damage probability distribution to the facility was calculated based on the estimated performance point. In this context, the probability distribution represents the probability that the building will be in each of several damage states, e.g., light damage, moderate damage, etc.

Each damage state was associated with a mean damage factor. The estimated direct stock loss was the sum of the product of a damage-state probability, mean damage factor, and replacement cost. The process was repeated for each of several hazard levels. The scenario losses and the frequency of events were integrated to calculate an annual expected loss for the duration of the life of the building. This future stream of annual loss was then brought back to present value using standard discounting techniques. The difference between the direct stock loss before and after mitigation is the estimated mitigation benefit in terms of reduced direct stock loss.

4.2.1.1 Hazard Data

An important source for currently accepted hazard information for earthquake is the U.S. Geological Survey (e.g., Frankel et al., 1996). For hurricane wind speeds, HAZUS®MH uses a wind field model that is updated to include all historical storms of 1886 through 2001.

4.2.1.2 Exposure Data

FEMA grant applications provided data on the characteristics of the facilities being analyzed. Some grant applications, however, included poor geolocations; lacked data on structural types, total value of structures, square footage, and/or occupancy; or did not fully describe the mitigation activity. To overcome these problems, the available data were supplemented by geo-locating (latitude and longitude) each property using street address and mapping software such as Streets and Trips® (Microsoft, 2004) and by inferring HAZUS®MH style structure type information using the description of the facility (its construction material and age) or readily available information about the facility from web pages that discuss the mitigation effort. Occupancy loads were often readily inferred from occupancy type and square footage (ATC, 1985).

4.2.1.3 Vulnerability Data

The vulnerability models built into HAZUS®MH formed the basis for all damage calculations. Those models come from a variety of sources (see the various HAZUS®MH Technical Manuals, 2003) and are based on empirical, analytical, and expert opinion data. In some cases, it was necessary to develop alternative vulnerability models to address special situations (e.g., assess the life-safety improvement produced by replacing pendant lights in California schools).

4.2.2 Business Interruption (Flow Loss)

This discussion focuses on direct business interruption impacts (i.e., business continuity losses caused by direct property damage to facilities or businesses or by interruption of utility lifeline services), indirect business interruption effects (i.e., losses that stem from an interruption of supplies or services upstream or downstream), and economic data used in the analysis.

4.2.2.1 Direct Business Interruption

HAZUS®MH was used to evaluate the business interruption benefits of hazard mitigation. This section focuses on the Direct Economic Loss Module and Indirect Economic Loss Module of HAZUS®MH (NIBS and FEMA, 2003a, b, c), which evaluate regional economic impacts of a disaster given estimates of physical damage developed by the HAZUS®MH damage modules. The Direct Economic Loss Model estimates capital stock losses from a disaster and various forms of direct regional income loss in dollar terms. The Indirect Economic Loss Model estimates indirect impacts (losses or gains) to regional income by major economic sector.

While property damage represents a decline in stock value and usually leads to a decrease in service flows, business interruption losses are a flow measure and most, but not all of them, emanate from property damage. However, direct business interruption losses can take place even in the absence of property damage. For example, a factory may be unscathed by a hurricane but may be forced to shut down if its electricity supply is cut off due to hurricane-induced damage to generation facilities or transmission or distribution lines.

Attention to flow losses represents a major shift in the focus of hazard loss estimation — that losses are not a definite or set amount but are highly variable depending on the length of the “economic disruption,” typically synonymous with the recovery plus reconstruction periods (Rose, 2004a). This also brings home the point that disaster losses are not simply determined by the hazard intensity (coupled with initial vulnerability) but are also highly dependent on human ingenuity, will, and resources.

Another major aspect of loss estimation that needs to be incorporated to the extent possible is *resilience* or the ability to cushion losses by such actions as conservation, use of inventories, and input substitution (Tierney and Dahlhamer, 1998; Rose, 2004b). Several of these adaptations have been incorporated into the Indirect Economic Loss Model. However, one major aspect of resilience that is contained in the Direct Economic Loss Model is the "recapture" factor or the ability of a firm whose production has been interrupted to make up its lost output later by working overtime. Sectors, such as manufacturing, which have a steady demand and excess capacity have high recapture factors, whereas sectors like services (especially restaurants, hotels, theaters), which have a soft (time-related) demand and limited excess capacity, have low recapture factors.[4]

4.2.2.2 Indirect Business Interruption

Further losses stem not only from reduced production by businesses suffering property damage but also from several other sources (Brookshire et al., 1997). For example, additional losses stem from "ripple" effects to chains of upstream suppliers and downstream customers of damaged businesses or those cut off from their utility lifelines or access by their employees or customers. These indirect effects can be in the case of large, highly interdependent and self-sufficient regional economies, even larger than the direct flow losses (Rose and Liao, 2005).

A major feature of the HAZUS®MH Indirect Economic Loss Model is that consumers will have to redirect some of their ordinary spending to cover property repair/rebuilding costs. Thus, their overall expenditures are increased in the immediate aftermath of a disaster but are offset by a decrease of ordinary spending in subsequent years while they pay back loans or replenish savings. Borrowing costs further reduce subsequent spending. Economies are more resilient when borrowing costs, as well as the societal discount rate used to translate results into present value terms, are relatively low.

A major factor affecting overall business interruption losses was the level of outside aid, typically dominated by insurance payments and government relief. In cases where the proportion of outside aid was very high, this inflow, coupled with the positive ripple effects of reconstruction, can even result in the economy reaching a higher level of economic activity than prior to the disaster. However, this seemingly beneficial depiction of extreme hazard events is misleading in a pure benefit-cost analysis sense. The increased economic activity was mainly due to transfer payments coming into the region, but at the expense of economic activity elsewhere. From the standpoint of the nation as a whole, there was no net gain (see, e.g., Cochrane, 1997). Therefore, outside aid was omitted from the simulations to avoid including what are essentially artificial benefits.

Direct and indirect business interruption losses were not relevant in all cases. For example, a buyout in a residential area will not engender any such losses. Moreover, losses stemming from damage to schools or other public buildings will result in minimal business losses. On the supply side, they are not actual inputs to more standard economic activity (i.e., businesses). However, reduced operations of private sector buildings and some public buildings (e.g.,

[4] HAZUS®MH also computes displacement costs for businesses and government in the Direct Economic Loss Model. Displacement for households is discussed in the Section 4.2.3.3 on societal impacts.

hospitals) will reduce orders for inputs into them. The impact will primarily be in terms of lost wages/salaries, because public services are highly labor intensive and require a much lower proportion of material inputs than conventional businesses, especially manufacturing. Even then, indirect effects from reduced wages/salaries will be minimal because empirical work indicates people maintain much of their spending by withdrawing from savings, especially for necessities, in the aftermath of a disaster. Moreover, HAZUS®MH takes this into account.[5]

4.2.2.3 Economic Data

HAZUS®MH contains some economic information, primarily on individual structures, but also, to a lesser extent, on the regional economies in which they are located. Examples include asset values and operating incomes (where applicable). However, these data are based on estimated functions of physical characteristics (e.g., translating square footage and other variables for individual building types into economic values). These "data," along with included values (i.e., the data entries in HAZUS®MH in place of region-specific data, usually based on national averages), represent what is called a Level 1 analysis in HAZUS®MH. The user has the option, however, to substitute data that are more accurate and perform a higher level or Level 2 analysis. Where possible, the project investigators improved the data to perform a Level 2 analysis.

HAZUS®MH economic data were supplemented with:

1. Primary data from FEMA grant application files regarding wage/salary income, capital-related income, rental income, and total operating revenue.
2. Secondary data collected from public sources on type of economy (service, trade, or manufacturing), unemployment rate (a proxy for excess capacity), and sectoral national averages of labor and capital income ratios per dollar of output (revenue).

Economic data generally were absent from the FEMA grant files. Moreover, some of the economic data entries that did appear in the files were vague. For example, information on operating revenues often applied to a company as a whole rather than to the building or utility system component to which the mitigation applied.

Finally, it was cumbersome to substitute the secondary data into the HAZUS®MH simulations, and it was not evident that this would lead to results that are more accurate, because the former are also national averages. These data were considered only in those cases where the HAZUS®MH results were beyond the extreme bounds of benefit-cost ratios.

One of the important issues discussed early in this study was the selection of an appropriate discount rate. The real rate used for discounting is based on market interest rates. The base case

[5]A prevailing economic hypothesis, and one that has been verified in some instances, is that government expenditures do not have a full expansionary effect on the economy but are offset in part, in full, or even have contractionary effects due to inefficiency offsets. That is, government expenditures require increased taxes (and, hence, reduced consumer spending or business investment) or that government borrowing raises interest rates and reduces private investment. This may well be the case for government spending on hazard mitigation but would apply equally to continued government spending on post-disaster assistance. Part of this presumed displacement effect might be attributable to the fact that much of the product of government spending is in the form of non-market goods and services and hence does not show up in GNP accounts. In fact, some analysts have found there to be sizeable returns to government infrastructure spending because of broader societal benefits (typically externalities, or spillover effects). This, in fact, is the opposite of the displacement theory and represents a type of investment enhancement effect. Because of the controversy surrounding this consideration and the lack of definitive measures, this study omits it from analysis.

real discount rate used was 2 percent, the rate recommended by the Congressional Budget Office (1998). This rate is based on a CBO estimate of the long-term cost of borrowing for the federal government and generally is considered a conservative estimate of the long-term real market risk-free interest rate. The Office of Management and Budget (OMB) recommends that the real rate should be based on the rate of return to private investment (OMB, 1992). Sensitivity tests were performed using 0 percent as a lower bound and 7 percent as an upper bound. The 7 percent rate approximates the marginal pretax rate of return on an average investment in the private sector in recent years. This rate was generally considered an upper bound for federal projects because the rate of return for public sector projects is lower than for private sector projects. The 2005 real discount rates required by OMB are within the range of discount rates used for this study.[6] Note, again, that it is considered inappropriate to discount the economic value of avoiding future statistical deaths and nonfatal injuries, so no discount rate is applied to these benefits. This is because there is no well-established concept of the time value of life. Although the method requires a dollar value for a statistical life saved, life need not be treated as if it were interchangeable with money or is subject to all of the same processes that affect money. There are no loans for human lives, no interest payments, no life bank accounts, and there is no generally accepted principle that a life next year is worth less than a life this year.

4.2.3 Societal Impacts

Two types of societal impacts are measured in HAZUS®MH: casualties and displacement. Some modifications to the HAZUS®MH methodology were necessary to address the special needs of this study (e.g., estimation of benefits from nonstructural hazard mitigation). These are discussed below and in Appendix E.

Because societal impacts are not readily quantifiable, these impacts often are mentioned, but not analyzed in cost-benefit analyses. This project has attempted to go beyond a cursory mention of these savings to better understand the relationship, on a societal level, between impact and mitigation. Two major methodological issues required resolution because the potential societal

[6] The rationale for the use of a market interest rate is that it is equal to the rate at which those in the economy are willing to trade present for future consumption and therefore reflects societal preferences. Market interest rates are equal to the sum of the real rate of interest (i.e., the rate of return on capital) and inflationary expectations. Most variations are due to changes in inflationary expectations because the rate of return on capital is fairly stable over time. The real rate of interest is the appropriate discount rate for benefit-cost analysis. Both the U.S. Government Accountability Office and the Congressional Budget Office use discount rates for benefit-cost analysis based on U.S. Treasury borrowing rates. U.S. Treasury bonds are virtually risk free. The maturity date typically quoted is the 10-year U.S. Treasury note, which is used as a benchmark rate by many financial institutions. The yield to maturity on the 10-year U.S. Treasury note was 4.34 percent in the week ending September 12, 2003 (Wall Street Journal, 2003).

Expected inflation, relative to historical inflation, is very difficult to measure. One of the most commonly used measures of expected inflation is the current inflation rate. The most widely used measure of the inflation rate is the Consumer Price Index (CPI) for all urban consumers. The CPI is measured monthly by the U.S. Bureau of Labor Statistics (U.S. Bureau of Labor Statistics, 2005). Assuming expected inflation is equal to the August 2003 CPI (2.6 percent), the real rate of risk-free interest on the 10-year Treasury note is 1.74 percent. Another estimate of the real rate of risk-free interest is the yield to maturity on a Treasury Inflation Protection Security (TIPS), which is indexed to the inflation rate measured by the CPI. Because of this indexing, the market interest rate of the TIPS is equal to the real interest rate. The TIPS that is most similar to the 10-year U.S. Treasury note matures in July 2013. The market interest rate for the 10-year TIPS is 2.23 percent (Wall Street Journal, 2003). Based on this interest rate, the market expectation for future inflation is 2.11 percent. The 2.23 percent real market interest rate incorporates market expectations about the inflation rate rather than the historical inflation rate. For simplicity, a 2 percent market interest rate was adopted for this study. The 2 percent rate is almost the midpoint between the real rate based on historic inflation and the real rate based on expected inflation.

savings of mitigation had not been modeled and some of the savings/impacts could not be quantified. The first issue stemmed directly from the difficulty of quantifying many societal impacts as little work has been done to model them. Even more problematic was that the data needed to evaluate the societal impacts and possible savings of mitigation are not routinely collected (H. John Heinz III Center for Science, Economics and the Environment, 2000). As a result, much of the quantified work on this project was limited based on the timeframe, scope of the study, and available data.

One of the major facets of this study was a focus on quantifying societal consequences of disasters so that they can be translated into dollar savings. Although this was a very limited approach, it was the only viable approach given time and financial constraints. The modeling focused primarily on how mitigation reduces casualties and associated expenses. Other aspects included reduction in displacement and associated costs. Due to the nature of the mitigation grants funded by FEMA, these costs applied only to the flood hazard mitigation activities.

4.2.3.1 Casualties

HAZUS®MH does not explicitly provide detailed societal impact due to nonstructural damage. HAZUS®MH can generate casualty estimates only for earthquakes and, even then, can model only the effect of mitigation when such efforts are structural. Other methods were developed that used engineering judgment to estimate reduction in societal consequences.

Analysis of each mitigation project determined how the protective measure reduced societal consequences. FEMA grant application files provided specific details of the projects in terms of overall project goal, number of structures, or number of replacements or retrofits. Overall, few projects reduced displacement of people and, consequently, the need for shelter. Instead, the majority of the quantifiable reduction in societal consequences was in reduction of injuries and deaths. Table 4-2 lists, by hazard, the major types of mitigation projects sampled and analyzed for this project, and how the project type reduces casualties. In addition, Appendix E summarizes the details of each casualty model developed in this study.

4.2.3.2 Casualty Models and Value of Human Life and Injuries

Translating injuries and loss of life into quantifiable dollar figures is difficult. Estimates of the value of life vary greatly ─ from $1 to $10 million depending on the agency making the assessment or the use of the value of life figure (see Porter et al., 2002, for discussion). One of the more applicable figures is from a study for the Federal Aviation Administration (1998), in which a value of $3 million per statistical death avoided is used to value the benefit of investment and regulatory decisions.

Quantifying the costs of injuries is equally problematic. Little research has focused specifically of the cost of injuries from disasters. However, the Federal Highway Administration in 1994 published a technical report, based on a 1991 Urban Institute study, which provided figures of estimated costs of injury damages in car accidents. Bringing the figures to 2002 dollars, the estimates based on injury severity are provided in Table 4-3.

This severity scale, however, does not correspond directly into the HAZUS®MH scale and, as such, has been modified for this project. Using a geometric mean approach to combine categories, minor and moderate severity costs were merged for HAZUS®MH Level 1; the serious severity level was used for HAZUS®MH Level 2; and severe and critical injuries were merged for HAZUS®MH Level 3. As discussed earlier, the Federal Aviation Administration value of human life was used to represent the HAZUS®MH Level 4 category. Based on these adjustments, Table 4-4 lists the adopted values for life and injury costs for this study.

Table 4-2 Major types of mitigation projects designed to reduce casualties by hazard

Hazard	**Mitigation**	**Benefit**
Earthquake	Variety of structural projects designed to reduce damage to buildings during an earthquake	Earthquakes have no warning, and as a result, individuals have little opportunity to take self-protective measures. Injuries, in part, result from structural damage. Reducing the potential for structural damage decreases injuries. Benefits modeled with HAZUS®MH .
Earthquake	Pendant lighting retrofit and replacement in schools; ceiling retrofit and replacement	Pendant lights and certain types of ceiling systems, particularly in schools, have the propensity to fall during earthquakes. Documented injuries are rare since most major earthquakes have occurred outside of school hours. The assumption, however, is that mitigation activities focused on pendant lights and ceiling systems will reduce the number of lights that fall in an earthquake. Benefits were modeled using engineering judgment.
Flood	Purchasing and demolishing homes in flood-prone areas	Mitigation to purchase and demolish homes in flood-prone areas reduces the potential for injuries that can result each time the structure floods. Some data in the FEMA grant applications for these mitigation projects specify that the project specifically was aimed at reducing future repeat outbreaks of hepatitis. Benefits were modeled using injury rates in other flood events as reported by the Centers for Disease Control.
Wind	Constructing tornado saferooms	Tornado threats develop relatively quickly, but there often is a short window for individuals to take protective action. These mitigation projects focus on building saferooms in public spaces or in homes to offer a safe refuge during threatening weather. Estimation of benefits used probability of tornado events in a given location in conjunction with HAZUS®MH and ATC-13 (ATC, 1985) casualty estimates.
Wind	Shelter hardening and shuttering	Evacuations from hurricanes focus on storm surge effects, not wind. Evacuations protect those in low-lying areas from potential injuries from surge. Shelter retrofitting appears to focus on bringing shelters, particularly those in Florida, to the highest level of wind resistance so that the shelters will be safer and on increasing the shelter inventory. Estimation of benefits used shelter capacity information in conjunction with injury estimates in previous hurricane events.

Table 4-3 Cost of injuries (Urban Institute, 1991)

Severity	Cost (2002 $)
Minor	6,000
Moderate	49,000
Serious	180,000
Severe	590,000
Critical	2,400,000
Fatal	3,200,000

Table 4-4 Casualty values mapped into HAZUS®MH

Severity	Cost (2002 $)
HAZUS1	17,000
HAZUS2	180,000
HAZUS3	1,200,000
HAZUS4	3,000,000

It was beyond the scope of the present study to develop and justify new, hazard-specific comprehensive costs to reflect HAZUS®MH injury levels. Thus, the Federal Aviation Administration (1998) and Federal Highway Administration (1994) figures were used. Note that these values are not limited to car crashes and that the comprehensive costs in Table 4-3 reflect medical costs, lost earnings, lost household production, emergency services, vocational rehabilitation, workplace costs, administrative, legal, pain and lost quality of life, and other factors. Medical costs alone represent a relatively small portion of the comprehensive cost, typically 10 percent or less. Further, note that the costs shown in Table 4-3 are not uncertain. They are not mean values with statistical distributions but rather discrete values chosen by the agencies of the federal government to represent the benefit associated with avoiding one such statistical death or injury. The only exercise of judgment in the present application was in the mapping from Abbreviated Injury Scale (AIS) to HAZUS®MH injury levels (see Appendix F). Note also that AIS Levels 1 through 5 each represent a range of injuries. Regardless of how the reader would value any particular injury in some AIS level, how it might be treated, or whether it should be equated with another injury in the same AIS level, the federal government assigns them the same value for use in benefit-cost analysis.

4.2.3.3 Displacement

Displacement of persons during recovery time is a fundamental social impact of disasters. HAZUS®MH provides estimates of displacement time that can be used to estimate displacement cost associated with relocation. All residential flood mitigation projects included properties with 100-year flood depths that warranted long-term displacement cost calculations. HAZUS®MH recovery times by flood depth were used to estimate displacement cost and are included in Table 4-5.

Table 4-5 Relationship between flood depth and recovery time in days

Flood Depth (feet)	Recovery Time (days)
1	90
2	180
3	270
4	360
5 – 7	450
8	720

The benefits associated with displacement cost were calculated for the 100-year flood event. The benefits included rent for an apartment, furniture and other household items. Median rent by county from the U.S. Census determined rental costs. Rent for furniture and household items are a fixed $300 per month. An additional $100 per month covered an average increase in commute time. Sensitivity studies consider an overestimation of monthly displacement cost of 25 percent and an underestimation of 50 percent.

4.3 Supplemental Methodologies

During the course of this study, it was necessary to develop additional methods to supplement the HAZUS®MH loss estimation methodology and to address new types of benefits or losses. The additional methods were developed to assess:

1. Direct property loss from flood,
2. Direct property loss from tornado,
3. Business interruption loss from utility outage,
4. Environmental and historic benefits, and
5. Benefits from grants for process mitigation activities.

4.3.1 Direct Property Loss from Flood

Because HAZUS®MH (Flood) was not available in time for this study, an alternative methodology was developed and used to estimate future flood losses. The basic methodology consisted of four steps:

1. Determine property location and associated channel. Determine the latitude, longitude, elevation, floodplain, and channel center associated with each sample property. This was done by matching the property's address number range, street name, city, and state to a database and then interpolating the address number between block endpoints to estimate the location of the property. Using elevation maps and Q3 floodplain maps (digital map data available from FEMA), the property elevation, floodplain, and channel center closest to the property was then determined (see Figure 4-1). These calculations were performed using a Geographic Information System (GIS) tool.

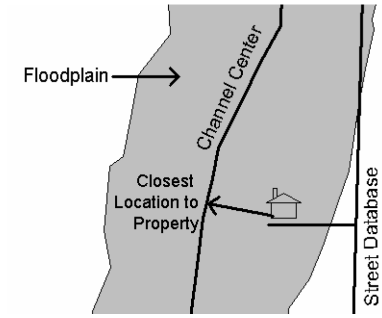
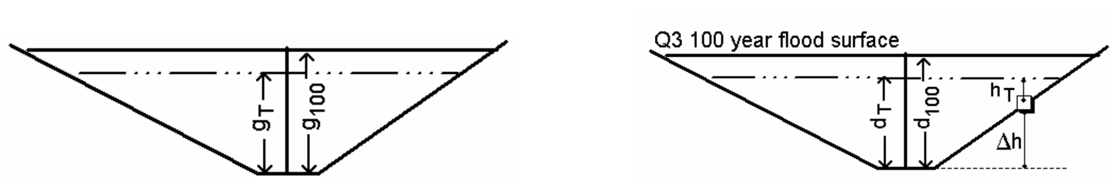


Figure 4-1 Schematic of floodplain showing how the point in the channel center closest to the property is determined.

2. Determine channel center flood depths. For each channel, the channel-center flood depths and their associated recurrence frequencies were determined. The 100-year flood depth at the channel center, denoted by d_{100}, was calculated as the elevation difference between the channel center and the elevation at a point on the edge of the 100-year floodplain, determined using Q3 digital floodplain maps and digital elevation maps. The channel center flood depth associated with other recurrence periods was then calculated using stream gauge data. Referring to Figure 4-2 A and B , if d_T denotes the channel-center flood depth associated with the T-year recurrence period, and g_T denotes the depth at a nearby stream gauge and associated with the T-year recurrence period, then d_T is estimated as $d_T = d_{100} + (g_T - g_{100})$.



A) Cross-section at USGS stream gauge   B) Cross-section at property

Figure 4-2 Variables used to calculate flood depths.

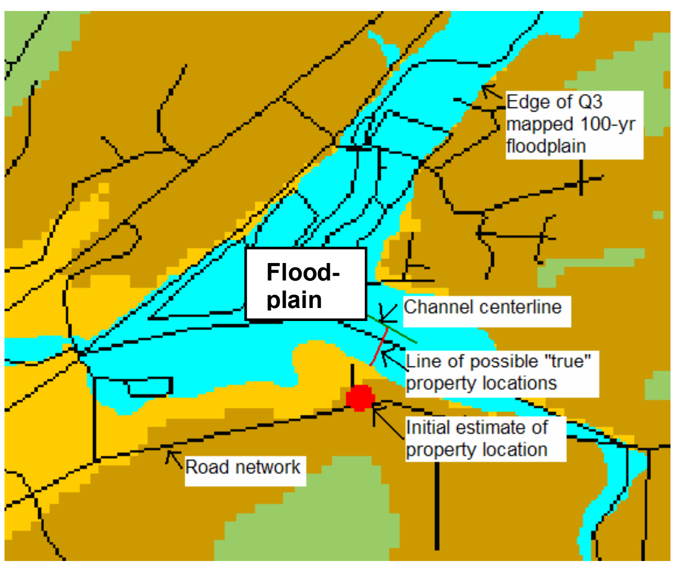
3. Determine flood depths at the property. This was done by subtracting from the channel center flood depth the difference in elevation between the property and the channel center. Referring to Figure 4-2B, if h_T denotes the T-year flood depth at the property and Δh denotes the elevation difference between the channel center and the property, then $h_T = d_T - \Delta h$.

4. Calculate property losses. Property characteristics such as number of stories, foundation type, presence of basements, replacement value, etc., were determined from the grant application and the National Emergency Management Information System (NEMIS) database. Damage functions that relate property loss with flood depth were taken from HAZUS®MH. These relationships were used with the property flood depths h_T to determine T-year flooding losses for several values of T. The T-year losses and recurrence frequency were numerically integrated to calculate the expected annualized property loss.

These four steps were performed twice: once without and once with mitigation. The difference between expected annualized loss without and with mitigation is the expected annualized benefit for property losses. A present-value calculation yields the present value of property benefits of the mitigation. Other factors that contribute to benefit, such as environmental and dislocation costs, were added to estimate the overall mitigation benefit and the benefit-cost ratio for the property.

In this study, the first step proved to be problematic, largely because of imprecise address information in the grant applications and because of discrepancies between the estimated location calculated during Step 1 and the true property locations. When mapping the estimated property locations along with the floodplains as shown in the Q3 maps it became evident that a large number of properties appeared to lie *outside* of the 100-year floodplain. (An example is shown in Figure 4-3.) This caused concern because mitigation funding rules require that the building be subject to flooding. It was not surprising, however, because geocoding errors are common. The geocoding error (defined here as the distance between the estimated and true property locations) can reach 1,000 ft in urban areas and 2.2 miles in rural areas with the true location of 1 in 100 rural properties lying more than 1,600 feet from the estimated location.

Because of this difficulty, Step 1 was modified. As described above, each property was geocoded (e.g., large dot in Figure 4-3) and associated with a floodplain (floodplain region in Figure 4-3) and channel center. It then was assumed that the “true” property location lay at some uncertain distance along the line segment between the edge of the 100-yr floodplain and the channel center, with uniform (equal) probability of lying at any given point along the line segment. As in Steps 2 through 4, losses then were calculated for each of several points along the line segment. A numerical technique called Hermite-Gauss quadrature was used to integrate losses and the probability distribution of the property location. Appendix G provides a more detailed description of this procedure.



Note: The building site (large dot) is placed on the road network where it falls just outside the 100-year flood boundary. The actual location of the building is off the road network and in the floodplain.

Figure 4-3 Illustration of geocoding error in flood analysis.

4.3.2 Direct Property Loss from Tornado

One of the pilot studies for this project (Tulsa, Oklahoma) identified the need to evaluate the benefits of "saferooms" in tornadoes. HAZUS®MH currently does not address tornado hazards; therefore, an alternative method was developed. First considered were methods by Grazulis (1993) and Hart (1976). GIS data on tornado occurrences sorted by time-period and by Fujita scale rating from the Storm Prediction Center at the National Oceanic and Atmospheric Administration (NOAA) were retrieved.

The approach selected for modeling economic and societal losses in terms of number of casualties caused by tornado damage assumes that the country can be divided up into one-degree by one-degree cells that contain tornado frequency information on events that have affected that cell. To model the areas affected by these events, a degradation model was used that allows for attenuation of effects (e.g., wind speed) with longitudinal distance and width in calculating the probability of a given wind speed. To estimate losses caused by these events, HAZUS®MH damage and fragility functions were used. To estimate casualty levels, the model described above and in Appendix E was used. The overall method for estimating tornado losses is described in detail in Appendix H.

4.3.3 Business Interruption Loss from Utility Outages

FEMA mitigation grants that make electricity and water utilities more disaster-resistant are intended not only to reduce property damage but also to prevent business interruption losses. However, the ability of HAZUS®MH to estimate business interruption losses stemming from utility lifeline failures is very limited. HAZUS®MH only provides estimates of utility "downtime," which then requires external data to be translated into lost income to utilities themselves. Moreover, HAZUS®MH currently lacks the ability to calculate losses to direct and indirect utility customers. This study developed a method for calculating and business interruption losses caused by utility outage; it is described in detail in Appendix I.

The overall strategy to simulate these omitted customer losses involved performing some supplementary calculations outside HAZUS®MH and then inserting the results back into the HAZUS®MH model to exploit its ability to compute indirect losses. First, HAZUS®MH downtime results were translated into utility business interruption loss. This result was used to estimate the direct business interruption effects of a utility outage on its customers. These first round supply shortage effects were inserted into the HAZUS®MH Indirect Economic Loss Module as an entire vector of final demand changes. HAZUS®MH then internally performed flexible input-output model computations of what is now conventionally referred to as the indirect category of business interruption losses from utility service disruptions (income losses to suppliers and customers of the initial customers whose utility service is disrupted). This captures impacts on businesses that are neither directly physically damaged nor actually cut off directly from utility services but that lose income because at least one member of their supply chain or customer chain is without water or power.

4.3.4 Environmental and Historic Sites Benefits

Several nonmarket valuation methods are available for estimating the environmental and historic sites benefits of natural hazard mitigation. These methods include stated preference and revealed preference approaches. Contingent valuation, contingent behavior, and conjoint/choice analysis methods are examples of stated preference approaches. Travel cost, averting behavior, and hedonic price methods are examples of revealed preference approaches. The current state of the art in benefit estimation is to combine stated and revealed preference approaches to exploit the strengths of each approach and better deal with the weaknesses.

It is costly to use the revealed and stated preference methods. First, the travel cost and hedonic pricing methods require location-specific datasets. A single study would have been feasible in the time allotted, but the number of studies required to assess the environmental benefits of several mitigation projects, was not feasible due to time constraints. Second, using a single revealed preference method would exclude large classes of environmental values from the benefits assessment. The travel cost method focuses on recreation benefits. The hedonic price method focuses on benefits to property owners. Because mitigation projects can have recreation, property value and other environmental benefits, a focus on one valuation method could lead to large errors. Consideration of multiple revealed preference valuation methods also is costly.

When the cost of primary data collection is prohibitive, the benefit transfer approach, a specialized version of data transfer developed by environmental economists, is the wisest approach (Brookshire and Neil, 1992; Bergstrom and DeCivita, 1999). In this study, benefit estimate transfer and meta-analysis transfer methods were used. With benefit estimate transfer, researchers obtain a benefit estimate from a similar study conducted elsewhere and use it for the current policy analysis case study. Benefit estimate transfer using meta-analysis has three advantages over benefit estimate transfer alone. First, by employing a large number of studies, benefit estimates will be more rigorous (e.g., controlling for outliers[7]). Second, meta-analysis may be used to control for differences in functional form and other methodological differences across studies. Third, differences between the study site and the policy site can be better controlled.

Appendix J summarizes how the benefit transfer method was employed in this study to assess the following types of environmental and historical benefits: water quality; drinking water; outdoor recreation trips; hospitals and hazardous waste; wetlands; aesthetic, health, and safety benefits from underground power lines; and cultural and historic resources.

4.3.5 Grants for Process Mitigation Activities

The basis of measuring benefits of a process mitigation activity is whether it leads to mitigation action(s). An information campaign, for example, results in tangible benefits only if it induces behavioral changes that lead to mitigation efforts. The printing of brochures alone is not sufficient to generate benefits.

[7] Anomalous or extreme results.

The difficulty is in establishing a causal link between the process product and subsequent action and accurately measuring that linkage. The desired measure would incorporate the change in the probability that mitigation will occur that is attributable to the process grant and not to some other source, such as a project grant. However, it is not likely that this can be accurately measured except in rare instances. The best way to determine the change in the probability might be to survey decision makers who are responsible for implementing mitigation actions; however, no such survey data that could be combined with information on process grant costs and benefits were readily available. Measurement is further complicated by several factors including the possibility that one grant for process activities may lead to another process grant before eventually leading to mitigation action. What is most easily observed are savings in damages attributable to many different sources or inputs. In addition, other factors may obscure the relationship, including the event of a major disaster and funding from non-FEMA sources.

A grant for a process activity yields a benefit primarily when it results in a "spin-off," a type of "synergistic activity" defined as a mitigation activity not directly funded by FEMA that is the direct result (an action that would have not otherwise taken place) or indirect result (an action that is accelerated in timing, but would have taken place eventually) of FEMA hazard mitigation grant support. A process that itself cannot lead to action or to a subsequent FEMA-funded project grant for project activities requires a spin-off to achieve benefits. The exceptions are economic spillovers or when the process grant involves the more effective use of the previous expenditure without incurring additional costs (e.g., brochures urging people to stay alert for existing tornado sirens).

Information on the benefits and costs of process activity grants is scant, at best. The analysis performed in this study drew heavily on similar analyses activity as only a few studies allow a direct comparison of some type of benefits to the cost of the grant (URS Group, 2001; Porter et al., 2004; Taylor et al. 1991). Thus, in each category, the benefits relative to the costs of mitigation actions (not the costs of process activity grants per se) are mainly considered.

See Appendix K for more details in the logic behind these conclusions. A wide range of studies was reviewed but, unfortunately, only a handful provided information that could be used directly in the analysis. First, the TriNet project review (see URS Group, 2001) may be used to assess the effectiveness of a process activity grant in the area of multihazard mitigation. The grant appears to be consistent with the definition of a process activity grant, and has a total cost of $16.76 million. The overall grant emphasizes improved building codes, but was funded under FEMA's hazard mitigation grant program with other features, including a plan for improved data transmission, improved spatial resolution of the geographic variation in earthquake ground motions, and improved motion sensors. This multi-faceted strategy was designed as part of an overall plan to reduce damage from earthquakes, but several features protect against other hazards (e.g., the building codes protect against landslides and strong winds, and the warning systems protect against flash floods and some man-made hazards). The impact of the grant was not only on reduced building damage but also on reductions in power outages and reduced casualties. In addition to the process grant's cost, there were projected costs of $23.1 million for replacing/retrofitting old code buildings and $12.4 million for developing codes for new buildings, or a total implementation cost of $35.5 million. The total net benefits of mitigation, excluding the process activity grant, were estimated at $37.8 million (total benefit of $73.3

million minus $35.5 million). Netting out the $16.76 million in process grant activity costs, it is immediately seen that net benefits are still positive. Put another way, the benefit-cost ratio without the process activity grant cost is 2.06. The ratio, including the grant as part of costs, falls to 1.4, but is still above one.

A flood mitigation planning study for Mecklenburg County in North Carolina also was used for multihazard mitigation analysis. This study suggested that if the county implemented new floodplain restrictions, future damage to structures could be reduced from $25 million to $8.5 million. The benefit-cost ratio associated with these new measures was estimated to be 1.25. The results of the two multihazard studies were used to establish a benefit-cost ratio of 1.25 in this category. This is a conservative estimate of the benefit-cost ratio for multihazard process grants.

For risk communication, two studies provided useful data. The first was a series of reports that addressed the cost-effectiveness of the U.S. Environmental Protection Agency's public information program that urged public testing for radon before and after real estate transactions; the second involved the use of Geographic Information System maps for communicating the risk of nearby landfill or waste disposal sites to homeowners. Based on these studies, a benefit-cost ratio of 1.2 was assumed for risk communication activities as they relate to warnings. The project investigators were unable to establish a benefit-cost ratio for risk communication activities related to public education.

The economics of building code benefits pertaining to specific structural and property changes or impacts from hurricane-force winds is discussed in Lombard (1995). She estimates benefit-cost ratios for different mitigation strategies (lateral bracing, roof covering, anchorages, etc.) for different categories of hurricanes using an equation developed for the analysis. As is the case with most studies examined, the costs cited in her dissertation are not the costs of process activity grants, and, in fact, her analyses do not relate to any grants per se. They are the *actual costs of mitigation* that arise when conforming to new building code guidelines, and the benefit-cost ratios are based on an equation she derives for this type of analysis. These benefit-cost ratios vary from less than one in some cases to benefit-cost ratios of over 60, depending on the hurricane category (1 to 5) and the mitigation strategy as well as the size of the house and initial cost per square foot of the house. Lombard (1995) concludes that most benefit-cost ratios for types of building code strategies are positive and large but that the benefit-cost ratio is smallest for lateral bracing at Hurricane Category 1 and for many of the mitigation strategies at Hurricane Category 5. There is a great range in the estimated benefit-cost ratio, depending on these key factors.

One rigorous study of building codes to protect against earthquake damage was conducted by Taylor et al. (1991). This study examined benefits and costs from implementing new codes in Utah (the Wasatch Front) and Los Angeles, California. Benefits were based on savings in property damage as well as lives saved. An average benefit-cost ratio over five types of building codes for earthquake Zone 4 in Los Angeles is 6.3. For Los Angeles, a benefit-cost ratio of 16.5 is estimated, and for the Wasatch Front, one estimate is 4.3. The Los Angeles estimate is the highest suggested benefit-cost ratio observed for process activity grants and the magnitude may reflect the fact that many of the assessed impacts compare no building codes at all to Zone 4 codes, and that assumptions were made for the number of people per square foot in buildings with new codes.

For improved building codes, another study proved useful. Porter et al. (2004) provide an analysis of the benefits associated with designing wood frame homes to be stiffer or stronger than current codes require. Benefits were measured by building losses averted, whether these were minor repair bills over time or more major reconstruction. Using simulation techniques, the authors estimated that stronger-than-required construction could be cost-effective for certain kinds of buildings in many locations.

The range in potential benefit-cost ratios that pertain to process activity grants is likely very large, reflecting uncertainty and the factors that determine them. Literature suggests that some specific building code improvements and types of hazards may lead to very large and positive benefit-cost ratios for actual mitigation and implementation (see Lombard, 1995), while for others, the benefit-cost ratio could be less than one. These are not identical to the benefit-cost ratios that would pertain to process grants that led to adoption of the building codes, but they have a relationship to them.

By averaging the available information on the lower benefit-cost ratios from the Taylor et al. (1991), Porter et al. (2004) and Lombard (1995) studies, the building code process activity grant benefit-cost ratio appears to be about 4. Therefore, a benefit-cost ratio of 4 for building code process activity grants was adopted for this study. If higher values are included, such as the Los Angeles value of 16.5 (Taylor et al., 1991), or even higher values provided by Lombard (1995), then the benefit-cost ratio could be much higher.

4.3.6 Other

In addition to the methods described above, other modifications to HAZUS®MH were made to estimate expected earthquake losses for base-isolated buildings (see Appendix L) and for flood damage caused by debris flow (see Appendix M).

4.4 Community Studies Analysis

The community studies analysis is based on a multicase study methodology that examined eight community hazard mitigation programs in depth. This analysis, as contrasted with the benefit-cost analysis of FEMA mitigation grants, permitted greater depth in evaluating hazard mitigation projects by placing them into a community context.

The methodology employed included three major components:

1. Data collection and processing,
2. Computing benefit-cost ratios and determining cost-effectiveness for activities with qualitative characteristics, and
3. Developing diagrams called "activity chronologies" to identify synergistic mitigation activities and display their temporal relationship to FEMA hazard mitigation projects.

Figure 4-4 provides an overview of the community studies methodology and makes the distinction between basic data, computational or analytical steps, and study results.

Data for the community studies were collected using techniques commonly associated with qualitative research (Patton, 2002; Phillips, 2002). Section 3.2 of this report describes the data collection process and summarizes some of the primary data collected during this phase of the study. The eight communities studied were purposively selected using quota sampling procedures. Data on these communities were collected from archival files, public reports, and both face-to-face and telephone interviews with knowledgeable persons. Structured questionnaires helped to guide the telephone interviews.

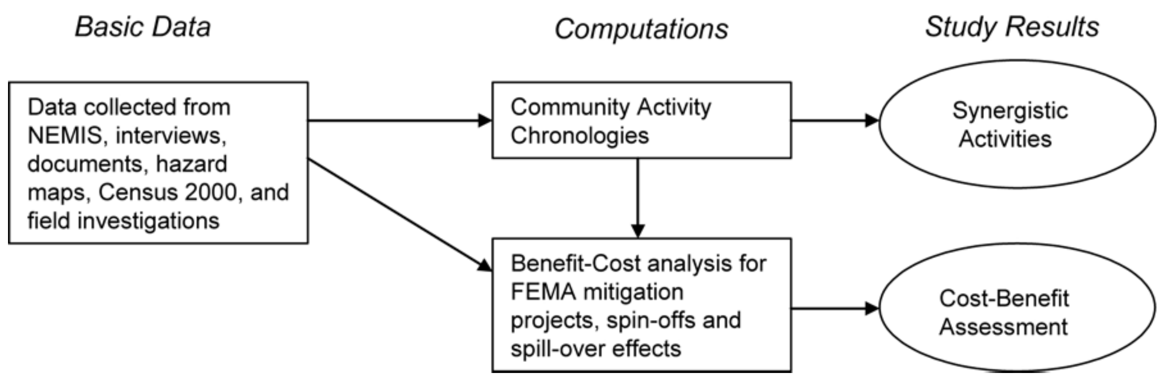


Figure 4-4 Overview of community studies methodology.

Benefit-cost analyses were performed for FEMA mitigation activities that were identified through the NEMIS database, interviews, field investigations, and project reports. When possible, the project investigators used HAZUS®MH to estimate the future benefits of specific mitigation activities. In many respects, the analysis requirements for the community studies were more extensive and demanding (compared to the benefit-cost analysis of FEMA mitigation grants), because of the diversity of projects analyzed.

4.4.1 Purposive Sampling Techniques

To provide a more nuanced and complete understanding of the benefits realized through community mitigation activities, it is not necessary that the communities reflect the distribution of the larger population of communities or that the sample allow for the evaluation of deviations from population values. Rather, the aim is to select communities with diverse characteristics to explore the variability of mitigation outcomes when viewed in a community context.

To ensure that the small number of case studies results in a rich dataset, purposive sampling techniques were used. A combination of intensity, maximum variation, and critical case sampling strategies were employed. Intensity sampling strategies focus on selecting cases that provide rich, in-depth data but that are not highly unusual. Maximum variation sampling yields cases that vary on selected dimensions of interest. A critical case sampling strategy helps to select cases that provide the most information and have the greatest impact on the development of knowledge. Use of a combination of strategies permits triangulation, flexibility, and meets multiple needs.

Purposive sampling techniques involve the use of sound judgment and an appropriate strategy to select cases such that the chosen sample is satisfactory given the objectives of the study (Hoyle, Harris and Judd, 2002). Given that only a small number of case studies were conducted, no selection procedure could ensure inclusion of all the diverse elements inherent in the population. Furthermore, random sampling procedures, which would maximize the probability that the sample communities represented the population from which they were drawn, were prohibited because the sample population was too small. In this study, purposive sampling techniques were combined with quota sampling to help ensure that the selected sample was sufficiently diverse in terms of theoretically relevant community attributes. Theoretically relevant attributes included: size of the community; type of hazard it may be subject to; number of grants received and whether both project and process grants have been awarded; geographic distribution of the communities selected; whether the jurisdiction is a city, town, borough, parish, or county; and various socioeconomic and societal structure characteristics of the community. In selecting communities, the project investigators also examined the characteristics of the community as a whole, and not just segments that may have been affected by a recent disaster.

Of greatest concern was to ensure that the range of hazards and the levels of exposure to each hazard were adequately represented among the selected communities. Quota sampling methods (analogous to stratified sampling methods in probabilistic designs) were used to ensure diverse representation of the types and levels of hazard.

For sampling purposes, a "universe" was defined as "all the people or entities that meet the designated criteria" and a population was defined as "all the people or entities that can be located, identified, or listed as being in the universe" (Bourque and Fielder, 2003, p. 178). For the selection of communities, the universe was defined as all communities that received an award from FEMA under the Hazard Mitigation Grant Program, Project Impact, or the Flood Mitigation Assistance Program. To arrive at the population, the project investigators used the NEMIS dataset as described in Section 3.1.1.

The project investigators applied a set of eligibility criteria to narrow the data available in the NEMIS database so that a sample of communities could be selected. Specific selection criteria were based on: guidelines presented in the MMC (2002, pp. 22-23) in the plan for the study; literature reviews; findings from the pilot study performed in Tulsa, Oklahoma; and discussions with the project review committees for this study. To be eligible for selection for this study, the communities had to meet the following criteria:

1. Received awards from FEMA where the objective was to mitigate damage from earthquakes, flood, or wind (coastal storm, hurricane, severe storm, tornado, typhoon);
2. Be at high or medium risk of earthquakes, floods, or wind hazard(s);
3. Be a single jurisdiction identified with a legal title as a city, town, borough, village, or county within one of the 50 states;
4. Received grants for both project and process mitigation activities (including Project Impact);
5. Received grants that total greater than or equal to $500,000;
6. Received a total of no more than 15 grants; and

7. Completed at least one mitigation grant before this study was initiated.

Table 4-6 identifies the list of eight communities studied. Originally, 10 communities, including Mandeville, Louisiana, and Ft. Walton Beach, Florida, were selected for inclusion in the community studies. During the last half of 2004, however, significant hurricanes (Charley and Ivan) affected Florida and the Gulf Coast. Because of demands placed on FEMA staff and local and regional emergency officials in response to these hurricanes, conducting field visits or interviews and collecting much of the basic information needed to establish the key parameters for two originally selected communities (Mandeville, Louisiana, and Ft. Walton Beach, Florida) would have been impossible, these two communities were dropped from the analysis.

Table 4-6 Communities selected for analysis

Community Hazard	Small Communities (Population 10,000-49,999)	Medium Communities (Population 50,000-499,999)	Large Communities (Population > 500,000)
Earthquake only		Hayward, California (in FEMA Region IX) Orange, California (in FEMA Region IX)	
Flood only	Jamestown, North Dakota (in Region VIII)		Multnomah County, Oregon (in FEMA Region X)
Flood and wind	Freeport, New York (in FEMA Region II)	Tuscola County, Michigan (in FEMA Region V)	Jefferson County, Alabama (in FEMA Region IV)
Flood, earthquake, and wind		Horry County, South Carolina (in FEMA Region IV)	

4.4.2 Field Research

There were five main goals of the field visits:

1. Collect relevant reports on past, ongoing and future mitigation activities,
2. Identify knowledgeable people for telephone and face-to-face interviews,
3. Conduct both formal and informal interviews with knowledgeable people,
4. Perform follow-up inquiries to fill in missing information or data, and
5. Perform site visits of key mitigation projects.

Table 4-7 provides an outline of the types of reports that were sought during each field visit. Depending on the location (FEMA regional office, state hazard mitigation office, or local jurisdiction), different documents were sought. In general, similar documents were available at the FEMA regional offices and the state hazard mitigation office (see discussion in Section 3.1.2). The more detailed summaries of mitigation projects were generally available at the local office of the jurisdiction that received the grant.

Table 4-7 Typical search protocol for community studies

Agency	Documents
National	
FEMA Regional Office	1. Section 404 administrative documents 2. Section 404 application instructions 3. Section 404 completed applications of subgrantees 4. FEMA mitigation policy 5. Access to NEMIS database 6. Post-disaster studies
U.S. Army Corps of Engineers, Division Office	1. River basin plans 2. After-action studies 3. Status reports, Section 205 studies 4. Rehabilitation studies of damaged Corps facilities
State	
Emergency Management Office	1. Section 409 hazard mitigation plans 2. Section 404 administrative documents 3. Section 404 application instructions 4. Section 404 completed applications of subgrantees 5. Reports including benefit-cost calculations/procedures 6. Flood maps 7. Interagency hazard mitigation team reports for prior and subsequent disasters
Governor's Office	1. Executive Orders 2. Applications for disaster declaration 3. Correspondence with FEMA and communities 4. Blue Ribbon Investigative Commission reports 5. Reports from Cabinet or other state agencies
Community affairs/housing	1. Buyouts and elevations (floods) 2. Damage assessments 3. Reconstruction plans 4. Section 404 administrative documents 5. Section 404 application instructions 6. Section 404 completed applications of subgrantees 7. Community Development Bloc Grant post-disaster applicant manuals
Planning	1. Regional Plans
Health	1. Post-disaster mortality and morbidity statistics 2. Post-disaster studies 3. Mutual aid agreements
Natural resources/environment	1. Post-disaster studies 2. Earthquake and wind maps 3. Historic preservation policies and guidelines for rehabilitation
Emergency Management Office	1. Section 404 administrative documents 2. Section 404 application instructions 3. Section 404 completed applications of subgrantees 4. Reports, including benefit-cost calculations/procedures 5. Project Impact materials

Agency	Documents
Mayor's office and city council	1. Organizational charts 2. Agendas and minutes of meetings 3. Local legislation
Building and safety	1. Damage estimates 2. Inspection protocols 3. Building permits 4. Buyout and elevation records (floods)
Planning	1. Planning studies 2. Zoning regulations 3. Redevelopment plans
Housing	1. HUD applications and awards 2. Section 404 completed applications 3. Reports including benefit-cost calculations/procedures
Health	1. Protocols for first responders 2. Emergency response plans
Public works	1. Buyout and elevation records (floods) 2. Infrastructure damage reports 3. Mitigation policies

The field research program generally proceeded in four main steps:

1. Obtain relevant reports prior to field visit. Upon selecting a particular community for analysis, the NEMIS database was used to identify all FEMA hazard mitigation awards to the community. In addition, basic demographic information about the community was also collected. Where possible, information on state laws pertaining to natural hazards mitigation that are enforced locally, and local natural hazards regulations and ordinances, were sought. Much of this information was available through the Internet.
2. Obtain relevant reports during site visits to FEMA regional offices. The goals of this step were to establish working relationships with FEMA Hazard Mitigation Officers and elicit their cooperation in gathering data for the study; become intimately familiar with the Hazard Mitigation Grant Program (HMGP), Project Impact, the Flood Mitigation Assistance Program (FMA), and synergistic activities associated with the community; and gather names and contact information of community mitigation leaders who would be contacted in the next step.
3. Obtain reports during community field visit. This step took place in the community itself. By this time, the overall community hazard mitigation program was understood, but only limited information had been gathered on early activities and details. Therefore, the goals at this stage were to develop a comprehensive understanding of how the community had dealt with its natural hazard risks over time, to explain the benefits and costs associated with the individual mitigation programs, and to explain the synergistic effects provided by the total of all their mitigation activities. The data collected were needed to determine quantitatively if mitigation has been cost-beneficial and the qualitative nature and benefits of synergistic activities.

4. Follow-up inquiries. The goal of this step was to complete the data collection effort. After returning from the community, field researchers completed a preliminary study

report that contained a summary of the information that had been collected to this point and a list of data still needed. The field investigators also consulted with project economists to see if additional data were needed to complete the economic analyses. This summary includes a list of the probable locations of any desired data as well as contact information for individuals who can be asked whether the data were available. Inquiries were generally made by telephone or e-mail.

4.4.3 Interview Guides

To standardize the telephone interview process, an interview guide was developed, tested and used. This interview guide was initially tested during the pilot study in Tulsa, Oklahoma. The guide consisted of several different parts: basic information about the person being interviewed, the interviewees' knowledge of existing hazard mitigation regulations or laws, their knowledge of current natural hazard risks, their knowledge of community hazard mitigation activities, their knowledge of specific FEMA-sponsored mitigation activities and their effectiveness, their knowledge of any partnerships that were key in affecting mitigation for the community, and referral information for other contacts. The specifications for this guide, as well as the guide itself, are part of Appendix B.

4.4.4 Benefit-Cost Analysis for Community Studies

A benefit-cost analysis was performed on all FEMA-funded activities identified in the community studies analysis. The basic principles for this analysis were discussed in Section 2.1 of this report. Unlike the benefit-cost analysis of FEMA mitigation grants, which assessed the indirect benefits of mitigation, the community studies concentrated mostly on quantifying the direct benefits of mitigation (i.e., expected reductions in damage or repair costs). Indirect effects in the form of synergistic activities, however, were identified and discussed as part of the community analysis.

4.5 Methodology for Benefit-Cost Analysis of FEMA Mitigation Grants

The benefit-cost analysis of FEMA mitigation grants was comprised of four major steps. In Step 1, a stratified sample of FEMA mitigation grants was created. A "stratified sample" consists of individual grants for detailed analysis, i.e., for which all applicable project-specific benefits were calculated. The sample was stratified by hazard type (earthquake, wind and flood) and mitigation type (project and process activities), for a total of six strata. In Step 2, the benefit-cost ratio for an individual project within a stratum was calculated. In Step 3, the benefits and costs from the sample were scaled up to the entire population of project and process activities. Finally, in Step 4 the future savings to the federal treasury were estimated. These steps are discussed in Sections 4.5.1, 4.5.2, 4.5.3, and 4.5.4 below. Section 4.5.5 provides a discussion on issues affecting uncertainty and its quantification.

4.5.1 Stratified Sample

The population of all grants was first stratified (grouped) by hazard (flood, wind, or earthquake) and mitigation activity type (project or process). Thus, one such stratum (or group) contains only flood-related, project mitigation activities. Another contains only flood-related, process mitigation activities. The reason for stratifying in this way is that benefit-cost ratios may differ among these broad categories of mitigation grants, and the project investigators wanted to ensure that several activities in each stratum were represented in the sample.

Mitigation activities within a stratum do not contribute equally either to total benefit or to total cost. It is likely that a small number of costly activities dominate both cost and benefit. To ensure reasonable results, this fact should be reflected in the sample. Furthermore, it is desirable that activities of all cost levels were present in the sample. Therefore, mitigation activities within each stratum were sorted in decreasing cost. They were binned (grouped in batches of similar cost) so that the total cost of bins were approximately equal — a smaller number of costly mitigation activities in the higher-cost bins, a larger number of lower-cost mitigation activities in the lower-cost bins. One mitigation activity was then selected at random from each bin. As a result, the sample contains more grants for high-cost mitigation activities than for low-cost ones, and yet still contains at least some grants for low- and medium-cost activities. Mathematical tests were performed to confirm that this approach produces more accurate estimates for the population benefit with less uncertainty than any of several competing alternatives.

The sample included 89 grants for project activities, costing $458 million (in 2004 constant dollars), and 47 grants for process activities, costing $114 million. Table 4-8 summarizes the distribution of these grants among various types.

Table 4-8 Distribution of grants in the stratified sample

	Project Type Code	Mitigation Activity Type Description	% by No.	% by Cost
Project Activities	200.1-204.4	Acquire, Relocate, Elevate, or Floodproof Property	23	16
	205.3-205.4	Nonstructural Retrofitting/Rehabilitating – Seismic	8	24
	205.5-205.6	Structural Retrofitting/Rehabilitating – Seismic	16	48
	205.7-205.8	Retrofitting Structures – Wind	34	6
	206.1-206.2	Safe Room (Tornado and Severe Wind Shelter)	13	3
	300.1-405.1	Shoreline, Wetlands, Utilities, Flood Mgt, Roads, Bridges	5	1
	500.1-501.1	Flood Control - Major Structural Projects	0	0
	600.1-602.1	Warning Systems, Generators, and Other Equipment	1	2
		Grants for Project Mitigation Activities Total	100%	100%
Process Activities	90.4, 91.1	Mitigation Plan – Local Multihazard Mitigation Plan	25	6
	90.6, 92.1	Mitigation Plan – State Multihazard Mitigation Plan	9	11
	100.1	Public Awareness and Education	13	10
	101.1	Professional Education (Inspectors, Architects, etc.)	2	2
	103.1	Feasibility, Engineering and Design Studies	11	4
	104.1	Codes, Standards, Ordinances and Regulations	19	21
	105.1	Applied R&D in the Building Sciences	6	14
	106.1	Other Non Construction (Regular Project Only)	4	1
	106.2	Project Impact	0	0
	600.1	Warning Systems	9	4
	800.1	Miscellaneous	2	27
		Grants for Process Mitigation Activities Total	100%	100%

The reader should not expect the fraction of samples in each project category to approximate the fraction of grants in the NEMIS database because of the stratified sampling technique. The upper portion of the table details grants for project-type activities, the lower portion, grants for process-type activities. It shows that the dominant sample grants for project activities involve retrofitting of structures for earthquake or wind, or flood acquisitions or floodproofing. The sample of grants for process activities is dominated by multihazard mitigation plans, codes and standards, and public awareness efforts. Project Impact grants are not assessed, owing to the lack of available final project data.

4.5.2 Calculating Benefit-Cost Ratios for Sample Activities

The total benefit and total cost for each project mitigation activity in the sample was calculated using the following procedure. First, the location, value, facility type, and functional characteristics (such as use and number of occupants) of each facility in a sample project were tabulated from the NEMIS database and from a reading of the grant application documents on file at FEMA regional offices. In many cases, more than one property (more than one building, for example) is affected by a mitigation grant. In such cases, as many properties within a project were examined as possible.

Next, the hazard function at each property site was calculated. The “hazard function” is defined by the frequency with which the property experiences various levels of excitation, where excitation could mean ground shaking intensity for earthquake grants, wind speed for hurricane or tornado mitigation grants, or flood depth for flood-mitigation grants. Different methods were used to calculate hazard potential for each hazard type.

Next, vulnerability functions were applied to each property at each level of excitation, once for pre-mitigation conditions, and once for post-mitigation conditions. A vulnerability function relates economic or human loss to the hazard excitation level, given the value, facility type, and functional characteristics of the facility. The expected annualized loss for each property, pre- and post-mitigation, were then calculated as the integral of loss conditioned on excitation and the absolute value of the first derivative of the hazard function. The difference between the annualized loss, pre- and post-mitigation, is taken as the annualized benefit of mitigation for that property.

Finally, the present value of the annualized benefit for these sampled properties was calculated and divided by the present value of the cost of the mitigation efforts. The result was taken to be the benefit-cost ratio for the project. The benefit-cost ratio for process mitigation activities was calculated in a different fashion, as discussed in Section 4.3.5.

4.5.3 Extrapolating Benefits and Costs from Sample to Population

The benefits and costs associated with each sampled grant were calculated. The ratio of the former to the latter is the benefit-cost ratio for the grant. The average of these figures is taken as the benefit-cost ratio for the stratum sample. Recall that each stratum contains a number of grants that were not sampled and whose benefit is unknown. However, their costs are known. The total cost of the stratum (sampled and not sampled) was multiplied by the benefit-cost ratio for the stratum sample. The product is the estimated benefit for the entire stratum, including grants that were included in the sample and those that were not. The sum of the estimated benefits for all strata is the total estimated benefit of the population of grants (referred to as the estimated population benefit). The sum of the costs for all strata is the total cost of the population of grants (population cost). The ratio of the estimated population benefit to population cost is the population benefit-cost ratio.

Such a sampling approach produces some uncertainty regarding the true population benefit-cost ratio. A series of statistical tests was performed to estimate the degree of systematic error and uncertainty produced by this approach (see Appendix N for details on different methods investigated for scaling sample results to the population). It was found that this approach produced an average error of the benefit-cost ratio of less than 0.03, with a standard deviation of error of 0.39, where error is defined as the difference between estimated and true population benefit, as a fraction of true population benefit.

4.5.4 Potential Future Savings to the Federal Treasury

For the most part, the methodological procedures described previously are based on the standard benefit-cost analysis approach. The cost of FEMA mitigation programs, plus mitigation expenditures by any other entity (typically state or local government), is compared to the benefits to society as a whole (avoided losses to private and public sectors).

In contrast, future net savings to the federal treasury because of FEMA hazard mitigation programs differ from net benefits to society in the following ways:

1. Costs: Only FEMA expenditures (about 75 percent of the total eligible project costs, which exclude state and local government matching) were considered.
2. Savings: Savings are not the same as total benefits to society, but rather include only:
    a. Reduced future federal government spending by various agencies for recovery and future mitigation.
    b. Avoided federal tax revenue losses because of reduced individual and business income tax casualty[8] loss deductions and increased individual income tax payments from the continued earnings of those who were not injured or killed.

Table 4-9 lists categories of federal expenditures that can be reduced by implementing hazard mitigation activities. Table 4-9 also includes the source of data used to estimate each category.[9]

[8] Casualty loss in this section refers to the tax code definition of the term — property damage — in contrast to its use elsewhere in this report, which refers to deaths and injuries.

[9] The National Flood Insurance Program is not included because it is actuarially sound, i.e., payouts are equivalent to premiums in the long run. Also, HUD Community Bloc Grants are not listed because data could not be obtained on the percentage of these grants devoted to hazard mitigation. A rough calculation that these funds are applied to cover 40 percent of the 25 percent local match to FEMA hazard mitigation grants yields an estimate that is less than 1.0 percent of the total of savings in the other categories listed in Table 4-9 (see also Section 6). Finally, the Small Business Administration (SBA) savings listed in Table 4-10 do not include the cost to the federal government of the actual loan subsidies. This transfer would amount to the differential between the market interest rate and the SBA loan rate. This may be small in today's market, but is likely to be more significant when interest rates increase. Unfortunately, there is no accurate way to measure this interest rate differential and the associated transfer.

Table 4-9 Federal government relief and mitigation categories

Category	Source of Data
Public assistance	FEMA (2005)
Individual assistance/human services	FEMA (2005)
Mission assignments/standby grants	FEMA (2005)
FEMA administrative costs	FEMA (2005)
Mitigation expenses	FEMA (2005)
SBA default and cost of administration	SBA (2005)
U.S. Army Corps of Engineers emergency measures	USACE (2005)

Table 4-10 lists categories of avoided federal tax revenue losses, their base, and their source. For this study, corporate tax revenue savings are a small category because the vast majority of FEMA mitigation grants go to public entities rather than private businesses. The notable exceptions are some private hospitals and private electric and water utilities. Similarly, individual casualty losses influenced by FEMA hazard mitigation grants are also limited, in this case to the subset of flood mitigation (primarily to buyouts of flood-prone homes).

Table 4-10 Federal tax revenue categories affected by hazard mitigation

Category	Base	Source of Data
Individual casualty loss deduction	Residential property[a]	This study
Individual income tax payments related to reduction in injury and death	Death and injury	This study
Corporate income tax payments related to reduction in casualty loss and business interruption	Property and business interruption[b]	This study

[a] Applied to uninsured household property damage following deduction of 10 percent of average adjusted gross income.
[b] Applied to uninsured property and business interruption losses of tax-paying entities only.

The analysis assumes that government assistance will decrease in proportion to decreases in "commonly measured" natural hazard losses.[10] While some might argue that government agencies have a target level of expenditures regardless of conditions, this analysis assumes that these agencies behave rationally in light of their objectives. This means that if hazard losses were reduced, the funds devoted to them would be reduced in the long run. In the short run, of course, if hazard mitigation more than pays for itself, it would represent a public "investment" opportunity worthy of at least a continuation of base spending until some overall level of hazard loss reduction is attained. These considerations are the reason why the term "potential" is

[10] "Commonly measured" losses are those visible to providers of post-disaster funds (property damage and casualties), but exclude categories like business interruption, environmental, historical, societal, and administrative cost.

applied to the savings measured ─ the savings represent a justification for reduced public spending on post-disaster recovery, but whether the reduction is actually realized depends on several considerations. Nevertheless, hazard recovery needs are definitely reduced.[11]
The estimate of total avoided losses from annual average mitigation in this study is $1.4 billion, and the "commonly measured" avoided losses due to property damage and casualties are $1.32 billion.[12] The latter represents 17.4 percent of average annual hazard losses in the U.S. over the period 1993-2000, or $7.6 billion (University of South Carolina, 2005).[13,14] Hence, the base used in the estimation of savings to the federal treasury is 17.4 percent of the various federal payments listed in Table 4-10.

The 17.4 percent figure reflects the fact that mitigation projects have long useful lives (assumed to be 50 years for most structures in this study). Thus, the 17.4 percent represents benefits of mitigation initiated in a given year, but realized in each of the next 50 years (the present value of all the future savings). These savings were compared to total (unmitigated) hazard losses in a single year. This comparison is appropriate because, in the absence of the mitigation, the losses would have otherwise continued for an average of 50 years.

Finally, given the difficulty of projecting future benefits of hazard mitigation, the continuation of current conditions with regard to various federal assistance rates, tax rates, base philanthropic giving rates, and insurance coverage is assumed, as is a constant proportional relationship between mitigated loss and overall disaster loss trends.

The methodology described above applies only to grants for project mitigation activities. It is modified for grants for process mitigation activities because the estimation of benefits of process mitigation activity grants does not result in separate estimates for individual components such as property damage and casualties. Process mitigation activity grant benefit components were assumed to be in the same proportion as project mitigation activity grant components. Total benefits per dollar of expenditure will still differ between project and process activity grants.

4.5.5 Analyzing Model Sensitivity and Uncertainty

Many of the parameters of the mitigation effort are imperfectly known, as are many of the parameters used to model the resulting benefit. These imperfectly known parameters are referred to as uncertainties, and can include the site characteristics of affected facilities: soil type; facilities' physical aspects, such as the code design level; or their social and economic features, such as the facilities' number of occupants. Uncertainties for process mitigation activities can

---

[11] Individual and corporate philanthropy for hazard recovery generates a tax deduction. One viewpoint is that reducing hazard damages would reduce philanthropy and hence the deduction, thereby providing additional savings to the federal treasury. However, most experts in the area suggest that individuals and corporations have a fixed target of "giving," which is not affected much by marginal changes in perceived philanthropic need.

[12] The annual average losses are one-tenth of the total avoided losses for the ten years of mitigation grants estimated in this chapter.

[13] This total relates only to hazards directly related to earthquake, wind (including severe storm), and floods. It excludes lightning strikes, wildfires, droughts, etc.

[14] Viewed another way, the average annual losses reduced in a given year are $42 million, or only about 0.55 percent of the average annual hazard property losses in the U.S ($7.6 billion). At the same time, every dollar of losses avoided in a given year is accompanied by a present value of $31.42 of losses avoided over a 50-year period. Hence, $31.42 x $42 million = $1.32 billion; and $1.32 billion divided by $7.6 billion = .174, or 17.4 percent).

include the number of people influenced (e.g., by a public-information campaign) and the material impact of the process (e.g., the degree to which a code change actually improves building performance). Sensitivity analyses quantify the effect that these input uncertainties have on the final calculations. An example would include how uncertainty in site-soil classifications affects the total benefit of earthquake project grants.

These input uncertainties propagate through the analysis and cause the estimate of the total mitigation benefit to be imperfectly known. The challenge was to estimate the mean value of total benefit and, perhaps, a measure of its uncertainty, such as the standard deviation considering the variability of the input uncertainties. To address that challenge, the project investigators used a procedure discussed by Rosenblueth (1975), Julier et al. (2000), Julier and Uhlmann (2002), and Julier (2002). In brief, one first identifies the input parameters that are uncertain and will most likely have the greatest effect on the variability of the output parameter (generally, benefit). This decision is made using expert judgment. Next, one estimates the mean and standard deviation of these input uncertainties, and quantifies their expected value and upper- and lower-bound values (in particular, $m \pm 1.73s$, where m equals the expected value and s equals the standard deviation). In many cases, these bounds are determined using expert judgment. A series of calculations are then performed that test both the sensitivity of the overall benefit to the uncertain inputs, and that can be used to estimate the mean, standard deviation, and other statistical features (skewness, kurtosis, etc.) of the total benefit. See the Rosenblueth and Julier publications noted above, as well as Porter, Beck, and Shaikhutdinov (2002) for details. To gain a better understanding of the impact these uncertainties had on the final results, various sensitivity or parametric studies were performed. For those parameters for which sensitivity studies were employed, Table 4-11 lists the benefit categories considered, the hazard that the mitigation measure was designed to offset, and the lower and upper bounds used to test the variability of the results.

The credibility of results was assessed by examining more closely those mitigation activities that produced extreme values of benefit-cost ratio, either very low or very high. Very low values suggest the possibility that the project investigators overlooked a benefit that appeared relevant to the applicant and to FEMA. Very high values suggest either a higher cost-share than was tabulated in the FEMA database or an overly optimistic assessment of benefit by the project investigators.

Table 4-11 Sensitivity parameters for project mitigation activities

Benefit Category and Variable	Hazard	Lower Bound	Expected Value	Upper Bound
Direct property damage [a]				
Site classification	Earthquake	-1 class	Mapped value[b]	+1 class
Location of the house	Flood	$0.113d_{100}$	$0.5d_{100}$	$0.887d_{10}$
Flood depth	Flood	-50%	Estimated value	+50%
Roughness	Wind	Open	Estimated value	Trees
Indirect business interruption:				
Unemployment rate	All	2.6%	Actual value	13.1%
Environmental/historical [c]				
Relevant population	All	-50%	Estimated value	+40%
Duration of loss	All	-75%	Estimated value	+100%
Casualty				
Value of injuries/death	All	-50%	Estimated value	+50%
Number of occupants	Earthquake and Wind	-75%	Estimated value	+75%
Injury rate % of shelter capacity	Wind (Hurricane)	0.2%	.55%	.9%
Injury rate % of population	Flood	6.375%	12.75%	25.5%
Homeless				
% population using shelters	Flood	-25%	Estimated value	+50%
Cost of sheltering	Flood	-50%	Estimated value	+50%
General Considerations				
Discount Rate	All except casualty	0%	2%	7%

[a] Variables listed under "direct property damage" also affect other categories.
[b] California Geological Survey (Wills et al., 2000).
[c] Sample of several sensitivity parameters for these categories.

Chapter 5
COMMUNITY STUDIES RESULTS

The chapter presents the results of the community studies. These studies were based on a comprehensive analysis of hazard mitigation activities undertaken by eight purposively sampled communities using the methods described in Chapter 4 and Appendix O. First, each community is briefly described. Second, the results of benefit-cost calculations for grants awarded by FEMA (Hazard Mitigation Grant Program, Flood Mitigation Assistance, Project Impact) undertaken by each community are presented. Cost-effectiveness results for grants awarded for process activities are also discussed. Finally, the development of a comprehensiveness factor is presented.

5.1 Sample Communities

Eight communities were selected using purposive sampling techniques (see Section 4.4.1) to represent the characteristics of communities that had received grants from FEMA for mitigation activities.

The National Emergency Management Information System (NEMIS) data file received on July 23, 2003, was used to identify the population from which the communities were selected. To be eligible for consideration, communities had to:

1. Have received grants from FEMA whose objective was to mitigate damage from earthquakes, flood, or wind (coastal storm, hurricane, severe storm, tornado, typhoon).
2. Be at high risk for earthquakes, flood, or wind hazard(s).
3. Be a single jurisdiction identified with a legal title as a city, town, borough, village or county within one of the 50 states.
4. Have both project and process (includes Project Impact) activities funded.
5. Have received FEMA grants that totaled at least $500,000.
6. Have received no more than 15 grants.

One hundred thirteen (113) communities met Criteria 1 and 3 through 6, but only 76 communities were at high risk of at least one hazard.

Communities were sorted and quota limits were set to maximize the probability that the communities selected for study varied in: (1) the combination of grants they had received from FEMA (earthquake only, wind only, flood only, earthquake and flood, wind and flood, earthquake, wind and flood); (2) whether they were at high risk of earthquake, flood, and/or wind; (3) community population (10,000-49,999; 50,000-499,999; 500,000 and over); and (4) FEMA region. Information about the 76 eligible communities was written on pieces of paper. The 76 pieces of paper were placed in a basket, shaken up, and the first community was drawn. The process was repeated until all communities were drawn. The papers were shuffled between each draw. Once a community was drawn and either accepted or rejected for inclusion in the sample, it was permanently removed from the pool of eligible communities. Appendix O presents the details of the community selection process.

Data were collected in four phases: pre-interview activities; formal telephone interviews; field visits; and data or information processing. Pre-interview activities included the collection of documents, reports, and other data that could be used both in benefit-cost analysis and in identifying knowledgeable persons to interview in each community. Persons identified in each community were interviewed by telephone using a standardized interview guide. Respondents were asked about existing hazard mitigation regulations or laws, their knowledge of current natural hazard risks, their knowledge of community hazard mitigation activities, their knowledge of specific FEMA-sponsored mitigation activities and their effectiveness, their knowledge of any partnerships that were key in affecting mitigation for the community, and referral information for other knowledgeable persons in the community. The specifications for the interview guide and the guide itself are part of Appendix B.

Documents or written records for each community were collected from four locations: the FEMA Regional Office, the state emergency management office, in the community during field investigations, and on the Internet. The list of all documents collected and referenced can be found in Appendix P.

For each community, the first documents collected were the Hazard Mitigation Grant Program (HMGP) grant, Flood Mitigation Assistance grant, and Project Impact grant files listed in National Emergency Management Information System (NEMIS) at the FEMA Regional Office. Similar files were collected at the state emergency management office with the expectation that there would be overlap but that some unique items not found in the federal files would be found in the state files. After two community studies, it was determined that the files at the FEMA Regional Office and the state emergency management office were virtually identical and subsequent searches at the state emergency management office were foregone. (See Sections 3.1.2, 3.1.3, and 3.1.4 for the description of the contents of a mitigation grant file.)

Field investigations took place after telephone interviews had been completed and the mitigation grant and Project Impact files had been reviewed. Field investigations had two goals: to find information needed to complete computational analyses and to conduct a broader search for information, independent of information contained in the federal and regional files or gathered in telephone interviews. The focus was on collecting written documents, compact discs, videos, and other records rather than opinions and perceptions. (See Section 4.4.2 for a discussion of field research elements.)

Searches on the Internet were conducted throughout the community studies to locate documents, to prepare questions during field investigations, and to find information that could not be located in the field.

5.2 Community Descriptions

The following sections provide a summary of the communities examined in this study:

1. Freeport, New York;

2. Hayward, California;
3. Horry County, South Carolina;
4. Jamestown, North Dakota;
5. Jefferson County, Alabama;
6. Multnomah County, Oregon;
7. City of Orange, California; and
8. Tuscola County, Michigan.

Community summaries track project decisions and activities chronologically and use the descriptions provided in local documents and comments by interviewees to present the community stories as faithfully as possible. Each community summary contains four parts: a background statement with a description of the community, its risk of natural disasters, historical decisions concerning hazard mitigation, and hazard mitigation activities that preceded FEMA hazard mitigation grants; a list and discussion of FEMA hazard mitigation grants; a discussion of Project Impact if the community had received a Project Impact grant; and an activity chronology to illustrate the temporal relationship of hazard mitigation decisions and activities included in the previous three parts. The activity chronology diagram is generally constructed in two dimensions, i.e., an x-axis and a y-axis. The vertical axis (y-axis) is comprised of those factors or elements that generally characterize hazard mitigation programs. They consist of community participation plans, capacity building, ordinances and regulations, other state and federal grants and programs, FEMA grants and programs, and state laws. The pilot study in Tulsa, Oklahoma helped to refine the selection of these elements; leaders in Tulsa expressed a belief that "improved maintenance, continuing capital projects, stringent regulations, and aggressive citizen awareness programs" were the ingredients of a community program that would lead to a reduction in future flood losses (City of Tulsa 2002, Chapter 2, page 7). The horizontal axis of an activity chronology diagram illustrates the chronological relationship between the start of grants for project mitigation activities or process mitigation activities funded by FEMA and community mitigation activities. This visualization provides a simple means of determining if there is a potential causal relationship between FEMA grants and synergistic community activities.

5.2.1 Freeport, New York

The Village of Freeport is located on the southern shore of Long Island in Nassau County, New York, approximately 13 miles east of John F. Kennedy Airport. It was first settled in 1659 but was not incorporated as a village until 1892.[15] In 1892, Freeport was a rural community with a population of 1,821; by 1967, on its 75th anniversary, Freeport "was a thriving business and industrial community with an estimated population of 42,000," roughly its current population of 43,783 according to the 2000 Census.[16] From the start, Freeport relied on its waterfront location; it began as a fishing port and now is the recreational boating center of Long Island.

Originally, coastal Freeport was a low meadowland or wetlands, essentially a combination of a saltwater marsh and farmland that flooded regularly at high tides and during storms. Developers purchased the land from the farmers in the late 1890s and dug several canals "using the dredged-

[15] Historical information used in this description was taken from the *Freeport Diamond Jubilee Commemorative Booklet 1892 – 1967* published by the Village of Freeport in September 1967.

[16] Ibid., p. 3.

out earth to fill the low meadowlands."[17] The first canal, dug in 1898, was the commercial Woodcleft Canal fronted by Woodcleft Avenue, now referred to as the Nautical Mile because its length is exactly a nautical mile.

As mentioned during many interviews, the canal digging operation left two legacies. First, the canals were not dug deeply enough to provide sufficient draft for newer commercial ships. Second, insufficient earth from dredging was used to fill the wetlands, thereby not eliminating the regular flooding that occurred during high tides and storms. The latter consequence did not bother the first residents, fishermen, who constructed houses on the marshland. As quoted in 1998, the superintendent of public works for the village stated, the fishermen "wanted to be right on the water, and, if that water flowed in their front door and out their back door every so often, they didn't mind so much. They had their waders on anyway and were heading out to fish."[18]

Other residents began to move to Freeport around 1920. First were New York City residents who built weekend retreats. Later, especially following World War II, were those seeking full-time permanent homes. A building boom occurred during the 1950s, and the full-time population began to swell in the old meadowlands, now referred to as South Freeport. With the new residents came a demand to reduce the constant flooding. In 1960 and 1961, the village responded with drainage work and road grade level raising in South Freeport. This original flood mitigation work was entirely paid for by the Village of Freeport.

In 1983, Freeport began to routinely elevate streets in South Freeport. Because of the cost, the time to complete the elevation of all streets at flood risk was estimated to be decades. To this point, the majority of the financing, between $1 and $2 million annually, came from the issuance of general obligation bonds. However, periodically, after 1983 Freeport has received financial assistance from both the state and federal Departments of Transportation. By the mid-1990s, many streets had been elevated, including Woodcleft Avenue, which is now a fishing and tourist attraction as well as the most significant commercial business district. The Village of Freeport and private citizens raised $10 million to redevelop the Nautical Mile, including installation of new bulkheads, replacement of overhead electric wires with underground wiring, and construction of new upscale restaurants.

In its Project Impact Baseline Report, completed in 2000 shortly after the start of Project Impact, Freeport noted that it was at risk from hurricane and tornado winds and tidal flooding. In its Project Impact Progress Report completed a year later, Freeport noted that just 1 percent of its building stock met the current building code standard for wind and that 4,000 of a total of 12,000 homes and an unspecified number of businesses were currently located in the regulatory floodway. The high flood risk was reflected in FEMA NFIP statistics; between 1978 and 2003, FEMA paid a total of 1,448 flood insurance claims totaling $10.1 million.

Freeport also noted in the two Project Impact reports that it had adopted a Flood Mitigation Plan in 1997 and that it had one of the most stringent building codes for the New York area, "above and beyond the New York State Building Code." For example, Freeport adopted a 100-mile-per-hour (mph) wind load as opposed to the 75-mph load specified in the New York State Building

[17] Ibid., p. 61.

[18] "'Rising to the Challenge', Freeport, N.Y.," *American City & Country*, December 1998.

Code. Freeport entered the NFIP in 1976 and joined the Community Rating System (CRS) in 1992; it had a Class 8 rating in 2001.

5.2.1.1 FEMA Hazard Mitigation Grants Awarded to Freeport, New York

Freeport has received six FEMA hazard mitigation grants since 1997, all related to elevating roads or individual private residences above the 100-year floodplain (Table 5-1).

Table 5-1 HMGP and FMA grants awarded to Freeport, New York[19]

Disaster Number	Project Number	Title	Type	Date Approved	Approved Net Eligible Project Cost ($)	Federal Share Obligated ($)
1196	4063	Grade and raise road improvement project	Infrastructure protective measures (roads and bridges)	5/24/99	1,144,902	858,677
1296	0010	Elevate residential structures above BFE [Base Flood Elevation]	Elevation of private structures – coastal	7/12/01	783,620	120,413
1335	0010	Elevate road	Infrastructure protective measures (roads and bridges)	1/2/02	1,523,000	1,142,250
--	FMA-PJ-02NY-1997001	Elevate residential structures	Elevation of private structures – coastal	9/16/97	441,240	330,930
--	FMA-PJ-02NY-1998001	Elevate residential structures	Elevation of private structures – coastal	7/27/98	741,173	555,880
--	FMA-PJ-02NY-1999006	Elevate residential structures	Elevation of private structures – coastal	10/16/99	216,360	162,270

One of the Hazard Mitigation Grant Program and the three Flood Mitigation Assistance grants were received by Freeport between 1997 and 2001. They totaled just over $1 million in federal funds and were used to elevate 23 individual private houses in South Freeport. All seven persons interviewed by telephone were familiar with and had some information on these grants. They reported that the major objectives were: "reducing property damage" (number of respondents = 3); "reducing residents' disruption and displacement" (number of respondents = 1); "reducing business disruption" (number of respondents = 1); "reducing insurance premiums" (number of respondents = 1); and "increasing property values" (number of respondents = 1). Interviewees said that these grants were successful. Participating homeowners, who had to contribute the full local match of 25 percent of the total cost (as much as $25,000 of a $100,000 elevation), benefited from "increased property values," "reduced insurance losses," and had "no

[19] Data for this table comes from the NEMIS database.

further flood (insurance) claims" since the elevations occurred. The interviewees also believed that there were failures associated with the grants. One said "[when the] project ended, there were other homes we wanted done" but they could not be done. Another mentioned that some homeowners could not afford the 25 percent match and therefore could not participate.

In 1999 and 2002, Freeport received the two remaining HMGP grants totaling $2 million to elevate two segments of streets whose crests were below the level of the 100-year floodplain. The total amount provided by FEMA was approximately equal to what the community would spend on road elevations in a two-year period or less than 10 percent of the total spent so far on elevating roads.

Telephone respondents were familiar with one or both of the street elevation grants. Just as for the house elevation grants, they thought the major objectives of the street elevation grants included "reducing stress and trauma" (number of respondents = 1), "reducing property damage" (number of respondents = 1), "reducing residents' disruption and displacement" (number of respondents = 1), and "stimulated local economy" (number of respondents = 1). The interviewee who mentioned the latter objective elaborated, saying "[Freeport] is a now a major destination in Long Island. Private sector got involved, three or four new restaurants, miniature golf, tourist shops, electrical moved underground. . . ."

5.2.1.2 Project Impact Grant

Freeport received a Project Impact grant in 1998.[20] Freeport proposed 13 activities that it divided into two general categories, those concerned with "education" and those broadly concerned with "retrofitting" for flooding and hurricane wind. Table 5-2 lists the Project Impact activities initiated by Freeport, including their benefits, completion details, and final status.

As described in Table 5-2, all but one of the 13 activities was completed with some degree of success. The only failure was the project that sought volunteer homeowners to raise their heating units to prevent damage from floods. All the homeowners who were asked to participate withdrew.

Two telephone interviewees knew about Project Impact and saw its major objectives as "improving disaster mitigation capacity," "becoming a disaster resistant community," and "laying the ground work for emergency management coordination." When asked about how the Project Impact activities fit into the overall community hazard mitigation program, telephone respondents gave the following comments:

[20] See Appendix Q for a complete description of Freeport's Project Impact grant.

Table 5-2 Project Impact activities initiated by Freeport

Activity	Benefits	Completion Details and Final Status
Education		
Project Impact coordinator	Salary	N/A
Public awareness events	Increase the public's awareness of natural hazard mitigation measures, preparedness and recovery	Held three Project Impact Awareness Days and one public awareness event for Nassau County elected officials. Freeport planned to continue to use public forums and mailings for disaster awareness and preparedness.
Mobile fire safety house/ disaster resistant house	Increase public's awareness of fire safety, natural hazard mitigation measures, and preparedness	Completed project. Purchased through contract, the Fire Safety House, a mobile classroom used mainly by the Freeport School District, a community partner. It is part of an ongoing education program.
Seminars and demonstrations on retrofitting	Increase public's awareness of natural hazard mitigation measures	The Freeport building department conducted site visits to educate home and business owners on mitigation measures. Two community partners, Simpson Strong-Tie and Home Depot, conducted workshops. These are ongoing activities.
Adult education classes on natural hazard preparedness	Increase public's awareness of natural hazard preparedness measures	Freeport Emergency Management Office developed and offered an adult education class on disaster preparedness through the Freeport School District. It is an ongoing course.
Communication network and video conferencing	Distance learning and transmission of emergency information	Completed project. Maintenance and expansion of the system will be supported by the Village of Freeport, Freeport utilities, and the Freeport school district.
Early warning system – tidal gauge	Reduce loss of property, thus reducing NFIP claims	Completed project. Record keeping, data production, and maintenance jointly supported by Freeport and the USGS.
Retrofitting		
Tree removal	Reduce loss of property	Part of a long-term program to remove trees that pose a threat to power lines and buildings and replace them with smaller "power friendly trees." Approximately $100,000 is allocated in the village budget to the program each year.
Preliminary design for road elevation projects	Reduce the effects of flooding	Paid consultant to prepare designs for elevating 13,400 linear feet of roadway of which 1,500 feet were completed and 11,900 scheduled for later construction. Part of an ongoing project that dates back to 1983.
Elevation of heating units	Reduction in flood insurance claims	Originally, $60,000 was allocated, but all homeowners who were contacted to participate in the program withdrew. Nothing was accomplished.
Hurricane resistant windows and doors for village emergency operation center	Reduction in damages due to wind	Project completed. Windows and doors were installed.
Bulkhead program	Reduction in flood damage and business losses	Progress was made to develop program to replace existing bulkheads along Woodcleft Avenue and the approval of bonds for homeowners to take out loans to replace their bulkheads. The program began prior to Project Impact and has continued since with portions of the project being completed and the first loan made.
Roadway grade raise and drainage improvement project	Reduce the effects of flooding	Ongoing program dating back to 1983 to raise all streets in the floodplain 3 feet above the level of the 100-year flood.

> Project Impact was not about dollars, [it] was about partnerships, people with problems going along with government and projects getting done.
>
> It was a catalyst that pushed us into full gear, spurred us on; we got aggressive.
>
> Project Impact gave us a goal to set up projects. Community wanted projects. Businesses were willing to jump on board. It was good.

Since Project Impact funding ended, several completed projects have continued with community support. The early warning system/tidal gauge placed in the bay is still maintained jointly by the Village of Freeport and the U.S. Geological Survey. At least five educational programs to increase public awareness of hurricanes, flooding, and measures to mitigate potential damage have become either ongoing activities or regularly scheduled educational courses.

The bulkhead improvement program that would replace deteriorating wooden bulkheads with hard plastic ones that are not affected by wood worms – the main cause of bulkhead deterioration – and raise them to 3 feet above the level of the 100-year flood was originally planned in 1993 when the village council approved a new bulkhead code to protect homes along the canals from flooding. Project Impact ended before the community was able to act on this project. Subsequently, the community council developed a plan and approved the issuance of bonds to provide low-interest loans to citizens for the purchase of bulkheads. Citizens would pay back the loans through assessments on their utility bills. The first bulkhead improvement loan was approved in summer 2004.

Since Project Impact concluded in 2001, officials of the Village of Freeport who were in charge of its programs have become advocates of hazard mitigation throughout the state of New York, especially in Nassau and neighboring Suffolk Counties. They speak to other communities and promote mitigation whenever asked.

Telephone interviewees thought Freeport's success in meeting major objectives of all FEMA-funded activities, including Project Impact, were very high ─ ranging from 7 to 10 on a 10-point scale ─ and that the community's ability to accomplish these same objectives without FEMA funding was very low, ranging from 1 to 2.

Five of the seven telephone interviewees thought that Freeport had a natural hazard mitigation program that was "much better" than those of other communities. Six of the seven stated that the community has plans to expand its natural hazard mitigation activities. On a scale of 1 to 10, all seven thought the program was very appropriate (mean = 9.4; standard deviation = 1.1) and effective (mean = 9.6; standard deviation = 0.5) for Freeport's needs.

When asked to assess the community's overall natural hazard mitigation program, respondents gave the following answers:

> Aggressive program to help prevent damages by natural causes.
>
> Freeport started getting serious in 1992. Formed Emergency Management Team. Goes to conferences annually. Goes after mitigation. Gets involved a lot. Very aggressive in last 6-7 years especially.
>
> It's excellent. The Village fathers are proactive, have gone leaps and bounds to alleviate the problems in the Village.
>
> Very proactive in terms of flooding, wind, hurricanes, storms.

> Mayor and Board of Trustees comprise political body [that] controls mitigation. [The] goal is to be flood-free. We do education, are part of CRS [Community Rating System] and should be moving to 7 soon.
>
> We've taken the lead almost countrywide. There are a number of different mitigation efforts: we've raised most roads, there are ongoing projects – both private and commercial. The Nautical Mile just completed a $7 million project.

As noted above, both the street elevation and the bulkhead improvement activities began prior to the receipt of FEMA hazard mitigation grants. In addition, while FEMA has contributed to these activities, the funds received from FEMA were a fraction of the total amount spent. Using the definitions of synergistic activities discussed in Section 4.3.5, the elevating streets mitigation activities are considered collateral activities and the Nautical Mile redevelopment is a spill-over effect. The bulkhead improvement activities are considered a collateral activity.

5.2.1.3 Activity Chronology

An activity chronology was created for Freeport that illustrates the relationship between FEMA mitigation grants, community mitigation activities, and synergistic activities encouraged by the FEMA grants (Figure 5-1).

5.2.2 Hayward, California

The City of Hayward, California, is located on the east shore of the San Francisco Bay, 25 miles southeast of San Francisco, 14 miles south of Oakland, and 26 miles north of San Jose. It encompasses approximately 45 square miles and its population was 140,000 in 2000. The city was incorporated in 1876 and then included what is today the downtown business district that straddles the Hayward earthquake fault. The city remained relatively lightly populated until the 1960s.

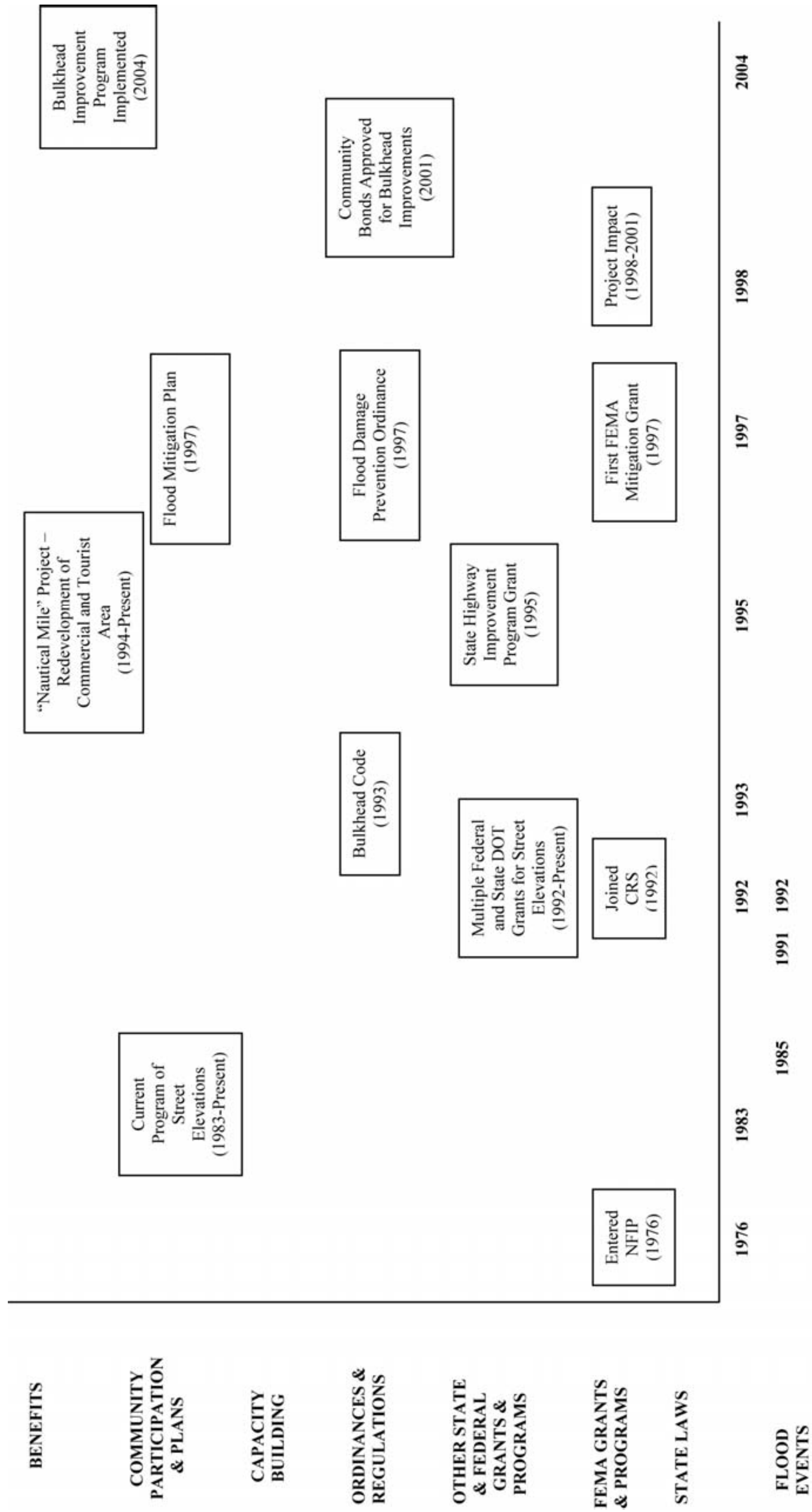


Figure 5-1 Activity chronology for Freeport, New York (unless otherwise indicated, activity dates above show start date).

Although the city is in "earthquake country," it has not suffered severe damage from any earthquake. Even in the 1989 Loma Prieta earthquake, which caused considerable damage in nearby communities like Oakland, Hayward had only light damage.[21]

Prior to 1986, when the state of California enacted the Unreinforced Masonry (URM) Building Law, Hayward did not have an earthquake hazard mitigation program.[22] The URM Building Law mandated that all communities identify all URM buildings that were potentially hazardous and then establish a mitigation program including at least the notification to the legal owners. The deadline for turning in the list of URM buildings was January 1, 1990.

When asked whether Hayward had a natural hazard mitigation program, five persons interviewed by telephone said yes, one person said no, and one person did not know. None of the five respondents thought they knew much about the program (mean = 3.4 on a scale of 1 to 10; standard deviation = 2.8). Those who commented thought the focus was on earthquake.

To meet the state requirements of the URM Building Law, the City of Hayward formed the Hazardous Building Mitigation Task Force to create an inventory of *all* seismically hazardous buildings in its jurisdiction. The Hazardous Building Mitigation Task Force included URMs built before 1944, all tilt-up buildings constructed prior to the 1973 building code adoption, and all high-occupancy (300 or more persons) reinforced concrete buildings built prior to 1976. Before the inventory was completed, the Loma Prieta earthquake struck northern California. In the next year, Hayward not only completed the inventory but also established hazard mitigation programs to retrofit the URMs and tilt-up buildings and secure HMGP grants to retrofit public buildings (see Table 5-3 for a list of HMGP grants). The initial count of seismically hazardous buildings as of October 16, 1990, was 282, of which 72 were URMs, 185 were tilt-ups, and 25 were high occupancy.[23]

5.2.2.1 Hazard Mitigation Grants Awarded to Hayward, California

In the year following the 1989 Loma Prieta earthquake, five important events occurred that led Hayward to adopt many mitigation activities. First, the Hazardous Building Mitigation Task Force was given the additional task of recommending mitigation activities the city should undertake. Second, the state Office of Emergency Services established priorities for funding under FEMA's Hazard Mitigation Grant Program.[24] The top eight priorities were:

1. Repair and retrofit of URMs;
2. Repair and retrofit of nonductile concrete structures, including pre-cast tilt up buildings;
3. Retrofit of privately owned buildings;
4. Retrofit of essential public facilities;

[21] This community study focuses on the earthquake risk in Hayward. Hayward is also subject to flooding and entered the National Flood Insurance Program (NFIP) in 1981. However, it has never suffered a serious flood. According the FEMA NFIP statistics, from 1978 through 2003, FEMA paid just 11 flood insurance claims totaling less than $50,000.

[22] Hayward adopted seismic building codes that governed the construction of new buildings in accordance with California state regulations.

[23] City of Hayward Agenda Report, Agenda Item 15, October 16, 1990 (includes as an attachment a report on the Hazardous Building Mitigation Program submitted by the Hazardous Building Mitigation Task Force November 28, 1989).

[24] Letter from Paula Schulz to Elliott Mittler, December 16, 2003.

5. Mitigation of hazardous materials spills;
6. Hardening of communication systems;
7. Emergency public information; and
8. Alternate or mobile emergency operating systems.

Because the first three priorities generally apply to privately owned structures, none were feasible for consideration in HMGP grants. Hayward, in response to a call for HMGP proposals, submitted applications for the following eight projects:

1. "Seismic retrofit of the city center building,
2. Seismic retrofit of the police station,
3. Seismic retrofit of the main library,
4. Seismic retrofit of Fire Stations 2 through 6 and Corporation Yard buildings,[25]
5. Relocation of Fire Station 1,
6. Hazmat release prevention and response equipment,
7. Mobile communications center, and
8. Emergency public information."[26]

Four submittals were eventually approved (Table 5-3).

Table 5-3 FEMA Hazard mitigation grants awarded to Hayward, California[1]

Disaster Number	Project Number	Title	Type	Date Approved	Approved Net Eligible Project Cost ($)	Federal Share Obligated ($)
845	0014	Hazardous materials release prevention / response equipment	Other equipment purchase and installation	12/31/91	811,575	405,788
845	0015	Relocation of Fire Station 1	Structural retrofitting/rehabilitating public structures — seismic	5/3/94	3,186,000	1,593,000
845	0074	Seismic retrofit – Fire Stations 2, 3, 4, 5, 6, & Yard Building.	Structural Retrofitting/ rehabilitating public structures – seismic	4/9/92	980,000	490,000
845	0079	Emergency public information	Public awareness and education (brochures, workshops, videos, etc.)	4/9/92	20,800	10,400

[1] Data for this table comes from the NEMIS database.

The first grant led to the reconstruction of the Hayward Wastewater Treatment Plant (state priority 5). The next two grants permitted the retrofitting and rebuilding of fire stations (state

[25] A yard is a location where vehicles and equipment are maintained.

[26] Letter from Harvey Edmark, City of Hayward Department of Public Works, to Christopher D. Adams, State Hazard Mitigation Officer, California Office of Emergency Services, October 26, 1990.

priority 4). And the last grant permitted the city to develop an emergency preparedness handbook for citizens (state priority 7).

Third, the state legislature enacted Senate Bill 1250, the Earthquake Safety and Public Building Rehabilitation Bond Act of 1990, which was then passed by the voters on June 5, 1990. The bill provided for the issuance of $300 million in general obligation bonds for reducing seismic hazards in public buildings, with $50 million obligated for local governments. The State Architect was responsible for determining which projects would be eligible and the procedures for submitting applications. Final rules were not worked out until March 1993, and submittals were due on October 15, 1993.[27]

After the submittals, the State Architect approved 114 projects, including seven for Hayward (Table 5-4).

Table 5-4 Projects approved for the city of Hayward funded under the State of California Earthquake Safety and Public Building Rehabilitation Bond Act of 1990

Project	Award ($)
Rebuild Fire Station 1	584,750
Hayward Air Terminal (HAT) Tower Generator	79,190
EOC and Corporation Yard Emergency Generators	533,250
Fairview Fire Generator Project (reinforce masonry walls)	21,375
City Center Structural Retrofit	500,000
Highland Reservoir Emergency Generators	567,000
Portable Emergency Generator for Emergency Water Well A	72,750

The first project listed in Table 5-4 was the same as the HMGP grant to relocate Fire Station 1. The funds from the state were used as part of the local match.

Fourth, in January 1989, the Hayward city council adopted the goal of retrofitting all vital city facilities including those that received HMGP awards, estimated at $15 million not including any state or federal grants.[28] Measure E, developed by the Hayward director of finance, asked for $15 million in general obligation bonds and was placed on the local April 10, 1990 ballot. It received about 57 percent of the vote, but failed to reach the required two-thirds needed for passage.[29]

The Hayward director of finance then was asked to find a funding alternative. Eventually, an ordinance establishing the Emergency Services Facilities Tax to generate the needed funds to repay the bonds was recommended. These funds would be collected as part of the normal

[27] *Local Government State Grant: Earthquake Safety and Public Buildings Rehabilitation Bond Act of 1990*, Division of the State Architect, Sacramento, California, January 1994.

[28] At this time the local match on HMGP grants was 50 per cent.

[29] City of Hayward Agenda Report, Worksession Item #1, June 19, 1990 (includes a report Financing Alternatives for Earthquake Safety Retrofit Program submitted by the Director of Finance).

residential bill for water service and in the same manner as business taxes were collected. The ordinance was adopted by the city council on September 18, 1990.[30]

Fifth, the Hazardous Building Mitigation Task Force recommended to the city council that the owners of privately owned URMs and the tilt-up buildings identified as potentially hazardous be required to be retrofit. Ordinances for the retrofit of URMs and the tilt-ups were adopted by the city council on November 13, 1990. Both the URM and the tilt-ups were required to meet the seismic provisions of the 1973 Uniform Building Code. Owners of URMs were given approximately 5 years to retrofit, and owners of tilt-ups were given approximately 3 years to retrofit. According to building officials interviewed during the community site visit, there was little opposition. All the tilt-ups were retrofit and all but two of the URMs were retrofit.[31]

In the course of attempting to complete its retrofit program, the city made significant changes to three of its four HMGP projects. First, the reconstruction of the Hayward Wastewater Treatment Plant was originally intended to be a structural retrofit. Instead, a new plant was constructed using a technology that posed less of a hazardous materials threat. Second, Fire Station 1 was not retrofit. Instead, it was torn down and rebuilt. Third, after the emergency preparedness handbook was written, a translation from English into Farsi was printed but the original artist successfully sued the city for copyright infringement and the city had to destroy all the copies. One interviewee believed that a substitute publication was created, but no copy was located.

Four of the seven telephone interviewees had some knowledge of the HMGP projects and two said they were extremely involved in the design and implementation of the projects. In contrast, one respondent thought the reconstruction of the treatment plant and the seismic retrofit of fire stations and yard buildings was ongoing in 2004 when, in fact, all four grants were completed by the late 1990s. Major benefits of the four HMGP grants were reported to be: reducing death, injury and illness (number of respondents = 1); reducing environmental damage (number of respondents = 1); reducing stress and trauma (number of respondents = 1); improving emergency response capacity (number of respondents = 3); and public education about risks and risk reduction options (number of respondents = 1). An additional benefit of the emergency preparedness handbook, volunteered by respondents, was that it provided "a sense of community [that we] can make [the] community better, stronger." All respondents thought that the objectives had been attained and that the likelihood that these objectives would have been attained without FEMA funding was substantially lower.

After the Loma Prieta earthquake, the 11-story city hall building was abandoned. City officials moved to an existing building and planned to retrofit that building. Eventually, the cost was deemed prohibitive and a new city hall was constructed on base isolators.[32]
The City of Hayward has continued to develop proposals for the retrofit of its few remaining seismically hazardous public buildings. It is currently planning to either retrofit its main library or construct a new one. It is also retrofitting all its remaining water storage facilities.

[30] City of Hayward Agenda Report, Worksession Item #26, June 9, 1992 (includes a Status Report on Seismic Retrofit Program Funding).

[31] The city is still pursuing the owners of the two remaining URMs to retrofit and expects to shortly get compliance. Both were delayed because of problems identifying legal owners.

[32] The total cost of the City Hall was borne by the city.

Determining what effect FEMA's HMGP grants had on the city was a difficult task. Before the Loma Prieta earthquake, which led to the HMGP grants, the Hayward Hazardous Building Mitigation Task Force was already inventorying its URM buildings as required by state law but also included pre-1973 tilt-up and pre-1976 high-occupancy reinforced concrete buildings in the inventory of hazardous buildings. Interviewees had mixed feelings about the impact of HMGP grants, especially on the enactment of the mandatory URM and tilt-up retrofit ordinances. Some said that seeing the damage in the Santa Cruz area following the earthquake convinced them that something should be done immediately. Others thought that the city council's enactment of a funding mechanism that would include paying the city share of the HMGP grants had an effect on the timing of the two ordinances. Others thought that FEMA actions had no impact.

It was ultimately decided that the enactment of the two retrofit ordinances would be considered to be "spin-off" activities. Because opinions were varied, the decision was based on the fact that Hayward had no prior history of mitigation activities. If the earthquake and subsequent HMGP grant opportunity had not occurred, it was not likely that the city would have done anything beyond creating the inventory of hazardous buildings. Up to 1990, only a handful of California communities had enacted either voluntary or mandatory URM retrofit programs and none had enacted a tilt-up retrofit program. In addition, the city council committed itself to mitigation by first adopting the funding ordinance to pay Hazard Mitigation Grant Program local shares in September 1990 and then, in October 1990, adopting the two retrofit ordinances. It seemed that the city council wished to commit the city to the retrofit of public buildings before asking private owners to retrofit their buildings.

5.2.2.2 Project Impact

Hayward did not participate in Project Impact.

5.2.2.3 Activity Chronology

An activity chronology was created for Hayward that illustrates the relationship between FEMA mitigation grants, community mitigation activities, and synergistic activities encouraged by the FEMA grants (Figure 5-2).

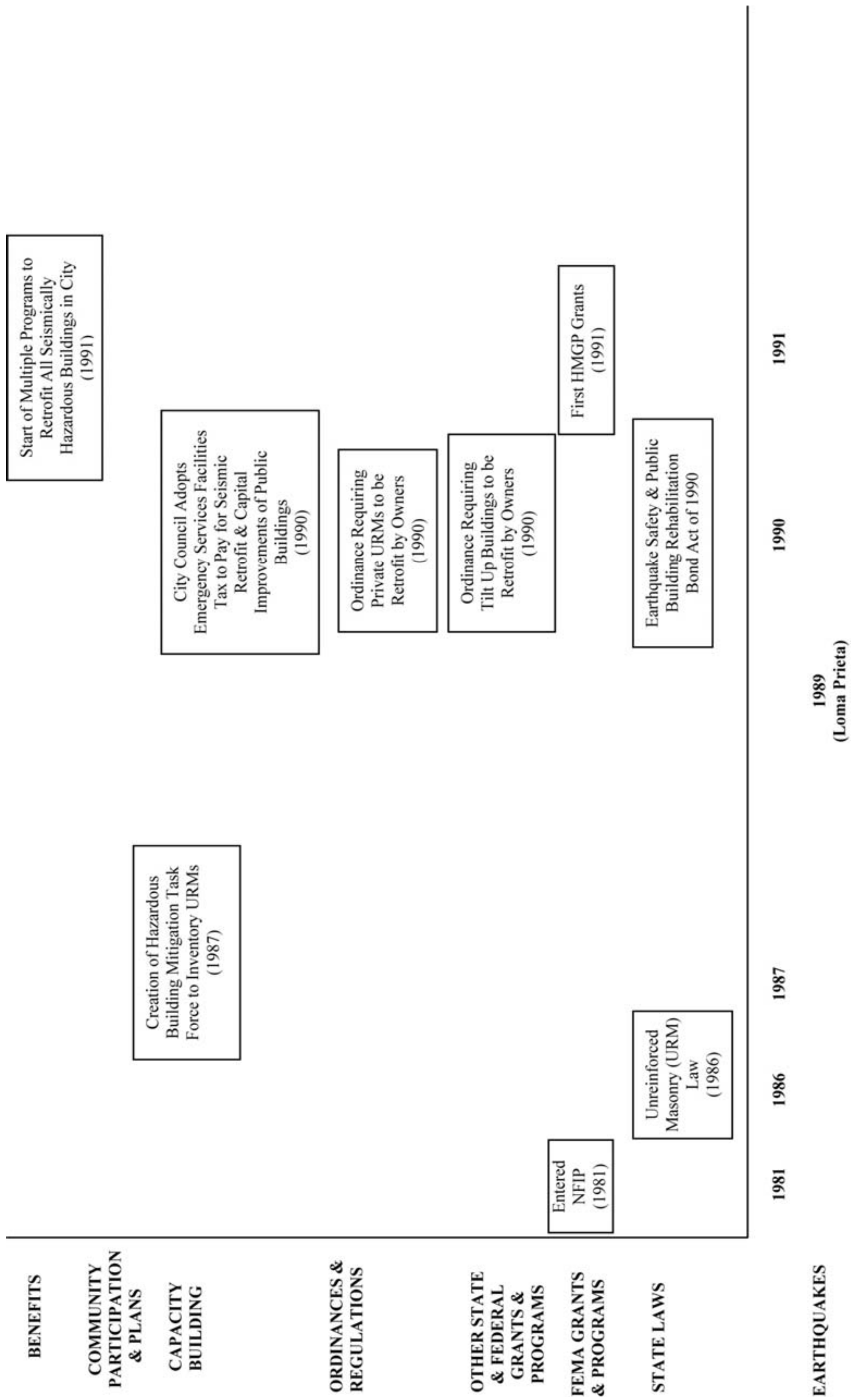


Figure 5-2 Activity chronology – Hayward, California (unless otherwise indicated, activity dates above show start date).

5.2.3 Horry County, South Carolina

Horry County is located on the Atlantic Coast and is bordered on the north by the state of North Carolina. The county is approximately 100 miles north of Charleston, South Carolina. It encompasses 1,134 square miles and had a population of over 196,000 year-round residents in 2000. Approximately 60,000 people live in its four largest incorporated cities, Conway, Myrtle Beach, North Myrtle Beach, and Socastee.

The county is relatively flat and is filled with wetlands and rivers. It also has a lengthy beachfront. It was incorporated in 1801 and remained a small, secluded community until the railroad arrived in 1887. Developers then turned the beach into a resort location. A construction boom in the 1970s and 1980s doubled the population (66,992 in 1970 to 144,053 in 1990). Today the Census reports that the area is the thirteenth fastest growing region in the country. According to the Myrtle Beach Economic Development Corporation, more than 13 million tourists visit the beach areas, called the Grand Strand, each year, mostly during the summer months at the height of the hurricane season.

Horry County was the only community in this study that is at risk from floods, hurricanes, and earthquakes. The county has been flooded several times in the past century; because of the flat and swampy terrain, floods are typically slow rising, slow moving, and long lasting. The county has also been the victim of multiple hurricanes, including several since Hurricane Hugo in 1989. Even though the county is located in an earthquake zone, it has not been affected by one since the Charleston earthquake of 1885.

When evaluating the risks from natural hazards, the six telephone interviewees thought that Horry County was a risk from flood (mean = 8.67 on a 10-point scale; standard deviation = 1.0) and wind (mean = 8.67; standard deviation = 1.4) but not earthquake (mean = 3; standard deviation = 2.5).

Prior to Hurricane Hugo, Horry County and the largest incorporated cities (Conway, Myrtle Beach, and North Myrtle Beach) joined the National Flood Insurance Program. In 1987, the Horry County Council adopted Ordinance No. 8-87 that authorized the appointment of a flood hazard reduction officer to review all development permits to ensure that all new structures met NFIP compliant regulations including that the first floor be elevated above the 100-year flood level. The flood hazard reduction officer was placed in the Engineering Department where evaluations of new construction are made. In 2000, the county adopted a Stormwater Management and Sediment Control Ordinance to control changes in rain runoff caused by urban development. The ordinance requires contractors to provide for the construction and maintenance of storm drains, ditches, and ponds to reduce flooding, erosion, and pollution problems.

When asked about the county's hazard mitigation program, the mean knowledge score of the telephone interviewees was 4.8 (standard deviation = 4.0) on a 10-point scale. In spite of the wide range of knowledge, five of the six respondents thought Horry County's program was "much better" (5 on a scale from 1 to 5) than those in other communities. When asked for their overall assessment of the program, respondents provided the following statements:

County does a good job educating the public to prepare for disasters. Don't know much about it. Not a lot of knowledge about what the county is doing. I know they have raised houses down by the coast.

Don't know anything.

I think we have an excellent program – managed well through the emergency coordinator.

Not familiar with it.

Pretty good. Further along than most. Top in the state – have had several presidentially declared disasters which opened [us] up [to] HMGP grants. Spent lots of dollars on mitigation. HMGP used to implement mitigation grant projects - $5 or $6 million.

We do quite a bit to reduce the damages. Over the last seven or eight years a number of grants, acquisitions, elevations, beach erosion, strengthening of public buildings.

5.2.3.1 Hazard Mitigation Grants Awarded to Horry County, South Carolina

Horry County received its first FEMA HMGP grant to develop a beach renourishment plan after Hurricane Hugo in 1989 (Table 5-5). Only one of the six telephone interviewees was familiar with the grant. That person said its major objective was "enhancing a critical public resource."

According to interviewees, a Local Beach Comprehensive Beach Management Plan was written, implemented once, and then apparently forgotten.[33] Five of the six telephone interviewees remembered this project but thought that it had been funded by the county, not by FEMA.

Following Hurricane Floyd in September 1999, Horry County received several grants to acquire private houses substantially damaged by floods, to elevate private houses substantially damaged by floods, and to retrofit public buildings for wind and earthquake. The majority of the funds received were used to purchase private houses, many with repetitive NFIP losses. Three telephone interviewees were familiar with the projects and thought the major objective was to "reduce property damage."

Throughout the country, communities typically either sell the acquired houses so they can be relocated out of the floodplain or tear them down. Horry County, however, decided to join a Clemson University civil engineering professor in a project that would involve destruction of 13 houses systematically to test their ability to withstand forces equivalent to strong winds (Reinhold, 2002). The project was funded by a grant from the South Carolina Department of Insurance and an additional contribution from the Institute of Business and Home Safety. Also taking part in the project were the Horry-Georgetown Homebuilders Association and local building inspectors. Three of the telephone interviewees knew of the project and identified it as a "spin-off" of a HMGP grant. The results of the study will be used to make recommendations for improving wind resistance in private houses and to support the development of proposed changes to the nation's model building codes and standards.

[33] No copy of the plan could be found at the FEMA regional office, at the state emergency management office, or at the county. No one was located who could remember when it was last used or its content.

Table 5-5 FEMA hazard mitigation grants awarded to Horry County, South Carolina[1]

Disaster Number	Project Number	Title	Type	Date Approved	Approved Net Eligible Project Cost ($)	Federal Share Obligated ($)
843	0019	Local beach management plan	Mitigation plan - local multihazard mitigation plan	4/14/95	30,000	15,000
1243	0006	Horry County public buildings window and portal protection	Retrofitting public structures – wind	5/3/00	72,585	54,439
1243	0007	Horry County acquisition of two properties	Acquisition of private real property (structures and land) – riverine	2/14/01	383,567	287,676
1299	0014	Horry County elevation project	Elevation of private structures — riverine	Not available	Not available	97,502
1299	0021	Horry County property acquisition	Acquisition of private real property (structures and land) – riverine	11/12/03	794,179	595,634
1299	0032	Horry County critical facility retrofit	Structural retrofitting / rehabilitating public structures – seismic, and retrofitting public structures — wind	1/19/02	415,600	311,700
4299	003	Horry County acquisition (Supplemental to 1299)	Acquisition of private real property (structures and land) – riverine	7/24/00	2,780,326	2,085,245
4299	005	Horry County acquisition (Supplemental to 1299)	Acquisition of private real property (structures and land) – riverine	Not available	1,374,545	1,030,909

[1]Data for this table came from the NEMIS database.

Horry County was eager to participate in the study because expectations are that thousands of houses will be constructed in the county in the near future and, while all will be constructed above the level of the 100-year flood, they still will be subject to hurricane wind.[34] It is considered to be a direct spin-off of the HMGP acquisition grants.

After the buyouts, Horry County made arrangements with neighbors or homeowners associations to maintain the cleared properties and eliminate long-term maintenance costs. Their primary use is open space. In a few cases, however, the county uses the cleared locations adjacent to rivers with boat ramps as emergency access points to the river system and for annual exercises by the fire department or other emergency services department. The goals are to limit drowning, improve the response time in emergencies, and provide staging areas for floods or sites for disaster field offices.

In addition to the HMGP grants to purchase houses, Horry County received one grant to elevate four private houses. Five telephone interviewees knew of the grant but were not very familiar with it (mean = 2.6; standard deviation = 3.6). As a rule, owners of substantially damaged houses who had riverfront property were reluctant to sell but agreed to elevate their houses instead.

Horry County also received a HMGP grant to retrofit four county buildings for both wind and earthquake. Again, five telephone interviewees knew of the grant but were not very familiar with it (mean = 2.6; standard deviation = 3.6). The majority of the funds were spent on providing wind shutters for the buildings. A review of the engineering descriptions of the projects indicated that there was no earthquake retrofit planned or completed.

5.2.3.2 Project Impact

In 2001, Horry County received a Project Impact grant for $150,000. FEMA made the announcement of the award just after the agency had announced that Project Impact was being discontinued. The coincidental announcements had a depressing affect on the community. One telephone interviewee said "This administration is not behind Project Impact. FEMA [is] not promoting [it, which] makes it hard to get [community] buy-in. [It's] not even part of the FEMA website. Focus is on terrorism. [We] still need natural disaster mitigation."

The Project Impact director tried to complete the items in the memorandum of agreement the community signed with FEMA, but there was a pall over the project that prevented the county from attracting long-term partners. The county partially or fully completed nine of eleven planned activities including its four top projects: enhancing the weather detection system by placing four new units on the roofs of fire stations; developing a critical facilities/hazard risk assessment GIS capability; placing road reflectors to identify the location of fire hydrants; and creating public service announcements for television that promoted the Resident and Tourist Hazard Awareness Program. The first three activities are still being maintained by the county. In addition to these projects, there was several small education projects aimed at school children. Horry County was unable to complete several projects including the Resident and Tourist Hurricane Awareness Program because the person intended to produce several public service announcements to be broadcast on local television stations went on maternity leave. (See Appendix Q for a detailed examination of Project Impact.)

[34] Contractors of expensive subdivisions interviewed in the field said they had already incorporated some of the results into their construction practices.

At the time of the field site visit, Horry County had not completed all its Project Impact projects and had not submitted a final report, and it appeared that many unfinished projects would not be completed. The Project Impact director mentioned that she was unable to spend all the allocated funds and had initiated action to return the unspent funds to FEMA.

Two telephone interviewees commented on what Project Impact did for the community. The first said that "it brought the community together – homeowners, businesses to plan more effectively – look at areas of vulnerability privately and corporately." The second said that Project Impact "supplemented the [hazard mitigation] program. Added more community outreach; everyone benefits."

5.2.3.3 Activity Chronology

An activity chronology was created for Horry County that illustrates the relationship between FEMA mitigation grants, community mitigation activities, and synergistic activities encouraged by the FEMA grants (Figure 5-3).

5.2.4 Jamestown, North Dakota

Jamestown is a small rural city with a stable population of 15,500. It is located in east central North Dakota, midway between Bismarck and Fargo, at the confluence of the James and Pipestem Rivers. Jamestown has had a history of flooding, mostly caused by spring runoff from melting snow in upstream mountains. Because of recent high water tables, heavy local rain storms can overwhelm the 100-year old sanitary and storm water sewer systems and cause basement flooding. Jamestown was included in 11 Presidential disaster declarations related to flooding between 1966 and 1999.

The Bureau of Reclamation constructed the Jamestown Dam and reservoir in 1954 on the James River above the city to lessen the probability of floods. Flooding in the southern half of the city was still possible, however, because the Pipestem River, a tributary of the James, ran wild. In 1973, the U.S. Army Corps of Engineers completed the Pipestem Dam and lake to control river flows.

Since 1973, flows of the James and Pipestem rivers have been regulated by the U.S. Army Corps of Engineers. There is still a small probability that the two dams will not be adequate to prevent overbank flooding beyond the 100-year level. Three floods in the mid-1990s demonstrated that additional physical projects were needed to protect the city dry from a rising river. However, after becoming a Project Impact community in FY 2000, when asked in the Project Impact Baseline Report what natural hazards threaten the community, Jamestown officials listed "flash flooding following heavy rains" and did not mention overbank floods of the James River.

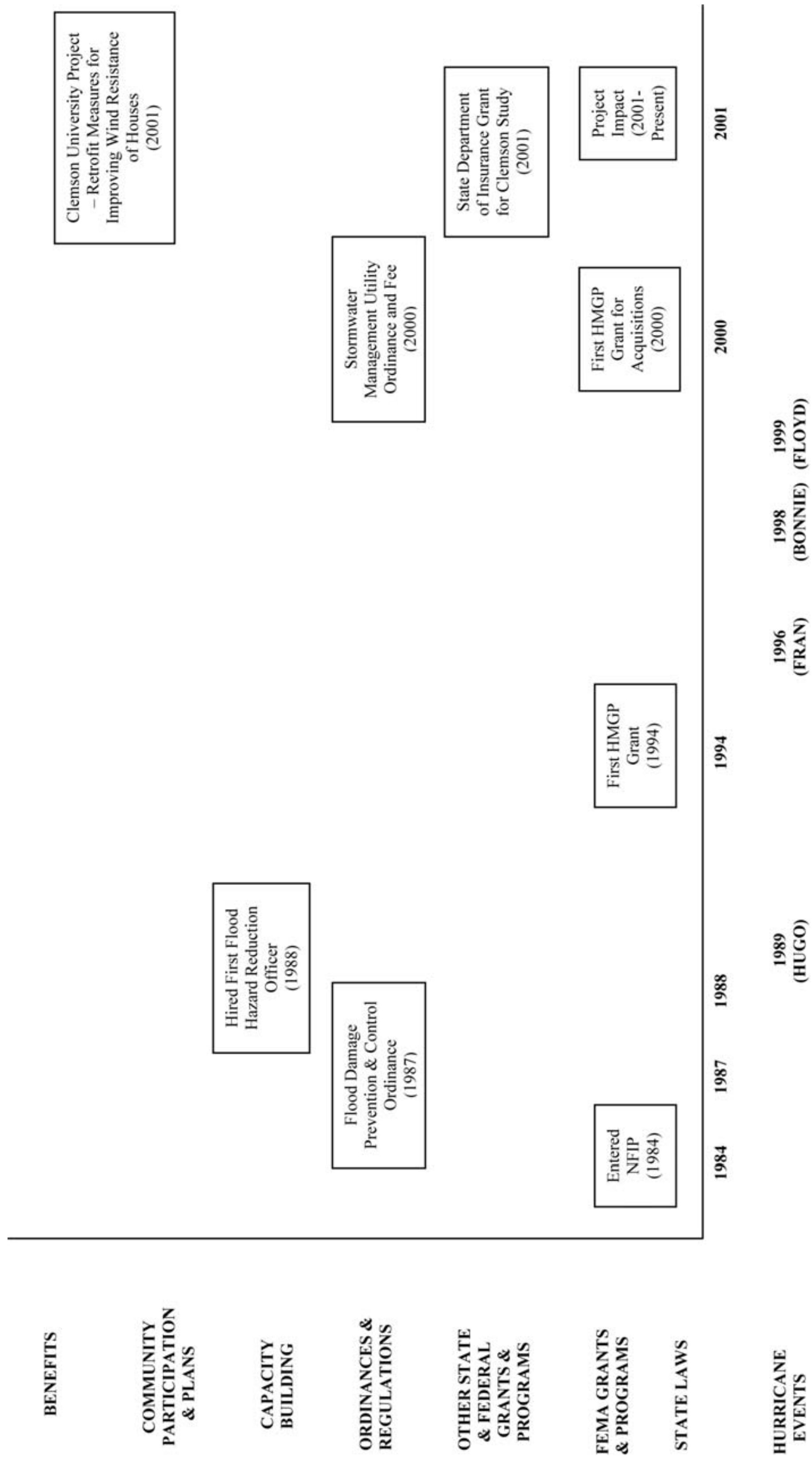


Figure 5-3 Activity chronology – Horry County, South Carolina (unless otherwise indicated, activity dates above show start date).

There are very few structures vulnerable to flooding. According to the Project Impact Baseline Report filled out by community officials after Jamestown became a Project Impact Community, only about 60 of the city's 5,000 houses and 600 businesses were located in the regulatory floodplain. Current FEMA statistics show that in the 26 years from 1978 through 2003 there have been only 26 paid NFIP claims totaling $64,000. The Baseline Report also listed high winds and tornadoes as threats to the community. One telephone interviewee summed up the situation, saying "[We] don't have tornado shelters – need a few. From a flooding stand point, [we are] probably the safest place in the state. [We] have an adequate [hazard mitigation] plan. Need better, but costs money."[35]

Jamestown joined the National Flood Insurance Program in 1972. In accordance with the program's regulations, Jamestown adopted ordinances regulating building in the floodplain. According to information provided in the Project Impact Baseline Report, these are the only city ordinances that include mitigation provisions.

When asked in the Baseline Report to identify public awareness campaigns or training classes currently being offered in the community, Jamestown officials listed four:

1. National Weather Service Weather Spotters Class for attendees to learn how to identify types of summer weather events;
2. An Emergency Services Day with booths set up at a local mall addressing floods, tornadoes, and school violence;
3. A school evacuation plan with evacuation and safety drills in case of fires or tornadoes; and
4. A public health fair with booths at a local mall demonstrating CPR and emergency response.

5.2.4.1 Hazard Mitigation Grants Awarded to Jamestown, North Dakota

Jamestown has received two HMGP grants (Table 5-6).

Table 5-6 FEMA hazard mitigation grants awarded to Jamestown, North Dakota[1]

Disaster Number	Project Number	Title	Type	Date Approved	Approved Net Eligible Project Cost ($)	Federal Share Obligated ($)
1001	0016	Modification of lift station	Other equipment purchased and installed	4/4/95	45,002	33,750
1032	0001	Oxbow Dike flood control project	Flood control - berm, levee, or dike	7/15/97	517,660	376,701

[1] Data for this table comes from the NEMIS database.

The first was for the improvement of a lift station to prevent sewage backup problems, including the installation of wet well pumps to assure continuity of function. The second was for the construction of two box culverts and gate controls that would prevent flooding of private houses

[35] Jamestown does not write its own mitigation plan. It is part of the county plan written by the Stutsman County Office of Emergency Management.

in a large oxbow area of the James River. During the 1997 flood, Jamestown also received a grant from the U.S. Army Corps of Engineers to install temporary dikes at different locations around the city as an emergency flood fighting measure. At the urging of the U.S. Army Corps of Engineers, the city also removed a bridge over the James River that had been responsible for holding debris and causing backup flooding when the river rose. Since the completion of the two FEMA projects, there have been no subsequent major floods to test the capacity of the two structures.

Eleven persons interviewed by telephone knew something about the improvement of the lift station. They felt that the existence of FEMA funds substantially increased the community's ability to attain objectives such as reducing property damage, reducing infrastructure damage, reducing residents' disruption and displacement, and reducing environmental damage over its ability without FEMA funds.[36]

Ten of the 11 respondents knew about the FEMA grant to install dikes at the Oxbow, although most had little involvement in the design. They had a similar opinion of the grant as that for the lift station. Respondents believed that the availability of FEMA funds increased its ability to accomplish objectives such as reducing death, injury, and illnesses, reducing property damage, and reducing residents' disruption and displacement over its ability without FEMA funds.[37]

5.2.4.2 Project Impact

Jamestown was awarded a Project Impact grant for $300,000 in December 1999.[38] The city and its Project Impact partners ultimately completed 10 of 13 projects proposed including:

1. A city-wide storm water runoff study;
2. Preparing Jamestown to qualify for and receive a "Storm Ready" designation from the National Weather Service;
3. GIS project implementation including installing and utilizing digital flood maps on the GIS system;
4. Establishing and implementing a 24 hour "skywarn system" by retrofitting a trailer to become a 24 hour emergency communication center;
5. Providing generators and other equipment including Red Cross emergency supplies to make the Civic Center a post disaster community shelter;
6. Improving the community early warning system by installing five new outdoor sirens and updating two existing ones (old sirens were recycled to smaller towns in the county);
7. Providing hazardous materials training to firemen and equipping a haz-mat trailer;

---

[36] On a 10-point scale ranging from a low of 1 to a high of 10, respondents had a mean score of 9.2 (Standard Deviation = 1.3) when asked if the existence of FEMA funds substantially increased the community's ability to attain these objectives over its ability without FEMA funds (mean = 2.6, standard deviation = 1.5).

[37] Respondents had a mean score of 9.0 (standard deviation = 1.5) when asked if the existence of FEMA funds substantially increased the community's ability to attain these objectives over the its ability without FEMA funds (mean = 2.0, standard deviation = 1.2).

[38] Much of the information on Project Impact comes from the community's Project Impact Final Report that was issued on a compact disk in 2004. See Appendix Q for a complete description of Jamestown's Project Impact grant.

8. Conducting public awareness and education programs including purchase of computer equipment for disaster presentations and other safety classes, "Master's of Disasters" for elementary schools, purchase of weather radios for public buildings and all public schools, and purchases supplies for Red Cross emergency shelter;
9. Developing a model home demonstration project with students from the James Valley Vocational Center to show citizens how to protect their homes from wind and flood; and
10. Establishing a fire and police training facility for the region.

Not completed were projects to:

1. Implement the storm water runoff study,
2. Install storm sewer flood gate controls, and
3. Join the CRS and lower CRS rating from a 10 to 9.

Although the community categorized the first of the three projects listed above as not completed, it was actually integrated into in the first completed project and dropped as an independent project. Therefore, the community actually completed ten of twelve projects.

Project Impact was completed December 31, 2002. Since it ended, the community has maintained all the completed projects and begun either follow-on or additional projects. The local schools have instituted two follow-on projects to make schools safer and a new high school has been designed using a storm water runoff analysis based on the completed citywide storm water runoff study by Project Impact.

Ten telephone interviewees knew about Project Impact. Most were familiar with some aspects such as how much the community received from FEMA, how much the community match was, and that it provided the community with resources to meet such objectives as "improving emergency response capacity," "reducing death, injury, and illnesses," "improving disaster mitigation capacity," and "public education about risks and risk reduction options." As a group, they were more familiar with Project Impact than they were with the HMGP grants.

On the whole, Jamestown respondents did not think that they were as successful meeting stated objectives for Project Impact as they had been for the modification of the lift station and the Oxbow Dike Flood Control Project (mean = 8.8; standard deviation = 1.6); however, they felt that without Project Impact there would have been much less possibility of attaining the objectives outlined and the activities completed (mean = 1.8, standard deviation = 0.8).

According to respondents, partners were heavily involved in Project Impact activities. Partnerships formed for a variety of reasons including the Internet (number of respondents = 1), personal friendship (number of respondents = 1), community betterment (number of respondents = 2), company policy and good citizenship (number of respondents = 1), properties at risk (number of respondents = 1); and most cogently because it was required (number of respondents = 4)! Respondents pointed out that both the announcement and the city required that partners be involved if Project Impact monies were to be obtained, although one respondent stated that "partnerships already [were] formed, [we] didn't form [them] for Project Impact."

5.2.4.3 Activity Chronology

An activity chronology was created for Jamestown that illustrates the relationship between FEMA mitigation grants, community mitigation activities, and synergistic activities encouraged by the FEMA grants (Figure 5-4).

5.2.5 Jefferson County, Alabama

Jefferson County is located in north central Alabama on the southern extension of the Appalachians and is in the center of the iron, coal and limestone belt of the South. Approximately 150 miles west of Atlanta, Georgia, it is about 1,132 square miles in area and is the most densely populated county in Alabama with 662,000 people counted in the 2000 census. There are 35 political jurisdictions (incorporated cities or towns) in the county, the largest being Birmingham with a population of 242,000. The county was established in 1819 by the Alabama legislature.

A five-member commission with legislative and executive duties governs the county. By commission vote they divide executive responsibilities for the county departments such that each commissioner is the executive head of the agencies that fall under one of the five following categories: roads and transportation and community development, environmental services, health and human services, technology and land development, and finance and general services. Emergency management, planning, and land use fall under technology and land development.

Because of its geographical location in the foothills of the Appalachians, Jefferson County is susceptible to flash flooding and tornadoes. However, until being devastated by an F-5[39] tornado on April 8, 1998, the county government had not been very active in hazard mitigation.[40] On the other hand, in response to recurring floods on Village Creek, the City of Birmingham had independently participated in one of the largest buyouts of private houses in the United States (Mittler, 1997).[41]

When asked to assess the current hazard mitigation plan (that was funded through both Project Impact and two HMGP grants described below), nine of the ten persons interviewed by telephone said they knew something about the program; the mean was 6.67 on a scale of 1 to 10 where 10 indicates knowing a lot and the standard deviation was 2.18). Overall, the respondents believed that the plan was appropriate to the community needs (mean =

[39] The F-5 notation refers to an “incredible tornado” on the Fujita scale, which rates the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure. It is associated with maximum wind speeds ranging from 261 to 318 miles per hour.

[40] A document entitled “Mitigation Projects and Studies” written by the Jefferson County Emergency Management Agency in 1999 indicates that joining the National Flood Insurance Program in 1982 and purchasing 21 outdoor warning sirens placed in various locations in the county were the only mitigation activities undertaken by the county until 1999. One of ten telephone interviewees believed the county had a hazard mitigation program that dated back to 1951, but the others either did not know when it started or considered it recent.

[41] A study conducted by the U.S. Army Corps of Engineers on the Village Creek floodplain in Birmingham led to the purchase of 642 structures.

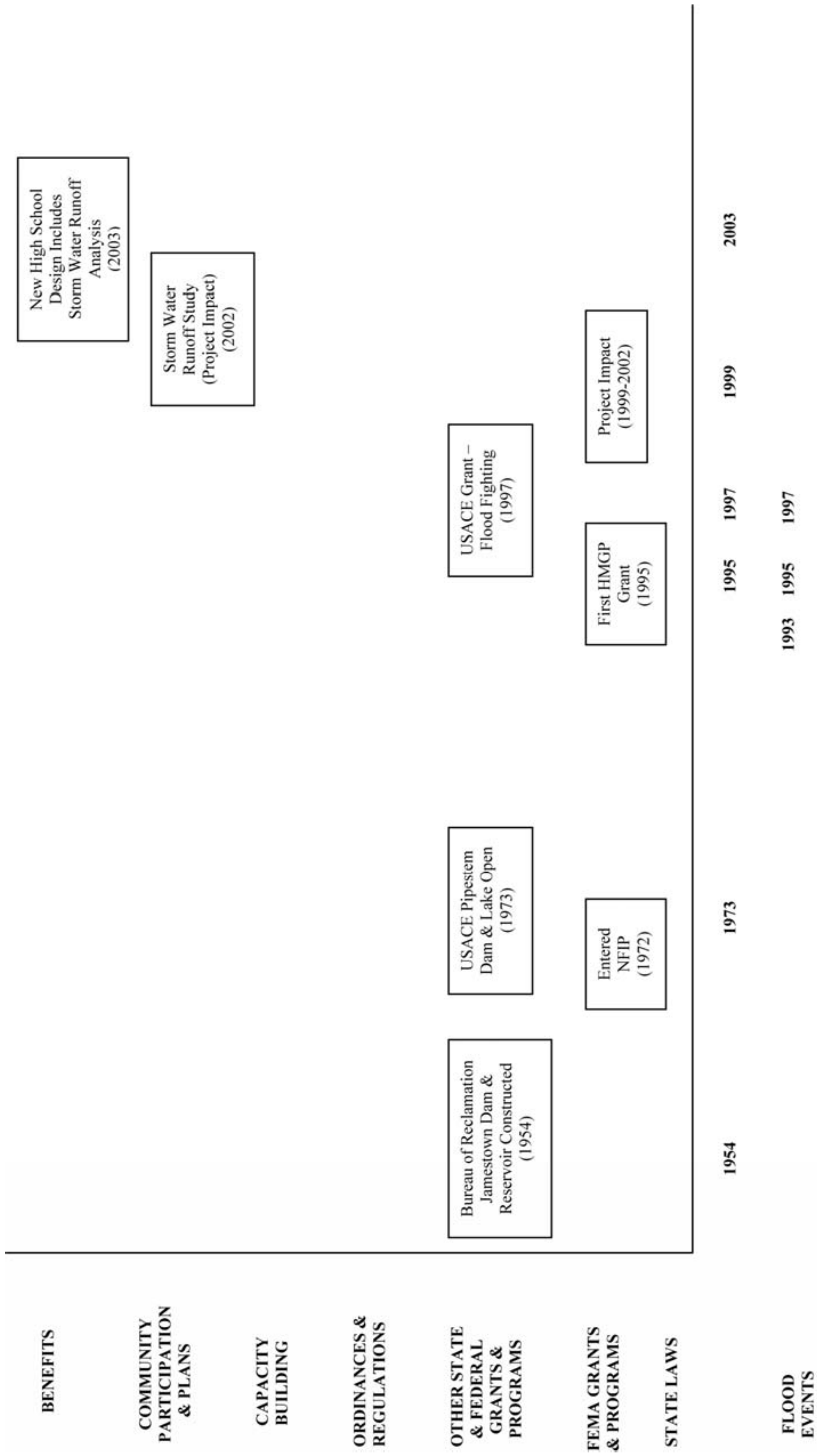


Figure 5-4 Activity chronology – Jamestown, North Dakota (unless otherwise indicated, activity dates above show start date).

8.22 and standard deviation = 2.1). Several respondents provided explanatory comments including:

> Community is being proactive – trying to take on activity of protecting its citizens. They are on their way. It's good. Haven't ended the journey, but they are on the road.
>
> Relatively good job. [The] Flood program has been [the] main focus.
>
> We have a progressive program for flood, tornado, and winter storms.
>
> I think it's good. It has become more updated in recent years. Just completed all hazards plan.

When asked to compare Jefferson County's program to those of other communities on a scale of 1 to 5 where 1 is much worse and 5 is much better, the mean score was 4.33 (standard deviation = 0.87).

The 1998 tornado killed 32 and injured over 200 residents of the county, many of them low income. In addition, the tornado destroyed 343 homes and damaged several hundred more homes and businesses. The county received several U.S. Department of Housing and Urban Development (HUD) grants to assist in recovery and provide low income residents with new or improved housing to replace that which was either destroyed or damaged in the tornado. At the time of the tornado, FEMA was just starting to promote the use of safe rooms and provided the state of Alabama an HMGP award to partially fund the construction of safe rooms in private houses in communities subject to tornadoes throughout the state.[42] The Jefferson County Emergency Management Agency coordinated the construction of 100 safe rooms in the county.

5.2.5.1 Project Impact

Jefferson County was awarded a two-year Project Impact[43] grant for $150,000 in April 1999.[44] Four activities were undertaken including:

1. The development of the 2001 Jefferson County Local Mitigation Strategy,
2. The creation of the "Web EOC" (an information systems upgrade of the county emergency operations center),
3. The initiation of the annual "Community Awareness Day" (a public education and outreach event held annually on the park between the Birmingham City Hall and the Jefferson County administrative complex), and
4. An upgrade of the Early Warning System (sirens).

The first three projects were completed on schedule. No Project Impact funds were used for the fourth project. During Project Impact funds for the upgrading were raised from other sources, and after Project Impact ended, upgrading began.[45]

[42] Unlike other HMGP grants for local activities, FEMA grants for safe rooms were awarded directly to states rather than communities. Local governments coordinated the program in their jurisdictions, and the state reimbursed the participating homeowners for partial payment after inspections were completed that verified the safe rooms met the FEMA construction guidelines. This practice began earlier in 1999 in Oklahoma and Kansas.

[43] Jefferson County was the only community in this study that received a Project Impact grant before it was awarded either a HMGP or FMA grant. For clarity, the grants are discussed chronologically.

[44] Jefferson County later applied for and was granted a one-year extension, so the duration of Project Impact was three years.

All of the activities continued after Project Impact ended. The Local Mitigation Strategy became the foundation for the creation of the 2003 Natural Hazards Mitigation Plan. The EOC has been further upgraded with a new server, new software, and 40 laptops. Community Awareness Day occurred during the one year after the end of Project Impact but not thereafter. The U.S. Department of Justice awarded the county two grants in 2001 and 2003 to replace 30 old sirens, upgrade the remaining existing 127 sirens, and install between 80 and 90 new units. Finally, the Jefferson County Emergency Management Agency maintains its original Project Impact website as www.impactalabama.com.

5.2.5.2 Hazard Mitigation Grants Awarded to Jefferson County, Alabama

Only a few months after Jefferson County received its Project Impact grant, it was subject to severe flooding in June 1999 on Upper Shades Crest Creek, the first of what county officials believed were three 100-year floods in four years. Shortly after the flood, Jefferson County received the first HMGP grant directly awarded to it as a subgrantee (Table 5-7).

Between 1999 and 2001, Jefferson County received three HMGP and three Flood Mitigation Assistance grants to purchase severely damaged private houses in the floodplain, two HMGP grants to complete the Upper Shades Creek Flood Hazard Mitigation Plan, and one HMGP grant to create an Automated Hazard Mitigation Information System with GIS coverage for all hazards.

Most telephone interviewees were not familiar with or involved with the HMGP grants but thought that they met their objectives, normally giving scores of either 9 or 10 on 10-point scales. The exception was the Automated Hazard Mitigation Information System where four said they were involved in priority setting, carrying out activities, providing resources, and grant administration and management. Their reactions were mixed. When asked how they would rate the community's success in meeting the major objective of the Automated Hazard Mitigation Information System, some rated it low and others rated it high. Those who rated it low did not think it would work. However, one said "In practical terms, don't know if [the] system has been used." In response to a different question, one respondent said "System has capabilities to warn and didn't – example from last May's flood." Another respondent was worried that after the information arrived at the Emergency Operation Center there were no established procedures to handle the information. And another said there was "a major lack of foresight in terms of funding the maintenance. Some had been corrected in-house [e.g., for for clearing leaves from rain gauges], but [it] hasn't been corrected for major things [e.g., if lightening strikes disabling the rain gauges]."

[45] When telephone interviewees were asked about Project Impact, only three of the ten were able to describe any Project Impact activities. Any comments they gave on mitigation projects in Jefferson county concerned HMGP grants and will be found below in a discussion of these grants.

Table 5-7 FEMA hazard mitigation grants awarded to Jefferson County, Alabama[1]

Disaster Number	Project Number	Title	Type	Date Approved	Approved Net Eligible Project Cost ($)	Federal Share Obligated ($)
1208	0007	Automated Hazard Mitigation Information System	Other equipment purchase and installation	5/17/99	758,700	569,025
1208	0025	Jefferson County buyout	Acquisition of private real property (structures and land) – riverine	3/13/01	343,343	257,507
1214	0010	Jefferson County hazard mitigation plan	Mitigation plan - local multihazard mitigation plan	6/22/99	414,617	310,963
1214	0023	Jefferson County Five Mile Creek buyout continuation	Acquisition of public real property (structures and land) — riverine	3/20/01	337,334	253,008
1250	0007	Jefferson County hazard mitigation plan	Mitigation plan - local multihazard mitigation plan	6/29/99	77,383	58,037
1250	0020	Jefferson County buyout	Acquisition of private real property (structures and land) – riverine	9/25/00	1,913,602	1,435,202
--	FMA-PJ-04AL-1999001	Jefferson County, Alabama project	Acquisition of private real property (structures and land) – riverine	11/21/00	75,918	56,939
--	FMA-PJ-04AL-1999002	Jefferson County, Alabama project	Acquisition of private real property (structures and land) – riverine	11/21/00	212,015	159,011
--	FMA-PJ-04AL-1999003	Jefferson County, Alabama project	Acquisition of private real property (structures and land) – riverine	11/21/00	214,524	160,893

[1]Data for this table comes from the NEMIS database.

The county council became proactive on hazard mitigation during the aftermath of the 1998 tornado and the 1999 flood. The councilperson in charge of technology and land development was the key person responsible. She was the driving force behind the passage of a 2003 ordinance that allocates $2 million annually for the purchase and removal of private houses throughout the county subject to severe flooding.[46] She also promoted the Community Development Agency's initiative to provide safe rooms in the new Edgewater Oaks subdivision that will ultimately contain 80 residences constructed for low income families.[47] HUD provided the majority of the funds. Both of these activities were inspired by the HMGP grants and/or Project Impact. Before the HMGP and Project Impact grants, the county was subject to recurrent floods and severe tornadoes, but had not initiated hazard mitigation programs to address the risks. Only after the county had participated in the FEMA-funded projects did the county take any initiative. Also as described in more detail in Appendix Q, both the Project Impact coordinator for the county and FEMA Region 4 representatives attributed the initiation of the safe room program to Project Impact. Because of the timing between the FEMA projects and the subsequent county programs and beliefs expressed by the local officials, the initiatives taken by the councilperson are both spin-offs of the FEMA grants and/or Project Impact.

5.2.5.3 Activity Chronology

An activity chronology was created for Jefferson County that illustrates the relationship between FEMA mitigation grants, community mitigation activities, and synergistic activities encouraged by the FEMA grants (Figure 5-5).

5.2.6 Multnomah County, Oregon

Multnomah County is located in northwest Oregon along the Columbia River. It is bordered on the north by the state of Washington. The county is one of three contiguous Oregon counties, including Hood River and Wasco that are part of the Columbia River Gorge National Scenic Area. All lands that can be seen from the Columbia River are included in a "viewshed," which may extend inland from the river from 0.25 to approximately 2 miles. All property in the scenic area is subject to strict development rules, which include a prohibition on any construction that changes the "viewscape."

In 2000, Multnomah County had a population of 660,486. Physical growth was restricted due to the establishment of an "urban growth boundary" that the state created in 1974 to reduce urban sprawl. As a consequence, development was limited to specifically defined urban regions, and most of the county residents (94 percent) lived in either of its two largest incorporated cities, Portland (529,121) and Gresham (90,205). Residents (less than 35,000) in the unincorporated area governed by the county were outside the urban growth boundary and spread out in suburban and rural areas to the east and west of Portland within about 20 miles of the Columbia River. Hazard mitigation activities established by the county affected those residents in the unincorporated areas and not those in incorporated cities.

---

[46] $4 million from the first two annual appropriations has been set aside as the county works out procedures for eligibility and implementation. As of February 2005, the county was seeking public input to a draft of the program.

[47] The community of Edgewater was devastated by the 1998 tornado.

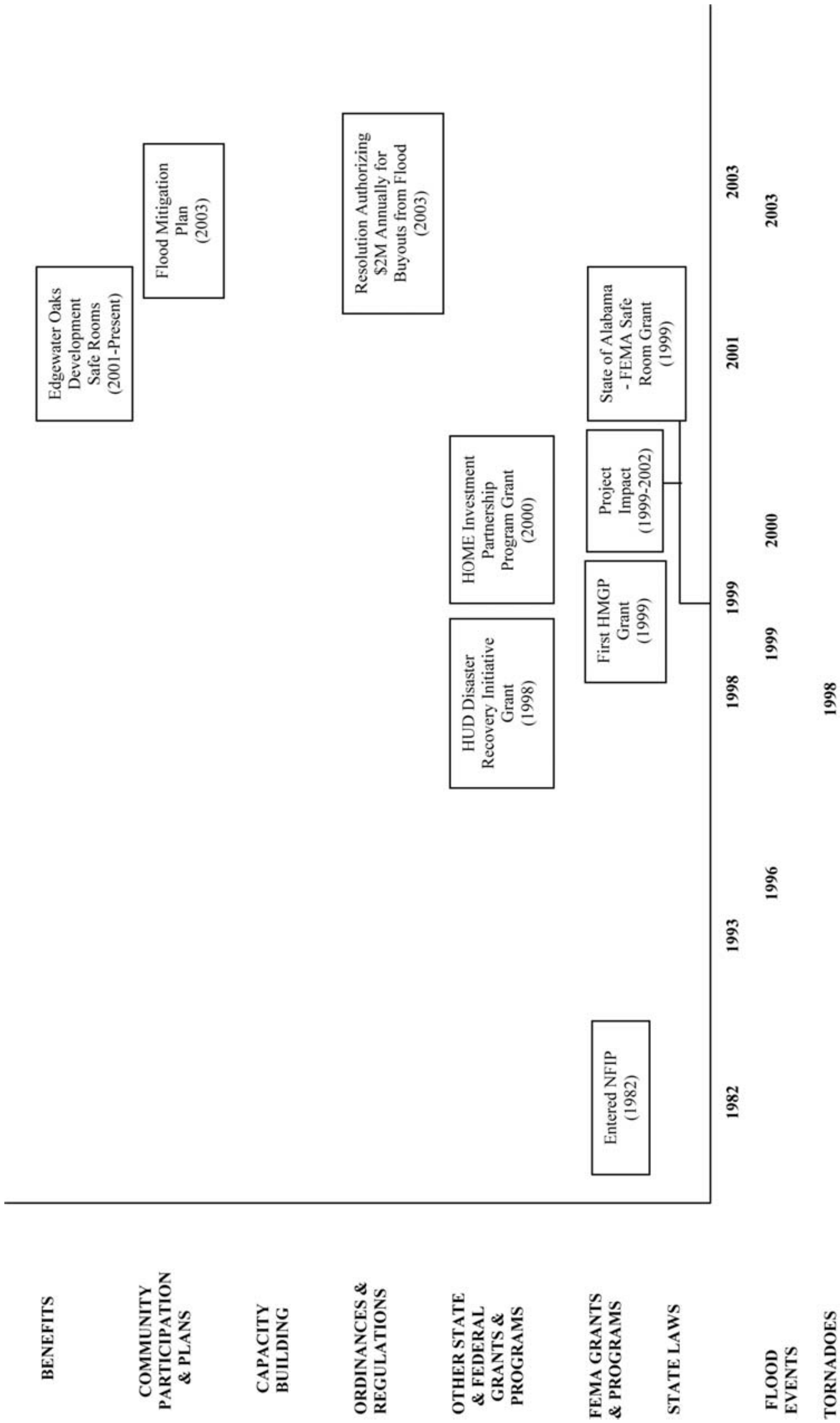


Figure 5-5 Activity chronology – Jefferson County, Alabama (unless otherwise indicated, activity dates above show start date).

Multnomah County had joined the National Flood Insurance Program in 1982 and adopted the required ordinances regulating construction in the floodplain; until joining Project Impact in 1999, the county has not developed any additional hazard mitigation programs. (See the discussion of Project Impact below.) Interviewees in the field stated that the City of Portland had a significant program and there was no need to duplicate it.

Seven telephone interviews were conducted with persons in Multnomah County. When asked about the community's hazard mitigation plan, most were either noncommittal or negative. One interviewee said "Quite frankly, I don't think it's very good." Another said "We really do not have one." Finally, a third interviewee said "They're working on their plan. I don't think they have the resources to focus on it as much as [Portland]."[48]

In 1996, severe storms caused a landslide and debris flow in the Dodson/Warrendale area of eastern Multnomah County, which is located in an unincorporated section of the county. Even though the area was lightly populated, the landslide damaged several houses and just missed others. After the storms became a Presidentially declared disaster, FEMA approved two HMGP awards to the county for just under $1 million to purchase either damaged structures or some that were barely bypassed by the debris flow (Table 5-8).[49]

5.2.6.1 Hazard Mitigation Grants Awarded to Multnomah County, Oregon

Both HMGP grants shown in Table 5-8 were to buyout properties in the Dodson/Warrendale area of the county. Nineteen properties in this area, all located in the Columbia River Gorge National Scenic Area, were deemed eligible to be purchased. Eleven filed applications, but funds were sufficient only to purchase six. Attempts to secure additional FEMA funding were unsuccessful.

Only one of the telephone interviewees was "extremely familiar" with these HMGP grants, and four others claimed having only limited knowledge. They provided no substantive comments on either grant.

Before the six purchased structures were demolished, all were first used in Special Weapons and Tactics and Crisis Emergency Response teams training. One house also was used in the County Fire Department's "Burn to Learn" program.

One consequence of the landslide and efforts of FEMA and local emergency management officials to encourage owners to sell their homes was the evacuation of a school that suffered minimal damage during the landslide. The local school district closed the school and relocated the students to nearby schools outside the landslide area.

---

[48] Telephone interviewees were also asked about the community's risk of natural hazards. Respondents said the county was at high risk of earthquake (mean = 8.1 on a ten-point scale; standard deviation = 1.7), high risk of flood (mean = 7.1; standard deviation = 1.8) and moderate risk of wind (mean = 4.9; standard deviation = 2.3). Because most of the county is incorporated and not subject to county emergency management activities, the responses concerning risk should be taken with some caution. NFIP statistics show that there were just 379 insurance policies in force in the unincorporated area of the county as of December 31, 2003 and, in the 26 years between and including 1978 and 2003, FEMA paid just 59 claims totaling just over $1 million.

[49] FEMA's share was 75 percent; the local share, 25 percent, came from Community Development Block Grant (CDBG) funds that were approved by Congress in the Supplemental Appropriations Bill of 1996 (Title II of Public Law 104-134) and subsequently awarded to Multnomah County.

A significant debris flow occurred in 2002. There was no damage to any residence or other structures.

Table 5-8 FEMA hazard mitigation grants awarded to Multnomah County, Oregon[1]

Disaster Number	Project Number	Title	Type	Date Approved	Approved Net Eligible Project Cost ($)	Federal Share Obligated ($)
1099	0005	Acquisition: Dodson – Warrendale	Acquisition of private real property (structures and land) – riverine	4/11/97	803,499	602,587
1160	0020	Multnomah County acquisition	Acquisition of private real property (structures and land) – riverine	Unknown	18,311	13,733

[1]Data for this table comes from the NEMIS database.

5.2.6.2 Project Impact

Multnomah County received a Project Impact grant of $300,000 in 1999.[50] The genesis of the county's proposal was unusual. Originally two groups representing East Multnomah County and the Johnson Creek Watershed applied independently to the state to be considered for a Project Impact grant. In the fall of 1998, they decided to join forces and asked Multnomah County to submit a joint application on their behalf, which was approved.

After the grant was awarded, Multnomah County entered into an Intergovernmental Agreement with the City of Portland to transfer $150,000 or 50 percent of the Project Impact grant to the City of Portland to manage the Johnson Creek Watershed portion. The City of Portland wanted control of the project so it could be integrated into a Community Rating System application that would be submitted in 2001, thereby improving the city's chance of receiving a higher rating.[51] Multnomah County considered this a "pass through" project and did not maintain detailed files on it. Because hazard mitigation activities undertaken by the City of Portland were not evaluated in this study, details of the Johnson Creek Watershed portion of the Project Impact grant were not investigated.

Multnomah County spent the remaining $150,000 working with local K-12 schools to prepare 72-hour emergency preparedness kits, establishing a Business Continuation and Mentoring Program, establishing Neighborhood Emergency Response Teams, completing a flood hazard information web site, and retrofitting an existing building for earthquake to demonstrate the methods employed as an educational model for contractors and engineers. However, before Project Impact ended in 2002, Multnomah County suffered a major budget shortfall and had a change in administration. Except for the continuation of the school's commitment to continuing

[50] See Appendix Q for a complete description of Multnomah County's Project Impact grant.

[51] On September 26, 2001, FEMA announced that Portland had received a Class 6 rating (on a 10-point scale the higher the flood protection activity, the lower the rating). At the time, this was one of the best ratings nationwide.

to prepare 72-hour emergency preparedness kits, the Project Impact initiatives were discontinued and the web site was shut down.

Telephone interviewees and those interviewed in the field were more familiar with Project Impact than the HMGP grants. As a group, the interviewees suggested that Project Impact had some positive effects on the county. One stated that "it brought people to the table that had never been to the table before." One thought Project Impact stimulated private sector mitigation. Similarly, one thought it permitted open communications between members of the business community that led to the development of many business continuity plans. Two persons believed it provided public education about risks and risk reduction options. One said that NERT trained many people in emergency response, increasing the capacity of the county to respond to potential disasters. And the retrofit building, nicknamed the "Bates Motel," was believed by some to have instructed the majority of contractors and engineers in the building community in earthquake retrofit methods.

On average, telephone respondents did not think Project Impact had been particularly successful in reaching its major objectives (mean = 6; standard deviation = 2.3). Since deciding not to pursue activities begun under Project Impact, Multnomah County also has decided not to establish a Citizen Corps. Interviewees said that the county did not want to incur costs that would duplicate efforts in Portland and Gresham.

5.2.6.3 Activity Chronology

An activity chronology was created for Multnomah County that illustrates the relationship between FEMA mitigation grants, community mitigation activities, and synergistic activities encouraged by the FEMA grants (Figure 5-6).

5.2.7 City of Orange, California

The City of Orange, California, is located approximately 32 miles southeast of Los Angles and is just south of Anaheim in Orange County. It was incorporated in 1888. At that time it was just 3.1 square miles. The small town was constructed around a central Plaza, called "Old Towne, Orange," which still exists today. Many of the original structures are still standing.

The city remained a small town until the end of World War II. At that time, three events occurred that caused a growth boom: returning servicemen and their families moved to the area, the southern California freeway system being constructed was turning out-of-the-way real estate into prime locations, and the city began to annex land where future development could occur. As a result of these events, the City of Orange expanded from 3.8 square miles and a population of 10,027 in 1950 to 23.9 square miles and a population of 128,821 in 2000.

Although the City of Orange has never experienced major flood or earthquake damage, hazard mitigation in the city has focused on preventing flooding near the Santa Ana River, which runs through the city, and the earthquake retrofit of older buildings. Flood mitigation has been almost entirely the concern of the U.S. Army Corps of Engineers, which has controlled the river's flow

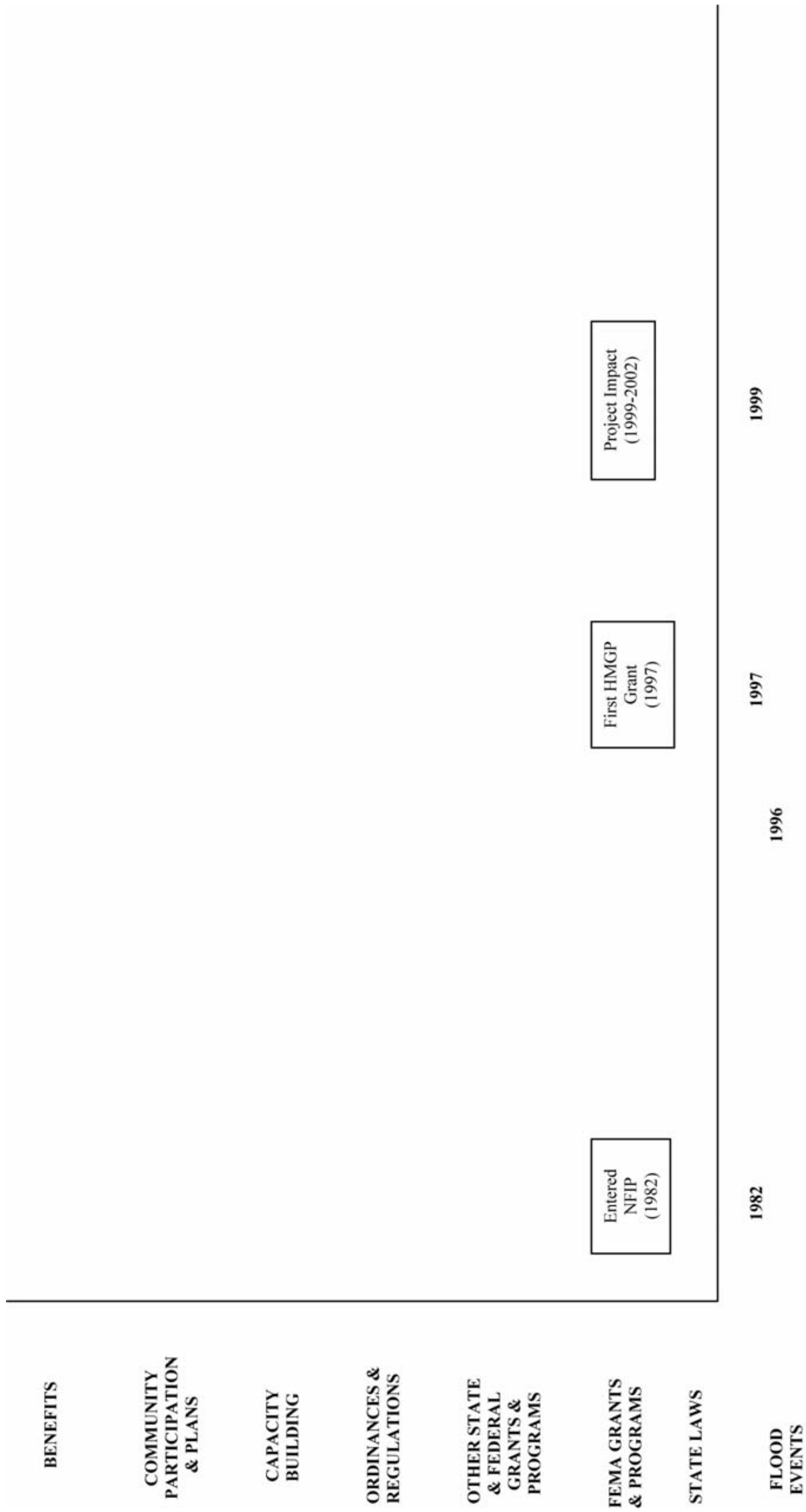


Figure 5-6 Activity chronology – Multnomah County, Oregon (unless otherwise indicated, activity dates above show start date).

through the city with the Prado Dam, built upstream of the city. According to one of the engineers in the Department of Public Works, recent improvements to the U.S. Army Corps of Engineers flood prevention structures have taken all of the existing buildings out of the 100-year floodplain. The risk from flood is now considered to be low. That opinion is backed up by NFIP data. According to information located on the FEMA website, from 1978 through 2003, FEMA paid just 11 flood insurance claims totaling $57,000.[52]

Despite the fact that the city has had little experience with natural hazards, the five telephone interviewees think the City of Orange is at high risk from earthquake (mean = 8.4 on a 10-point scale, standard deviation = 1.1) and at moderate risk from wind (mean = 6, standard deviation = 0.7) and flood (mean = 5.6, standard deviation = 1.9). Four of the five believed the city has a hazard mitigation plan, but none were particularly knowledgeable about its contents. One said "We're required to have various elements in our plan. We are updating. We do emergency training regularly." That person finished his comments with the following that seems to describe the city's history: "We only had to operate our EOC twice in the past 10 years." And another respondent said "I live in the city and I feel we're safe."

Earthquake retrofit began after the state legislature passed Senate Bill 547, the URM Building Law of 1986, mandating communities to inventory their unreinforced masonry buildings.[53] The City of Orange completed its survey in early 1990 and identified approximately 60 such buildings in the city, most located in Old Towne.[54] The city council then adopted Ordinance 7-92, which established minimum standards for structural seismic retrofit. Realizing that the cost of the retrofit might be prohibitive to individual building owners, the city council adopted Resolution 8010, which outlined their intent to create a URM financial assistance program.

The URM financial assistance program consisted of two phases. In Phase 1, the city hired an outside structural engineer to prepare engineering assessments and cost estimates to complete improvements to seismically retrofit identified properties. A total of $400,000 was allocated to the task; but actual expenditures were just $175,000. In Phase 2, the city provided $2,000,000 in grants equal to 45.98 percent of project costs to individual property owners to undertake the necessary improvements. Actual expenditures totaled approximately $1,700,000.

Approximately 50 property owners initially completed improvements under the program, which had a sunset date of December 1998. One additional property owner was allowed to complete improvements after the sunset date, bringing the total number of improved properties to 51 or 85 percent of the eligible buildings.

Following the 1995 Northridge earthquake, which caused no appreciable damage in the City of Orange, all communities were asked by the state Office of Emergency Services to submit proposals for FEMA HMGP awards to mitigate earthquake deficiencies in their public buildings. Five proposals submitted by the city were approved (Table 5-9).

[52] The City of Orange entered the NFIP in 1987. According to informants, it adopted the required floodplain building codes of the NFIP and the state of California.

[53] Like other cities in California, the City of Orange has adopted seismic building codes for the construction of new buildings because they were required by the state.

[54] The history of the URM inventory and subsequent retrofit of most of the identified URM buildings is described in a memo entitled "URM Update" from the Acting Economic Development Director to the City Manager, January 9, 2004.

Table 5-9 FEMA hazard mitigation grants awarded to the City of Orange, California[1]

Disaster Number	Project Number	Title	Type	Date Approved	Approved Net Eligible Project Cost ($)	Federal Share Obligated ($)
1008	3010	Retrofit of city yard warehouse – Phase 1 structure evaluation	Structural retrofitting / rehabilitating public structures – seismic	6/23/98	229,226	171,957
1008	3216	Structural and nonstructural retrofit of city hall	nonstructural retrofitting / rehabilitating public structures – seismic	6/18/98	99,851	74,888
1008	3217	Fire department headquarters - City of Orange	Feasibility, engineering and design studies	6/5/98	206,163	123,103
1008	3218	Retrofit of city yard garage/Phase 1 structural evaluation	Feasibility, engineering and design studies	6/17/98	432,465	324,349
1008	3219	Structural retrofit of water plant	Feasibility, engineering and design studies	6/30/98	207,456	155,592

[1]Data for this table comes from the NEMIS database and files from the City of Orange

5.2.7.1 Hazard Mitigation Grants Awarded to the City of Orange, California

The five HMGP grants awarded to the city included the retrofit of the city yard warehouse, city hall, fire department headquarters, the city yard garage, and the main water plant (Table 5-9)[55]. Three projects, the retrofits of the city yard warehouse, the city yard garage, and the water plant, were completed before the end of 1999. However, the other two projects, the retrofits of city hall and the fire department headquarters, had to be abandoned following initial design studies completed by consulting engineers when the projected costs far exceeded the estimated costs that were used to determine the amounts of the awards and FEMA would not amend the awards to reflect the additional costs.[56] The City of Orange officials decided the costs were too high for them to bear alone. As was discovered in the field visit to the City of Orange, one respondent describing the city hall project pointed out "This project never was completed because the estimate we got was four times the estimate FEMA had and the city could not afford the costs."

Of the five persons interviewed by telephone in the City of Orange, all five had some knowledge about the retrofit of the city hall, three about the retrofit of the fire department headquarters, five about the city yard warehouse, five about the city yard garage, and five about the water plant. "Reducing infrastructure damage" was thought to be the major objective of all five activities by all respondents who had an opinion with the exception of one respondent who thought the major objective of retrofitting the city yard warehouse was "reducing death, injury, and illness."

[55] A yard is a location where vehicles and other equipment are maintained.

[56] The discrepancy between the initial estimated costs and costs derived from consulting engineers appears to be due to the process used by the City of Orange to arrive at the initial estimated costs. In a letter from the City's Emergency Services Coordinator to the California Office of Emergency Services dated March 18, 1998, the City of Orange agreed to participate in a "technical assistance program available for structural evaluations" provided by FEMA at no cost to the City to determine the cost of retrofitting City Hall. It is noted in the letter that "this is not a design and engineering but a building analysis to help FEMA evaluate our application." Apparently the "free" analysis was not adequate.

In spite of the fact that the City of Orange abandoned the retrofit of the city hall and the fire department headquarters because of high cost and no additional assistance from FEMA, the five respondents thought the five projects had been quite successful with mean scores on a scale of 1 to 10 that ranged from a low of 7 for the retrofit of city hall to a high of 8.67 for the fire department headquarters, city yard garage, and water plant. When asked to comment on specific HMGP grants, one said about the city yard warehouse "Those buildings are better able to withstand a major earthquake – our fire trucks and police cars are in those buildings and they are essential."

Since the cancellation of the two projects, the city has decided that it would be more prudent to construct a new city hall instead of retrofitting the old one. The new building would be larger, which would accommodate a larger staff, and the cost of the new, larger building would be about the same as the cost of retrofit. The city also began to set aside funds to complete the retrofit of the fire department headquarters and build the new city hall; however, last year, the funds were diverted for the construction of a new city library.

5.2.7.2 Project Impact

The City of Orange did not participate in Project Impact.

5.2.7.3 Activity Chronology

An activity chronology was created for the City of Orange that illustrates the relationship between FEMA mitigation grants, community mitigation activities, and synergistic activities encouraged by the FEMA grants (Figure 5-7).

5.2.8 Tuscola County, Michigan

Tuscola County is a rural county with a relatively stable population of about 58,000. It is 914 square miles in size and is located in east central Michigan just north of Flint and just east of Saginaw. Approximately 10 percent of the land is covered by water, and the northern border of the county is the southern shore of Lake Huron. There are 34 incorporated towns or villages in the county.

The county is subject to flooding and tornado winds. Eleven people were interviewed by telephone in Tuscola County. As a group, they thought that the county was at high risk from floods (mean = 8.7; standard deviation = 1.0) and moderate risk from wind (mean = 5.8; standard deviation = 0.81).[57]

[57] Responses were on a 10-point scale ranging from a low of 1 to a high of 10.

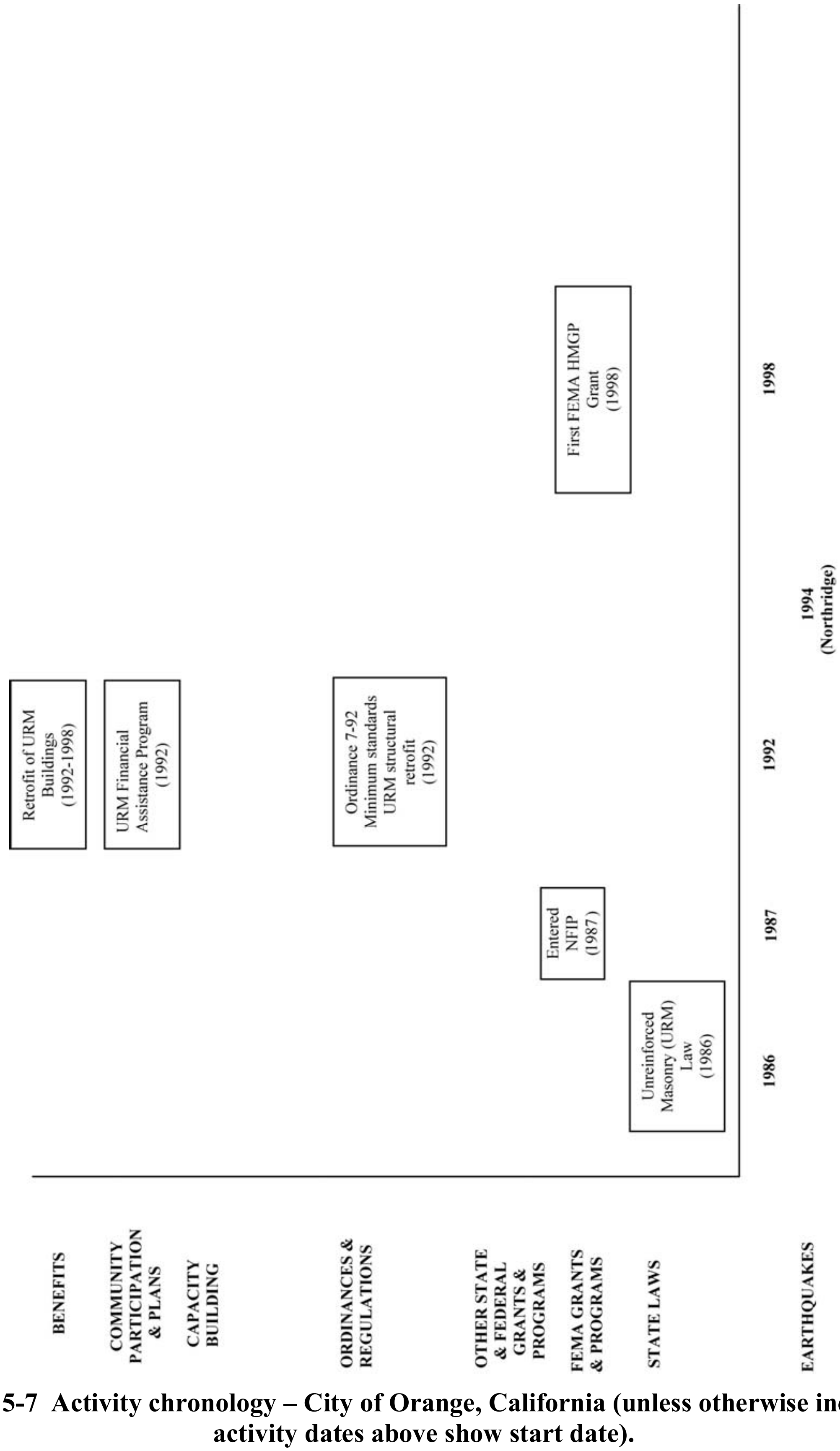


Figure 5-7 Activity chronology – City of Orange, California (unless otherwise indicated, activity dates above show start date).

Because the Michigan constitution affirms that all property in the state must be included in incorporated municipal jurisdictions, municipalities, not counties, are responsible for land use and other decisions affecting hazard mitigation. The only exceptions are those powers specifically granted to counties that are denoted in the constitution.

According to the Michigan Drain Code of 1956, counties are responsible for all drainage activities, including flood mitigation. Counties have the authority to develop flood mitigation policies, but counties and municipalities must work cooperatively to achieve compliance.

In Michigan, a drain commissioner is elected in each county to manage drainage activities permitted under the Drain Code of 1956.[58] The commissioner acts autonomously and is legally responsible for all drainage initiatives taken in the county. Consequently, a county's flood mitigation program is directly dependent on the actions of the drainage commissioner. The current drain commissioner in Tuscola County is a strong supporter of flood mitigation and has devoted considerable effort to reducing potential flood damages in highly vulnerable locations such as the Village of Vassar. Since 1997, following a devastating 1996 flood, the drain commissioner and the village have worked together to eliminate small flood events that occur several times a year.

Because rivers cross county boundary lines and may drain outside their borders, drain commissioners can become involved with flood mitigation activities in neighboring counties and municipalities outside their jurisdictions. As will be discussed below, two FEMA hazard mitigation grants awarded to the Tuscola County Drain Commission involved such multijurisdictional activities.

As noted above, the ultimate management of hazards is in the hands of the incorporated towns and villages. In Tuscola County, that would entail an examination of 34 distinct communities, something far beyond the resources of this study and the charge to limit the eight community studies to eight single communities. Therefore, no detailed study of the hazard mitigation experiences, properties at risk, or existing plans of all the municipalities has been conducted.[59] What is clear, however, is that a number of communities in the county have a significant flood risk that has led the Tuscola County drain commissioner to apply for HMGP grants.

When asked about whether Tuscola County had a hazard mitigation plan, one telephone respondent said "Every county is putting together a hazard mitigation plan, a FEMA directive in order to be eligible for grants. [We] don't have a plan currently from a county-wide perspective. It is more about enforcing building codes. [The Village of] Vassar actually has a plan."

Because the HMGP grants awarded to the Tuscola County Drain Commission most affected the Village of Vassar, information on its flood risk and past experiences was sought. Vassar was organized around a sawmill in 1849 and incorporated in 1851. Flooding from the Cass River and the Moore Drain whose confluence is near the center of the city has been a significant problem since at least 1900. Many commercial structures that have been repeatedly damaged by floods

[58] One of the interviewees explained that before statehood in 1837, Michigan could be characterized as being "swampy." After statehood, water needs and water hazards were such critical issues that county drainage commissioners were among the first elected officials in the state.

[59] A search for an existing county-wide study proved fruitless.

were constructed in the early 1900s and now comprise what Vassar citizens today consider a historic district. Within Vassar, the M-15 is a major commuter route with a bridge over the Cass River that has been flooded numerous times. M-15 is a transportation route for emergency services and flooding results in substantial detours for ambulances and other emergency service vehicles.

During the period from 1900 to 1947, several interviewees stated that the Village of Vassar transitioned from a lumber-based economy with some farming and commercial activities to a more agricultural economy with more commercial activities. As part of agricultural practices, the capacity and flow of the Cass River were modified. Farmers built ditches and used tiles to force runoffs into the Cass River so they could plow fields in the spring. These activities upstream of Vassar increased peak flows on the Cass River into the village.

Between 1947 and 1985, the Cass River flooded 14 times in Vassar. Many of these recorded floods were severe. Overflows of the Cass River began when the height of the river surpassed the expected height of a 5-year flood. As a result of a 1947 flood, Vassar citizens petitioned the U.S. Army Corps of Engineers to look at possible solutions to the flood damages in Vassar caused by the Cass River. The U.S. Army Corps of Engineers presented its first solution in 1951, but it was deemed too expensive for the community and thus not accepted because of the amount of the required local match.[60] Later proposals (1976, 1982) submitted by the U.S. Army Corps of Engineers met with similar fates again in part due to costs but also because of conflict between community constituencies regarding who would benefit from structural solutions and who would pay for them. Farmers and persons living outside the floodplain generally were reluctant to assume costs for structural solutions from which they might not directly benefit.

Although the three U.S. Army Corps of Engineers evaluations did not result in a solution acceptable to the community, they did result in clarifying the relationship between the Moore Drain and the Cass River. It was found that in severe floods, the Moore Drain overtopped before the Cass River. Two informants said that this finding led a private engineering firm to propose a solution in the late 1970s that encompassed both waterways. It was not implemented at that time.

No counties in Michigan, including Tuscola, have entered the National Flood Insurance Program. Municipalities, not counties, have jurisdiction over structures within their boundaries and are responsible for regulating construction in floodplains. Thus, municipalities may join the NFIP, but counties are not eligible. Normally, a consequence of not being in the NFIP is not being eligible for public assistance or mitigation grants following floods. However, in this situation, counties are eligible to apply for and receive flood mitigation grants.

The Village of Vassar joined the NFIP in 1977 and enacted its first floodplain regulations. At the same time, the state of Michigan began to pass floodplain laws that were stricter than those of the NFIP and mandated their local adoption. According to one informant, “what could once be constructed in the floodway was no longer possible.”

[60] The U.S. Army Corps of Engineers proposal was $7 million in 1951 dollars. The local match was 5 percent of the total.

Between 1985 and 1996, there were five floods, two of which, 1985 and 1996, were severe. During this time, the state of Michigan further tightened its floodplain regulations. Construction in floodways was virtually prohibited and buildings that were damaged at more than 50 percent of their value, if rebuilt, had to meet current building code regulations.

As a result of a decision in 1984 by FEMA to acquire private homes following floods under the authority of Section 1362 of the National Flood Insurance Act, FEMA's former Federal Insurance Administration started a program to purchase substantially damaged houses (i.e., those that suffered damage exceeding 50 percent of the value of the structure. One respondent reported that, in 1988, nine residences were acquired directly from their owners, not using the community as an intermediary.[61] Over time, Vassar officials realized that those who sold residences did not necessarily stay in the community boundaries and people who vacated small businesses because of the cost of rebuilding did not reopen. One consequence was the loss of tax revenues, a major source of local income.

After the 1996 flood, increased recognition of how severe flooding impacts residences, the historic business district, and the delivery of emergency services within the community combined with increasingly strict state laws regulating floodplains, continuing revenue losses associated with purchasing damaged property, and some shift of political power away from agriculture led the citizens of Vassar and landowners in Tuscola County to petition the county drain commissioner to assist in finding a solution to the flooding problem. According to the Drain Code of 1956 as amended, the drain commissioner can write grants, manage grants, and also provide special assessments to offset funding of flood-related projects. Following these discussions, the drain commissioner worked with concerned citizens and local officials to submit proposals for grants from the Hazard Mitigation Grant Program (Table 5-10).

Telephone interviewees explained why partnerships between municipalities and the county were important. One said that "towns had more damage than their budgets could tolerate." Another commented that "mutual cooperation from all entities and funding would entice property owners to enter." A third said that the common goal is to "reduce flooding, improve the infrastructure, and reduce floods on highways, farms, and homes." A fourth believed there was a "trickle down effect. Once there was one successful project, then others jumped on board."

5.2.8.1 Hazard Mitigation Grants Awarded to the Tuscola County Drain Commission

The Tuscola County Drain Commission received four HMGP grants between 1998 and 2004 (Table 5-10). The first was to install culverts in the Coleman Drainage District. The second was to construct detention basins as part of the Reese Intercounty Drain. The third was a feasibility study of the Moore Drain. The fourth was a major structural project

[61] The Village of Vassar received Flood Mitigation Assistance grants between 1998 and 2001 for the acquisition and elevation of homes in the floodplain.

Table 5-10 FEMA hazard mitigation grants awarded to Tuscola County, Michigan[1]

Disaster Number	Project Number	Title	Type	Date Approved	Approved Net Eligible Project Cost ($)	Federal Share Obligated ($)
1128	0021	Coleman Drainage District	Stormwater management - culverts	3/2/98	165,167	123,500
1181	0053	Tuscola County Drain Commission – relief branches of the Reese Intercounty Drain	Stormwater management – detention/retention basins	6/23/00	400,000	300,000
1226	0016	Tuscola County Drain Commission – flood study	Feasibility, engineering, and design studies	6/3/99	140,000	105,000
1346	0029	Moore Drain Flood Mitigation Project	Stormwater management – diversions	1/26/04	2,383,000	1,787,000

[1]Data for this table comes from the NEMIS database

to reduce flooding caused by overflows from the Moore Drain. It followed the findings of the previous study.

The first two grants involved jurisdictions both inside and outside Tuscola County. Even though the grants were written by and monitored by the Tuscola County Drain Commission, the actual management of the projects entailed multijurisdictional issues that were beyond the scope of this study, which was to evaluate hazard mitigation projects conducted by single jurisdictions. Consequently, these grants have not been evaluated in this study. The third and fourth grants affected one community wholly within Tuscola County and are evaluated.

The Moore Drain Flood Mitigation Project has only just begun. As such, there will be no test of its effect until is finished. However, work on the project has inspired some to redevelop the downtown. Some building owners believe that the flood risks will be tolerable so investment is justified.

Of the nine people interviewed by telephone who knew about the feasibility study for the Moore Drain, most reported that its main objective was obtaining "new knowledge about hazards and their effects." The respondents thought the objective was met (mean = 8.5; standard deviation = 2).

Seven telephone interviewees knew about the Moore Drain Flood Mitigation Program. Among the most knowledgeable respondents, the major objectives were identified as "reducing stress and trauma" (number of respondents = 1) and "reducing property damage" (number of respondents = 3). One respondent suggested there was "a psychological impact. There used to be a flood pole [which was] watch[ed] everyday. Watch water climb up the pole. It must really influence people, stressful."

Speaking of hazard mitigation in general, one interviewee commented: "There are only 55,000 people in the county. Because of such a small population, we wouldn't be able to complete projects if not for the hazard mitigation process."

Not everyone agreed with this statement. One person said: "Mitigation is something Vassar has fought over tremendously. A river and a drain run through downtown Vassar. Some say move the downtown, and some say move the water. Many people don't want government telling them what they can build."

5.2.8.2 Project Impact

Tuscola County did not participate in Project Impact.

5.2.8.3 Activity Chronology

An activity chronology was created for Tuscola County that illustrates the relationship between FEMA mitigation grants, community mitigation activities, and synergistic activities encouraged by the FEMA grants. The community activities in the chronology only refer to the Village of Vassar (Figure 5-8).

5.3 Mitigation Activities Undertaken

This section begins by summarizing the FEMA-funded mitigation activities performed in each community. Next, synergistic activities and effects are identified and then summarized for the eight communities evaluated

5.3.1 FEMA-Funded Mitigation Activities

Based on the NEMIS database and supplemented by local field data, Table 5-11 summarizes specific HMGP grant expenditures (2002$) in terms of total mitigation cost and the amount that FEMA contributed to the total cost. Total costs include local maintenance costs.

Based on field data, Table 5-12 summarizes expenditures for Project Impact communities. Five communities received Project Impact grants. Total costs include the cost to FEMA and local governmental expenditures beyond those required by the cost-sharing agreements but do not reflect the full range of private sector donations.

5.3.2 Synergistic Activities or Effects

Synergistic activities are activities or effects that follow or accompany the award of FEMA grants for project mitigation or process mitigation activities or the strong expectation that a grant would be awarded, that reduce risks (or increase benefits of risk-reduction activities) from floods, earthquakes, and severe winds. These activities are not funded by FEMA. In Section 2.5.2, three types of synergistic activities or effects were defined: spin-off activities, collateral risk-reduction activities, and spill-over effects. Table 5-13 summarizes the synergistic activities or effects identified in the eight communities.

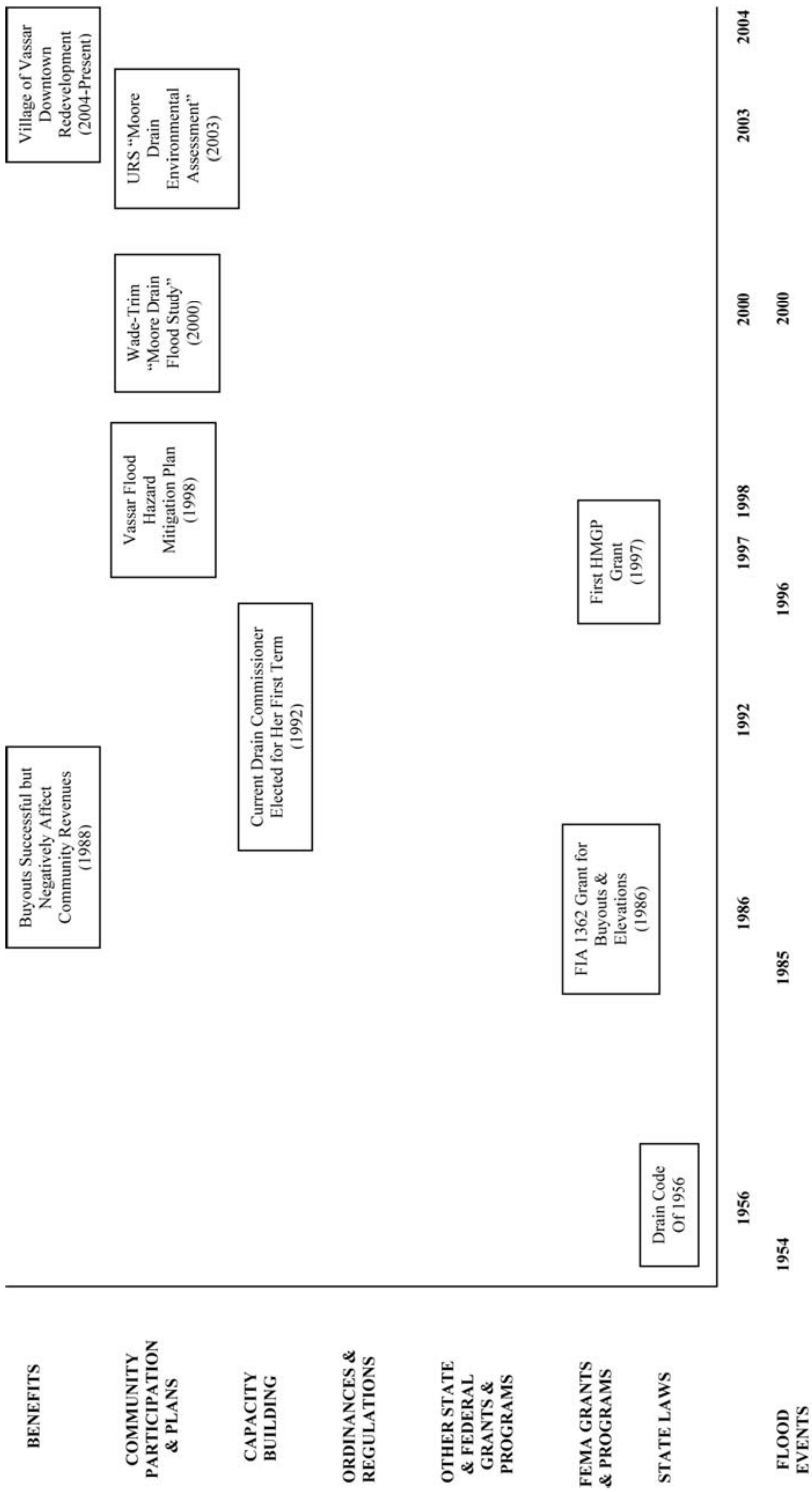


Figure 5-8 Activity chronology – Tuscola County, Michigan (unless otherwise indicated, activity dates above show start date).

Table 5-11 Summary of FEMA HMGP grants for eight communities studied

Community	Description of Mitigation Activity	Total Cost (2002$M)[1,2]	FEMA Share of Total Cost (2002$M)[2]
Freeport, New York	Elevating streets	2.76	2.07
	Building Elevations	2.36	1.77
	Total—Freeport	5.11	3.83
Hayward, California	Seismic Retrofit of Fire stations	5.11	2.60
	Sodium Hypochlorite Wastewater facility	1.84	0.50
	Total—Hayward	6.95	3.10
Horry County, South Carolina	Hazard mitigation plan	0.16	0.08
	Purchase emergency generators	0.05	0.02
	Shutter retrofits	0.26	0.20
	Other wind retrofits	0.45	0.33
	Buyouts and elevations	6.53	4.90
	Total—Horry County	7.45	5.54
Jamestown, North Dakota	Lift station	0.05	0.04
	Oxbow dike	0.60	0.45
	Total—Jamestown	0.65	0.49
Jefferson County, Alabama	Acquisition Grants	3.17	2.38
Multnomah County, Oregon	Acquisition grants	0.91	0.68
Orange, California	City garage retrofit	0.27	0.20
	City yard retrofit	0.27	0.20
	Water pump station retrofit	0.32	0.24
	Total— Orange, CA	0.86	0.65
Tuscola County, Michigan	Acquisitions	0.12	0.04
	Moore Drain structural mitigation	2.40	1.80
	Total—Tuscola County	2.52	1.84

[1] May include local government maintenance costs.

[2] Sums may be off due to rounding.

Table 5-12 Project Impact costs for five communities

Community	Total Cost (2002$K)	FEMA Cost Share (2002$K)
Freeport, New York	626	162.8
Horry County, South Carolina	160	120
Jamestown, North Dakota	314.7	236.0
Jefferson County, Alabama	314	236
Multnomah, Oregon	150	113

* Excludes donations, but includes annual local government maintenance costs for completed projects.

Table 5-13 Summary of synergistic activities or effects[1]

Community	Spin-off Activities	Collateral Activities	Spill-over Effects
Freeport, New York	None found	Elevating streets	Development of the commercial Nautical Mile
Hayward, California	Seismic retrofit of tilt-up and unreinforced masonry buildings	None found	Impacts of seismic retrofit of commercial buildings
Horry County, South Carolina	Wind code development and implementation	None found	None found
Jamestown, North Dakota	School storm drain improvement	None found	None found
Jefferson County, Alabama	Saferooms in new residential development; local expenditures in additional buyouts	None found	None found
Multnomah County, Oregon	None found	Evacuated school	None found
City of Orange, California	None found	Seismic retrofit of downtown un-reinforced masonry buildings	None found
Tuscola County, Michigan	Increased level of elevations by residential owners; and subdivision grading by developer	None found	Downtown redevelopment

[1]Synergistic activities are activities or effects that follow or accompany the award of FEMA grants for project mitigation or process mitigation activities or the strong expectation that a grant would be awarded, that reduce risks (or increase benefits of risk-reduction activities) from floods, earthquakes, and severe winds. These activities are not funded by FEMA.

5.4 Benefit-Cost Results

This section summarizes the calculation of benefit-cost ratios for HMGP activities, Project Impact grants, and spin-off activities. In addition, the results of a cost-effectiveness analysis of FEMA-funded process activities are also discussed. For community studies, the basic unit for analysis is ultimately the community itself. Thus, the focus is on those benefits and costs that have a significant impact on overall community net benefits.

5.4.1 Hazard Mitigation Grant Program Grants

Table 5-14 provides a summary of the costs, benefits, benefit-cost ratios and benefit-cost ratio ranges for all the major HMGP grants for project mitigation activities identified in the community studies. This table breaks these values down by mitigation activity and community. Frequently, multiple grants are used to buy out or elevate structures that were damaged in a single flood. In Horry County, for example, one grant (1243-0007) funded the acquisition of two properties; a second grant (1299-0014) funded the elevation of four houses, and a third grant (1299-0021) funded the acquisition of additional properties. In this case, these three grants are grouped together with two disaster 1299 supplemental grants (4299-0003 and 4299-0005) under a single mitigation activity descriptor in Table 5-14.

Table 5-14 Summary of costs, benefits, benefit-cost ratios and ranges by HMGP project grant activities and by community

Community	Brief Description of Mitigation Activity	Total Costs (2002 $M)	FEMA Costs (2002 $M)	Best Estimate		
				Benefits (2002 $M)	Benefit-Cost Ratio	BCR Range
Freeport	Street grading / elevations	2.76	2.07	6.52	2.4	0.19 – 9.6
	Building elevations	2.36	1.77	13.5	5.7	0.18 – 16.3
	Freeport Totals	*5.11*	*3.83*	*20.0*	*3.9*	*0.19 – 12.7*
Hayward	Fire stations	5.11	2.60	38.1	7.5	1.65 – 15.0
	Wastewater facility	1.84	0.50	12.8	7.0	2.84 – 17.2
	Hayward Totals	*6.95*	*3.1*	*50.9*	*7.3*	*1.96 – 15.6*
Horry County	Hazard mitigation plan	0.16	0.08	0.21	1.25	–
	Purchase emergency generators	0.05	0.02	0.05	1	–
	Shutter retrofits	0.26	0.20	2.27	8.6	1.9 – 17.2
	Other wind retrofits	0.45	0.33	0.45	1	–
	Buyouts and elevations	6.53	4.90	13.19	2.02	0.44 – 4.04
	Horry County Totals	*7.45*	*5.54*	*16.16*	*2.17*	*0.55 – 4.2*
Jamestown	Lift station	0.05	0.04	0.63	11.8	0.8 – 43.2
	Oxbow dike	0.60	0.45	0.39	0.66	0.05 – 6.9
	Jamestown Totals	*0.65*	*0.49*	*1.02*	*1.57*	*0.11 – 9.7*
Jefferson County	Acquisition grants	3.17	2.38	5.71	1.8	0.4 – 3.6
Multnomah County	Acquisition grants	0.91	0.68	1.06	1.17	0.13 – 11.7
City of Orange	Garage retrofit	0.27	0.2	1.28	4.7	1.03 – 9.4
	Yard retrofit	0.27	0.2	0.31	1.16	0.13 – 4.6
	Pump station retrofit	0.32	0.24	0.15	0.46	0.1 – 1.6
	City of Orange Totals	*0.86*	*0.65*	*1.73*	*2.0*	*0.4 – 5.0*
Tuscola County	Acquisitions	0.12	0.04	0.18	1.72	0.76 – 3.4
	Moore Drain structural mitigation	2.40	1.8	31.30	13	2.9 – 26.0
	Tuscola County Totals	*2.52*	*1.84*	*31.48*	*12.5*	*2.8 – 24.9*

Data collected in the field included actual mitigation costs and information needed to estimate mitigation benefits. To the extent possible, these field data were used in conjunction with HAZUS®MH to estimate benefit-cost ratios. For example, HAZUS®MH was used to estimate the impact of earthquakes on fire stations and the possibility of fire following an earthquake; to develop damage estimates and plume contours for determining potential losses from an accidental chlorine release; to estimate the benefits of shutters in wind-prone regions; and to estimate the damage to buildings subject to various wind velocities and flood depths.

In many cases, HAZUS®MH was supplemented by other methods to estimate benefits. For example, the impact from chlorine release was estimated using models developed by Seligson et al. (1998) to supplement existing plume modeling capabilities in HAZUS®MH. Data from local communities based both on flood gauges and on 100-year flood depths of specific properties were used to estimate expected flood losses. The direct use of local data thus stands in contrast to the regional approach used in the benefit-cost analysis for flood-related acquisitions.

For safe room evaluations, many sources of data were used to construct a new method for assessing the frequencies of severe tornado wind velocities based on an historic account of tornadoes in the general region (Section 4.3.2).

If quantitative methods for calculating benefit-cost analyses could not be found or developed, benefit transfer methods (Section 2.3) were used. Thus, these methods were used to analyze the development of hazard mitigation plans and the assessment of benefits of some wind mitigation activities. In these cases, no sensitivity analysis was performed.

The sensitivity evaluations shown in Table 5-14, use extreme ranges of benefit-cost ratios that take into account factors that can affect these ratios significantly. These factors are also shown in Tables 5-15 and 5-16. Uncertainties in the following five major estimates are considered:

1. Frequency of occurrence of the pertinent hazard,
2. Casualty rates/costs,
3. Impacts of alternative discount rates,
4. Exposure, and
5. Clean-up costs.

Uncertainties used in estimating the frequency with which pertinent hazards occur are derived from the alternative, credible models that have been developed in the considerable ongoing research being conducted particularly on earthquakes, hurricanes, and floods. A factor of two (multiplying by 2.0 on the upside and by 0.5 on the downside) is used based on results from earthquake probabilistic hazard modeling. A factor of two may underestimate uncertainties for hazards for which less research on frequency of occurrence has been conducted (Perkins, 2002; Harmsen, 2005; American Lifelines Alliance, 2002).

Uncertainties for casualty rates and cost are used for models for which HAZUS®MH is not wholly applicable. These uncertainty estimates cover special cases of debris flows and tornadoes.

Table 5-15 Downside factors used in uncertainty calculations for Table 5-14

Community	Brief Description of Mitigation Activity	Frequency of Occurrence	Casualty Rates / Costs	Discount Rate Impact	Exposure	Clean-up Costs
Freeport	Street grading / elevations	1.0 (Already lower bound)	1.0	0.44	0.5	0.36
	Building elevations	1.0 (Already lower bound)	1.0	0.44	0.2	0.36
Hayward	Fire stations	0.5	1.0	0.44	1.0	1.0
	Wastewater facility	0.5	1.0	0.81 (maintenance)	1.0	1.0
Horry County	Hazard mitigation plan	1.0	1.0	1.0	1.0	1.0
	Purchase emergency generators	1.0	1.0	1.0	1.0	1.0
	Shutter retrofits	0.5	1.0	0.44	1.0	1.0
	Other wind retrofits	1.0	1.0	1.0	1.0	1.0
	Buyouts and elevations	0.5	1.0	0.44	1.0	1.0
Jamestown	Lift station	0.5	1.0	0.78 (short life span)	0.5	0.36
	Oxbow dike	0.5	1.0	0.78 (short life span)	0.5	0.36
Jefferson County	Acquisition grants	0.5	1.0	0.44	1.0	1.0
Multnomah County	Acquisition grants	0.5	0.5	0.44	1.0	1.0
City of Orange	Garage retrofit	0.5	1.0	0.44	1.0	1.0
	Yard retrofit	0.5	1.0	0.44	0.5	1.0
	Pump station retrofit	0.5	1.0	0.44	1.0	1.0
Tuscola County	Acquisitions	1.0 (Already lower bound)	1.0	0.44	1.0	1.0
	Moore Drain structural mitigation	1.0 (Already lower bound)	1.0	0.44	0.5	1.0

Uncertainties in discount rates used and life-span of the mitigation project pertain chiefly to policy-level selection of discount rates. The base rate used here is 2 percent; however, in the recent past, 7 percent has been used. This higher discount rate reduces the present value of downstream benefits. At the same time, if there are significant downstream maintenance costs, a higher discount rate also will reduce the present value of these costs. In only one case (Jamestown), has the life span of mitigation been considered an uncertain factor.

Uncertainties about exposure result in part from limitations in field investigations conducted and the documents obtained. More extensive research might clarify the size of the population within a structure and the number of occupants exposed. In other instances, the field data do not adequately indicate the extent, if any, of process activities undertaken within the eight communities studied.

Uncertainties in clean-up costs result because expert judgment (oral communication, Oren Nelson, President of Nelson Brothers Construction Company, 2005) has been required to develop ranges of such clean-up costs. These ranges can be considerable for flooded basements and significant uncertainties can result from estimates of the savings that result, for example, from sandbagging.

Table 5-16 Upside factors used in uncertainty calculations for Table 5-14

Community	Brief Description of Mitigation Activity	Frequency of Occurrence	Casualty Rates / Costs	Discount Rate and / or Life Span Impact	Exposure	Clean-up Costs
Freeport	Street grading / elevations	2.0	1.0	1.0	2.0	1.0
	Building elevations	2.0	1.0	1.0	1.0	1.43
Hayward	Fire stations	2.0	1.0	1.0	1.0	1.0
	Wastewater facility	2.0	1.0	1.23 (maintenance)	1.0	1.0
Horry County	Hazard mitigation plan	2.0	1.0	1.0	1.0	1.0
	Purchase emergency generators	2.0	1.0	1.0	1.0	1.0
	Shutter retrofits	2.0	1.0	1.0	1.0	1.0
	Other wind retrofits	2.0	1.0	1.0	1.0	1.0
	Buyouts and elevations	2.0	1.0	1.0	1.0	1.0
Jamestown	Lift station	2.0	1.0	1.83 (life span)	1.0	1.0
	Oxbow dike	2.0	1.0	1.83 (life span)	2.0	1.43
Jefferson County	Acquisition grants	2.0	1.0	1.0	1.0	1.0
Multnomah County	Acquisition grants	2.0	5.0	1.0	1.0	1.0
City of Orange	Garage retrofit	2.0	1.0	1.0	1.0	1.0
	Yard retrofit	2.0	1.0	1.0	2.0	1.0
	Pump station retrofit	2.0	1.0	1.0	2.0 (water benefits only; resulting 1.72 overall)	1.0
Tuscola County	Acquisitions	2.0	1.0	1.0	1.0	1.0
	Moore Drain structural mitigation	2.0	1.0	1.0	1.0	1.0

For Freeport, frequency of flooding is the dominant variable in the high benefit-cost ratios. For lower bound estimates, several key assumptions were made to decrease the exposure of structures (elevating streets by a multiplier of two, elevations by a multiplier of five) and to limit future repair costs (reducing clean-up costs by a multiplier of 2.8 because of water-proofing as a result of prior floods). Inasmuch as models used did not capture all the flooding, no lower bound adjustments were made for estimates of frequency of occurrence of flooding. For upper bound estimates, clean-up costs were increased by a factor of 1.43 for building elevation projects and the exposure was doubled for street elevating projects. The results show that in the extreme lower case, the benefit-cost ratio can be lower than one. In the extreme upper-case, the benefit-cost ratio can be close to four times higher than the mean value. As discussed in the paragraph above, these extreme estimates included variation of discount rates and hazard level frequencies (here, only in the upper bound case).

The benefit-cost ratios for Hayward are high. The most significant hazard for this community is earthquake. Largely because of the high indirect benefits associated with the continued functionality of the fire stations and the potential for a large number of casualties should chlorine be released from wastewater facility, the benefit-cost ratio for the community exceeds seven. Even varying the assumptions for the wastewater facility (e.g., including future maintenance costs) and increasing the discount rate to 7 percent still results in benefit-cost ratios greater than one. Note that the high marginal increased maintenance costs at the sodium hypochlorite facility influence the impact of the use of a 7 percent as opposed to a 2 percent discount rate. Maintenance costs are lower if the discount rate is higher.

The average benefit-cost ratios for all activities in Horry County are above one despite the fact that many of the individual properties within the overall project to buy-out properties for flood (about 30 percent) were less than one. Uncertainties evaluated pertain only to shutter retrofits, buyouts, and elevations. Both discount rate uncertainties and uncertainties in frequencies of occurrence yield a lower bound benefit-cost ratio below one.

In Jamestown, the benefit-cost ratio for the Oxbow dike is lower than one because there are few residences with basements that would be protected from flooding by the mitigation measure. As indicated previously, the expected cost to repair flooded basements was obtained from Nelson (oral communication, Oren Nelson, 2005). In the case of the lift station, more individual residences would benefit from the upgrade of this facility and, thus, the benefit-cost ratio is greater than one. The community benefit-cost ratio is greater than 1.0. Downside uncertainties cover all five types of estimates and could yield an overall estimate less than 1.0. These downside estimates include a reduction in the number of flooded basements by a factor of two and a reduction in clean-up costs by a factor of 2.8. Upside estimates increase the number of structures exposed by a factor of two and take into account possible increases in clean-up costs in the Oxbow area and a possible doubling of the life span of the mitigations. Upside uncertainties indicate that the extreme range of benefit-cost estimates is very high.

For Jefferson County, where all the mitigation projects were flood buy-outs, the benefit-cost ratio is above one, even though a number of the individual purchases had benefit-cost ratios less than one. The extreme range of benefit-cost ratios depends only on uncertainties in frequency of occurrence and discount rate selected.

In Multnomah County, the hazard being mitigated is debris flow. The best estimate of the benefit-cost ratio is above one. Yet, this value is highly dependent on the assumptions made with regard to number of reduced casualties. On the downside, estimates of rates of casualties are reduced by a factor of two along with dividing the frequency of occurrence by a factor of two and using a 7 percent discount rate. On the upside, estimates of rates of casualties are multiplied by a factor of five along with increasing the frequency of occurrence by a factor of two. By varying this assumption, the benefit-cost ratio can be as low as 0.13 or as high as 11.7. The extreme range exhibits how little is known about estimating benefits of buyouts in locales prone to debris flows.

In the City of Orange, the overall best estimate of the benefit-cost ratio for earthquake mitigation activities is two. The benefit-cost ratio for the complete seismic retrofit of a critical water pump station is low because a full-scale water system evaluation was not performed; only (conservative) proxy estimates of systemic consequences of pump station failure were included. Twenty percent of the water supply was assumed to be lost during the downtime of this facility with its four wells and associated pumps. Note that these wells can produce up to 80 percent of the water supply for the City of Orange. A much more comprehensive systems evaluation would be required to account for the apparent redundancies in the City of Orange potable water system (oral communication plus calculations, Robert Baehner, P.E., City of Orange Water Department, 2005). To estimate the downside uncertainties in the City of Orange estimates, estimates of the exposed population in the city yard are divided by two along with normal reductions in estimates of the frequency of hazard occurrence and resulting impacts of using a 7 percent discount rate. Estimates of upside estimates considers doubling the benefits of the pump station retrofit and doubling the exposed population in the city yard as well as doubling the frequency of occurrence of the hazard. Varying these assumptions yields an extreme range of benefit-cost ratios from 0.4 to 5.0.

In Tuscola County, flooding is frequent and reaches high levels, thus causing serious damage at 5- and 10-year recurrence intervals. Because of this high frequency of damaging floods, the average benefit-cost ratio is over 12. In the sensitivity analysis, downside estimates considered a 7 percent discount rate and a reduced exposure for the Moore Drain structural mitigation of 50 percent. Owing to the high frequency of flooding (and the fact that the two-year flood was not analyzed), no downside uncertainties were estimated for frequency of occurrence of flooding. On the upside, only the frequency of occurrence was considered. Note that including of factors such as adjusting for such additional factors as reduced trip delays, emergency care benefits, and benefits of advance warning could yield even higher benefits. Even without these additional possible benefits, the range of benefit-cost ratios is from 2.8 to 24.9.

5.4.2 Project Impact Grants

Project Impact grant expenditures are generally small relative to other types of FEMA grants. Furthermore, in many cases, it is extremely difficult to calculate the benefits associated with these types of grants, largely because of their unique nature. Some of the more common mitigation projects include community warning systems, education activities, and purchase of special equipment or hardware. In many cases, Project Impact grants were used for multihazard mitigation process and small project activities. Each community began its mitigation efforts by creating a coalition to support grass roots engagement in mitigation.

Table 5-17 presents, for each community, the types of mitigation activities funded, the costs of these activities (including FEMA's share), estimates of the total benefits, estimates of the benefit-cost ratios, and ranges of benefit-cost ratios. Tables 5-18 and 5-19 clarify how the ranges of benefit-cost ratios are derived. As with similar evaluations for HMGP grants, the uncertainty evaluations consider impacts of uncertainties in the following estimates:

1. Frequency of occurrence of the hazard,
2. Casualty rates/costs,
3. Discount rate impacts,
4. Exposure, and
5. Clean-up costs.

Table 5-17 Summary of costs, benefits, benefit-cost ratios and ranges by Project Impact activity and community

Community	Brief Description of Mitigation Activity	Total Costs including Annual Maintenance (2002 $M)	FEMA Costs (2002 $M)	Best Estimate		
				Benefits (2002 $M)	Benefit-Cost Ratio	BCR Range
Freeport	Community early warning system	0.44	0.02	7.86	17.9	1.8 – 71
	Education	0.13	0.10	Not calculated	Not calculated	Not calculated
	Hurricane shutters	0.03	0.02	0.01	0.3	0.15 – 0.6
	Tree removal	0.02	0.02	Not calculated	Not calculated	Not calculated
	Freeport Totals	*0.63*	*0.16*	*7.87*	*12.6*	*1.3 – 50*
Horry County	Warning systems	≤0.13	0.04	0.16	1.20	1.20
	Fire hydrant reflectors	≤0.04	0.02	0.05	1.20	1.20
	Education activities	≤0.04	0.03	Not calculated	Not calculated	Not calculated
	Horry County Totals	*0.16 (limits of governmental funds)*	*0.12*	*0.21*	*1.28*	Not calculated
Jamestown	Civic center as safe room, warning for safe rooms	0.12	.10	0.24	1.96	0.2 – 6.07
	Other activities	0.19	1.44	0.18	0.93	0.28 – 0.93
	Jamestown Totals	*0.31*	*0.24*	*0.42*	*1.33*	*0.28 – 2.92*
Jefferson County	Community early warning and emergency information systems	0.12	0.09	0.40	3.45	0.85 – 10.5
	Other activities including Edgewater Oaks safe rooms	0.19	0.14	0.42	2.2	0.55 – 6.8
	Jefferson County Totals	*0.31*	*0.24*	*0.82*	*2.6*	*0.67 – 8.3*
Multnomah County	Emergency kits and model home	0.15	0.11	0.08	0.53	0.2 – 0.6

Table 5-18 Upside factors used in uncertainty calculations for Table 5-17

Community	Brief Description of Mitigation Activity	Frequency of Occurrence	Casualty Rates / Costs	Discount Rate Impact	Exposure	Clean-up Costs
Freeport	Community early warning system	2.0	1.0	1.0	1.0	2.0
	Hurricane shutters	2.0	1.0	1.0	1.0	1.0
Jamestown	Civic center as safe room, warning for safe rooms	2.0	1.55	1.0	1.0	1.0
Jefferson County	Community early warning and emergency information systems	2.0	1.55	1.0	1.0	1.0
	Other activities including Edgewater Oaks safe rooms	2.0	1.55	1.0	1.0	1.0
Multnomah County	Emergency kits and model home	1.0	1.0	1.0	1.13 (incomplete data on activities undertaken)	1.0

Table 5-19 Downside factors used in uncertainty calculations for Table 5-17

Community	Brief Description of Mitigation Activity	Frequency of Occurrence	Casualty Rates / Costs	Discount Rate Impact	Exposure
Freeport	Community early warning system	0.5	1.0	1.0	0.2
	Hurricane shutters	0.5	1.0	1.0	1.0
Jamestown	Civic center as safe room, warning for safe rooms	0.5	1.0	1.0	0.2
	Other activities	1.0	1.0	1.0	0.3 (incomplete data on activities undertaken)
Jefferson County	Community early warning and emergency information systems	0.5	1.0	1.0	0.5
	Other activities including Edgewater Oaks safe rooms	0.5	1.0	1.0	0.5
Multnomah County	Emergency kits and model home	1.0	1.0	1.0	0.38 (incomplete data on activities undertaken)

Uncertainty ranges are not evaluated for those activities whose best estimate is derived through use of the benefit transfer method. As with similar uncertainty evaluations for HMGP grants, the function of uncertainty evaluations is to expose the extreme range of possible estimates rather than to demonstrate the robustness of the evaluation. Benefit-cost evaluations for natural hazard risk reduction activities generally contain inherent uncertainties in the estimation of frequencies of occurrence of the natural hazard and potential uncertainties in policy-level determinations of a discount rate. Practical uncertainties also arise to the extent that the costs of gathering additional information to reduce some uncertainties become prohibitive relative to the gains.

For Freeport, the dominant activity was the development of warning systems that permit Freeport residents to use sandbags to avoid damages especially to appliances and other items found in lower stories. Warning systems were assumed to permit 500 residences to use sandbags every two years, with a savings of $1000 per residence per event. Uncertainties on the downside consider a reduced exposure of 100 residences and a frequency of occurrence that is halved. Discount rate impacts do not exist because casualty estimates were not discounted. On the upside, clean-up costs are doubled as is the frequency of occurrence of the flooding. HAZUS®MH was used to evaluate the benefits of hurricane shutters. Benefits from other activities were not estimated. Overall, given the efficacy of sandbagging, the basic benefit-cost ratio is above 12, and the extreme range of benefit-cost ratios ranges from 1.3 to 50.

For Horry County, benefit transfer estimates from the benefit-cost analysis of FEMA mitigation grants methodology were used to provide benefit estimates for two of the major activities: warning systems and fire hydrant reflectors. Some of the funding of these activities came through donations. The overall benefit-cost ratio considers only government funding, whether local or federal. No range of benefit-cost ratios is estimated.

For Jamestown, the tornado model developed in this project was used to estimate benefits of the community early warning system (Section 4.3.2). It was assumed that up to 3000 people could use the civic center as a safe room during tornado events. Based on the field investigation, the civic center can easily hold 3000 people and shelter time for tornado warnings tends to be relatively brief in the experience of the project investigators. No travel time evaluation was performed to determine whether or not parties could reach the shelter in sufficient time before the tornado arrived. Downside estimates reflect this uncertainty through a reduction of the exposed population by a factor of five as well a frequency of occurrence that is doubled. No discount rate is applied to casualties. For other activities in Jamestown, the benefit transfer methods are uncertain on the downside only to the extent that field documents did not fully clarify that all proposed activities were undertaken.

The Jefferson County Project Impact grant had a spin-off, the Edgewater Oaks residential development with safe-rooms. For this spin-off, it was assumed that safe rooms had private costs of $3000 each, that there were 80 such safe rooms constructed, and that the estimated gross casualty benefit was $8087 for each safe room. Downside uncertainties included a reduction of people exposed by 50 percent along with doubling the frequency of occurrence. Upside uncertainties included uncertainties in the casualty costs in the tornado model as well as dividing the frequency of occurrence by a factor of two. The early warning system connected with the Jefferson County Project Impact grant applies to flash floods, severe weather, and tornadoes. Only tornado warnings were evaluated. These assumed conservatively that 100 people received tornado warnings and moved to safe shelters. The net benefit per person was $4,043, as calculated by the tornado model. The downside uncertainty range included a reduction in people exposed and a doubling of the frequency of tornado occurrence. Upside uncertainties included a reduction in the frequency of occurrence along with an increase in casualty cost estimates. Omitted from the calculations were additional advantages of flash flood and other warnings.

The Multnomah County Project Impact grant suffered from an administrative change that led to the discontinuation of many of the activities started or only planned. Of the $150,000 allocated, $30,000 was used for a school project to develop an advanced version of a perennial 72-hour emergency kit program. Another $50,000 may be credited to the retrofitting of an older flood prone house to train homeowners and contractors on alternative seismic and other retrofitting approaches. Based on a benefit transfer benefit-cost ratio of 1.0 for these two activities, the overall benefit-cost ratio was 80/150, or 0.53. Uncertainties primarily pertained to limitations in the field investigations pertaining to the extent to which these activities were undertaken. No evaluations were performed of the $150,000 transferred to the City of Portland, for which additional investigations might find significant benefits.

5.4.3 Spin-Off Activities Resulting from HMGP Grants

As described in the discussion of Jamestown in Section 5.2.4, the design of the storm water runoff system for the new high school can be linked to the Project Impact grant. One activity in Project Impact was to complete a community storm water run off study; after its completion, the new high school in Jamestown was designed using this study. In the case of other spin-off activities, there was no cost that could be considered apart from the costs of HMGP grants. To develop benefit-cost ratios for these spin-offs would have counted the costs twice. Hence, benefit-cost ratios could not be developed for several spin-off activities. These spin-off activities are summarized in Table 5-20.

Table 5-20 Net benefits for spin-off activities not covered in Table 5-17

Community	Mitigation Descriptor	Costs Not Borne by or Required by FEMA (2002$M)	Net Benefit treated as an acceleration (2002$M)	Net Spin-Off Benefit not treated as an acceleration (2002$M)
Hayward	Tilt-ups	42.9	7.6	213.6
	URMs	10.8	1.3	49.2
	TOTALS	*53.7*	*8.9*	*262.8*
Horry County	Code development	36		3.6
Tuscola County	A few residences elevated more than required	Low	Low	Low
	Residential development grading	Low to medium	Low to medium	Low to medium

For Hayward, there was strong, but not indisputable evidence that the seismic retrofit ordinances for tilt-ups and unreinforced masonry retrofits would not have occurred had FEMA not provided Hazard Mitigation Grant Program funding. Still, for the sake of conservatism, it was also assumed that adoption of these ordinances may only have been accelerated by ten years. Because this evaluation did not apply a discount rate to casualties, no casualty benefit reduction could be calculated for the assumption of acceleration. Only property benefits were calculated given the assumption of acceleration. Thus, the assumption of acceleration yielded much lower net benefits than the assumption that the tilt-up seismic and unreinforced masonry retrofits would not have taken place at all in the absence of Hazard Mitigation Grant Program funding.

The Horry County spin-offs are speculative. Evidence exists that the Clemson University study, which used purchased buildings for destructive testing, will result in improved national model building codes and that these will affect the very rapid residential development in Horry County. A benefit-cost ratio of 1.1 was used to estimate these based on benefit-transfer methods. Marginal wind-resistance costs were assumed to be about 0.4 percent of the dwelling replacement cost. Based on field data, it is expected that 10,000 new residences (or roughly $1 billion in residential construction costs in 2002 dollars) will be built in Horry County per year over the next 10 years. When these marginal wind-resistance costs are annualized, these amount to about four million dollars. Over a ten-year period at a 2 percent discount rate, these private marginal wind-resistance costs are about $36 million. Net benefits are similarly estimated to be $3.6M. Uncertainties depend on the fact that this study may result in no code improvements, on the lower bound side. On the upper bound side, benefit-transfer methods used assumed a very low benefit per new residence based on these code improvements. Moreover, hearsay evidence (not found in the field investigations) suggests that these Clemson studies are producing benefits in other jurisdictions, including other states. Thus, future investigations may yield very significant spin-off benefits for these spin-offs resulting from the Clemson studies.

Other spin-off benefits, such as those in Tuscola County, were only generally estimated based on other calculations made for flooding impacts on residences in the Village of Vassar.

5.4.4 Cost-Effectiveness Analysis of Grants for Process Mitigation Activities

Data and methods are largely lacking for quantifying benefits for process mitigation activities. Instead of cost-benefit analysis, therefore, a cost-effectiveness approach was used. Cost-effectiveness analysis is a commonly used alternative to cost-benefit analysis in situations where the inability to monetize benefits prevents the implementation of cost-benefit analysis. In cost-effectiveness analysis, alternative actions are compared on the basis of their costs and a single quantified measure of effectiveness (Boardman et al., 2001).

The approach here involved using the telephone interview data to compare the effectiveness of process mitigation activities with the effectiveness of comparable project mitigation activities for which quantitative results were available on benefit-cost ratios. Comparability was determined from interview data on mitigation objectives. Note that the costs of process mitigation activities are typically much less than those of comparable project mitigation activities. Consequently, if a process mitigation activity is found to be at least as effective as a comparable project mitigation activity and if this project mitigation activity has a benefit-cost ratio greater than one, it can be inferred that the process mitigation activity is cost-effective. Results consisted of binary ratings for each community indicating whether or not it had invested in cost-effective process mitigation activities. The telephone interview database identifies four "process" mitigation activities in the NEMIS database, seven Project Impact mitigation cases (some of which included process mitigation activities), eleven spin-off mitigation activities (some of which included process mitigation activities), and one "other process" mitigation activity. One community, Jamestown, did not have any process mitigation activities in the telephone interview database.

The following procedure is used to determine the value of the cost-effectiveness variable for each community. Using the telephone interview database, process mitigation activities were identified for each community. For each process mitigation activity, it was then determined whether there were other project mitigation activities in that community that have a similar major objective and for which quantitative benefit-cost ratios are calculated in the current study. These project mitigation activities were compared to the process mitigation in terms of respondents' perceptions of their effectiveness. Specifically, data were used from the respondents' assessments, on a scale of 1 to 10, of "the community's success in meeting this objective" both with and without the specific mitigations. Finally, this relative effectiveness was considered in light of the available benefit-cost ratios. For example, if a process mitigation activity is more effective at achieving a certain objective than a project mitigation activity with a similar objective (e.g., safety) and the project mitigation activity had a high benefit-cost ratio, the process mitigation activity is regarded as being cost-effective.

Only information from respondents who are at least moderately familiar with the mitigation activity was considered in the cost-effectiveness analysis. Respondents' assessments of mitigation effectiveness are weighted by their degree of familiarity with the mitigation. Respondents indicated their familiarity on a scale of 1, "not at all familiar" to 10, "extremely familiar." The following weights were applied: for respondents with a familiarity level of 9 or 10, a weight of 1.0; for a familiarity level of 7 or 8, a weight of 0.75; for a familiarity level of 5 or 6, a weight of 0.5; and for a familiarity level of 1 to 4, a weight of 0. Information on spin-off activities created by the mitigation also was considered. Table 5-21 summarizes the resulting cost-effectiveness estimates. This table does not include process mitigation activities that could not be evaluated by the procedure described above due to insufficient data.

Table 5-21 Cost-effectiveness estimates for process activities

Community	Process Mitigation Activities in Analysis	Cost-Effective
Freeport	Project Impact (warning system)	Yes
Hayward	Public awareness and education	No
Horry County	Local beach management plan	Yes
Jamestown	None identified	No
Jefferson County	Project Impact (warning system)	Yes
Multnomah County	Project Impact (emergency kits)	No
Orange	Feasibility studies for retrofits	Yes
Tuscola County	Feasibility study of Moore Drain	Yes

5.5 Nonquantifiable Benefits

In benefit-cost and cost-effectiveness analyses, benefits are defined as avoided losses and do not include such positive benefits as community awareness and peace of mind. In this study, no estimates were made to quantify the value of knowledge in the general population of hazard risks, preparedness activities, recovery activities, or other emergency management topics that were the foci of educational programs. Also no estimates were made of the distribution of acceptable risk made by citizens that might be used to determine the percentage of the population who might have incorporated mitigation activities to limit their future losses and gain peace of mind. Interviewees in the communities, however, did indicate risk averse citizens invested in mitigation activities, i.e., saferooms, window shutters, preparedness kits, electric generators, or plywood for boarding.

Communities also benefited from open discussions of community plans and educational programs. When opposition existed, advocates or champions had to strengthen their positions and improve their products, leading to plans and programs that were more attuned to community wishes and likely increased the buy-in of citizens to make these programs successful.

Changes in the community esprit de'corps because of mitigation projects were not quantified. Again, anecdotal evidence indicated that highly visible mitigation programs (i.e., street elevations, storm water management facility improvements, and physical improvements to flood control works) improved the community image, which inspired residents to improve their homes and infrastructure. These results were very evident in Tuscola and Freeport where redevelopment took place in historic commercial centers. Coincident with redevelopment were increased demand for homes, higher home prices, home improvements, and infrastructure improvements to parks and other community meeting places.

Finally, it should be noted that the value of synergistic activities calculated using benefit-cost analysis does not accurately portray the value to the communities. Several synergistic activities (e.g., downtown redevelopment, preservation of an historic district, and related efforts to increase community revenues) were matters of extreme local significance but are insignificant on a national scale. Increased business in the Village of Vassar will, for instance, not have significant impacts regionally inasmuch as these businesses could have located in nearby communities. Likewise, increased city revenues resulting both from increased businesses and not having further residents and businesses leave this small community mean a great deal to those in this small city, but little regionally or nationally from a standard economic viewpoint.

5.6 Comprehensiveness Factor

The results of the community studies provide valuable insight into how synergistic effects (i.e., spin-off effects) may result from FEMA expenditures. As discussed earlier, collateral effects are not regarded in this study as resulting from FEMA expenditures. Spin-off effects are already included in the estimation of direct benefits of HMGP grants.

The comprehensiveness factor indicates the additional benefits, relative to the total cost of the grant — original FEMA and matching costs — that may be estimated from spin-off activities and effects. Spin-off benefits do not overlap with any specific benefits associated with the grant itself (e.g., risk reductions that take place in accordance with the grant itself). The comprehensiveness factor is not a benefit-cost ratio factor.

Table 5-22 provides basic information how on the comprehensiveness factor was estimated in this study. Table 5-22 begins with a statement of FEMA costs. These costs may be derived based solely on HMGP costs. In this case, derived spin-off benefits result only from HMGP grants. Alternatively, these costs may be derived based on the combined costs of HMGP and Project Impact grants. In this case, spin-off benefits are derived from both types of grants. These alternative accounts of the comprehensiveness factor (i.e., based on HMGP grant costs only, or on both HMGP and Project Impact grant costs) provide an indication of the sensitivity of this factor on two different assumptions regarding total cost.

Table 5-22 Basic estimates used in deriving a comprehensiveness factor

Community	Total HMGP Costs ($M)	Total Project Impact Costs ($M)	Project Impact Spin-off Benefits (best estimate; $M)	Spin-off Benefits from HMGP Grants (high estimate; $M)	Spin-off Benefits from HMGP Grants (low estimate; $M)
Freeport	5.11	0.626	0	0	0
Hayward	6.95	0	0	213.6	8.9
Horry	7.45	0.160	0	3.6	0.009
Jamestown	0.65	0.315	0	0	0
Jefferson	3.17	0.314	0.403	0	0
Multnomah	0.91	0.150	0	0	0
Orange	0.86	0	0	0	0
Tuscola	2.52	0	0	0.100	0.100
TOTALS	$27.62	$1.565	$0.403	$217.3	$9.0

In the case of Hayward, because it can be argued whether or not the spin-off activities were a direct result of or were only accelerated by the FEMA mitigation grants, alternative estimates were developed both for the lower estimate (on the assumption that these activities were merely accelerated) and for the higher estimate (on the assumption that these activities would not have occurred without the FEMA grant).

Based on Table 5-22, one can derive the following low and high estimates for this comprehensiveness factor:

> 0.324 as the low estimate relative to total costs [weighting equally 0.326, or 9000/27,618 for HMGP grants only and 0.322, or (9000+403)/(27618+1564.7) for HMGP and Project Impact grants]
>
> 7.78 as the high estimate relative to total costs [7.87, or 217,300/27,618, for HMGP grants only and 7.46, or (217,300+403)/(27,168 + 1564.7) for HMGP and Project Impact grants]

The variations between low and high estimates demonstrate how much the comprehensiveness factor depends on whether or not one treats the Hayward spin-offs as being accelerated. The sensitivity of these results further demonstrates how skewed the distribution is from the synergistic benefits estimated in the limited community studies.

The variations between using HMGP grants only and using both HMGP and Project Impact grants are very small, but nonetheless arise because Jefferson County spin-offs result from the Project Impact grant. Hence, if this spin-off is included in the development of the comprehensiveness factor, then all Project Impact costs should be included. Other Project Impact benefits are not included because they are not spin-off benefits.

For this study, it is assumed that that the Hayward spin-offs should be treated as being accelerated. Thus, for each dollar spent by FEMA and the local government (in cost-sharing), the synergistic benefits are estimated to be $0.32.

5.7 Summary

In each of the eight communities studied, federal hazard mitigation grants, including Project Impact, were a significant part of the community's mitigation history. As shown in the eight activity chronologies (Figures 5-1 through 5-8), the federal hazard mitigation grants often led to additional or synergistic activities. Interviewees in all communities, as reported in Section 5.1.2, thought the grants were important in reducing community risks, preventing future damages, and increasing a community's capacity to mitigate natural hazards. Most believed the grants permitted their communities to achieve mitigation goals that might not otherwise have been reached.

Overall benefit cost ratios were over one in all eight communities without including additional calculations for activities such as public education. While some individual projects had benefit cost ratios less than one, for the most part, communities undertook cost beneficial projects. Interviewees in each community believed that benefits of the mitigation projects went beyond what could actually be measured quantitatively. These included increased community awareness, esprit de corps, and peace of mind. Virtually every interviewee believed that their community was better off after mitigation project and process activities were completed.

Chapter 6
BENEFIT-COST ANALYSIS OF FEMA MITIGATION GRANTS

The results of the benefit-cost analysis of FEMA mitigation grants are presented and explained below. These results are based on the data and methods summarized in Chapters 3 and 4. Results are presented for two major categories of grants ─ those for project activities and those for process activities; and for three hazards ─ earthquake, flood, and wind.[62] Classification thus resulted in six strata. Specific methods and data used in the estimation of each stratum are also identified.

Because this was a statistical analysis, the emphasis was placed on major statistical indicators applicable to an entire stratum the mean benefit and its standard deviation ─ rather than on individual grants. Explanations are offered for statistical outliers (extreme values) and for those cases where the results are unusual or counterintuitive.

Overall, the benefit-cost analysis of FEMA mitigation grants found that the benefit-cost ratio of all strata were greater than 1.0. Moreover, this result is robust to formal sensitivity tests and informal evaluations of methodological limitations and assumptions.

The sample results also were extrapolated to the population totals. The total national benefits of FEMA hazard mitigation grants between mid-1993 and mid-2003 are $14.0 billion compared with $3.5 billion in costs. This yielded an overall benefit-cost ratio of 4.0. This means that the benefits of these grants to the nation significantly exceed their costs.

In addition, the savings to the federal treasury were estimated. Federal expenditures on hazard mitigation were juxtaposed against potential savings in federal post-disaster recovery expenditures and recouped federal taxes. The results were that every dollar of hazard mitigation expenditures potentially saves the federal treasury $3.65 of future discounted expenditures or lost taxes. Thus, in addition to providing broad-based benefits to society, the FEMA hazard mitigation grant programs more than pay for themselves.

6.1 Project Selection

This study addresses all FEMA-funded mitigation grants that satisfy the following criteria: (1) the grant was listed in the NEMIS database provided by FEMA in July, 2003; (2) the grant was associated with presidentially declared disaster number 993 (Midwest floods of June 1993) or later; and (3) the grant was intended to reduce future losses associated with earthquake, flood, or wind (including both hurricanes and tornadoes) as determined using FEMA's coding for project type. Where the project-type code did not reveal the hazard to be mitigated, the hazard was assumed to be the same as that of the declared disaster, and this assumption was cross-checked by a review of the grant application.

[62] The results for a third category of grants, Project Impact grants, are presented in Chapter 5.

6.2 Stratified Sample

Project data were acquired in electronic format for 5,479 approved or completed grants to mitigate flood, earthquake, or wind risk. The data were stratified by hazard type (flood, earthquake, or wind) and mitigation type (project or process activity). A selection of 357 mitigation grants was made for examination. Each combination of mitigation type (project or process) and hazard represents one stratum. The study investigators collected additional data on as many of these grants as possible (see Section 3.2.2 for discussion of this process).

A rigorous random sampling technique was applied to select these 357 grants (see Section 4.5.1 for details). The sample grants were selected to represent the distribution of mitigation costs and to ensure the inclusion of low, medium, and high-cost mitigation efforts in each stratum. FEMA was able to provide paper copies of 312 grant applications. Data were extracted from these paper files and transcribed to electronic coding forms in a detailed and structured fashion. The form for project mitigation activities contained 200 data fields for each property or location mentioned in the grant application. Eventually, 54,000 data items were extracted for the stratified sample, consisting of 1,546 properties in project mitigation activities and 387 distinct efforts in process-type activities. Many of the 312 grant application files contained insufficient data to estimate benefits of mitigation, and a few produced results that caused investigators to exclude them from the final sample (these "outliers" are discussed later). Eventually, 136 grant applications remained in the sample.

Table 6-1 summarizes the distribution of these grants by mitigation type and hazard for the entire population of grants that satisfy the criteria listed in Section 6.1 and for the sample that was selected to represent the population. The table distinguishes grants that involve the actual mitigation of risk (project mitigation activities such as structural retrofit) from activities involving support functions (process mitigation activities such as public awareness campaigns or research).

Table 6-1 Distribution of grants by mitigation type and hazard (in 2004 dollars)

		Population		Sample	
Hazard	**Type**	**Count**	**Cost ($M)**	**Count**	**Cost ($M)**
Wind	Project	1,190	280	42	38
	Process	382	94	21	38
Flood	Project	3,404	2,204	22	84
	Process	108	13	6	2
Earthquake	Project	347	867	25	336
	Process	48	80	20	74
Total		5,479	$3,538	136	$572

6.3 Sample Results

6.3.1 Sampled Grants for Project Mitigation Activities

This section covers grants for project mitigation activities only for earthquake, wind, and flood. Section 6.3.2 discusses the sampled grants for process mitigation activities for these hazards.

The results of the benefit-cost analysis of FEMA project grants are discussed below. Although some details are presented at the individual grant level, the benefit calculations and the benefit-cost ratio results are valid only at the aggregate level. This is consistent with the general nature of statistical studies of this kind. The benefit-cost ratios calculated in this part of the study were independent of those provided in grant applications. There were several reasons for this, including the need to develop and implement an independent methodology for estimating future benefits, and the fact that the focus of this study was on aggregate benefits and not on the benefits of individual grants.

A list of methods used to measure each benefit type for each hazard is presented in Table 6-2. Table 6-2 also includes the section of this report in which a detailed explanation of the method is found.

6.3.1.1 Grants for Earthquake Project Mitigation Activities

The earthquake stratum of grants for project mitigation activities includes grants for both structural activities (e.g., base isolation of public buildings) and nonstructural activities (e.g., retrofit of pendant lighting in schools). Overall, the stratum sample included 25 grants involving 128 buildings. Pendant lighting projects in schools accounted for the majority of the buildings analyzed in this stratum, with one grant addressing the replacement or mitigation of seismically vulnerable light fixtures in 78 sample buildings. Higher cost grants included seismic upgrades and seismic safety corrections of hospitals, university buildings, and other public buildings.

HAZUS®MH was the primary methodology used in estimating property damage, direct and indirect business interruption losses, and some societal impacts such as casualties. It was applied using structural, economic, and societal information and data obtained from grant applications found in FEMA files, and supplemented with published data on some key projects.

New methods were developed for estimating some types of avoided losses (see discussion in Section 4.3). These avoided losses included business interruption impacts associated with utility outages, damage to pendant lighting and ceilings, environmental/historical benefits and some societal benefits (see Appendices C through K). Section 2.1.1 discusses the fact that independent estimates of the costs of administering FEMA grants could not be obtained.

The simple average benefit-cost ratio for the 25 grants in this stratum is 1.4, with a standard deviation of 1.3. The total benefit for this stratum is $1.2 billion. Individual grant benefit-cost ratios range from near zero for a nonstructural retrofit to an electricity substation (intended to reduce physical injury to workers) to 3.9 for a nonstructural retrofit of a hospital.

Table 6-2 Methods used to estimate benefits for grants for project mitigation activities[1]

	Hazard			
	Earthquake	Wind		Flood
Benefit Type		**Hurricane**	**Tornado**	
Property Damage	HAZUS®MH (Section 4.2.1)	HAZUS®MH (Section 4.2.1)	HAZUS®MH Reduced Form (Appendix H)	HAZUS®MH Reduced Form (Appendix G)
Business Interruption				
Utilities	HAZUS®MH Extension[2] (Appendix I)	HAZUS®MH Extension[2] (Appendix I)	HAZUS®MH Extension[2] (Appendix I)	n.a.[3]
Other	HAZUS®MH (Sec 4.2.2, 4.2.3)	HAZUS®MH (Sec 4.2.2, 4.2.3)	HAZUS®MH (Sec 4.2.2, 4.2.3)	n.a.[3]
Displacement	HAZUS®MH[4] (Sec 4.2.2)	HAZUS®MH[4] (Sec 4.2.2)	HAZUS®MH Extension [2,4] (Sec 4.2.2)	HAZUS®MH Extension[2] (Sec 4.2.3.3)
Casualty[5]				
Structural	HAZUS®MH (Appendix E)	Benefit Transfer (Appendix E)	HAZUS®MH Reduced Form[6] (Appendix E)	Benefit Transfer (Appendix E)
Nonstructural	Benefit Transfer (Appendix E)	n.a.[7]	n.a.[7]	n.a.[7]
Environmental and Historical	Benefit Transfer (Sec 4.3.4; Appendix J)	Benefit Transfer (Sec 4.3.4; Appendix J)	Benefit Transfer (Sec 4.3.4; Appendix J)	Benefit Transfer (Sec 4.3.4; Appendix J)

[1]A "surrogate benefit" method was used to estimate all benefit categories for process activities (Section 4.3.5 and Appendix K).
[2]Extension refers to a method that builds on HAZUS®MH with a similar and compatible approach.
[3]None of the sampled flood projects involved business interruption.
[4]Measured as part of business interruption.
[5]Also includes emergency services benefits.
[6]Reduced Form refers to the use of component parts, such as functional relationships and data, from a HAZUS®MH module.
[7]Only relevant to earthquakes.

HAZUS®MH was used to estimate property damage avoidance (benefits) due to the structural upgrades. These benefits can be significant, with property loss reductions measuring between a few percent and 3.9 times the cost of the retrofit. The total property loss reduction for this stratum is $319 million. Property loss reduction alone, however, was not sufficient for the average benefit-cost ratio from mitigation measures in this stratum to exceed 1.0. Of the 25 hazard mitigation grants in the earthquake project stratum, three avoided business interruption. The cases where business interruption was applicable included impacts on utilities and hospitals; no conventional business activities other than these were in the sample. (This estimation here and for other hazards excludes public buildings such as police and fire departments, civic arenas, and schools.[63]) In addition, an inherent assumption of the HAZUS®MH methodology is that only structural mitigation results in business interruption benefits.[64] The vast majority of nonstructural mitigation measures in this stratum are for pendant lighting in schools, and is assumed only to affect casualty rates.

For the three applicable cases in the earthquake project grant sample stratum, business interruption benefits average $52.9 million, and range from a low of $1.3 million for a pump station to a high of $139.5 million for a hospital. Business interruption benefits contribute about 10 percent to the overall average benefit-cost ratio for this stratum.

The largest component of benefits in the earthquake project stratum was the reduction of casualties, which accounted for 62 percent of the total benefits. Analysis shows that a reduction of about 542 injuries and 26 deaths in this stratum is expected, which translates into $131.3 million. The mean benefit per grant is about $6.3 million, with a standard deviation of $6.4 million. The projects with zero calculated casualty benefits included electrical substation upgrades, a school arcade replacement, and nonstructural mitigation activities to emergency power and communication facilities (rather than patient services) in a hospital.

Three earthquake grants provided environmental or historical benefits, including improving water quality, protecting historic buildings, and positive health benefits. The highest environmental benefit was for an earthquake retrofitting of a police headquarters building ($293,000), while the lowest pertains to health benefits of a hospital retrofit. The average benefit of these three grants is nearly $143,000, and they accounted for less than 1 percent of the total benefits in the earthquake project grant stratum.

No significant outliers exist in the earthquake project stratum, with the exception of two nonstructural mitigation grants. These two grants did not provide much property protection, almost no casualty reduction, and no protection at all against business interruption.[65]

For this stratum (as well as for the others below), the overall approach has leaned toward conservatism. In this stratum, estimates of the diffusion of university research and of demonstration projects, as well as several types of societal impacts related to psychological trauma, were omitted because there was no adequate means of quantifying these measures. Also omitted in this and other strata were: indirect property damage (e.g., prevention of ancillary fires), avoided negative societal impacts relating to psychological trauma (e.g., crime, divorce), air quality benefits (improvements in visibility and health due to reduced burning debris), benefits from reduced disposal of debris (land quality), and aesthetic benefits including visibility and odors of reduced debris.

---

[63] These public sector activities, although not priced as a business product or service, do yield commensurate value even if usually not transacted through the market. However, they have been omitted from business interruption calculations because, in the aftermath of a natural disaster, most of their functions are provided by other locations or "recaptured" at a later date. Moreover, payments for major inputs continue even when the original facility is closed (e.g., wages to unionized employees).

[64] For the earthquake and wind project strata, business interruption also included the costs of displacement effects. For the case of buyouts of flood-prone residences, these effects were calculated separately.

[65] Those projects with low benefit-cost ratios include some cases of nonstructural mitigation intended primarily for life safety. Other cases of this same type of mitigation yield some of the higher benefit-cost ratios, along with structural retrofit of large buildings. The seeming incongruity of the benefits of nonstructural retrofits is explained primarily by differences in the number of individuals at risk of death and injury.

Box 1 provides an example of where HAZUS®MH was used to calculate the benefits of mitigation for an earthquake-related project grant. Some calculations (i.e., the assessment of indirect economic benefits) were completed outside of HAZUS®MH, and these are clearly identified in the example.

6.3.1.2 Grants for Wind Project Mitigation Activities

Although several mitigation measures are included in the sample grants for the wind project grant stratum, the majority are hurricane storm shutters and saferooms. HAZUS®MH readily handles property benefit calculations for hurricane storm shutters. However, supplemental methodologies were developed by the study investigators to estimate property damage impacts of tornadoes and casualty impacts for both hurricanes and tornadoes (see Table 6-2). Benefit transfer methods were used to estimate environmental/historic benefits.

The simple average benefit-cost ratio for the 42 grants in the wind project stratum was 4.7, and the standard deviation was 7.0. The total benefit for this stratum is $1.3 billion. Individual grant benefit-cost ratios range from less than 0.05 for retrofit of a police department building to greater than 50, for a variety of utility protection measures.[66]

Several of the grants that had large benefit-cost ratios (>10.0), including all four outliers that exceeded 50.0, were cases of electric utility mitigation, such as relocating utility power lines below ground. In these cases, property damage savings were relatively small, but the business interruption savings were large. A downed power line, or a substation that has been disrupted because of a hurricane, can cause the economy of a city to come to a halt for days (Rose et al., 1997). Even the prevention of an outage of a few hours can pay for itself several times over in some instances.

Property loss benefits can be significant, with reductions measuring up to 4 times the cost of the retrofit. The sample average benefit-cost ratio associated with property loss reduction is 0.59. The estimated total reduction in property loss for all wind project grants (not just those in the sample) is $166 million.

[66] Benefit-cost ratios outside these bounds were ignored for the purpose of calculating the stratum-average benefit-cost ratios, which results in a conservative estimate. The projects with a benefit-cost ratio less than 0.05 or greater than 50 are referred to here as outliers; all projects with benefit-cost ratio between 0.05 and 50 are referred to as the censored set. The bounds of 0.05 and 50 were initially selected somewhat arbitrarily. However, when one calculates the 1st and 99th percentiles of the lognormal distribution with the same moments as the censored set (±2.3 standard deviations), all members of the censored set have benefit-cost ratios within these 1st and 99th percentiles, so the bounds are in a way "stable." Note that the benefit-cost ratios of the censored set are approximately log normally distributed, passing a Kolmogorov-Smirnov goodness-of-fit test at the 5 percent significance level.

Box 1 HAZUS®MH EXAMPLE - Earthquake

Background

This is an example of where HAZUS®MH was used to calculate expected annual losses from earthquake with and without a mitigation activity. What is illustrated in this example are the input and output of HAZUS®MH and what calculations were done outside of HAZUS®MH to estimate the benefit-cost ratio associated with this mitigation activity. For this example, structural retrofit measures were implemented to improve the overall seismic resistance of a hospital.

HAZUS®MH Basic Input Information

Building Characteristics	Original Building	Retrofitted Building
Occupancy	Hospital	Hospital
Building Type	Concrete Shear-walls	Concrete Shear-walls
Design Level	Low	High
Building Quality	Inferior	Code

HAZUS®MH Models

Damage (median displacement for onset of damage, in inches)	Original Building	Retrofitted Building
Slight	0.96	1.2
Moderate	1.83	3
Extensive	4.74	9
Complete	12	24

Functional Loss		
None (Days)	0	0
Slight (Days)	2	2
Moderate (Days)	68	68
Extensive (Days)	270	270
Complete (Days)	360	360

Recovery Time		
None (Days)	0	0
Slight (Days)	20	20
Moderate (Days)	135	135
Extensive (Days)	540	540
Complete (Days)	720	720

Economic Factors		
Recapture Factor/Business Income	0.6	0.6
Recapture Factor/Wages	0.6	0.6

HAZUS®MH Iutput

Return Period	Peak Ground Acceleration (g)
100 Year	0.20
500 Year	0.38
1000 Year	0.50
2500 Year	0.66

Annualized Losses	Original Building	Retrofitted Building
Building Capital Loss	$235,608	$74,860
Direct Business Interruption Loss	$412,968	$69,083
SUBTOTAL ($)	$648,576	$143,943
Casualty - Level 1	0.3322*	0.0154*
Casualty - Level 2	0.1048*	0.0019*
Casualty - Level 3	0.0176*	0.0001*
Casualty - Level 4	0.0352*	0.0002*

*Absolute number of persons in a given casualty level per year.

Calculations Completed Outside of HAZUS®MH

Annualized Losses	Original Building	Retrofitted Building
Casualty value	$151,343	$1,435
Annualized Benefit		
Reduced Building Capital Loss		$160,748
Reduced Direct Business Interruption Loss		$343,885
Reduced Environmental Loss		$38
Reduced Casualty Loss		$149,908
Benefits and Costs in Project Year		
Project Year		1997
Amortization Period		100 yr (lifeline)
Discount Rate (Non-casualty only)		2%
Reduced Building Capital Loss		$6,927,974
Reduced Direct Business Interruption Loss		$14,820,877
Reduced Environmental Loss		$1,638
Reduced Casualty Loss		$12,618,519
Cost		$26,449,484
Benefits and Costs in 2004		
CPI 2004/CPI 1997		1.188
Reduced Building Capital Loss		$8,230,433
Reduced Direct Business Interruption Loss		$17,607,201
Reduced Environmental Loss		$1,946
Reduced Casualty Loss		$14,990,800
Total Benefit		$40,830,380
Cost		$31,421,987
Benefit-Cost Ratio		1.30

Casualty benefits apply to 25 grants in the wind stratum. All of these projects are either hurricane shelters or tornado saferooms. The hurricane grants involved mitigation of multiple properties, usually schools; however, not all of the schools are on the shelter inventory. The methodology calculated benefits for only those schools that also serve as hurricane shelters. Collectively, the schools that met this condition were able to shelter, at capacity, about 33,189 evacuees. The tornado grants involved the building of saferooms in public and private spaces, the majority of which were community shelters (sheltering 750 to 1,000) with one notable exception that sponsored the construction of saferooms in hundreds of private residences.

Considering both types of wind project grants — hurricane and tornado — together, mitigation activities reduced casualty losses in the sample by about $108 million, or an estimated $794 million for all wind project grants. The per-project mean casualty benefit is $4.3 million.

Some intangible benefits of shelters could not be quantified, and were therefore excluded from the benefit-cost analysis. Regardless of the financial benefit of sheltering, shelters are beneficial by reducing uncertainty and stress in those at risk. In addition, available hurricane shelter space keeps people off the highways during dangerous periods. More important, shelters offer the only safe haven for those without the financial means to take other protective measures.

Historical benefits were applicable to only one wind hazard grant: door and window protection for an historic town hall (a total estimated benefit of $115,000). For the wind project grant stratum overall, however, historic benefits contributed little to the average benefit-cost ratio.

Estimates of casualties avoided because of grants for wind mitigation project activities are high compared to the number of lives lost annually from high wind in the United States. In this study, the estimated casualties avoided are all tornado-related. Because the body of peer-reviewed scientific literature relating to probabilistic estimates of loss reduction from tornado mitigation is scant relative to that of other natural hazards covered in the study, the project investigators developed loss models without benefit of years of input from the scientific community in developing, testing and validating modeling techniques. (See Appendix H.)

Because of these issues, ATC contracted with Professor James McDonald of Texas Tech University, a noted wind engineering expert, to review and comment on the entire loss estimation methodology for tornado. Because of this review, changes were made to the methods used to quantify tornado impact areas. The Project Management Committee and the Internal Project Review Panel agree that the model used is logical. Avoided casualties have a limited effect on the aggregate results of the current study. The sensitivity analysis found that the benefit-cost ratio for the stratum of grants for wind project mitigation remained above one when casualty rates were reduced an order of magnitude lower than the estimated rates. If only 10 percent of the estimated benefits attributed to avoided casualties are counted, the benefit-cost ratio for grants for wind-project mitigation activities would decline from 4.7 to 2.1. Moreover, given the relatively small number and size of grants for wind mitigation, the benefit-cost ratio of all mitigation programs would be reduced from 4.0 to 3.8.

Box 2 provides an example of where relationships from HAZUS®MH were used to calculate the benefits of mitigation for a tornado-related project grant. Note that because HAZUS®MH currently does not address tornado hazards, almost all of the analysis was done outside of HAZUS®MH.

6.3.1.3 Grants for Flood Project Mitigation Activities

HAZUS®MH damage functions formed the basis for estimating property damage due to flooding. The hazard calculations, however, were performed outside of the HAZUS®MH flood module because this component was not available at the time of this study. Instead, an alternative methodology was developed that used a probabilistic approach to locate properties in the flood plane and to estimate the expected distribution of flood heights (see Section 4.3.1 for a description of this methodology). Casualties and displacement costs, and historic site and environmental benefits were calculated separately using the methodologies noted in Chapter 4. Because all mitigation measures applied to residential properties, no business interruption benefit was calculated.

The study investigators coded 71 grant files (consisting of 990 properties) into the project database. Approximately two-thirds, 625 properties, were geocoded through a combination of address matching tasks:

1. Matching to previously located properties in the NEMIS database;
2. Geocoding using TIGER street data; and
3. Matching addresses with geographic coordinates using online services such as MapQuest.

Out of the 625 geocoded buildings, 486 were within an acceptable distance of 3,567 meters[67] to allow mapping in the FEMA Q3 digital flood map and the USGS National Hydrography Dataset (NHD) stream data (see Appendix G for a description of the databases). Several projects were subsequently eliminated from the analysis because of insufficient data. A final selection of 483 properties corresponded to 22 grants. For each flood grant, only properties that matched all the above criteria were analyzed for direct property damage.

The number of geocoded properties in a single grant ranged from 1 to 133, with a mean of 42 and a standard deviation of 33. The property benefits realized for grants range from $0.19 million to $1.1 million. The average benefit per property ranged from $0.13 to $0.74 million, with an average benefit of $0.28 million, and a standard deviation of $0.14 million. The only significant outlier was the acquisition of a school, with a total benefit of $18.7 million.

Grants for flood acquisition projects also reduce the societal impacts of flooding by reducing injuries to the residents of the properties. For the flood project grant stratum, 22 grants had enough data to estimate casualty reduction benefits. The grants varied in size, with some mitigating many properties and others only a few. Overall, buying these properties reduced approximately 68 injuries for a total benefit of $12.3 million. On average, the 22 projects have a

[67] 3,567 meters was chosen because it corresponds to the maximum geocoding error associated with rural areas.

Box 2 USE OF HAZUS®MH DAMAGE FUNCTIONS - Tornado

Background

HAZUS®MH damage functions were used to help calculate the benefits (i.e., reduction in number of casualties) associated with shelter installations, i.e., saferooms. In this case, the hazard being mitigated was tornado wind. Because HAZUS®MH is not currently set up to estimate tornado losses internally, the project investigators used the basic wind damage functions in HAZUS®MH (that are used for estimating the effects of hurricane wind) and applied these functions using an existing tornado risk assessment methodology (see Appendix H for details). The following example illustrates how these damage functions were used for a masonry school in the Midwest. To define the hazard potential for this region, an historic tornado incident catalog developed by NOAA was used.

Step 1: The tornado track data were aggregated to one-degree latitude by one-degree longitude grids. The count of tornado vectors by Fugita rating was extracted for the grid that contained the site location. The data were then normalized by the number of years surveyed in the NOAA dataset and adjusted using a linear multiplier for undercount.

Incidence of Tornados

	F-1	F-2	F-3	F-4	F-5
Total	39	13	16	2	0
Per Year	1.2675	.4225	.52	.065	.0

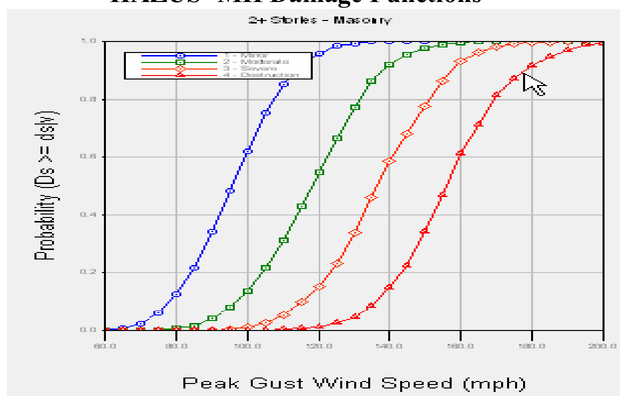
Step 2: A buffer was calculated for each tornado vector that represented the drop-off in wind speed with increasing distance from each tornado path. For each buffer, the length and width of degradation by Fujita scale was used to calculate a total degradation matrix. This step results in an (annualized) exposure area (sq. kms.) associated with each wind speed. Summing these exposure areas by wind speed and dividing by the total grid area yields an estimate of the annualized probability of the structure being exposed to a given wind speed.

Annualized Exposure Areas by Wind Speed

	100 mph	150 mph	200 mph	250 mph	300 mph
F-1	.061811	0	0	0	0
F-2	.103917	.054265	0	0	0
F-3	.552378	.289046	.175237	0	0
F-4	.209148	.13194	.060325	.037042	0
F-5	0	0	0	0	0
Total	.927253	.475251	.235563	.037042	0
Freq.	.000235	.000120	.000060	.000009	0

Step 3: HAZUS®MH damage functions were used to estimate the expected damage by damage state. The annual wind speed probabilities provided in Step 2 were multiplied by the probability of being in a given damage state. This resulted in the following damage state probabilities: minor: 2.87×10^{-4}, moderate: 1.12×10^{-4}, severe: 7.39×10^{-5}, and destroyed: 7.17×10^{-5}.

HAZUS®MH Damage Functions



Step 4: ATC (1985) injury and death rates, as applied by the FEMA Benefit-Cost Analysis toolkit, were used to estimate the number of injuries and deaths from tornado wind. These rates were multiplied by the (annualized) damage state probabilities above. For purposes of quantifying exposure, an average of 300 individuals were assumed to the shelter.

ATC (1985) Injury and Death Rates

	Minor injury	Major injury	Death
Minor	0.0001	0.00001	0
Moderate	0.0012	0.00016	0.00004
Severe	0.06857	0.00914	0.00229
Destruction	0.4	0.4	0.2

Step 5: Casualty rates were then converted into dollar amounts using $17,000 for minor injuries, $180,000 for major injuries and $3,000,000 for deaths. The value of avoided casualties for this sample is compared to the cost of the tornado mitigation projects to yield the benefit cost ratio.

Benefit-Cost Calculations

Annualized Avoided Casualty Benefits	$8,279
Discount Rate (Casualty)	0%
Amortization Rate	50 years
Total Casualty Benefit	$413,950
Project Cost	$327,000
Benefit Cost Ratio	1.27

mean benefit of $0.56 million and standard deviation of $0.85 million. The large project standard deviation results from the large grant size range.

The majority of the grants in the flood project grant stratum were for residential structures that had experienced repeated flooding. Costs associated with residential flooding included displacement costs for the families to relocate while their homes underwent repair. By buying out repeatedly flooded properties, mitigation activities reduced displacement expenditures. Twenty-two sampled grants included sufficient information to estimate displacement costs. The total sampled stratum benefit is $2.3 million.

Sixteen of the flood mitigation grants yielded environmental benefits, and none yield historical benefits. Fourteen of the environmental benefits pertained to establishing wetlands following the removal of structures, rather than direct environmental benefits of reduced flooding per se. The environmental benefits of these grants were estimated by applying wetland values from the literature to each acre created. Conservative assumptions were made about the wetland acreage created for each property purchased, the percentage of these acres that actually function as wetlands, and the number of years that the acreage would function as such. Strictly speaking, these are side-effects of mitigation, rather than intended consequences. This report could have listed them as offsets to mitigation costs, but it is less confusing to list them under benefits.

The grant with the highest environmental benefit was for the purchase and removal of 262 flooded properties (approximately $0.32 million), while the lowest benefit was for the purchase and removal of one flooded property (approximately $6,000). The average environmental benefit associated with these 16 grants is nearly $96,000.

The total of all benefits realized for each grant ranged from $0.19 to $116.5 million, with a standard deviation of $27.3 million. The high standard deviation is directly attributable to the differences in the number of acquisitions.

All individual flood grants had benefit-cost ratios greater than 1.0, with an average benefit-cost ratio of 5.1, a minimum of 3.0, a maximum of 7.6, and a standard deviation of 1.1.

6.3.2 Sampled Grants for Process Mitigation Activities

This section presents the results for grants for process mitigation activities. The reader is reminded that process grants do not yield benefits themselves, but rather provide the basis for subsequent mitigation action. The benefits estimated here reflect only a portion of eventual benefits, the cost of which is often borne by nonfederal government agencies or the private sector. The essence of the process benefit estimation procedure is that grants for process mitigation activities have the same benefit-cost ratio as the mitigation activities that they eventually inspire. The analysis was based on the "surrogate benefit" approach presented in Sections 2.3 and 4.3.5.

Only the following major types of process activities were evaluated:

1. Information/warning (risk communication),

2. Building codes and related regulations, and
3. Hazard mitigation plans.

These three types of activities accounted for more than 85 percent of all process grants.

6.3.2.1 Grants for Earthquake Process Mitigation Activities

Twenty earthquake grants for process mitigation activities were evaluated. The average benefit-cost ratio of the sample is 2.5. Benefit-cost ratios for individual grants ranged from 1.1 for an engineering task force, to 4.0 for several grants for hazard mitigation plans and building codes. The surrogate benefit methodology analyzes each grant in its entirety and does not separate out the different types of benefits as was done for grants for project mitigation activities. The methodology does not lend itself to the calculation of the standard deviation of benefit-cost ratio, so that figure was omitted here. The majority of grants for earthquake process mitigation activities are for mitigation plans and improvement of building codes and regulations. The only grant for information activities was for vulnerability evaluations.

6.3.2.2 Grants for Wind Process Mitigation Activities

Twenty-one wind-related grants for process mitigation activities were evaluated. The average benefit-cost ratio is 1.2. Individual grant benefit-cost ratios ranged from 1.1 for risk communication activities to 1.4 for evaluation and training activities. Ten of the grants in this stratum were for hazard mitigation plans, and nine were for risk communication activities. The standard deviation of benefit-cost ratio was omitted because the surrogate benefit methodology does not lend itself to this calculation.

6.3.2.3 Grants for Flood Process Mitigation Activities

Only six grants for flood process mitigation activities were evaluated. The small number reflects the fact that the majority of grants for flood hazard process mitigation originally sampled were Project Impact grants, which were subsequently dropped from the benefit-cost analysis of FEMA grants study component because the files lacked sufficient data for a complete analysis. The average benefit-cost ratio for this stratum is 1.3, with little variation across individual grants. Five of the six grants were for mitigation plans and the other was for streamlining a building permit process. Again, the standard deviation of benefit-cost ratio for was omitted.

6.3.2.4 Summary of Results for Process Mitigation Activity Grants

A conservative estimate of the benefit-cost ratio for most grants for mitigation planning is about 1.4 (for a further explanation of this and other benefit-cost ratios used in this analysis the reader is referred to Section 4.3.5 and Appendix K). This estimate is based on the Mecklenburg (Canaan, 2000) studies, the study by Taylor et al. (1991), and the URS Group (2001) report, which is most applicable to multihazard grants. For grants for activities involving building codes a conservative estimate is higher than for multihazard grants, at a value of approximately 4. This estimate is an average based on the lower benefit-cost ratios provided in the studies by Taylor et al. (1991), Porter et al. (2004), and Lombard (1995). The estimate is likely conservative because of the very wide range of potential benefit-cost ratios estimated for actual adopted building codes and savings in property damage from hurricanes of different size categories, including a few very high benefit-cost ratios for building codes (Lombard, 1995). With regard to a grant for seismic mapping, another estimate to confirm this range for the benefit-cost ratio is 1.3 based on the Bernknopf et al. (1997) study of the value of map information, which assumes that property value changes fully capitalize the hazard disclosure effects via the housing market.

Grants for building code activities likely will have a larger benefit-cost ratio than grants for information/warning and hazard mitigation plan activities. If a grant is inexpensive, it is quite likely that its net benefits will be positive, based on the Litan et al. (1992) study of earthquake mitigation, which found average benefit-cost ratios of about 3. Therefore, any small grant for process activities that does not have negative consequences in obtaining mitigation will only slightly raise costs and, therefore, only slightly reduce the benefit-cost ratios in this category. As Lombard (1995) notes, the benefit-cost ratio in some cases (e.g., smaller homes), and some hurricane categories (on a scale of 1 to 5), could be very large. An example is a benefit-cost ratio of 38 for anchorages for a Category 2 hurricane. Lombard's ratios are based on actual costs of mitigation, not related to grants per se, and there is no way to know how the probability of adopting specific building codes is changed by the grant.

Based on logic and effectiveness found in other contexts (Golan et al., 2000), there is reason to believe that grants for process mitigation activities provide positive net benefits in many situations. Project mitigation activities in many cases would never take place if a process activity had not generated the initial plan or building code that led to implementation. A common sense conclusion is that when net benefits from mitigation in a particular category, exclusive of a grant process for activities, are large, then a small grant certainly cannot reduce the net benefits by much; hence, any grant in that category is likely to be positive. However, when actual mitigation was quite costly, it was less likely that a grant for process activities was going to lead to positive net benefits.

Several caveats are warranted. First, in the literature search, no studies were found that specifically and clearly estimated the benefits of a hazard mitigation process activity. As noted in this report, to do so would require knowledge of how the probability of decision makers adopting a mitigation strategy changed after implementation of a process activity. Possible key differences have been noted between radon risk communication and a natural hazard risk warning. In general, the information that is available, even for conventional natural hazards, largely pertains to benefits and costs for mitigation projects or mitigation costs in general, i.e., not related to any grant activity. Second, there is still not enough information in the literature on the effectiveness of process activities to induce adoption of a mitigation action to generalize in the above categories. Third, blanket categorical benefit-cost ratios are unwise. Last, there is regional variation in rates of adoption of mitigation practices because of differences in conditions, experience, and perceptions (see the community studies discussion in Section 5).

6.4 Extrapolation of Sample Results to Population

The results presented in previous sections were scaled to the population of grants using the arithmetic mean approach described in Section 4.5.3. These population totals are presented in Table 6-3 for grants for project and process mitigation activities. The results indicate that the present value discounted benefits for FEMA hazard mitigation grants between mid-1993 and mid-2003 is $14.0 billion. This is juxtaposed against grant costs of $3.5 billion, for an overall benefit-cost ratio of 4.0. Table 6-4 summarizes the calculation of stratum benefit-cost ratio. The benefit-cost ratios for project mitigation activities in descending size are 5.1 for flood, 4.7 for wind, and 1.4 for earthquake. Benefit-cost ratios are the reverse order for grants for process mitigation activities, with 2.5 for earthquake, 1.7 for wind, and 1.3 for flood.

Table 6-3 Mitigation benefits and sample size by hazard (in 2004 dollars)

Hazard	Type	Population		Sample	
		Count	Benefits ($M)	Count	Benefits $M)[1]
Wind	Project	1,190	1,307	42	219
	Process	382	161	21	44
Flood	Project	3,404	11,172	22	388
	Process	108	17	6	2
Earthquake	Project	347	1,194	25	365
	Process	48	198	20	93
Total		5,479	$14,049	136	$1,111

[1]The reader should *not* expect that (stratum sample benefit) = (stratum sample cost) x (stratum average BCR), because of the sampling and scale-up strategy discussed in sections 4.5.1 and 4.5.3. Stratum BCR is taken as 1/n*□(BCR_i), where BCR_i = (sample i benefit)/(sample i cost), and n = count of grants in the stratum sample. The BCR for each grant in the stratum sample is weighted equally. Grants are sampled from the population so that more-costly grants are more likely to be selected for sampling, with likelihood of being selected for the sample approximately proportional to cost. This procedure for sampling grants and scaling up to the population was found to produce lower error and lower uncertainty than randomly sampling grants from the stratum with equal probability, summing their benefits, summing their costs, and taking the resulting ratio as the estimate of the population's BCR for that stratum. Furthermore, it should *not* be expected that (total population benefit)/(total population cost) = (total sample benefit)/(total sample cost), because of the sampling and scale-up technique.

Table 6-4 Scale-up of results to all FEMA grants (all $ figures in 2004 constant dollars)

	Project Grants			Process Grants			Total
	Quake	Wind	Flood	Quake	Wind	Flood	
Total grant cost ($M)	867	280	2,204	80	94	13	$ 3,538
Total grant benefit ($M)	1,194	1,307	11,172	198	161	17	$ 14,049
Total benefit-cost ratio (BCR)*	1.4	4.7	5.1	2.5	1.7	1.3	4.0
Standard deviation of BCR	1.3	7.0	1.1	n.a.	n.a.	n.a.	n.a.

*Row 2 (benefit) divided by row 1 (cost) equals row 3 (benefit-cost ratio)

n.a. = not applicable because of estimation method used

As shown in Figure 6-1, in terms of contribution to the benefit-cost ratio overall, casualty reduction was by far the dominant factor in earthquake and wind, and avoidance of property damage was the dominant factor in flood. This is attributable to a great extent to the life safety feature of most earthquake and hurricane/tornado project grants, and the property emphasis of flood grants (in addition to the longer warning time for the latter). Given the sample studied, business interruption avoidance was significant in earthquake and wind, but not for flood. This stems from the fact that the vast majority of flood project grants were for buyouts of residences in floodplains. Environmental and historic benefits proved to be very minor in dollar terms, but still do affect a large number of people in each affected community.

6.4.1 Breakdown of Results

The results are summarized by hazard type in Table 6-5, which shows that overall, mitigation for each hazard has a benefit-cost ratio greater than one, with flood being the most cost-beneficial (BCR = 5.0). Table 6-6 also summarizes the benefit-cost analysis results by major mitigation type. It shows that both project and process activities are cost beneficial, with projects having an average benefit-cost ratio of 4.1, and processes having an average benefit-cost ratio of 2.0. Overall, flood grant benefits (both project and process) represent 80 percent of the total FEMA grant benefits. Wind and earthquake benefits each represent approximately 10 percent of the total.

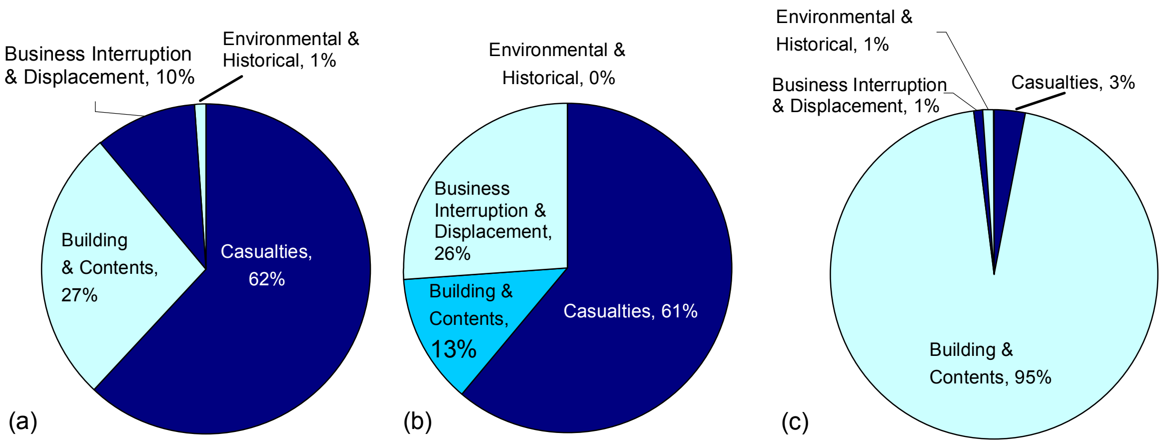


Figure 6-1 Contribution to benefit-cost ratio by factor for (a) earthquake, (b) wind, and (c) flood.

Table 6-5 Summary of benefits and costs by hazard

Hazard	Cost ($M)	Benefit ($M)	Benefit-Cost Ratio
Earthquake	947	1,392	1.5
Wind	374	1,468	3.9
Flood	2,217	11,189	5.0
Total	$ 3,538	$14,049	4.0

Table 6-6 Summary of benefits and costs by type of mitigation activity

Type	Cost ($M)	Benefit ($M)	Benefit-Cost Ratio
Project	3,351	13,673	4.1
Process	187	376	2.0
Total	$3,538	$14,049	4.0

In assessing the results, recall that grants for process mitigation activities (including Project Impact) represent only 10 percent of the total number of FEMA grants in the NEMIS database (the total population). Moreover, they represent only about 5 percent of the total FEMA grant expenditures. As shown in Table 6-6, benefits from grants for process mitigation activities represent 2.7 percent of FEMA grant total benefits to the nation. This is consistent with the result that the benefit-cost ratio for grants for project mitigation activities, which is estimated to be twice as high as for grants for process activities.

Benefit-cost ratios vary significantly across hazards. One major reason is that the type of avoided damage differs significantly between earthquakes, hurricanes, tornados, and floods. For example, 95 percent of flood benefits are attributable to avoided losses to structures and contents, and only three percent is for casualty reduction, as opposed to casualty reductions slightly over 60 percent each for the cases of earthquake and wind hazards. The cost-effectiveness of measures to reduce property damage is higher than that for reducing casualty in the grants sampled in our study. This is due in part to the lower variability of factors affecting structures (which are of a fixed location, size, etc.) than of casualties (where occupancy rates vary by time of day), thereby making it harder to protect the latter.[68] In a similar vein, a higher proportion of wind mitigation grants are for the purpose of reducing the vulnerability of electric utilities to hurricane and tornado winds, than is the case for earthquakes. The largest individual grant benefit-cost ratios found in our study stemmed from reduced business interruption associated with damage to utilities.

Also, flood mitigation grants have a higher probability of success, and hence a higher benefit-cost ratio because they pertain to properties with known histories of vulnerability in the heart of floodplains, and recurrence of floods in a given location is much more certain than for other hazards. Finally, given that process mitigation grants have lower benefit-cost ratios than project mitigation grants across all hazard categories, the fact that process grants represented only 0.15 percent of total flood project mitigation benefits, in contrast to 1.2 percent of wind mitigation grant benefits, kept the flood process mitigation grants from pulling down the overall flood benefit-cost ratio as much as they did for overall wind benefit-cost ratio.

6.4.2 Deaths and Injuries

Table 6-7 highlights the reduction of casualties as a result of the mitigation activities conducted under the grants in the sample and for the entire population of grants. Because the NEMIS database does not include data on the number of people exposed, scale-up requires estimates based on proportional grant costs. The ratio of sample grant injury reduction to sample grant costs was applied to population costs to estimate national reduction by stratum.

Mitigation grants will prevent an estimated 4,699 injuries and 223 deaths over the assumed life of the mitigation activities, which in most cases is 50 years. As illustrated in Table 6-7, grants for wind mitigation activities will prevent the most injuries (1,790) and the most deaths (156). As with any casualty figures, these estimates require caution, as they are based on a scientifically sound methodology, but are difficult to validate because of limited available empirical data.

The grants examined not only benefit society by reducing financial expenditures, but also, and equally as important, reduce associated stress and family interruption. While consideration was

[68] For example, mitigation grants to replace pendant lighting in schools provided potential protection but did not always yield actual benefits, as in the cases of the Northridge and Loma Prieta earthquakes, which took place when schools were not in session.

not able to be given to the financial benefit of these reductions, they are an important component of the benefit of mitigation.

6.4.3 Net Benefits to Society

As noted above, the overall benefit to society for all 5,479 grants is approximately $14.0 billion, and the cost to society is $3.5 billion. The net benefit to society of FEMA-funded mitigation efforts is thus $10.5 billion, which includes the financial benefits and dollar-equivalent benefit of saving 223 lives and avoiding 4,699 nonfatal injuries (Table 6-7).

Table 6-7 Estimated reduction in casualties by grants for both project and process mitigation activities in sample and population of grants

	Injuries	Deaths
Earthquake sample	542	26
Population	1,399	67
Flood sample	63	0
Population	1,510	0
Wind sample	275	24
Population	1,790	156
Total samples	880	50
Population total	4,699	223

6.4.4 Impacts on the Federal Treasury

The methodology described in Section 4.5.4 was applied to estimating the potential future savings to the federal treasury of FEMA hazard mitigation grants. The two major categories of savings are:

1. Reductions in government spending on disaster recovery and future natural hazard mitigation.
2. Recouped federal taxes for reductions in individual and business casualty loss and increase in federal tax revenues from income subject to tax from individuals who avoided death or injury.

Individual components of these savings are listed in the Category column of Table 6-8, along with the sources of the base data. Adjustments made to the data are identified in the third and fourth columns and in the table notes. Examples of more straightforward adjustments include annual averaging and present value calculations. Other adjustments required that assumptions be made based on indications in the literature regarding insurance coverage and the ratio of government and nonprofit sector to total business losses. (Average tax rates are used rather than marginal rates because the latter would have required determination of the income status of all disaster victims.) In all, 10 different categories of savings are estimated.

Table 6-8 Annual potential savings to the Federal Treasury

Category	Base (2004 $ in millions)	Adjusted Base (2004 $ in millions)	Factor	Savings (2004 $ in millions)	Source of Base Data
Federal Government Expenditures Saved					
Public assistance	2,240.9	n.a.	.174[1]	389.9	FEMA (2005)
Individual assistance/human services	889.8	n.a.	.174	154.8	FEMA (2005)
Mission assignments /standby grants	126.6	n.a.	.174	22.0	FEMA (2005)
FEMA administrative costs	594.6	n.a.	.174	103.5	FEMA (2005)
Mitigation grants and contracts	386.7	n.a.	.174	67.3	FEMA (2005)
U.S. Small Business Administration default and administrative costs	463.4	n.a.	.174	80.6	SBA (2005)
U.S. Army Corps of Engineers emergency measures	104.8	n.a.	.174	18.2	USACE (2005)
Subtotal	n.a.	n.a.	n.a.	$836.3	
Federal Tax Revenues Recouped					
Individual income tax casualty loss deduction	1,061.3[2]	530.7[3]	.171[4]	90.7	This study
Individual income tax payments related to reduction in injury and death	208.9[5]	n.a.	.171	35.7	This study
Corporate income tax payments related to reduction in casualty loss business interruption	108.9[6]	23.0[7]	.252[8]	5.8	This study
Subtotal	n.a.	n.a.	n.a.	$132.2	
Grand Total	n.a.	n.a.	n.a.	$968.5	

n.a. — not applicable

[1]Ratio of average annual property damage and casualty (death and injury) reduction from grants for project and process mitigation activities in this study (present value for 50 years discounted at 2 percent, which amounts to $1.32 billion) divided by average annual property damage and casualty values from natural hazards in the U.S. ($7.6 billion in 2004 dollars), from University of South Carolina (2005).

[2]Based on avoided residential property damage from floods from average annual mitigation (present value discounted at 2 percent).

[3]Applied to uninsured household property damage associated with floods (FEMA-funded mitigation applicable to individual taxpayers pertains only to flood hazard). Assumes 50 percent of damage was uninsured. Proportion of individual property loss avoided to total property loss avoided from floods was based on ratio of private to total (private and public) number of properties mitigated. A further 10 percent reduction was assumed to cover people who do not itemize deductions and to cover the exclusion of individual casualty loss that can be deducted.

[4]10-year average individual tax rate for 1993-2002 (IRS, 2003; 2004a,b).

[5]Based on avoided death and injury from earthquake, wind, and flood from average annual mitigation (not discounted).

[6]Based on avoided private (not including public and nonprofit sector building) property damage and business interruption (including displacement costs) from earthquake and wind (FEMA flood mitigation had minimal application to business) from average annual mitigation (present value discounted at 2 percent). Assumes property damage to private sector was 1.0 percent of annual average total property damage in case of earthquake and wind. Assumes that private for-profit sector business interruption loss for earthquake and wind was 77 percent of total business interruption loss (based on national average of business activity in the for-profit sector).

[7]Assumes that 50 percent of business losses are insured.

[8]10-year average corporate tax rate for 1993-2002 (IRS 2003; U.S. Department of Commerce, 2003).

The estimate of the present value of total annual savings in terms of federal government expenditures in present value terms is $836.3 million. The largest category is FEMA Public Assistance ($389.9 million) and the smallest is U.S. Army Corps of Engineers emergency measures ($18.2 million).

The estimate of the present value of total annual savings in terms of recouped federal taxes is $132.2 million. The largest category here is income tax payments by those individuals who are spared casualty loss (in tax parlance, this refers to property rather than death or injury) ($90.7 million) and the smallest category is corporate income tax payments relating to reduced casualty loss and reduced business interruption to private entities ($5.8 million). The latter is rather small because the vast majority of federal mitigation grants go to public institutions, which do not have to pay federal business related taxes. The majority of the tax revenue benefits stem from utility customers.

The present value of total annual potential future savings to the federal treasury is $968.5 million. The average annual FEMA expenditure for hazard mitigation in the population of grants for which benefits were estimated in this study is $265.4 million (the federal share of the average annual cost of mitigation grants is 75 percent of $353.8 million). This means that on average every $1 of FEMA expenditures generates a present value of future savings to the federal treasury of $3.65. This result indicates that the FEMA hazard mitigation program more than pays for itself in terms of cost to the federal treasury. Also, this is to a great extent separate[69] from the benefits of avoided hazard losses to the American people.

The reader should bear two things in mind. First, the majority of the savings in Table 6-8 are not reductions in costs to society as a whole, but rather are transfers from one entity to another. Transfers do not represent the avoided destruction of real resources (e.g., buildings, human casualties, wetlands), but are only a shift of money from one entity to another, as in the payment of a tax or subsidy. Real resource savings are counted in the benefit-cost analysis. The entries in Table 6-8 that are not merely transfers are various administrative cost reductions and resources actually used in recovery and for future mitigation. Second, the savings are *potential*. Reduced hazard losses make private and public expenditures for recovery efforts unnecessary for those hazards that are mitigated. However, substantial unmitigated hazard losses may still attract federal and private assistance. These payments may not actually be reduced over the short term by the amount of the full potential savings identified in this report. The sum total of hazard recovery *needs*, however, is definitely reduced and is increasingly likely to lead to reductions in recovery spending in the long run.

The base numbers in this analysis reflect actual government expenditures and estimates of hazard losses presented in this report. Many of these bases required no adjustments for application of savings factors applied in this analysis, and the few that did were adjusted by standard tax code deductions. Some savings factors are simply average tax rates. The exception is the 17.4 percent annual hazard reduction rate, which was based on estimation of the present value of categories of commonly measured (property damage, death, and injury) avoided hazard losses in relation to like categories of total annual hazard losses (see also Section 4.5.4). The remaining assumption — that federal expenditures on disaster recovery is potentially reduced in full proportion to hazard losses — is one that can be argued both ways. The exact outcome is likely to lie somewhere between the extreme positions of no decrease, or a full decrease, in spending. This is the main reason why savings have been labeled as "potential." However, as mitigation cumulates, the reduced need for post-disaster expenditures will surely be evident.

[69] The overlap is limited to actual resource use for disaster recovery and natural hazard mitigation.

The estimates of savings are also in keeping with the objective of erring on the side of conservatism. Consequently, potential increased tax revenue associated with a possible reduced level of philanthropic giving, lower tax deductions, and potential reductions of HUD Block Grants were not included in this analysis.

6.5 Sensitivity Analysis

Sensitivity analyses were performed on the parameters listed in Table 4-11. Figures 6-2, 6-3, and 6-4 illustrate how making different assumptions affects the total estimated benefit for those that revealed the greatest range of sensitivities. In each figure, there is a solid vertical line that represents the baseline (best) estimate of total benefit for all mitigation grants for that hazard. There is a dashed vertical line that represents the total cost for mitigation grants for that hazard.

Each black bar in the diagram reflects what happens to the total population estimated benefits for that hazard if one parameter (number of occupants, discount rate, etc.) is changed from a lower-bound to an upper-bound value. A longer bar reflects greater sensitivity of benefit to that parameter. Here, the “lower-bound” and “upper-bound” values are estimates of the 4^{th} and 96^{th} percentile values of the parameter in question. The parameters are sorted so that the longest black bar ─ the one for the parameter to which the benefit is most sensitive ─ is on top, the next most sensitive is second from the top, etc. The resulting diagram resembles a tornado in profile, and is called a tornado diagram.

The diagram does two things: first, it shows the conditions under which benefit exceeds cost. Second, the baseline benefit and the values of benefit at the ends of the bars can be used to estimate the parameters of a probability distribution of total nationwide benefit. These parameters include the mean and standard deviation of total benefit, among others. To calculate them, a mathematical procedure was used called an “unscented transform”[70] (Julier and Uhlman, 2002). Using this procedure, it was possible to estimate the probability that the “true” total nationwide benefit for a given hazard exceeds the cost. The unscented transform makes it unnecessary to vary several parameters simultaneously; it accounts for the probability that several parameters will be greater or less than their best-estimate values.

6.5.1 Grants for Earthquake Project Activities

Results for earthquake project mitigation benefits are illustrated in Figure 6-2. In the figure, the solid vertical line at $1.2 billion reflects the baseline benefit for earthquake project grants; the dashed line at $0.87 billion represents the cost of those grants. Total benefit is most strongly sensitive to number of occupants, then to discount rate, then to value of casualties. Notice that the only bar that crosses below the cost of mitigations is the first one, number of occupants. In all other cases, benefits exceed costs.

Using the unscented transform, it was found that the expected value of benefit from earthquake mitigation grants is $1.3 billion (approximately the same as the baseline figure of $1.2 billion). The standard deviation of benefit is $470 million. Assuming that benefit is lognormally

[70] An unscented transform is a mathematical technique for selecting samples of set of uncertain variables, to estimate the mean value, variance, and other statistics of a function of those variables. The technique is far more efficient than random sampling (such as by Monte Carlo simulation), meaning that far few samples are required using the unscented transform than using random sampling to achieve the same level of accuracy.

distributed, the ± 1 standard deviation bounds of benefit are $850 million and $1.7 billion. Benefit exceeds cost with 83 percent probability. The expected value of benefit-cost ratio is 1.5, approximately the same as the baseline value of 1.4.

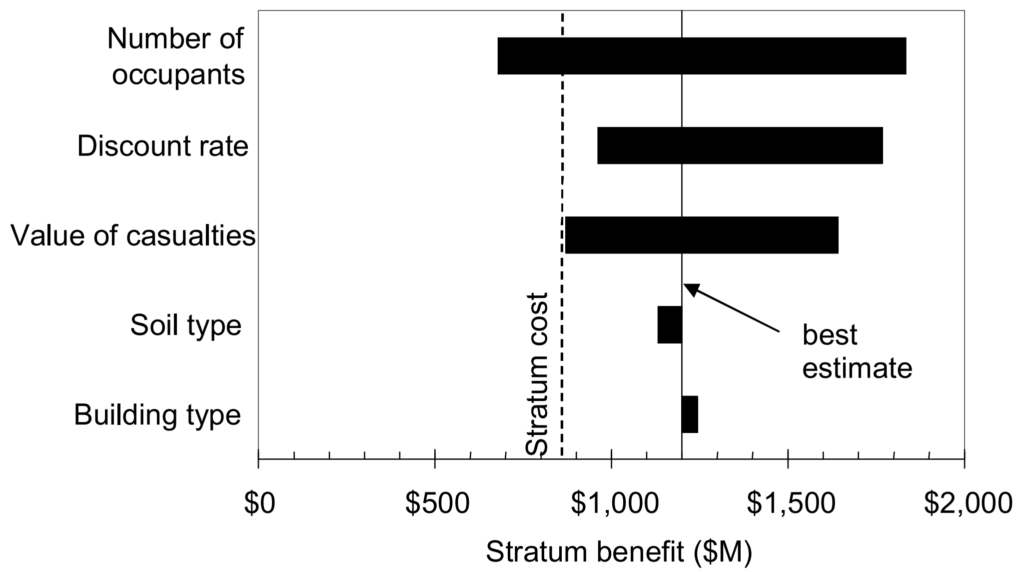


Figure 6-2 Sensitivity of benefit to uncertainties (grants for earthquake project mitigation activities).

A word of caution regarding the comments about the probability that benefit exceeds cost. According to standard benefit-cost analysis, earthquake project grants *are* cost effective, because under baseline conditions, benefit exceeds cost by a ratio of 1.4:1. The additional diagram analysis merely acknowledges that the estimated benefit is uncertain, and that under most reasonable assumptions, benefits still exceed cost. Considering these uncertain parameters, earthquake projects are estimated to save $1.50 in reduced future losses for every $1 spent.

6.5.2 Grants for Wind Project Mitigation Activities

Figure 6-3 shows the diagram for grants for wind project mitigation activities. In all cases, the benefit exceeds the cost. Wind project benefits are approximately equally sensitive to injury rate, discount rate, value of casualties, and number of occupants. The expected value of benefits is $1.3 billion, and the standard deviation is $560 million. Assuming a lognormal distribution, the ± 1 standard deviation bounds of benefit are $800 million and $1.8 billion. There is greater than 99 percent probability that the "true" benefit exceeds the cost, despite the uncertain parameters examined here. The expected value of benefit-cost ratio is 4.7. That is, every $1 spent on wind project grants is estimated to save almost $5.

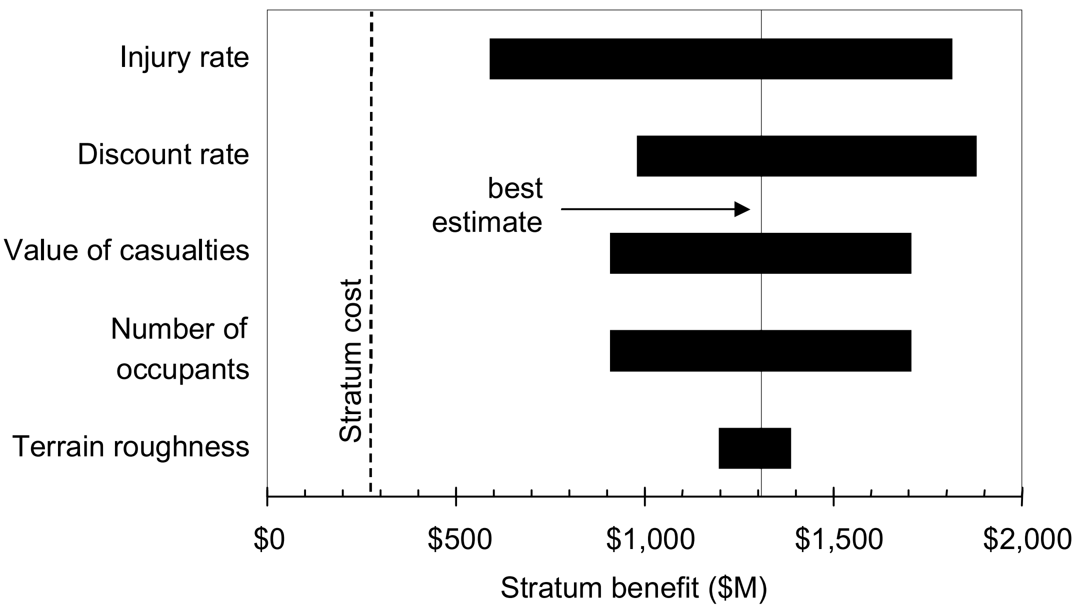


Figure 6-3 Sensitivity of benefit to uncertainties (grants for wind project mitigation activities).

6.5.3 Grants for Flood Project Mitigation Activities

Figure 6-4 shows the diagram for grants for flood project mitigation activities. Flood project benefits are most sensitive to discount rate, then to uncertainties in flood depth. In all cases, the benefit exceeds the cost, i.e., under all reasonable assumptions about the values of these parameters, flood project grants are estimated to be cost effective. The expected value of benefit is $11 billion, and the standard deviation is $3.8 billion. Assuming lognormal distribution, the ± 1 standard deviation bounds of benefit are $7 billion and $15 billion. There is greater than 99 percent probability that the "true" benefit exceeds the cost, despite uncertainties in the parameters examined in this study. The expected value of the benefit-cost ratio is 4.8. That is, on average every $1 spent on flood project grants is estimated to save almost $5.

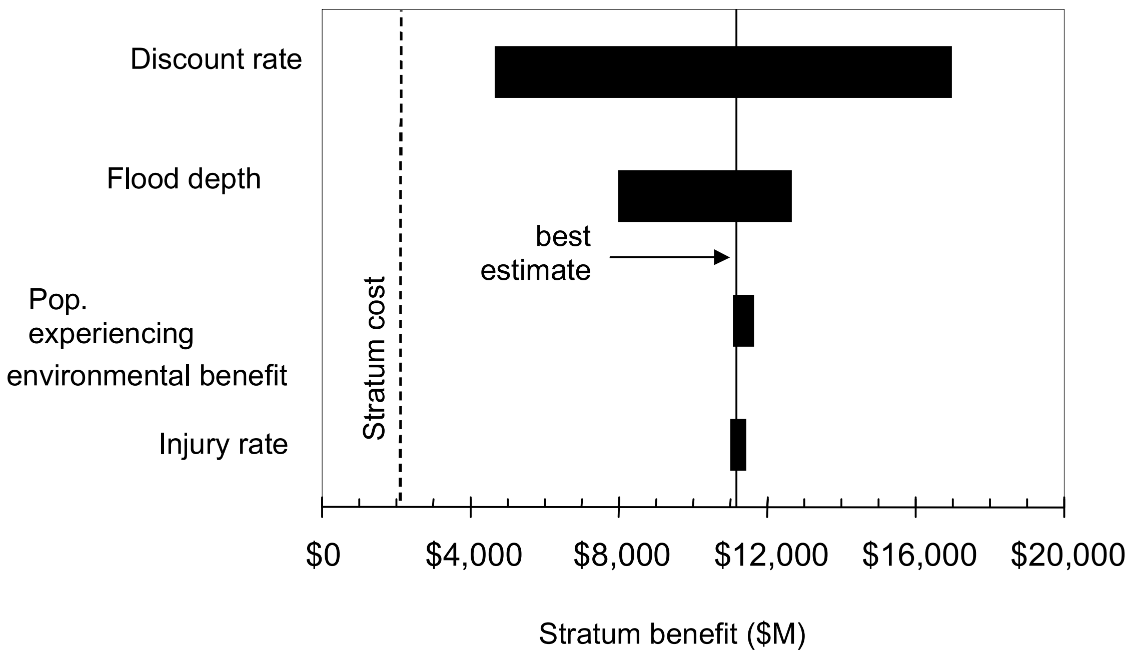


Figure 6-4 Sensitivity of benefit to uncertainties (grants for flood project mitigation activities).

6.6 Other Sensitivity Analyses

Sensitivity analyses were not performed for direct business interruption for two reasons. First, direct business interruption estimates were derived to a great extent from direct property damage. Although not perfectly correlated, further sensitivity analyses would probably have been redundant. Second, there were few factors that could be subjected to sensitivity analysis of direct business interruption in HAZUS®MH . Sensitivity analyses were performed for indirect business interruption with respect to the regional economy unemployment rate (as a proxy for excess production capacity). The analysis indicates that the overall stratum benefit-cost ratios are not sensitive to this parameter because of the small number of cases where business interruption was applied, the small size of indirect business interruption in all cases (except the few mitigation projects affecting utilities), and the narrow variation in this parameter.

The unemployment rate, as a proxy for excess capacity, is one of several sources of resilience to disasters factored into this study. Another is the recapture factor (the ability to make up lost production at a later date), which is automatically included in the HAZUS®MH Direct Economic Loss Module (DELM). This recapture factor was also included in the HAZUS®MH Extension (defined in Table 6-3) for utilities developed in this study, and in fact the recapture factor for services was increased in line with the study's conservative assumptions. Other aspects of resilience pertained to inventories, import of goods for which there is a shortage, and export of surplus goods. These were automatically computed in the HAZUS®MH Indirect Economic Loss Module (IELM). Resilience effects were not separated out, because that was not the focus of this study. The values provided by HAZUS®MH were used for these parameters (inventories, import and export of goods) and sensitivity analysis was not undertaken because HAZUS®MH import and export resilience factors only affect indirect business interruption, which was relatively minor, and because inventories were not a factor in nearly all of the cases where direct business interruption was large (e.g., electricity cannot be stored). It was assumed that hospital inventories would not be significantly affected by most disasters, given the tendency of hospitals to place priority on this feature and to have emergency plans in place to meet shortages. This results in a narrow range in possible inventory holdings.

The savings to the federal treasury are robust as well. Although no formal sensitivity tests were performed here, these estimates (i.e., savings to the federal treasury) are based on government expenditure data, loss estimation data estimated in this study (and for which sensitivity tests were performed), and straightforward parameters like federal tax rates and insurance coverage.

6.7 Combining Sampling Uncertainty and Modeling Uncertainty

As has been noted elsewhere, the total benefit of FEMA grants is uncertain. It is desired to quantify and combine all important sources of uncertainty. This information can then be used to calculate two interesting parameters: confidence bounds for the total benefit of FEMA grants for each hazard and the probability that the "true" benefits exceed the cost. By "confidence bounds" is meant upper and lower bounds between which the "true" total benefit lies with any given level of probability. The uncertainty in total benefit of FEMA grants results from two principle sources:

1. Sampling uncertainty ─ Total benefits are uncertain because they are estimated from a sample (a subset) of FEMA grants, not the entire population of them. Here, sampling uncertainty is quantified in Table 6-4, via the standard deviation of benefit-cost ratio.
2. Modeling uncertainty ─ Total benefits are uncertain because a mathematical model of benefits has been created and applied, and that mathematical model has its own uncertain parameters. For this report, modeling uncertainty is quantified in Section 6.5, via the standard deviation of benefit.

As detailed in Appendix R, these two sources of uncertainty can be combined to estimate overall uncertainty in benefit of FEMA grants. Two observations are made:

1. Modeling uncertainty dominates total uncertainty so a larger sample would not improve the accuracy of the estimated benefits.
2. The results reaffirm the observation that grants for project mitigation activities produce benefits in excess of costs with high probability for all three hazards.

6.8 Conclusions

This chapter summarizes the application of several practical methods to estimate the benefits of FEMA-funded hazard mitigation activities. These are not necessarily the ideal methods that one might consider for this purpose, were data and time less constrained (see the Scoping Study report (ATC, 2003a) for a discussion of various alternative methods). However, they represent the best practical methods available given limitations of data and time.

This study estimated that total benefits to the nation of FEMA mitigation grants between mid-1993 and mid-2003 yielded a present discounted value of $14 billion. (Grants outside of this date range and grants to mitigate risk from winter storm and some other hazards were not studied.) Compared to a cost of $3.5 billion, the overall benefit-cost ratio is 4.0. These results indicate that, on average, FEMA-funded project and process mitigation activities have benefit-cost ratios greater than 1.0 for all hazard types. In fact, for wind and flood projects, the benefit-cost ratios are 4.7 and 5.1, respectively. Grants for earthquake process mitigation activities have a high benefit-cost ratio of about 2.5 as well. Moreover, the sensitivity analyses performed indicate that these results are robust even to extreme variations in key parameters.

Potential annual savings to the federal treasury of these grants is estimated to be $969 million. Juxtaposed against grant costs, this means that on average every dollar of FEMA mitigation grant expenditures will potentially lead to an average of a $3.65 combination of reduction in future post-disaster relief and increased federal tax revenues. These results are robust as well.

The benefit-cost analysis of FEMA mitigation grants can be considered to have yielded lower-bound estimates for three reasons. First, the analysis used conservative assumptions regarding vulnerability of buildings, the scope of business interruption losses, and the extent of casualties. Second, "outliers" were excluded in calculating sample stratum benefit-cost ratios. Outliers with especially high benefit-cost ratios had the potential to significantly increase the sample mean benefit-cost ratio much more than outliers with low values had to decrease the sample mean. Third, several categories of the benefits of reduced losses were omitted because they could not be quantified. These include the avoidance of: several types of societal impacts related to psychological trauma; indirect property damage such as ancillary fires; environmental damage to complex ecosystems; air quality of burning debris; land-use and costs of reduced disposal of debris. It also excludes the outright benefits of the diffusion of hazard mitigation research and demonstration projects.

Chapter 7
STUDY RESEARCH FINDINGS

A summary of key findings from the benefit-cost analysis of FEMA mitigation grants and community studies is presented below.

1. **The net benefits of FEMA's hazard mitigation program to society as whole are positive.**

   This study estimated that total benefits to the nation of FEMA mitigation grants between mid-1993 and mid-2003 yielded a present discounted value of $14 billion. Compared to a cost of $3.5 billion, the overall benefit-cost ratio is 4.0. These results indicate that, on average, FEMA-funded project and process mitigation activities have benefit-cost ratios greater than 1.0 for all hazard types. In fact, for wind and flood projects, the benefit-cost ratios are 4.7 and 4.1, respectively. Earthquake process grants have a high benefit-cost ratio of about 4.0 as well. Moreover, the sensitivity analyses performed indicate that these results are robust, even to extreme variations in key parameters.

2. **A federal dollar spent on hazard mitigation potentially saves the federal treasury about $3.65.**

   The present value of annual savings to the federal treasury emanating from the FEMA mitigation grants studied is $968.5 million. When juxtaposed against the federal share of grant costs, a dollar spent on mitigation grants potentially will lead to an average savings of $3.65 in avoided post-disaster relief and increased federal tax revenues. This potential benefit to the treasury is in addition to the societal savings considered in the benefit-cost analysis. These results are robust as well.

3. **Synergistic activities occur in communities that have institutionalized their hazard mitigation programs.**

   In each of the eight communities studied, federal hazard mitigation grants were a significant part of the community's mitigation history. As shown in the activity chronologies developed for each community (Figures 5-1 through 5-8), the federal hazard mitigation grants often led to additional or synergistic activities. Interviewees in all communities thought the FEMAgrants were important in reducing community risk, preventing future damage, and increasing a community's capability to mitigate natural hazards. Most interviewees believed the grants permitted their communities to attain mitigation goals that might not otherwise have been reached. Interviewees also believed that the benefits of the mitigation projects went beyond what could actually be quantitatively measured. These included increased community awareness, esprit de'corps, and peace of mind. Virtually every interviewee believed that their community was better off as a result of FEMA mitigation project and process grants being completed.

4. The findings above are judged to be robust, given an analysis of uncertainties and assumptions.

The impact of uncertainties was analyzed through formal sensitivity studies and informal evaluations of methodological limitations and assumptions for he benefit-cost analysis of individual FEMA mitigation grants and grants within the context of communities,. In the case of the benefit-cost analysis of FEMA mitigation grants, benefit-cost ratios remained above one in all sensitivity analyses (13 total cases), with one exception where the ratio was slightly less than one. In the community studies, an analysis of extreme lower-bound values resulted in about half of the cases remaining above one. The Validation and Quality Control Plan described in Appendix S was implemented as part of this study.

Appendix A
MMC AND ATC PROJECT PARTICIPANTS AND ATC INTERNAL PROJECT REVIEW TEAM ENDORSEMENT LETTER

MULTIHAZARD MITIGATION COUNCIL

Board of Direction

Chair: Brent Woodworth, IBM Crisis Response Team (representing the building/facility owner community)
Vice Chair: Ronny J. Coleman, Commission on Fire Accreditation, International (representing the fire community)
Secretary: Ann Patton, City of Tulsa, Oklahoma (ex-officio member representing community interests)

Members:
Andrew Castaldi, Swiss Reinsurance America Corporation (representing the reinsurance community)
Arthur E. Cote, PE, National Fire Protection Association (representing the fire hazard mitigation community)
Ken Deutsch, The American Red Cross (representing the disaster recovery community; through 2004)
Ken Ford, National Association of Home Builders (representing the contracting/building community)
Michael Gaus, State University of New York at Buffalo (representing the wind hazard mitigation community)
David Godschalk, Ph.D., University of North Carolina at Chapel Hill (representing the planning/development community)
George Hosek, Michigan Department of Environmental Quality (representing the flood hazard mitigation community)
Klaus H. Jacob, Ph.D., Columbia University, Lamont-Doherty Earth Observatory (representing the geological hazards research community)
Gerald H. Jones, PE, Kansas City, Missouri (representing the building code enforcement community)
Howard Kunreuther, Ph.D., Wharton School, The University of Pennsylvania (representing the economic/statistics community; through 2004)
David McMillion, Consultant (representing the emergency management community)
Michael Moye, National Lender's Insurance Council (representing the financial community)
Dennis Mileti, Ph.D., Natural Hazards Center, University of Colorado at Boulder (representing the multihazard risk reduction community)
Michael J. O'Rourke, PE, Rensselaer Polytechnic Institute (representing the snow hazard mitigation community)
Timothy Reinhold, Institute for Business and Home Safety (representing the insurance community)
Paul E. Senseny, Factory Mutual Research (representing the fire hazard research community)
Lacy Suiter, Consultant, Alexandria, Virginia
Alex Tang, P.Eng., C. Eng. Chair, ASCE Committee on Lifeline Earthquake Engineering, Mississauga, Ontario (representing the lifelines community)
Charles H. Thornton, Ph.D., SE, CHT and Company, Inc. (representing the structural engineering community)
Eugene Zeller, City of Long Beach, California (representing the seismic hazard mitigation community)

Project Management Committee

Philip T. Ganderton, Ph.D., Professor and Chair, Department of Economics, University of New Mexico, Albuquerque
David Godschalk, Ph.D., Stephen Baxter Professor, Department of City and Regional Planning, University of North Carolina, Chapel Hill
Anne S. Kiremidjian, Ph.D., Professor of Civil and Environmental Engineering, Department of Civil and Environmental Engineering, Stanford University, Palo Alto
Kathleen Tierney, Ph.D., Professor and Director, Natural Hazards Research and Applications Center, University of Colorado, Boulder
Carol Taylor West, Ph.D., Professor, Department of Economics, University of Florida, Gainsville

Project Consultant

L. Thomas Tobin, Tobin & Associates, Mill Valley, California

Project Staff

Claret M. Heider, National Institute of Building Sciences, Vice President for Building Seismic Safety Council and Multihazard Mitigation Council Programs (BSSC/MMC), Washington, D.C.
Bernard F. Murphy, PE, Director, Special Projects, BSSC/MMC, Washington, D.C.
Carita Tanner, Communications Director, BSSC/MMC, Washington, D.C.

APPLIED TECHNOLOGY COUNCIL

Research Team

Project Director: Ronald T. Eguchi, ImageCat, Inc., Long Beach, California
Community Studies Leader: Elliott Mittler, Consultant, Woodland Hills, California
Community Studies Co-Leader: Craig Taylor, Natural Hazards Management, Inc., Torrance, California
Benefit-Cost Analysis of FEMA Mitigation Grants Leader: Adam Z. Rose, The Pennsylvania State University, University Park
Benefit-Cost Analysis of FEMA Mitigation Grants Co-Leader: Keith Porter, Consultant, Pasadena, California
Project Manager: Thomas R. McLane, Applied Technology Council, Arlington, Virginia

Team Members:
Corey Barber, University of California, Berkeley
Jawhar Bouabid, PBS&J, Atlanta, Georgia
Linda B. Bourque, University of California, Los Angeles
Stephanie Chang, University of British Columbia, Vancouver
Nicole Dash, University of North Texas, Denton
James Delahay, LBYD, Inc., Birmingham, Alabama
Charles Huyck, ImageCat, Inc., Long Beach, California
Christopher Jones, Consultant, Durham, North Carolina
Megumi Kano, University of California, Los Angeles
Karl Kappler, University of California, Berkeley
Lukki Lam, University of California, Berkeley
Rebecca C. Quinn, CFM, RCQuinn Consulting, Inc., Annapolis, Maryland
Christopher Rojahn, Applied Technology Council, Redwood City, California

Archana More Sharma, University of California, Los Angeles
Kenneth Strzepek, University of Colorado, Boulder
John Whitehead, Appalachian State University, Boone, North Carolina
Michele M. Wood, University of California, Los Angeles
Kathryn Woodell, University of California, Berkeley
Bo Yang, The Pennsylvania State University, University Park

Internal Project Review Team

William Petak (Chair), University of Southern California, Los Angeles
David Brookshire, University of New Mexico, Albuquerque
Stephanie King, Weidlinger Associates, Inc., Los Altos, California
Dennis Mileti, University of Colorado, Rancho Mirage, California
Doug Plasencia, AMEC Earth and Environmental, Tempe, Arizona
Zan Turner, City and County of San Francisco, California

Consultants

James R. McDonald, McDonald-Mehta Engineers, Lubbock, Texas
Bruce Miya, Consultant, Salt Lake City, Utah
Douglass Shaw, Texas A&M University, College Station

Contributors of Data and Source Materials

Alan Escobar, Small Business Administration, Washington, DC
Jeffrey Jensen, U.S. Army Corps of Engineers, Washington, DC

USC
UNIVERSITY
OF SOUTHERN
CALIFORNIA

March 24, 2005

School of Policy,
Planning, and
Development

Thomas R. McLane
Director of Business Development
Applied Technology Council
2111 Wilson Boulevard
Suite 700
Arlington, VA 22201

Subject: Endorsement by the Applied Technology Council's Internal Project Review Team of ATC-61: *Independent Study to Assess Future Savings from Mitigation*

Dear Tom:

Thank you for providing the opportunity to participate as members of an Internal Project Review Team (IPRT) during the conduct of the effort leading to development of the subject report. As members of the team, it is our pleasure to provide this letter of final endorsement for this very significant piece of work.

The IPRT was asked to provide strategic and global input to the ATC-61 Project Team on project direction and on development of the major deliverables. We were also asked to ensure that the Project Team remain focused on the "target objectives."

To accomplish this task, the IPRT held seven conference calls over the course of the project and communicated frequently via email to transmit constructive input to you and the Project Team. Members of the IPRT carefully reviewed work product and provided written comments on deliverables; had lively discussions on technical issues needing resolution; and came to consensus on all significant issues. You should know that, in view of the complexity of the tasks involved in providing independent assessment of the benefits and costs of mitigation policies and programs and the critical importance of the results, the IPRT took this task very seriously.

University of
Southern California
Los Angeles,
California 90089-0626
Tel: 213 740 2241
Fax: 213 740 0001
web page:
www.usc.edu/sppd

The IPRT is satisfied with all aspects of the ATC-61 *Final Report: Independent Study to Assess Future Savings from Mitigation*. Having been closely involved with project direction and key decisions affecting project outcomes, we stand by the results, and strongly endorse the report in the highest possible terms.

You and your entire Project Team, especially the core members, Ron Eguchi, Adam Rose, Elliott Mittler, Linda Bourque, Craig Taylor, and Keith Porter, should be very proud of this report, and we commend you for a job extremely well done.

Sincerely,

William J. Petak   David Brookshire   Stephanie A. King

Dennis Mileti   Douglas J. Plasencia   Zan Turner

cc: Claret Heider
Tom Tobin
Christopher Rojahn

Appendix B
COMMUNITY STUDIES: DATA COLLECTION GUIDELINES AND QUESTIONNAIRE SPECIFICATIONS

The ultimate goal of the community studies was to help answer two questions: to what degree are mitigation costs beneficial and to what extent are there spin-off benefits that emanate from FEMA Hazard Mitigation Grant Program (HMGP), Project Impact, and the Disaster Mitigation Act of 2000 (DMA, 2000) mitigation activities? The critical elements in this approach may be broken down into five subjects: research method; the pilot community study; the selection of additional communities for study; data gathering procedures and protocols by which data are going to be processed and set-up for analysis; and estimating costs and benefits.

Congress proposed this overall study to find out whether mitigation funding by FEMA has led to future savings or reduced losses for either the federal government or community stakeholders and members who benefited from the mitigation activities. The research question can be rephrased as: what set of conditions would lead to high net savings?

Prior to this study, there has been no systematic examination of what comprises a community's hazard mitigation program, how the program got started, why it got started, if and how it was sustained, and what quantitative impacts individual activities and the portfolio of all activities have made immediately and over time on reducing future community losses (see Mileti, 1999). The community studies were designed to provide data to address these questions, to find what may explain a specific outcome, in this case, future savings or reduced losses from natural hazards.

Guidelines issued to interviewers who conducted data collection interviews follow. The questionnaire used in the interview process is provided at the end of this appendix.

General Guidelines

Interview instructions are printed in all caps; this indicates text that should not be read out loud. Interviewers are to read everything that is not in all caps. To ensure consistency of data collection conditions and consistent meaning of data, it is important for interviewers to pay careful attention to distinguish between categories that are read aloud, and those that are not. The all-cap convention will help make this distinction more easily.

It is highly preferable that interviewers use blue ink. This shows up best against the black-and-white page, and helps speed the time and reduce errors for data entry. Do NOT complete the interview using red ink or pencil, and do not use whiteout.

Any changes to the interview should be initialed and dated. Cross the error out, and write the correction clearly next to the error. Any edits made after the interview is completed should be made in red ink, and also should be initialed and dated. This will allow us to easily track any changes made to the data.

Study Objectives

This study has two main objectives. The study is designed to first, determine the degree to which mitigation costs are beneficial, and second, the extent to which there spin-off benefits that emanate from FEMA HMGP, Project Impact, and DMA 2000 mitigation activities.

Data Collection Forms

There are four different data collection forms: (1) Contact Log, (2) Main Interview, (3) Mitigation Activities (Question 23 of the Main Interview), and (4) Referral Form.

The Contact Log is used to track all communication with potential and actual study participants. Separate Contact Logs may be completed for the same participant if more than one interviewer is contacting the individual. These may be transferred to the same log, or the logs may be stapled together. It is important that we record and enter complete data on all attempted and successful contacts with potential and actual participants.

The Main Interview is completed for each study participant. It includes general questions about efforts in the community to reduce the damage caused by natural disasters.

Question 23 (Q23) collects information about Mitigation Activities that are included in the National Emergency Management Information System (NEMIS); a separate Q23 is completed for each activity in the NEMIS database. It may also be used to collect information about spin-offs from FEMA activities, and other (non-NEMIS) mitigation efforts.

The Referral Form is used to collect information about other potential participants. We want to collect complete information on all individuals who are referred to us, so we will record ID#s and names of ALL referrals on the main interview, and contact information on actual NEW referrals on the Referral Form. This will allow us to link each participant will all of the individuals providing referrals.

Data Tables

The data set is entered in MS Access and includes six data tables: (1) Activities, (2) Communities, (3) Contact Log, (4) Main Interview, (5) Mitigation Activities, and (6) Participants. Each table can be exported to Excel and Statistical Package for Social Sciences (SPSS) software, as desired.

The Activities table records all of the mitigation activities that are asked for in Q23 for each community. This data set will serve as a reference for correctly coding and entering data for the Mitigation Activities in Q23. There is one record per mitigation activity per community.

The Communities table is used to document the ID# assigned to each community. This two-digit code is the first two digits of the participant ID#. There is one record per community.

The Contact Log table is used to document each contact with each potential and actual participant. This is a transactional data set. That is, there is one record per contact.

The Main Interview table collects all of the interview data excluding information about Mitigation Activities, Q23. There is one record per participant.

The Mitigation Activities table collects information for Q23 for each NEMIS activity, as well as for spin-offs and other mitigation activities mentioned, as time permits. There is one record per mitigation activity, per participant.

The Participant table collects information describing each participant including contact and referral information, as well as dates of major study milestones.

Data Entry Forms

There are five data entry forms: (1) Contact Log, (2) Dates, (3) Main Interview, (4) Mitigation Activities, and (5) Referral Form. The Contact Log form is used to enter information from the Contact Log. There is one entry per contact. A check mark written to the right of each entry of the Contact Log indicates that that contact has been entered.

The Dates form is used to record the dates of major study milestones and is used to help internal monitoring of study progress. It includes dates of all Introduction and Thank You letters as well as appointment times and interview completion dates. There is one record per participant.

The Main Interview form is used to enter data from the Main Interview, excluding Q23 on Mitigation Activities. The interview is initialed and dated on the bottom, right-hand corner to indicate that it has been data entered.

The Mitigation Activities form is used to enter each NEMIS and spin-off or other activity discussed in Q23 and Q24, respectively. Each Q23 packet is initialed and dated on the bottom, right-hand corner to indicate that it has been entered.

The Referrals form is used to enter contact information collected on the Referral form. There is one record for every person who is mentioned, regardless of whether or not they are pursued for interview. Contact information is initially entered the first time an individual is referred, and is confirmed and augmented during the actual interview with the participant. Thus, the referral data for each participant are entered once, and then updated later. Space is provided on the bottom of this form to indicate when and by whom initial and subsequent data entry has been completed.

Informant Questions Purpose

If the informant questions the purpose of the study, explain that the interview asks about knowledge of natural hazard mitigation programs and that the findings will be used to evaluate the benefits obtained from investment in mitigation activities.

Why This Informant

If you are asked why you are interviewing this particular individual, explain how he or she was referred to you, and that it is very important that we obtain information from the kinds of people she/he, this job title, represents. Indicate that for us to get a complete picture of the community, we need to talk to many different people.

Informant Questions Time Required for Interview	If the informant asks how much time will be required for the interview, state that the usual length is about an hour. Do not say that the interview will take only a few minutes.
Informant Questions Use of Tape Recorder	We will attempt to tape-record each interview so that there will be a back-up copy in the event that information is not written down, it is written down incorrectly, or the paper copy of the interview is inadvertently destroyed. The interviewer must: (1) ask permission to tape-record the interview prior to doing so, (2) document consent on the Interview, and (3) alert the informant whenever the tape recorder is being turned on or off. The tape recorder should be turned on just prior to reading the introduction on the top of page 2 (Q8), and should be turned off after the interview is completed and the final script is read, on page 17. The interviewer should label each tape with the date of the interview, the initials of the interviewer, and the informant ID#. Care must be used in safeguarding the tapes, and securing informant privacy. If an informant questions the use of a tape-recorder, explain that it is to help ensure that we obtain the best and most accurate information possible, that the tapes will be carefully guarded, and will be destroyed after the data have been analyzed.
Refusals	Our experience has been that few informants actually refuse to cooperate. However, if you have difficulty obtaining an interview, explain the purpose and importance of the study and stress the confidential treatment accorded to all information furnished by the informant. This should be done also at any point during the interview if the respondent should hesitate to answer certain questions. If the informant doubts that he/she has anything to contribute, restate the person(s) who identified the informant as someone important for us to talk to and reiterate that it is important for us to talk to many different people in order to get a complete picture of the community.
Your Manner	Your greatest asset in conducting an interview efficiently is to combine a friendly attitude with a businesslike manner. If an informant's conversation wanders away from the interview, try to cut it off tactfully—preferably by asking the next question on the

questionnaire. Over-friendliness and concern on your part about the informant's personal troubles or experiences may lead to your obtaining less information.

It is especially important in this interview that you maintain an objective manner.

Other Languages

All interviews will be conducted in English.

Note: Policy for "Don't Knows"

Whenever the interviewer receives a "don't know" response that is not pre-coded on the questionnaire (alternative answers to questions are not followed by "DON'T KNOW" with separate code number), the interviewer must write clearly the abbreviation "DK" in the right margin next to the response categories. These will be numerically coded following completion of the interview.

Clarifying Notes

Record any notes that may clarify informant responses in the interview margins.

Scales

Cards are not used in this interview because all of the scales are set up in a similar manner. Therefore, alternatives must be read to informants carefully. Circle the appropriate value on the scale. If the informant uses a half-number, ask him or her to choose the best whole number to represent his or her answer.

Probing

We have adopted standards on probing to assist interviewers. This will result in a much better interview.

Unless specified, all open-ended questions require probes to get complete, clear information. Please use the following standards:
The probe, "anything else" should never be used. Instead, use, "what else?" It is too easy for the informant just to say "No" in response to this probe.

Never leave an open-ended question without an ending probe (e.g., What else?) that yields a final response, (e.g., "That's all.").
You may probe by repeating keywords (e.g., "Other relevant information?" repeating the question, asking for an example ("give me an example") or asking for explanation ("please explain").
4. Common probes for this interview include: "What else?" "Where else?" "Who else?" "How else?"

Final Probes

Unless specified, all open-ended questions must have a final probe. This is your way of ensuring that the informant has not further information on a subject.

Missing Codes	Missing Values for numeric fields will be distinguished by: (1) Don't Know, (2) Refused, and (3) Not Applicable or Skipped (Not Asked). The entire field width will be coded with 7s, 8s, and 9s, respectively. Thus, appropriate missing values for the 10-point scale items will be 77, 88, and 99. Remember to assign missing value codes for the entire width of the field to ensure that a missing value code is not mistaken for real data. Missing data for text fields shall be left blank.
Editing	Each questionnaire should be edited carefully as soon as possible after its completion, while it is still fresh in your mind. A thorough edit on your part is essential, so that editing at other stages can proceed quickly. The audio recording of the interview may assist you in filling in any gaps. The interviewer edit involves the following tasks: checking that handwriting is legible; no questions have been missed; all SKIP directions have been followed; all information in boxes is coded; code numbers are circled, unless otherwise specified. If you have circled the code for "other", check that you SPECIFY exactly what the "other" is. Remember, editing is more than "tidying up" the questionnaire. It is your way of providing a clear picture of the interview situation and the informant, and of what went on. Data entry also will occur at this stage, and will be completed by the interviewer. Data entry for each interview will be reviewed by a second interviewer.
Checklist for Editing	Here are some things to check while editing: • Questions are filled out completely. • Days and dates in the call log agree with the interview. • Your writing is legible. • Skip rules have been followed correctly. • Specify categories are included for all "Other" responses.
Study Timetable Deadlines	The pilot data community visit occurred the week of September 8th-12th, 2003. The due date for the pilot study report was October 8th, 2003. Timing will continue to be an important issue in this study. Therefore, it is essential that data be processed in a timely and efficient manner. Paper copies of the questionnaires and the accompanying cassette tapes should be forwarded to UCLA following data collection.

Contact Log

The Contact Log is used to document all attempted interactions with informants by telephone, email, fax, and regular mail. When multiple interviews are being scheduled or conducted, logging call activities will help avoid errors and confusion (Bourque & Fielder, 2003). It also will allow us to document our effort to reach informants, and possibly, to justify dropping a particular community.

Information on the Contact Log should be completed for each attempted interview, including contacts for those interviews that are not completed.

Call Script

The Call Script is used to ensure that each informant receives the same basic information about the study prior to agreeing to participate. For this study, we are using the content of the Introduction Letter as a script.

Main Interview

The vast majority of questions was drawn from a draft interview guide prepared by Elliott Mittler and submitted as Appendix 4-C of the July 22nd Community Studies Scoping Report. To assist in the development of the interview guide, Elliott Mittler reviewed two interview guides that were used in Project Impact and that were provided by Kathleen Tierney. These included the “Year III Community Interview Schedule”, used for non-pilot communities, and the “Year IV Community Interview Schedule”, used for non-Project Impact communities. The questions contained in the Project Impact Interview Guides were considered to be informative, but also to be too limited in scope to cover all of our areas of concern and too simplistic to collect the details we are seeking in the present study. Therefore, Elliott Mittler indicated that he drafted an interview guide appropriate for communities that did receive Project Impact awards, as well as those communities that did not receive such funds.

The interview guide prepared by Elliott Mittler contained four different schedules or sets of questions, with items focused differently for the four different types of respondents based on the respondent’s likely familiarity with the content. Because of the large degree of overlap in these items, and also in an effort to simplify procedures, the content of the four interview guides was combined into one general outline of the interview content to be sought. The single interview approach also helps us avoid making a priori assumptions about what informants do and do not know. Additional items relating to project costs and cost-benefit analyses were provided by Stephanie Chang, and these were incorporated into the outline. The outline was included in the 9/22/03 version of the Community Studies Scoping Study as Appendix 4-A to provide members of the Project Management Team with a sense of the range of content areas under consideration. The outline also was used in the Pilot Study to guide interviews.

Next, the outline of potential topics was translated into a structured questionnaire. The structured questionnaire format includes specific wording of questions for each content category listed in the outline. Specific wording for probes, and response formats also were created. During a conference call on 9/15/03, having reviewed only the topical interview outline, the Internal Project Review Team (IPRT) expressed its strong support for the development of a structured questionnaire based on the topical outline. A few suggestions were recommended by the IPRT, and these were incorporated into the current version of the interview guide. A copy of the formatted questionnaire draft is included as an Appendix in the 10/15/03 Community Studies Pilot Study report.

Participant ID# is recorded on the top of pages 1 and 2.

Q1 Questions 1-5 should be completed before the interview, to the greatest extent possible.

Q1 is the name of the community that the interview describes.

Q2 Q2 documents the actual start and end dates of the interview.

Q3 Q3 documents the name of the interviewer; initials are entered in the data table.

Q4 Q4 documents whether the interview was conducted over the telephone or in person, and the number dialed or the location of the interview. Circle the appropriate code. If the interview is completed over the telephone, complete QA (phone number); if the completed in person, complete QB (location). If the interview is completed in person, record (999) 999-9999 in Q4A to indicate the item is not applicable.

Q5 Q5 documents the number and names of any documents provided by the informant prior to the interview. This documentation will help ensure that if a document received at such time is inadvertently misplaced, it will be sought and submitted and the information collected will be as complete as possible. Circle the appropriate code. If documents were provided, answer Q5A and fill in the number of documents provided and the document titles. To avoid confusion, use the exact title printed on the document. If Q5= “no”

(2), then Q5A=99.

Q6 — This records the start time of the interview. Fill in the time you start the interview, and circle “AM” or “PM.”

Q7 — This asks the interviewer to review the referral form to make sure that contact information for the informant is complete and accurate. Be sure to confirm telephone number, email address, mailing address, and title, at a minimum. Circle 1 (“yes”) or 2 (“no”) to indicate if changes have been made to the Referral Form. Mark corrections directly on the Referral Form. The updated contact information will be re-entered following completion of the interview.

Q8-Q9 — These items ask about knowledge about state and local laws, ordinances, or regulations relating to hazard mitigation, respectively. Don’t Know, Refused, and Skipped are coded as 7, 8, and 9.

Q10-Q12 — These questions ask the informant to rate the community’s natural hazard risk, on a scale of 1-to-10, for earthquake, wind, and flood, respectively. On the scale, “1” represents “very low” and “10” represents “very high.” Don’t Know, Refused, and Skipped are coded as 77, 88, and 99.

Q13 — Q13 asks about the informant’s assessment of the community’s natural hazard mitigation program. Record the response in the spaces provided. Try to use the informant’s own words, and use quotation marks to indicate when you have done so. If there is not enough room, use Q40 to record the response.

Q14 — This item asks for the informant’s opinion on whether or not the community has a natural hazard mitigation program. Circle the appropriate code. If the informant indicates, “yes”, ask Q15-16; if “no”, skip to Q17. Don’t Know, Refused, and Skipped are coded as 7, 8, and 9.

Q15 — This item asks the informant to rate the natural hazard mitigation program, using a 10-point scale, where “1” means “not very much” and “10” means “very much.” Circle the appropriate value on the scale. Don’t Know, Refused, and Skipped are coded as 77, 88, and 99.

Q16 — This item asks how long the community has had a natural hazard mitigation program. Record the number of years the community has had a program in the spaces provided. Use the blank space to record any information, as needed. Then ask Q21A, when the program started (in what year). Record the year in the spaces provided. For Q16 (YEARS), Don't Know, Refused, and Skipped are coded as 77, 88, and 99. For Q16A (year the program started), Don't Know, Refused, and Skipped are coded as 7777, 8888, and 9999.

Q17	This item asks who is responsible for administering the program. Record the response in the spaces provided. You are seeking both position titles and names, so probe, if necessary.
Q18	This item asks where the natural hazard mitigation program is housed, what department. Record the response in the spaces provided.
Q19	This item asks about the sources of funding for the community's natural hazard mitigation program. Circle all that apply. Probe as necessary. Write notes in margin to clarify. Mentioned is entered as 1; Not Mentioned is entered as 2. For Don't Know, Refused, and Skipped, enter 7, 8, and 9 for each funding source.
Q20-Q21	These items ask the informant to rate the appropriateness and effectiveness of the community's hazard mitigation efforts for the community's needs using a 10-point scale, where "1" means "not at all appropriate" and "10" means "very appropriate." Circle the appropriate value on the scale. Don't Know, Refused, and Skipped are coded as 77, 88, and 99.
Q22	This item asks the informant to rate how the community's program compares to natural hazard mitigation programs in other communities. Response options are: much worse, somewhat worse, about the same, somewhat better, or much better. Repeat the response options, if necessary, and circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9.
Mitigation Activities Q23A-U	This item is to be completed for each mitigation activity that is listed in NEMIS, plus Project Impact, if applicable. Each Q23 is a separate, stapled packet. Record the Participant ID# in the space provided in the upper right corner on the first page of Q23 for each mitigation activity discussed.

Prior to the interview, prepare a Q23 packet for each activity listed in NEMIS. (Each of the relevant NEMIS activities for each community should be entered in the Activities table.) Also include some blank Q23 packets for any spin-offs or other mitigation activities mentioned in Q24.

QA classifies the activity as a NEMIS Project (1), NEMIS Process (2), Project Impact (3), Spin-off (4), Other Project (5), or Other Process (6) activity.

If QA is a NEMIS Project (1) or NEMIS Process (2) award, then record the disaster number and project number in the 8-digit space provided, and code the 2-digit space for the line number from Q24 as 99.

If QA is Project Impact (3), then record 9999-9999 and 99 in the spaces provided for the disaster, project, and Q24 line numbers.

If QA is a spin-off from Q24 (4), then record the disaster number and project number in the 8-digit space provided and record the line number from Q24 in the 2-digit space provided.

If QA is Other Project (5) or Other Process (6) activity, then record 9999-9999 in the space provided for disaster and project number, and code the line number from Q24 in the 2-digit space provided.

Write the project name and description in the space provided.

QB and C ask for the month and year the activity started and ended. Record responses in the spaces provided. Fill in leading zeros. Don't Know, Refused, and Skipped are coded as 77 and 7777, 88 and 8888, and 99 and 9999.

QD asks how the activity was funded. Circle all that apply. Mentioned is entered as 1; Not Mentioned is entered as 2. For Don't Know, Refused, or Skipped, enter 7, 8, or 9 for all funding options.

QE asks about which natural hazards led to the mitigation activity. Circle all that apply. Mentioned is entered as 1; Not Mentioned is entered as 2. For Don't Know, Refused, or Skipped, enter 7, 8, or 9 for all hazards.

QF asks about benefits provided by the activity. Read the entire list. Circle all that apply. Mentioned is entered as 1; Not Mentioned is entered as 2. For Don't Know, Refused, or Skipped, enter 7, 8, or 9 for all benefits.

QF1 asks which of the benefits mentioned was the major objective of the activity. Read the list of all the benefits that were mentioned by the informant. Circle one major objective. Don't Know, Refused, and Skipped are coded as 77, 88, and 99. If the informant is unable to provide a single response, then circle the competing major benefits and enter the codes in the Notes section for Q23.

QG asks if a cost-benefit analysis was conducted. Circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", QG1 asks where a copy of the analysis can be obtained. If "No", QG2 asks why an analysis was not conducted. Record the responses as given.

QH asks whether the informant can provide any quantitative information about the benefits of the activity. Record response as given in the space provided.

QI asks whether the informant is aware of any studies, reports, or knowledgeable persons who can help describe and quantify the benefits of the activity. Circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", Ask QI1, where copies may be obtained or whom we should contact. Record response in space provided.

QJ asks if there are any cost data available about this activity. Circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", ask J1, where the information may be obtained. Record the response in the spaces provided.

QK-M are scale items that ask about familiarity with, involvement in the design, and involvement in the implementation of the activity. Circle the appropriate whole number on the scale. These questions should always be asked for every participant, even if the participant is not familiar with the activity. Don't Know, Refused, and Skipped are coded as 77, 88, and 99.

Q29N asks about the informant's roles and responsibilities in the activity. Circle all that apply. If you are not sure how to categorize a role, record the informant's response in the margin. If the informant was not really involved in the activity, circle the appropriate code (7). This question should always be asked for every participant, even if the participant is not familiar with the activity. Mentioned is entered as 1; Not Mentioned is entered as 2. For Don't Know, Refused, or Skipped, enter 7, 8, or 9 for all roles.

QO-P are scale items that ask the informant to rate the community's success in achieving the major objective with and without the activity. Circle the appropriate whole number. Don't Know, Refused, and Skipped are coded as 77, 88, and 99.

QQ asks if there are any documents like grant announcements, grant applications, or reports that could help describe the activity. Circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", ask Q1, where copies can be obtained. Record the response in the space provided.

QR asks if this was a partnership activity. Circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", then ask QR1-R6. If "No", go to QS.

QR1 asks what resources were provided through this activity. Circle all that apply. Mentioned is entered as 1; Not Mentioned is entered as 2. For Don't Know, Refused, or Skipped, enter 7, 8, or 9 for all resources.

QR2 asks why this partnership formed. Circle all that apply. Mentioned is entered as 1; Not Mentioned is entered as 2. For Don't Know, Refused, or Skipped, enter 7, 8, or 9 for all reasons.

QR3 asks about indicators of this partnership's success. Record response in space provided.

QR4 asks about indicators of this partnership's failure. Record response in space provided.

QR5 asks about what contributed to making this partnership successful. Record responses in the space provided.

QR6 asks about what contributed to making this partnership unsuccessful. Record responses in the space provided.

QS is used to document if this activity is Project Impact. If "Yes", then ask QS1-S2. If "No", then skip to QT. QS1 asks what else the community did for Project Impact. QS2 asks how Project Impact activities fit into the overall hazard mitigation program. Record responses in spaces provided.

QT asks what else the informant can report to help us understand the activity. Record the response given in the spaces provided.

QU asks if this activity lead to any new hazard mitigation activities. Circle the appropriate response. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", then ask QU1, what spin-offs resulted from this activity. If "No", then return to the beginning of Q23, and ask items for the next NEMIS activity until all activities have been completed.

Q24

This item asks about other natural hazard mitigation activities in the community with which the informant is familiar. QA asks for a name or brief description of the activity.

QB asks if this activity was initiated as a result of a FEMA activity. Circle the appropriate code (1=Yes, 2=No). Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", then complete QC.

QC documents the Disaster Number and Project Number for the FEMA activity that initiated the spin-off. Don't Know, Refused, and Skipped (not a spin-off) are entered as 7777-7777, 8888-8888, and 9999-9999.

For each spin-off, and for each other mitigation activity, complete Q23, as time permits. Then go to Q25. This study is focused on spin-offs, so it is important that we get complete data for every spin-off possible.

Q25

Complete the box at the top of page 15, prior to Q25; do not read the item in the box aloud. The box asks whether the informant is a community partner. If "Yes", ask Q25. If "No", skip to Q26. Don't Know is coded as 7. Q25 asks if the informant's agency (or the informant if not affiliated with any agency) has any plans for future involvement in hazard mitigation activities? Circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9.

If "Yes", answer A and B. If "No", answer C. Q25A asks how the informant's agency decides what activities to become involved with. Q25B asks why the agency has chosen the hazard mitigation activities they plan to participate in. Q25C asks why the agency is not going to be involved in future hazard mitigation activities. For questions 25A-C, write responses in the space provided.

Q26

This item asks if the community plans to expand its natural hazard mitigation activities. Circle the correct code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If "Yes", ask QA-B; if "No", skip to QE.

QA asks for more detail about the community's plans to expand its natural hazard mitigation activities.

QB asks if cost-benefit analyses are performed on each potential project. Circle the correct code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9. If QB= "Yes", then ask QC and D. If QB="No", then skip to Q27.

QC asks who performs the cost-benefit analysis. Record the response in the space provided.

QD asks how the cost-benefit analyses are conducted. Record the response in the space provided.

QE asks why the community is not planning to expand its natural hazard mitigation activities. Record the response in the spaces provided.

Q27 — Q27 asks for additional contacts, that is, individuals we might be able to interview and who could help us understand the community's natural hazard mitigation activities. For each person suggested, record the name in the side margin, and complete a Referral Form for each name given. Write the corresponding ID#s in the spaces provided following the interview, after ID#s have been assigned. Don't Know, Refused, and Skipped are coded as 7777, 8888, and 9999. When the informant indicates that he/she does not know of any other appropriate referrals, the first blank would be coded as Don't Know, with subsequent blanks coded as Skipped.

Q28 — This item asks if we may contact the informant for additional assistance in the future. Circle the appropriate code. Don't Know, Refused, and Skipped are coded as 7, 8, and 9.

Q29 — This item records the end time. Circle "AM" or "PM."

Read the script at the bottom of page 17. After thanking the informant, announce that you are turning off the tape recorder, and do so.

Q30-40 — Q30-40 are to be completed after the interview is conducted.

Q30 — This item documents the number of sittings it took to complete the interview. Don't Know is coded as 7.

Q31 — This item documents the length of the interview in minutes. Combine the length of time for each sitting.

Q32 — This item documents whether or not the informant was given a copy of the interview guide. Don't Know is coded as 7.

Q33 — This item records the number and names of any documents provided by the informant at the time of the interview. This documentation also will help ensure that the data collected are as complete as possible. Circle the appropriate code. If documents were provided, fill in the number of documents provided for QA and the document titles for QB. To avoid confusion, use the exact title printed on the document. If Q33 is “No”, QA (number of documents) is coded as 99.

Q34	This item records the number and names of any documents promised by the informant at the time of the interview. This documentation also will help ensure that the data collected are as complete as possible. Circle the appropriate code. If documents were provided, fill in the number of documents provided for QA and the document titles for QB. To avoid confusion, use the exact title printed on the document. If Q34 is “No”, QA (number of documents) is coded as 99.
Q35	This item asks if the interviewer is already acquainted with the informant. Circle the code for “Yes” if any of the interviewers present during the interview is already acquainted with the informant. If “Yes”, ask QB, length of acquaintance. Fill in the number of months and/or years of the acquaintance in the spaces provided. The information collected in this item may be used to answer questions regarding potential interviewer bias.
Q36	Use the 10-point scale to rate how cooperative the informant was, with “1” meaning “not at all cooperative” and “10” meaning “extremely cooperative.” Circle the appropriate response.
Q37	Use the 10-point scale to rate how knowledgeable the informant was, with “1” meaning “not at all knowledgeable” and “10” meaning “extremely knowledgeable.” Circle the appropriate response.
Q38	Use the 10-point scale to rate how biased the informant seemed, with “1” meaning “not at all biased” and “10” meaning “extremely biased.” Circle the appropriate response.
Q39	This item asks if there was anything unusual about this interview. If “Yes”, explain in space provided for QA.
Q40	This item provides space for any additional comments or explanations pertaining to the interview. Use the space provided to record notes.

ID# ____ ____ ____ ____

QUESTIONNAIRE

COMPLETE BEFORE INTERVIEW:

1. COMMUNITY NAME____________________________ COMMUNITY ID ___ ___

2. INTERVIEW DATE ___ ___ / ___ ___ / ___ ___ (START DATE) ___ ___ / ___ ___ / ___ ___ (END DATE)

3. INTERVIEWER ____

4. INTERVIEW TYPE

   TELEPHONE...................COMPLETE A................. 1
   FACE-TO-FACE.............COMPLETE B................. 2

   A. NUMBER DIALED: (___ ___ ___) ___ ___ ___ - ___ ___ ___ ___

   B. INTERVIEW LOCATION ____

5. WERE ANY DOCUMENTS <u>RECEIVED</u> FROM THIS INFORMANT <u>PRIOR</u> TO THE INTERVIEW?

   YES .... ANSWER A & B...................... 1
   NO 2

   A. HOW MANY DOCUMENTS? ____ ____

   B. LIST DOCUMENT TITLES:
   1) ____
   2) ____
   3) ____
   4) ____
   5) ____
   6) ____

ID# ____ ____ ____ ____

6. INTERVIEW START TIME: ___ ___ : ___ ___ AM / PM

7. REVIEW REFERRAL FORM.
IS CONTACT INFORMATION COMPLETE AND ACCURATE?

YES	1
NO , UPDATE CONTACT DATA............................	2

CONSENT FOR TAPE (CIRCLE): YES...1, OR NO...2.

I'm going to turn the tape-recorder on now. TURN ON TAPE RECORDER. Thank you for agreeing to talk to us about hazard mitigation activities in <COMMUNITY>. I want to start by asking you some general questions about the community.

8. As far as you know, are there any state laws, ordinances, or regulations relating to hazard mitigation in <COMMUNITY>?

YES ....ASK A	1
NO	2
INFORMATION ALREADY OBTAINED...............	9

A. Please tell me about them.

1) ____________________

2) ____________________

3) ____________________

9. As far as you know, are there any local laws, ordinances, or regulations relating to hazard mitigation in <COMMUNITY>?

YES ....ASK A	1
NO	2
INFORMATION ALREADY OBTAINED...............	9

A. Please tell me about them.

1) ____________________

2) ____________________

3) ____________________

I want to ask you some questions about your assessment of <COMMUNITY'S> natural hazard risk.

10. On a scale of one-to-ten, where 1 means "very low" and 10 means "very high", how would you rate the community's risk for earthquake?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10

Very Low ... ***Very High***

11. On a scale of one-to-ten, where 1 means "very low" and 10 means "very high", how would you rate the community's risk for wind?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10

Very Low ... Very High

12. On a scale of one-to-ten, where 1 means "very low" and 10 means "very high", how would you rate the community's risk for flood?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10

Very Low ... Very High

Now I want to talk about the community's overall natural hazard mitigation program.

13. What is your assessment of the community's overall natural hazard mitigation program?

____

____

____

____

____

____

14. In your opinion, does the community have a natural hazard mitigation program?

YES	CONTINUE	1
NO	SKIP TO Q17	2

15. On a scale of one-to-ten, where 1 means "not very much" and 10 means "very much", how much do you know about <COMMUNITY'S> natural hazard mitigation program?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10

Not very Much ... Very Much

16. How long has <COMMUNITY> had a natural hazard mitigation program?

____ YEARS: ____ ____

A. When did the natural hazard mitigation program start? ___ ___ ___ ___

17. Who is responsible for administering the program?

____

____

____

18. Where is the program housed, what department?

____

____

____

19. What are the sources of funding for <COMMUNITY'S> natural hazard mitigation program?
CIRCLE ALL THAT APPLY

HMGP/FEMA	1
PROJECT IMPACT	2
OTHER FEDERAL FUNDING	3
STATE FUNDING	4
PRIVATE ORGANIZATIONS	5
OTHER	6

SPECIFY: ____________________

20. On a scale of one-to-ten, where 1 means "not at all appropriate" and 10 means "very appropriate", how appropriate do you consider these efforts for the community's needs?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10

Not at all Appropriate — Very Appropriate

21. On a scale of one-to-ten, where 1 means "not at all effective" and 10 means "very effective", how effective do you consider these efforts?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10

Not at all Effective — Very Effective

22. In your opinion, how does this community's program compare to natural hazard mitigation programs in other communities? Would you say that it is:

much worse,	1
somewhat worse,	2
about the same,	3
somewhat better, or	4
much better?	5

COMPLETE QUESTION 23 FOR EACH ACTIVITY INCLUDED IN THE NEMIS DATASET, AND FOR PROJECT IMPACT, IF APPLICABLE.

23. Now I want to find out about specific hazard mitigation activities that have been conducted in <COMMUNITY>.

A. WHAT TYPE OF ACTIVITY IS THIS? (CIRCLE ONE)

NEMIS PROJECT	1	__ __ __ __ - __ __ __ __
NEMIS PROCESS	2	__ __ __ __ - __ __ __ __
PROJECT IMPACT	3	
SPIN-OFF (Q23U, Q24)	4	__ __ __ __ - __ __ __ __; Q23A1#: __ __
OTHER PROJECT (Q24)	5	Q23A1#:__ __
OTHER PROCESS (Q24)	6	Q23A1#:__ __

First (Now) I want to know about ____.
ACTIVITY TITLE OR DESCRIPTION

B. When did < ACTIVITY> start? That is what month and year? ___ ___ / ___ ___
MONTH YEAR

C. When did it end? ___ ___ / ___ ___
MONTH YEAR

D. How was <....> funded? CIRCLE ALL THAT APPLY

HMGP/FEMA	1
PROJECT IMPACT	2
OTHER FEDERAL	3
STATE FUNDS	4
COMMUNITY FUNDS	5
PRIVATE FUNDS	6
OTHER	7

SPECIFY:______________________

E. Was <...> done because of:

CIRCLE ALL THAT APPLY

Flood,	1
Wind, or	2
Earthquake?	3

F. Which of the following benefits were provided by < ...>? Would you say:

F. CIRCLE ALL THAT APPLY.	F. BENEFITS	F1. MAJOR OBJ.
Reducing deaths, injuries, and illnesses	1	1
Reducing stress and trauma	1	2
Reducing property damage	1	3
Reducing infrastructure damage	1	4
Reducing emergency response and management costs	1	5
Reducing residents' disruption and displacement	1	6
Reducing business disruption	1	7
Reducing government disruption	1	8
Reducing environmental damage	1	9
Reducing damage to historic sites	1	10
Reducing insurance premiums	1	11
Improving emergency response capacity	1	12
Improving disaster mitigation capacity	1	13
Stimulating private sector mitigations	1	14
New knowledge about hazards and their impacts	1	15
Public education about risks and risk reduction options	1	16
Increase in property values	1	17
Environmental benefits	1	18
What other benefits were provided? SPECIFY: ________	1	19
What other benefits were provided? SPECIFY: ________	1	20
What other benefits were provided? SPECIFY: ________	1	21

F1. In terms of providing the benefits you mentioned, what was the major objective of this activity?

READ ANSWERS GIVEN BACK TO RESPONDENT. RECORD IN F1, ABOVE. CIRCLE ONLY ONE.

G. Was a cost-benefit analysis done for <...>?

YES...............ASK G1 1
NO................GO TO G2............. 2

G1. Where can we get a copy of the cost benefit analysis?

____
RECORD AS GIVEN

G2. Why wasn't a cost benefit analysis done?

____
RECORD AS GIVEN

H. Can you provide any quantitative information about the benefits of this activity? PROBE: Any estimates of benefits in either physical (e.g., lives saved) or monetary terms?

____
RECORD AS GIVEN

I. Are you aware of any studies, reports, or knowledgeable persons that can help us describe and quantify the benefits of this activity?

YES.......ASK I1 1
NO.........GO TO J...................2

I1. Where could we get copies of these reports or whom should we contact?

____
RECORD AS GIVEN

J. Are there any cost data available about this activity?

YES.......ASK J1 1
NO.........GO TO K 2

J1. Where could I get this information?

____
RECORD AS GIVEN

K. On a scale of 1 to 10, where 1 means "not at all familiar" and 10 means "extremely familiar," how familiar are you with this particular activity?

1.........2........3.........4.........5.........6.........7.........8.........9.........10

Not at all Familiar ... Extremely Familiar

L. On a scale of 1 to 10, where 1 means "not at all involved" and 10 means "extremely involved," how involved were you in the design of this particular activity?

1.........2........3.........4.........5.........6.........7.........8.........9.........10

Not at all Involved ... Extremely Involved

M. On a scale of 1 to 10, where 1 means "not at all involved" and 10 means "extremely involved," how involved were you in the implementation of this particular activity?

1.........2........3.........4.........5.........6.........7.........8.........9.........10

Not at all Involved ... Extremely Involved

N. What were your roles and responsibilities in this activity or were you not really involved? Were you involved in:

CIRCLE ALL THAT APPLY

Priority setting 1

Planning 2

Carrying out activities....................................... 3

Providing resources... 4

Educating the community 5

What else?... 6

SPECIFY: ____________________________

____

Not really involved 7

O. Thinking back to the major objective or benefit of this activity, <INSERT FROM F1>, on a scale of 1 to 10 where 1 means "extremely low" and 10 means "extremely high," how would you rate the community's success in meeting this objective with this activity?

1.........2........3.........4.........5.........6.........7.........8.........9.........10
Extremely Low ... Extremely High

P. How would you rate the community's success in meeting this objective without this activity?

1.........2........3.........4.........5.........6.........7.........8.........9.........10
Extremely Low ... Extremely High

Q. Are there any documents like grant announcements, applications, or reports that could help me describe this activity?

YES.............ASK Q1 1
NO...............GO TO R.................. 2

Q1. Where can I get copies of those documents?

____
____
____
____

R. Was this a partnership activity?

YES........... ASK R1-R6 1
NO. .... GO TO S 2

R1. What resources were provided through this activity?

Time 1
Technology.. 2

Skills 3
Money.. 4
Materials.. 5
Audience 6
Equipment 7
Other (SPECIFY: ________________________________)...... 8
Other (SPECIFY: ________________________________)...... 9

R2. Why did this partnership form? PROBE: What other reasons were there for this partnership?

Internet 1
Personal Friendship 2
Community Betterment 3
Company Policy of Good Citizenship 4
Properties at Risk 5
Other (SPECIFY: ______________________________).......... 6
Other (SPECIFY: ______________________________).......... 7

R3. What are some indicators of this partnership's success?

____

R4. What are some indicators of this partnership's failure?

____

R5. What do you think contributed to making this partnership successful?

____

R6. What do you think contributed to making this partnership unsuccessful?

____

S. IS THIS PARTICULAR ACTIVITY PROJECT IMPACT?

....................................YES...ASK S1 AND S2 1

....................................NO..SKIP TO T 2

S1. What else did the community do for Project Impact?

S2. How did the Project Impact activities fit into the overall hazard mitigation program?

T. What else can you tell me about this activity that would help me understand it?

____

____

____

____

____

____

U. In your opinion, did this project lead to any new hazard mitigation activities?

Yes, this activity created spin-off activities.......... ASK U1 1

No, there was no spin-off from this
activity into others.. RETURN TO Q23..........2

U1. What other activity or activities were spin-offs from this activity?

____

____

____

RECORD IN Q24 GRID. COMPLETE Q23 FOR EACH SPIN-OFF.

COMPLETE Q23 FOR NEXT ACTIVITY.

WHEN ALL ACTIVITIES ARE DESCRIBED,
GO TO Q24, STARTING WITH SPIN-OFFS.

DOUBLE-CHECK USING NEMIS TABLE.

24. A. What other natural hazard mitigation activities do you know about in <*community*>? What else? B. Was this activity initiated as a result of a FEMA activity? C. What FEMA activities led to <…>?

Now I'd like to talk some more about <OTHER ACTIVITY>.

COMPLETE Q23 FOR EACH ACTIVITY THAT WAS A SPIN-OFF FROM A FEMA MITIGATION ACTIVITY.

COMPLETE Q23 FOR ADDITIONAL OTHER MITIGATION ACTIVITIES, AS TIME PERMITS.

A. OTHER MITIGATION ACTIVITIES…	B. SPIN-OFF FROM FEMA ACTIVITY? YES NO	C. WHICH FEMA ACTIVITY?	
		RECORD DISASTER # FROM Q23.	RECORD PROJECT # FROM Q23.
1.	1...............2		
2.	1...............2		
3.	1...............2		
4.	1...............2		
5.	1...............2		
6.	1...............2		
7.	1...............2		
8.	1...............2		
9.	1...............2		
10.	1...............2		

IS THE INFORMANT A COMMUNITY PARTNER?

YES (REFERRAL FORM Q6=4)........................ASK Q25.......................1
NO..GO TO Q26...................2

25. Does your agency have any plans for future involvement in hazard mitigation activities?

YES .... ANSWER A & B 1
NO........................ANSWER C 2

A. How does your agency decide what activities to become involved with?

____

____

____

____

B. Why did your agency choose the activities you are planning to participate in?

____

____

____

____

C. Why isn't your agency going to be involved in future hazard mitigation activities?

____

____

____

26. Does the community have plans to expand its natural hazard mitigation activities?

YES ....ASK A-D 1
NO..................ASK E 2

A. Tell me about this.

____

____

____

____

____

____

B. Are cost-benefit analyses performed on each potential project?

YES ....ASK C & D................ 1
NO..................GO TO Q27................ 2

C. Who performs the cost-benefit analysis?

____

____

____

____

D. How are the cost-benefit analyses conducted?

____

____

____

____

E. Why isn't the community planning to expand its natural hazard mitigation activities?

____

____

____

____

27. ASK FOR ADDITIONAL CONTACTS USING REFERAL FORM, Q4.
COMPLETE REFERRAL FORM FOR EACH NAME GIVEN.

DID THE INFORMANT PROVIDE REFERRALS?

YES, PROVIDED NEW REFERRALS .... 1 (RECORD ID#S BELOW)
NO, PROVIDED ONLY DUPLICATES .... 2 (RECORD ID#S BELOW)
NO, PROVIDED NO REFERRALS 3

#__ __ __ __ #__ __ __ __ #__ __ __ __
#__ __ __ __ #__ __ __ __ #__ __ __ __
#__ __ __ __ #__ __ __ __ #__ __ __ __

28. If we need to ask you anything else, can we contact you again?

Yes 1
No 2

29. INTERVIEW END TIME ___ ___ : ___ ___ AM / PM

That is the end of the interview. Thank you again for your time and the information you provided.
TURN TAPE RECORDER OFF.

COMPLETE AFTER INTERVIEW:

30. HOW MANY "SITTINGS" DID IT TAKE TO COMPLETE THE INTERVIEW? _____

31. HOW LONG DID THE INTERVIEW TAKE TO COMPLETE? ___ ___ ___ MIN.

32. WAS THE INFORMANT GIVEN A COPY OF THE INTERVIEW GUIDE?

YES	1
NO	2

33. DID THE INFORMANT <u>PROVIDE</u> ANY DOCUMENTS <u>DURING THE INTERVIEW</u>?

YES .... ANSWER A & B	1
NO	2

A. HOW MANY DOCUMENTS? ____ ____

B. LIST DOCUMENT TITLES:

1) ____________________
2) ____________________
3) ____________________
4) ____________________
5) ____________________

34. DID THE INFORMANT PROMISE ANY DOCUMENTS DURING THE INTERVIEW?

YES ....ANSWER A & B....................... 1
NO 2

A. HOW MANY DOCUMENTS? ____

B. LIST DOCUMENT TITLES:
1) ____________________
2) ____________________
3) ____________________
4) ____________________
5) ____________________

35. WAS THE INTERVIEWER ALREADY ACQUAINTED WITH THE INFORMANT?

YES ....ANSWER A.............................. 1
NO ....GO TO Q36 2

A. LENGTH OF ACQUAINTANCE....................... ___ ___ ___ MONTHS

36. HOW COOPERATIVE WAS THIS INFORMANT?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10
NOT AT ALL COOPERATIVE — EXTREMELY COOPERATIVE

37. HOW KNOWLEDGABLE WAS THIS INFORMANT?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10
NOT AT ALL KNOWLEDGABLE — EXTREMELY KNOWLEDGABLE

38. HOW BIASED DID THIS INFORMANT SEEM?

1------- 2------- 3------- 4------- 5------- 6------- 7------- 8------- 9------- 10
NOT AT ALL BIASED — EXTREMELY BIASED

39. WAS THERE ANYTHING UNUSUAL ABOUT THIS INTERVIEW?

YES..................ASK Q39A................................. 1
NO.. 2

A. EXPLAIN:

40. RECORD ANY OTHER NOTES PERTAINING TO THE INTERVIEW HERE:

Appendix C
DEMOGRAPHIC CHARACTERISTICS OF COMMUNITIES

As reported in the 2000 Census, the demographic characteristics of the eight communities selected for study are diverse (Table C-1). Communities vary in size from 15,527 to 662,047; median age varies from 31.9 to 38.6 years. Two communities have very few non-white inhabitants while two communities are more than 50 percent non-white. The proportion of households with a child under the age of 18 varies from 28.2 to 43.5 percent and the percentage of female-headed households with children varies from 5.5 to 9.3 percent. Households with persons over 64 years of age range from 19.3 to 29.9 percent. With the exception of a resort community with a 33 percent vacancy rate of primarily seasonal housing, vacant units range from 2.3 to 8.6 percent, and the proportion of renter-occupied units ranges from a low of 15.9 percent to a high of 46.8 percent. Labor force participation by persons over the age of 16 is between 61.5 and 69 percent, with a median family income between $42,245 and $64,573, a per capita income between $16,686 and $24,294, and the percent of families below the poverty level ranging from 5.4 to 11.6 percent. Poverty rates are correlated with median family income and percent in the labor force, but do not appear to be correlated with the percent non-white, percent of female-headed households or with the percent of households with persons over 64. Median family income is correlated positively with having children under 18 and negatively with having an adult over 64.

Tables C-2 through C-4 show how the demographic characteristics of communities selected for study compare with those of other communities in the population. In each table, communities selected for study are compared with other communities that were the same size, in the same FEMA region, and received the same combination of awards.

C.1 Communities with Grants for Earthquake

The first set of communities received awards only for earthquakes. The two selected communities differ from each other and from the three unselected communities (Table C-2). Common to all five communities is the fact that they are all in California. Median age is similar for all five communities and at least 26 percent of each community is non-white, but the proportion of female-headed households (4.7-9.9 percent), renter-occupied units (37.4-59.5 percent) and income varies substantially.

C.2 Communities with Grants for Flood and Wind

No communities in the sample received FEMA grants only for mitigation of wind hazards, or for a combination of flood and earthquake hazards. Two communities in the sample (of four in the NEMIS file) received grants only for flood mitigation but the two are different in population and in region (Table C-3). Thus, it is not surprising that they differ substantially in demographic characteristics with one community having essentially no non-white residents as well as having a somewhat older population.

The largest number of communities in both the population and the sample were communities that received FEMA grants for both flood and wind. As seen in Table C-4, most of the small communities meeting this criterion are in Region IV, but none of these 12 small communities in Region IV that received grants for flood and wind were studied. Two small communities in Region II, both located on the coast, received FEMA grants for flood and wind. The unselected community is a resort community with a small permanent population, few non-whites, relatively few households with children and nearly 40 percent of the households containing persons over age 64. The selected community is 53.2 percent non-white with 43.5 percent of households containing children.

The remaining two communities in the sample are one of three medium-sized communities, all located in Michigan, and one of three large communities, all located in Region IV, that received grants for flood and wind. In contrast to other strata, demographic characteristics within these two strata are homogeneous. The selected community in Michigan is the smallest community in the strata with a somewhat older population (median age = 37.0), few non-whites (2.8 percent), 37.2 percent of households having children, and 24.1 percent having persons over 64. Sixteen percent of households are renter occupied (range: 15.9-20.7 percent), and 8.2 percent are vacant (range: 5.4-8.2 percent). Sixty-two percent of persons over 16 are in the labor force (range: 61.7-72.5 percent), median family income is $46,729 (range: $46,729-$59,896), per capita income is $17,985 (range: $17,985-21,676), and 5.4 percent of families are below the poverty level (range: 3.1-6.7 percent).

The large community selected from Region IV has a population of 662,047 (range: 662,047-695,454) with a median age of 36 (range: 33.1-36.7) and 41.3 percent non-white (21.4-41.3 percent). Thirty-five percent of households have children (range: 32.8-35.2 percent) and 9.3 percent are female-headed households with children (range: 7.6-9.3 percent). Twenty-five percent of households have persons over 64 (range: 15.3-24.7 percent). Renters occupy 33.5 percent of households (range: 35.1-37.7 percent) and 8.6 percent of households are vacant (6.2-8.6 percent). Median income is $45,951 (range: $45,951-60,608), per capita income is $20,892 (range: $20,892-27,352), 61.5 percent are in the labor force (range: 61.5-72.4 percent), and a relatively high percentage of families, 11.6 percent, are below the poverty line (range: 6.6-11.6 percent).

The last stratum contains one community, which was selected and studied. This is community 03 in Table C-1, which is one of 56 medium-sized communities, one of 30 communities in Region IV, and the only community that received grants for earthquake, flood and wind.

C.3 Summary

In summary, there is substantial diversity both across the eight selected communities and between each selected community and the other communities in the population it was selected to represent.

Sources: Demographic profile tables for each community were obtained using the *American FactFinder* on the U.S. Census Bureau's website: http://factfinder.census.gov. The variables "Population" through "Renter-Occupied" were taken from: DP-1. Profile of General Demographic Characteristics: 2000, Data Set: Census 2000 Summary File 1 (SF 1) 100-Percent Data. The variables "In Labor Force >16" through "Families Below Poverty Level, 1999" were taken from: DP-3. Profile of Selected Economic Characteristics: 2000, Data Set: Census 2000 Summary File 3 (SF 3) Sample Data.

Note: The variable "Non-White" was calculated using the percentage of White under the heading, "Race alone or in combination with one or more other races."

Table C-1 Demographic characteristics of eight communities in the community studies sample

Community	Population	Median Age	Non-White %	Female-Headed House-hold with Child < 18 years %	House-hold with Child < 18 years %	House-hold with Member > 64 years %	Vacant Units %	Renter Occupied %	In Labor Force %	Median Family Income $	Per Capita Income $	Families Below Poverty Level in 1999 %
01	140,030	31.9	51.8	7.7	42.5	22.2	2.4	46.8	63.8	54,712	19,695	7.2
02	662,047	36.0	41.3	9.3	34.8	24.7	8.6	33.5	61.5	45,951	20,892	11.6
03	196,629	38.3	18.0	6.6	29.5	25.4	33.0	27.0	64.2	42,676	19,949	8.4
04	43,783	34.6	53.2	9.0	43.5	24.5	2.3	34.8	64.8	61,673	21,288	8.0
05	15,527	38.6	2.4	6.1	28.2	29.9	6.7	40.4	64.0	42,245	16,686	6.5
06	58,266	37.0	2.8	5.5	37.2	24.1	8.2	15.9	61.7	46,729	17,985	5.4
07	660,486	34.9	17.4	6.5	29.1	19.3	5.7	43.1	69.0	51,118	22,606	8.2
08	128,821	33.2	26.3	6.0	40.8	20.9	2.3	37.4	66.5	64,573	24,294	6.8

Table C-2 Demographic characteristics of study communities that received FEMA grants for earthquakes only (communities 01 and 08) compared to those with similar sample criteria*

Community	Population	Median Age	Non-White %	Female-Headed House-hold with Child < 18 years %	House-hold with Child < 18 years %	House-hold with Member > 64 years %	Vacant Units %	Renter Occupied %	In Labor Force %	Median Family Income $	Per Capita Income $	Families Below Poverty Level in 1999 %
A	102,743	32.5	36.3	4.7	19.8	17.7	4.1	57.3	65.8	70,434	30,477	8.3
01	**140,030**	**31.9**	**51.8**	**7.7**	**42.5**	**22.2**	**2.4**	**46.8**	**63.8**	**54,712**	**19,695**	**7.2**
B	399,484	33.3	65.3	9.9	33.5	20.9	4.3	58.6	61.6	44,384	21,936	16.2
08	**128,821**	**33.2**	**26.3**	**6.0**	**40.8**	**20.9**	**2.3**	**37.4**	**66.5**	**64,573**	**24,294**	**6.8**
C	108,724	32.0	26.8	5.5	32.0	17.0	3.0	59.5	69.2	55,456	23,342	8.2

*Communities 01 and 08 are two of the 56 medium-sized (50,000-499,999) communities in the NEMIS population of 113; two of the 10 communities that received FEMA awards only for earthquakes; two of the 30 communities at high risk of earthquakes; and two of the nine communities located in Region IX. Both communities are included in Table 3-1, Received HMGP and/or Project Impact Grants for Earthquake Only, *Track B Scoping Study,* September 22, 2003, page 43.

Table C-3 Demographic characteristics of study communities that received FEMA grants for floods only (communities 05 and 07) compared to those with similar sample criteria

Community	Population	Median Age	Non-White %	Female-Headed House-hold with Child < 18 years %	House-hold with Child < 18 years %	House-hold with Member > 64 years %	Vacant Units %	Renter Occupied %	In Labor Force %	Median Family Income $	Per Capita Income $	Families Below Poverty Level in 1999 %
Small (10,000-49,999) Communities in Region VI												
D	10,489	37.7	7.0	6.8	37.8	21.4	10.0	39.7	67.7	70,043	26,420	4.9
Small (10,000-49,999) Communities in Region VIII												
05[1]	**15,527**	**38.6**	**2.4**	**6.1**	**28.2**	**29.9**	**6.7**	**40.4**	**64.0**	**42,245**	**16,686**	**6.5**
E	11,893	40.3	3.1	5.6	27.9	32.3	10.4	37.1	64.8	40,234	18,275	8.1
Large (≥500,000) Communities in Region X												
07[2]	**660,486**	**34.9**	**17.4**	**6.5**	**29.1**	**19.3**	**5.7**	**43.1**	**69.0**	**51,118**	**22,606**	**8.2**

[1]Community 05 is one of 46 small (10,000-49,999) communities in the NEMIS population of 113; one of 38 that received FEMA awards only for floods; one of the 64 communities considered at high risk of floods; and one of seven communities in Region VIII. Community 05 and Community E are the only two communities in the population that meet all four criteria: small, awards for flood only, at high risk of flood, and in Region VIII.

[2]Community 07 is one of 11 large (≥ 500,000) communities in the NEMIS population; one of 38 that received FEMA awards only for floods; one of 64 considered at high risk of floods; and one of nine communities in Region X. Community 07 is the only community in the population that meets all four criteria: large, awards for flood only, at high risk of flood, and in Region X.

Table C-4 Demographic characteristics of study communities that received FEMA grants for floods and wind (communities 02, 04 and 06) compared to those with similar sample criteria

Community	Population	Median Age	Non-White %	Female-Headed House-hold with Child < 18 Years %	House-hold with Child < 18 Years %	House-hold with Member > 64 Years %	Vacant Units %	Renter Occupied %	In Labor Force %	Median Family Income $	Per Capita Income $	Families Below Poverty Level, 1999 %
Small (10,000-49,999) Communities in Region II												
04*	**43,783**	**34.6**	**53.2**	**9.0**	**43.5**	**24.5**	**2.3**	**34.8**	**64.8**	**61,673**	**21,288**	**8.0**
F	15,378	47.8	5.7	4.5	18.4	37.7	63.2	38.0	60.7	61,731	33,217	4.3
Small (10,000-49,999) Communities in Region IV												
G	19,973	38.7	18.4	7.5	29.5	27.3	6.1	35.9	66.8	45,791	21,085	7.3
H	42,987	22.6	21.0	4.4	19.9	10.4	8.1	59.1	56.1	55,619	16,431	14.0
I	12,938	36.3	14.7	6.4	34.7	26.0	9.7	31.0	65.2	40,200	19,690	8.3
J	38,978	39.0	36.4	9.9	29.5	34.9	12.5	36.4	50.3	31,740	15,610	18.1
K	24,757	32.6	17.2	9.0	52.1	13.8	6.6	21.7	68.8	53,132	19,897	6.5

*Community 04 is one of 46 small (10,000-49,999) communities in the NEMIS population of 113; one of 49 communities that received FEMA awards for floods and wind; one of 29 communities considered at high risk of wind; one of 64 communities considered at high risk of flood; one of 20 communities considered at high risk of both flood and wind; and one of four communities in Region II. Community 04 and Community F are the only two communities in the population that meet all four criteria: small, awards for flood and wind, at high risk of flood and wind, and in Region II.

Table C-4 continued

Community	Population	Median Age	Non-White %	Female-Headed Household with Child < 18 Years %	Household with Child < 18 Years %	Household with Member > 64 Years %	Vacant Units %	Renter Occupied %	In Labor Force %	Median Family Income $	Per Capita Income $	Families Below Poverty Level, 1999 %
L	10,916	37.1	8.6	5.6	36.1	26.5	9.3	20.0	60.0	39,240	15,722	10.3
M	25,944	33.8	55.9	13.1	34.8	27.0	9.4	45.7	57.9	32,596	16,848	21.0
N	17,320	35.7	11.2	9.1	39.6	21.8	8.9	33.7	65.7	50,014	19,305	7.7
O	14,692	36.2	6.5	5.0	49.6	15.4	2.4	6.1	75.1	77,202	29,082	2.1
P	13,472	21.4	5.5	2.3	10.6	15.0	7.9	70.5	57.7	49,762	12,256	9.2
Q	41,082	38.8	26.5	6.0	33.5	25.2	22.8	17.4	58.5	41,633	17,882	9.5
R	10,974	48.1	4.7	3.3	17.3	31.2	70.1	28.0	59.9	46,052	27,006	5.1
Medium (50,000-499,999) Communities in Region V												
06[3]	**58,266**	**37.0**	**2.8**	**5.5**	**37.2**	**24.1**	**8.2**	**15.9**	**61.7**	**46,729**	**17,985**	**5.4**
S	110,157	38.4	3.6	6.6	33.0	25.7	5.4	20.7	62.8	48,111	19,698	6.7
T	238,314	32.3	7.2	4.9	41.2	19.1	6.0	19.3	72.5	59,896	21,676	3.1
Large (≥ 500,000) Communities in Region IV												
02[4]	**662,047**	**36.0**	**41.3**	**9.3**	**34.8**	**24.7**	**8.6**	**33.5**	**61.5**	**45,951**	**20,892**	**11.6**
U	693,604	36.7	21.4	8.7	32.8	23.5	6.2	35.1	65.0	49,161	22,352	9.5
V	695,454	33.1	34.8	7.6	35.2	15.3	6.6	37.7	72.4	60,608	27,352	6.6

[3]Community 06 is one of 56 medium-sized (50,000-499,999) communities in the NEMIS population, one of 49 that received FEMA awards for wind and flood; one of 29 communities considered at high risk of wind; one of 64 communities considered at high risk of flood; one of 20 communities considered at high risk of both flood and wind; and one of eight communities in Region V. Communities S and T are the only other communities that meet all four of these criteria.

[4]Community 02 is one of 11 large (≥500,000) communities in the NEMIS population, one of 49 that received FEMA awards for wind and flood; one of 29 communities considered at high risk of wind; one of 64 communities considered at high risk of flood; one of 20 communities considered at high risk of both flood and wind; and one of thirty communities in Region IV. Communities U and V are the only other communities that meet all four of these criteria.

Appendix D
ASSUMPTIONS AND LIMITATIONS

D.1 Benefit-Cost Analysis of FEMA Mitigation Grants - Assumptions

D.1.1 Overall

Risk neutrality. This is a benefit-cost analysis, which requires the assumption of risk neutrality.

Seventeen categories of costs and benefits. Benefits were calculated as the expected present value of reduction in uncertain future losses. Costs were calculated as the expected present value of the cost to undertake a mitigation measure. Ten categories of benefit and seven categories of cost were considered, as listed in Tables 2 and 3 of the scoping study report for the benefit-cost analysis of FEMA mitigation grants (ATC, 2003a). Other benefits and other costs were ignored.

Constant 50-year or 100-year planning period. Unless otherwise noted, property mitigation efforts were assumed to be effective for 50 years for ordinary structures or 100 years for important structures and infrastructure, regardless of the age of the property mitigated. For convenience, mitigation efforts were treated as if they became effective on January 1, 2002 and remain effective until December 31, 2052.

Constant discount rates. Future economic values were brought to present value at time-constant discount rates of 2%, and results were sensitivity tested to discount rates between 0% and 7%. Value of human health was not discounted.

Present value of past prices per Consumer Price Index (CPI). All past prices were brought to present value (as of January 1, 2002) per the Consumer Price Index (U.S. Dept. of Labor, Bureau of Labor Statistics, 2004).

D.1.2 Repairs, Casualties, and Environmental Impacts

Accuracy of FEMA data. This project used as input three FEMA resources: the NEMIS database provided on July 23, 2003, geocoded information on flood projects provided on February 9, 2004, and data gleaned from FEMA grant applications. These data were assumed to be correct. (Note that limited Quality Control was performed on these data, per Porter [2004a]).

Accuracy of USGS and California Geologic Survey (CGS) site soil data. The US Geological Survey and the California Geological Survey have compiled GIS maps of site soils in California and elsewhere. See, e.g., Wills et al. (2000). These data were assumed to be accurate.

Accuracy of HAZUS-MH. The project team relied on the use of HAZUS-MH for estimates of mean annualized losses for earthquake and hurricane wind losses. While its accuracy remains to be fully proven over the course of time, it nonetheless, represents the only available national standard multi-hazard loss-estimation tool. The project team did not undertake testing or validation of the software.

Estimation of Flood Losses. Because the flood module in HAZUS-MH was in a pre-beta state at the time these analyses were conducted, the project team had to develop a less sophisticated and more empirically-based approach for estimating flood losses for large property portfolios. This new development pertained mainly to the estimation of flood depths. The project team, however, utilized the damage functions that are contained in the HAZUS flood module to estimate expected damage given a particular flood depth.

Adequacy of assumed hazard strata. The project team assumed that hazard levels can be stratified as low, medium, or high, for each of three perils: flood, earthquake, and wind. The stratification scheme for wind and earthquake is defined in the scoping study report for the benefit-cost analysis of FEMA mitigation grants (ATC, 2003a); the flood hazard stratification scheme is defined in an internal written communication (Porter, 2004b).

Value of human health per FHWA assumptions. Values were assumed for unpriced resources, most notably the environment and human health. For human health, values for statistical deaths and injuries per FHWA (1994) were assumed.

Constant hazard levels. Unless otherwise noted, hazard levels were assumed to be time-invariant as codified in HAZUS-MH.

Projects approved before 1 January 1994 were ignored. Per McLane (2004), the project excluded from its scope of work all projects with an approval date of December 31, 1993 or earlier.

No interaction between projects. Unlike the Community Studies, The benefit-cost analysis of FEMA mitigation grants assumed no interaction between mitigation efforts, i.e., mitigation effort X does not increase or reduce costs or benefits for mitigation effort Y, for different X and Y.

D.2 Benefit-Cost Analysis of FEMA Mitigation Grants - Limitations

D.2.1 Repairs, Casualties, and Environmental Impacts

Sociological benefits are probably underestimated. The major limitations in evaluating the sociological benefits of mitigation are: (1) sociological benefits are not easily quantifiable; (2) sociological benefits are very rarely included in cost-benefit analysis and as a result, there are not state-of-the-art models to build from; (3) sociological data are not readily and easily available; and (4) because of the difficulties of data collection, the quantifiable sociological benefits of mitigation are limited to two major variables: casualties and displaced households. As a result, sociological benefits of mitigation are probably underestimated.

Environmental benefits may be underestimated because of lack of data. The major limitation in evaluating the environmental benefits is the lack of information on the environmental effects of any given mitigation project. Without this information, the project team assumed that the environmental benefits are zero or a very small component of the total benefits. As a result, environmental benefits will tend to be underestimated.

D.2.2 Direct Business Interruption

1-3 year old Business Interruption (BI) data. Most input data for direct business interruption calculations are 1-3 years old. There is no known bias, although accuracy is less by some unknown amount than if current BI data were available.

Several HAZUS default values used. The following variables will always require the use of HAZUS default values: relocation costs, repair duration, building recovery time, rental income, and recapture factor. See Table 2 of the *Project Pilot Study: St. Agnes Medical Center* (ATC, 2003b) for the location of HAZUS default values. There is no known bias, although accuracy is less by some unknown amount than if site-specific data were available.

Reliance on some recent IMPLAN I-O variables. The following variables were adapted (data transfer) from value-added composition of the most recent U.S. IMPLAN Input-Output Table: capital-related income, wages and salaries, and rental income. There is no known bias, although accuracy is less by some unknown amount than if site-specific data were available.

Direct BI not applicable for residences. Direct business interruption losses are not applicable to residences directly impacted by the hazard. The project team believes this is a reasonable assumption that does not bias the results.

D.2.3 Indirect Business Interruption

Regional economy delineated by county or county group. The regional economy is delineated as a county or county group (metropolitan area) that incurs physical damage, when, in fact, most economic regions, or trading areas, do not conform precisely to political boundaries. The political boundary is likely to be larger than the trading area. The result is that estimates of the regional economy are biased upward, with accuracy less than if regional economy mapped with more attention to each individual case. At the same time, indirect business interruption impacts are limited by the same boundaries, with the result of a likely downward bias.

Transfer payments set to zero. To exclude transfer payments, outside aid (government aid, private philanthropy, and insurance payments) are set at zero. Note, this still allows for reconstruction spending, but it is offset as individuals and businesses repay loans or replenish savings. This is a controversial point; whether it produces any bias has not yet been determined.

Use of HAZUS Level-1 "synthetic" regional input-output tables. These tables were developed from a sample of actual IMPLAN regional I-O tables in three categories for earthquakes and wind hazards: (1) manufacturing/service, (2) service/manufacturing, and (3) service/trade. Two additional categories relating to agriculturally-based economies are included in the HAZUS flood version. This improves the accuracy of the flood module relative to the wind and earthquake models. The HAZUS input-output (I-O) algorithm is superior to standard I-O formulations. It retains the standard limitations: (1) lack of input substitution, and (2) absence of the explicit role of prices, both of which reduce accuracy. The effect is a bias toward higher indirect business interruption losses. The use of HAZUS Level-1 I-O tables offers greater accuracy than the standard I-O model, in two respects: (1) flexible import and export structures, as well as inventories, to eliminate shortages and surpluses, and (2) explicit constraints on capacity, especially with regard to construction.

1-3 year-old I-O data. Most input data and the I-O tables are 1-3 years old. Accuracy is reduced, with an unknown bias.

Unemployment rate is used as a proxy for excess capacity. Accuracy is reduced, and BI impact estimates experience an upward bias.

HAZUS default values used. The following variables will always require the use of default values (see Table 3 of the *Project Pilot Study: St. Agnes Medical Center* [ATC, 2003b]): (1) import capability - all sectors, though differentiated, (2) export capability - all sectors, though differentiated, (3) restoration of function - all sectors, though differentiated, and (4) rebuilding pattern - all sectors, though differentiated. Accuracy is reduced, but there is no known bias.

Best available data used for other parameters. The following variables are specified with best available data: (1) inventory demand - all sectors, though differentiated, (2) inventory supply - all sectors, though differentiated, and (3) discount rate. Accuracy is reduced, but there is no known bias.

Indirect business interruption losses are not applicable in several cases. These cases are those where the mitigation grant is confined to: (1) residences (reasonable assumption, no known bias) or (2) individual or small in-city groups schools, libraries, hospitals, and fire houses (reduces accuracy, downward bias). In most instances, these cases have no forward linkage to business and backward linkages are maintained by the absorption of their activity by similar units within the region.

D.3 Community Studies — Assumptions

D.3.1 Overall

Scope of Quantification. The main charge of the quantitative side of the community studies is to evaluate benefit-cost ratios for FEMA grants, including market spillover effects when they occur, and spin-offs of these grants. The community studies provide only qualitative accounts of allied or collateral risk-reduction activities. In many cases, as for process grants, qualitative cost-effectiveness accounts were provided.

Interaction between the benefit-cost analysis of FEMA Mitigation Grants and the Community Studies. Local data and circumstances were much richer for the community studies than for the benefit-cost analysis of FEMA mitigation grants. Quantitative studies performed in the community studies provided a feedback loop for the benefit-cost analysis of FEMA mitigation grants in the sense that details found in the field often assisted in clarifying and supplementing more national data. Moreover, the community quantitative studies served as a vanguard for the benefit-cost analysis of FEMA mitigation grants to the extent that quantitative procedures were developed for several unexpected situations. These included consideration of tornado risks, debris flow risks, chlorine releases, underground flood risks to wastewater and storm drain systems, central business district spillover effects, various flood structural mitigations such as diversions, berms, and detention ponds, various flood acquisition and elevation risk reduction activities in cases in which local flood hazards are challenging to model, and localized distress in emergency services when floods cut a community into two isolated areas.

Use of Local Results. In some cases, The community studies found that the risk evaluation tools used by local practitioners are sometimes far more advanced than the more economic methods used in the community studies. Some tools used locally have been exercised over years and sometimes decades by specialists. Small libraries of technical reports sometimes exist that provide support for decisions made. In some cases, owing to resource constraints, all pertinent activities could not be analyzed in the community studies (e.g., acquisitions made for properties in over a dozen riverine basins). In all cases, however, the community studies provided an independent check of general results for a community. In no cases were local results, however credible, used as the sole basis for this independent check.

Treatment of Uncertainties. The community studies have in some instances exposed rather than reduced uncertainties in risk evaluations. Even when risk evaluation tools are mature, but even more clearly when these tools are less mature, the number and variety of possible sensitivity evaluations can become very large (see Porter et al., 2002, Taylor et al., 2004).

Identification of Key Parameters for Benefit-Cost Estimation. Representations of results will stress the primary issue of the credibility of favorable versus unfavorable benefit-cost outcomes. Hence, sensitivity evaluations focused on some of the major parameters affecting this determination.

Acceleration of Pre-Disaster Mitigation Activities. Evaluations of instances in which risk-reduction activities are moved forward in time (i.e., accelerations), are consistent with principles implied by Carol Taylor West (2004).

Discount Rates. Same as assumed for the benefit-cost analysis of FEMA mitigation grants.

Risk Neutrality. Same as assumed for the benefit-cost analysis of FEMA mitigation grants. Exceptions were considered especially on private expenditures for such matters as safe rooms. The assumption that concave elements (risk averse elements) in preference functions play a key role in local and private investments has long been emphasized in the literature (see Markowitz, 1959).

Interaction Between Project Grants. The community studies considered interactions among project grants. This was accomplished through an analysis of spin-off and/or collateral risk reduction activities.

*Augmentation of NEMIS Data. F*ield data were found to clarify or modify as needed NEMIS data on such matters as actual costs.

Useful Life of Projects. Fifty-year time horizons for projects were assumed unless field data suggested otherwise. Some sensitivity evaluations on this matter were made for benefit-cost outcomes for which this assumption may be critical.

Present Value Calculations. Same as assumed for the benefit-cost analysis of FEMA mitigation grants.

D.3.2 Direct Loss Estimation

HAZUS®MH. The community studies relied on HAZUS®MH in all cases in which it is mature with respect to materials and practices for developing risk evaluations. These cases include its use for evaluating earthquake risks, and the response of buildings to severe winds. For estimating flood losses, the project team had to develop a less sophisticated and more empirically-based approach that uses HAZUS damage functions but alternative methods for estimating flood depths.

D.3.3 Indirect Loss Estimation

Indirect Losses. Same as assumed for the benefit-cost analysis of FEMA mitigation grants. Grants pertaining to residential structures were assumed not to be subjected to indirect loss estimation. None of the first seven communities studied yielded grants or spin-offs that would induce the use of indirect loss estimation tools.

D.4 Community Studies - Limitations

Limitations in Loss Estimation Modeling. The maturity of risk assessment tools in cases where HAZUS cannot be used in its entirety ranges from poor to good. Less mature tools are often those in which risk evaluations are often made with either tools dependent on very localized information or in which risk judgments are often made more qualitatively. (See ALA, 2002, especially Section 2, on how models for diverse natural hazards compare in terms of the maturity of risk evaluation practices.) Additional qualifications on results were added to this report to convey the state-of-the-practice in cases in which HAZUS is not used in its entirety.

Appendix E
CASUALTY ESTIMATION METHODOLOGY

E.1 Earthquake – Structural Mitigation Projects

The most developed component of HAZUS is the earthquake module, which was used on this project to determine the benefits of Structural Mitigation projects (e.g., retrofitting a building to improve the earthquake resisting properties of its structural framing system). The benefit of mitigation, expressed in terms of reduced casualties, is the difference between the number of casualties for the structure in its unmitigated state, and the number of casualties for the structure in its mitigated (e.g., retrofitted) state. HAZUS bases its casualty methodology primarily on structural and nonstructural damage. The methodology does not consider casualties due to secondary sources such as power outage or car accidents. The methodology uses casualty rates predominantly based on ATC-13 (Applied Technology Council, 1985), but updated through historical data. (ATC-13 documents an earthquake loss-estimation methodology and provides extensive damage-evaluation data for California). The HAZUS methodology for estimating casualties from structural damage combines a variety of inputs from other HAZUS modules including the probability of being in the damaged state and the relationship between the general occupancy classes and the model building type with specific casualty inputs in combination with occupancy data and time of event. Table E-l highlights the inputs needed for the HAZUS earthquake casualty estimates.

The output from HAZUS reports casualties based upon magnitude of modeled event, day or night scenario, and estimated injury classification. Injury classification focuses on the severity of the estimated injury.

Table E-1 Input variables for HAZUS casualty module in relation to damage state

Variable	Slight	Moderate	Extreme	Complete		Comments
1. Occupancy						
a. 2 p.m.	Same	Same	Same	Same		Day Occupancy
b. 2 a.m.	Same	Same	Same	Same		Night Occupancy
2. Indoor Casualty Rates				*No Collapse*	*Collapse*	Default based on building type
a. Severity 1	.05	.25	1	5	40	
b. Severity 2	0	.030	.1	1	20	
c. Severity 3	0	0	.001	.01	5	
d. Severity 4	0	0	.001	.01	10	
3. Collapse Rate	n.a.	n.a.	n.a.	10%		Default based on building type
4. Probability of Building being in Damage State	Default	Default	Default	Default		Input from other HAZUS Modules

Severity 1 injuries are the least life threatening, but may require basic medical aid from paraprofessionals such as paramedics. Severity 2 injuries require more medical care and the use of medical technology such as x-ray. These types of injuries are not expected to be life threatening. Severity 3 injuries pose an immediate life threatening condition if not treated quickly and thoroughly. Severity 4 injuries instantly kill or mortally injure (see HAZUS Technical Report, Table 13.1)

Translating injuries and loss of life into quantifiable dollar figures is difficult. Estimates of the value of life vary greatly – from $1 to $10M depending on the agency and use of the figure (Porter, 2002). One of the most applicable figures is from a 1998 study for the Federal Aviation Administration by Hoffer et al. (1998), who estimate the value of a human life at $3M. The methodology uses the $3M figure as its estimate for loss of life.

The development of injury costs for each HAZUS level used Federal Highway Administration data. The least serious injury is valued at $17,000 while the most extreme, loss of life, uses the $3 million FAA estimate discussed above. These values are used for all hazards.

E.2 Earthquake — Nonstructural Mitigation Projects

HAZUS is unable to model the benefit of nonstructural mitigation (projects that result in reduced casualties as a result of reduced damage to nonstructural components, such as ceilings and light fixtures) as it relates to deaths and injuries. For this project, three broad types of nonstructural mitigation were most prevalent: pendant lighting retrofit in schools, ceiling retrofit, and various types of bracing. A literature search revealed that little data exist to help model the reduction of injuries and deaths from these three types of nonstructural mitigation projects. Most available studies examine injuries that occur from other kinds of nonstructural damage. This is because no major earthquake has occurred during school and work hours. Following the 1994 Northridge Earthquake it was reported that "The Northridge Earthquake caused hundreds of lighting units to fall onto desks in classrooms that the students and teachers would normally occupy during a school day. Fortunately, the earthquake occurred early in the morning when the schools were closed in observance of Dr. Martin Luther King, Jr. Day (FEMA, 2004)". Such information highlights the issue, but does not provide enough data to estimate the probability either that lights will fall or that falling lights will injury people.

This project conservatively estimates the benefits of this type of mitigation. Assumptions are based on engineering judgment developed and reviewed by individuals with considerable experience in earthquake engineering and mitigation.

Seligson et al. (1998) suggest that without mitigation, pendant lighting in areas with high shaking likelihood has a moderate probability of falling, and with mitigation, a low probability of falling. The authors do not estimate numeric savings, but the methodology used here focuses on "low probability" of falling as a general guideline.

The project team estimated that without mitigation, between 1% and 10% of pendant lights will fall in earthquakes some time during the life of the building (assumed to be 50 years). A best-estimate value of 5% is used. Next, the method assumes that mitigation reduces the potential for collapse by half. Thus, 2.5% of the lights would have fallen during the next 50 years but will not fall after mitigation. Therefore, if a mitigation project replaces 1,000 pendant lights, 25 lights that would have fallen in an earthquake prior to mitigation now will not fall.

A second assumption relates to how many of those 2.5% (or in the above example, 25) would injure a person. The project team considered a variety of issues that would influence whether someone was injured from a falling pendant light including: (1) likelihood of a light falling where someone was standing or sitting immediately before the earthquake and (2) the likelihood that an individual would either not take protective action or that that action would be inadequate to protect him or her from being hit by the falling debris.

While empirical data are unavailable about these important likelihoods, it is asserted that: (1) the likelihood of a light falling on someone depends on how desks and classrooms are set up (when projects mitigate lights in schools) or where people are located spatially within a room or building; and (2) in areas with high earthquake risk, people are taught to take protective measures when they first become aware of ground shaking. In schools, children receive specific education to go under their desks, and as with fire, they routinely participate in earthquake drills. For purposes of this project, pendant lights are assumed to be approximately 6 inches wide, spaced approximately 6 ft apart, and typically almost the length of the room, meaning they hang over approximately 8% of the floor area. It is also assumed that a falling light could harm someone standing beneath or within 9 inches on either side of the light, thus affecting approximately 33% of the floor area, and therefore impacting 33% of unprotected occupants. Since schools are occupied approximately 25% of the time, it is assumed that approximately 0.33 x 0.25 or 8% of unprotected occupants would be injured if a light fell on them. Further assuming a 50-50 chance that an occupant would effectively protect him- or herself, 4% of the lights that would fall are judged to hit someone and, thus, could cause a major injury in the context of HAZUS.

A similar methodology was used for ceiling retrofit and upgrade. In this case, it was assumed that 2.5% of the retrofitted area would have fallen if the retrofit had not occurred and that, for every 300 square feet of area (area assumed to be occupied by one person) that would not have fallen, an injury would be avoided. Therefore, if a project mitigated 100,000 square feet of ceiling, 2,500 square feet that may have fallen without mitigation will not fall with the mitigation, and of that 2,500 square feet, 8.3 injuries will be avoided (2,500 divided by 300). For mitigation of hard ceilings, the assumption is a reduction of a moderate HAZUS 2 injury, and for hanging ceilings which tend to be a lighter material, the assumption is a reduction of a minor HAZUS 1 injury.

While these estimates appear reasonable, caution must be used when considering them. The estimates are based on assumptions developed using engineering judgment, but are not grounded in empirical evidence. They should not be considered as exact empirically driven estimates, but rather, as best estimates considering available data and sound engineering judgment.

E.3 Flood Mitigation Projects

The majority of flood mitigation projects recorded in NEMIS are buy-outs of repeatedly flooded properties that HAZUS cannot model. To quantify social benefits, a method was developed that considers the number of units bought as part of each project. The method uses data on a variety of flood events that was published by the Center for Disease Control in *Morbidity and Mortality Weekly*. The challenge was to find reports that used households as the unit of analysis and, thus, could be applied to the current project.

Reports were examined on the Midwest Floods in 1993 (CDC MMWR Weekly, October 22, 1993), a 1994 flooding event in Georgia (CDC MMWR Weekly June 29, 1994), and Tropical Storm Allison in Houston (CDC MMWR Weekly May 3, 2002). The first two studies examined the deaths and injuries reported by hospitals and medical examiners while the third study examined injuries within households. The main hazard that resulted from Tropical Storm Allison was flooding. A cluster sample of housing units in selected census tracts was surveyed. Instead of relying on medical examiners or hospital reports, this assessment of injuries relied on self-reports from households.

The Tropical Storm Allison methodology is the most applicable to the current project since it uses housing units as the unit of analysis. While flood intensities do vary, we can already assume that the properties have a high likelihood of being flooded considering their inclusion in the buy-out program.

The Tropical Storm Allison study indicated that 8% of survey respondents reported that at least one person in their household experienced a flood-related injury. Flood related injuries include falls, blunt injuries, animal bites, and cuts or puncture wounds.

One of the major limitations of this method is that it focuses on one flooding event. As a result, the method uses one-half of the injury rate reported in the Allison study (4%) as the rate of injury for the properties purchased. Sensitivity studies used 2% and 8% as the lower and upper bound.

E.4 Wind Mitigation Projects – Hurricane

The majority of hurricane wind projects involved installing or upgrading hurricane shutters on a variety of public buildings such as city halls or hospitals. Because there is a warning period before hurricane landfall, most public buildings have little if any occupancy during a hurricane. The major exceptions are schools that act as hurricane shelters and hospitals that cannot evacuate all patients. Developing a methodology to estimate the social benefits of shutter mitigation was challenging. As a result, the method focuses on only those buildings used as shelters. Two hospital projects in the sample are not included because little empirical evidence supports the development of an appropriate method.

Similar to the flood methodology, the hurricane shutter methodology is based on three Center for Disease Control reports of injuries sustained in hurricane events. Injury estimates are conservative, and focus on injuries reported during hurricanes where evacuation orders were in place

The first report focuses on 1992's Hurricane Andrew in Louisiana (see CDC MMWR Weekly, April 9, 1993, 42:130). Findings indicate that the three parishes closest to the hurricane's track had injury rates over 200 per 100,000. Using these numbers, the hurricane injury rate is 0.2% for this storm.

In 1995, Hurricane Opal made landfall in the Florida Panhandle with sustained winds of 115 mph (Category III on the Saffir-Simpson Scale). A review of emergency department records for the six days before Hurricane Opal made landfall and the six days after Hurricane Opal made landfall shows no significant change in the number of visits for lacerations, wounds, sprains and fractures (CDC MMWR Weekly, February 2, 1986, 45:4).

A more recent CDC MMWR report focused on 2003's Hurricane Isabel, which made landfall on the Outer Banks of North Carolina. Using a cluster sample methodology, 210 interviews were completed (62.3% response rate). These 210 interviews represented 93,738 occupied housing units. Of the 210 interviews, only two households reported a hurricane related injury. Using these numbers, the hurricane injury rate is 0.9% for this storm.

Since these injury rates are case specific, the Project Team averaged the two rates to get a point estimate of 0.0055, and used .002 as the lower bound for a sensitivity study and .009 as the upper bound.

For each school shuttering project, the schools that were shuttered were divided into those that are used as shelters and those that are not designated as shelter . Based on the assumption that over the life of the project one hurricane will occur that will fill the shelter, shelter capacity information was retrieved from the State of Florida emergency management shelter status website (http://www.eoconline.org/EM_Live/shelter.nsf), and the proportions designated above were applied to represent quantified reduction in injuries. The majority of the shelter projects are in the State of Florida. Projects not in Florida are harder to model since required data, such as shelter capacity, are not readily available. The injuries avoided are moderate, HAZUS Level 2 injuries.

The assumption of one Andrew or Isabel-sized hurricane per 50 years is probably reasonable or modestly conservative. Hurricane Andrew's peak gusts were roughly 140 mph, approximately equal to 50-year design wind speeds, per NOAA. Hurricane Isabel's peak gust velocities were roughly 100 mph over a fairly wide region (NOAA, 2003). The 50-year design wind speeds there are approximately 130 mph, indicating that Isabel's wind speeds have an approximately 10-year recurrence period using Peterka and Shahid's wind speed-recurrence relationship (1998).

While the numbers appear conservative because they reflect evacuation, data from Hurricane Andrew supports the numbers. Hurricane Andrew had about 14 deaths (out of a population of 1.9M) directly due to the hurricane in an area that had limited evacuation. Using these numbers, the mortality rate would be approximately .000007368. This area had limited evacuation since evacuation is based on water (storm surge) and not wind. The area hardest hit by Hurricane Andrew was the southernmost locations such as Florida City, Homestead, and Kendall. These areas suffered significant damage, but were inland as compared to areas such as Miami Beach that were subject to evacuation orders. In fact, many people evacuated from low-lying areas to the area that was most devastated by the winds.

E.5 Wind Mitigation Projects – Tornado

The majority of tornado wind mitigation projects focus on construction or retrofit of saferooms in public spaces such as schools. HAZUS at present cannot model casualty estimates for tornadoes, so a probabilistic site-specific method of estimating the benefit of tornado saferooms was developed.

Using this methodology, the U.S. is first divided into 1 degree x 1 degree cells, and then, tornado touchdowns are counted. A baseline model is calculated to estimate annualized frequency at a site. This estimate uses models to determine response of structures to wind velocities and to estimate casualties per damage degree. The probabilities of occurrence are aggregated to different Fujita levels to correspond with 100 mile per hour and 200 mile per hour values. The following table illustrates the injury rates used for the tornado estimation:

Table E-2 Injury rates used for tornado estimation

		Casualties per 1000 people**		
Degree of Damage	Damage State (percent damage)*	minor injuries	major injuries	deaths
minor	2%	0.1	0.01	0
moderate	10%	1.2	0.16	0.04
severe	50%	68.57	9.14	2.29
destruction	100%	400	400	200

* Repair cost divided by replacement cost
** Based on ATC-13 Injury and death rates

This methodology estimates the reduction in annualized casualties after mitigation, and the cost per injury type discussed above in the earthquake section, is applied to estimate dollar benefit of mitigation activities.

Appendix F
HAZUS INJURIES AND THE ABBREVIATED INJURY SCALE

F.1 Overview

To obtain monetary value for avoiding statistical injuries (including fatal injuries), the project team used the monetary values of avoided statistical injuries assigned by the Federal Highway Administration (FHWA 1994). That study attached values to the six-category Abbreviated Injury Scale (AIS). These values are comprehensive, in that they reflect pain and lost quality of life, medical and legal costs, lost earnings, lost household production, etc. Medical costs alone represent a relatively small portion of the comprehensive cost, typically 10% or less.

When actual injuries are coded in research studies, a single person does not necessarily receive a single code; each individual injury is coded. Thus, if the AIS scale is being used to code the injuries obtained, one can code each injury, record the maximum AIS level, or combine the injured person's AIS scores to produce a single number for further data processing and analysis.

Regardless of these issues, the AIS is a commonly used scale with equivalent monetary values assigned by agencies of the US government explicitly for use in cost-benefit analysis. The challenge for this project was to apply the AIS and its monetary values to HAZUS injuries. HAZUS's injury levels are not defined in terms of AIS injuries, and the HAZUS scale has four levels (1 through 4, where 4 is fatal) whereas AIS has six (1 through 6, where 6 is fatal).

This appendix describes the mapping between HAZUS injury severities to the AIS. Four references are examined here. The HAZUS Technical Manual (NIBS and FEMA, 2003a) provides a general description of each of four injury levels and provides 3 to 5 examples of each; see Table F-1, below. The AIS dictionary (AAAM, 2001) lists approximately 1,300 injuries, each provided with a distinct 7-digit numerical injury identifier, of which the last digit after the decimal place is the AIS level. The differences between HAZUS and AIS injury definitions virtually assure an ambiguous mapping between HAZUS and AIS levels.

In an attempt to reduce the ambiguity in mapping, two additional publications were examined. Peek-Asa et al. (1998) and Mahue-Giangreco et al. (2001) both studied large numbers of medical records of people injured in the 1994 Northridge earthquake. However, neither study includes transcriptions of the injuries studied as they were described in the medical records, prior to coding using AIS. In addition, neither the number of injuries nor the type of treatment by assigned AIS score was reported. No other readily available data were found about relative frequencies of AIS injury levels within HAZUS injury levels, based on data from the Northridge Earthquake or other natural disasters.

The method applied for this project was to quote the example injuries as given in the HAZUS Technical Manual Table 13.1 (duplicated in Table F-1 below), list several AIS injuries that appear to correspond to each HAZUS example, and note the range of possible AIS levels for each example. It is not defensible to infer relative frequencies with which injuries at a given AIS level occur simply by counting the number of distinct AIS injuries that correspond to a particular HAZUS level.

Only HAZUS levels 1, 2, and 3 were examined. HAZUS level 4 (fatal) was unequivocally mapped to AIS level 6 (maximum), so no detail was required to support this mapping.

Table F-1 HAZUS Injury Classification Scale

Injury Level	Injury Description
Severity 1	Injuries requiring basic medical aid that could be administered by paraprofessionals. These types of injuries would require bandages or observation. Some examples are: a sprain, a severe cut requiring stitches, a minor burn (first degree or second degree on a small part of the body), or a bump on the head without loss of consciousness. Injuries of lesser severity that could be self treated are not estimated by HAZUS.
Severity 2	Injuries requiring a greater degree of medical care and use of medical technology such as x-rays or surgery, but not expected to progress to a life threatening status. Some examples are third degree burns or second degree burns over large parts of the body, a bump on the head that causes loss of consciousness, fractured bone, dehydration or exposure.
Severity 3	Injuries that pose an immediate life threatening condition if not treated adequately and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome.
Severity 4	Instantaneously killed or mortally injured

F.2 HAZUS Level 1

The project team assigned the monetary value of avoiding a HAZUS level-1 injury the geometric mean of the monetary values of avoiding injuries of AIS levels 1 and 2. (By geometric mean is meant the square root of the product, i.e., cost = $(\text{cost}_1 \times \text{cost}_2)^{1/2}$. It produced a result less than the simple arithmetic average, as if the lower value were somewhat more likely than the upper value.) From the HAZUS technical manual (see Table F-1), HAZUS injury level 1 is described as "Injuries requiring basic medical aid that could be administered by paraprofessionals. These types of injuries would require bandages or observation. Some examples are: a sprain, a severe cut requiring stitches, a minor burn (first degree or second degree on a small part of the body), or a bump on the head without loss of consciousness." Table F-2 lists examples of AIS injuries that roughly correspond to example HAZUS level 1 injuries (i.e., include the words used in the HAZUS injury descriptions). Note that the last digit in the numeric identifier of each AIS coded injury is the AIS level for that injury. For example, "750620.1 Elbow joint sprain" is AIS level 1. The range of AIS levels in Table F-2 is 1 to 3.

F.3 HAZUS Level 2

The project team equated HAZUS level 2 and AIS level 3. From the HAZUS technical manual (see Table F-1), HAZUS injury level 2 is described as "Injuries requiring a greater degree of medical care and use of medical technology such as x-rays or surgery, but not expected to progress to a life threatening status. Some examples are third degree burns or second degree burns over large parts of the body, a bump on the head that causes loss of consciousness, fractured bone, dehydration or exposure." Table F-3 lists AIS injuries that roughly correspond to example HAZUS level 2 injuries (i.e., include the words used in the HAZUS injury descriptions). The range of AIS levels is very broad, ranging between 1 and 5.

F.4 HAZUS Level 3

The project team assigned the monetary value of a HAZUS level 3 injury the geometric mean of the monetary values of AIS 4 and 5. From the HAZUS technical manual (see Table F-1), HAZUS injury level 3 is described as "Injuries that pose an immediate life threatening condition if not treated adequately

Table F-2 HAZUS Level-1 injuries and related AIS-coded injuries

HAZUS example	Similar AIS-coded injuries, with numerical injury identifier. The last digit is the AIS level.	AIS
A sprain	The word "sprain" appears 14 times in the AIS dictionary. Some instances are:	
	750620.1 Elbow joint sprain	1
	751020.1 Shoulder sprain	1
	751420.1 Wrist sprain	1
	850206.1 Ankle sprain	1
	850404.1 Foot joint sprain	1
	850826.2 Knee sprain	2
A severe cut requiring stitches	The AIS dictionary contains 179 instances of "laceration." Here are 14 that could be called a severe cut, representing 2 kinds of injuries on each of 7 body sections. A third was identical to the first two, except with blood loss >20% by volume; this injury level is considered HAZUS level 3.	
	110602.1 Scalp laceration, minor	1
	110604.2 Scalp laceration, major (> 10 cm long and into subcutaneous tissue)	2
	210602.1 Face skin/subcutaneous/muscle laceration, minor, superficial	1
	210604.2 Face skin/subcutaneous/muscle laceration, major (> 10 cm long on hand or 20 cm long on entire extremity and into subcutaneous tissue)	2
	310602.1 Neck skin/subcutaneous/muscle laceration, minor, superficial	1
	310604.2 Neck skin/subcutaneous/muscle laceration, major (> 10 cm long on hand or 20 cm long on entire extremity and into subcutaneous tissue)	2
	410602.1 Thorax skin/subcutaneous/muscle laceration, minor, superficial	1
	410604.2 Thorax skin/subcutaneous/muscle laceration, major (> 10 cm long on hand or 20 cm long on entire extremity and into subcutaneous tissue)	2
	510602.1 Abdomen skin/subcutaneous/muscle laceration, minor, superficial	1
	510604.2 Abdomen skin/subcutaneous/muscle laceration, major (> 10 cm long on hand or 20 cm long on entire extremity and into subcutaneous tissue)	2
	710602.1 Upper extremity skin/subcutaneous/muscle laceration minor, superficial	1
	710604.2 Upper extremity skin/subcutaneous/muscle laceration, major (> 10 cm long on hand or 20 cm long on entire extremity and into subcutaneous tissue)	2
	810602.1 Lower extremity skin/subcutaneous/muscle laceration minor, superficial	1
	810604.2 Lower extremity skin/subcutaneous/muscle laceration, major (> 10 cm long on hand or 20 cm long on entire extremity and into subcutaneous tissue)	2
A minor burn (first degree or second degree on a small part of the body)	The AIS dictionary contains 3 injuries that meet these criteria:	
	912002.1 Burn, 1°, > 1 yr old, any fraction of total body surface area	1
	912004.2 Burn, 1°, ≤ 1 yr old, >50% of total body surface area	2
	912006.1 Burn, 2°, <10% of body area	1
A bump on the head without loss of consciousness.	Aside from 110402.1, the AIS dictionary lists 4 injuries that explicitly exclude unconsciousness.	
	110402.1 Scalp contusion (includes subgaleal hematoma)	1
	160402.1 No prior unconsciousness, but may have headache or dizziness known to be a result of	1
	head injury	2
	160404.2 [Same as 160402.1] with neurological deficit	2
	160602.2 Lethargic, stuporous, obtunded post resuscitation or on limited observation at scene	
	(can be aroused by verbal or painful Stimuli; GCS* 914), no prior unconsciousness.	3
	160604.3 [Same as 160602.2] with neurological deficit	

and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome." Table F-4 lists AIS injuries that roughly correspond to HAZUS level 3 injuries (i.e., include the words used in the HAZUS injury descriptions). The associated AIS levels range from 3 to 5.

F.5 Discussion

Peek-Asa et al. (1998) examined medical records of hospitalized injury victims of the 1994 Northridge Earthquake. They coded injuries according to the Abbreviated Injury Severity (AIS) scale. The Injury Severity Score (ISS) is also used, but it is calculated as a function of AIS (ISS is calculated as the sum of the squares of the highest AIS code in the three most severely injured body regions.) The authors report that injuries most commonly affected legs and arms, but at least some injuries were recorded to all other body regions except the neck. The paper does not provide raw injury data, so no inferences can be made as to the relative likelihood of various AIS coded injuries within a HAZUS level.

Table F-3 HAZUS Level-2 injuries and related AIS-coded injuries

HAZUS example	Similar AIS-coded injuries, with numerical injury identifier. The last digit is the AIS level.	AIS
3rd degree burn, 2nd degree burn over large parts of the body	The AIS dictionary lists 12 nonfatal burn injuries meeting these criteria. They are: 912007.1 Burn, 3° ≤ 100 cm^2 (except face ≤ 25 cm) 912008.2 Burn, 3° > 100 cm^2 (except face ≥ 25 cm) up to 10% of total body surface 912012.2 Burn, 2° or 3° (or full thickness) 10-19% of total body surface 912014.3 Burn, 2° or 3° (or full thickness) 10-19% of total body surface, < 5 years old 912016.3 Burn, 2° or 3° (or full thickness) 10-19% of total body surface, face/hand/genitalia involvement 912018.3 Burn, 2° or 3° (or full thickness) 20-29% of total body surface 912020.4 Burn, 2° or 3° (or full thickness) 20-29% of total body surface, < 5 years old 912022.4 Burn, 2° or 3° (or full thickness) 20-29% of total body surface, face/hand/genitalia involvement 912024.4 Burn, 2° or 3° (or full thickness) 30-39% of total body surface 912026.5 Burn, 2° or 3° (or full thickness) 30-39% of total body surface, < 5 years old 912028.5 Burn, 2° or 3° (or full thickness) 30-39% of total body surface, face/hand/genitalia involvement 912030.5 Burn, 2° or 3° (or full thickness) 40-89% of total body surface	 1 2 2 3 3 3 4 4 4 5 5 5
A bump on the head that causes loss of consciousness	The AIS dictionary lists 27 injuries with explicit reference to unconsciousness. Some are: 160202.2 Head injury, unconscious < 1 hr 160204.3 Head injury, unconscious < 1 hr, with neurological deficit 160206.3 Head injury, 1-6 hr unconsciousness 160208.4 Head injury, 1-6 hr unconsciousness, with neurological deficit 160210.4 Head injury, 6-24 hr unconsciousness 160212.5 Head injury, 6-24 hr unconsciousness, with neurological deficit 160214.5 Head injury, >24 hr unconsciousness	2 3 3 4 4 5 5
Fractured bone	There are approximately 181 instances of the word "fracture" in the AIS dictionary. Here is a sample of 8. 450212.1 One rib fracture 450220.2 Two to three ribs fractured or multiple fractures of a single rib 450230.3 Three ribs on one side and no more than 3 ribs on other side, stable chest 450240.4 More than three ribs on each of two sides, with stable chest 752602.2 Humerus fracture, closed/undisplaced 752604.3 Humerus fracture open, displaced, or comminuted 851606.2 Fibula fracture, head, neck, shaft 851801.3 Femur fracture, open, displaced, or comminuted	 1 2 3 4 2 3 2 3
Dehydration	The word "dehydration" does not appear in the AIS dictionary	
Exposure	The word "exposure" does not appear in the AIS dictionary	

Mahue-Giangreco et al. (2001) similarly examined medical records and other emergency-department records, addressing a larger population of injury victims than Peek-Asa et al. (1998), because they included non-hospitalized injury victims as well as hospitalized injuries. As with Peek-Asa et al. (1998), Mahue-Giangreco et al. (2001) do not provide raw injury data, so no inferences can be made as to the relative likelihood of various AIS coded injuries within a HAZUS level.

F.6 Summary

Table F-5 lists AIS injury levels that are possible under each HAZUS level and shows the mapping used in the present study (Mapping 1), as well as an alternative mapping (Mapping 2).

The table shows that, considering the examples given for each HAZUS injury level, both the original and alternative mapping can be defended solely on the basis of the examples and the definitions of some of the 1,300 AIS-coded injuries in the AIS dictionary (AAAM, 2001).

Table F-4 HAZUS Level-3 injuries and related AIS-coded injuries

HAZUS example	Similar AIS-coded injuries, with numerical injury identifier. The last digit is the AIS level.	AIS
Uncontrolled bleeding	Neither the phrase "uncontrolled bleeding" nor just the word "uncontrolled" appear in the AIS dictionary. However, many injuries are qualified by amount of blood lost. The expression "blood loss >20%" appears approximately 31 times. Some examples follow. 110606.3 Scalp laceration, blood loss > 20% by volume 216006.3 Face penetrating injury, blood loss > 20% by volume 320212.4 Carotid (common, internal) artery, laceration, major (blood loss > 20% by volume) 320214.5 Carotid (common, internal) artery, laceration, major (blood loss > 20% by volume), with neurological deficit (stroke) not head injury related 416006.3 Thorax penetrating injury with blood loss > 20% by volume 716006.3 Upper extremity penetrating injury with blood loss > 20% by volume 816006.3 Lower extremity penetrating injury with blood loss > 20% by volume	3 3 4 5 3 3 3
Punctured organ	The word "puncture" appears approximately 42 times in the AIS dictionary, but always in relation to blood vessels, never organs. Some examples of internal-organ lacerations include the following. 441012.5 Heart laceration, perforation 441420.4 Lung laceration, with blood loss > 20% by volume 441422.5 Lung laceration, with tension pneumothorax 540624.4 Bladder laceration, perforation; full thickness but not complete transaction 541826.4 Liver laceration, parenchymal disruption of ≤ 75% of hepatic lobe or 1-3 Couinaud's segments within a single lobe; multiple lacerations > 3 cm deep; "burst" injury; major 542824.3 Pancreas laceration, moderate, with major vessel or major duct involvement	5 4 5 4 4 3
Spinal column injuries	The AIS dictionary lists approximately 80 spinal injuries, ranging from AIS 2 to 6. Some nonfatal examples: 630212.2 Cervical spine, brachial plexus injury, incomplete plexus injury, contusion (stretch injury) 630604.3 Lumbar spine, cauda equina contusion, with transient neurological signs, with fracture 630632.4 Lumbar spine, complete cauda equina contusion, with no fracture or dislocation 640224.5 Cervical spine, cord contusion, complete cord syndrome, C4 or lower, with no fracture or dislocation	2 3 4 5
Crush syndrome	The phrase "crush syndrome" does not appear in the AIS dictionary. There are approximately 27 instances of the word "crush" in the AIS dictionary. Some nonfatal examples are: 340212.5 Larynx, laceration, puncture, avulsion, crush, rupture; transection; massive destruction 340610.5 Pharynx or Retropharyngeal area, laceration, puncture, avulsion, crush, rupture; transection; massive destruction 640240.5 Cervical spine cord laceration (includes transection and crush) 640640.5 Lumbar spine cord laceration (includes transection and crush) 713000.3 Upper extremity massive destruction of bone and of muscles/nervous system/vascular system of part or entire extremity (crush)	5 5 5 5 3

Table F-5. Two options for mapping from HAZUS to AIS Injury levels

HAZUS level	AIS in Tables F-2 through F-4	AIS mapping 1		AIS mapping 2	
		AIS levels	Cost	AIS levels	Cost
1	1-3	1-2	$17,000	1	$6,000
2	1-5	3	$180,000	2-3	$114,000
3	3-5	4-5	$1,200,000	4-5	$1,500,000
4	Not addressed	6	$3,000,000	6	$3,000,000

No statistical data from natural disasters were readily available that might improve the mapping by providing actual rates of various AIS-coded injuries by HAZUS level.

The table also shows the equivalent monetary value of avoiding one such statistical injury, using government-endorsed values of avoiding statistical injuries, as listed in Table 4-3. It bears repeating that the costs in Table 4-3 and Table F-5 are comprehensive, reflecting medical costs, lost earnings, lost household production, emergency services, vocational rehabilitation, workplace costs, administrative, legal, pain and lost quality of life, and other factors. Medical costs alone represent a relatively small portion of the comprehensive cost, typically 10% or less.

Note that, where two AIS levels are applied to a single HAZUS injury level in Table F-5, the average of the two amounts is used. In the mapping for this project, where two AIS levels apply, the cost given in the table is the geometric mean, i.e., $\text{cost} = (\text{cost}_1 \times \text{cost}_2)^{1/2}$. This method reflects the notion that the lower level is more likely than the higher one. This approach may be considered overly complicated, and in the alternative mapping, the more common, easily-understood, simple arithmetic mean is applied, i.e., $\text{cost} = \frac{1}{2}(\text{cost}_1 + \text{cost}_2)$

F.7 Conclusion

The definitions of HAZUS injury levels in the HAZUS Technical Manual (NIBS and FEMA, 2003a) are somewhat vague and cannot be mapped uniquely to particular AIS levels using the AIS dictionary (AAAM, 2001). Empirical data are lacking to reduce or eliminate the ambiguity in mapping from HAZUS to AIS. As a result, the mapping is subject to judgment and disagreement. Either the mapping used for this project ("Mapping 1" in Table F-5), or an alternative examined here ("Mapping 2" in Table F-5), can be defended solely on the basis of a strict reading of the HAZUS Technical Manual and of the AIS dictionary.

Appendix G
PROPERTY LOSS ESTIMATION – FLOOD

This appendix describes the approaches followed for estimating property loss due to flood.

G.1 Locating the Structure within the Flood Plain

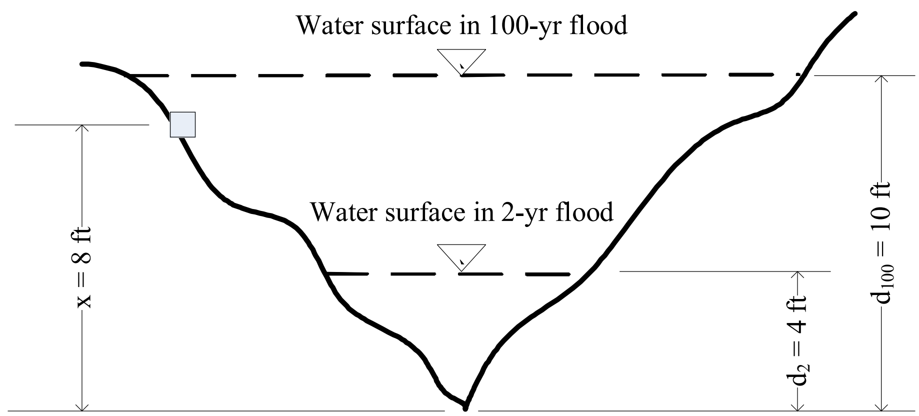


Figure G-1. Illustration of flood-loss calculation

Given: Let d_n denote the n-yr flood depth at the stream channel center. For example, d_{100} denotes the 100-year flood depth at a stream channel center, d_2 denotes the 2-year flood depth at a stream channel, etc. These flood depths are calculated using the methodology that is documented in Section G.5. For this illustration, assume that d_{100} = 10 ft and d_2 = 4 ft.

Let $\underline{d}$ denote the set of flood depths at the stream channel center, d_5, d_{10}, d_{20}, d_{50}, d_{100}, etc. (It is common notation to use an underline to indicate that a parameter is a vector, potentially containing many scalar values.)

Let x denote the height of the building site above the stream channel center, assuming that $x \geq 0$, i.e., the building is located at a higher elevation than the stream channel center. In the Figure G-1, x = 8 ft.

Let h_n denote the depth of flooding at the site in the n-yr flood. For example, h_{100} denotes the depth of flooding at a particular site in the 100-yr flood, h_{50} denotes the depth of flooding at the site in the 50-yr flood, etc. For any return period n,

$$h_n = \text{larger of } (h_n - x) \text{ and } 0 \qquad \text{(G-1)}$$

For example, in Figure G-1 and using the above equation, h_{100} = 2 ft, and h_2 = 0 ft. If x and $\underline{d}$ were known, it would be possible to calculate all the associated values of h.

Let & (ampersand) denote all of the information needed about a building to calculate loss, other than flood depth, such as the value of the building.

Let y_n denote the loss in the n-yr storm. For example, y_{100} denotes the loss given 100-yr flooding.

Let f denote a function that calculates loss for a known flood depth h and &. (Note: the depth-damage relationships in HAZUS are used but these functions are not detailed here.) Since h_n is a function solely of y and d_n, y_n can be expressed as:

$$y_n = f(x,\ d_n,\ \&) \qquad \text{(G-2)}$$

Let y_{ann} denote the average annualized loss to the facility, considering all possible depths h_n, the resulting losses y_n and their associated return periods, n. (Typically y_{ann} is calculated by numerical integration, which is not detailed here.)

Let g denote the function used to perform the numerical integration for y_{ann}. It uses several values of n for y_n. We denote by $\underline{y}_n$ the set of values y_n, and the associated set of return periods by $\underline{n}$, and write

$$y_{ann} = g(\underline{y}_n,\ \underline{n}) \qquad \text{(G-3)}$$

Problem statement: Assume that $\underline{d}$ can be calculated (this calculation is treated elsewhere), that "&" is known from the grant-application data, that the depth-damage relationships are known (which are taken from HAZUS), and that the numerical integration of the various values of loss and frequency can be calculated. In this case, x is not known precisely, owing to shortcomings in the grant-application data, geocoding difficulties, and the lack of a very accurate nationwide elevation model. The problem is: how can y_{ann} be calculated without a known value of x?

Solution:

Uncertain X. In this case, the elevation difference is recognized as uncertain, and is denoted using a capital letter, X. (Common mathematical notation. That is, x is a particular value, whereas X is uncertain and has a probability distribution.)

Uncertain Y_{ann}. Since X is uncertain, so is y_{ann}, in which case, the uncertain annualized loss is denoted by Y_{ann}. The goal is to obtain the expected value of Y_{ann}, which is denoted by $E[Y_{ann}]$. (That is, y_{ann} is a particular value for a known value x, Y_{ann} is uncertain and has a probability distribution, and $E[Y_{ann}]$ is a best-estimate, average value of Y_{ann}.)

Distribution of X. Next, it is assumed that $0 < X < d_{100}$, i.e., the building site elevation is somewhere between that of the stream channel center ($x = 0$) and the edge of the mapped 100-yr floodplain ($x = d_{100}$). Without any additional knowledge, according to information theory, the proper assumption is that X is uniformly distributed between 0 and d_{100}. That is, the difference in elevation between the building site and the stream channel center is equally likely to be 0, d_{100}, or anywhere in between. If more were known about the difference in elevation, a better assumption could be made, but without more knowledge, the best assumption for X is the uniform distribution.

Alternatives for simulating Y_{ann}. Given the values $\underline{d}$, the information &, the functions f and g, and the assumed distribution for X, samples of X can be created, y_{ann} can be calculated for each sample, and the expected value $E[Y_{ann}]$ can be calculated using the samples of y_{ann}. There are at least four reasonable methods (as described below) to select samples of X, illustrated in Figure G-2, which shows a cross-section (or transect) of a floodplain, gray boxes for sample sites, and the calculated flood level in the 100-yr flood.

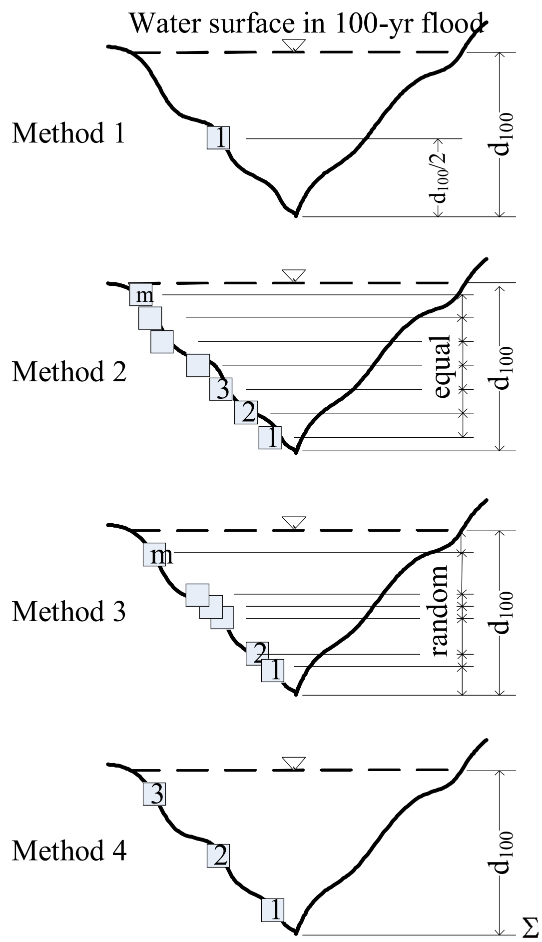


Figure G-2. Four methods of simulating X

Method 1: Select the best-estimate value of X, namely $x = d_{100}/2$, which yields x, $\underline{d}$, &, f, and g, and enables the calculation of y_{ann} as before. The problem is that f is a nonlinear function, in which case the estimate of y_{ann} might be significantly biased.

Method 2: Select m evenly spaced values of X: $x_i = i/m + d_{100}/(2m)$, where $i = 0, 1, \ldots m\text{-}1$. Calculate y_{ann} for each site i, and take the simple average, $E[Y_{ann}] = \Sigma_i(y_{ann,i})/m$, where $y_{ann,i}$ corresponds to sample x_i. This avoids the problem of nonlinear f, if enough samples are used.

Method 3: Use various Monte Carlo simulation approaches, in which X is simulated randomly m times. Calculate $E[Y_{ann}]$ as in Method 2.

Method 4: Use Hermite-Gauss quadrature, in which case a few samples of X are carefully selected and assigned weights (or probabilities) w_i, so that they match the first several moments of X (mean, variance, etc.). The losses $y_{ann,i}$ for each value of x_i, and a weighted average of the values $y_{ann,i}$ using the weights w_i are then calculated. This approach is similar to Method 2, except the values of x_i are not evenly spaced, and a weighted, rather than simple, average of the sample losses $y_{ann,i}$ is created. This approach provides a good estimate of $E[Y_{ann}]$ and is exact if f can be represented by up to a 5th-order polynomial.

Preferred Method: Hermite-Gauss quadrature for $E[Y_{ann}]$ (Method 4). Without presenting the pros and cons of each choice, we note that Method 4 is more accurate and efficient.

Following is the approach followed for estimating $E[Y_{ann}]$ using Method 4. Again, X is assumed to be uniformly distributed between 0 and d_{100}, and three Gauss points are used, which means that the uncertain X is replaced by three particular values, denoted here by x_1, x_2, and x_3, each with an associated weight (or probability), denoted by w_1, w_2, and w_3. Under these conditions,

$$\begin{aligned} x_1 &= 0.1127 * d_{100} \qquad w_1 = 0.2778 \\ x_2 &= 0.5000 * d_{100} \qquad w_2 = 0.4444 \\ x_3 &= 0.8873 * d_{100} \qquad w_3 = 0.2778 \end{aligned} \tag{G-4}$$

$E[Y_{ann}]$ is then computed as

$$E[Y_{ann}] = \Sigma_i(w_i * y_{ann,\mathrm{i}}) \text{ where } i = 1, 2, 3 \tag{G-5}$$

where Σ_i denotes summation over the three values of i, and where $y_{ann,i}$ denotes the annualized loss given site i. The methodology is illustrated in Figure G-3.

Imagine the 100-yr flood depth at the center of a certain basin (d_{100}) is 10 ft, as shown in Figure G-3, and that d_{20} = 3 ft and d_{50} = 6 ft. (In practice additional flood depths are used, but for illustration, consider just these three.) From Equation G-4, rounding for illustration purposes, x_1 = 1 ft, x_2 = 5 ft, and x_3 = 9 ft. Those elevations would put the building at sites 1, 2, and 3, respectively.

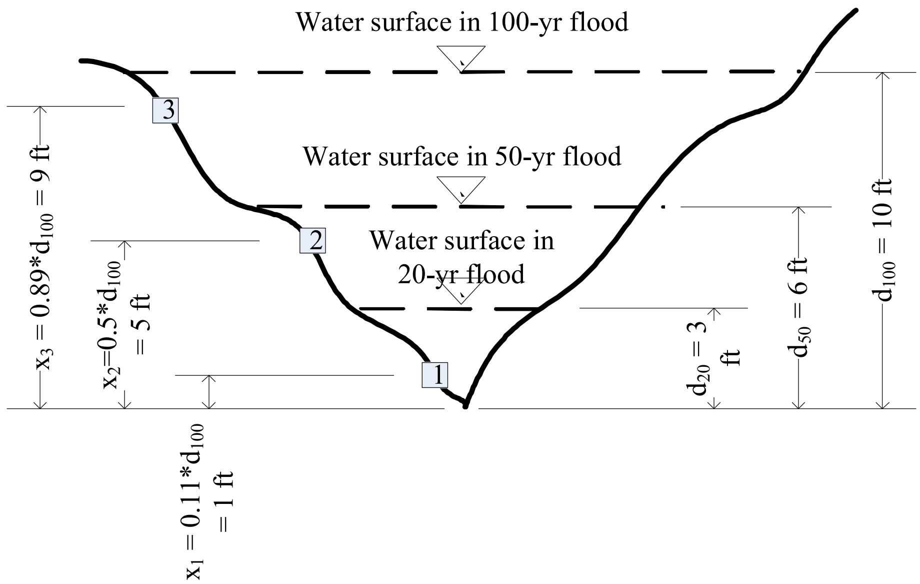


Figure G-3. Illustration of elevation differences X used in Hermite-Gauss quadrature for flood loss.

The next step is to calculate flood depths for each storm (20, 50, and 100-yr) for each sample site, using Equation G-1, as shown in Table G-1

Table G-1 Flood depth h_n given return period and site elevation

Site	20 yr	50 yr	100 yr
1	2 ft	5 ft	9 ft
2	0 ft	1 ft	5 ft
3	0 ft	0 ft	1 ft

Next, the loss for each site and each storm is calculated, using these flood depths, and integrated to get the expected annualized loss for each site, y_{ann}, using Equation G-3. Assumed losses are as shown in Table G-2.

Table G-2 Annualized losses Y_{ann} for each site elevation X

Site	y_{ann}	weight w_i
1	$10,000/yr	0.2778
2	$5,000/yr	0.4444
3	$2,000/yr	0.2778

Finally, a weighted average of the loss for all three sites is created, using the weights in Equation G-4 and the weighted average in Equation G-5:

$$E[Y_{ann}] = 0.2778*10,000 + 0.4444*5,000 + 0.2778*2,000$$
$$= \$5,600/yr$$

G.2 Quality Control/Quality Assurance

The following steps were implemented to assure the reliability of the results:

1. The geographic locations of all properties were checked against the Q3 digital floodplain boundaries and stream data by plotting each site on maps and performing visual inspections. This was done for the 486 properties included in the analysis.
2. Simple models reflecting the loss calculation process were developed to ensure that the damage functions from HAZUS were being implemented correctly.
3. Independent hand calculations were performed for five (5) projects to check the accuracy of the software program developed to estimate BCA ratios. These calculations were performed by an individual who was not involved with the initial development of the methodology.
4. The results of the current analysis were compared to benefit-cost analysis ratios documented in the NEMIS database. In general, there was good agreement between these estimates.
5. Sensitivity studies were performed to quantify the variability of results to changes in key input parameters. The results did not identify any unusual trends or anomalies.

G.3 GIS Data used in Flood Hazard Analysis

<u>USGS NED:</u>

The National Elevation Dataset (NED) conveniently provides USGS Digital Elevation Models (DEM) in a seamless form that corrects many data artifacts such as mismatched edges, data sinks, and rippling effects. The NED has a resolution of 30 meters, and is based on a variety of data collection techniques including stereoscopic interpretation, processing of Digital Line Graph (DLG) data, and Shuttle Radar Topography Mission (SRTM).

<u>USGS NHD level 1 stream data:</u>

The National Hydrography Dataset (NHD) from the USGS contains information about surface water features such as streams. The NHD is based on USGS Digital Line Graph (DLG) hydrography data, which correlates with the USGS NED elevation data. Additionally, these data integrate with the EPA Reach File Version 3 (RF3) stream designation. These data are at a scale of 1:100,000, but may incorporate more detailed data in certain areas.

<u>FEMA Q3 digital flood maps:</u>

The FEMA Q3 digital flood maps are digital versions of FEMA's Flood Insurance Rate Maps (FIRM) that are intended for planning use. The Q3 digital flood maps were developed by scanning the existing FIRM paper maps which had street layers that did not always correspond with real world coordinates. The Q3 data captures only the major features of the paper maps, such as the 1% annual chance of flooding, and does not include the base flood elevation or cross section data.

G.4 Assumptions used in Modeling Flood

ASSUMPTION	JUSTIFICATION
A building included in a FEMA-funded mitigation project is located in a floodplain.	Although FEMA's Flood Insurance Rate Maps are the basis for local regulation of flood hazard areas, it is widely acknowledged that the maps do not show all areas that actually experience flooding. The evidence is found in FEMA's statement that nearly one-third of all flood insurance claims paid are on buildings that are not within the flood hazard areas shown on the maps. Furthermore, about 60% of the nation's waterways have flood maps that were delineated using approximate methods that have insufficient detail to delineate all flood-prone areas. FEMA is authorized to provide grant funds for flood mitigation projects that will avoid or reduce future flood damage. Grants are provided only for projects that are in the floodplain. If a location is not in a FEMA-mapped flood hazard area then applicants must demonstrate that the area is subject to flooding.

ASSUMPTION	JUSTIFICATION
The depth of flooding at the center of the channel of the 1%-annual chance flood is at least 5 feet deep. (This depth, d_{100}, is computed using the routine described in Section G.5 of this appendix).	The height to which water will rise above the stream bottom (flood depth) is a function of many variables. When water rises out of the channel, the adjacent land begins to flood. The horizontal extent of land that is affected, and the depth of flooding above any point of ground, depends on the elevation of the ground relative to the flood depth. If the 1%-annual chance flood depth is 5 feet (measured in the channel), the depth of water in the adjacent floodplain will always be less than 5 feet. For most parts of the country, flood depths this shallow would be found only in small streams. The elevation information used to estimate the flood depth in the channel is taken from the 30-meter Digital Elevation Model (DEM). Although there is no estimate of how elevations from the DEM vary from actual elevations, some smoothing is expected. The assumption that the flood depth in the channel of the 1%-annual chance flood is at least 5 feet underestimates the actual flood depth at locations other than along small streams.
The first (finished) floor of the building is at-grade (i.e., the floor elevation is the same as the ground elevation).	Virtually all flood-prone buildings that are mitigated using FEMA funds are older buildings that were built before communities joined the NFIP or had begun regulating construction (most notably to require new buildings to have their lowest floor raised above the ground to be at or above the depth of flooding associated with the 1%-annual chance flood). Barring specific information about prevalent foundation types, the assumption is that all buildings included in mitigation projects have their first (finished) floor levels "at grade." At specific locations, this disregards the fact that the types of foundations and construction practices vary regionally (basements, crawlspaces, piers/columns, slabs-on-grade). Traditional foundation types (before floodplain regulations) are influenced by local conditions such as high groundwater, frost depth, soil types, termite activity, and simple historic practices.
For non-basement buildings, there is no damage to the building when the water surface elevation is at or below the ground floor elevation at the building site, which is also assumed to the first (finished) floor.	It is assumed that the first (finished) floor is at-grade (the floor and the ground are at the same elevation). Therefore, when the flood level does not rise to the elevation of the floor/ground, the building is not touched by floodwater. Buildings that are not touched by floodwater are not damaged.

ASSUMPTION	JUSTIFICATION
Where descriptions of building types and building/contents values and project costs are available, they are used. Otherwise, average values determined from the entire dataset (486) are used.	1. 2/3 of buildings (out of the 486) do not have basements. 1/3 have basements. 2. 88% of the buildings are 1 story, 12% are 2 story. 3. Where the values of the structure and the property are unknown, a value of $42,576 is used, which is the median of the known values. Where the value of the structure is unknown, the ratio of structure value to the sum of the value of the structure and the property (where both values are known) is used (this ratio is 75%). Where both values are unknown, 75% of $42,576 or $31,932 is used.
Benefits are calculated using a discount rate of 3% for 50 years.	This assumption is being used for all benefit-cost analysis calculations.
Contents are 50% of structure cost.	This assumption comes from HAZUS-MH.

G.5 Flood Depth-Frequency Methodology Options[72]

G.5.1 Background

In order to examine the benefits of a flood mitigation measure located at a specific site, characteristics of the flood hazard at that site are required. The standard default parameter used to characterize flood hazard is depth. Flood characteristics that may contribute significantly to damage include velocity, duration, wave impacts, debris impacts, and scour/erosion. The depth-damage functions developed by FEMA, the Corps of Engineers, and others, generally aggregate damage from all types of flooding so that the influence of each flood characteristic is not separately considered.

Depth-damage functions are developed for different types of buildings. They relate damage (expressed in a percent of value) to the depth of floodwater above the lowest floor. Ideally, one would know the floodwater depths for different frequency floods. The floodwater depths at a specific building are functions not only of the flood frequency, but the ground elevation and the elevation of the lowest floor (Figure G-4).

G.5.2 Problem Statement

In order to examine flood losses it is necessary to know the depth of flooding, for different frequency floods at different project locations along riverine bodies of water (rivers, streams, creeks and the like, that flow downstream under the force of gravity). This project was

[72] Source: R. Quinn project memo.

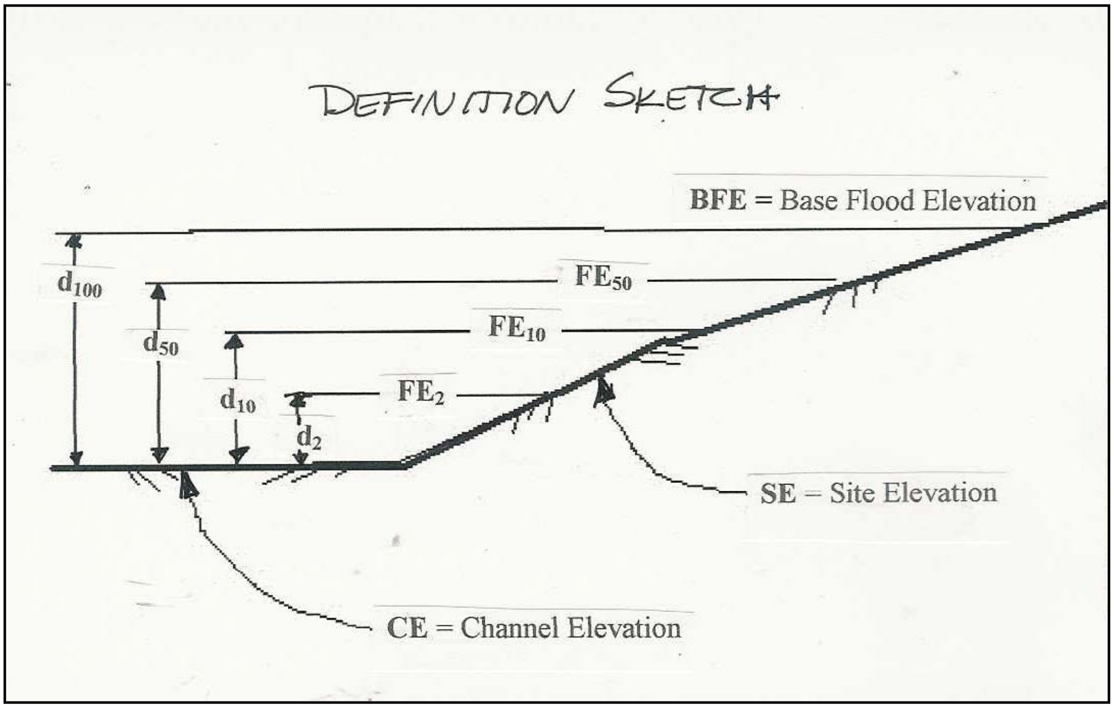


Figure G-4 Sketch showing definitions of various parameters of interest in flood studies.

constrained, however, by the need to apply a method to many different locations with a minimum level of effort.

While depth of flooding is the parameter of interest, it is useful to talk in terms of elevations in order to arrive at depths. For any given location, the flood hazard area associated with the 1%-annual chance flood is usually refered to as the Base Flood Elevation (BFE). The BFE is the height to which floodwaters of the 1%-annual chance flood will rise. Flood discharges of different frequencies produce different water surface elevations (Figure G-4). Many factors influence discharge and elevation, and those factors vary as one moves up and down a stream or river valley (see Figure G-2) and from watershed to watershed. Those factors include:

a. **Hydrology variables** influence the volume and rate of rainfall-runoff (climatic region, drainage area, basin shape, elevation, longitudinal channel slope, land use, vegetation types, soil types, drainage patters, storage (ponds), etc.).
b. **Hydraulic variables** affect the height to which water rises at a given location (valley shape, longitudinal channel slope, frictional effects, constructions such as roads and buildings, etc.)

Within any given floodplain, water depths along the cross-section that is perpendicular to the channel (Figure G-3) as a function of the ground elevation. Thus, in order to apply a depth-damage function at a specific location, it is necessary to know the depth of water above the ground for a range of flood frequencies.

Following are four possible solutions to the problem statement.

G.5.3 Alternative 1 - Solution to the Problem Statement

Alternative 1 would involve accessing flood hazard maps prepared by FEMA. FEMA has prepared Flood Insurance Rate Maps (FIRMs) to show flood hazard areas along most of the waterways in the U.S., except for those in the many rural locations. The maps show Special Flood Hazard Areas that are considered to be the area inundated by the Base Flood (1%-annual-chance flood):

a. **Approximate zones**. More than 60% of the stream miles mapped by FEMA show approximate flood zones, areas that are designated using approximate methods that do not produce BFEs.

b. **Numbered zones.** About 40% of the stream miles mapped by FEMA were done so with detailed hydrologic and hydraulic methods that produced computed water surface elevations. These maps show BFEs referenced to a datum (i.e., a BFE of 285 would mean 285 feet above mean sea level – which in turn is defined based a national datum).

Although FEMA has captured flood hazard areas in digital format for about 1,000 counties (called Q3), the digital files do not contain BFEs. Thus, the paper maps would have to be accessed in order to determine the BFE at specific sites (if the BFE was determined by FEMA; additional manual steps are required to estimate the BFEs for approximate zones). Obtaining the depths for other frequency events involves another manual operation using the flood profiles (only prepared for waterways studied in detail) that are contained in each community's Flood Insurance Study.

Most applications for FEMA grant funding are accompanied by flood depth/elevation data derived from the FIRMs and flood profiles to describe the flood hazard. Other site-specific data are provided, including the ground elevation and lowest floor elevation of specific buildings.

PROS	CONS
1. Precision of data	1. Time to obtain paper FIRMs and companion Flood Insurance Studies 2. Manual determination of BFEs and elevations of other frequency floods from paper FIRMS, (including estimating BFE for unnumbered zones) 3. Replicates the methods likely used by applicants

Analysis

Using the paper maps is not only labor intensive, but it is not an independent check because they are the source of data provided by grant applicants. The cons clearly outweigh the pros.

Recommendation for Alternative 1

Do not consider Alternative 1.

G.5.4 Alternative 2 – Solution to the Problem Statement

Alternative 2 would involve using FEMA's loss estimation methodology, Hazards US (HAZUS). FEMA developed a basic automated flood hazard analysis capability as part of HAZUS. The tool can generate discharges and depths for different frequency flood events. The tool will estimate losses "out of the box" for any return period. However, the analysis is very time consuming in terms of both set-up and analysis. The program analyzes single stream segments, rather than a large geographical area. An analysis of properties nationwide would not be reasonable. Additionally, there have been several revisions to the software platform since the release this year, addressing both analytical and software deficiencies.

PROS	CONS
1. FEMA and NIBS approved.	1. Software has not been pilot tested. 2. Analytical and software bugs remain. 3. Time consuming to set-up and run. 4. Interactive process not suitable for nationwide automation.

Analysis

Alternative 2, in addition to offering use of software that is not fully prepared for use, is not appropriate for automated, nationwide analysis.

Recommendation for Alternative 2

Do not consider Alternative 2.

G.5.5 Alternative 3 – Solution to the Problem Statement

In this alternative, we consider the flood depth data for different frequency flood events that is generated during in-depth analysis for specific locations in the community studies. Using just five study regions, a single "flood-depth frequency curve" could be developed as a function of the depth of the 1%-annual chance flood. This curve could be used to estimate flood depths at any location to yield depths for various return periods, provided the depth of the 1%-annual chance flood depth is known.

PROS	CONS
1. Utilizes data from Track B. 2. Simple to implement.	1. Still requires knowing the 1%-annual chance flood depth at specific locations (discussed in Alternative 3) 2. Flood depths at any location have multiple local variables which would not be accounted for 3. Extremely wide error distribution for flood-depth frequency curve. 4. Relies on questionable HAZUS analysis where higher return intervals often result in decreased flooding.

Analysis

The cons out-weigh the pros, in particular the unmet need to determine the depth of the 1%-annual chance flood at project locations. Even if that depth is determined as described in Alternative 4, the use of depth-frequency data from only 5 locations to develop a single relationship is unacceptable. The relationship between depth and frequency varies significantly in different parts of the country.

Recommendation for Alternative 3

Do not consider Alternative 3.

G.5.6 Alternative 4 – Solution to the Problem Statement

Using statistical parameters developed for discharge records at USGS stream gages and GIS-based methods to estimate the Base Flood Elevation and certain ground elevations in the vicinity of project sites, estimation of flood depths for different return intervals can be automated using a standard hydrologic method that applies statistical relationships at nearby gages. The matter of the starting depth, the depth of the 1%-annual chance flood, is addressed.

PROS	CONS
1. Applicable in 1000 counties, where digital flood data are available 2. Using statistical parameters developed for 'nearby' USGS gages to approximate conditions is a common practice 3. Can be automated with GIS programming 4. More likely to produce results that are applicable to each location than reliance on a national average	1. BFE and ground elevations are selected using 30-meter DEMs 2. Elevations from the DEM at a point corresponding to the location of the stream (on stream layer) is assumed to be the elevation of channel bottom 3. Without digital flood maps for several communities, it is not possible to fully test this method

Analysis

The most significant advantage of this approach is that it is based on stream gage data so that regional and hydro-geomorphic variations are captured. The drawback is in the selection of the depth of the 1%-annual chance flood at project location, a drawback that are found in Alternative 3. No methodology can be automated with current tools to account for very local variations, such as presence of a bridge.

Recommendation for Alternative 4

Use Alternative 4

G.5.7 Overall Recommendation

Based on the analysis above, Alternative 4 was recommended and used for this project.

G.6 Approximating Flood Depths for Different Frequency Floods

Following is an approach to approximate depths for different frequency flood events if the depth of the 1%-annual chance flood – as measured in the channel – is known.[73] The key formula is :

$$\log d_T = \log d_{100} - 0.6\,[(K_{100} - K_T)\,S_{logQ}\,]. \qquad \text{(G-6)}$$

where:

d_T is the depth for a flood with recurrence interval T; specifically, d_{100} is the depth of the 1%-annual chance flood (estimated as the BFE minus the estimated elevation of the bottom of the channel, see following notes).

K_T is a Pearson Type III frequency factor that is a function of recurrence interval T; K_T values can be obtained from Appendix 3 in Bulletin 17B for various values of skewness G.

$S_{\log Q}$ is the standard deviation of logarithms of discharges for each USGS gage (available in HAZUS)

G is skewness computed for each USGS gage (available in HAZUS)

Therefore, if d_{100} is known, as well as the other variables, then depths for other frequencies can be estimated which, in turn, allows estimation of depths d_T at a site.

Before outlining the specific steps necessary, the following notes provided additional explanation, background, justification, and assumptions.

A. Notes on d_{100}

This depth, used in the depth-frequency relationship (above), is the depth of the 1%-annual chance flood as measured in the channel.

The following ways to estimate d_{100} do not meet the need for ease of use and nationwide applicability for this project:

a. For waterways studied with detailed methods, d_{100} and/or the elevation of the channel bed, referenced to a datum, can be obtained manually by accessing the water surface profiles found in the Flood Insurance Study.

b. Thomas' paper (see footnote 7 above) for FEMA's Unnumbered "A Zone" workgroup has a table that lists 20 states (or parts of states) for which USGS has some depth-area relationships that yield d_{100}. Those states are AL, AR, CO, GA, IL, KA, LA, MD, MA, MO, NJ, NY, NC, OK, OR, PA, TN, UT, VA, WY.

[73] Wilbert Thomas, "*An Approximate Method for Estimating Flood Depths for Various Recurrence Intervals"* prepared for Christopher P. Jones, December 2003.

c. For each USGS gage, there is a "gage height". This is an arbitrary datum, selected so that stage (height of water above the datum) is always a positive number. Thomas' paper indicated that the gage height is not the channel bottom, but probably "close" in most cases. In order to relate the gage height to the point of zero flow (bottom of the channel), one would need to reference the gage's rating curve (stage-discharge curve).

Therefore, it is necessary to explore more traditional approaches that rely on standard analyses of long records of discharges at USGS stream gages. Flood discharge is a function of many variables, including volume and rate of rainfall-runoff (climatic region, drainage area, basin shape, elevation, longitudinal channel slope, land use, vegetation types, soil types, drainage patters, storage (ponds), etc.).

B. Notes on G (skew)

A value of *G* is provided for every USGS gage and is contained in HAZUS. G is shown with three decimal places. The lookup table in Appendix 3 of 17B (used to extract values of K_T) is set up for values of *G* in decimal increments from +1 to -1. Given the grossness of other assumptions, Thomas' paper (see footnote 7 above) indicates that it would be acceptable to round *G*. Or, if the Appendix 3 lookup table is automated, interpolation could be done. However, it is notable that the values of K_T do not vary much between whole decimal values of *G*.

C. Notes on $S_{\log Q}$ (Standard Deviation)

A value of $S_{\log Q}$ is provided for every USGS gage and is contained in HAZUS.

D. Notes on Watersheds with USGS Gages

For locations in the same watershed as a USGS gage, the values of $S_{\log Q}$ and *G* for the gage can be applied if the location is "near." That is, the values at the gage are "usually applicable if the drainage area [at the location of interest] is within 50 to 200 percent" of the area at the gage (per the FEMA standards & guidelines). This approach is better than using the gross regional values (see paper by Wilbert Thomas for Chris Jones).

E. Notes on Watersheds without USGS Gages (or where drainage area is more than 200% of the gage in the same watershed)

In geomorphologically similar areas, the factors of $S_{\log Q}$ and *G* do not vary strongly with drainage area. Therefore, it is acceptable to apply values determined for one site to others, within reason. The methodologies for doing so in a very detailed manner are outlined in USGS publications, and generally involve looking for gaged watersheds that are similar in several characteristics.

There are two approaches, with different degrees of reasonableness, for approximating values of $S_{\log Q}$ and *G*:

1. Use the gross regional values (see paper by Wilbert Thomas for Chris Jones), which advises that using nearby gages is always preferable provided they are in watersheds that are not too dissimilar.
2. Use the average values for the closest gage or gages (ideally selecting gages where the drainage area and other characteristics are similar). Using the average values for the closest gage or gages involves developing a routine to determine the closest gages to each project site. The latitude and longitude of each gage are in HAZUS.

G.6.1 Estimating Depths for Different Frequency Floods

To estimate depth of flooding for different frequency floods (d_T in the channel), for each project site or cluster of building locations, the following steps are required:

1. Determine the *BFE* using Q3;
2. Determine d_{100} (determine the elevation from the DEM that corresponds to the location of the stream from the stream centerline layer and subtract this elevation from the *BFE*);
3. Find the one or two closest gages[74];
4. In HAZUS, extract the values of $S_{\log Q}$ and G for the one or two closest gages (and compute the average values if using two gages);
5. Using the computed G, round to hundredths and look up values of K_T (interpolate) for the frequencies of interest; and
6. Use the formula to compute d_T using K_T and $S_{\log Q}$.

G.6.2 Determining the Depth of Flooding for Different Frequency Floods at a Site

For each site (represented by the 30-meter DEM), the Site Elevation, the Base Flood Elevation, estimated depth of the 1%-annual chance flood (d_{100}) and estimated depths for other frequency floods (d_T) are known. The next step, then, is to determine the depths of those frequency floods at the site – these are the depth values used in the Depth/Damage function.
Figure G-4 is a definition sketch. If:

SE = Site Elevation (known from DEM)
CE = Channel Elevation (determine the elevation from the DEM that corresponds to the location of the stream from the stream centerline layer);
BFE = Base Flood Elevation (known from Q3)
FE_T = Elevation of Flood of frequency T
d_{ST} = Depth at Site for Flood of frequency T

then:

$$FE_T = CE + d_T \quad \text{(G-7)}$$

and

$$d_{ST} = FE_T - SE \quad \text{and} \quad d_{100} = BFE - SE \quad \text{(G-8)}$$

Note: When d_{ST} is a negative number it means the ground at the site is dry (higher than the water for that frequency event).

[74] Need to intervene if one or both of the gages are "far away" or is on a watershed that is dramatically different than the site, i.e., the site is a "small" watershed and the gage is on a large river.

G.6.3 Cautions:

1. The differences between water surface elevations for different frequency flood events often are not large (see Figure G-5 for a sample profile from a Flood Insurance Study).
2. The differences between water surface elevations for different frequency flood events varies with several other site-specific factors, such as valley shape and presence of constrictions such as bridges (see Figure G-5).
3. Every step is an approximation.

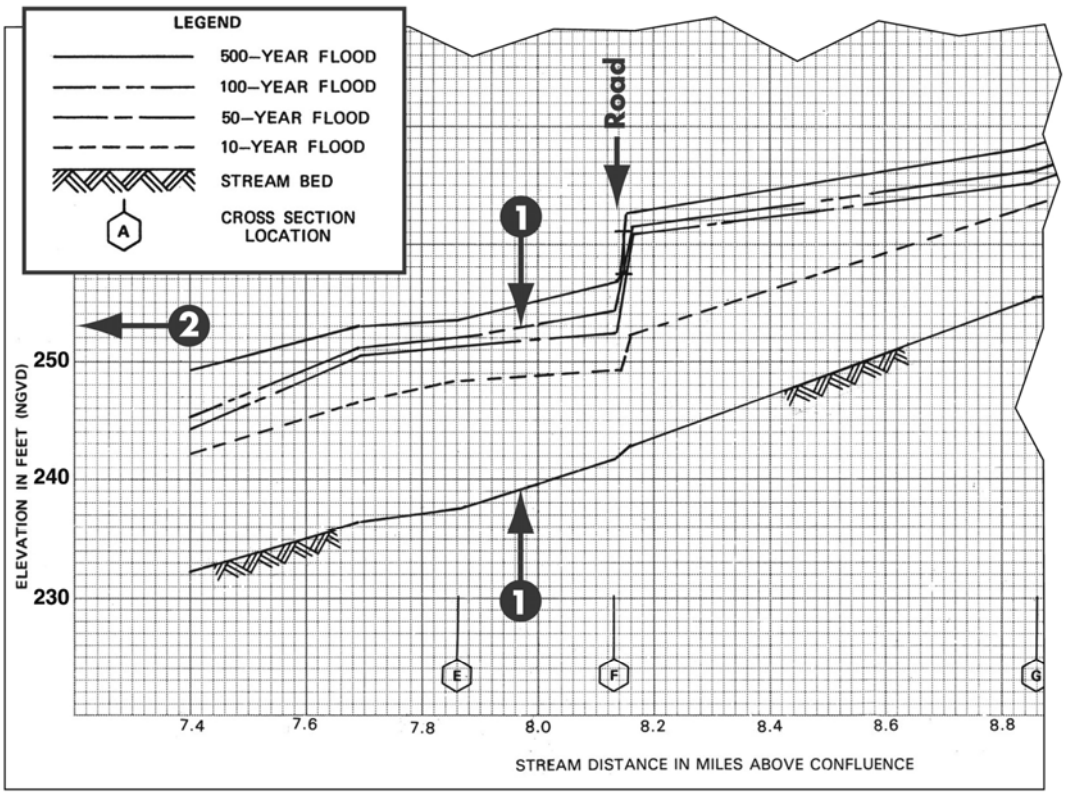


Figure G-5 Plot showing various flood levels for a sample profile from a flood insurance study

Appendix H
PROPERTY AND CASUALTY LOSS ESTIMATION – TORNADO

This appendix describes the steps followed in making probabilistic tornado hazard estimates and related impacts for individual sites considering tornado hazards.

Step 1. Pick a one-degree latitude by one-degree longitude grid that covers the site in question.

Step 2. Estimate the area covered by this macro-grid (e.g., 10,242 km^2).

Step 3. Use NOAA data having tornado vectors and their Fujita ratings to count the number of tornadoes (by their starting-point) in the macro-grid.

Step 4. Divide each count by the number of years surveyed in the NOAA data.

Step 5. Use a linear multiplier for undercount. J. McDonald (oral communication, 2004) suggested a much lower multiplier than Sigal et al. (2000) used; the multiplier of 1.3, or a 30 percent increase, is not adjusted by Fujita rating.

Step 6. Use data by Brooks (2003) from NOAA studies to determine a "mean-based" rectangle that represents each Fujita level tornado. Each rectangle is assumed to occur wholly within the macro-grid, and contains all Fujita level winds associated with each tornado.

Step 7. For each rectangle, determine length degradation (from Sigal et al., 2000) and width degradation (McDonald, oral communication, 2004) matrices, and combine them to determine a total degradation matrix (e.g., how much of the total area of a Fujita 5 tornado has Fujita 5 level winds, Fujita 4 level winds, and so on).

Step 8. Use the foregoing steps to derive the total annualized area in the macro-grid that is exposed to Fujita level 5 winds, Fujita 4 winds, and so on.

Step 9. Divide these total annualized areas by the total macro-grid area in order to estimate the annualized probability of Fujita level 5 winds, Fujita level 4 winds, and so on at each site in the macro-grid.

Step 10. Use HAZUS damage functions to estimate damages and casualties for one- and two-story wood-frame dwellings, with and without safe rooms. Safe rooms are assumed to withstand 250 mph winds as tested by Texas Tech. They are assumed conservatively to be no safer than normal dwellings in higher level winds.

Step 11. Make estimates of casualties as based on HAZUS.

Appendix I
BUSINESS INTERRUPTION BENEFITS – ELECTRICITY AND WATER UTILITIES

Following are the steps undertaken to estimate Business Interruption (BI) losses resulting from damage to water and electric utility systems. The benefit is the reduction in loss resulting from increased resilience of the utility due to execution of a mitigation grant activity.

1. **Calculate the Partial Business Interruption Loss in Dollar Terms**.
   Begin with the HAZUS physical unit downtime loss estimate for the utility in question for one recurrence interval. The dollar loss can be calculated in one of two ways:

   a. Obtain a gross income or net income figure for the utility system component to which the mitigation applies. If provided, this is usually expressed in terms of an annual number. Multiply this annual figure by the ratio of HAZUS-computed downtime and annual operating time (e.g., 4 weeks of downtime yields a ratio of 4/52). Multiply this ratio by the income loss of the utility component to obtain an estimate of the lost income to the utility from failure of this component.

      (1) If an income figure is not available, one can estimate it by using physical component capacity multiplied by unit revenue (e.g., cents/kwh)

      (2) If neither component income nor component physical size are available, the following proxy is used: the ratio of component parts to the total system parts. For example, if the mitigation grant applies to 2 electricity sub-stations of a total of 20 in the system, we assume it applies to 10% of the system. This ratio can be applied to gross or net income estimates or total physical service estimates from Step 1a.

   b. For the calculations below it is necessary to be especially mindful of the distinction between gross income (total revenue or gross output) and net income (total revenue minus total non- primary factor cost, or value added). The desired total BI estimate is expressed in net terms, but some HAZUS calculations require the use of gross income. Translation of one income definition to the other can be accomplished by the use of the following conversion factors: The ratio of net income to gross income for electric utilities is: .646; for water utilities, it is .684.

2. **Calculate Direct Customer BI Losses.**

   Adapt a base vector of gross output changes due to utility outages for each of the 10 sectors of the Indirect Economic Loss Model (IELM) per million dollars of utility income change (actually only 9 sectors, since the Misc Sector is just a placeholder for special computations). The elements of the vector are the reciprocal of the utility input per unit of gross output for each sector weighted according to the sectoral mix of a standard HAZUS model input-output table (i.e., the elements represent the gross output change per unit of utility input change for each sector). One need only multiply each element of the vector by the total gross income loss to the utility from Step 1 (say $40 million) to determine the full *direct* BI loss for each customer sector. Actually, there are 2 separate vectors to choose from because of differences in input intensities and relative use for electricity and for water

	Electricity	**Water**
Agriculture	2.1	192.8
Mining	6.4	1638.8
Construction	72.3	3760.0
Manufacturing	11.1	1084.3
Transportation/Communication/Utility	41.9	2588.3
Trade	17.3	1706.9
Finance/Insurance/Real Estate	55.3	2214.3
Services	70.0	3911.8
Government	38.8	468.1

3. **Set Up the IELM Simulation and Compute Preliminary Estimates of Total BI Losses.** Insert the 9-element vector of sectoral income losses from step 2 into the IELM Module in order to simulate an initial estimate of *total* BI losses to the regional economy. The insertion is to the user option called "Stimulus" as a vector of negative numbers.

   a. Be sure to set some of the user options as follows for the utility sector in question (the "Transportation" sector in HAZUS is actually the Transportation/Communication/Utility or, TCU, sector);

      (1) set inventories for the TCU sector to zero for the case of electricity outages (electricity cannot be stored); set inventories to default value for water outages

      (2) set imports and exports for the TCU sector to zero for both electricity and water

   b. Input other parameter specifications from the "Supplementary Economic Data Sheet" supplied for each stratum:
      - economy-type
      - unemployment rate

   c. set the "outside aid" option to the desired level (for this project equal to zero)

4. **Calculate a "Resilience-Adjusted" Estimate of Total Income Losses.** The IELM will compute a preliminary set of total *net* income losses from the utility disruption. Then:

   a. Multiply each element (sector) of the 9-element "(net) income change" vector by that sector's recapture factor from the list below. (Recapture factors in HAZUS are provided in terms of occupancy categories, so it is necessary to assign them to economic sectors externally according to the following values, see also Rose and Lim, 2002):

Manufacturing, Mining, and Construction	95%
Trade and Finance/Insurance/Real Estate	90%
Government	80%
Agriculture	75%

Services	80%
Transportation	30%

Actually multiply each element of the "net income change" vector by unity minus that sector's recapture factor expressed as a decimal fraction, e.g., for services it would be (1 - 0.8) = .2.

b. Sum the 9-sector computation in 4a to obtain the adjusted total BI (net income) impact on the economy.

5. Compute a "Multiplier" to Apply to Other Recurrence Intervals
(Other Levels of Direct Utility Damage and Downtime). Take the result of Step 4b and the partial BI estimate from Step 1 and compute a ratio, or "multiplier" of total *net* income change/partial *net* income change (say 10.65). The analysis reasonably assumes linearity, so one can apply the same "multiplier" to all the partial net income change results all of HAZUS runs for this mitigation grant (each recurrence interval run for the basic property damage estimate, where each yields a partial BI estimate). Also, this same multiplier should apply to both "with mitigation" and "without mitigation" HAZUS simulations.

Appendix J
ENVIRONMENTAL AND HISTORIC BENEFIT ESTIMATION

This appendix summarizes the benefit transfer methodology for particular types of environmental and historical benefits provided by hazard mitigation. Benefits that accrue for more than one year are discounted using 2 percent and 7 percent rates.

Water quality. Benefit estimate transfer is used to measure the water quality benefits obtained from mitigation of flood hazards. Water quality benefits are primarily enjoyed by freshwater recreational anglers in the form of increased catch. The total water quality benefit is the product of the number of anglers affected by the policy and the value of additional catch. A report from the 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation estimates the value of an additional bass/trout caught per year using the contingent valuation method (Waddington, Boyle, and Cooper, 1994).

The number of anglers in the population is the percentage of those who fish but do not also hunt in the relevant state obtained from the 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. The number of anglers affected by the hazard mitigation policy is equal to the product of the percentage of anglers in the relevant state, the portion of anglers assumed to enjoy the water quality improvement, and the relevant population. The negative recreational impacts of a flood event last for various amounts of time.

Drinking Water. Benefit estimate transfer is used to measure the drinking water quality benefits. A review of averting behavior and contingent valuation studies of the value of safe drinking water provides a monthly mean value of safe drinking water per household (Whitehead and Van Houtven, 1997). The drinking water benefits are equal to the expected value of the product of household benefits, the number of households affected, and the time period affected.

Outdoor Recreation Trips. Benefit estimate transfer and meta-analysis transfer are used to measure outdoor recreation benefits other than recreational fishing. The benefit estimate transfer is the average recreation value per person per activity day provided by Rosenberger and Loomis (2000). The meta-analysis transfer function is from Rosenberger and Loomis (2000). Values for state-of-the-art valuation methodology variables are chosen to calibrate the meta-analysis function.

The estimate of the number of recreation trips is the product of recreation participants and the number of trips per participant. Recreation participation estimates are from the 1995 National Survey of Recreation and the Environment. The total outdoor recreation benefits are equal to product of the individual benefit and the number of trips.

Hospitals and Hazardous Waste. The benefit estimate transfer method is used to estimate the benefits of avoiding health risk from exposure to hospital hazardous wastes. The willingness to pay estimate used is from duVair and Loomis (1992) who estimate the value of avoiding premature death from hazardous waste exposure for 25 percent, 50 percent, and 75 percent reduction in the risk of death. The willingness to pay for a percentage reduction in the risk of premature death is extrapolated from the benefit estimates assuming linearity and various assumptions about the magnitude of the risk of exposure to hazardous waste from a hospital experiencing a natural hazard event. The total benefit is equal to the product of the household benefit, the number of households affected and the exposure time.

Wetlands. Meta-analysis transfer is used to estimate the benefits of mitigation projects that involve the purchase and removal of flooded residences that create open space areas and, potentially, functioning wetlands. The environmental benefits of these projects are estimated by applying wetland values to each acre created. We use a meta-analysis of wetland values (Woodward and Wui, 2001) and low, medium, and high assumptions for the number of acres of open space/wetlands created for each property purchased. The meta-analysis model is calibrated for the hazard mitigation application by using the mean values for independent variables included in the model and adjusting the benefit estimate for the number of wetland acres provided by the project. Wetland values are aggregated across time using various assumptions about how long the open space areas might function as wetlands.

Aesthetic, Health and Safety Benefits from Underground Power Lines. The benefit estimate transfer method is used to estimate the benefits of projects that bury power lines and provide aesthetic, health and safety benefits. A recent unpublished study estimates the willingness to pay to bury power lines (Palm Beach County, 2002). No other study has specifically addressed this issue. Annual aesthetic, health, and safety benefits are measured by the product of per household total power line benefit and the household population under various assumptions about the number of households affected.

Cultural and Historical Resources. Cultural and historical values provided by mitigation projects are estimated with the meta-analysis function in Noonan (2003). To calibrate the model, values for state-of-the-art methodology variables and site variables to best fit the case study are chosen. The cultural and historical benefits are the product of the household benefit and the number of households under various assumptions about the number of households affected by protection of the cultural and historical resources.

Appendix K
PROCESS GRANT BENEFIT ESTIMATION

K.1 Overview

Process mitigation leads to policies, practices, and projects that reduce risks (MMC, 2002). The goal of this section of the report is to estimate net benefits for specific process grants within three general types of mitigation-related activities:

A. information/warning (risk communication)
B. multi-hazard mitigation plans
C. building codes

The analysis below should be considered to be one step beyond a qualitative analysis, for reasons that follow. The benefits of a process grant likely involve two components:

1. spawning and encouraging the development of mitigation plans and activities, such as building codes
2. enhancing the probability that mitigation actions will be taken

As such, it would be difficult to estimate the benefits of a process grant, isolating these from the benefits of actual mitigation activities. Working from the end point of mitigation, assume that individuals' tendency to mitigate (e.g. adopt new building code regulations) increases by some factor, say 50 percent. This in turn leads to benefits in terms of reduced damages from hazards. One would have to isolate the contribution to these benefits from the process grant alone to do an accurate benefit-cost analysis of process grants. However, doing so would be complicated. An individual's propensity to mitigate might increase because his neighbor convinced him to do so, or because his assessment of risk increased. Are these changes due to the process grant and how would we know? Measuring the benefits of hazard risk reduction are most easily done in terms of reduced property damage or a reduction in injuries or mortality. Again, these savings can be directly tied to mitigation activities themselves, but perhaps without the initial process grant, the activities would not have been undertaken (e.g. new building codes would not even exist).

Because of this complexity, and because virtually no known study isolates the benefits of a process grant from benefits of mitigation actions, it is assumed that the net benefits from mitigation activities (total benefits minus the costs of implementation) that are related to a process grant, inclusive of the cost of the process grant, are rough indicators or measures of the net benefits of a process grant.

The limited resources of this study do not allow primary methods to be used to assess the benefits of process grants in these categories. The next best approach is to base benefits estimates on the "Benefits Transfer" approach using existing literature and expert judgment. However, strictly speaking, this approach can not be applied, because no data on process grant benefits are available in any study the project team could find. One generally undisputed outcome in the literature that gauges the effectiveness and accuracy of the Benefit Transfer approach is that the transfer context should be as similar as possible to the original study context. For example, if one wishes to use literature to assess the effectiveness of a process grant for developing new building codes in southern California's urban areas, specifically targeting reduced earthquake damage to multi-dwelling buildings (apartment buildings), then the ideal study is one with the same conditions. Therefore, it is best to consider the analysis below a step beyond a *qualitative analysis*.

K.2 Analysis

With the time available for this project the project team looked across a wide range of studies in all three categories of process grants. No studies were found that explicitly and carefully focused on the benefits of a process grant only, or isolated the two components above. Only two studies were found that could be used to examine a specific process grant and its cost. One study examines impacts from a grant to study the impacts on damages to woodframe homes from earthquakes (Porter et al. 2004). The other examines impacts from an improved multi-hazard planning network, again related to earthquake damages (URS Group, 2001). Both studies were conducted in California. In both cases, the mitigation action costs and benefits are included in the calculations. The project team's assumption is that the benefit-cost ratios provided in these studies roughly pertain to the benefits of a process grant in these categories. In one case, the grant cost is added to the total mitigation costs, and the resulting net benefits and benefit-cost ratio are used to represent the benefit-cost ratio for the process grant.

Benefits from reduced hazard risk are typically calculated as estimates of damages avoided, including lives saved, and materials damage avoided. Costs are the costs of the process grant. Ideally, the estimated ratio of the approximate process grants, by category, based on coded information on benefits, cost, location, and other site specific variables would be calculated. If several process grant studies were available, the analyst could weigh the quality of each study and evaluate which study would be appropriate for a transfer.

K.2.1 Process Grants for Information/Hazard Warnings, and Risk Communication

Process grants might also be used to fund improved communication of risks or better warnings of natural hazards. Current issues in risk communication are summarized in Bostrom and Löfstedt (2003), and a report on the state of the art in effective hazards communication is offered by Mileti (2004).

There were no studies we could find that completely assessed the benefits and costs of a process grant in this category, but the one with the most relevance was a cost-effectiveness study for reducing the risks from radon gas (Marcinowski and Napolitano 1993; Doyle et al. 1990). There are examples of risk-reducing projects, but these differ from process grants because the costs are typically associated with direct hazard reduction.[73] There are also hundreds of studies that assess the likely adoption of various hazard mitigation activities. These should not be ignored, and could perhaps be used in a qualitative assessment. For example, the radon risk studies (see

[73] For example, see the discussion of the use of the FEMA benefit-cost analysis module for estimating the net benefits of flood hazard reductions (http://www.demo.dcc.state.nc.us/mitigation/case_mecklenburg.htm)

Åkerman, Johnson, and Bergman (1991) or Smith et al. 1995) suggest that when faced with mitigation costs, individuals do assess the information provided to them and many do adopt mitigation, or engage in averting behavior.

There are also studies about information campaigns and their effectiveness that demonstrate that such programs can be highly beneficial to society (e.g. the Smokey the Bear advertising campaign, which reduced forest fires), and studies of government-funded programs to label goods and services which pose risks to consumers (e.g., Golan et al., 2000, conclude that nutrition labeling programs have been effective, and cite a case study by the Food and Drug Administration that showed benefits outweighed costs)[74].

The closest study that could be found addresses the cost-effectiveness of the U.S. Environmental Protection Agency's public information program to urge public testing for radon, before and during real estate transactions (Doyle et al., 1990; Marcinowski and Napolitano, 1993). Doyle et al. (1990) surveyed 920 households to gauge responses to the public information and awareness campaign on radon, which they name the "Washington, D.C. Radon campaign." This campaign was a cooperative effort between WJLA-TV, Safeway foodstores, and Air Check, Incorporated (see Chapter 2 details in Doyle et al,. 1990). As part of the campaign, radon test kits were sold at 125 Safeway stores at a 50% discounted price. Doyle et al. (1990) offer no estimate of the cost of this program.

They estimate that only 1.2% of the group of households with radon concentrations exceeding the EPA action level of 4 picocuries per liter of air, or pC_i/L, took remedial actions in response to the campaign. They conclude somewhat negatively:

> "A radon testing and information campaign aimed at the general public was shown to result in very low ultimate mitigation rates. Many of those who claimed to mitigate did not do so in an effective way…many of those who did test could not recall their radon reading or recalled it incorrectly." [Doyle et al., 1990, p. 55]

The Macinowski and Napolitano (1993) analysis also considered the basic standard level set at 4 pC_i/L. The authors apparently did not know the exact response rate to the public information campaign, stating only that it is known to be less than 100 percent. However, they conclude that even if only 10 percent of all homeowners test and mitigate, 220 lives would be saved annually, and that the EPA information program would be cost-effective. This might be high, given the findings by Doyle et al. (1990).

The conclusion is based on the comparison of cost per life saved (in the range of $400,000 to $2.4 million) to the value of a statistical life (in 1991, $2 million to $10.5 million). The authors state that the cost of a radon public information program would be about $2.2 to $3.3 billion per year nationally (they state 0.2 to 0.3 percent of the $115 billion the nation spent on pollution control in 1991). However, it is not clear whether this total program cost includes testing (such

[74] FDA estimates that the benefits of enhanced nutrition information (e.g. reduced fat and cholesterol) greatly exceed the costs of the program to provide such information. This study would not be appropriate for use in this analysis however, because the nature of the risks associated with fat and cholesterol are quite different than those associated with natural hazards.

as mentioned above by Doyle et al., 1990), mitigation, and other activities that are over and above any program cost that might be construed to be a process grant.

It should be noted that for radon, most all of the high risk (when the concentration is over 4 pC_i/L) occurs in only about 6 percent of U.S. homes. The average lifetime risk of getting lung cancer from exposure to radon in these homes is quite high: 1 in 50 (for a non-smoker the average falls to 1 in 500, which would still be considered a high risk). Averaging across all homes in the U.S., average risks would be quite low because most homes have radon levels below the EPA action level.

The validity of the radon risk example for use in assessing other natural hazard risks (flood, hurricanes, earthquakes) would depend on key differences between radon risk and natural hazard risk. One immediate difference is that radon gas releases are ongoing, while most of the natural hazards of interest would be sporadic or episodic. Another is that radon gas is colorless and odorless, giving no cues as to the risks. The validity would also depend on whether the hazard risks are highly concentrated in a few local areas, and the difference between the mortality risks in those areas and the mortality risks in homes with high concentrations of radon.

Another study that has relevance on the value of communicated risk information was a study of land fill or waste disposal siting by Bernknopf et al. (1997). In this study the authors examine the value of improved geographic information system (GIS) maps, weighing the costs of improving the maps and the resulting benefits in terms of avoided expected losses in property values. They find that the net benefits for their example context of Loudoun County, Virginia, are approximately $0.34 million. Using the cost and benefit numbers provided in their analysis, the implied benefit-cost ratio is 1.29. Benefits are expressed as the difference in expected losses when using one of two maps, and are solely couched in terms of average county property values.

We assume that for risk information, the benefit-cost ratio is 1.2, which is lowered from the Bernknopf et al. factor of 1.29 because of the discussion for the radon study.

K.2.2 Process Grants for Multi-Hazard Mitigation Plans

Mecklenburg County, North Carolina (which contains the city of Charlotte) recently revamped the use of, and type of floodplain maps because these were out of date. In the process of doing this, they county realized they had an opportunity to consider regulation of new development, adding future flood protection. Overall, this fits into the category of a multi-hazard mitigation plan.

The Mecklenburg floodplain is an area that has floods that led to 754 claims and $13 million in insured losses, up to the year 2000 (Canaan, 2000). The County hired a consulting firm at a cost of $1.4 million to update its maps. It also hired a consulting firm to assess flood losses, using the NIBS/FEMA HAZUS methodology (EQE, 2000).

The EQE (2000) study is informative, but it is not exactly a process grant, nor is the analysis consistent with the idea study that could be used here. The consultants use methods, including the Federal Insurance Administration's depth-damage curves, to assess damages in the

Mecklenburg floodplain under several scenarios, including projected future losses. Estimates of the percentage of buildings damaged by floods matching three scenarios are presented in this report, varying from 3.3 percent (for schools and libraries) to a high of 39.4 percent (business/professional and technical service buildings).

They project a total increase in structure damage from $8.5 to $25.2 million, based on a comparison between new estimates of current damage using the new floodplain delineation and future damage, projecting growth and development within the newly delineated floodplain. They suggest that County pursue mitigation measures to avoid this $16.7 million increase in structural damage, with similar analysis for avoiding content damage. Reversing this picture, one could say that the study would lead to savings of $16.7 million in structural damage, and $16.4 million in content damage, if mitigation measures are adopted to avoid the future scenario. The study mentions that removing the structures from the floodplain would cost approximately $12 million. One estimate of net benefits in the structural damage avoidance is then about $3 million ($16.7m less $12m, less $1.4m for the process grant), or a benefit-cost ratio would be about 1.25 ($16.7/13.4).

The TriNet project (see URS Group, 2001) is one of the only other studies found that might be used to assess the effectiveness of a process grant in this area. The project emphasizes improved building codes, but was funded under FEMA's Mitigation Grant Program with other features, including a plan for improved data transmission, improved spatial resolution of the geographic variation in earthquake ground motions, and improved motion sensors. These features were designed as part of an overall plan to reduce damage from earthquakes, so it might be best placed in this multi-hazard plan category. The grant is a process grant, for a total of $16.76 million. The impact of the grant was not only on reduced building damage, but also on reductions in power outages, and reduced casualties. In addition to the grant's cost, there were costs of $23.1 million for replacing/retrofitting old code buildings, and $12.4 million in developing codes for new buildings. The total net benefits of mitigation, excluding the process grant, were estimated to be $37.8 million. Assume that the process grant can be added as a cost, and that the net benefits of the project are then total benefits minus total costs. By adding the $16.76 million to the estimate provided in the report, net benefits are still positive. Put another way, the benefit-cost ratio without the grant cost is 2.06. The benefit-cost ratio, including the grant as part of costs, falls to 1.4, but is still above one. The assumption is that the benefit-cost ratio that is relevant to the process grant is the same 1.4.

Another study that has some relevance was recently completed by the North Carolina Division of Emergency Management (see NCDEM in conjunction with FEMA, 2004). This study assesses the savings (benefits) of a hazard mitigation grant to relocate and elevate homes in the floodplain in Belhaven, North Carolina, as they accrued from avoided losses from Hurricane Isabel. The grant, including state matching funds, was for about $9.3 million. Preliminary estimates indicate that within 2 years of the grant being provided, a return on investment of about 37% has been achieved. It is too early to consider this a complete benefit-cost ratio, but the study is optimistic regarding the return on this mitigation grant.

K.2.3 Process Grants for Changed/Improved Building Codes

This category pertains to the adoption of various building codes to mitigate against hazard damage, most frequently from earthquakes. Earthquakes cause property damage depending on the intensity that buildings are shaken. At the more moderate end of impacts, there will be the need for slight repairs and at the more severe end, entire structures can collapse and be beyond repair. Under many zoning plans various urban or regional zones are designated with codes as to their seismic risk, and building codes are adjusted to factor seismic loads. The benefits of more earthquake-resistant buildings (again, not a process grant per se) are going to be related to reduced property damage, injury, and mortality rates (Schulze et al. 1987).[75]

The risk and economic issues are similar to the ones above in this category of process grants, with two important additional features:

1. Tradeoff of destroying existing structures with loss in buildings of historical value and importance or loss of low-income housing; and
2. Perception of some buildings as public goods, and building code adoption as a public good; differentiation with privately owned buildings.

Porter et al. (2004) provide an extensive and careful analysis of the benefits of retrofitting woodframe homes. This is the one paper that does seem to tie the analysis to a process grant ($5.2 million for the CUREE-California Woodframe Project). Most analyses of the benefits of building codes, such as theirs, focus on property damage. Benefits are measures as losses averted, whether these be in minor repair bills over time, or more major reconstruction. Using a series of equations and Monte Carlo simulation of some of the probability distributions involved, the authors estimate whether retrofitting is cost-effective for areas corresponding to 1,653 California zip-codes. Assuming a 3 percent discount rate and a 30 year planning horizon, the authors estimate that the reduced future earthquake repair cost exceeds the cost to retrofit a certain small house (by adding foundation bolts, structural sheathing to unbraced cripple walls, and the strapping water heater to the frame), if the house were located in any of about half of California ZIP Codes (781 of 1,653). An above-code design for a particular townhouse building is estimated similarly to reduce future earthquake repair costs by more than the additional construction cost of exceeding code requirements, if the building were located in any of 300 California ZIP Codes.

Porter et al. (2004) also examine the benefits of high-quality construction, finding that median savings stemming from reduced seismic risk are from $1,000 to $10,000 over a thirty year period. The paper argues for frequent construction inspection, based on the results.

K.3 Conclusions/Caveats

Information on the benefits and costs of process grants is scant, at best. The analysis above draws heavily on similar analyses, as only two studies allow a direct comparison of some type of

[75] The Schulze et al. (1987) study is dated, but these authors use simulation methods and conclude that expected benefits from adopting uniform building codes that reduce wind, property damage, and reduce mortality from earthquakes along the Southern San Andreas fault outweigh the costs, at an assumed 4.5% real discount rate.

benefits to the cost of the grant (URS Group, 2001; Porter et al., 2004). Therefore, in each category the benefits relative to the costs of mitigation actions (not process grants per se) are mainly considered, but the table reflects consideration of whether the process grant would tip the balance so that net benefits were negative (or the benefit-cost ratio was less than one). When the difference between benefits and costs of mitigation is large relative to the cost of the process grant, it is more likely that a process grant is cost-effective.

Recall that there are no available benefit-cost analyses for category A, the natural hazard risk communication studies. This category is split into two separate subcategories, risk warnings, and risk education. It is more likely that a process grant will have positive net benefits when it relates to direct warnings. The project team used information from the radon risk public information program study (the Washington Study), and differences between the radon context and the natural hazards context have been noted above.

Table K-1 Conclusions on likely benefit-cost ratio for process grant categories

Category of Process Grant	Likely Net Benefits or Benefit-Cost Ratio
A1. Risk Communication (warnings)	Qualitative Adjustment from Radon - Judgment Only- Positive (1.2)
A2. Risk Communication (education)	Inconclusive
B. Multihazard Mitigation	1.25 - Weakly Positive (1 to 1.4)
C. Building Codes	Positive (> 1)

Many of the process grants analyzed are for earthquake-related damages, and are most likely related to building codes. One of the grants (Grant 7201) is for Steel buildings, but no information is available on grants or mitigation activities in that category. Grants related to Tsunami guides and grading are most likely falling into the multi-hazard category. Except for Steel Buildings and for the seismic map project, a conservative estimate of the benefit-cost ratio applicable for process grants in these categories is 1.25 to 1.4. This range is based on the Mecklenberg studies and the URS Group report, which is most applicable to multi-hazard grants. As there is a map involved for the seismic mapping process grant, another estimate to confirm this range for the benefit-cost ratio is 1.29, which based on the Bernknopf et al. (1997) study of the value of map information. Applying this study assumes that property value changes fully capitalize the hazard warning effects via the housing market.

Building code process grants likely have a larger benefit-cost ratio. In addition, if a process grant is small, it is quite likely that its net benefits will be positive, based on the Litan et al. study of earthquake mitigation. The reason is that their average benefit-cost ratio is about 3. Therefore, any process grant that is small, and which does not have negative consequences in obtaining mitigation, will only slightly raise costs, and therefore slightly reduce the benefit-cost ratios in this category.

First, as noted above, most of the literature available does not assess the benefits of a process grant in any of the above categories. Rather, some of the literature assesses the benefits and costs of a particular mitigation action itself.

Based on logic and effectiveness in other contexts (see Golan et al., 2000) there is reason to believe that process grants provide positive net benefits in many situations. The mitigation action in many cases would never have taken place if a process grant had not spawned the initial plan or building code that led to implementation. A simple, common sense conclusion would be that when net benefits from mitigation in a particular category, exclusive of a process grant, are large, then a small process grant certainly cannot much reduce the net benefits, so any grant in that category is likely to be positive. However, when actual mitigation is quite costly to the individual, it is much less likely that a process grant is going to lead to positive net benefits.

Some caveats are warranted. It has to be stated clearly here that in the project team's literature search, no studies were found that specifically estimated the benefits of a process grant, which is the goal of this analysis. Possible key differences between radon risk communication and a natural hazard risk warning were noted: it is not known, however, if the Doyle et al. (1990) finding of about 1.2 percent adoption would pertain to natural hazard migitation adoption. Therefore, one view of this is that none of the estimates are free from concern regarding their accuracy. Only available information is being used, which largely pertains to benefits and costs for mitigation activity grants.

Second, there is still not enough information on the effectiveness in terms of adoption of a mitigation action in the literature to generalize in the above categories. Third, blanket categorical benefit-cost ratios are unwise. Last, there is likely substantial regional variation in adoption rates, and hence, regional variation in the effectiveness of process grants (e.g. see Lindell and Prater, 2002).

Appendix L
BASE-ISOLATED BUILDINGS LOSS ESTIMATION

One effort to base-isolate a building appears in the sample of earthquake mitigation grants. The question arises, how to model the benefits of this grant, and more specifically, how to model the post-mitigation property loss? HAZUS does not contain loss functions for base-isolated buildings, and the paper grant application does not contain pushover parameters (the parameters required for a HAZUS analysis). While a great deal of structural engineering literature exists on base isolation, it was impossible within a reasonable period of time to discover any generic pushover parameters for base-isolated buildings.

It was therefore assumed for present purposes that base isolation virtually eliminates the expected present value of loss, relative to pre-mitigated conditions. The benefit-cost ratio calculation is fairly insensitive to whether the loss is reduced by 90 percent, 95 percent, or 99 percent; the benefit is essentially equal to the pre-mitigation loss. Since the pre-mitigation loss is not that of a base-isolated building, pushover curves for the base-isolated case become immaterial.

Appendix M
DEBRIS FLOW DAMAGE ESTIMATION

Following are the steps taken to estimate damage from debris flow.

Step 1. *Assess the frequency of significantly damaging debris flows*. This is the most challenging step. For the Multnomah County regions affected, two precipitation-induced (low energy source) debris flows occurred in a seventy-year period. In addition, when corrected, a geologic evaluation of debris material accumulations led to estimates of 17-35 years per debris flow for the sites in question. One prominent geologist in charge of natural hazards for geology and knowledgeable about the area estimated a 50-year return interval. She noted that a high-energy source might occur about every 500 years. One other geologist who had made extensive studies thought that a 35-year return interval was reasonable given the paucity of the data. A third geologist, in charge of hazard mapping for the region, claimed that this hazard mapping was designed for land-use and other planning purposes, and not for analysis of risks. All noted that there had been debris flows in the region, even as recently as 2002, that had not caused damage.

Recommendation: Assume a 35-year return interval, with 17-years and 50-years as assumptions for sensitivity evaluations. Assume that a high-energy source might initiate debris flows every 500 years.

Step 2. *Estimate the damages to the six residences based on significantly damaging debris flows.* (see also step 4) In the original benefit-cost evaluation, a very high dollar amount was put on such damages, about 80 percent higher than the market value of properties. This step consists of estimating the replacement value of these six residences and then estimating the degree of damages expected from debris flows. Data should be gathered to estimate replacement values. Since the debris flows selected in Step 1 are "significantly damaging," it is assumed that losses are 100 percent of replacement value. This at least is consistent with the original benefit-cost evaluation. Costs to clean up the debris, should the damage be less than 100 percent, should be made in consultation with a knowledgeable contractor.

Step 3. *Estimate casualties from significantly damaging debris flows.* There is to date no indication of casualties in the 1996 debris flow. There is much evidence, however, that debris flows worldwide cause many casualties. Debris flows that have low energy sources (precipitation-induced) provided days of prospective warnings. Thus, even though debris flows may only take a few minutes to cause damage once they begin, preparations for precipitation-induced debris flows can occur days in advance. Debris flows caused by high-energy sources may be another matter. They do typically require some degree of prior precipitation, but they may have less warning. In this case, simplified accounts of how many people might be present, and how many might be able to evade, say, 500-year events could be devised. However, because such a simplified technique is highly speculative, it should not govern the benefit-cost ratio. Therefore, assume one death per 500 years as a conservative (lower bound) estimate, and conduct sensitivity evaluations to estimate a possible range of answers.

Step 4. *Determine the degree of damage in the 1996 event*. This step should help not only in refining the prospective degree of damage in debris flows, but more critically should define more clearly the "marginal costs" of buyouts. If the residences are substantially damaged, then buyouts can be a substitute for other payments, such as those through FEMA directly, or from FEMA/FIA (Federal Insurance Agency).

Appendix N
FOUR METHODS TO SELECT SAMPLE AND SCALE-UP BENEFIT

N.1 Summary

This appendix documents four methods to select a sample of size $N = 25$ from a population of mitigation efforts and to calculate total stratum benefit. In all four methods, stratified sampling is used to ensure sampling of the tails of the distribution of approved net eligible project cost (referred to hereafter as cost). In summary, the methods are as follows.

Method 1**:** mitigation efforts are selected for sampling with equal probability, using strata of equal sizes, and population benefit is estimated as the sum of the sample benefits times L/N, where L is the number of mitigation efforts in the population.

Method 1b**:** mitigation efforts are selected for sampling with equal probability, using strata of equal sizes, and population benefit is estimated as $B' = C^*\mu_{bcr}$, where μ_{bcr} is the sample-average benefit-cost ratio.

Method 2**:** mitigation efforts are selected with probability in proportion to their cost, using strata of equal cumulative cost, and population benefit is estimated as the sum of the sample benefits times C/c, where C is the population cost and c is the cost of the sample.

Method 3**:** mitigation efforts are selected with probability in proportion to their cost, using strata of equal cumulative cost, and population benefit is estimated as $B' = C^*\mu_{bcr}$, where μ_{bcr} is the sample-average benefit-cost ratio.

Let:

L = population size (number of mitigation efforts in the population)
N = sample size (number of mitigations in the sample)
c_i = cost of mitigation i.
bcr_i = benefit-cost-ratio of mitigation i
b_i = benefit of mitigation i = $c_i bcr_i$
C = the total cost of all mitigations
B' = estimated benefit of population based on sample

$= (L/N)^*\Sigma_N b_i$	method 1	(N-1)
$= (C/\Sigma_N c_i)^*\Sigma_N b_i$	method 2	(N-2)
$= C^*\Sigma_N bcr_i/N$	methods 1b and 3	(N-3)

B = true population benefit = $\Sigma_L b_i$
ε = relative error of benefit estimate

$$= (B' - B)/B \qquad \text{(N-4)}$$

μ_ε = mean relative error of benefit estimate
σ_ε = standard deviation of relative error of benefit estimate

Two reasonable criteria for accepting a sampling method are: (1) it produces an unbiased estimate of total benefit, i.e., $\mu_\varepsilon \approx 0.0$, and (2) it produces a small uncertainty in the estimate of total benefit, i.e., σ_ε is small. The criterion for acceptable σ_ε is that the uncertainty is small enough that one can answer with 90% confidence whether FEMA grants have been cost effective, i.e., either:

$$B'*(1 - 1.28\sigma_\varepsilon)/C > 1.0 \text{ or equivalently } (1 - C/B')/1.28 > \sigma_\varepsilon$$

or

$$B'*(1 + 1.28\sigma_\varepsilon)/C < 1.0$$

In the former case, one can say with 90% confidence that the population of mitigation efforts within the stratum is cost-effective; in the latter, one can say with 90% confidence, the population of mitigation efforts within the stratum is not cost-effective. Both assume normality of B', an unbiased estimate of B, and ignore error in the estimation of benefit for an individual mitigation effort, b_i. For an unbiased estimator, $E[B'] = B = \$5.57*10^9$ and $C = \$2.36*10^9$. An acceptable sampling approach must therefore have $\sigma_\varepsilon < (1 - C/B)/1.28$, or $\sigma_\varepsilon < 0.45$. Only method 3 passes this criterion.

Explanations of the mechanics of these selection and benefit-calculation procedures follow.

N.2 Method 1

This method applies an equal probability of a grant being sampled, and benefits are scaled up in proportion to number of grants sampled. Method 1 is performed as follows.

1. Stratify project-type mitigation activities by peril (earthquake, wind, flood) and hazard level. The following steps are repeated for each stratum.
2. Select N, the number of samples per stratum. In this project, $N = 25$.
3. Sort the population in increasing c_i.
4. Divide the stratum population in N contiguous bins of increasing cost, with an equal number n of projects in each bin (±1, to account for a stratum population that is not an integer multiple of N).
5. Assign a random number u, uniformly distributed between 0 and 1, to each mitigation effort.
6. Re-sort projects by increasing bin number and then by increasing u within the bin.
7. Select from each bin the project with the lowest value of u. The result is N randomly selected projects that nonetheless span the range of project costs.
8. Calculate the benefit for each mitigation effort in the sample, b_i: $i = 1, 2, \ldots N$, where i now indexes mitigation efforts in the sample.
9. Calculate B' per Equation N-1.

N.3 Method 1b

This method applies an equal probability of a grant being sampled, and scales up benefits by averaging sample benefit-cost ratio (BCR). Method 1b is performed as shown under Method 1, except that B' is calculated per Equation N-3.

N.4 Method 2

This method applies probability of a grant being selected in proportion to its cost, and scales up benefit in proportion to the cost of sampled grants. It works as follows.

1. Stratify project-type mitigation activities by peril (earthquake, wind, flood) and hazard level. The following steps are repeated for each stratum.
2. Select N, the number of samples per stratum. In this project, $N = 25$.
3. Sort the population in increasing c_i.
4. For each mitigation effort i, calculate the cumulative fraction of total cost, $F_C(c_i) = \Sigma_{j=0..i}c_j$. Divide the population in N contiguous bins of increasing project cost, with equal total bin cost, i.e., bin k includes mitigation efforts p, p+1, … q such that $\Sigma_{j=p..q}c_j = C/N$.
5. Assign a random number u, uniformly distributed between 0 and 1, to each mitigation effort.
6. Select from each bin the project with the lowest value of u. The result is N randomly selected projects that both span the range of cost and place more emphasis on costlier projects.
7. Calculate the benefit for each mitigation effort in the sample, $b_i = bcr_i*c_i$, $i = 1, 2, \ldots N$, where i indexes mitigation efforts in the sample.
8. Calculate B' per Equation N-2.

N.5 Method 3

In this method, the probability of sample selection is proportional to its cost, and the benefit is scaled up by calculating the sample-average BCR and applying this BCR to the stratum.

1. Stratify project-type mitigation activities by peril (earthquake, wind, flood) and hazard level. The following steps are repeated for each stratum.
2. Select N, the number of samples per stratum. In this project, $N = 25$.
3. Sort the population in increasing c_i.
4. For each mitigation effort i, calculate the cumulative fraction of total cost, $F_C(c_i) = \Sigma_{j=0..i}c_j$. Divide the population in N contiguous bins of increasing project cost, with equal total bin cost, i.e., bin k includes mitigation efforts p, p+1, … q such that $\Sigma_{j=p..q}c_j = C/N$.
5. Assign a random number u, uniformly distributed between 0 and 1, to each mitigation effort.

6. Select from each bin the project with the lowest value of *u*. The result is *N* randomly selected projects that both span the range of cost and place more emphasis on costlier projects.
7. Calculate mean benefit-cost ratio for the sample, μ_{bcr}: = $\Sigma_N bcr_i/N$, $i = 1, 2, \ldots N$, where *i* indexes mitigation efforts in the sample.
8. Calculate B' per Equation N-3.

N.6 Tests of Method 1

Simulated population. A simulated (hypothetical) population of $L = 1000$ mitigation efforts was created whose cost distribution match that of the FEMA grants, i.e., lognormal with median cost = $732,000 and logarithmic standard deviation = 1.80. It was necessary to assign a value of benefit to each mitigation effort. To do this, the benefit-cost ratios (BCRs) in the NEMIS grant database were examined, and those with project cost (denoted by *C*) > 1 and BCR > 1 extracted. Of the extracted grants, it is found that the average estimated BCR is 10.3, with a logarithmic standard deviation of 0.87. Project cost and BCR appear to be uncorrelated, either for the population (correlation coefficient $\rho = -0.0097$, $N = 3176$), wind mitigation grants ($\rho = -0.025$) or flood mitigation grants ($\rho = -0.024$); a modest negative correlation exists for earthquake mitigation grants ($\rho = -0.10$). A lognormal distribution was assigned to BCR using the statistics quoted above and BCRs were simulated for each mitigation grant in the simulated population.

Testing for bias. The hypothetical population was grouped into $N = 25$ strata of $M = L/N = 40$ samples per stratum, with the substrata grouped by increasing cost, per the sampling approach described above. The Excel add-in "Insight.xla" (see www.duxbury.com) was used to create Q = 1000 simulated sample sets of 25 mitigation efforts, each time calculating the actual population benefit $B = \Sigma_L b$ and the estimated benefit $B' = M\Sigma_N b$, and calculated the error per Equation N-4. There is one value of ε for each sample set, i.e., there are $Q = 1000$ samples of ε. One can calculate a mean bias as $\mu_\varepsilon = 1/Q^*\Sigma_Q\varepsilon$. A value of $\mu_\varepsilon \neq 0.0$ indicates a bias. In these expressions, b is the benefit from one mitigation effort, Σ_L indicates the sum over the population of L mitigation efforts, Σ indicates the sum over the sample of N mitigation efforts, Σ_Q indicates a sum over Q sample sets, B indicates the "true" total population benefit, and B' indicates the estimated population benefit extrapolated from the sample.

Observations. This simulation approach produces an unbiased estimate of benefit. Using Q = 1000 simulation produces an estimated mean error, $\mu_\varepsilon = -0.022$, and an estimated standard deviation of error $\sigma_\varepsilon = 0.69$, which is too large. One observes an unbiased estimate if BCR is assumed to be a constant value (BCR = 2 produces $\mu_\varepsilon = 0.0014$), if BCR is assumed to increase linearly with cost (BCR = 1 + C/100 produces $\mu_\varepsilon = 0.013$), to linearly decrease with cost (BCR = 5 – C/100 produces $\mu_\varepsilon = 0.013$) or to be quadratic with cost (BCR = 1 + $(C/100)^2$ produces μ_ε = 0.039).

Testing using the NEMIS population. The bias test was repeated using a subset of the NEMIS portfolio: all those in-scope mitigation efforts whose $C > 1$ and whose BCR > 1. The subset includes $L = 3176$ mitigation efforts. These were stratified into $N = 25$ strata of $M = 127$ efforts each (the first stratum had $M = 128$). The Microsoft Excel add-in Insight.xla was used to create

1000 sample sets of 25 mitigation efforts, each time calculating the actual population benefit and the estimated benefit $B' = (L/N)\Sigma b$, and calculating the error per Equation N-4. For the "actual" population benefit, the estimated BCRs from the NEMIS database were used: $B = \Sigma_L b = \Sigma_L bcr_i * c_i$. Again using $Q = 1000$, it is found that $\mu_\varepsilon = 0.00058$, which suggests no bias, and a standard deviation of error, $\sigma_\varepsilon = 0.55$, which is approximately equal to that obtained using the simulated portfolio. A test using Method 1b produces a biased and highly uncertain estimate: $\mu_\varepsilon = 0.82$ and $\sigma_\varepsilon = 1.56$.

Method 1 has unacceptably high uncertainty. Method 1b has unacceptable bias and uncertainty.

N.7 Tests of Method 2

This approach was tested once using the simulated population (with random BCR distributed the same as FEMA's estimate shown in the NEMIS population) and once using the NEMIS population. Using the simulated population, this approach produces an unbiased estimate of total benefit, with better accuracy than Method 1: in $Q = 1000$ simulation, one finds $\mu_\varepsilon = -0.010$, and standard deviation of error $\sigma_\varepsilon = 0.17$. Comparing this $\sigma_\varepsilon = 0.17$ with 0.69 using Method 1 suggests that Method 2 produces a much more-accurate estimate of total population benefit.

However, using the NEMIS population and NEMIS benefits, this method underestimates the population benefit, albeit with very low variability: $\mu_\varepsilon = -0.40$ and $\sigma_\varepsilon = 0.05$. The reason appears to be the slight negative trend of BCR with cost; although $\rho_{c,bcr} = -0.0097$, the trend is strong enough to produce a consistent under-estimate of benefit. That is, benefit accrues disproportionately from smaller projects. Again, this test assumes that the existing FEMA estimates of benefit are unbiased with respect to cost, i.e., that the "true" BCR follows the same trend with cost as does the BCR estimated by FEMA.

Method 2 has unacceptably high bias.

N.8 Tests of Method 3

Method 3 was tested both with the synthetic population and the NEMIS population. The former produced an unbiased estimate of B, with $\mu_\varepsilon = 0.0078$ and $\sigma_\varepsilon = 0.13$; the latter a biased estimate: $\mu_\varepsilon = 0.42$ and $\sigma_\varepsilon = 5.18$. The reason is that there are four mitigation efforts in the NEMIS portfolio with $bcr \approx 3300$ and one with $bcr \approx 6200$. They have low cost, so their effect is small under method 2, but method 3 is sensitive to them. When these are eliminated from the population, $\mu_\varepsilon = 0.023$ and $\sigma_\varepsilon = 0.39$, i.e., an unbiased estimate of benefit with a moderate uncertainty. (The previous methods were also checked after censoring these high BCRs; this approach makes too little difference to accept Methods 1, 1b, or 2.)

Method 3 has an acceptable uncertainty, as long as one assumes that samples of BCR > 1000 are erroneous.

Appendix O
COMMUNITY SELECTION PROCESS

Initially fourteen communities were selected for possible study in accordance with the selection procedures described below. Ultimately, for budgetary, scheduling, and operational reasons, eight communities were selected for study.

Communities to be considered for study by the project team were selected using non-probabilistic sampling procedures, specifically quota and purposive sampling procedures. Generally, non-probability sampling is used when the researcher is unable to describe the population from which a sample is to be drawn and, hence, cannot describe the "probability" with which a person, community or some other unit of analysis within the population will be selected for the sample. Non-probabilistic quota samples are sometimes considered roughly analogous to probabilistic stratified samples in that certain variables thought to be important in describing the population are identified and efforts are made to insure that people or communities are selected so that they represent the range or diversity of values or types on those variables.

The following ordered criteria or variables were used in selecting the communities for study: (1) the combination of hazards for which communities had received FEMA awards; (2) validation according to available hazard maps that a community was at high risk of at least one of the three hazards (wind, flood, earthquake) being studied[76]; (3) community size defined as small (10,000-49,999), medium (50,000-499,999) and large (≥ 500,000)[77] [78]; and (4) the geographic distribution of communities. The geographic distribution of communities was largely established once the pattern of awards received and the level of hazard risk were applied, since the distribution of floods, wind and earthquake hazards is not constant across the United States. To further insure geographic distribution the project team examined the distribution of awards across the ten FEMA regions. While noted, demographic characteristics of communities and whether they had or had not received a Project Impact award were not used in selecting communities.

Ultimately, however, the last stage in the selection of any non-probability sample, including a quota sample, is a judgment made by the person or group selecting the sample. Purposive sampling is the application of expert judgment to the selection of who is in the sample. Unusual in the selection of the communities to be studied is the fact that, unlike most non-probability samples, the population of communities from which the sample was drawn can be described. As a result, this sample is somewhat analogous to the multi-stage sampling procedures used in the Gallup Poll where the first stages of selection are probabilistic and the final stages of selection involve, first, *quota sampling* and, second, *purposive sampling* where the interviewer

---

[76] The community selection procedures are described in the *Community Studies Scoping Study Report* of September 22, 2003, and represent one of multiple procedures explored by the Project team.

[77] Proposed by E. Mittler and C. Taylor in July 2003; approved by the MMC Project Management Committee (PMC) on August 6, 2003.

[78] The PMC recommended the inclusion of at least one county in July 2003.

(in a Gallup Poll) selects the actual persons interviewed. Judgment was used to establish the quotas and in deciding how to structure the actual selection of communities.
The sample that is reflected in this appendix was selected in three stages based on several factors: (1) the project team would sample six communities as a minimum; (2) if additional funds were provided, the project team would include as many as four additional communities, bringing the total number of communities to ten; and (3) a third set of four communities was selected to serve as replacement communities in the event that a community in one of the first set of six communities or second set of four communities was unavailable.

O.1 The Population

The National Emergency Management Information System (NEMIS) data file that ATC received on July 23 2003 was used to identify the population from which the project team selected the additional communities for study. This data set is a transactional database that includes one record for each award. It includes 8,030 awards that had been completed or closed. To be eligible for consideration, communities had to: (1) have received awards whose objective was to mitigate damage from earthquakes, flood, or wind (coastal storm, hurricane, severe storm, tornado, typhoon); (2) be at high or medium risk of earthquakes, flood, or wind hazard(s) as identified on hazard maps as described in the Community Studies Scoping Study of September 22, 2003; (3) be a single jurisdiction identified with a legal title as a city, town, borough, village or county within one of the 50 states; (4) have both project and process (includes Project Impact) activities funded; (5) have received project and process grant awards that total ≥ $500,000; and (6) have received a total of ≤ 15 awards. One hundred thirteen (113) communities met all six criteria.

O.2 Database Considerations

It should be noted that the combination of awards assigned to communities that were used to make the selection of communities for further study may be unavoidably incorrect. There are several reasons for this judgment. First, there are errors in the NEMIS database. One of the findings in the Community Studies Pilot Study was that the NEMIS database for Tulsa, Oklahoma, did not contain any reference to some grants the project team found in Tulsa, and misidentified others. Second, when the description of the grant did not clearly identify what hazard the grant activity referred to, the project team labeled the grant the same as the proximate cause of the Presidential disaster declaration, i.e., flood grant for a flood, earthquake grant for an earthquake. In some cases, these will not be correct because in recent years FEMA has awarded mitigation grants for all hazards following a disaster declaration such that, for example, flood and wind grants can be awarded after an earthquake. Limitations of time and other resources prevented the project team from identifying possible errors, which the team believes were minimal and did not significantly affect choices.

In recognition of problems in the NEMIS data set, once the sample of communities is selected data available in the NEMIS data set for each community was again examined. The objective here was to insure that each community jurisdiction selected had received no more than 15 awards, process and project combined, that totaled at least $500,000, and that the awards had, in fact, been made to the jurisdiction selected. Of particular concern were situations, such as

Atlantic City and Atlantic County, New Jersey, where both a city and a county have the same name. Many grants listed in the NEMIS data set do not clearly indicate which of the two same-name jurisdictions received the award. Information that is not in the data set must be available to determine the awardee.

O.3 Setting and Applying Criteria and Quotas for the Sample

Available funding and other considerations specified that a sample of fourteen communities would be selected iteratively in groups of six, four and four. The last set of four communities selected would be studied *only if* one or more communities within the first ten selected were unavailable for study. One possible reason for a dropout is that the community was severely impacted by a disaster during the conduct of this study, thus limiting possible access to key individuals, organizations, etc. Five criteria were used to determine which communities were selected for inclusion. They were: (1) the combination of awards received; (2) the hazard risk as determined by the maps available in August 2003 (see Community Studies Scoping Study of September 22, 2003; (3) the size of the community; (4) the FEMA region in which communities were located; and (5) a post-selection check of the awards received by each community against the NEMIS data base.

Step 1: Combination of Awards Received. In*n* the *first step*, communities were sorted according to the *combination of awards* they had received from FEMA: earthquakes only (N = 10; 8.8%); wind only (N = 8; 7.1%); flood only (N = 38; 33.6%); earthquake and flood (N = 4; 3.5%); wind and flood (N = 50; 44.2%); and earthquake, wind and flood (N = 3; 2.7%), and quota limits were established for the selection of the sample. In Table O-1[79], Column 4 shows constraints placed on each category in terms of the maximum number of communities that could be selected with that combination of FEMA awards. These were set to be roughly proportionate to how the patterns were represented in the population of 113 communities[80].

Fourteen communities were selected for study in sets of six, four and four. For purposes of this evaluation it was important to allow each combination of awards in the sample to be potentially represented by at least one community. It was also important to insure that all the communities were not selected from only one or two award patterns. If maximum limits were not set in advance of the draw, it was possible, although unlikely, that all of the communities selected for the sample would represent only one or two combinations of awards. For example, the first 14 communities drawn could be the 10 communities with only earthquake awards and the four communities with flood and earthquake awards.

[79] Ninety-five (85%) of the 113 communities in this population received at least one FEMA award for floods; hence, given criteria 2, communities with flood awards are necessarily underrepresented in this sample.

[80] Fourteen communities were to be selected distributed as FEMA awards were distributed in column 1 of Table O-1. The expected number of communities in each category was: 1.23 for earthquake only; 4.7 for flood only; 0.99 for wind only; 0.49 for flood and earthquake only; 6.19 for flood and wind; and 0.378 for flood, quake and wind. Obviously fractions of communities cannot be studied so a lower boundary of one community was set for each award combination. Thus, at least one community had to be selected for the two smallest categories, flood and earthquake, and flood, earthquake, and wind; up to two communities were allowed for the next two smallest categories, earthquake only and wind only. Since no more than 14 communities would be selected in all, this restricted the largest two categories, flood only and flood and wind, to a maximum of four communities.

Table O-1 Distribution of communities and quota limits set for the sample by the pattern of FEMA awards received by a community (N =113)

Awards Received	Population		Sample Limits for Category	Communities Selected in the Sample Draw (Set)[1]
	N	%		
Earthquake Only	10	8.8	≤ 2	Hayward (1) Orange (2)
Flood Only	38	33.6	≤ 4	Jamestown, ND (1) Mandeville, LA (2) East Haven, CT (3) Des Moines, IA (3) Multnomah County, OR (3)
Wind Only	8	7.1	≤ 2	Virginia Beach (3)
Flood and Earthquake	4	3.5	≤ 1	Los Angeles (2)
Flood and Wind	50	44.2	≤ 4	Freeport, NY (1) Tuscola County, MI (1) Jefferson County, AL (1) Ft. Walton Beach, FL (2)
Flood, Quake & Wind	3	2.7	≤ 1	Horry County, SC (1)

[1]This column shows how the 14 communities drawn when the sample was selected (see Table O-6) match with the criteria set for the pattern of FEMA awards received. "Set" refers to whether the community was selected to be in the first set of six communities, the second set of four communities, or the third set of four communities.

In determining how to set upper limits for the combination of awards received, the proportion of awards received was stratified as follows. Award combinations with less than 5% of the communities in the population were limited to no more than one community in the total sample. Thus, no more than one community could be drawn from the four communities with awards for flood and earthquake and the three communities with awards for flood, quake and wind. Two award combinations included more than 30% of the awards, namely flood only and flood and wind. An upper limit of four communities was set for each of these categories. The remaining two award combinations included, respectively, 8.8% of awards (earthquake only) and 7.1% of awards (wind only). Maximum limits for these two groups were set at no more than two communities.

For the first set of six communities drawn, one community (16.7%) was drawn for earthquake only, one (16.7%) was drawn for flood only, none (0.0%) was drawn for wind only, none (0.0%) was drawn for flood and earthquake, three (50.0%) were drawn for flood and wind, and one (16.7%) was drawn for flood, quake and wind. This demonstrates the difficulties associated with drawing a "representative" sample when both the sample and the population are small.

Step 2: High Risk of Wind, Flood and/or Earthquake. In the *second step*, communities were sorted according to high risk of hazards with 26.5% (N = 30) being at high risk from earthquakes, 56.7% (N = 64) at high risk from floods, and 25.7% (N = 29) at high risk from wind. These are not mutually exclusive categories since communities could be at high risk from more than one hazard. This means that any of the 113 communities can appear in Table O-2 more than once; therefore the total may be greater than 113. Since such a large proportion (67.3%) of communities were at *high risk* of at least one of the three hazards (earthquake, flood, wind) according to the hazard maps available in August 2003, the 37 communities that were not at high risk of at least one hazard were deleted from further consideration. Since it was only important that every community in the sample was judged to be at high risk from at least one hazard and because the experts available to the community studies team were having difficulty establishing hazard levels for floods, in setting the limits for these criteria, rough limits rather than absolute maximums were set. Column five of Table O-2, shows that the approximations were exceeded in each hazard category. This is because many communities in the population are at high risk from multiple hazards.

Table O-2 Distribution of communities and quota limits set for the sample by being at high risk of earthquake, flood or wind hazard (N =113).

Hazard for Which Community is at High Risk	Population		Sample Limits for Criteria	Communities Selected in the Sample Draw (Set)[1]
	N	%		
Earthquake	30	26.5	≈ 4	Hayward (1) Horry County, SC (1) Orange, CA (2) Los Angeles (2)
Flood	64	56.7	≈ 7	Freeport, NY (1) Horry County, SC (1) Jefferson County, AL (1) Jamestown, ND (1) Tuscola County, MI (1) Ft. Walton Beach (2) Los Angeles (2) Des Moines (3) East Haven, CT (3) Multnomah County, OR (3)
Wind	29	25.7	≈ 4	Freeport, NY (1) Horry County, SC (1) Mandeville, LA (2) Virginia Beach (3) East Haven, CT (3)

[1]Shows how the 14 communities drawn when the sample was selected (see Table O-6) match with the criteria set for being at high risk of at least one hazard. "Set" refers to whether the community was selected to be in the first set of six communities, the second set of four communities, or the third set of four communities.

Step 3: Community Size. In the *third step*, criteria were set for *community size* (Table O-3). Within the population, 40.7% (N = 46) were small communities, 49.6% (N = 56) were medium communities, and 9.7% (N = 11) were large communities. In July 2003[2] it was decided that one large community and at least one small community would be included in each set of communities selected for study. This decision reflected a concern that large communities, even if drawn, might be skipped over because it was anticipated that it would be more difficult to study them. Absolute limits were set here for each draw with the *first draw* of 6 communities being two small communities (10,000-49,999), three medium communities (50,000-499,999), and one large community (≥ 500,000). Note that this set of six communities roughly represents the size of communities as represented in the population: 33% small communities; 50% medium communities; and 16.7% large communities. The *second draw* was set at two small communities, one medium community, and one large community, and the *third draw* was set at one small community, two medium communities and one large community. If all 14 communities were studied, the second and third draws result in small communities (35.7%) and medium communities (42.8%) being slightly underrepresented and large communities (21.4%) being substantially overrepresented. If the first two sets of communities were studied, which was the expectation, small communities were correctly represented (40%), medium communities were underrepresented (40%) and large communities were overrepresented (20%).

Table O-3 Distribution of communities and quota limits set for the sample by population Size (N = 113)

Community Size	Population		Sample Limits for Criteria			Communities Selected in the Sample Draw[1]		
	N	%	Set 1	Set 2	Set 3	Set 1	Set 2	Set 3
Small (10,000-49,999)	46	40.7	2	2	1	Jamestown, Freeport	Mandeville, Ft. Walton Beach	East Haven
Medium (50,000-499,999)	56	49.6	3	1	2	Hayward, Tuscola County, Horry County	Orange, CA	Des Moines, Virginia Beach
Large (≥ 500,000)	11	9.7	1	1	1	Jefferson County	Los Angeles	Multnomah County

[1]Shows how the 14 communities drawn when the sample was selected (see Table O-6) match with the criteria set for community size. "Set" refers to whether the community was selected to be in the first set of six communities, the second set of four communities, or the third set of four communities

Step 4: FEMA Region. In the *fourth step*, communities were sorted by the *FEMA region* where they were located, and criteria were established. As expected, the largest number of communities are in Region IV and Region IX. The distribution of communities across regions is somewhat similar to the distribution of communities across award patterns in that each of four regions have less than 7% of the awards, four regions have between 7% and 12% of the awards, one region has 10.6% of awards, and one region has 26.5% of awards. These four groupings were identified as strata for purposes of setting limits, while simultaneously attempting to obtain at least one community in each of the ten regions. Regions that contained no more than 6.2% of communities were limited to no more than one community in the sample. These include Regions I, II, VII and VIII. Regions with approximately 10% of communities were limited to no more than two communities in the sample; these were Regions III, V and X. Up to three communities could be selected from Region IX and up to four communities could be selected from Region IV. As can be seen in Table O-4, these limits were exceeded for Region IX.

Step 5: Post-Selection Against NEMIS In recognition of some of the limitations in the NEMIS data base noted earlier under *Data Base Considerations*, after the 14 communities were selected, information available in the NEMIS data base was again examined in detail for each community.

O.4 Drawing the Communities for the Sample.

Once limits for the four criteria were set, information about each of the 76 communities that were at high risk from at least one hazard was written on pieces of paper. The 76 pieces of paper

Table O-4 Distribution of communities and quota limits set for the sample by FEMA region (N = 113)

FEMA Region	Population		Sample Limits for Criteria	Communities Selected in the Sample Draw (Set)[1]
	N	%		
Region I	7	6.2	≤ 1	East Haven, CT (3)
Region II	4	3.5	≤ 1	Freeport, NY (1)
Region III	11	9.7	≤ 2	Virginia Beach (3)
Region IV	30	26.5	≤ 4	Jefferson County, AL (1) Horry County, SC (1) Ft. Walton Beach, FL (2)
Region V	8	7.1	≤ 2	Tuscola County, MI (1)
Region VI	12	10.6	≤ 2	Mandeville, LA (2)
Region VII	7	6.2	≤ 1	Des Moines (3)
Region VIII	7	6.2	≤ 1	Jamestown, ND (1)
Region IX	18	15.9	≤ 3	Hayward (1) Orange (2) Los Angeles (2)
Region X	9	8.0	≤ 2	Multnomah County (3)

[1]Shows how the 14 communities drawn when the sample was selected (see Table O-6) match with the criteria set for the distribution across the ten FEMA regions. "Set" refers to whether the community was selected to be in the first set of six communities, the second set of four communities, or the third set of four communities.

were placed in an egg basket, shaken up, and the first community was drawn for the first set of six communities. The process was repeated until all fourteen communities were drawn. The papers were shuffled between each draw. Once a community was drawn and either accepted or rejected for inclusion in the sample, it was permanently removed from the pool of eligible communities.

Table O-5 shows the communities that were drawn and rejected, in order, for each of the three sets of selections. As can be seen, the first four communities, Freeport, Jefferson County, Horry County, and Jamestown, were easily drawn and represented the first four communities drawn. At that point, there were two small communities, one medium-sized community, and one large community for the first set of six communities. Given the criteria established for community size, only medium-sized communities could then be selected for the sample. Colusa County was drawn and rejected because it is a small community. Then Tuscola County was drawn, which met the need for a medium-sized community. Then Houma was selected, which again was rejected because it is a small community, and finally Hayward was selected to complete the first set of six communities. Eight communities, the six selected and Colusa County and Houma—the two rejected communities—were now eliminated from the pool of 76 leaving 68 in the pool.

In the second set, the first community drawn was "4 Tampa Bay Counties." After consultation, it was decided that this community did not meet the criteria for a single jurisdiction and it was rejected. The next community in the second set, Mandeville, was the 10th community drawn; it was accepted. The 11th community drawn, Hawaii County, was rejected because it duplicated

Table O-5 Communities that were accepted for the sample and communities that were rejected because one or more limit had been reached by stage of the draw (N = 76)

Stage of the Draw	Accepted	Rejected	
		Community	**Reason**
First Set of 6 Communities	Freeport, NY Jefferson County, AL Horry County, SC Jamestown, ND Tuscola County, MI Hayward, CA	Colusa County, CA Houma, LA	Needed a Medium Sized Community Needed a Medium Sized Community
Second Set of 4 Communities	Mandeville, LA Orange, CA Ft. Walton Beach, FL Los Angeles, CA	4 Tampa Bay Counties	Rejected as not meeting the jurisdictional criteria.
		Hawaii County	Rejected; had all 3 awards
		Oakland, CA Pittsburgh, PA	Rejected because either a small community or a large community had to be drawn
		Ouachita Parish, LA Ft Payne, AL Gadsden, AL Salem, NH Carteret County, NC Wauwatosa, WI Craven County, NC Westport, CO Ft. Collins, CO Colerain, OH Saco, ME Clermont City, OH Cape Girardeau, MS	All communities rejected because only a large community could be selected
		Seattle	Rejected; have earthquake only

Table O-5 Communities that were accepted for the sample and communities that were rejected because one or more limit had been reached by stage of the draw (N = 76)(continued)

Stage of the Draw	Accepted	Rejected	
		Community	Reason
Third Set of 4 Communities	Des Moines, IA East Haven, CT Virginia Beach, VA Multnomah County, OR	Terrebonne Parish, LA Berkeley, CA Darby Borough, DE Benton County, OR Honolulu	Had 4 communities with awards for flood and wind Had 3 communities in Region IX Had 4 communities with awards for flood and wind Needed a small or large community or one with wind awards Next large community drawn; poor jurisdiction and overdraws for Region IX Overdraws for flood only communities

Horry County in having received wind, flood and quake awards. Orange, California, was the 12th community drawn; it was accepted. At that point, the project team could only accept a large community or a small community for inclusion in the second set of four. Two communities—Oakland, and Pittsburgh—were drawn and rejected because they were medium-sized communities. Next, Fort Walton Beach, Florida, was selected, which was accepted. Then, thirteen communities were drawn and rejected because only a large community could be selected. Seattle was drawn and rejected because it would be the third community with awards only for quakes. Los Angeles was selected next and accepted; the set was completed.

Des Moines was drawn next and accepted for the third set of four communities. Terrebonne Parish was selected next and rejected because the sample already included four communities with FEMA awards for both floods and wind. Then Berkeley was drawn and rejected because the sample already included three communities from Region IX. East Haven was selected next and accepted for the sample. Darby Borough and Benton County were drawn and rejected both because the quota for communities with both flood and wind awards was filled and because it would be helpful to have a community that was simultaneously large or medium and had received FEMA awards only for wind. Virginia Beach, Virginia, was the next community drawn; it was selected.

Unfortunately, the last community selected for the third set of communities had to be large. The next large community drawn was Honolulu. Although included as the 14th community in the sample, it presents problems in that (1) it is not a regular jurisdiction, and (2) it is the fourth community selected in Region IX. The other two large communities still in the pool were Multnomah County, Oregon, in Region X at high risk of quakes, with two flood grants, and San Bernardino County, California, in Region IX, at high risk of quake and flood, with one quake award. Replacing Honolulu with Multnomah County would have resulted in five rather than four communities with flood awards only (over the quota) but would have reduced the overrepresentation of Region IX communities and would have meant the selection of a community in Region X.

After consultation, the project team selected Multnomah County, Oregon as the last community in the third set.

O.5 Post-Selection Check against NEMIS.

Once the 14 communities were selected the NEMIS data set was again examined. When combined with information about the organization of Los Angeles County and City, which was available to the researchers but not available in the NEMIS data set, this revealed that awards attributed to the County of Los Angeles actually were awarded to the city of Los Angeles. Thus, Los Angeles actually had received over 30 FEMA grants, thereby exceeding the eligibility limit of 15 grants or less. Los Angeles in set 2 was replaced with Multnomah County from set 3. If a third large community was needed, San Bernardino, California, would have been selected.

O.6 Final Sample.

The final sample of communities as distributed by community size and pattern of FEMA awards is shown in Table O-6.

Table O-6 Communities selected for the sample by community size, pattern of FEMA awards received, and whether they were selected to be in the first, second or third set of communities (N = 13)

Pattern of FEMA Awards	Small Communities (10,000-49,999)	Medium Communities (50,000-499,999)	Large Communities (≥ 500,000)
Earthquake Only ≤ 2		Hayward, CA (1), Orange, CA (2)	
Flood Only ≤ 4	Jamestown, ND (1), Mandeville, LA (2), East Haven, CT (3)	Des Moines (3)	Multnomah County, OR (3)
Wind Only ≤ 2		Virginia Beach (3)	
Flood and Quake ≤ 1			
Flood and Wind ≤ 4	Freeport, NY (1), Fort Walton Beach, FL (2)	Tuscola County, MI (1)	Jefferson County, AL (1)
Flood, Earthquake, and Wind ≤ 1		Horry County, SC (1)	

(1) Selected in the first set of 6 communities for study.
(2) Selected in the second set of 4 communities for study.
(3) Selected in the third set of 3 communities for study.

Appendix P
BIBLIOGRAPHY OF COMMUNITY DOCUMENTS

Agency for Toxic Substances and Disease Registry. (1995). Hazardous Substances Emergency Events Surveillance (HSEES) Annual Report. Atlanta, GA (Hayward).

Agency for Toxic Substances and Disease Registry. (1996). Hazardous Substances Emergency Events Surveillance (HSEES) Annual Report. Atlanta, GA (Hayward).

Agency for Toxic Substances and Disease Registry. (1997). Hazardous Substances Emergency Events Surveillance (HSEES) Annual Report. Atlanta, GA (Hayward).

Agency for Toxic Substances and Disease Registry. (1998). Hazardous Substances Emergency Events Surveillance (HSEES) Annual Report. Atlanta, GA (Hayward).

Agency for Toxic Substances and Disease Registry. (1999-2000). Hazardous Substances Emergency Events Surveillance (HSEES) Biennial Report. Atlanta, GA (Hayward).

Agency for Toxic Substances and Disease Registry. (2001). Hazardous Substances Emergency Events Surveillance (HSEES) Annual Report. Atlanta, GA (Hayward).

American Water Works Association. (2003). Study Cites Chlorine Risks at Wastewater Plants (Hayward).

Andress, C. (2003). Eliminating Hometown Hazards: Cutting Chemical Risks at Wastewater Treatment Facilities. New York, NY: Environmental Defense (Hayward).

Armas, J. (April 22, 1993). City of Hayward Agenda Report: Update on the Seismic Safety Retrofit Program, Updated May 7, 1993. Hayward, CA: City of Hayward (Hayward).

Armstrong, M. J. (2000). Letter to Edward and Dona Poineau Regarding Approval of the Acquisition of Their Property. Washington, DC: Federal Emergency Management Agency (Tuscola).

Armstrong, M. J. (2000). Memorandum to Mitigation Division Directors Regarding Guidance for the FMA program. Washington, DC: Federal Emergency Management Agency (Tuscola).

Baehner, Robert, 2005, Oral Communication to Craig Taylor, January 21, 2005.

Bartow & King Engineers. City of Vassar Zoning Districts. Bay City, MI (Tuscola).

Bauman, R. A. (May 12, 1993). Letter to Charles Wynne at OES (Hayward).

Berlogar Geotechnical Consultants. (October 8, 1992). Fault Investigation, Hayward Fire Station, "C" Street and Main Street, Hayward, CA. City of Hayward, CA (Hayward).

Bradley, M. (January 14, 1992). Letter to Chris Adams at OES (Hayward).

Bradley, M. (October 22, 1993). Memorandum to Jodi Pascual at Public Works Regarding Fire Station No.1. Hayward, CA (Hayward).

Bradley, M., Hutchins, J. F. and Singer, W. M. (1993). Disaster Operation Guide, Fire and Rescue: City of Hayward Fire Department Office of Emergency Services (Hayward).

Buckelew, M. M. (June 18, 1999). Letter to Todd Davidson of FEMA Regarding Project 1214-0010. Birmingham, AL: Jefferson County Emergency Management Agency (Jefferson County).

Buikema, E. G. (2002). Letter to John Ort of the Emergency Management Division Regarding Approval for EMC-2001-GR-0017. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Buikema, E. G. (February 19, 1999). Letter to Dale Shipley of FEMA Regarding the Submission of Project Applications Under 1226-MI-DR. Lansing, MI: Michigan State Police (Tuscola).

Buikema, E. G. (February 23, 2000). Letter to Dale Shipley of FEMA Requesting Close-out of 1128-DR-MI HMGP Projects. Lansing, MI: Michigan State Police (Tuscola).

Buikema, E. G. (January 10, 2000). Letter to Dale Shipley of FEMA Regarding the Submittal of Project Applications Under 1181-DR-MI. Lansing, MI (Tuscola).

Buikema, E. G. (May 20, 1998). Letter to Janet Odeshoo of FEMA Regarding an Alteration in Funding for FY'96 and '97. Lansing, MI (Tuscola).

Buikema, E. G. (November 19, 1997). Letter to Michelle Burkett of FEMA Regarding Project Application for Project 1128-0021. Lansing, MI: MIchigan State Police (Tuscola).

Burkett, M. M. (1997). Letter to Robert Tarrant of the Emergency Management Division Regarding the Requirements for Amending the FY'97 Cooperative Agreement. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Burkett, M. M. (July 24, 1997). Letter to Robert Tarrant of the Emergency Management Division Regarding Approval for Funding of Mitigation Projects. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Butler, D. L. (April 1, 1991). Letter to Charles Wynne at OES. Hayward, CA (Hayward).

Butler, D. L. (August 10, 1993). Letter to Genevieve Pastor at OES Regarding the Stafford Grant Application for Fire Station No. 1. Hayward, CA (Hayward).

Campbell-Smith, M. (April 27, 1998). Memorandum to Paula Schulz, State Hazard Mitigation Officer (Hayward).

Centers for Disease Control and Prevention. (2003). Facts About Chlorine. Atlanta, GA: Department of Health and Human Services (Hayward).

City of Hayward. (1990). Hazard Mitigation Grant Program Grant Application for the Hazardous Materials Release Prevention and Response Equipment Program, Amended April 1991, Revised July 1992. (Hayward).

City of Hayward. (1990). Hazard Mitigation Grant Program Project Application Summary Sheet for Hazard Release Prevention and Response Equipment. Hayward, CA (Hayward).

City of Hayward. (1990). HMGP Grant Application for the Seismic Retrofit of Fire Stations 2, 3, 4, 5 and 6 and Corporate Yard Buildings Project (FEMA-845-DR-CA), With Supporting Documentation. Hayward, CA (Hayward).

City of Hayward. (1990). Tilt-up Retrofit Project Files, including Mittler-Herman e-mail correspondence, copy of city ordinance, list of potentially hazardous tilt-up buildings, and cost-benefit analysis charts. Hayward, CA (Hayward).

City of Hayward. (1992). Hazard Mitigation Grant Program Revised Grant Application for the Hazardous Materials Release Prevention and Response Equipment Program, with supporting documentation. Hayward, CA (Hayward).

City of Hayward. (1993). HMGP (FEMA-845-DR-CA) Proposal Evaluation and Technical Review for Relocation of Fire Station #1. Hayward, CA (Hayward).

City of Hayward. (1993). HMGP Project Application Summary Sheet for Relocation of Fire Station #1. Hayward, CA (Hayward).

City of Hayward. (1993). Structural Retrofit of Corporation Yard Buildings and Fire Stations 2-5: Sub-grantee final report. Hayward, CA (Hayward).

City of Hayward. (1993-1998). Fire Station No. 1 Replacement Project Files, including estimate of construction cost, acceptance of work letter from Director of Public Works to Mayor, sub-grantee final report, and grant funding summary. Hayward, CA (Hayward).

City of Hayward. (1997). Final Claim for Replacement of Fire Station No. 1. Hayward, CA (Hayward).

City of Hayward. (1997). Hazardous Materials Release Prevention, Hypochlorite Conversion Project Files, including request for reimbursement, acceptance of work letter from Director of Public Works to Mayor, and internet articles/resources on chlorine and chlorine management. Hayward, CA (Hayward).

City of Hayward. (April 1991). Fire Station No. 1 Reconstruction, Alternative Site Studies Report. Hayward, CA (Hayward).

City of Hayward. (April 1997). Engineering Project Cost Summary for Construction of Fire Station No. 1. Hayward, CA (Hayward).

City of Hayward. (April 1997). Fire Station No. 1 - Hazard Mitigation Grant Summary. Hayward, CA (Hayward).

City of Hayward. (April 9, 1997). Hazard Mitigation Grant Program (FEMA-845-DR-CA) Subgrantee Quarterly Report Form, Final Report. Hayward, CA (Hayward).

City of Hayward. (August 4, 1993). City of Hayward Grant Application for Fire Station No. 1 (FEMA 845-DR-CA); Revised August 6, 1993; Further revised December 3, 1993, with supporting documentation. Hayward, CA (Hayward).

City of Hayward. (December 4, 1990). HMGP (FEMA-845-DR-CA) Proposal Evaluation for Hazardous Materials Release Prevention and Response Equipment. Hayward, CA: Reviewed by CS and J Perkins (Hayward).

City of Hayward. (June 9, 1994). HMGP (FEMA-845-DR-CA) Subgrantee Quarterly Report Form, Final Report for Seismic Retrofit of Fire Stations 2-5 and Corporate Yard Buildings. Hayward, CA (Hayward).

City of Hayward. (March 7, 1956). The Charter of the City of Hayward. Hayward, CA (Hayward).

City of Hayward. (November 16, 1990). HMGP (FEMA-845-DR-CA) Proposal Evaluation for Seismic Retrofit of Fire Stations 2, 3, 4, 5 & 6 and Yard Building. Hayward, CA (Hayward).

City of Hayward. Disinfection System-City of Hayward (Hayward).

City of Hayward. Final Program Report for City of Hayward Hazardous Materials Release Prevention. Hayward, CA (Hayward).

City of Hayward. Hazard Mitigation Grant Program Grant Application for the Emergency Public Information Project (FEMA-845-DR-CA) (Hayward).

City of Hayward. Seismic Evaluation of Utility Structures, Executive Summary. City of Hayward (Hayward).

City of Hayward. Subgrantee Final Report-Structural Retrofit of Corporation Yard Buildings and Fire Stations 2-5, Project No. 845-121-74. Hayward, CA (Hayward).

City of Orange. (1995-2003). Hazard Mitigation Grant Program Application for Project 1008-3217 including application, narrative for approval of architectural and engineering scope of work, approval letter, financial documents, correspondence, quarterly reports, and other supporting documents. Orange, CA (Orange).

City of Orange. (1995-2003). Hazard Mitigation Grant Program Application for Project 1008-3216 including application, addendum #1, financial documents, approval letter, correspondence, quarterly reports, and other supporting documents. Orange, CA (Orange).

City of Orange. (1997-2003). Hazard Mitigation Grant Program Application for Project 1008-3218 including addendum #1, financial closeout documents, approval letter, administrative files, quarterly reports, benefit cost analysis, correspondence, and other supporting documents. Orange, CA (Orange).

City of Orange. (1998-2003). Hazard Mitigation Grant Program Application for Project 1008-3219 including financial closeout documents, approval letter, correspondence, quarterly reports, narrative for approval, architectural and engineering scope of work, reviewer's documentation, benefit cost analysis, and other supporting documents. Orange, CA (Orange).

City of Orange. (1998-2003). Hazard Mitigation Grant Program Application for Project 1008-3010 including addendum #1, financial documents, approval letter, correspondence, quarterly reports, and other supporting documents. Orange, CA (Orange).

City of Orange. (2002). HMPG 1008-3010 Closeout Report including project accomplishments and results report, budget, inspection report, photos/materials and other supporting documents. Orange, CA (Orange).

City of Orange. (2002). HMPG 1008-3218 Closeout Report including project accomplishments and results report, and project photos/materials. Orange, CA (Orange).

City of Orange. (2003). HMPG 1008-3217 Closeout Report. Orange, CA (Orange).

City of Tulsa, 2002, *Multi-Hazard Mitigation Plan*, November 25, 2002, Public Works Department, Tulsa, Oklahoma.

City of Vassar. (1997). Vassar City Ordinance Related to Floodplain Management. Vassar, MI (Tuscola).

City of Vassar. (1998). Flood Hazard Mitigation Plan Adoption Resolution, Resolution Number R-1-1998. Vassar, MI (Tuscola).

City of Vassar. (November 5, 2001). Vassar City Council Meeting Minutes. Vassar, MI: City of Vassar (Tuscola).

City of Vassar. (September 2002). Vassar City Council Minutes. Vassar, MI (Tuscola).

City of Vassar. (September 21, 1998). Flood Hazard Mitigation Plan, City of Vassar, Michigan. Vassar, MI (Tuscola).

City of Vassar. Repetitive Losses in Vassar. Vassar, MI (Tuscola).

Codd, F. L. (August 4, 1993). Letter to Jodi Pascual in Public Works. Hayward, CA (Hayward).

Conway, B. D. (July 23, 2001). Letter to Jeanne Millin of FEMA. Lansing, MI: State Historic Preservation Office (Tuscola).

Conway, B. D. (June 22, 1999). Letter to Matt Schnepp of the Emergency Management Division Stating that Project 1181-0046 Will Have No Effect on Historic Properties. Lansing, MI: State Historic Preservation Office (Tuscola).

Conway, B. D. (March 23, 1999). Letter to Dawn Schulert of the Emergency Management Division Stating that the Acquisition Project Will Have No Effect on Historic Properties. Lansing, MI: State Historic Preservation Office (Tuscola).

Conway, B. D. (March 6, 2000). Letter to Matt Schnepp of the Emergency Management Division Stating that Project 1181-0053 Will Have No Effect on Historic Properties. Lansing, MI: State Historic Preservation Office (Tuscola).

Conway, B. D. (March 6, 2000). Letter to Matt Schnepp of the Emergency Management Division Stating that Project 1181-0048 Will Have No Effect on Historic Properties. Lansing, MI: State Historic Preservation Office (Tuscola).

Craigo, S. R. (November 9, 1993). Letter to Roy Kite at FEMA. Sacramento, CA (Hayward).

Czarnecki, C. A. (January 18, 2000). Letter to Matt Schnepp of the Emergency Management Division Regarding Endangered Species Request List. East Lansing, MI: Fish and Wildlife Service (Tuscola).

Czarnecki, C. A. (January 2, 2002). Letter to Dawn Schulert of the Emergency Management Division Regarding the Endangered Species List Request for FY 2001 FMA program. East Lansing, MI: Fish and Wildlife Service (Tuscola).

Czarnecki, C. A. (July 3, 2001). Letter to Dawn Schulert of the Emergency Management Division Regarding the Endangered Species List Request. East Lansing, MI: Fish and Wildlife Service (Tuscola).

Dames & Moore. (1995). Chapter 3: Seismic and Geologic Hazard Evaluation, *Seismic Retrofit Study for City of Hayward Utility Structures, Final Report* (Vol. 1). Hayward, CA (Hayward).

Division of Public Health,Occupational and Environmental Epidemiology Branch. (2000). Occupational Illnesses and Injuries: Chlorine Facts: North Carolina Department of Health and Human Services (Hayward).

Donahoe, S. (1999). Email to Steve Colman et al Regarding the FY 2000 FMA & CAP Program Guidance (Tuscola).

Dunn, P. (August 26, 1993). Memorandum to Leo Levenson at FEMA Offering A Technical Review of the Fire Station No. 1 Application (Hayward).

Eckert, K. B. (March 5, 1997). Letter to Jeanne Kern of FEMA Stating that Project 1128-0021 Will Have No Effect on Historic Properties. Lansing, MI: State Historic Preservation Office (Tuscola).

Eckert, K. B. (March 5, 1997). Letter to Jeanne Kern of FEMA Stating that Project 1128-0012 Will Have No Effect on Historic Properties. Lansing, MI: State Historic Preservation Office (Tuscola).

Emergency Management Division. (1998). FMA Program Quarterly Status Summary Planning Grant/Technical Assistance. Lansing, MI: Michigan State Police (Tuscola).

Emergency Management Division. (1999). HMGP Project Application for Phase I - Implementation of Flood Mitigation Program. Lansing, MI: Michigan State Police (Tuscola).

Emergency Management Division. (2000). Application for FMA Program Grant. Lansing, MI: Michigan State Police (Tuscola).

Emergency Management Division. (2001). Application for FMA Program, Floodplain Elevation Project - Phase 2. Lansing, MI: Michigan State Police (Tuscola).

Emergency Management Division. (December 2, 1999). HMGP Project Application for Project 1181-0048, Property Acquisition on Hudson Street, Village of Reese. Lansing, MI: Michigan State Police (Tuscola).

Emergency Management Division. (December 23, 1996). HMGP Project Application for Project 1128-0012. Lansing, MI: Michigan State Police (Tuscola).

Emergency Management Division. (December 3, 2001). FMA Program Project Grant Application for the Elevation of Residential Structures in the City of Vassar. Lansing, MI: Michigan State Police (Tuscola).

Emergency Management Division. (January 2, 2000). HMGP Project Application for Project 1181-0053, Relief Branches of the Reese Intercounty Drain. Lansing, MI: Michigan State Police (Tuscola).

Emergency Management Division. (March 20, 1997). Application for Federal Assistance for HMGP Project 1128-0021, Coleman Drainage District, Amended March 1998, April 2000 and January 2001. Lansing, MI: Michigan State Police (Tuscola).

Emergency Management Division. (November 17, 1998). HMGP Project Application for 1226-0016, Elimination/Reduction of Flooding Impact on Moore Drainage District. Lansing, MI: Michigan State Police (Tuscola).

Emergency Management Division. (November 20, 1998). HMGP Project Application for Project 1181-0046, Cass River Floodway Acquisition Project. Lansing, MI: Michigan State Police (Tuscola).

Environmental Defense. (2003). Chlorine Gas Poses Threat to More Than 19 Million People: Environmental Defense (Hayward).

EQE Engineering. (1989). Identification of Potentially Hazardous Buildings in the City of Hayward Interim Report #2: Consequence Analysis. San Francisco, CA (Hayward).

EQE International. (1997). EQE Report for Project 1008-3219: Seismic Strengthening Investigation of The Pumphouse at the City of Orange Water Department Report. Orange, CA (Orange).

Farhat, M. (2003). Project Accomplishments and Results Report for Project 1008-3216. Orange, CA (Orange).

Federal Emergency Management Agency and New York State Emergency Management Office. (1998). Hazard Mitigation Strategy Report Following January '98 Ice Storm in State of New York. New York, NY (Freeport).

Federal Emergency Management Agency and New York State Emergency Management Office. (1999). Hazard Mitigation Strategy Report Following Tropical Storm Floyd. New York, NY (Freeport).

Federal Emergency Management Agency. (1991-1992). Beachfront Management Project Files, including application for federal assistance, FEMA approval letter, state/county grant agreement, financial closeout, and supporting documents. Atlanta, GA (Horry County).

Federal Emergency Management Agency. (1991-1997). Sub-grantee Grand Strand Water and Sewer Authority Generator Upgrade Files, including application for federal assistance, amendments to scope of work, budget, approval letter, supporting documents. Atlanta, GA (Horry County).

Federal Emergency Management Agency. (1993). Press Release: Hayward Receives $200,000 FEMA Grant to Remove Chlorine Gas Threat. San Francisco, CA (Hayward).

Federal Emergency Management Agency. (1994). Finding of No Significant Environmental Impact for City of Hayward, California, HMGP #845-15. San Francisco, CA (Hayward).

Federal Emergency Management Agency. (1995). Riverine Flood Infrastructure Small Project Benefit-Cost Program for Project 1128-0021 (Tuscola).

Federal Emergency Management Agency. (1995). Riverine Flood Infrastructure Small Project Benefit-Cost Program for Project 1128-0012 (Tuscola).

Federal Emergency Management Agency. (1996). Notification of Final Approval for HMGP Fund Approvals Following Disaster Declaration 1128, including preliminary cost estimate and modified permit plans for sea-wall alignment for the Cass River Rehabilitation Work project. Chicago, IL (Tuscola).

Federal Emergency Management Agency. (1997). Approval Letter for Project 1008-3219 to Cheryl Tateishi. Pasadena, CA (Orange).

Federal Emergency Management Agency. (1997). Narrative of Approval of Architectural and Engineering Scope of Work for Project 1008-3217 (Orange).

Federal Emergency Management Agency. (1997). Narrative of Approval of Architectural and Engineering Scope of Work for Project 1008-3219 (Orange).

Federal Emergency Management Agency. (1998). Approval Letter for Project 1008-3216 to Cheryl Tateishi. Pasadena, CA (Orange).

Federal Emergency Management Agency. (1998). Approval Letter for Project 1008-3010 to Cheryl Tateishi. Pasadena, CA (Orange).

Federal Emergency Management Agency. (1998). Approval Letter for Project 1008-3218 to Cheryl Tateishi. Pasadena, CA (Orange).

Federal Emergency Management Agency. (1998). Approval Letter for Project 1008-3217 to Cheryl Tateishi. Pasadena, CA (Orange).

Federal Emergency Management Agency. (1998). Categorical Exclusion for HMGP Project 1128-0021, Coleman Drainage District (Tuscola).

Federal Emergency Management Agency. (1998). Flood Mitigation Plan Review Sheet for Vassar, Michigan. Chicago, IL (Tuscola).

Federal Emergency Management Agency. (1999). Memorandum of Agreement Between the Federal Emergency Management Agency and the Michigan State Historic Preservation Officer Submitted to the Advisory Council on Historic Preservation Pursuant to 36 CFR 800.6(b)(1) Regarding the Demolition of 221 Cass Avenue, Vassar, Tuscola County, Michigan (Tuscola).

Federal Emergency Management Agency. (1999). Obligating Document for Award Amendment for EMC-2000-GR-0018 (Tuscola).

Federal Emergency Management Agency. (1999). Preliminary R IV HMGP Environmental Considerations Checklist for Project 1214-0010, Hazard Mitigation Plan. Atlanta, GA (Jefferson County).

Federal Emergency Management Agency. (2000). Buyout Files, including application for federal assistance, scope of work, budget, property acquisition worksheets, and supporting documents. Atlanta, GA (Horry County).

Federal Emergency Management Agency. (2000). Floodplain Management Acquisition Project Application--Residential Buyouts. Atlanta, GA (Horry County).

Federal Emergency Management Agency. (2000). FMA Program Guidance (Tuscola).

Federal Emergency Management Agency. (2000). Interim Extension Policy for FEMA Assistance Agreements. Washington, DC (Tuscola).

Federal Emergency Management Agency. (2000). Notification of Approval for HMGP Project 1250-0020, Jefferson County Phase I Buyout, including State Historic Preservation Approvals, Substantial Damage Statements, Acquisition Candidates, Action Detail Report. Atlanta, GA (Jefferson County).

Federal Emergency Management Agency. (2000). Public Notice of the Intent of FEMA to Fund a Project. Chicago, IL (Tuscola).

Federal Emergency Management Agency. (2000-2001). Buyout files, including application for federal assistance, scope of work, property acquisition worksheet, and supporting documents. (Horry County).

Federal Emergency Management Agency. (2000-2003). Floodplain Management Elevation Project Files, including original application, request for amendment, FEMA approval letter, maps, supporting documents. Atlanta, GA (Horry County).

Federal Emergency Management Agency. (2000-2003). Residential Acquisition Project Files, including grant application, FEMA approval letter, project management report, requests/approvals for amendment, project closeout docs, and supplemental acquisitions/maps. Atlanta, GA (Horry County).

Federal Emergency Management Agency. (2000-2003). Supplemental Acquisition Grants to Hurricane Floyd, including FEMA approval letter, closeout documents, and administrative files. Atlanta, GA (Horry County).

Federal Emergency Management Agency. (2000-2003). Wind Retrofit Project Files, including original application, amendment to application, FEMA approval letter, request and approval for extension, and supporting documents. Atlanta, GA (Horry County).

Federal Emergency Management Agency. (2000-2004). Project Impact Files, including application for federal assistance, approval letter, grant guidance, agreement articles, scope of work, environmental guidance, financial status report and financial records, assurances and certification, amendments, and supporting documents. Atlanta, GA (Horry County).

Federal Emergency Management Agency. (2001). Amended Application for Supplemental Acquisition Projects. Atlanta, GA (Horry County).

Federal Emergency Management Agency. (2001). Federal Emergency Management Agency Agreement Articles: Horry County Government, SC; Agreement Number EMA-2001-GR-0081; Amendment Number M001; Performance Period June 1, 2001 through May 31, 2003 including Budget, Scope of Work, Approval for Amendment M002, and Obligating Document for Award/Amendment (Horry County).

Federal Emergency Management Agency. (2001-2002). Critical Facility Retrofit Project Files, including original application, FEMA approval letter, project amendment request and FEMA approval letter, maps/photos of fire stations to be wind-retrofitted, and cost-benefit analysis for 4 properties on 2 diskettes. Atlanta, GA **(Horry County)**.

Federal Emergency Management Agency. (2001-2003). Acquisition Project Files, including FEMA approval letter, site visit report, closeout documents. Atlanta, GA (Horry County).

Federal Emergency Management Agency. (2002). Obligating Document for Award/Amendment for EMC-2001-GR-0017 (Tuscola).

Federal Emergency Management Agency. (2003). FEMA HMGP Project Management Report for the Moore Drain Flood Mitigation Project. Tuscola County, MI (Tuscola).

Federal Emergency Management Agency. (April 15, 1997). Group Categorical Exclusion for Identified Actions With a Low Potential for an Adverse Effect on the Environment, 1214-DR-AL. Atlanta, GA (Jefferson County).

Federal Emergency Management Agency. (April 1998). Mitigation Strategy Report, Alabama Tornadoes, FEMA-1214-DR-AL. Atlanta, GA (Jefferson County).

Federal Emergency Management Agency. (April 1998). The President's Long-Term Recovery Action Plan for the March 1998 Alabama Floods. Washington, DC (Jefferson County).

Federal Emergency Management Agency. (December 2000). HMGP Obligation Report, Supplement Number 37, Disaster Number 1128 (Tuscola).

Federal Emergency Management Agency. (December 31, 1997). Report of Benefit-Cost Analysis for Project 1181-0053, Relief Branches of the Reese Intercounty Drain (Tuscola).

Federal Emergency Management Agency. (December 31, 1997). Report of Benefit-Cost Analysis for Project 1181-0048, Property Acquisition in the Village of Reese (Tuscola).

Federal Emergency Management Agency. (December 31, 1997). Report of Benefit-Cost Analysis for Project 1181-0046, Cass River Floodway Acquisition (Tuscola).

Federal Emergency Management Agency. (December 31, 1998). Report of Benefit-Cost Analysis for the Elevation of Residential Structures in the City of Vassar (Tuscola).

Federal Emergency Management Agency. (January 13, 1999). Flood Mitigation Plan Review Sheet. Chicago, IL (Tuscola).

Federal Emergency Management Agency. (June 13, 2000). HMGP Obligation Report, Supplement Number 75, Disaster Number 1181 (Tuscola).

Federal Emergency Management Agency. (June 20, 2000). HMGP Obligation Report, Supplement Number 76, Disaster Number 1181 (Tuscola).

Federal Emergency Management Agency. (June 30, 1997). HMGP Allocation Request Report, Disaster Number 1128 (Tuscola).

Federal Emergency Management Agency. (June 30, 1997). HMGP Funding Estimate for Disaster Number 1128 (Tuscola).

Federal Emergency Management Agency. (June 30, 1997). HMGP Obligation Report, Supplement Number 2, Disaster Number 1128 (Tuscola).

Federal Emergency Management Agency. (June 30, 1997). Summary Project Application for Project 1128-0012 (Tuscola).

Federal Emergency Management Agency. (June 30, 1997). Summary Project Application for Project 1128-0012 (Tuscola).

Federal Emergency Management Agency. (June 30, 2000). HMGP Obligation Report, Supplement Number 80, Disaster Number 1181 (Tuscola).

Federal Emergency Management Agency. (March 1999). HMGP Application Completeness Checklist for Project 1214-0010. Atlanta, GA (Jefferson County).

Federal Emergency Management Agency. (March 1999). HMGP Eligibility Checklist for Project 1214-0010. Atlanta, GA (Jefferson County).

Federal Emergency Management Agency. (March 2, 1998). HMGP Funding Estimate, Disaster Number 1128 (Tuscola).

Federal Emergency Management Agency. (March 2, 1998). HMGP Obligation Report, Supplement Number 10, Disaster Number 1128 (Tuscola).

Federal Emergency Management Agency. (May 1996). Federal Emergency Management Agency Agreement Articles for Michigan State Police, Emergency Management Department, 10/1/96 - 9/30/97, Amended March 1997 (Tuscola).

Federal Emergency Management Agency. (May 6, 1999). HMGP Obligation Report, Supplement Number 12, Disaster Number 1226 (Tuscola).

Federal Emergency Management Agency. (October 13, 1999). Request for Allocation Advice Action, Upper Shades Creek Mitigation Plan (Jefferson County).

Federal Emergency Management Agency. (October 20, 1999). HMGP Obligation Report, Supplement Number 4, Disaster Number 1250 (Jefferson County).

Federal Emergency Management Agency. Notification of Approval for HMGP Project 1214-0010, Upper Shades Creek Hazard Mitigation Plan. Atlanta, GA (Jefferson County).

Federal Emergency Management Agency. Public Notice of the Intent of FEMA to Fund a Project, Residential Acquisition in the City of Vassar. Chicago, IL (Tuscola).

Federal Emergency Management Agency. Record of Environmental Review for HMGP Project 1128-0021, Coleman Drainage District (Tuscola).

Federal Emergency Management Agency. Record of Environmental Review for HMGP Project 1128-0012, City of Frankenmuth-Cass River Stabilization (Tuscola).

FEMA Community Mitigation Programs Branch, Mitigation Division. (April 16, 1999). Scope of Work for State of Alabama's FMA FY 98-99 Project and Technical Assistance Funds, including amendment approval, extension request, and extension approval (Jefferson County).

FEMA Community Mitigation Programs Branch, Mitigation Division. (November 21, 2000). FMA FY-1999 Announcement of Individual Project Approval for FMA-PJ-04AL-1999001, FMA-PJ-04AL-1999002, and FMA-PJ-04AL-1999003, including scope of work, technical scope of work, extension approval, project final costs, financial status report, and final report (Jefferson County).

FEMA Region V. (1997). HMGP Project Notification for Project 1128-0012. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V. (1997). Programmatic Categorical Exclusion: Ground Restoration and Slope Stabilization Integral to the Protection and/or Repair of Eligible Facilities, FEMA 1128-DR-MI. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V. (1998). HMGP Project Notification for Project 1128-0021. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V. (1999). HMGP Project Notification for Project 1226-0016. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V. (1999). Items to be Included in the HMGP Approval Package for Project 1181-0046, Acquisition in the City of Vassar. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V. (2000). HMGO Project Notification for Project 1181-0046. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V. (2000). HMGP Increase of Project Funds Notification for Project 1128-0021. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V. (2000). HMGP Project Notification for Project 1181-0053. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V. (2000). HMGP Project Notification for Project 1181-0048. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V. (2000). Items to be Included in the HMGP Approval Package for the Construction of the Detention Pond, Project 1181-0053. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V. (2000). Items to be Included in the HMGP Approval Package for Project 1181-0048, Acquisition in the Village of Reese. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V. (2001). Executive Order 11988 - Floodplain Management, Executive Order 11990 - Wetland Protection, FMA, HM, & PI Checklist for Acquisition and Elevation of Bourn Street Structures. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V. (2001). Executive Order 11988 - Floodplain Management, Executive Order 11990 - Wetland Protection FMA, HMGP, & PI Checklist, FMA project for elevation of residential structures, City of Vassar. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V, Mitigation Division. (1999). Record of Environmental Review for Demolition/Elevation of Structures in the City of Vassar. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V, Mitigation Division. (1999). Record of Environmental Review for Project 1226-0016, Moore Drainage District. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V, Mitigation Division. (2000). Level 2 - Categorical Exclusion for Project 1181-0046, Cass River Floodway Acquisition. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V, Mitigation Division. (2000). Record of Environmental Review for Project 1181-0053, Relief Branches of the Reese Intercounty Drain. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V, Mitigation Division. (2000). Record of Environmental Review for Project 1181-0046. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V, Mitigation Division. (2000). Record of Environmental Review for Project 1181-0048, Village of Reese Acquisition. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V, Mitigation Division. (2001). Record of Environmental Review for the Elevation of the Bourn Street Structures. Chicago, IL: Federal Emergency Management Agency (Tuscola).

FEMA Region V, Mitigation Division. (2001). Record of Environmental Review for FMA Project, Elevation of Residential Structures, City of Vassar. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Fire Department, City of Hayward. (1991). Hazard Mitigation Grant Proposal #119 Vulnerability Analysis, Revised January 25, 1992. Hayward, CA (Hayward).

Flood Grant Makes First Round. (March 7, 2001). *Vassar Pioneer Times*. Vassar, MI (Tuscola).

Flood Mitigation Assistance Program. (1996). Program Narrative Statement for FMA Planning and Technical Assistance Grant: State of Michigan (Tuscola).

Freedman, Tung & Bottomley. (September 1992). City of Hayward Fire Station No.1 Master Plan (Hayward).

Fryer, J. L. (October 20, 2000). HMGP Quarterly Progress Report Form for Project 1181-0048. Reese, MI: Village of Reese (Tuscola).

Garcia, L. N. (May 11, 1992). Letter to Charles Wynne at OES. Hayward, CA (Hayward).

Garcia, L. N. (October 20, 1990). Memorandum to the File Regarding Designation of Agent. Hayward, CA (Hayward).

Glithero, P. (1997). Request Memorandum for Obligation of HMGP Funds (Tuscola).

Glithero, P. (2000). Email to Edward Poineau Regarding the Acquisition of Properties in Reese, Project 1181-0048 (Tuscola).

Hamner, T. C. (February 26, 1991). Letter to Charles Wynne at OES. San Francisco, CA (Hayward).

Hamner, T. C. (January 20, 1994). Letter to Richard Ray at OES. San Francisco, CA (Hayward).

Hamner, T. C. (May 1994). Letter to Nancy Ward at OES Stating Approval of #845-15, Hayward Fire Station Replacement. San Francisco, CA (Hayward).

Harris, J. (March 7, 2000). Memorandum to Jeanne Millin Regarding Project 1181-0053 (Tuscola).

Harris, J. (March 8, 2000). Memorandum to File Regarding US Army Corps of Engineers Consultation for Project 1181-0053 (Tuscola).

Harris, M. S. and Wright, E. E. (2004). Proposed Northeastern South Carolina Hazards and Risks Research Facility. Conway, SC: Coastal Carolina University, Center for Marine and Wetland Studies (Horry County).

Harza Engineering Company of California. (1996). Geotechnical Investigation for Proposed Hypochlorite Building. Hayward, CA (Hayward).

Hazardous Substances Emergency Events Surveillance System. Chlorine Facts: Iowa Department of Public Health (Hayward).

Hembling, J. (October 16, 2001). HMGP Quarterly Progress Report Form for Project 1181-0048. Reese, MI: Village of Reese (Tuscola).

Horry County. (2000). South Carolina Loss Mitigation Grant Application 2000-2001: Evaluation of Practicality, Acceptability, and Effectiveness of Retrofit Measures for Improving the Wind Resistance of Houses and Support of Outreach Programs. Conway, SC (Horry County).

Horton, K. D., Berkowitz, Z. and Kaye, W. E. (2002). Adverse Public Health Consequences from Acute Chlorine Releases, *The 130th Annual Meeting of the American Public Health Association*. Philadelphia, PA (Hayward).

Horton, K. D., Berkowitz, Z. and Kaye, W. E. (2002). The Public Health Consequences From Acute Chlorine Releases, 1993-2000. *The Journal of Occupational and Environmental Medicine, 44*(10), 906-913 (Hayward).

Jefferson County Emergency Management Agency. (2000). Property acquisition information for project 1208-0025, including Obligation Report, Allocation Request Report, Action Detail Report, and Amendments. Birmingham, AL (Jefferson County).

Jefferson County Emergency Management Agency. (2000). Property Acquisition Information for Project 1250-0020. Birmingham, AL (Jefferson County).

Jefferson County Emergency Management Agency. (2001). Property Acquisition Information for Project 1214-0023, Jefferson County Floodway Buyout, including Project Application Summary, Allocation Request, Obligation Report, and Environmental Determination Memorandum. Birmingham, AL (Jefferson County).

Jefferson County Emergency Management Agency. (October 30, 1998). HMGP Application for Upper Shades Creek Hazard Mitigation Plan, Project 1214-0010. Birmingham, AL (Jefferson County).

Joles, A. (September 11, 2002). Vassar Hopes Funding Helps End Flood Threat, *Tuscola Advertiser*. Vassar, MI (Tuscola).

Kavetsky, R. (March 1, 1999). Letter to Dawn Schulert of the Emergency Management Division Regarding the Endangered Species List Request for Proposed Home Acquisition and Demolition, Vassar, MI (Tuscola).

Kischnick, B. (April 26, 2001). HMGP Quarterly Progress Report Form for Project 1181-0046. Vassar, MI: City of Vassar (Tuscola).

Kischnick, B. (January 15, 2001). HMGP Quarterly Progress Report Form for Project 1181-0046. Vassar, MI: City of Vassar (Tuscola).

Kischnick, B. (July 26, 2001). HMGP Quarterly Progress Report Form for Project 1181-0046. Vassar, MI: City of Vassar (Tuscola).

Kischnick, B. (October 12, 2000). HMGP Quarterly Progress Report Form for Project 1181-0046. Vassar, MI: City of Vassar (Tuscola).

Kite, A. R. (June 18, 1992). Letter to Charles Wynne at OES Regarding Hayward Water Treatment Plant. San Francisco, CA (Hayward).

Kite, A. R. (November 5, 1993). Letter to Steade Craigo at Department of Parks and Recreation Regarding Eligibility of Fire Station No. 1 for the National Register of Historic Places. San Francisco, CA (Hayward).

Kite, A. R. (October 19, 1993). Letter to Richard Ray at OES. San Francisco, CA (Hayward).

Klima, D. L. (2000). Letter to Dale Shipley of FEMA Regarding the Protection of Historic Properties Under Project 1181-0046. Washington, DC: Advisory Council on Historic Preservation (Tuscola).

Knitt, L. (October 14, 1999). Email to Martha MacFarlane: HP MOA for Vassar, MI-221 Cass Ave. (Tuscola).

Kodavatiganti, S. (September 12, 1997). E-mail to Steve Luhrs at OES (Hayward).

Kokolus, J. (1999). Email to Stuart Rifkind, Norbert Schwartz, Terry Fell, Christine Stack and James Opoka Regarding CAP Funding (Tuscola).

Lacey, D. M. (December 20, 1996). Letter to Nancy Ward at OES Approving 10% of Grant Increase Request (Hayward).

Lacey, D. M. (March 16, 1998). Letter to Paula Schulz at OES Stating the Grant Close-out of HMGP # 845-119-15, City of Hayward Fire Station #1 Replacement (Hayward).

Letter to Louis Armas Regarding Funding Approval for the Emergency Public Information Project and the Seismic Retrofit of Fire Stations 2, 3, 4, 5 & 6 and Yard Building. (April 28, 1992). Sacramento, CA (Hayward).

Levenson, L. (July 28, 1993). Memorandum to the File Regarding Conversation with Bob Bauman. San Francisco, CA (Hayward).

Levenson, L. (September 11, 1997). Email to Steve Luhrs at OES. San Francisco, CA (Hayward).

Levenson, L. and Puziss, G. (January 26, 1994). Environmental Assessment: Hayward Fire Station #1 Replacement (FEMA 845, Hazard Mitigation Grant Program # 0015). San Francisco, CA: Federal Emergency Management Agency Region IX (Hayward).

Liebsch, B. and Liebsch, J. (1999). *It's A Disaster and What Are YOU Gonna Do About It? (Sample of books purchased by Horry Co. with Project Impact funds and made available to the public)* (2nd ed.). Tucson, AZ: FedHealth (Horry County).

Light, C. H. (February 4, 1998). Letter to Nancy Ward of OES Describing Final Award (Hayward).

MacFarlane-Faes, M. (January 25, 2002). Letter to Matt Schnepp of the Emergency Management Division Stating that the FMA Project for the City of Vassar Will Have No Effect on Historic Properties. Lansing, MI: State Historic Preservation Office (Tuscola).

Mayson, P. (January 24, 2003). Memo to File: "Lost/Misplaced Documents--FMA Grant Program". Jefferson County Emergency Management Department (Jefferson County).

Menerey, B. E. (April 13, 2001). Letter to David White Discussing the Proposed Berm for the Cass River/Moore Drain Flood Mitigation Project. Lansing, MI: Department of Environmental Quality (Tuscola).

Menerey, B. E. (December 18, 2001). Memorandum to Matt Schnepp Regarding the Environmental Review for the FMA program, City of Vassar, Tuscola County. Lansing, MI: Department of Environmental Quality (Tuscola).

Menerey, B. E. (February 16, 2000). Memorandum to Matt Schnepp of the Emergency Management Division Regarding the Environmental Review for Project 1181-0053. Lansing, MI: Department of Environmental Quality (Tuscola).

Menerey, B. E. (February 4, 2000). Memorandum to Matt Schnepp Regarding the Environmental Review for Project 1181-0048. Lansing, MI: Department of Environmental Quality (Tuscola).

Menerey, B. E. (July 19, 2001). Memorandum to Dawn Schulert of the Emergency Management Divsion Regarding the Environmental Review for Floodplain Elevation Project - Phase 2. Lansing, MI: Department of Environmental Quality (Tuscola).

Menerey, B. E. (March 15, 1999). Memorandum to Dawn Schulert of the Emergency Management Division. Lansing, MI: Department of Environmental Quality (Tuscola).

Menerey, B. E. (March 27, 1997). Memorandum to Doran Duckworth of the Emergency Management Division Regarding the Environmental Review for 1128-DR-MI Hazard Mitigation Projects: Department of Environmental Quality (Tuscola).

Meyer, C. L., Brooks, H. E. and Kay, M. P. (2002). A Hazard Model for Tornado Occurrence in the United States, *The 16th Conference on Probability and Statistics in the Atmospheric Sciences and the 13th Symposium on Global Change and Climate Variations* (Hayward).

Millin, J. H. (2001). Letter to Bryan Conway of the Michigan Historical Center Explaining that the Residential Elevation Project Will Have No Adverse Effects on Historic Properties. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Millin, J. H. (2001). Letter to Dawn Schulert of the Emergency Management Division Regarding Approval of the Elevation of Three Residential Structures in the City of Vassar. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Millin, J. H. (2002). Letter to John Ort of the Emergency Management Division Regarding FMA Program-City of Vassar Environmental Review. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Millin, J. H. (June 28, 2000). Letter to Dawn Schulert of the Emergency Management Division Regarding Categorical Exclusion of Project 1181-0046. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Millin, J. H. (May 15, 2000). Letter to Dawn Schulert of the Emergency Management Division Regarding Environmental Clearance of Project 1181-0048. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Millin, J. H. (May 25, 1999). Request Memorandum to Stuart Rifkind for Obligation of HMGP Funds for Project 1226-0016. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Minutes of a Regular Meeting of the City Council, City of Hayward. (May 11, 1993). *Mayor and City Council of Hayward*. Hayward, CA (Hayward).

National Safety Council. Chlorine Chemical Backgrounder (Hayward).

Nelson, Oren, 2005, Oral Communication to Craig Taylor, January 5, 2005

Odeshoo, J. M. (June 15, 2000). Letter to Edward Buikema of the Emergency Management Division Regarding Approval for Obligation Request for 1181-0048. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Odom, W. (October 30, 1998). Letter to Lee Helms of the Alabama EMA Regarding Mitigation Projects in Jefferson County. Birmingham, AL: Jefferson County Emergency Management Agency (Jefferson County).

Office of Response and Restoration, National Ocean Service. (2001). Ask Dr. ALOHA: Some ALOHA Case Histories: National Oceanic and Atmospheric Administration (Hayward).

OLMM Consulting Engineers. (1999). Seismic Evaluation of Highland 500 Reservoir City of Hayward, including final report and letter from consulting engineers responding to Public Works Dept.'s comments on draft report. Hayward, CA (Hayward).

Ort, J. (January 8, 2002). Letter to Edward Buikema of FEMA Regarding the Submission of FMA Project, Elevation of Residential Structures in the City of Vassar. Lansing, MI: Michigan State Police (Tuscola).

Pascual, J. (September 13, 1996). Memorandum to Leo Levenson Including Financial Documentation. Hayward, CA (Hayward).

Pastor, G. P. (October 29, 1993). Memorandum to File Regarding Reconstruction of Fire Station No.1. Hayward, CA (Hayward).

Peery, D. (June 21, 1999). Letter to Clayton Saucier of FEMA Regarding the Upper Shades Creek Hazard Mitigation Plan, Project 1214-0010. Clanton, AL: Alabama Emergency Management Agency (Jefferson County).

Peery, D. (September 1999). Fax to Linda Rankin of FEMA, including the addition to the Upper Shades Creek plan to cover the cities of Homewood and Irondale. Clanton, AL: Alabama Emergency Management Agency (Jefferson County).

Philipsborn, C. (November 12, 1998). Amended Flood Mitigation Assistance Plan for Vassar, Michigan. Boulder, CO: The Mitigation Assistance Corporation (Tuscola).

Philipsborn, C. (November 16, 1998). Email to Richard Roth of FEMA Submitting Response to FEMA's Review of the Vassar Flood Mitigation Plan. Boulder, CO: The Mitigation Assistance Corporation (Tuscola).

Pistro, S. M. (April 10, 2000). HMGP Quarterly Progress Report Form for Project 1226-0016. Caro, MI: Tuscola County Drain Commissioner (Tuscola).

Pistro, S. M. (April 20, 2001). HMGP Quarterly Progress Report Form for Project 1181-0053. Caro, MI: Tuscola County Drain Commissioner (Tuscola).

Pistro, S. M. (April 27, 2001). HMGP Quarterly Progress Report Form for Project 1226-0016. Caro, MI: Tuscola County Drain Commissioner (Tuscola).

Pistro, S. M. (January 14, 1999). HMGP Quarterly Progress Report Form for Project 1226-0016. Caro, MI: Tuscola County Drain Commissioner (Tuscola).

Pistro, S. M. (January 29, 2001). HMGP Quarterly Progress Report Form for Project 1226-0016. Caro, MI: Tuscola County Drain Commissioner (Tuscola).

Pistro, S. M. (January 4, 2001). HMGP Quarterly Progress Report Form for Project 1181-0053. Caro, MI: Tuscola County Drain Commissioner (Tuscola).

Pistro, S. M. (July 10, 2000). HMGP Quarterly Progress Report Form for Project 1226-0016. Caro, MI: Tuscola County Drain Commissioner (Tuscola).

Pistro, S. M. (July 18, 2001). HMGP Quarterly Progress Report Form for Project 1181-0053. Caro, MI: Tuscola County Drain Commissioner (Tuscola).

Pistro, S. M. (July 20, 2001). HMGP Quarterly Progress Report Form for Project 1226-0016. Caro, MI: Tuscola County Drain Commissioner (Tuscola).

Pistro, S. M. (October 16, 2001). HMGP Quarterly Progress Report Form for Project 1181-0053. Caro, MI: Tuscola County Drain Commissioner (Tuscola).

Pistro, S. M. (October 20, 2000). HMGP Quarterly Progress Report Form for Project 1181-0053. Caro, MI: Tuscola County Drain Commissioner (Tuscola).

Pistro, S. M. (October 4, 1999). HMGP Quarterly Progress Report Form for Project 1226-0016. Caro, MI: Tuscola County Drain Commissioner (Tuscola).

Poineau, E. (April 23, 2000). Email to Pat Glithero of FEMA Requesting Information About the Acquisition of Properties in Reese, Project 1181-0048. Reese, MI (Tuscola).

Poineau, E. (June 22, 2000). Letter to James Lee Witt of FEMA Requesting a Timeline for Project 1181-0048. Reese, MI (Tuscola).

Prestin, S. (July 16, 1997). Email to Jeanne Kern Regarding MI 1128 B/C Reviews. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Ramsey, A. A. (June 22, 1999). Letter to Ernest Hunter of FEMA Requesting Support for Project 1214-0010. Irondale, AL: City of Irondale (Jefferson County).

Ray, R. (January 12, 1994). Letter to Tommie Hamner at FEMA. Sacramento, CA (Hayward).

Rickart, R. (2002). Email to Matt Schnepp of the Emergency Management Division Regarding the FY 1998 FMA Closeout for MI. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Rickart, R. (September 19, 2002). Memorandum to Iris Andrade Regarding the Closeout of FMA Grants - Final Programmatic Progress Reports. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Rifkind, S. A. (1997). Letter to Edward Buikema of the Emergency Management Division Regarding Funding for FY'97. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Rifkind, S. A. (2000). Letter to Edward Buikema of the Emergency Management Division Regarding Approval of Obligation Request for Project 1181-0053. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Rifkind, S. A. (2000). Letter to Edward Buikema of the Emergency Management Division Regarding Approval of Obligation Request for Project 1181-0046. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Rifkind, S. A. (2001). Letter to Edward Buikema of the Emergency Management Division Regarding Funding Approval. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Rifkind, S. A. (2001). Letter to Edward Buikema of the Emergency Management Division Regarding Closeout for Project 1128-0021. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Rifkind, S. A. (2001). Letter to Edward Buikema of the Emergency Management Division Regarding the FY2001 FMA Application Deadline. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Rifkind, S. A. (April 27, 1998). Letter to Robert Tarrant of the Emergency Management Division Regarding Approval for Funding for Project 1128-0021. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Rifkind, S. A. (January, 1999). Letter to Dawn Schulert of the Emergency Management Division Stating that Vassar's Flood Mitigation Plan Complies with the FMA Program. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Rifkind, S. A. (July 1, 1997). Memorandum to Michael Moline Requesting Allocation Advice for FEMA-1128-DR-MI. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Rifkind, S. A. (October 22, 1998). Letter to Edward Buikema of the Emergency Management Division Regarding Closeout for Project 1128-0012. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Ringland, D. L. (1999). Hazardous Materials Release Prevention-Final Report. Hayward, CA: Department of Public Works, Engineering and Transportation Division (Hayward).

RMS Engineering & Design. (February 1998). Seismic Strengthening of The Water Department Pump House Report for City of Orange Water Department including special provisions, engineer's opinion of construction cost, technical specifications and structural calculations. Orange, CA (Orange).

Rogers Ludke Consulting Structural and Civil Engineers. (1991). City of Hayward Seismic Assessment of Essential Facilities, Phase II Report. San Francisco, CA (Hayward).

Roveda, D. and Glithero, P. (April 21, 1998). Request Memorandum to Stuart Rifkind of FEMA for Obligation of HMGP Funds for Project 1128-0021 (Tuscola).

Sacia, L. (April 21, 1998). State and FEMA Awards Hazard Mitigation Grants to Michigan Community, Press Release: Federal Emergency Management Agency (Tuscola).

Sacia, L. (June 14, 2000). Email to Adrew Vlack Regarding Press Release for Project 1181-0048 (Tuscola).

Sargent, L. G. (February 15, 2000). Letter to Matt Schnepp of the Emergency Management Division Regarding Environmental Review for Hazard Mitigation Projects. Lansing, MI: Department of Natural Resources (Tuscola).

Sargent, L. G. (February 15, 2000). Memorandum to Matt Schnepp of the Emergency Management Division Regarding Environmental Review for Hazard Mitigation Projects. Lansing, MI: Department of Natural Resources (Tuscola).

Sargent, L. G. (February 27, 1997). Letter to Doran Duckworth of the Emergency Management Division Regarding Environmental Review for Hazard Mitigation Projects. Lansing, MI: Department of Natural Resources (Tuscola).

Sargent, L. G. (January 3, 2002). Memorandum to Dawn Schulert of the Emergency Management Division Regarding the Environmental Review for FMA FY 2001 Project Funds. Lansing, MI: Department of Natural Resources (Tuscola).

Sargent, L. G. (March 5, 1999). Memorandum to Dawn Schulert of the Emergency Management Division Regarding the Environmental Review for Flood Mitigation Project. Lansing, MI: Department of Natural Resources (Tuscola).

Sargent, L. G. (May 2, 1997). Letter to Charlie Graham of the City of Frankenmuth Regarding a Botanical Survey Report for Project 1128-0012. Lansing, MI: Department of Natural Resources (Tuscola).

Saucier, C. E. (July 2, 1999). Letter to Mayor Ramsey of Irondale, AL Regarding Approval of Project 1214-0010. Atlanta, GA: Federal Emergency Management Agency (Jefferson County).

Saucier, C. E. (June 22, 1999). Letter to Lee Helms of the Alabama EMA Regarding Approval of HMGP Project 1214-0010. Atlanta, GA: Federal Emergency Management Agency (Jefferson County).

Saucier, C. E. (November 16, 1999). Letter to Lee Helms of the Alabama EMA Regarding Further Funding and Federal Share of Project 1214-0010. Atlanta, GA: Federal Emergency Management Agency (Jefferson County).

Schnepp, M. (April 13, 2000). Letter to Andrew Vlack of FEMA Regarding Federal Share for Project 1128-0021. Lansing, MI: Michigan State Police (Tuscola).

Schnepp, M. (February 11, 1999). Memorandum to Don Roveda and Georgette Waterford Regarding Cost-Effectiveness of HMGP Project 1226-0016. Lansing, MI: Michigan State Police (Tuscola).

Schnepp, M. (May 22, 2000). Letter to Andrew Vlack of FEMA Regarding Benefit-Cost Analyses for HMGP Projects. Lansing, MI: Michigan State Police (Tuscola).

Schnepp, M. (September 29, 2000). Letter to Janet Odeshoo of FEMA Requesting Closeout of Project 1128-0021. Lansing, MI: Michigan State Police (Tuscola).

Schulert, D. (1999). Email to Christine Stack of FEMA Regarding the 1998 FMA Project. Lansing, MI: Michigan State Police (Tuscola).

Schulert, D. (December 11, 2001). Letter to Craig Czarnecki of the Fish and Wildlife Service Regarding the Environmental Review for FMA FY 2001 Project Funds. Lansing, MI: Michigan State Police (Tuscola).

Schulert, D. (December 11, 2001). Memorandum to Bruce Menerey of the Department of Environmental Quality Regarding the Environmental Review for FMA FY 2001 Project Funds. Lansing, MI: Michigan State Police (Tuscola).

Schulert, D. (December 11, 2001). Memorandum to Lori Sargent of the Department of Natural Resources Regarding the Environmental Review for FMA FY 2001 Project Funds. Lansing, MI: Michigan State Police (Tuscola).

Schulert, D. (December 11, 2001). Memorandum to Martha MacFarlane of the State Historic Preservation Office Regarding the Environmental Review for FMA FY 2001 Project Funds. Lansing, MI: Michigan State Police (Tuscola).

Schulert, D. (June 25, 2001). Letter to Craig Czarnecki of the US Fish and Wildlife Service. Lansing, MI: Michigan State Police (Tuscola).

Schulert, D. (June 25, 2001). Memorandum to Bruce Menerey of the Michigan Department of Environmental Quality. Lansing, MI: Michigan State Police (Tuscola).

Schulert, D. (June 25, 2001). Memorandum to Lori Sargent of the Michigan Department of Natural Resources. Lansing, MI: Michigan State Police (Tuscola).

Schulert, D. (June 25, 2001). Memorandum to Martha MacFarlane-Faes of the State Historic Preservation Office. Lansing, MI: Michigan State Police (Tuscola).

Schulert, D. (May 23, 2000). Fax to Christine Stack. Lansing, MI: Michigan State Police **(Tuscola)**.

Schulert, D. (May 24, 1999). Letter to Jeanne Millin of FEMA Regarding Funding for the Moore Drain study. Lansing, MI: Michigan State Police (Tuscola).

Schulert, D. (November 24, 1998). Memorandum to Richard Roth of FEMA Regarding Information Requested for the Vassar Flood Mitigation Plan. Lansing, MI: Michigan State Police (Tuscola).

Schulert, D. (October 7, 1998). Letter to Janet Odeshoo of FEMA Requesting Closeout of Project 1128-0012. Lansing, MI: Michigan State Police (Tuscola).

Schulert, D. (September 28, 1998). Letter to Richard Roth of FEMA Submitting Vassar Flood Mitigation Plan for Review. Lansing, MI: Michigan State Police (Tuscola).

Schulz, P. (December 19, 1997). Letter to Dorothy Lacey of FEMA (Hayward).

Schulz, P. (May 10, 1991). Memorandum to Christopher Adams at OES in Response to Alternative Sites Proposed for Fire Station No. 1 (Hayward).

Schwartz, N. F. (1998). Letter to Clancy Philipsborn of the Mitigation Assistance Corporation. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Schwartz, N. F. (1998). Letter to Dawn Schulert of the Emergency Management Division Outlining Amendments to be Made to the Vassar, Michigan Flood Hazard Mitigation Plan So That It Meets the Requirements of the FMA Program. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Schwartz, N. F. (April 6, 1998). Letter to Les Weigum of the Army Corps of Engineers Regarding Compliance of Project 1128-0021 With Environmental Requirements. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Schwartz, N. F. (April 6, 1998). Letter to Mike MacMullen of the EPA Regarding Compliance of Project 1128-0021 With Environmental Requirements. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Schwartz, N. F. (April, 6, 1998). Letter to Charles Wooley of the Fish and Wildlife Service Regarding Compliance of Project 1128-0021 With Environmental Requirements. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Shelton, T. (2002). Copy of "Federal Emergency Management Agency Community Rating System Publications" Request Form, documenting copies of publications purchased from FEMA, received 8-12-02, and placed in each of 12 county libraries including spreadsheet listing publication title, author, ISBN, binding type, % discount, original cost, number purchased, and actual cost for each of 31 publications acquired, and sample of Project Impact label placed on library copies of publications acknowledging FEMA as source of funding. Conway, SC: Horry County Emergency Management (Horry County).

Sherrill, J. (October 10, 2000). Memorandum to Sarah Pistro on the Development of the Hydraulic Model for the Moore Drain Study. Detroit, MI: Wade-Trim Associates, Inc. (Tuscola).

Sherrill, J. (October 9, 2000). Memorandum to Sarah Pistro on the Development of the Hydrologic Model for the Moore Drain Study. Detroit, MI: Wade-Trim Associates, Inc. (Tuscola).

Shipley, D. W. (1999). Letter to Edward Buikema of the Emergency Management Division regarding approval for FMA program EMC-98-PA-1337. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Shipley, D. W. (1999). Letter to Edward Buikema of the Emergency Management Division Stating Approval for Project 1226-0016. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Shipley, D. W. (2000). Letter to Edward Buikema of the Emergency Management Division Regarding Approval of Obligation Request for Project 1128-0021. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Shipley, D. W. (November 29, 1999). Letter to Martha Catlin of the Advisory Council on Historic Preservation Regarding the Effect of Project 1181-0046 on Historic Properties. Chicago, IL: Federal Emergency Management Agency (Tuscola).

Sigal, B. M., Singhal, A., Pan, K., Seneviratna, P. and Zadeh, M. M. (2000). Simulation of the Tornado Hazard in the U.S. In J. A. Joines, Barton, R. R., Kang, K. and Fishwick, P. A. (Eds.), *Winter Simulation Conference*: K2 Technologies, Subsidiary of E.W. Blanch (Hayward).

South Carolina Emergency Preparedness Division. (1997-2000). General Information/Documents on Flood Hazard Mitigation, including Horry County Code on flood damage prevention and control. West Columbia, SC (Horry County).

Spicer Engineering Company. (August 27, 1997). Preliminary Estimate of Cost for the Coleman Drain, Tuscola County, Michigan. Saginaw, MI (Tuscola).

Stack, C. (1999). Email to Sheila Donahoe Regarding the MI FMA Project Application (Tuscola).

Stack, C. (July 11, 2000). Request Memorandum for Obligation of HMGP Funds for Project 1181-0046 (Tuscola).

Stack, C. (June 19, 2000). Request Memorandum for Obligation of HMGP Funds for Project 1181-0048 (Tuscola).

Stack, C. (June 23, 2000). Request Memorandum for Obligation of HMGP Funds for Project 1181-0053 (Tuscola).

Stack, C. (May 1, 2000). Request Memorandum for Obligation of HMGP Funds for Project 1128-0021 (Tuscola).

State of California Office of Emergency Services. (1998). Approval Letter for Phase II of Project 1008-3218 Sent to Doug Mochizuki. Pasadena, CA (Orange).

State of California Office of Emergency Services. (1998). Letter Requesting Supplemental Funding for Project 1008-3218 Sent to Leland Wilson of FEMA. Pasadena, CA (Orange).

State of California Office of Emergency Services. (June 28, 1990). Administrative Plan for the Hazard Mitigation Grant Program (Hayward).

State of Michigan. (August, 1997). State of Michigan Current General Mitigation Initiative. (Tuscola).

The Chlorine Institute. Sodium Hypochlorite Incompatibility Chart. Washington, DC (Hayward).

Tuscola County Drain Commission. (1998). Executive Order 12898: Environmental Justice in Minority Populations & Low Income Peoples Review for Project 1128-0021 **(Tuscola)**.

Tuscola County Drain Commission. (1999). HMGP Environmental Considerations Questionnaire for Project 1181-0053 (Tuscola).

Tuscola County Drain Commission. (2000). HMGP Environmental Considerations Questionnaire for Project 1181-0048 (Tuscola).

Tuscola County Drain Commission. (April 15, 2001). HMGP Project Application for the Moore Drain Flood Mitigation Project. Caro, MI (Tuscola).

Tuscola County Drain Commission. (February 19, 1997). Minutes of Board of Determination Meeting. Vassar, MI (Tuscola).

Tuscola County Drain Commission. HMGP Environmental Considerations Questionnaire for Project 1128-0012 (Tuscola).

URS Corporation. (2000). Structural Evaluation of the Hayward Main Library, including final report cover page, and letter from Public Works Dept. to Project Manager about conclusions and recommendations of the study. Hayward, CA (Hayward).

URS Group, Inc. (2003). Final Environmental Assessment of the Moore Drain Flood Mitigation Project. Tuscola County, MI: Tuscola County Drain Commission (Tuscola).

Vieira, M. A. (April 27, 1999). Memorandum to Linda Rankin of FEMA Regarding Review of Proposed HMGP Project 1214-0010, Jefferson County, AL (Jefferson County).

Vigo, G. (June 22, 1999). Fax to Debbie Peery of Alabama EMA Regarding Approval of HMGP Project 1214-0010. Atlanta, GA: Federal Emergency Management Agency (Jefferson County).

Village of Freeport. (1995). Benefit-Cost Analysis Reports for Elevation Project Homes Prepared for FEMA by Goettel & Horner Inc. Freeport, NY (Freeport).

Village of Freeport. (1997-1999). Flood Mitigation Assistance Program Elevation of Residential Homes Project Files, including project application dated 1997, Village's flood management and hazard mitigation plan, list of candidate properties, property assessments, financing of home elevations, certification of matching funds signed by property owners, photos of elevated homes, correspondence with FEMA re: additional funding, and correspondence re: complaint from one home-owner whose house was elevated. Freeport, NY (Freeport).

Village of Freeport. (1998-2002). Project Impact Files, including close-out summary, 2001 progress report, baseline report, memorandum of agreement with FEMA, action plan summary, Project Impact community directory, local news articles, community profile, contract and specifications for mobile fire safety house, hazard and risk analysis action plan for Village of Freeport prepared by FEMA, letter re: Project Impact Model Community Award, quarterly reports from 2000/2001, and 1999 Awareness Day documents. Freeport, NY (Freeport).

Village of Freeport. (1999-2001). Flood Mitigation Documents Sent from Freeport's Grants Administrator to FEMA, including elevation certificates for 23 homes elevated under the Flood Mitigation Assistance Program; Freeport Reconnaissance Study for Navigation, Flood Control and Ecosystem Restoration prepared by US Army Corps of Engineers dated 2001; Freeport's building permit application; Freeport's flood damage prevention code; and a list of flood mitigation measures initiated by Freeport. Freeport, NY (Freeport).

Village of Freeport. (1999-2001). Grade Raise and Street Improvement Project Files, including 1999 application and supporting documents; and 2000 application for additional grade raise/road improvement and supporting documents, which include cost-effectiveness information on Alternative #1: Grade Raise, FEMA approval letter, benefit-cost analysis of grade raise project, and determination of categorical exclusion by FEMA. Freeport, NY (Freeport).

Village of Freeport. (2000). Flood Mitigation Assistance Program Elevation of Residential Homes Project Files, including HMGP application to elevate ten structures dated April 2000; FEMA approval letter; benefit-cost analysis of the elevation of each of the ten structures; and close-out information. Freeport, NY (Freeport).

Village of Freeport. (2001-2003). Additional Documents for Flood Mitigation Assistance Program Elevation of Residential Homes Project, including contract and specifications, application for assistance for elevation of seven additional homes (duplicate), and photos of flooded and elevated homes. Freeport, NY (Freeport).

Village of Freeport. (2003). Flood Mitigation Assistance Program Elevation of Residential Homes Project Files, including application for assistance for the elevation of seven residential structures dated March 2003, which includes property assessments, cost information and copy of Freeport Village Code on flood damage prevention; FEMA letter outlining conditions of approval; and FMA Project Review files that include the review results and the benefit-cost analysis of the elevation project. Freeport, NY (Freeport).

Village of Freeport. A Revitalization Project in Freeport. Freeport, NY (Freeport).

Village of Freeport. Against the Tide. Freeport, NY (Freeport).

Vink, H. (April 30, 1996). Letter to Nancy Ward at OES Outlining New Cost Data. Hayward, CA (Hayward).

Vink, H. (February 18, 1997). Letter of Appeal to Nancy Ward at OES. Hayward, CA (Hayward).

Vink, H. H. (February 5, 1993). Letter to Charles Wynne at OES. Hayward, CA (Hayward).

Vlack, A. (June 13, 2000). Email to Linda Sacia of FEMA Regarding a Press Release for Project 1181-0048 (Tuscola).

Wade-Trim Associates, Inc. (October 2002). Summary Report of the Moore Drain Flood Study. Caro, MI: Tuscola County Drain Commission (Tuscola).

Ward, N. (1996). Letter to Dorothy Lacey at FEMA Including Subgrantee's Justification for an Increase in Funding. With supporting documentation (Hayward).

Ward, N. (February 7, 1997). Letter to Henry Vink in Public Works (Hayward).

Ward, N. (June 26, 1995). Letter to Jesus Armas Detailing Closeout of Retrofit of Fire Stations 2, 3, 4, 5 & 6 and Yard Building. Hayward, CA (Hayward).

Weber, D. (April 20, 2001). HMGP Quarterly Progress Report Form for Project 1181-0048. Reese, MI: Village of Reese (Tuscola).

Weber, D. (January 30, 2001). HMGP Quarterly Progress Report Form for Project 1181-0048. Reese, MI: Village of Reese (Tuscola).

Weber, D. (July 18, 2001). HMGP Quarterly Progress Report Form for Project 1181-0048. Reese, MI: Village of Reese (Tuscola).

Whitley, Burchett and Associates, Inc. (April 19, 1996). Letter to Henry Vink in Public Works Announcing Hypochlorite Disinfection Facilities Updated Project Cost Data. Walnut Creek, CA (Hayward).

Wooley, C. M. (April 10, 1998). Letter to Terrill Barnes of FEMA Regarding the Endangered Species Request List. East Lansing, MI: Fish and Wildlife Service (Tuscola).

Wynne, C. F. (April 16, 1991). Letter to Tommie Hamner at FEMA. Sacramento, CA (Hayward).

Wynne, C. F. (January 23, 1992). Letter to Roy Kite at FEMA (Hayward).

Wynne, C. F. (Jaunary 22, 1992). Letter to Louis Garcia Regarding HMGP Award of Funds (Hayward).

Wynne, C. F. (June 8, 1992). Letter with Enclosures to Roy Kite at FEMA. Sacramento, CA (Hayward).

Wynne, C. F. (March 1991). Letter to Louis Garcia. Sacramento, CA (Hayward).

Wynne, C. F. (March 20, 1992). Letter to Patrick Douglas Regarding Audit Requirements for the Hazardous Materials Release Prevention Project. Sacramento, CA (Hayward).

Wynne, C. F. (March 6, 1991). Letter to Louis Garcia. Sacramento, CA (Hayward).

Wynne, C. F. (March 8, 1993). Letter to Roy Kite at FEMA, including an environmental assessment questionnaire, Notice of Exemption, revised cost estimate and scope of work for HMGP federal project #0014. Sacramento, CA (Hayward).

Appendix Q
PROJECT IMPACT

Q.1 Introduction

In the community studies, five of the eight communities (Freeport, New York; Horry County, South Carolina; Jamestown, North Dakota; Jefferson County, Alabama; and Multnomah County, Oregon) participated in Project Impact. This appendix contains first a description of Project Impact, how communities were selected, the goals of the community programs, the signing ceremony, and reporting requirements. Second, it contains descriptions of the activities undertaken by the five Project Impact communities including benefit cost analyses of the individual projects that were completed.

Q.2 Background: Why and How Project Impact Started

Between 1989 and 1993, the United States was devastated by a series of major natural disasters: Hurricane Hugo and the Loma Prieta Earthquake in 1989, Hurricane Andrew in 1992, and the Midwest Floods in 1993. The loss of life and property led FEMA to adopt "The National Mitigation Strategy – Partnerships for Building Safer Communities," a proactive, predisaster mission "to strengthen partnerships among all levels of government and the private sector to empower all Americans to fulfill their responsibility for ensuring safer communities."[81] James Lee Witt, then Director of FEMA, explained

> "In response to the unacceptable loss of life and property from recent disasters, and the awesome prospect of even greater, catastrophic loss in the future, the National Mitigation Strategy has been developed to provide a conceptual framework to reduce these losses. Hazard mitigation involves recognizing and adapting to natural forces and is defined as any sustained action taken to reduce or eliminate long-term risk to human life and property. The Strategy is intended to engender a fundamental change in the general public's perception about hazard risk and mitigation of that risk and to demonstrate that mitigation is often the most cost-effective, and environmentally sound, approach to reducing losses. The overall long-term goal of the Strategy is to substantially increase public awareness of natural hazard risk and – within 15 years – to significantly reduce the risk of loss of life, injuries, economic costs, and disruption of families and communities caused by natural hazards".[82]

The content of The National Mitigation Strategy resulted from a series of eleven public Mitigation Forums conducted across the United States from September 1994 to June 1995 and completed questionnaires returned from 15,000 distributed to public and private sector entities.[83]

---

[81] Witt, James, L., "Forward" to *National Mitigation Strategy – Partnerships for Building Safer Communities*, Washington, DC: FEMA, Mitigation Directorate, December 6, 1995, page *i*.

[82] Ibid.

[83] Ibid. The document does not provide details on the questionnaire, the recipients, how many were returned, or what analysis was performed on the returned questionnaires.

In 1996, Witt's conceptualization of a Natural Hazard Mitigation Strategy was transformed into the operational Disaster Resistant Communities Initiative (later renamed Project Impact), with the goal of providing seed money for selected communities to develop and sustain a comprehensive hazard mitigation program. In describing Project Impact, Tricia Wachtendorf and her colleagues at the University Delaware Disaster Research Center said,

> "…rather than devising a program that would be managed through strict guidelines and tight regulation, FEMA designed Project Impact as a "bottom-up" approach to mitigation that gave local communities fairly wide latitude in deciding what mitigation goals they would pursue and how. The intent of the program was to establish a wide variety of community-based initiatives to address mitigation issues deemed important by the communities and to encourage the development of innovative solutions to hazard-related problems".

Although communities were actively encouraged to develop their own strategies for reducing disaster losses, FEMA did outline general goals and objectives for the program. These overall goals were: (1) to build community partnerships; (2) to identify hazards and community vulnerability; (3) to prioritize risk reduction actions; and (4) to develop communications strategies to educate the public about Project Impact and disaster mitigation more broadly. Communities were then asked to formally establish locally-based organizations and to initiate activities that would address these objectives.[84]

Project Impact was launched in the summer of 1997 with the selection of seven pilot communities, who each received $1 million in seed money to implement their community programs. Project Impact was funded until fiscal year 2001. In total, 250 communities in every state and some U. S. territories received a total of $77 million, ranging from $60,000 to $1,000,000 over three years or less. Most received $150,000 to $300,000 over a two-year period.

Q.3 Community Selection

Nothing in the natural hazards or public policy literature could be found that described exactly how communities were selected to participate in Project Impact. Information from documents obtained in the five Project Impact communities in this study suggests there was no uniform method of community selection. Available evidence suggests that communities were selected with a process that included input from the states, the FEMA regional offices, and FEMA national headquarters. Communities may or may not have participated in the initial decision process. In Oregon, communities like Multnomah County were asked to submit formal requests to be considered as a future Project Impact community. On the other hand, in New York, Freeport was notified by the state of New York after the decision to select had been made. In any event, all selected communities had to make an active agreement to participate at some point during the decision process.

---

[84] Wachtendorf, Tricia, Rory Connell, Brian Monahan, and Kathleen Tierney, *Disaster Resistant Communities Initiative: Assessment of Ten Non-Pilot Communities*, Report to the Federal Emergency Management Agency, Newark, DE: The University of Delaware, Disaster Research Center, August 30, 2002, pages 1-2.

All information presented herein is based solely on documents available to the project team. The most detailed information concerns the selection of Freeport, New York, as a Project Impact Community, which is presented next.

Community Selection – Freeport, New York.[85] The method by which the Village of Freeport, New York, was selected as a Project Impact community was based on "a combination of factors" listed in what was called the Project Impact Matrix developed by FEMA's National Director of Project Impact. Using the matrix as a guide, Region 2 established priorities with state input and forwarded its recommendations to FEMA national headquarters, where ultimately a final decision was made.

Six New York communities were evaluated to become 1998 Project Impact communities.[86] The Project Impact Matrix used in the evaluation consists of 14 variables plus additional comments. See Table Q-1 for a list of the variables, a general description of the type of information that was used for evaluation, and the information that was provided for Freeport.[87]

In Table Q-1, the first three variables (County, Square Miles, and Population) indicated whether the size of the community was manageable and located geographically close to the regional office in lower Manhattan so it was relatively accessible. A single variable, "Primary Hazard," established the risk from natural hazards. The remaining variables were all related to existing relationships with FEMA or existing community programs that indicated whether the community could establish partnerships and pursue Project Impact goals. The highest priority was given to the communities that were accessible, had a significant natural hazards risk, and had the greatest number of positive characteristics that might indicate success in Project Impact.

Freeport received the highest priority rating. A discussion of Freeport in the FEMA memo stated that it was both relatively small in size and very accessible to regional staff, both good characteristics. Furthermore, "The Village of Freeport has already demonstrated a proactive mitigation effort through its packaging of a major elevation project funded under FEMA's Flood Mitigation Assistance (FMA) program. Additionally, it has an updated and aggressive mitigation plan adopted by the Village Board of Trustees (to apply for CRS Class 8[88]); a very high policy base for a mid sized New York community of 2,268 policies; and, a full time emergency manager that could dedicate time to Project Impact." [89] The FEMA memo also noted

[85] This section is primarily based on an internal FEMA memorandum from Lynn C. Canton, Regional Director of FEMA Region 2 to Jane Bullock, FEMA Chief of Staff, and Michael J. Armstrong, Associate Director, Mitigation Directorate, with a c.c. to Maria Vorel (FEMA National Director for Project Impact) dated January 29, 1998 with the subject "Region 2 Project Impact Recommendations" describing the process used to recommend the first Project Impact communities in New York, New Jersey, Puerto Rico, and the Virgin Islands using a matrix of variables "identified by Maria Vorel and additional information that the Region thought would be helpful in making a determination on recommendations and potential selections."

[86] The Canton memo referred to above includes a completed matrix for three New York communities; the Town of Southhampton, the City of Rye, and the Village of Freeport.

[87] The Freeport comments are copied verbatim from the Canton FEMA memo except for some commas and the full spelling of some abbreviated words added for clarity. Similar comments for the Town of Southhampton and the City of Rye have been omitted.

[88] The Community Rating Service or CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum National Flood Insurance Program (NFIP) requirements.

[89] Ibid., p. 3.

that Freeport had a significant flood insurance repetitive loss history, specifying that since 1978, Freeport had 275 properties that suffered 796 losses.

Table Q-1 Project Impact – Matrix

Variable	Description	Village of Freeport
County	County name	Nassau
Square Miles	Area of community	5
Population	Approximate population of community	40,000
Primary Hazard	List of high risk natural hazards	Hurricanes, NorEasters, back bay flooding and high winds
CRS Class	Community Rating System class	Class 9 – close to Class 8 have excellent Hazard Mitigation Plan
HMGP Project (type & $)	Current HMGP grants, if any	NA
NFIP Status – CAV	Number of NFIP policies, % coverage of structures in floodplain, number of losses, past payouts, number of substantially destroyed structures, risk and input from observations made during Community Assistance Visits	As of 3/97 1750 losses paid, 269 are repetitive, total claims close to $10,000,000. This community is historically at significant risk for back bay flooding. Total of 2268 policies, about 70% covered
FMA Grant Status (type, plan, & $)	Current FMA grants, if any	Rec'd 620K in 1997 for elevation of 40 structures, Region 2's largest FMA project
PA/CA Unique Activity	Public Awareness activities, if any	Their local public awareness activities have been very good according to state and they will have a full time Emergency Manager pushing all projects
PA 406 Mitigation Projects (type & $)	Public Assistance grants with mitigation elements, if any	NA
B&I Status – Activity & Status	Current Business and Industry partnerships	NY SEMO will work with their B&I Loss Reduction Task Force with the community if selected
Political Overview	Names of Congresspersons with discussion of their interest in FEMA	Split (D) Carolyn McCarthy (R) Peter King
Potential Project Impact Funding Targets	Likely hazard mitigation projects that would be undertaken	Would continue with further elevation and retrofit projects consistent with FMA grant and their own mitigation plan
Local Leadership Support/Commitment	Evaluation of existing ties between community and business and industry	Recently hired a full time emergency manager to run all mitigation programs – have been very supportive of mitigation and state B&I
Comments	List of positive community characteristics not mentioned above	Very progressive – Community has Mitigation Planning Committee and the Village Board of Trustees have adopted their mitigation plan

The FEMA memorandum suggests that the selection in Region 2 communities in New York, New Jersey, Puerto Rico, and the Virgin Islands was based on (1) staff accessibility, (2) the receipt of FEMA hazard mitigation grants, (3) factors that indicated that the community was likely to develop partnerships with for profit businesses, and (4) political exigencies, whatever they might be. Risk from natural hazards was not a primary consideration in the ultimate selection of communities because all the communities that were evaluated apparently shared similar high risks and discrimination was not possible. High priorities were given for communities that were judged to have a high probability to succeed in developing partnerships that would lead to community-wide mitigation activities.

The decision process for Freeport did not end with the setting of priorities contained in the FEMA memo. On March 5, 1998, the New York State Emergency Management Office (SEMO) selected all six communities that were evaluated earlier by FEMA Region 2 as Project Impact – Disaster Resistant Communities in New York State.[90] The designation was misleading as each community was informed that it could become a Project Impact community by developing an acceptable program that would meet both SEMO and FEMA guidelines. On March 19, 1998, Freeport Village officials held their first steering committee meeting with representatives of local businesses, SEMO, and FEMA Region 2.[91] The business attendees were Home Depot, Lea Ronal Inc., Fleet Bank, Meadowbrook Care Center, and the Chamber of Commerce. In the next few months, Freeport Village officials formed partnerships with these and other local merchants to work with the Village officials "to plan innovative educational and public awareness programs in the village."[92] On June 3, 1998, FEMA Director James Lee Witt invited the Village of Freeport to become a Project Impact community.[93]

Q.4 Community Selection – General Comments

No information as detailed as that for Freeport was located for any of the remaining four Project Impact communities that were part of the community studies. However, the "Grant Guidance for FY99 Communities" provided by FEMA to all prospective Project Impact communities who wished to apply for 1999 funding (including Jefferson County, Alabama and Multnomah County, Oregon in this study) suggests that the Project Impact Matrix used in Region 2 to select Freeport was widely used elsewhere. In the section entitled "Application Review," it is stated:

> When the community's grant proposal is received, the FEMA regional office shall review it to determine if its implementation will reduce disaster costs, and whether there are sufficient measures taken to reduce in a permanent or long-term manner the potential losses from natural hazard events before the hazard occurs. Factors that will be considered will include: the community's current hazards and risks; mitigation projects already funded or completed in the

[90] *About FEMA – New York State Implements Project Impact Ideals in Six Communities*, FEMA News Release, www.fema.gov/about/r2webny.shtm

[91] Ibid.

[92] *Freeport, NY, Asked to Become a Project Impact Community to Reduce the Effects of Disasters*, FEMA News Release, June 3, 1998, www.fema.com/regions/ii/1998/98r2n003.shtm

[93] Ibid.

community; existing mechanisms for public-private partnering; and planned and implemented substantive mitigation measures in the community.[94]

An identical "Application Review" section was included in the FEMA "Program Guidance FY2000" document provided to all prospective Project Impact communities who wished to apply for 2000 funding including Jamestown, North Dakota.[95] Similarly, the FY2001 "Mitigation Grant Guidance" that was sent to Horry County, South Carolina included the same "Application Review" section.[96]

Q.5 Acceptable Project Impact Activities and Application Instructions for Communities

In their assessment of Project Impact, Wachtendorf and her colleagues stated that "Four activities – risk assessment, mitigation, partnership development, and public education and information – constitute core Project Impact goals."[97] Wachtendorf and her colleagues did not mention whether FEMA provided instructions to Project Impact communities that specified the categories within which projects should be undertaken or the kinds of projects that were preferred. Wachtendorf and her colleagues did say that FEMA encouraged the communities to select their own activities to strengthen overall community hazard mitigation.

The three FEMA program guidance documents mentioned above include categories of acceptable activities that are broader than suggested by Wachtendorf and her colleagues. The *Grant Guidance for FY99 Communities* document instructs communities to "categorize mitigation projects as one of the following:

- Mitigation for existing structures
- Mitigation of existing infrastructure, utility facilities, and transportation systems that are publicly owned and operated on a non-profit basis
- Adoption of policies and practices for mitigation in existing structures, development or redevelopment
- Activities that lead to building or sustaining public/private partnerships, or that support public awareness of mitigation
- Hazard identification and risk assessment
- Mitigation of new construction
- Personnel support"[98]

[94] *Program Description Disaster Resistant Community Mitigation Grant – Grant Guidance for FY99 Communities*, no date, page 3.

[95] *Program Guidance FY2000 – Disaster Resistant Community Mitigation Grant*, no date, page 4.

[96] *Project Impact Building Disaster Resistant Communities Mitigation Grant Guidance FY2001*, no date, page 4.

[97] Wachtendorf et al., op. cit., page *iii*.

[98] *Program Description Disaster Resistant Community Mitigation Grant – Grant Guidance for FY99 Communities*, no date, pages 2-3.

In slightly different language and order, the *Program Guidance FY2000* instructs communities to "identify each mitigation project or activity targeted for grant funding as one of the following:

a. Category A – Hazard identification and risk assessment
b. Category B – Adoption of policies or practices for mitigation in existing buildings or new construction
c. Category C – Mitigation for existing buildings
d. Category D – Mitigation of existing infrastructure: such as, utility facilities and transportation systems that are publicly owned and operated on a non-profit basis
e. Category E – Activities that lead to building or sustaining public/private partnerships, or that support public awareness of mitigation
f. Category F – Personnel support"[99]

The *Mitigation Grant Guidance FY2001* instructions are virtually identical to those of FY2000 except for Category C. In FY2001, Category C was expanded to "Mitigation for existing buildings and properties-at-risk."[100]

The first document varies in several ways from the latter two. The language in some of the categories has changed and two of the categories in the first document have been combined in the second and third documents. Most important are the orders of the categories. Specifically, "hazard identification and risk assessment" has risen from near the bottom of the 1999 list to the top of the 2000 list, and mitigation activities have fallen from the top two places in 1999 to the third and fourth in 2000. If these lists were interpreted by FEMA regions, states, and/or communities as priority lists, then one would expect to find different mixes of approved activities in communities whose funding began in FY 1999 and communities whose funding began in FY 2000 and FY2001.

Q.6 The Signing Ceremony

The signing ceremony was an orchestrated media event that was intended to take place on the official starting date of the Project Impact contract between FEMA and the community. It represented the community formally joining Project Impact. In some public setting, community, state, and federal officials as well as representatives from public, private for profit, and private non-profit organizations met for the formal signing of the memorandum of agreement (MOA). As a sign of commitment, many representatives added their signatures to the MOA.

Because of the public nature of this important event, FEMA recommended that several months be spent in planning and that the event take place at a time chosen by the community. FEMA Region 4's Project Impact Coordinator provided the following advice:

[99] *Program Guidance FY2000 – Disaster Resistant Community Mitigation Grant*, no date, page 3.
[100] *Project Impact Building Disaster Resistant Communities Mitigation Grant Guidance FY2001*, no date, page 3.

> "Based on other communities [sic.] experience, we recommend formation of a special Signing Ceremony committee to organize, prepare for, and operate the event. Several of our Southeastern communities have done a superlative job in this regard. We encourage you to contact your sister communities that have already held Signing Ceremonies and to coordinate closely with your State Project Impact Coordinator. Please give us a two month's "head's up" so we can do our part to assist. Often we will be able to travel to your community to meet with the committee and State staff in advance of the Ceremony".[101]

Q.7 Reporting Requirements

As conceived, Project Impact was designed to encourage local initiative and to grant local control over mitigation strategies and the selection of activities to achieve community goals. FEMA also promised minimal reporting requirements.

Documents in the files of the five Project Impact communities that were part of the community studies do not include sufficient information to state with certainty what the complete reporting requirements for communities were.[102] However, it seems fairly certain that many of the following reports were required in most communities:

- A *Memorandum of Agreement* (MOA) (sometimes referred to as a Memorandum of Understanding (MOU)) that presented the intentions of the community, listing activities to be completed and their costs, including local contributions, and community partners. This was the document that was publicly signed by FEMA, the community, and community partners at the signing ceremony to begin the grant.
- A *Scope of Work* (SOW) (sometimes referred to as a Statement of Work) that provided details concerning the activities listed in the MOA and details concerning the time period in which work was to be completed. It might also contain revisions to the MOA after the community committees overseeing different aspects of Project Impact altered the activity mix. No specific required date of delivery was found; however, there apparently was some urgency in completing a SOW, as FEMA regions apparently required a SOW and a budget before FEMA approved the transfer of any funds.
- A *Budget* that accompanied the *Scope of Work*.
- A *Project Impact Baseline Report* due 60 days after the start of the grant that included a detailed risk assessment and vulnerability analysis. The questions asked mirrored the topics listed in the Project Impact Matrix (Table Q-1) but were more numerous and focused.
- A *Hazard Mitigation Plan* estimated to be completed within the first six months of the grant if the community had not written one prior to Project Impact.

---

[101] Randolph, Steven, Regional Project Impact Coordinator, to Project Impact Coordinators – FY99 Communities, *Memorandum Re: Disaster Resistant Community Grants (DRCGs),* April 6, 2000, page 3.

[102] For each community, the Project Impact files found at the community and in the FEMA regional office were not identical. Differences between them were often substantial. Also different sets of documents were found for each community. It was therefore unclear if the combined records of the Project Impact grants were complete or if communities were asked to submit different sets of documents. The latter conclusion seems more valid because grant files found for other mitigation projects -- Hazard Mitigation Grant Program (HMGP) and Flood Mitigation Assistance (FMA) -- were consistent and most often complete. It is hard to believe that Project Impact files would be treated differently.

- An *Action Plan* that appears to be an amended Scope of Work that was produced a year or more after the project commenced. It was a combination progress report and scope of work for the remaining time on the grant.
- A *Project Impact Progress Report* due annually after the start of the grant that listed in detail information concerning partnerships, risk, an evaluation of mitigation measures implemented, and a discussion of successes. Most grants ran for two years, so only one progress report was required.
- *Quarterly reports* describing activities completed in the previous three months and changes to the statement of work. These reports included narrative and financial information and were due every quarter. They were also required for communities to get reimbursed for the federal share of expenses incurred.
- *Semi-Annual Performance Reports* providing a narrative status report of the projects approved for federal funding.
- *Close out documents* to end the project that focuses mainly on the budget. Unspent monies were listed and deobligated by FEMA.
- *A final report*, often the last quarterly report, but sometimes a stand-alone document completed at the end of the grant. This report presents a discussion of exactly what was completed during the grant. Because of changes initiated throughout the life of the project, it is the only report that can be trusted as an accurate record of what the community achieved during Project Impact.

There were also indications that things did not always go smoothly, and changes were required. In 2000, FEMA realized that its reporting requirements did not provide communities sufficient time to make decisions that were needed to complete reports and later asked communities to make revisions. One year to the day after its signing ceremony, April 6, 2000, Jefferson County, Alabama, as well as all other Region 4 Project Impact communities was notified by Region 4:

> This is to advise you that we are prepared to accept a major revision to the approved Scope of Work and budget for the Disaster Resistant Community grants (DRCSs) issued for FY98 and FY99.
>
> The grant offer and application process for the ten FY98 and FY99 Project Impact communities was accelerated due to circumstances beyond our control. This did not allow most communities time to hire a Coordinator, form their Project Impact Steering Committees, develop partnerships with the private sector, conduct a complete risk assessment and vulnerability analysis, or develop a hazard mitigation plan. As a result, many of the DRCG grant awards do not reflect the Project Impact strategies and proposed projects now being formulated in these communities.
>
> At the time we promised each community the right to revisit the Scopes of Work and budgets in the DRCG grants awards at a later date. That time has come. Each community now has in place a Project Impact Coordinator and Project Impact committee or task force. Most communities have their Project Impact initiative well

> underway. And, as noted many projects are being proposed that are not within the approved Scope of Work.
>
> Any substantive revision to the Scope of Work as well as revisions to the approved budgets must be submitted for prior approval. To revise the DRCG, please submit revised SF 424 B & C budget forms and a new Scope of Work clearly defining each project and the amount of federal funds involved.[103]

Based on experience with past Project Impact communities, FEMA realized in 2000 that the start of Project Impact programs was often delayed because "most communities do not have the budgetary resources available…until receipt of the federal DRCG 'seed money.'" [104] Therefore, in 2000 FEMA changed the rules on its expectations and funding. For FY2001 communities, Project Impact became a two-phased grant. Phase 1 or "the initial start-up phase" would provide 20% of the grant monies for the "community to hire a project impact coordinator and organize a Project Impact Task Force" that would develop specific projects that would be funded under Phase 2 using the remaining 80% of the grant.[105] This meant that the FY2001 Project Impact communities would have to write two SOW's and two budgets, one for each phase.

The reporting documents collected in each of the five communities studied are shown in Table Q-2. It is clear that there is no consistency across communities.

The inconsistent reporting found in this research study was also found in the assessment of Project Impact completed by Wachtendorf and her colleagues. They found that some communities were pleased with their programs while others were "frustrated with bureaucratic requirements and inconsistencies."[106] Among the many findings reported was "Several communities believed that information and procedures were inconsistent across the country and had received conflicting information from FEMA headquarters and their regional offices."[107]

Q.8 Partnerships

One of the goals of Project Impact was for communities to build partnerships with other government entities, for-profit companies, and nonprofit organizations "to foster a community-wide approach to mitigation."[108] Partners would participate in the establishment of community activities, their management, and often provide services, materials, or funds for their completion. Partner contributions were eligible to be counted as part of the community share of the grant, 25% of the total.

---

[103] Randolph, op. cit., page 1.

[104] Randolph, Steven, Senior Project Impact Coordinator, to FY2001 Communities & State Project Impact Coordinators, Memorandum Re: Sample Budget: Initial One-Year Operation of a local Project Impact for FY 2001 *Disaster Resistant Community Grants*, October 27, 2000, page 1.

[105] Ibid.

[106] Wachtendorf et al., op. cit. page 64.

[107] Ibid., page 66.

[108] This goal is the foremost objective listed on the first page of the Grant Guidance documents for FY1999, FY2000, and FY2001.

Table Q-2 Project Impact reporting documents collected during visits to FEMA regional offices and communities[1]

Document	Freeport, NY 1998	Jefferson County, AL 1999	Multnomah County, OR 1999	Jamestown, ND 2000	Horry County, SC 2001
Memorandum of Agreement (MOA)	Yes	No	No	Yes	No
Scope of Work (SOW)	No	Yes	Yes	No	Yes
Budget[2]	No	Yes	No	Yes	Yes
Project Impact Baseline Report	Yes	No	No	Yes	No
Hazard Mitigation Plan	Yes	Yes	No	No	No
Action Plan	Yes	No	No	Yes	Yes
Project Impact Progress Report	Yes	No	No	No	No
Quarterly Reports (Number Present)	3	4	1	0	10
Semi-annual Performance Reports (Number Present)	0	0	2	0	0
Close Out Documents	Yes	Yes	No	No	No
Final Report	Yes	Yes	No	Yes	No

[1]The communities are placed from left to right in the chronological order that they joined Project Impact.

[2]According to an internal FEMA memorandum dated April 6, 1999 discussing project funding found in the Jefferson County, Alabama files, FEMA began requiring separate budgets for *Construction* and *Non-Construction* projects. Neither term was defined.

FEMA did not provide a definition of a partner. Wachtendorf and her colleagues defined partners as those who signed the Memorandum of Agreement at the start of the grant period.[109] They also defined "active" partners as those who "were ranked by any community respondent as a 3, 4, or 5 ('moderately active,' 'quite active,' or 'very active')" in a questionnaire given to the Project Impact Coordinator and between one and four other respondents who were knowledgeable about Project Impact.[110]

While the Wachtendorf et al. definitions have some value, they ignore many complicating factors. First, communities often had partners before joining Project Impact. It is obvious that

[109] Ibid., page 9.

[110] Ibid., page 20. The University of Delaware study was conducted while Project Impact grants were underway. The study ended before the researchers had the opportunity to review completed grants. Therefore, Wachtendorf and her colleagues were unable to update their definition of partners to include anyone who participated in Project Impact activities but who did not sign the MOA.

Project Impact was not responsible for the initiation of these partnerships. Second, during the life of the Project Impact grants, many community organizations and individuals beyond those who signed the MOA contributed services, materials, or funds. Some were involved at a single point in time and others over a period time. In the files of the five communities evaluated in this study, there are sometimes lists of people who contributed to Project Impact activities, but often there are not, making it impossible to know for certain all those who might have partnered with the communities. Third, communities did not keep records of how "active" partners were or even use the term "active" to describe partners. Fourth, because people or representatives of organizations who did not sign the MOA were not asked if they considered themselves partners, there is no method to determine their motivation or whether they would consider themselves partners.[111]

In light of the difficulties of finding and evaluating the status of potential partners, no attempt has been made to impose a definition on who might be considered a partner. When partnership information provided by the community is available, it is reported in the context it was created.

Q.9 Descriptions of the Project Impact Activities Carried out in Five Communities[112]

As mentioned above, this research study included the evaluation of eight communities, five of which were Project Impact communities. Details of their Project Impact experiences and activities are presented next. The order is based on the starting date, the earliest first. Thus, the order of presentation is: Freeport, New York (1998); Jefferson County, Alabama (1999); Multnomah County, Oregon (1999); Jamestown, North Dakota (2000), and Horry County, South Carolina (2001).

Q.10 Freeport, New York

As mentioned above, Freeport was selected as a Project Impact community because it had a significant flood and wind risk, a positive record of hazard mitigation, a full-time emergency manager who could devote time to Project Impact, and had private sector partners who previously completed projects with the village. One example of a pre-Project Impact partnership activity was the construction of a model demonstrating wind resistant construction that was built by the local Home Depot and Simpson Strong-Tie Company, Inc. It was placed and still remains in the foyer of Village Hall outside the offices of the Building Department for everyone, especially contractors and builders, to see.

Freeport was notified that it could become a Project Impact community on March 5, 1998. The community established a Steering Committee chaired by the Mayor that first met on March 19. From initial work completed on the development of a list of activities that would become part of

[111] During some community site visits, a few individuals were encountered who participated in community activities but did not sign the MOA and were asked if they considered themselves "partners." Some did and some did not.

[112] The community descriptions are based on records obtained from the FEMA regional offices and the communities. The records include the reporting documents listed in Table 2 and others that were produced by the community for other purposes. A review of the records indicates that there is significant missing information for each community. Therefore, the community descriptions include the best estimates provided in the record where omissions exist.

the Memorandum of Agreement (MOA) with FEMA, FEMA invited the village to become a Project Impact community on June 3. A signing ceremony was held on September 17, 1998.

In the MOA signed on September 17, Freeport proposed to:

> Strengthen the community's resistance to disaster by retrofitting and elevating homes and commercial structures. Improve the hazard resistance of the community's infrastructure. Develop and implement public awareness campaigns to insure that the public and private sectors and the residents of the community are educated to the need to support these Hazard Resistant Initiatives.[113]

To meet its goals, the village created five committees with mission statements:

(a) Commercial and Industrial: Identify developed and vacant properties that are subject to flooding.

(b) Bulkhead: Identify existing bulkheads that need to be repaired or replaced and areas without bulkheads that are a source of flooding.

(c) Public Awareness: Develop a program to educate the public about hazards to which our community is exposed, such as hurricanes, nor'easters, flooding, etc.

(d) Infrastructure: Identify essential infrastructure that are at risk and recommend preparedness response & recovery mitigation measures

(e) Retrofitting Residential Structures: Identify residential structures that are prone to flooding and have repetitive losses.[114]

Also in the MOA in Appendix B, Freeport included an Action Plan that listed commitments or partnership agreements with three village departments, Nassau County, the Town of Hempstead, five corporations, one bank, and six nonprofit organizations. In all, including the Mayor representing Freeport and James Lee Witt representing FEMA, there were 21 signatures. The commitments were linked to the goals of the five committees and representatives of the partners made up the membership of the committees.

Although a MOA was signed on September 17, that day did not represent the start of the FEMA grant. The Project Impact Progress Report and other documents indicate that another MOA was signed on December 23, 1998 and that FEMA agreed to grant Freeport $300,000 over a two-year period commencing January 1, 1999 and ending January 1, 2001.[115] Freeport was obligated to provide a local match of $100,000 or 25% of the sum.

As was typical of the five Project Impact communities studied, near the end of the two-year grant, Freeport requested and FEMA approved a no-cost extension to complete its activities. The ending date was extended one year to January 1, 2002.

---

[113] *Memorandum of Agreement*, September 17, 1998, Appendix A, page i.

[114] Ibid., Appendix A, pages i-v.

[115] The December 23, 1998 MOA was not located.

Q.10.1 A Review of the Project Impact Activities

Freeport proposed 13 activities that it divided into two general categories: those concerned with education and those broadly concerned with retrofitting. See Table Q-3 for a list of the activities, the benefits Freeport sought, and details of the activities with the final status of the project.[116]

The original five committees identified in the original MOA developed the 13 activities shown in Table Q-3. Over the three-year life of Project Impact, the partners identified in the MOA remained with the project as partners. While some Freeport documents mentioned partnership growth, none described or singled out any additional organizations having a partnership role.

According to the information provided in the February 2002 "Project Impact Close Out Summary," the Village of Freeport reported expending all $300,000 granted by FEMA and contributing $217,402.30 in matching funds or in-kind services. However, there was no breakdown according to activity.[117]

Q.10.2 Benefit Cost Analysis

Table Q-4 presents the types of mitigation activities funded that were completed, the costs of these activities (including FEMA's share), an estimate of the total benefits, an estimate of the benefit-cost ratio, and the range of the benefit-cost ratio. While the range of benefit-cost ratios is sometimes large for a particular activity, this estimate is meant to provide a general understanding of the extremes that are possible given the uncertainties present in the analysis. A more rigorous analysis would lead to a more statistically significant range.

For Freeport, the dominant activity was the development of a warning system, the installation of a tidal gage in the bay connected to a siren, that permits Freeport residents to use sandbags in order to avoid damages, especially to appliances and other items found in lower stories. Warning systems were assumed to permit 500 residences to use sandbags every two years, with a savings of $1000 per residence per event. HAZUS was used to evaluate the benefits of hurricane windows and doors installed at the Village Emergency Operation Center. Benefits from other activities were not estimated.

---

[116] The communities in this study each tracked their projects in different ways. The projects are discussed in their community context to avoid misrepresenting them.

[117] Other Freeport documents issued during the life of Project Impact include estimates of federal and local costs for various activities. However, they changed over time and no final detailed accounting could be located that specifically identified federal and local costs for each activity. The Village of Freeport apparently did not issue a stand-alone final report; the last report issued was the narrative statement to the final quarterly report dated December 31, 2001 that contained the final status of each activity.

Table Q-3 Project Impact activities initiated by Freeport, New York

Activity	Benefits	Completion Details and Final Status
(Education)		
Project Impact Coord.	Salary	N/A
Public Awareness Events	Increase the public's awareness of natural hazard mitigation measures, prepared-ness and recovery	Held three Project Impact Awareness Days and one public awareness event for Nassau County elected officials. Village planned to continue to use public forums and mailings for disaster awareness and preparedness.
Mobile Fire Safety House/ Disaster Resistant House	Increase public's awareness of fire safety, natural hazard mitigation measures, and preparedness	Completed project. Purchased through contract, the Fire Safety House, a mobile classroom used mainly by the Freeport School District, a community partner. It is part of an on-going education program.
Seminars and Demonstrations on Retrofitting	Increase public's awareness of natural hazard mitigation measures	The Freeport Building Department conducted site visits to educate home and business owners on mitigation measures. Two community partners, Simpson Strong-tie and Home Depot, conducted workshops. These are on-going activities.
Adult Education Classes on Natural Hazard Preparedness	Increase public's awareness of natural hazard preparedness measures	Freeport Emergency Management Office developed and offered an adult education class on disaster preparedness through the Freeport School District. It is an on-going course.
Communication Network and Video Conferencing	Distance learning and transmission of emergency information	Completed project. Maintenance and expansion of the system will be supported by Village, Freeport Utilities, and the Freeport School District.
Early Warning System – Tidal Gage	Reduce loss of property, thus reducing NFIP claims	Completed project. Record keeping, data production, and maintenance jointly supported by the Village and the USGS.
(Retrofitting)		
Tree Removal	Reduce loss of property	Part of a long-term program to remove trees that pose a threat to power lines and buildings and replace them with smaller "power friendly trees." Approx. $100,000 is allocated to the program each year.
Preliminary Design for Road Elevation Projects	Reduce the effects of flooding	Paid consultant to prepare designs for elevating 13,400 linear feet of roadway of which 1,500 feet were completed and 11,900 scheduled for later construction. Part of an on-going project that dates back to 1983.
Elevation of heating units	Reduction in flood insurance claims	Originally $60,000 was allocated but all homeowners who were contacted to participate in the program withdrew. Nothing was accomplished.
Hurricane Resistant Windows and Doors for Village Emergency Operation Center	Reduction in damages due to wind	Project completed. The windows and doors were installed.
Bulkhead Program	Reduction in flood damage and business losses	Progress was made to develop program to replace existing bulkheads along Woodcleft Avenue and the approval of bonds for homeowners to take out loans to replace their bulkheads. The program began prior to Project Impact and had continued since with portions of the project being completed and the first loan made.
Roadway Grade Raise and Drainage Improvement Project	Reduce the effects of flooding	On-going program dating back to 1983 to raise all streets in the floodplain three feet above the level of the 100-year flood.

Table Q-4 Benefit cost analysis of completed Project Impact activities in Freeport, New York

Community	Brief Descriptor of Mitigation Activity	Total Costs including Annual Maintenance (2002$M)	FEMA Costs (2002$M)	Best Estimate		
				Benefits (2002$M)	Benefit-Cost Ratio	BCR Range
Freeport	Community Early Warning System	0.44	0.02	7.86	17.9	1.8-71
	Education	0.13	0.10	Not calculated	Not calculated	Not calculated
	Hurricane windows and doors, bulkheads	0.03	0.02	0.01	0.3 (only windows and doors benefits estimated)	0.2-0.6
	Tree removal	0.02	0.02	Not calculated	Not calculated	Not calculated
	Freeport TOTALS	*0.63*	*0.16*	*7.87*	*12.6*	*1.3-50*

The unmeasured benefits were all seen as positive. The Village of Freeport was able to establish an ongoing education program to teach both school children and adults natural hazard preparedness and mitigation techniques. The contributions of Project Impact also were used to support and possibly accelerate ongoing street elevations and the bulkhead project. Because Freeport apparently did not keep a detailed cost accounting of its activities, there was no way to accurately estimate the value of its education programs or the efforts of the community to develop the bulkhead project.

One very positive benefit, according to the village officials interviewed during the community site visit and the letter of nomination sent by the FEMA Region 2 Project Impact Coordinator to the Project Impact Awards Committee nominating Freeport as a Project Impact Model Community, was that the community had undertaken the role of mentoring other Region 2 Project Impact communities and providing advice to neighboring communities in Nassau and Suffolk counties.[118] In this role, Freeport developed a reputation that Village officials said opened new doors to them to find funding and other assistance in their quest to make the community disaster resistant.

The only negative aspect of the Freeport Project Impact activities was the Village's inability to convince any homeowner to participate in the project to elevate a heating unit. The time and effort spent was unrewarded.

[118] Mabry, Marshall, Project Impact Coordinator, and Jaye M. Sutton, Project Impact Liaison to the Village of Freeport, to the Project Impact Awards Committee, Letter of Nomination of the Village of Freeport as s Project Impact Model Community, September 28, 2000.

Q.10.3 Conclusions

Not counting the payment of salary to the Project Impact coordinator, Freeport completed or achieved its objectives on 12 of the 13 projects that it undertook in Project Impact.

Q.11 Jefferson County, Alabama

No documentary evidence was located that discussed the process by which Jefferson County was selected as a Project Impact community. What is known is that Region 4 notified the state of Alabama that it had $300,000 that would be granted to a community of the state's choice for FY2000. The state of Alabama decided to split the award, asking FEMA to grant $150,000 to Jefferson County and $150,000 to Mobile County. Several telephone and on-site interviewees mentioned that this was a political decision based on a desire to divide the grant equally between recipients in northern and southern Alabama.

Jefferson County was chosen by FEMA to become a Project Impact Community on December 10, 1998. In the news release announcing the choice, FEMA noted the hazard risks faced by the county:

> The numerous small rivers and streams and hilly terrain of the metro area make flooding a chronic natural hazard. The area is also at risk from tornadoes and ice storms. Hazardous materials are a problem because of the region's heavy industrialization.[119]

The implication of this announcement was that FEMA had expanded Project Impact to include not only natural hazards but also man-made hazards.

FEMA notified Jefferson County on January 17, 1999 that it was "invited to submit an application to participate in [Project Impact]" and that the application must be received by February 17, 1999.[120] Although no copy of the completed application was found, a summary of a Scope of Work attached to the application that specified projects for funding was included in two internal FEMA memos containing technical evaluations of the projects.[121] (See Table Q-5 below for a list of the projects.)

According to the many financial statements in the Jefferson County documents, the official start date of the Project Impact grant was February 17, 1999, not the date of the signing ceremony, April 8, 1999. The project was originally scheduled to end on February 16, 2001.[122]

---

[119] *Jefferson County Joins Project Impact*, FEMA Region 4 News Release, December 10, 1998, www.fema.com/regions/iv/1998/98r4_099.shtm

[120] Housand, Helen J., FEMA Region 4 Contracting Officer, to Mary Buckelew, Commissioner, Jefferson County Commission, January 13, 1999, page 1.

[121] Randolph, Steven, FEMA Region 4 Project Impact Coordinator, to Helen Housand, Region 4 Contracting Officer, re: Jefferson County, Alabama Technical Evaluation for Disaster Resistant Community Grant, March 5, 1999 and a second letter from Randolph to Housand with a revised technical evaluation, April, 6, 1999.

[122] Several amendments to the grant eventually changed both the starting and ending dates of the Performance Period of the grant. The starting date was changed from February 17, 1999 to the date of the signing ceremony April 8, 1999, and the ending date was extended from February 16, 2001 to December 31, 2001. By the end of the grant period, Jefferson County had completed its projects but had not spent the full $5,000 given to each Project Impact community for "mentoring" or sharing its experiences

April 8, 1999 was selected as the signing ceremony date because it was the first anniversary of the devastating F-5 tornado that struck Jefferson County killing 32 and injuring hundreds. Included in the signing ceremony was a memorial service. Because no Memorandum of Agreement was found, it is not clear if one was signed at the ceremony or if the previously submitted application served as the MOA. However, among the documents found in the field were a copy of a list of names that was signed by 32 partners on April 8 and a typed list of unknown date that indicates there were 50 signing day partners. Among the partners were representatives of the 32 incorporated cities within the county.

The Statement of Work established that the Jefferson County Emergency Management Agency (EMA), in partnership with officials from Jefferson County and the 32 incorporated cities, would coordinate the Project Impact program. Four Project Impact committees were created to help manage the program and develop ideas for new projects. These committees were:

- Community Preparedness
- Construction
- Environment
- Insurance and Finance

Members of the committees were largely Jefferson County officials. Representatives from only six for-profit companies or nonprofit organizations were members.

Q.11.1 A Review of the Project Impact Activities

In the original statement of work, Jefferson County proposed completing three nonconstruction projects. These are the first three activities listed in Table Q-5. The remaining two projects were added after the project began. All of the $150,000 in federal grant money was allocated to the first three activities. According to the financial records, $20,000 was spent on the part-time Project Impact Coordinator's salary, $30,000 on the update of the Hazard Vulnerability Assessment, and $100,000 on the expanded and updated emergency operations center.

Jefferson County and the partners contributed funds and in-kind services totaling $413,136.17 according to the last Financial Status Report that was submitted on May 6, 2002, as part of the close-out documents. No breakdown according to activity was provided.

In addition to the activities in Table Q-5, the four Project Impact committees discussed other topics including shelters and safe rooms to protect residents from future tornadoes. Beginning with its first meeting on September 13, 1999, the Construction Committee discussed shelters and safe rooms in apartments and mobile home complexes, the possible requirement that safe rooms be included in the construction of new churches, tax credits for safe rooms, and the use of public funds for the construction of private safe rooms or shelters.[123] No specific Project Impact

with other Project Impact communities. An extension of five months was granted. On May 30, 2002, the grant was closed out and Jefferson County de-obligated an unspent $935.12 that was allocated for mentoring.

[123] Project Impact Construction Committee, Meeting One – September 13, 1999 Minutes.

Table Q-5 Project Impact activities initiated by Jefferson County, Alabama

Activity	Benefits	Completion Details and Final Status
Project Impact Coordinator	Salary	N/A
Update of 1996 Hazard Vulnerability Assessment (HVA)	Increase awareness of hazard risks and	Completed project. Information from the updated HVA combined with historical data for the county led to the creation of the *Local Mitigation Strategy*, a document published January 2001.
Community Emergency Information System or WEB EOC	Expand and update the county Emergency Operations Center (EOC)	Completed project. Brought the EOC up to a state-of-the-art information system capability that allows all governing officials, 28 police departments, safety and security personnel from business and industry, 59 fire departments, and the media to have access to up-to-the minute information during emergencies.
Community Education & Outreach	Increase the public's awareness of natural hazard mitigation measures, preparedness and recovery	Created an annual "Community Awareness Day" that was held for three years in 2000, 2001, and 2002. From 3 to 5,000 visitors were estimated to have attended each event.
Early Warning System	Increase the number of people that will be in the range of early warning sirens with and upgraded and expanded outdoor warning system.	During the grant period, the Jefferson County Commission raised money for the system. No Project Impact funds were used and the updating began after Project Impact ended.

activity emerged from these discussions but the committee supported the County's Community Development Agency's initiative to provide safe rooms in the new Edgewater Oaks subdivision that will ultimately contain 80 residences constructed for low-income families.[124]

Q.11.2 Benefit Cost Analysis

Table Q-6 presents the types of mitigation activities funded that were completed, the costs of these activities (including FEMA's share), an estimate of the total benefits, an estimate of the benefit-cost ratio, and the range of the benefit-cost ratio. While the range of benefit-cost ratios is sometimes large for a particular activity, this estimate is meant to provide a general understanding of the extremes that are possible given the uncertainties present in the analysis. A more rigorous analysis would lead to a more statistically significant range.

For Jefferson County, the dominant activities were the update of the information systems in the Emergency Operations Center and the update of the Hazard Vulnerability Assessment. In addition, the community with the assistance of the Project Impact committees went forward with the construction of safe rooms in the Edgewater Oaks subdivision. The Jefferson County Emergency Management Agency Coordinator described the project thusly:

[124] The dedication of the Edgewater Oaks Subdivision took place on March 19, 2000.

Table Q-6 Benefit cost analysis of completed project impact activities in Jefferson County, Alabama

Community	Brief Descriptor of Mitigation Activity	Total Costs including Annual Maintenance (2002$M)	FEMA Costs (2002$M)	Best Estimate		
				Benefits (2002$M)	Benefit-Cost Ratio	BCR Range
Jefferson County	Community Early Warning and Emergency Information Systems	0.12	0.09	0.40	3.4	0.3-34
	Other activities including Edgewater Oaks safe rooms	0.19	0.14	Not calculated	2.2	1.0-8.7
	Jefferson County TOTALS	*0.31*	*0.24*	*0.40*	*2.6*	*0.7-21*

> "This subdivision will be an excellent example of Project Impact concepts – building partnerships within a community to help save lives and decrease repetitive losses. This subdivision is being developed through a partnership between the Jefferson County Commission, the Alabama Dept. of Economic and Community Affairs (ADECA), Federal Home Mortgage Assn., Habitat for Humanity, YW Homes, Other Non-Profits and Private Lenders. Only $300,000 of county general fund monies will be used to leverage this $8,000,000 project. Habitat for Humanity and others will aid in construction of the homes.
>
> This subdivision will include eighty (80) single-family homes, a centrally located community center and a new fire station. Each home and the community center will include a safe room".[125]

In an internal FEMA e-mail message, a FEMA official stated that Jefferson County was successful in putting the Edgewater Oaks project together was "because they were a PI [Project Impact] Community it made it easier for them to get grants from the State, etc." Furthermore, "They used the partners and teamwork developed through Project Impact to help develop support and leverage to receive the grant."[126]

The unmeasured benefits were all seen as positive. In terms of partners, Jefferson County kept many lists including a Partner List Screen, a Commitment List Report, a Project Impact Partner List, Project Impact Partnership Signees, and a running list of in-kind contributions. In all, many hundred people and organizations are listed as either partners or contributing to partnership activities.[127]

[125] Odom, Woody, Coordinator – Jefferson County Emergency Management Agency, letter to Ms. Mary Lynne Miller, Acting Regional Director, Federal Emergency Management Agency, February 26, 2001.

[126] Denham, Steve e-mail to Christy Brown re: Jefferson Co. AL, May 7, 2001.

[127] No attempt was made to make a final determination of who in these lists should be considered Project Impact partners.

In addition, all of the Project Impact activities listed in Table Q-5 continued after Project Impact ended. The Local Mitigation Strategy became the foundation for the creation of the 2003 Natural Hazards Mitigation Plan. The EOC has been further upgraded with a new server, new software, and 40 laptops. The Community Awareness Day occurred one year after the end of Project Impact, but not thereafter. The U.S. Department of Justice awarded the county two grants in 2001 and 2003 to replace 30 old sirens in the early warning system, upgrade the remaining existing 127 sirens, and install between 80 and 90 new units. Finally, the Jefferson County Emergency Management Agency maintains its original Project Impact web site as www.impactalabama.com.

The only negative aspect associated with the Jefferson County Project Impact activities was the inability to sustain the momentum and keep the partners involved. The educational activities have virtually ended.

Q.11.3 Conclusions

Not counting the payment of salary to the Project Impact coordinator, Jefferson County completed or achieved its objectives on all four of the projects that it undertook in Project Impact.

Q.12 Multnomah County, Oregon[128]

The process by which Mulnomah County got selected as a Project Impact Community was unusual. Every year the State of Oregon asked communities to submit applications to be considered for selection in the next fiscal year. According to an untitled and undated summary of the grant history written prior to the signing ceremony, the document stated:

> In the Fall of 1998, both East Multnomah County and a group representing the Johnson Creek Watershed were pursuing independent applications to become designated as Project Impact Communities. Following a series of meetings and discussions, they combined their Project Impact Applications and requested Multnomah County be designated a Project Impact community.

The region of East Multnomah County extends from the common boundary between the cities of Portland and Gresham, Oregon eastward to the county line, a distance of over 30 miles. The area has a population of approximately 120,000 people in five cities and several unincorporated areas, covering about 130 square miles. The impetus for the grant application came from the Board of the East County User Group that ran the East County Emergency Management Program encompassing the four cities of Fairview, Gresham, Troutdale, and Wood Village, as well as most of the unincorporated area of Multnomah County. In 1997, the five jurisdictions adopted a comprehensive Inter-Governmental Agreement (IGA) that brought together city and county emergency managers to establish a comprehensive all-hazard East County Emergency Management Program. Under Oregon guidelines, IGAs were eligible to become Project Impact Communities.

[128] This community discussion is based on very little information as neither the FEMA region nor Multnomah County was able to find very many Project Impact documents. The discussion, like that for the other communities, will be limited to what was available. No attempt has been made to fill in the large gaps of knowledge.

According to the grant history mentioned above, the East County User Group was made up of a variety of public and private partners who were establishing programs in urban and rural hazard mitigation. These included the U.S. Forest Service, Columbia Gorge National Scenic Area, Chambers of Commerce, private businesses, school districts, and neighborhood associations. East Multnomah County originally applied to become a Project Impact Community to help build program identification, gain citizen confidence, and increase support for its mitigation programs.

The Johnson Creek Watershed is a large area extending from East Multnomah County, across the tip of Clackamas County, and into the City of Portland. Its geography features large floodplains in the lower watershed with a mixture of industrial and residential uses, forested dormant lava domes, and riparian and upland areas with agricultural and rural land uses. The watershed is subject to flooding on the average of every other year. The original Johnson Creek Watershed Project Impact application wanted to use Project Impact funds to inform residents, businesses, and industries about floodplain issues and how to mitigate damages.

The application of Multnomah County that was successful in getting the county named a Project Impact Community merged some of the original projects of both East Multnomah County and the Johnson Creek Watershed. See Table Q-7 below for a list of the projects.

Multnomah County was invited by FEMA to join Project Impact on December 10, 1998.[129] It held its signing ceremony on September 13, 1999.[130] No record was found of how many partners attended the ceremony or who they were. The initial partnership priorities were listed as "Establishing a flood hazard Community Rating System (CRS); developing a business and industry continuation plan; providing flood hazard information to homeowners and businesses; assisting schools in developing disaster educational programs; and establishing neighborhood emergency response teams."[131]

There were no documents found that established the actual dates for Project Impact. The inference from the dates on the quarterly and semi-annual reports located was that this was a two-year program that was scheduled to end in 2001 but extended to 2002.

Q.12.1 A Review of Project Impact Activities

At the start of the program, Multnomah County entered into an Intergovernmental Agreement (IGA) with the City of Portland to transfer $150,000 or 50% of the Project Impact grant to the City of Portland to manage the Johnson Creek Watershed portion. The duration of this IGA was originally specified as from March 31, 1999 until June 30, 2001. An amendment extended the IGA until March 30, 2002. One of the purposes of the Johnson Creek Watershed project was to enhance the City of Portland's CRS application that would be submitted at the start of 2001.[132]

---

[129] *Multnomah County Invited to Join Project Impact Disaster Resistant Community Partnerships,* FEMA Region 10 News Release, December 10, 1998, www.fema.com/regions/x/1998/98r10_053.shtm

[130] *Multnomah County and City of Portland Join "Project Impact,"* FEMA Region 10 News Release, December 10, 1998, www.fema.com/regions/x/1998/98r10_053.shtm

[131] Ibid.

[132] Except for some brief entries in the two semi-annual reports that were located, there is no information concerning the details of the Johnson Creek Watershed project. Multnomah County considered it a "pass thru" project. Also the procedures used to conduct community studies in this research project limited the investigation to the selected communities only; when counties

Table Q-7 Project Impact activities undertaken by Multnomah County, Oregon*

Activity	Benefits	Completion Details and Final Status
Schools Project	Increase the public's awareness of natural hazard mitigation measures, preparedness and recovery	Completed project. Included the development of the perennial 72-hour emergency preparedness kit program and a mitigation element that will assist students in making their classrooms and homes disaster resistant.
Business and Industrial Communities Project	Increase the capability of businesses, especially small businesses, to develop business continuation plans in light of disasters and mentoring skills	Due to a county budget shortfall and a change in administration, the county pulled its support and the project was unable to be completed before Project Impact ended.
Neighborhood Emergency Response Teams (NERT)	Increase the ability of neighborhoods to become self-reliant in the event of a major emergency or disaster	Due to a county budget shortfall and a change in administration, the county pulled its support and the project was unable to be completed before Project Impact ended.
Flood Hazard Information	Provide businesses and residents with real time data on a particular flood threat, including on a web-site	This was a major element in the Johnson Creek Watershed project. The outcome was not documented by this study.
Retrofitting an Older Flood Prone House	Train homeowners and contractors on alternative all-hazard retrofitting approaches	The retrofit building, nicknamed "the Bates Motel," was believed to have instructed the majority of contractors and engineers in the building community in earthquake retrofit methods.
Community Rating System Program	To create a more comprehensive flood mitigation strategy.	This was part of the Johnson Creek Watershed project. The CRS program was a City of Portland initiative. On September 26, 2001, FEMA announced that Portland had received a Class 6 rating (on a 10-point scale, the higher the flood protection activity, the lower the rating). At the time, this was one the best ratings in nationwide.

*The activities in this table are those listed in the *Project Impact Program – East Multnomah County & Johnson Creek Watershed – Executive Summary*, no date, but internal information suggests it was written while Project Impact was in progress.

Q.12.2 Benefit Cost Analysis

Table Q-8 presents the types of mitigation activities funded that were completed, an estimate of the costs of these activities (including FEMA's share), an estimate of the total benefits, an estimate of the benefit-cost ratio, and the range of the benefit-cost ratio. While the range of benefit-cost ratios is sometimes large for a particular activity, this estimate is meant to provide a general understanding of the extremes that are possible given the uncertainties present in the analysis. A more rigorous analysis would lead to a more statistically significant range.

were selected, there was no attempt to investigate actions taken by incorporated cities within them or their hazard mitigation activities. The costs to do otherwise were prohibitive.

Table Q-8 Benefit cost analysis of completed Project Impact activities in Multnomah County, Oregon

Community	Brief Descriptor of Mitigation Activity	Total Costs including Annual Maintenance (2002$M)	FEMA Costs (2002$M)	Best Estimate		
				Benefits (2002$M)	Benefit-Cost Ratio	BCR Range
Multnomah County	Emergency kits and model home	0.15	0.11	0.08	0.53	0.2-0.6

As shown in Table Q-8, the benefit cost analysis indicates that the completed projects carried out by Multnomah County had a benefit cost ratio of less than one. Except for the continuation of the school's commitment to continuing to prepare 72-hour emergency preparedness kits, the remaining Project Impact initiatives were discontinued and the web site was shut down.

On the positive side, however, because the final status of many activities, including those associated with the Johnson Creek Watershed, was unknown, a final conclusion cannot be drawn that Project Impact was not worthwhile in Multnomah County. The available quarterly and semi-annual progress reports, as well as telephone and on-site interviewees, indicated that all the activities listed in Table Q-7 were progressing and had shown positive results before the county suffered budgetary problems and the administration was changed. Interviewees suggested that Project Impact had some positive effects on the county. One stated that "it brought people to the table who had never been to the table before." Open communications between members of the business community also led to the development of many business continuity plans. NERT trained many people in emergency response, increasing the capacity of the county to respond to potential disasters. And the retrofit building, nicknamed the "Bates Motel," was believed to have instructed the majority of contractors and engineers in the building community in earthquake retrofit methods.

Q.12.3 Conclusions

Multnomah County completed or achieved its objectives on two of four projects that it undertook in Project Impact.[133]

Q.13 Jamestown, North Dakota

No documentary evidence was located that discussed the process by which Jamestown was selected as a Project Impact community. Both the Action Plan and the Final Report indicate that Jamestown was named a Project Impact City in December 1999. The grant provided $300,000 in federal funds to be matched by $100,000 in local funds or in-kind services for a two-year period starting December 1, 1999 and ending December 31, 2001. Later the grant was extended by a year to December 31, 2002.

[133] No status is included on any projects associated with the city of Portland or the Johnson Creek Watershed project.

Jamestown had been included in seven disaster declarations in North Dakota between 1993 and 1999 all related to flooding. The main reason for the flooding was high water tables that caused basements to flood when the water table rose above the basement floor. Overland flooding from the James River, which runs through the city, had been effectively prevented by two dams north of the city, one established by the U.S. Army Corps of Engineers and the other constructed by the U.S. Bureau of Reclamation and was not considered a major threat. According to the Project Impact Baseline Report, only about 60 of city's 5,000 houses and 600 businesses were located in the regulatory floodplain. Current FEMA statistics showed that in the 26 years between and including 1978 and 2003 there had been just 26 paid National Flood Insurance Program (NFIP) insurance claims totaling $64,000. The Baseline Report also listed high winds and tornadoes as threats to the community.

Between the time Jamestown was named a Project Impact Community and the signing ceremony on June 15, 2000, the city held three open community-wide planning meetings. Seventy-five people attended the first meeting, 15 the second, and 40 the third.
During these meetings, the community vulnerabilities and the upcoming Project Impact grant were discussed and attendees were asked to sign up as themselves or their companies as partners and to be placed on committees that would develop possible Project Impact projects. The committees were:

- Public Awareness and Education
- Storm Water Damage, Flood Control, and River Clean-Up
- Hazardous Materials
- Building and Zoning,
- Early Warning System, and
- Steering.[134]

By the signing ceremony, the first five mentioned committees had created lists of possible projects to be completed as part of Project Impact. The lists were sent to the Steering Committee, which selected 13. These 13 projects were the first and only ones that were attempted. See Table Q-9 for a list of the projects.

The signing ceremony was held on June 15, 2000 at the Civic Center culminating a 3-day Community Awareness Week, "with awareness activities on community safety, dam safety, boating and water safety, emergency management, Red Cross, and storm shelters."[135] Sixty-three partners signed the Memorandum of Agreement.[136] Describing what Project Impact intended to do, the Action Report related that "Jamestown plans to look at flood and tornado early warning systems, improvements to the storm water system, river channel clean-up,

[134] The Project Impact Final Report is a Power Point slide presentation. It is undated but issued in 2004. The community-wide planning meetings are discussed on slides 4, 5, and 6.

[135] *Jamestown, North Dakota Action Plan*, no date, page 3.

[136] This was the only list of partners created by Jamestown found in the documents.

emergency response training, tightening of building and zoning ordinance enforcement, safe school initiative and increased public awareness and education programs."[137]

Q.13.1 A Review of the Project Impact Activities

As mentioned above, Jamestown developed its activity list in time for the signing ceremony. Over the three-year period that Project Impact was operational, the city completed ten of these activities. See Table Q-9.

In its final report, Jamestown included the amount of federal funds and local in-kind match for each activity. The city also included either the lead or major partners. It was the only community of the five reviewed in this study that provided this information. See Table Q-10.

Jamestown spent the entire $300,000 allocated to it in the Project Impact grant even though a little less than $8,000 is unaccounted for in Table Q-10; other financial documents show that these funds were approved for start-up activities.

Q.13.2 Benefit Cost Analysis

Table Q-11 presents the types of mitigation activities funded that were completed, the costs of these activities (including FEMA's share), an estimate of the total benefits, an estimate of the benefit-cost ratio, and the range of the benefit-cost ratio. While the range of benefit-cost ratios is sometimes large for a particular activity, this estimate is meant to provide a general understanding of the extremes that are possible given the uncertainties present in the analysis. A more rigorous analysis would lead to a more statistically significant range.

For Jamestown, the tornado model developed in this project was used to estimate benefits of the community early warning system. It was assumed that up to 3,000 people could use the civic center as a safe room during tornado events. For the other activities, a benefit-cost ratio of 1.2 (via benefit transfer methods) was used for the city-wide storm study, whose uses were only beginning at the time of this study; benefit-cost ratios of 1.0 were used for the development of a training center and the purchase of a HAZMAT trailer.

There were many unmeasured positive benefits. Jamestown had a much better understanding of its hazard risks and was much better prepared to respond to both floods and tornadoes. Interviewees mentioned that the early warning system eased the minds of the residents. The city officials believed that their experience was a foundation for future developments and many groups had begun to apply what was accomplished during Project Impact. Since Project Impact ended, Jamestown has maintained all the completed projects above and begun either follow-on or additional projects. The local schools have instituted two follow-on projects to make schools safer and a new high school has been designed using the storm water runoff analysis developed in activity 1. In its final report, Jamestown also reported receiving grants from five organizations (Calgill Malting Company, Burlington Northern Santa Fe, North Dakota Farmers Union, RC&D, and Walmart) totaling $11,250 in support of the Fire Training Facility (activity 13).

[137] *Jamestown, North Dakota Action Plan, op. cit.*

Table Q-9 Project Impact activities initiated by Jamestown, North Dakota*

Activity	Benefits	Completion Details and Final Status
1 – City-wide Storm Water Runoff Study	Identify current storm water problem areas within the city and describe alternatives for alleviating problems	Activity #8 "Implement Storm Water Runoff Study" was moved into this project. It was completed by a consultant on June 10, 2002. Detailed maps were produced that can be used in the design of new structures to prevent flooding.
2 – Storm Ready Designation	Community is designated by the National Weather Service as being able to prepare for and respond to hazardous weather events	Activity completed on January 15, 2001. Jamestown was the fourth city in North Dakota to receive this designation.
3 – GIS Implementation	Installation and implementation of flood plain map on GIS system	Activity completed on April 4, 2001.
4 – 24-Hour Skywarn System	Provide emergency communications 24 hours each day	Activity completed on March 7, 2001. A trailer was modified and equipped for emergency communications.
5 – Post Disaster Community Shelter	Provide community with emergency shelter from wind and flooding events	Activity completed on June 10, 2002. An emergency generator was installed at the Civic Center along with storage areas for the Red Cross and National Guard. Contracts were being developed with the Jamestown Hospital and other organizations for using the Civic Center as an emergency evacuation center.
6 – Early Warning System Improvements	Update outdoor sirens in community early warning system for tornadoes and floods	Activity completed on November 14, 2001. Five new sirens were purchased and installed providing a larger reception area.
7 – Haz Mat Training and Equipment	Equip Haz Mat trailer and provide training to 2 firefighters and Red Cross official	Activity completed on November 14, 2001. Haz Mat trailer donated by a partner was equipped and three persons were trained, including 2 of 6 full time fire fighters.
8 – Implement Storm Water Runoff Study	N/A	Merged with Activity #1.
9 – Storm Sewer Flood Gate Controls	N/A	Community was unable to do this project.
10 – Public Awareness and Education	Increase the public's awareness of natural hazard mitigation measures, preparedness and recovery	Activity completed in November 2002. Multiple activities were completed including the purchase of materials for the emergency shelter run by the Red Cross, the purchase and distribution of weather radios, the purchase of computer equipment for disaster presentations and other safety classes, and the development of course for students and adults.
11 – Community Rating System Application	Join the CRS and lower CRS rating from a 10 to 9	Activity not completed.

*Data in this table was taken from the Jamestown Project Impact Final Report.

Table Q-9 Project Impact activities initiated by Jamestown, North Dakota (continued)

Activity	Benefits	Completion Details and Final Status
12 – Model Home Mitigation Project	Train homeowners and contractors on alternative all-hazard retrofitting approaches	Activity completed on September 1, 2002. Worked with students of James Valley Vocational Center to construct a model home demonstrating methods of flood and wind proofing.
13 – Fire and Police Training Facility	Increase fire and police capabilities	Completed project, date unspecified. The project involved building a concrete training pad, a cistern for testing truck pumps, and a building for use as a smoke building, which would provide firefighters with simulated fire situations. The facility will be also be used for Haz Mat drills and will be available for fire departments in smaller cities in the area.

Table Q-10 FEMA and local shares and partners of Project Impact activities*

Activity	FEMA Funds	Local In-Kind Match	Major or Lead Partners
1 – City-wide Storm Water Runoff Study	$60,000.00	$26,646.48	Interstate Engineering, Inc.
2 – Storm Ready Designation	0.00	7,500.00	Stutsman County Emergency Manager
3 – GIS Implementation	5,718.00	5,319.87	Interstate Engineering, Inc. and ESRI
4 – 24-Hour Skywarn System	6,237.25	22,400.00	Jamestown Amateur Radio Club
5 – Post Disaster Community Shelter	59,548.42	30,706.11	Jamestown Hospital
6 – Early Warning System Improvements	104,893.98	30,184.29	(None listed)
7 – Haz Mat Training and Equipment	25,392.28	32,932.10	Jamestown Fire Department and Bob Baumann
8 – Implement Storm Water Runoff Study	N/A	N/A	N/A
9 – Storm Sewer Flood Gate Controls	N/A	N/A	N/A
10 – Public Awareness and Education	28,770.02	24,791.39	Red Cross
11 – Community Rating System Application	0.00	2,000.00	N/A
12 – Model Home Mitigation Project	1,636.48	2,817.50	Jamestown Public Schools and Richard Laqua, Vocational Building Instructor
13 – Fire and Police Training Facility	0.00	190,000.00	(None listed)
Totals	$292,196.43	$375,297.74	

*Data in this table was taken from the Jamestown Project Impact Final Report.

Table Q-11 Benefit cost analysis of completed Project Impact activities in Jamestown, North Dakota

Community	Brief Descriptor of Mitigation Activity	Total Costs including Annual Maintenance (2002$M)	FEMA Costs (2002$M)	Best Estimate		
				Benefits (2002$M)	Benefit-Cost Ratio	BCR Range
Jamestown	Civic Center as saferoom, warning for saferooms	0.12	0.10	0.24	1.96	0.93-6.07
	Other activities	0.19	0.14	0.18	0.93	0.3-0.93
	Jamestown TOTALS	*0.31*	*0.24*	*0.42*	*1.33*	*0.56-2.92*

Q.13.3 Conclusions

Jamestown undertook 13 projects at the start of the Project Impact. Two were later merged. Of the 12 remaining projects, 10 were completed or met their objectives.

Q.14 Horry County, South Carolina

Horry County was the only community in this study that entered Project Impact after FEMA revised its application instructions. The following discussion reflects major changes in how the program was managed, obligations of the communities, and the introduction of the two-phased grant in which there was a Phase 1 or start-up phase that permitted the community time to hire a Project Impact Coordinator, form committees, attract partners, and develop activities to be funded in Phase 2 when the activities would be completed. Phase 2 was considered "conditional;" it would begin only at the completion of a FEMA approved Scope of Work and budget.[138]

On July 13, 2000, the Horry County Emergency Preparedness Director notified the South Carolina Emergency Preparedness Division (SCEPD) that Horry County would like to be considered to become a Project Impact Community.[139] No documents were located that confirmed the choice of Horry County as a Project Impact community. However, the FEMA Region 4 *Project Impact Grant Application Instructions [revised 10/27/00]* state that all FY 2001 communities were designated on September 13, 2000. Designated communities were then required to commit to the program and request an application and instructions from the FEMA regional office to qualify for the grant. On October 27, 2000, FEMA Region 4 responded to the request with a lengthy letter outlining what Horry County needed to do to complete the

[138] The Region 4 Grant Application Instructions FY 2001 [revised 10/27/00] contain very detailed requirements and deadlines. However, the only required reports after Phase 2 had begun were Quarterly Financial Reports and Quarterly Programmatic Reports or "Performance Report Narratives."

[139] Whitten, Paul D., Horry County Emergency Preparedness Director, to Stan M. McKinney, SCEPD, July 13, 2000, letter expressing an interest to be selected as a Project Impact Community.

application.[140] In this letter, Horry County was notified that it would receive a $150,000 grant that required a minimum local match of $50,000.

Although the grant application instructions were very detailed and provided a laundry list of required community activities and a timeline, no mention was made of the signing ceremony. In the documents collected, there were also none that discussed the signing ceremony or the date it was held. Interviewees suggested that the signing ceremony set the tone for the entire project. They said it was held in 2001 after the Bush administration announced that Project Impact would not be funded after FY 2001, casting a pall over the proceedings.[141] In the aftermath of the signing ceremony and the Bush administration announcement, interviewees also said that enthusiasm for the project was difficult to maintain and that many potential partners refused to participate. Horry County got off to a rocky start, and some interviewees said it never got better.

On September 21, 2001, an internal FEMA Region 4 memo indicated that the entire grant of $150,000 had been obligated but the community was only eligible to use $19,750 in Phase 1.[142] The Phase 1 grant was awarded effective June 1, 2001. The date for the submission of the Phase 2 Scope of Work and Budget was listed as February 28, 2002. According to dates specified in the *Grant Application Instructions* for FY 2001, Horry County was lagging far behind the original deadlines. The due date in the Grant Application Instructions for the submittal of Phase 2 Scopes of Work and Budgets was May 14, 2001.

Not only was Horry County far behind in meeting the original deadlines established by FEMA, it could not meet the extended ones. The Phase 2 Statement of Work with a list of eleven activities was actually submitted on August 12, 2002 and approved by FEMA on August 19, 2002.[143] Considering that the project duration was established as starting on June 1, 2001 and ending on May 31, 2003, there was little time left to actually complete any proposed activities on time. Horry County attempted to have the grant extended but ran into opposition from FEMA.[144] Although no document was located that specifically stated an extension was granted, apparently one was granted because completed Quarterly Financial Status Reports up to December 31, 2003 were found and there were indications on them that there would be a final Quarterly Report due on March 31, 2004.

During the community site visit conducted between June 28 and July 1, 2004, interviewees in Horry County reported that the project had not ended at that time, that there were still some

[140] Housand, Helen J. FEMA Region 4 Regional Assistance Officer to Paul D. Whitten, Emergency Preparedness Director, Horry County, letter re: Request for Application: EMA-2001-RFA-0011.

[141] One interviewee said that a FEMA representative refused to be in any photographs of the signing ceremony because he or she did not want to be seen as being associated with Project Impact.

[142] Denham, Steven A., FEMA Region 4 Community Liaison, to Brett Bowen, Environmental Specialist, September 24, 2001, memo re: Horry County, SC Project Impact Community Phase I DRCG Grant #EMA-2001-GR-0081 CATEX Review for Grant Projects.

[143] Housand, Helen J., FEMA Region 4 Assistance Officer, to Paul Whitten, Public Safety Director, Horry County, August 19, 2002 informing him that Horry County "has been approved to expend funds based on your approved Phased [sic.] 2 Application for Federal Assistance."

[144] An e-mail from Jacky Bell, FEMA Region 4 Hazard Mitigation Specialist, to Tabby Shelton, Horry County Emergency Management Department Emergency Planner, February 21, 2003, re: Time Extension Request, stated that "the Regional Director is not receptive to extending the Project Impact grants, so we have a challenge ahead." Later in the e-mail Bell said "We also need to look at a six month time extension vs. a year…we would like to at least get you a 6 month vs. not one at all." It should be noted that application instructions informed the communities that they would be eligible for one-year extensions if justified. All the other communities in this study were granted one-year extensions without difficulty.

activities to be completed. When data collection ended for this community at the end of July 2004, Horry County's Project Impact status had not changed.

Q.14.1 A Review of Project Impact Activities

The activities listed in Table Q-12 were those included in Horry County's Phase 2 Approved Statement of Work dated August 14, 2002. The completion details were provided by the county's Project Impact Coordinator during the community site visit. They reflect the status of the activities as of June 30, 2004.

Table Q-12 Project Impact activities initiated by Horry County, South Carolina

Activity	Benefits	Completion Details and Final Status
Program Administration	Salary	N/A
Enhanced Weather Detection System	Provides real-time weather data to the public and emergency responders	Completed project. Six freestanding weather stations were installed on existing fire stations in the county. A local television station agreed to provide the monthly service charges for each station and has exclusive rights to televise the information in the Horry County TV market.
GIS Critical Facilities and Risk Assessment	Incorporates information regarding critical facilities into existing GIS system, identifying risks that could be alleviated by future mitigation programs and providing information during emergencies	Partly completed. No details provided.
Fire Hydrant Awareness Program	Fire fighters will be able to locate fire hydrants, thereby reducing risk from wildfires	Completed project. Approximately 20,000 reflectors were purchased and installed on all roads in unincorporated areas of the county by fire fighters.
Resident/Tourist Hurricane Awareness Program	Inform residents and tourists regarding hurricane preparedness, evacuation, reentry, and recovery	Not completed. The intent was to create and broadcast public service announcements (PSAs) on local television stations. The person intended to create the PSAs went on maternity leave.
Hazard Analyses and Risk Assessment Exhibition	Inform residents of hazards affecting Horry County and what they can do to mitigate the risks	Not completed. The intent was to create a table top display called "Horry Town" made up of model railroad buildings that could taken to schools, expositions, and community awareness days.
Hazard Awareness Brochures/Posters	Inform residents of hazards, mitigation , and recovery	Partially completed. The community purchased 500 disaster books and passed all of them out. Some posters were created. Needed brochures were identified but not developed.
Hazard Awareness Poster Contest	Involve 4th grade students participating in the *Master of Disaster* program to express what they are learning	Completed project. Twelve posters, one for each month and a different disaster, were created by students and the best were selected for display in various locations in the county.
Fire Rescue & Satellite Police Stations Weather Radios	Enhance the community's warning and response capability	Project completed. Approximately 50 radios were purchased and distributed to all county fire rescue and satellite police stations.
Library Disaster/Preparedness/ Mitigation Books & Displays	Provide the public with disaster preparedness and mitigation information	Project completed. An identical collection of published disaster books was purchased and placed in 9 county libraries, one university, and a reference section within the Public Safety Department for Horry County employees.
Hurricane Strike CD	Provide the FEMA developed *Hurricane Strike* CD to all 6th grade teachers in county	Cancelled. FEMA began to give out the CD at no cost.

Despite its late start, Horry County appears to have successfully implemented many of its proposed activities. However, without a final report, it is not possible to verify whether the uncompleted activities were ever finished. Also, the Project Impact Coordinator said that approximately $40,000 in unspent federal funds as of July 1, 2004 might have to be deobligated.

Q.14.2 Benefit Cost Analysis

Table Q-13 presents the types of mitigation activities funded that were completed, the costs of these activities (including FEMA's share), an estimate of the total benefits, an estimate of the benefit-cost ratio, and the range of the benefit-cost ratio. While the range of benefit-cost ratios is sometimes large for a particular activity, this estimate is meant to provide a general understanding of the extremes that are possible given the uncertainties present in the analysis. A more rigorous analysis would lead to a more statistically significant range.

Table Q-13 Benefit cost analysis of completed Project Impact activities in Horry County, South Carolina

Community	Brief Descriptor of Mitigation Activity	Total Costs including Annual Maintenance (2002$M)	FEMA Costs (2002$M)	Best Estimate		
				Benefits (2002$M)	Benefit-Cost Ratio	BCR Range
Horry County	Warning Systems	0.13	0.04	.16	1.2	1.2
	Fire hydrant reflectors	0.04	0.02	0.05	1.2	1.2
	Education activities	0.04	0.03	N/C	N/C	N/C
	Horry County TOTALS	*0.16(limits of governmental funds)*	*0.12*	*0.21*	*1.28*	*1.03+*

It is difficult to estimate what benefits in addition to those shown in Table Q-13 were in Horry County. Because the overall Project Impact program was cancelled as the grant got underway, it did not have the cache that it had previously. However, Project Impact did bring people together to discuss and solve common problems and did increase the level of hazard and mitigation understanding among the public and emergency responders.

Q.14.4 Conclusions

Not counting the payment of salary to the Project Impact coordinator and the cancellation of the Hurricane Strike CD project, Horry County completed or met its objectives for five of the nine projects that it undertook in Project Impact.

Q.15 Overall Observations

One characteristic was common over all five Project Impact experiences. All five communities were unable to complete their grants in the initially contracted two-year timeframe. Two years was not enough for any community to establish partnerships, determine projects, carry out public events, and complete reporting requirements. Every community applied for and received a time extension.

Overall, the five Project Impact communities completed or met the objectives of 79% of the projects that they undertook (33 of 42).

Appendix R
COMBINED SAMPLING AND MODELING UNCERTAINTY

R.1 Methodology

Sources of uncertainty. As has been noted elsewhere, the total benefit of FEMA grants is uncertain. It was desired to quantify and combine all important sources of uncertainty. This information was then used to calculate two interesting parameters: (a) confidence bounds for the total benefit of FEMA grants for each hazard, and (b) the probability that the "true" benefits exceed the cost. By "confidence bounds" is meant upper and lower bounds between which the "true" total benefit lies with any given level of probability. The uncertainty in total benefit of FEMA grants results from two principle sources:

(1) *Sampling uncertainty*. Total benefits are uncertain because they are estimated from a sample (a subset) of FEMA grants, not the entire population of them.

(2) *Modeling uncertainty*. Total benefits are uncertain because a mathematical model of benefits has been created and applied, and that mathematical model has its own uncertain parameters.

Measures of uncertainty. Let X denote (uncertain) total benefit of FEMA grants. Let $x_{l,p}$ and $x_{u,p}$ denote the lower and upper bounds of X, respectively, that corresponding to probability p that total benefit lies between them. Further, let the confidence bounds be symmetric in that

$$\begin{aligned} p &\equiv P\left[x_{l,p} < X \le x_{u,p}\right] \\ P\left[x_{l,p} < X\right] &= P\left[X \le x_{u,p}\right] = \left(\frac{1+p}{2}\right) \end{aligned} \tag{R-1}$$

One can calculate the effect of each type of uncertainty and combine them into an overall estimate of the uncertainty of total benefit. To begin this process, it is reasonable to assume that the total must be greater than or equal to zero, i.e., that no mitigation actually has negative benefit. Without any additional knowledge, by information theory (Shannon and Weaver, 1963), the best assumption for the distribution of total benefit is the lognormal distribution, i.e.,

$$F_X(x) \equiv P[X \le x] = \Phi\left(\frac{\ln(x)-\lambda}{\beta}\right) \tag{R-2}$$

where x represents a particular value of X, $F_X(x)$ denotes the cumulative distribution function of X, P denotes probability, Φ denotes the cumulative standard normal distribution, and λ and β are parameters of the distribution, referred to as the logarithmic mean and logarithmic standard deviation. If C denotes the total cost of FEMA grants, then the probability that benefit exceeds cost is given by

$$\begin{aligned} P[X > C] &= 1 - F_X(C) \\ &= 1 - \Phi\left(\frac{\ln(C)-\lambda}{\beta}\right) \end{aligned} \tag{R-3}$$

and the confidence bounds $x_{l,p}$ and $x_{u,p}$ are given by

$$x_{l,p} = \exp\left(\Phi^{-1}\left(\frac{1-p}{2} \right)\beta + \lambda \right)$$
$$x_{l,p} = \exp\left(\Phi^{-1}\left(\frac{1+p}{2} \right)\beta + \lambda \right) \quad \text{(R-4)}$$

where Φ^{-1} denotes the inverse cumulative standard normal distribution. Denoting the sample mean value of X by m_X, parameter λ is given by

$$\lambda = \ln(m_X) - 0.5\beta^2 \quad \text{(R-5)}$$

Combining uncertainty. It is common to assume that sampling uncertainty is independent of modeling uncertainty, and that one can estimate β as

$$\beta = \sqrt{\beta_1^2 + \beta_2^2} \quad \text{(R-6)}$$

where β_1 denotes the logarithmic standard deviation of X resulting from sampling uncertainty, and β_2 denotes the logarithmic standard deviation of X resulting from modeling uncertainty.

Sampling uncertainty. One can calculate β_1 as

$$\beta_1 = \sqrt{\ln\left(1 + \left(\frac{s_X}{m_X \sqrt{n}} \right)^2 \right)} \quad \text{(R-7)}$$

where ln denotes the natural logarithm, s_X denotes the sample standard deviation of X and n denotes the sample size. If one knows m_X and the sample standard deviation and sample mean of benefit-cost ratio (s_{BCR} and m_{BCR}, respectively), it is straightforward to calculate s_X as

$$s_X = m_X \cdot \left(\frac{s_{BCR}}{m_{BCR}} \right) \quad \text{(R-8)}$$

Modeling uncertainty. One can calculate β_2 as

$$\beta_2 = \sqrt{\ln\left(1 + \left(\frac{\sigma_X}{\mu_X} \right)^2 \right)} \quad \text{(R-9)}$$

where σ_X denotes the standard deviation of X associated with modeling uncertainty, and μ_X denotes the mean value of X, considering modeling uncertainty.

R.2 Results

All the required parameters were available for these calculations. The values of C, m_X, s_{BCR}, and m_{BCR} are shown in Tables 6-1, 6-3, and 6-4. The values of n are not shown elsewhere, but were available from the sample data. The parameters σ_X and μ_X are presented in Section 6.5, the tornado-diagram analyses. Table R-1 presents the results for the symmetric 90% bounds of the total benefit of FEMA grants. Two interesting observations are apparent:

1. Modeling uncertainty dominates total uncertainty ($\beta_1 << \beta_2$, so $\beta \approx \beta_2$), so larger sample would not improve the accuracy of the estimated benefits.
2. The results reaffirm the observation that project mitigation grants produce benefits in excess of costs with high probability for all three hazards.
3.

Table R-1 Combined sample uncertainty and modeling uncertainty

Parameter of Interest	**Projects**			**Source**
	Earthquake	**Wind**	**Flood**	
Sample properties (n)	128	204	483	Sample data
Total cost of grants ($M) ($C$)	$ 867	$ 280	$ 2,204	Table 6-1
Total benefit of grants ($M) ($m_X$)	$ 1,194	$ 1,307	$ 11,172	Table 6-3
Total sample mean BCR (m_{BCR})	1.4	4.7	5.1	Table 6-4
Sampling uncertainty				
Sample standard deviation of BCR (s_{BCR})	1.3	7.0	1.1	Table 6-4
Standard deviation of benefit ($M) ($s_X$)	$ 1,157	$ 1,969	$ 2,424	Equation (R-8)
$_1$	0.09	0.11	0.01	Equation (R-7)
Modeling uncertainty				
Mean benefit of grants ($M) ($_X$)	$ 1,288	$ 1,308	$ 10,494	Section 6.5
Standard deviation of benefit ($M) ($_X$)	$ 468	$ 555	$ 3,778	Section 6.5
$_2$	0.35	0.41	0.35	Equation (R-9)
Total uncertainty				
	0.36	0.42	0.35	Equation (R-6)
	7.02	7.09	9.26	Equation (R-5)
Probability that benefit exceeds cost	76%	99.97%	99.9996%	Equation (R-3)
90-percent bounds of benefit of FEMA grants				
Lower-bound benefit ($M) ($x_{l,0.90}$)	$ 617	$ 600	$ 5,918	Equation (R-4)
Upper-bound benefit ($M) ($x_{u,0.90}$)	$ 2,029	$ 2,389	$ 18,670	Equation (R-4)

Appendix S
VALIDATION AND QUALITY CONTROL

S.1 External Quality Control

In a highly visible public project, multiple modes of quality assurance are desirable. One mode that is especially desirable is the formation of a review committee that is independent of the actual investigations undertaken. The Project Management Committee (PMC) of the Multihazard Mitigation Council (MMC) provided this external oversight management function. In this multi-disciplinary setting, the PMC included representatives of such disciplines and topics as natural hazards risk assessment, land-use planning, community studies, economics, and sociology.

In practice, the ongoing reviews by the PMC provided critical perspectives on the project in progress. These began with the development of the "Parameters" document that provided important guidelines, definitions, goals, and bounds during the undertaking of this project. During the course of this project, additional instances of the PMC critical assistance included:

- Posing challenging questions that required clarification of definitions and methods,
- Referring the project team to important advances in the literature,
- Assisting in resolving points of controversy among project participants,
- Acting through the PMC Project Manager to facilitate access of the project team to FEMA field offices, grantee staff, and data, and
- Providing feedback on such notions as spin-offs that are accelerations, and the procedures to be used in their quantitative evaluation.

S.2 Internal Quality Control Procedures

Two main types of internal quality control procedures were used in this project: the formal and the informal.

Formal procedures consisting of a variety of internal checks and a report form that was used by the Track A[145] team to check the work of Track B[146] and vice versa.

This Quality Control (QC) review form (Table S-1) was included as part of each internal report. A report passed the QC check if the reviewer was satisfied with each of the 13 points listed in the form. Final reports were not delivered to MMC until the report passed the QC check. Interim reports have been provided with the caveat that the QC procedure had not yet been applied.

[145] Benefit-cost analysis of FEMA hazard mitigation grants

[146] Community studies

The Track A co-leader acted as reviewer of Track-B reports at the draft and final stages. The Track B co-leader performed similar QC checks of Track-A reports.

Table S-1 QC Form (Track B reports)

Reviewer:____
Report: (Title)____
Date of review: ____

Tests: (explain any "no" responses in comments section, below)	**Satisfactory**
1. All important assumptions clearly stated & justified?	
2. All data sources clearly referenced, all bibliographic references complete & verified?	
3. All important study parameters clearly defined?	
4. Clear statement of study objectives?	
5. Clearly document data-collection procedures?	
6. All relevant data presented & summarized?	
7. All math clearly documented with numbered equations, no skipped steps?	
8. All conclusions supported by well documented data and analysis?	
9. Assess sensitivity of results to important alternative assumptions?	
10. Clear & complete statement of study limitations?	
11. Spot checks: calculations, selection of track-B communities, selection of track-A samples, and result tables. (List calcs & results tables checked in "comments" section.)	
12. Acceptable grammar, style, and organization?	
13. Response to prior QC commentary?	
Summary: does the report pass QC? (Yes if the answer to all of the above is yes)	

The QC form referred to "important" assumptions, limitations, study parameters, and relevant data. Track A provided to Track B, and vice versa, a draft document listing these important assumptions, limitations, etc.; the QC person also reviewed this document. Thus, QC attention was not paid to parameters, assumptions, and the like, that were unlikely materially to affect the study results.

These formal procedures were originally designed chiefly to fit situations in which mature risk evaluation tools, namely, HAZUS for specific types of wind, earthquake, and flood risks, were used. In these cases, parameters dominating outcomes were considered to be fairly well understood, and modification of inputs for sensitivity evaluations were likewise fairly mechanical. Greater ambiguities in the application of these formal procedures were believed to arise when the grants under consideration could not be evaluated through the use of these mature tools. In these cases, parameters and assumptions potentially dominating benefit estimates may be poorly understood. Absent extensive new research, assessment of the uncertainties in these benefit estimates may remain subjective.

Informal procedures included:

- The use of subject-matter specialists to review approaches and draft documents on matters pertaining to their specialties,
- Project team members reviewing general drafts of data, reports, analyses, and proposed approaches written by other project team members, and
- The technical project manager and project Track leaders reviewing all documents pertinent to their general charges.

These more informal procedures were continuously exercised no less than weekly and often more frequently in the course of this project.

S.3 Internal Project Review Team (IPRT) Input

Independent review of the project was provided by the periodic review and input of ATC's Internal Project Review Team (IPRT). The IPRT consisted of six experts, all of whom are nationally recognized experts in their respective fields. They all have long-term experience in working with FEMA and in hazard mitigation. They were selected to provide independent, broad, consensus-based input to the ATC Project Team. This broad input was extremely important to the success of this project, in order to keep the Project Team focused on the big picture, while they performed very detailed data collection and analysis tasks. This balance of long-term experience, coupled with the breadth and depth of expertise resident on the IPRT and project team, allowed the Project Team to make technical recommendations and draw conclusions based upon the best available science and expert judgment. The IPRT was composed of the following individuals:

- William Petak (Chair) – policy analysis
- David Brookshire – economics/non-market impacts
- Dennis Mileti – social science
- Doug Plasencia – flood hazard mitigation
- Zan Turner – building code implementation
- Stephanie King – loss estimation modeling.

These six experts provided input in the areas of benefit-cost analysis, social science research, economics, policy analysis, implementation of hazard mitigation programs at the local level, and on earthquake, flood, and wind hazard issues. All major deliverables were reviewed by the IPRT before delivery to the PMC. Their input was solicited via conference calls, documented in minutes, and disseminated to the Project Team.

S.4 Validation of Costs

For Track A, validation of costs was relatively straightforward, consisting chiefly of using RS Means (Means, R.S., 2002) to spot-check construction costs given facility type and geographic location. Track A also gathered secondary field data in order to substantiate costs.

Track B gathered cost data at the federal, state, and local levels, and so was not restricted to secondary data. Data gathered in the field provided corrections to secondary data. As a result, cost data for Track B had potentially greater certainty than cost data in Track A.

For both Track A and Track B, FEMA grants with multiple objectives were believed to have the potential for posing special cost estimation problems. For one thing, it was believed that costs of pertinent activities may need to be broken down for these grants. For another thing, some costs may not be pertinent to this project (e.g., grants for activities not pertaining to natural hazards mitigation).

S.5 Validation of Benefits

For situations in which HAZUS tools are mature, Track A had the following procedures to check primarily inputs to HAZUS.

Spot-check samples. Some parameters were spot-checked and some were checked for the entire population. Samples for performing spot checks were selected from the Track A study samples as follows. Track A examined three project-type mitigation efforts from each of three hazards and three hazard levels, and three process-type activities from each of three hazards (3 project samples × 3 hazards × 3 hazard levels + 3 process samples × 3 hazards = 36 mitigations, less empty strata). In particular, the samples from each stratum were those selected from the 1st, 12th, and 25th fractile of cost.

- *Hazard assignment*. Track A checked hazard assignment for the wind and earthquake population by mapping each project location and its associated hazard level. Track A produced one map for each hazard. Track A visually compared project hazard-level assignments for earthquake and wind with the FEMA 154 (2002) earthquake-hazard-level map and ASCE-7 windspeed map. Track A performed spot checks for flood projects, taking stream order and stream distance as given, and checked one property from each sample project to ensure that, given stream order and stream distance, the highest-hazard property in the project actually met the project definition of flood hazard.
- *Project location*. Track A spot-checked the address stated in NEMIS with the address stated in the grant application. Track A used online geo-location tools (e.g., MapQuest) to check general agreement with FEMA's geo-location. Mitigation efforts with a precise address had to agree within ±0.01° of latitude and of longitude. Mitigation efforts with imprecise location (e.g., processes applicable to a county) had to agree within ±0.1° of latitude and of longitude.
- *Mitigation type*. Track A spot-checked to ensure that the grant-application description agreed with HAZUS input data, which agreed with the FEMA project-type coding.
- *HAZUS coding*. Track A spot-checked pre- and post-mitigation HAZUS structure type, value, location, and all other parameters listed in the data-collection form, compared the data-collection person's assessments with that of either another data-collection person or of the Track A co-leader, based on a hardcopy of the hazard mitigation grant application or considered internal consistency. Approximately 1,500 changes were made to coded project data. Most were minor but there were obvious transcription or typographic errors such as data from one field entered in an adjacent one or incorrect state abbreviations. Many were

critical data missing from one field that could be readily inferred from another, such as HAZUS's code for occupancy type being inferred from the project description. Some critical additions were made to address, geolocation, occupancy, number of stories, etc., using data available on the Internet and via mapping software. Some systematic checks were also performed, such as checking that the ratio of building value to square footage or the ratio of content value to structure value was within reason.

In similar situations in which HAZUS was considered a suitable mature risk evaluation tool, Track B used field data at various levels of completeness but generally more complete than those used in Track A. These were geo-coded with sometimes very precise longitudes and latitudes, with clear designations of the mitigation type and the hazard type, respectively.

Greater challenges in QC arose when the available risk tools for quantitatively evaluating benefits were less mature. In these cases, non-linearities in benefit estimates were believed to arise as a result of parameters not well-understood. For instance, a risk evaluation tool that did not have a category for commercial-industrial-institutional buildings with and without shutters would likely require the substitution of another building category to develop any benefit estimates for a mitigation consisting of installing shutters. In these cases, it was expected that Track A and Track B would clearly document the relative credibility of risk evaluation tools, assumptions used, and their limitations.

REFERENCES

Akerman, J., Johnson, F.R., and Bergman, L., 1991, Paying for Safety: Voluntary Reduction of Residential Radon Risks, *Land Economics*, Vol. 67, No. 4, pp. 435-46.

American Lifelines Alliance (ALA), 2002, *Development of Guidelines to Define Natural Hazards Performance Objectives for Water Systems,* Natural Hazards Management Inc. for the American Lifelines Alliance supported by the Federal Emergency Management Agency, Torrance, California, www.americanlifelinesalliance.com.

Applied Technology Council, 1985, *Earthquake Damage Evaluation Data for California*, ATC-13 Report, Applied Technology Council, Redwood City, California.

Applied Technology Council (ATC), 2003a, *Scoping Studies: Independent Study to Assess Future Savings from Mitigation Activities Track A - Selection of Methods to Estimate Nationwide Benefits and Costs of Mitigation*, Applied Technology Council, Redwood City, California.

Applied Technology Council (ATC), 2003b, *Track A Project Pilot Study: St Agnes Medical Center Seismic Retrofit*, Applied Technology Council, Redwood City, California.

Association for the Advancement of Automotive Medicine (AAAM), 2001, *Abbreviated Injury Scale (AIS) 1990 - Update 98*, Barrington, Illinois, 68 pp.

Bergstrom, J.C., and DeCivita. P., 1999, "Status of benefit transfer in the United States and Canada: a review," *Canadian Journal of Agricultural Economics*, Vol. 47, Edmonton, Alberta, Canada, pp.79-87.

Bernknopf, R.L., Brookshire, D., McKee, M., and Soller, R., 1997, "Estimating the social value of geologic map information: a regulatory approach," *Journal of Environmental Economics and Management*, Vol. 32, pp. 204-18.

Boardman, A., Greenberg, D., Vining, A., and Weimer, D., 1996, *Cost-Benefit Analysis: Concepts and Practice*, Prentice Hall, Upper Saddle River, New Jersey.

Boardman, A., Greenberg, D., Vining, A., and Weimer, D., 2001, *Cost-Benefit Analysis: Concepts and Practice*, 2nd Edition, Prentice Hall, Upper Saddle River, New Jersey.

Bostrom, A. and Löfstedt, R.E., 2003, "Communicating risk: wireless and hardwired," *Risk Analysis*, Vol. 23, No. 2, pp. 241-48.

Bourque, L.B., and Fielder, E.P., 2003, *How to Conduct Telephone Surveys*, Sage Publications, Thousand Oaks, California.

Brooks, H.E., 2003, *On the Relationship of Tornado Path Length and Width to Intensity*, NOAA/National Severe Storms Laboratory, Norman, Oklahoma.

Brookshire, D., Chang, S., Cochrane, H., Olson, R., Rose, A., and Steenson, J., 1997, "Direct and indirect economic losses from earthquake damage," *Earthquake Spectra*, Vol. 13, pp. 683-701.

Brookshire, D.S., and Neil, H., 1992, "Benefit transfers: conceptual and empirical issues," *Water Resources Research*, Vol. 28, No. 3, American Geophysical Union, Washington, D.C., pp. 651-655.

Burby, R.J., editor, 1998, *Cooperating with Nature, Confronting Natural Hazards with Land-Use Planning for Sustainable Communities*, Joseph Henry Press, Washington, D.C.

Burby, R.J., 2003, "Making plans that matter, citizen involvement and government action," *Journal of the American Planning Association*, Vol. 69: pp. 33-49.

Burby, R.J., and May, P.J., 1998, "Intergovernmental environmental planning: addressing the commitment conundrum," *Journal of Environmental Planning and Management*, Vol. 41, pp. 95-110.

Canaan, D., 2000, "Charlotte-Mecklenburg's floodplain mapping data and decisions," *Research in Support of Hazard Mitigation, Symposium Proceedings,* North Carolina Division of Emergency Management.

Cochrane, H., 1997, "Forecasting the economic impact of a mid-west earthquake," *Economic Consequences of Earthquakes: Preparing for the Unexpected*, B. Jones (ed.), Multidisciplinary Center for Earthquake Engineering Research, Buffalo, New York.

Congressional Budget Office, 1998, *The Economic Effects of Federal Spending on Infrastructure and Other Investments*, Congressional Budget Office, Washington, D.C.

Dalton, L.C., and Burby, R.J., 1994, "Mandates, plans, and planners, guiding local commitment to development management," *Journal of the American Planning Association*, Vol. 60, pp. 444-461.

Doyle, J.K., et al., 1990, *An Evaluation of Strategies for Promoting Effective Radon Mitigation*, Report to the Office of Policy, Planning and Evaluation, U.S. Environmental Protection Agency. U.S. EPA Cooperative Agreement #DR-813686.

duVair, P., and Loomis, J., 1992, "Household's valuation of alternative levels of hazardous waste risk reductions: an application of the referendum format contingent valuation method," *Journal of Environmental Management*, Vol. 39, pp. 143-155.

EQE International, 2000, *Determination of Impacts from Flood Study Modifications, McAlpine Creek Watershed*, Report (May) prepared for Mecklenburg County Engineering and Building Standards, Charlotte, North Carolina.

Federal Aviation Administration (FAA), 1998, *Economic Values for Evaluation of FAA Investment and Regulatory Decisions*, Report FAA-APO-98-8.

FEMA, 2004, *Seismic Retrofitting of Non-Structural Elements: Lighting in the Los Angeles Unified School District*, Federal Emergency Management Agency, Washington, D.C.

FEMA, 2005, "Detailed Expenditure Data, 1993-2002," computer file, Federal Emergency Management Agency, Washington, D.C.

FHWA, 1994, *Technical Advisory: Motor Vehicle Accident Costs*, Technical Advisory No. 7570.2, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

Frankel, A., Mueller, C., Barnhard, T., Perkins, D. Leyendecker, E.V., Dickman, N., Hanson, S., and Hopper, M., 1996, *National Seismic Hazard Maps, June 1996 Documentation*, Open-File Report 96-532, US Geological Survey, Denver, Colorado, http://geohazards.cr.usgs.gov/eq/hazmapsdoc/Junedoc.pdf, 110 pp.

Ganderton, P., 2004, "Benefit-cost analysis of hazard mitigation: the current state of what counts and how to count it," *Mitigation and Adaptation Strategies for Global Change*, forthcoming.

Golan, E. et al., 2000, *Economics of Food Labeling*, Report No. 793, U.S. Department of Agriculture, Economic Research Service.

Grazulis, T.P., 1993, *Significant Tornadoes, 1680-1991*, Environmental Films, St. Johnsbury, Vermont.

Handmer, J., and Thompson, P., 1996, *Economic Assessment of Disaster Mitigation, A Summary Guide,* Australian ISNDR Coordination Committee, Centre for Resource and Environmental Studies, Australian National University, Canberra, Australia.

Hart, G.C., 1976, *Natural Hazards: Tornado, Hurricane, Severe Wind Loss Models*, J.H. Wiggins Company, Redondo Beach, California.

Harmsen, S., 2005, "PHSA Uncertainty Analysis: Applications to the CEUS and the Pacific NW," *Infrastructure Risk Management Processes: Natural, Accidental, and Deliberate Hazards* (forthcoming), American Society of Civil Engineers, Reston, Virginia, pp. 14-61.

The H. John Heinz III Center for Science, Economics and the Environment, 1999, *The Hidden Costs of Coastal Hazards*, Island Press, Washington, D.C.

Hoffer, S., Berardino, F., Smith J., and Rubin, S., 1998, *Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Decisions,* Report FAA-APO-98-8, Federal Aviation Administration, U.S. Department of Transportation, Washington, D.C.

Hoyle, R.H., Harris, M.J., Judd, C.M., 2002, *Research Methods in Social Relations,* 7th Edition. Wadsworth.

Internal Revenue Service (IRS), *Data Book, FY 2003*, Publication 55b. Table 7 – Internal Revenue Gross Collections, by Type of Tax, Fiscal Years 1973-2003.

Internal Revenue Service (IRS), 2004a, *Statistics of Income Bulletin,* Publication 1136 (Rev. 09-2004), Table 6 – Total Adjusted Gross Income Estimated from National Income and Product Accounts (NIPA) and as Reported on Individual Income Tax Returns per Statistics of Income (SOI), Tax Years 1950-2002.

Internal Revenue Service (IRS), 2004b, *Statistics of Income Bulletin*, Publication 1136 (Rev. 90-2004), *Statistics of Income–Individual Income*, Table 9–Number of Individual Income Tax Returns, by Type of Tax Settlement, Tax Years 1950-2002.

Julier, S.J., 2002, "The scaled unscented transformation," *Proceedings of the American Control Conference*, May 8-10, Anchorage Alaska.

Julier, S., Uhlmann, J., and Durran-Whyte. H.F., 2000, "A new method for the nonlinear transformation of means and covariances in filters and estimators," *IEEE Transactions on Automatic Control*, Vol. 45, No. 3.

Julier, S.J., and Uhlmann, J.K., 2002, "Reduced sigma point filters for the propagation of means and covariances through nonlinear transformations," *Proceedings of the American Control Conference*, May 8-10, Anchorage, Alaska.

Litan, R.E., Chair, Committee on Assessing the Costs of Natural Disasters, 1999, *The Impacts of Natural Disasters: A Framework for Loss Estimation,* Board on Natural Disasters, Commission on Geosciences, Environmental, and Resources, National Research Council, National Academy Press, Washington, D.C.

Litan, R., Kringold, F., Clark, K., and Khadilkar, J., 1992, *Physical Damage and Human Loss: The Economic Impact of Earthquake Mitigation Measures,* Insurance Information Institute Press, New York, New York.

Lombard, P., 1995, Ph.D. dissertation on the economics of building code benefits pertaining to specific structural and property changes or impacts from hurricane-forced winds, Texas A&M University.

Loomis, J.B., 1992, "The evolution of a more rigorous approach to benefit transfer: benefit function transfer," *Water Resources Research*, Vol. 28, American Geophysical Union, Washington, D.C., pp. 701-705.

Luken, R.A., Johnson, F.R., and Kibler, V., 1992, "Benefits and cost of pulp and paper effluent controls under the clean water act," *Water Resources Research*, Vol. 28, American Geophysical Union, Washington, D.C., pp. 665-674.

Mahue-Giangreco, M., Mack, W., Seligson, H.A., and Bourque, L.B., 2001, "Risk factors associated with moderate and serious injuries attributable to the 1994 Northridge Earthquake, Los Angeles, California," *Annals of Epidemiology*, Vol. 11, No. 5, pp. 347-357.

Marcinowski, F. and Napolitano, S., 1993, "Reducing the risks of radon," *Air & Waste*, 43 (July): 955-962.

Markowitz, H.H., 1959, *Portfolio Selection: Efficient Diversification of Investments*, John Wiley & Sons, New York.

McLane, T., 2004, "Pre-1993 projects to be excluded *from* sampling and CBA by Track A," email to Tom Tobin and Maria Vorel, 5 Feb 2004.

Microsoft Corporation, 2004, *Microsoft Streets and Trips 2005*, Redmond Washington.

Mileti, D., 1999, *Disasters by Design: A Reassessment of Natural Hazards in the United States*, Joseph Henry Press, Washington, D.C.

Mileti, D.S., 2004, "Public Hazards Communication and Education: The State of the Art," Discussion paper, Natural Hazards Research and Applications Information Center, University of Colorado, Boulder.

Mittler, E., 1997, *An Assessment of Floodplain Management in Georgia's Flint River Basin*, Institute of Behavioral Science, University of Colorado, Boulder, Colorado.

Multihazard Mitigation Council (MMC), 2002, *Parameters for an Independent Study to Assess the Future Benefits of Hazard Mitigation Activities*, prepared by the Panel on Assessment of Savings from Mitigation Activities (MMC/National Institute of Building Sciences), Multihazard Mitigation Council, Washington, D.C.

National Research Council (NRC), 1999, *The Impacts of Natural Disasters, A Framework for Loss Estimation*, Committee on Assessing the Costs of Natural Disasters, National Academy Press, Washington, D.C.

NIBS and FEMA, 2003a, *Multi-hazard Loss Estimation Methodology, Earthquake Model, HAZUS®MH Technical Manual,* National Institute of Building Sciences and Federal Emergency Management Agency, Washington, D.C., 690 pp.

NIBS and FEMA, 2003b, *Multi-hazard Loss Estimation Methodology, Hurricane Model, HAZUS®MH Technical Manual,* National Institute of Building Sciences and Federal Emergency Management Agency, Washington, D.C., 557 pp.

NIBS and FEMA, 2003c, *Multi-hazard Loss Estimation Methodology, Flood Model, HAZUS®MH Technical Manual,* National Institute of Building Sciences and Federal Emergency Management Agency, Washington, D.C.

National Oceanic and Atmospheric Administration (NOAA). 2003. *Hurricane Isabel*. Newport/Morehead City, North Carolina, http://www.erh.noaa.gov/mhx/HurricaneIsabel.html.

Noonan, D.S., 2003, "Contingent valuation and cultural resources: a meta-analytic review of the literature," *Journal of Cultural Economics*, Vol. 27, No. 3-4, Kluwer Academic Publishers.

North Carolina Division of Emergency Management (NCDEM in conjunction with FEMA), 2004, MITIGATION PRELIMINARY PERFORMANCE ASSESSMENT: *Losses Avoided During Hurricane Isabel in North Carolina. (Draft Report)*

Office of Management and Budget, 1992, *Circular No. A-94, Revised, (Transmittal Memo No. 64), October 29, 1992, Memorandum for Heads of Executive Departments and Establishments, Subject: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs,* Washington, D.C.

Palm Beach County, 2002, "Final report - Palm Beach County survey of residents," http://www.co.palm-beach.fl.us/PubInf/News_Room/03-03/03-18-03_Survey.html.

Patton, M., 2002, *Qualitative Research and Evaluation Methods*, 3rd Edition, Sage Publications, Thousand Oaks, California.

Peek-Asa, C., Kraus, J.F., Bourque, L.B., Vimalachandra, D., Yu, J., and Abrams, J., 1998, "Fatal and hospitalized injuries resulting from the 1994 Northridge Earthquake," *International Journal of Epidemiology*, Vol. 27, No. 3, pp. 459-65.

Perkins, D., 2002, "Uncertainty in probabilistic seismic hazard analysis," *Acceptable Risk Processes: Lifelines and Natural Hazards*, edited by C. Taylor and E. VanMarcke, American Society of Civil Engineers, Reston, Virginia, pp. 19-60.

Peterka, J.A., and Shahid, S., 1998, "Design gust wind speeds in the United States," *Journal of Structural Engineering*, American Society of Civil Engineering, Reston, Virginia, pp. 207-214.

Phillips, B., 2002, Qualitative methods and disaster research, edited by Robert Stallings, *Methods of Disaster Research,* Xlibris, pp. 194-211.

Porter, K.A. 2002, "Life-safety risk criteria in seismic decisions," *Acceptable Risk Processes: Lifelines and Natural Hazards, Monograph No. 21,* C. Taylor and E. VanMarcke (ed.), American Society of Civil Engineers, Technical Council for Lifeline Earthquake Engineering, Reston, Virginia, http://keithp.caltech.edu/publications.html.

Porter, K.A., 2004, "ATC-61 quality control plan," Applied Technology Council, Redwood City, California.

Porter, K.A., 2004, "Flood hazard stratification," email *to* Adam Rose, Charles Huyck, Ron Eguchi, and Tom McLane, 10 Feb 2004

Porter, K.A., Beck, J.L., and Shaikhutdinov, R.V., 2002, "Sensitivity of building loss estimates to major uncertain variables," *Earthquake Spectra*, Vol. 18, No. 4, Earthquake Engineering Research Institute, Oakland, California, pp. 719-743.

Porter, K.A. et al., 2004, *Cost-Effectiveness of Retrofit, Above-Code Design, and Construction Quality for Woodframe Buildings*, draft manuscript, California Institute of Technology.

Reinhold, T. A., 2002, "13 Homes Destroyed! [on purpose to test the practicality and effectiveness of wind resistant retrofit measures]," *Disaster Safety Review*, Volume 1, Number 1, pages 9-14.

Rose, A., 2004a, "Economic principles, issues, and research priorities in natural hazard loss estimation," *Modeling the Spatial Economic Impacts of Natural Hazards*, Y. Okuyama and S. Chang (eds.), Springer, Heidelberg, pp.13-36.

Rose, A., 2004b, "Defining and measuring economic resilience to disasters," *Disaster Prevention and Management*, Vol. 13, No. 4, pp. 307-14.

Rose, A., Benavides, J., Chang, S., Szczesniak, P., and Lim, D., 1997, "The regional economic impact of an earthquake: direct and indirect effects of electricity lifeline disruptions," *Journal of Regional Science*, Vol. 37, pp. 437-58.

Rose, A., and Liao, S., 2005, "Modeling regional economic resilience to disasters: a computable general equilibrium analysis of water service disruptions," *Journal of Regional Science*, Vol. 45, No. 1, pp. 75-112.

Rose, A., and Lim, D., 2002, "Business interruption losses from natural hazards: conceptual and methodological issues in the case of the Northridge earthquake," *Environmental Hazards: Human and Policy Dimensions*, Vol. 4, No. 2, pp.1-14.

Rosenberger, R.S., and Loomis, J.B., 2000, "Using meta-analysis for benefit transfer: in-sample convergent validity tests of an outdoor recreation database," *Water Resources Research*, Vol. 36, American Geophysical Union, Washington, D.C., pp.1097-1107.

Rosenblueth, E., 1975, "Point estimates for probability moments," *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 72, No. 10, pp. 3812-3814.

Schulze, W.D. et al, 1987, "Benefits and costs of earthquake resistant buildings," *Southern Economic Journal*, Vol. 53, No. 4, pp. 934-51.

Seligson, H.A., Blais, N.C., Eguchi, R.T., Flores P.J., and Bortugno, E., 1998, "Regional benefit-cost analysis for earthquake hazard mitigation: application to the Northridge Earthquake," *Proceedings of the Sixth U.S. National Conference on Earthquake Engineering, May 31 -*

June 4, 1998, Seattle, Washington, Earthquake Engineering Research Institute, Oakland, California.

Shannon, C.E. and Weaver, W., 1963, *The Mathematical Theory of Communication*, University of Illinois Press, Chicago, 125 pp.

Sigal, B.M., Singhal, A., Pan, K., Seneviratna, P. and Zadeh, M.M., 2000, "Simulation of the tornado hazard in the U.S.,"*Proceedings of the 2000 Winter Simulation Conference,* J. A. Joines, R. R. Barton, K. Kang, and P. A. Fishwick (eds.).

Small Business Administration (SBA), 2005, personal communication (January).

Smith, V., Kerry, W., Desvouges, H., and Payne, J.W., 1995, "Do risk information programs promote mitigating behavior," *Journal of Risk and Uncertainty*, Vol. 10, No. 3, pp. 203-21.

Taylor, C., Porush, A., Tillman, C., and Reaveley, L., 1991, *Seismic Code Decisions Under Risk*, (with A. Porush, C. Tillman, L. Reavely, and G. Blackham), Dames & Moore for the National Science Foundation, Los Angeles, California.

Taylor, C., Werner, S., Silva, W., Aschheim, M., and Scheibel, L., 2004, *Exogenous Uncertainties in Earthquake Risk Modeling for Infrastructure Systems: A Demonstration Evaluation in Northern California,* Natural Hazards Management Inc. for the U.S. Geological Survey, Award No. 03HQ6R0022.

Tierney, K. and Dahlhamer, J., 1998, "Earthquake vulnerability and emergency preparedness among businesses," *Engineering and Socioeconomic Impacts of Earthquakes*, M. Shinozuka et al. (eds.).

University of South Carolina: Hazard Research Lab, 2005, *Spatial Hazard Events and Losses Database for the United States*.

The Urban Institute, 1991, *The Costs of Highway Crashes*, Federal Highway Administration Research Report Number FHWA-RD-91-055, Washington, D.C.

URS Group, Inc., 2001, *A Report on the Cost-Effectiveness of the Trinet Project*, final report to the Federal Emergency Management Agency, Washington, D.C.

U.S. Army Corps of Engineers (USACE), 2005, personal communication, January, 2005.

U. S. Bureau of Labor Statistics, 2005, U.S. Department of Labor, CPI Data Extraction Website, Series ID: CUUR0000SAD.

U.S. Department of Commerce, 2003, NIPA Data Extraction Website, Table 1-12. National Income by Type of Income.

U.S. Department of Labor, Bureau of Labor Statistics, 2004, *Consumer Price Index*, *All Urban Consumers, U.S. City Average, All Items*, Washington, D.C., ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt

U.S. Government Accountability Office (GAO), 1990, *Case Study Evaluations*, PEMD 91-10.1.9, Program Evaluation and Methodology Division, Washington, D.C.

U.S. Government Accountability Office (GAO), 2002, *Program Evaluation: Strategies for Assessing How Information Assimilation Contributes to Agency Goals,* Report to Congressional Committees, Report No. GAO-02-923, Washington, D.C.

U.S. House of Representatives, 1999, *Trade Agency Authorizations, Drug Free Borders, and Prevention of On-Line Child Pornography Act of 1999*, House Report 106-161, Washington, D.C.

Waddington, D.G., Boyle, K., and Cooper, J., 1994, *1991 Net Economic Values for Bass and Trout Fishing, Deer Hunting and Wildlife Watching*, US Fish and Wildlife Service, Washington D.C.

Wall Street Journal, 2003, "Treasury Quotes," *Wall Street Journal Online*, http://online.wsj.com/documents/mktindex.htm?tsyquote.htm, accessed: September 12, 2003.

West, C.T., 2004, email of 7/30.

West, C. and Lenze, D., 1994, "Modeling the regional impact of natural disaster and recovery," *International Regional Science Review*, Vol. 17, pp. 121-50.

Whitehead, J.C., and Van Houtven, G., 1997, "Methods for valuing the benefits of the safe water drinking act: review and assessment," East Carolina University Department of Economics Working Paper 9705.

Wills, C.J., Petersen, M., Bryant, W.A., Reichle, M., Saucedo, G.J., Tan, S., Taylor, G., and Treiman, J., 2000, *A Site Conditions Map for California Based on Geology and Shear Wave Velocity*, California Geological Survey, Sacramento, California, 41 pp.

Woodward, R.T., and Wui., Y.-S., 2001, "The economic value of wetland services: a meta-analysis." *Ecological Economics*, Vol. 37, pp. 257-270.

Yin, R.K., 2003, *Case Study Research: Design and Methods*, Third Edition, Sage Publications, Thousand Oaks, California.

Wills, C.J., Petersen, M., Bryant, W.A., Reichle, M., Saucedo, G.J., Tan, S., Taylor, G., and Treiman, J., 2000, *A Site Conditions Map for California Based on Geology and Shear Wave Velocity*, California Geological Survey, Sacramento, California, 41 pp.

GLOSSARY

Annualized Benefits and Costs. The value of benefits and costs based on the probability the benefit or cost will be realized in a given year.

Alternative Valuation Methods. Techniques devised by economists to measure the monetary value of non marketed goods.

Assets. Lives, buildings, utilities and transportation systems, cultural, social.

Benefit. Any increase in utility or well-being to an individual, group, or society associated with an action or choice. The price of a good sold in a competitive market represents a lower bound on its benefit. Benefit is synonymous with value in economic theory. Benefits and costs are complementary; a cost is a negative benefit, since costs decrease well-being and benefits increase well-being. This is the source of much confusion in benefit-cost analysis, since different accounting methods will assign the same impact as a benefit or a cost. It is also the source of double counting and should be avoided. Benefits and costs should be identified separately because they are separated by individuals over space and over time. (From Ganderton, 2004)

Benefit-Cost Analysis. A systematic quantitative method of assessing the desirability of government projects or policies when it is important to take a long view of future effects and a broad view of possible side-effects. Benefit-cost analysis is recommended as the technique to use in a formal economic analysis of government programs or projects. (From OMB A-94).

Casualty. A death or nonfatal injury.

Cost. Any reduction in utility or well-being to an individual, group or society associated with an action or choice. Generally it is not the same as price, which bounds cost from above (from Ganderton, 2004).

Comprehensiveness Factor. Indicates the additional benefits relative to the original FEMA costs that may be estimated given spin-off activities and effects. In effect, if $C is spent in the aggregate by FEMA and by local cost-sharing, then in the aggregate $F is expected as a spin-off effect. This $F does not overlap with any specific benefits associated with the grant itself (e.g., risk reductions that take place in accordance with the grant itself, and these include spillover effects), other than spin-off benefits. That is, this $F does not duplicate any other benefits estimated. Thus, other benefits as calculated elsewhere may be ignored in the estimation of this comprehensiveness factor.

Cost Effective. The least cost alternative means for achieving the same stream of benefits or a given objective. Cost-effectiveness analysis is less comprehensive than benefit-cost analysis, but can be appropriate when the benefits from competing alternatives are the same or where a policy decision has been made that the benefits must be provided. It can be used to compare programs with identical costs but differing benefits. FEMA guidance has defined cost-effective as the benefits equal to or exceeding the costs. (From OMB A-94)

Damage. Damage refers to physical destruction measured by physical indicators such as the number of deaths and injuries or the portions of buildings destroyed, or altered so that repair is needed. When valued in monetary terms, damages become direct losses (from Litan, 1999).

Discount Rate. Discount rate is the interest rate used in calculating the present value of expected yearly benefits and costs. Net present value represents the discounted value of future benefits and costs. Discounting reflects the time value of money and the view that costs and benefits (other than the economic value of avoiding future statistical deaths and nonfatal injuries) are worth more when they are experienced sooner. OMB determines the discount rate for analysis of federally funded projects.

Empirical. Relying on experience or observation, capable of being verified or disproved by observation or experiment.

Expected Value. The probability weighted outcome of an activity.

Exposure. People, property, systems, or functions at risk of loss exposed to hazards.

Hazard. An act or phenomenon that has the potential to produce harm or other undesirable consequences to some person or thing.

Hazard load. The specific hazard level (e.g., peak ground acceleration for earthquake) applied to a facility in the assessment of structural performance.

Impacts. The impacts of a disaster include market-based and non market-based effects. Market-based impacts include destruction of property and a reduction in income and sales (Litan, 1999). Nonmarket effects include environmental consequences and psychological effects suffered by persons involved in a disaster (from Ganderton, 2004)

Injury. Damage or harm caused to the structure or function of the body caused by an outside agent or force, which may be physical or chemical. Synonymous with casualty, this term includes both nonfatal and fatal injuries.

Loss. Any reduction in value, or well-being to individuals, groups or society. A loss is a cost. Losses avoided are benefits.

> **Direct Losses**. Losses linked directly to a hazard event including all property damages and business interruption losses due directly to the closure of damaged facilities.
>
> **Indirect Losses**. All losses other than direct losses. Indirect losses include economic losses due to dislocations in undamaged factories or commercial ventures, banking, and insurance as well as non financial losses such as loss of historical resources, pain, and suffering.

Market Price. The price for which a good is bought and sold in a market. If restrictive conditions are satisfied, this price may be used to estimate the economic value of the good. Or, the market price may need to be corrected, a 'shadow price' derived, in order for the economic value of the good to be estimated (from Handmer, 1996).

Maximum Foreseeable Loss. An estimate of losses assuming the worst combination damage and disruption to a business. This estimate allows consideration of the worst possible consequences.

Mitigation. All actions taken to reduce or eliminate long-term risk to people and property from hazards and their effects. Mitigation activities contrast with short-term risk-reducing actions such as preparedness, response and recovery measures and risk spreading measures such as insurance.

Multiplier. The ratio between the direct effect on output or employment (in the denominator) and the full effect including the effects of second-order rounds of spending (in the numerator). (From OMB A-94)

Net Present Value. The discounted monetized value of expected net benefits (i.e., benefits minus costs). This is the standard criterion for deciding whether a government program can be justified on economic principles. Net present value is computed by assigning monetary values to costs and benefits, discounting future costs and benefits (other than the economic value of avoiding future statistical deaths and nonfatal injuries, which is not discounted) using an appropriate discount rate, and subtracting the sum total of discounted costs from the sum total of discounted benefits. (From OMB A-94)

Non-exceedance probabilities. A term used to quantify the likelihood or probability that a particular level of hazard or risk will not be exceeded in some time period.

Nonstructural. All elements of a building that are not expected to carry any of the external (earthquake) or internal (weight) loads of a building. These general include utility systems, elevators, light fixtures, internal partitions, etc.

Opportunity Cost. The value of alternatives foregone to achieve an economic activity. It can be thought of as the value of the good or service in its best alternative use. For example, the value of a park in its next highest alternative use as an industrial area (from Handmer, 1996).

Present Value. The value of a stream of benefits or costs when discounted back to the present time (from Handmer, 1996).

Probabilistic. Refers to the fact that an outcome will not take place with certainty but that there is a (probability) distribution of potential outcomes.

Probability distribution. A function that identifies the probability of being less than or equal to a particular parameter or value. Opposite of non-exceedance probability.

Process Mitigation. Indirect mitigation activities that lead to policies, practices and projects that reduce risk. They include efforts to assess hazards, vulnerability and risk; conduct planning to identify projects, policies and practices and set priorities; educate decision-makers and build constituencies and political will; and to facilitate the selection, design, funding and construction of projects.

Project Mitigation. Project mitigation includes measures to avoid or reduce damage resulting from hazard events. They include projects to elevate, acquire and/or relocate buildings, lifelines and structures threatened by floods, strengthen buildings to resist earthquake or wind forces, and to improve drainage and land conditions.

Pushover curve. A graphical depiction relating the approximate seismic force applied to a building and the degree to which it deforms.

Q3. Flood map data available from FEMA (http://www.fema.gov/fima/nfip.shtm). These data indicate where frequent flooding areas occur throughout the U.S.

Resilience. The ability of an individual, household, business, or community to cushion itself from losses (static definition). The ability of a unit to return to a desired state and the speed at which this is attained (dynamic definition).

Response spectrum. A set of curves that maps out the response of a structure (at different damping values) as a function of frequency or period.

Risk. The probability that the potential harm or undesirable consequences of a hazard will be realized; the convolution of the hazard, vulnerability (or fragility), and asset exposure.

Saving. Formally saving is the reduction in present consumption to increase future consumption. It defers benefits from the present to the future, and consequently allows temporal shifting of benefits. However, in some contexts, the word is used to mean losses avoided, so implying a benefit (from Ganderton, 2004).

Shadow Prices. If a market for a good is not perfectly competitive, then market prices will not reflect the opportunity costs of that good. The price of the good, as corrected to equal its opportunity cost, is termed its shadow price (from Handmer, 1996).

Statistical death. The death of an unknown person at an unknown future date.

Statistical injury. The death or nonfatal injury of an unknown person at an unknown future date.

Structural. The load-bearing part of a building. This would include the framing system, the roof and diaphragm system, and any internal elements designed to carry lateral or vertical loads.

Synergistic Activities. Synergistic activities are activities or effects that follow or accompany the award of FEMA grants for project mitigation or process mitigation activities or the strong expectation that a grant would be awarded, that reduce risks (or increase benefits of risk-reduction activities) from floods, earthquakes, and severe winds. These activities are not funded by FEMA.

Unscented transform. A mathematical technique for selecting samples of set of uncertain variables, to estimate the mean value, variance, and other statistics of a function of those variables. The technique is far more efficient than random sampling (such as by Monte Carlo simulation), meaning that far fewer samples are required using the unscented transform than using random sampling to achieve the same level of accuracy.

Vulnerability. The susceptibility to physical injury, harm, damage, or economic loss.