TRI-STATE HURRICANE LOSS AND CONTINGENCY PLANNING STUDY PHASE II

EXECUTIVE SUMMARY AND TECHNICAL DATA REPORT

JUNE 1990

ALABAMA **FLORIDA** **MISSISSIPPI**

US Army Corps of Engineers
Mobile District

FEDERAL EMERGENCY MANAGEMENT AGENCY

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

TRI-STATE HURRICANE PROPERTY LOSS AND CONTINGENCY PLANNING STUDY PHASE II

PARTICIPATING AGENCIES:

Federal Emergency Management Agency
Region IV

Office of Ocean and Coastal Resource Management
National Oceanic and Atmospheric Administration

U. S. Army Corps of Engineers
Mobile District

State of Alabama

State of Florida

State of Mississippi

This report was partially funded by the State of Florida Department of Environmental Regulation, Office of Coastal Zone Management, by a grant provided by the National Oceanic and Atmospheric Administration under the Coastal Zone Management Act of 1972.

BY
DEPARTMENT OF THE ARMY
MOBILE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 2288
MOBILE, ALABAMA 36628-0001

JUNE 1990

EXECUTIVE SUMMARY

Tri-State Hurricane Property Loss and Contingency Planning Study Phase II

INTRODUCTION

The Tri-State Hurricane Property Loss and Contingency Planning Study, Phase II, was conducted through cooperative agreements between and funding provided by the Federal Emergency Management Agency (FEMA), National Oceanic and Atmospheric Administration (NOAA) and the U.S. Army Corps of Engineers. The States of Alabama, Florida, and Mississippi provided in-kind services and coordination in support of the study. This report presents the results of the Phase II of a two-phase program designed to demonstrate the effectiveness of various property damage mitigation measures from such storms along the central Gulf coast.

The Federal Emergency Management Agency's Hurricane Preparedness Program involves two activities - first the protection of people from hurricane surge flooding through the evacuation of the hazardous areas and second the protection of property through the application of mitigation measures. FEMA's policy is to assist with population preparedness projects before dealing with property protection projects.

With the 1986 completion of the Tri-State Hurricane Evacuation Study, FEMA and the Corps contracted to perform a property loss and mitigation study. The NOAA's Office of Ocean and Coastal Resource Management approached FEMA and expressed an interest in jointly funding a property loss and mitigation study to complement the evacuation study. This effort was to be a prototype study, not to develop mitigation plans for local governments, but to research and summarize mitigation measures and to demonstrate to interested local governments how to develop and implement a plan to reduce future hurricane damages. The first step in the process was to determine the potential damages from future hurricane events. Using calculated surge heights and applying depth versus damage curves, the Mobile District provided a document which summarized the potential dollar value of flood and wind damages in the surge zones for varying categories of storms. This document (the Phase I of the current study) demonstrated to local officials the massive damage potential from hurricanes in the coastal portions of the Tri-State study area.

With the Federal government taking a stronger approach to storm damage mitigation and the fact that in a disaster situation, State and local governments are responsible for up to 25% of damages to public property, it is imperative that local governments begin to take steps to hold down damages from future storms. If a category 4 storm were to cause $65 million in damages to public property in Harrison County (as indicated in the Phase I report), the State and county could be liable for up to 25% of that amount or $16 million. It is normal for the States to evenly share with the local governments the non-federal portion of public assistance. (Note: Public damages in Charleston County, South Carolina, as a result of Hurricane Hugo are now estimated at $12.2 million of which only approximately $4.3 million is covered by insurance.) These amounts of monetary liabilities could wreak havoc with any jurisdiction's budget. Additionally, legislation has been introduced in Congress in the past 3 years which would have increased the local share to 50%. Although this has not yet been approved, more and more pressure will be applied to local governments to act responsibly in coastal areas.

Mitigation is here to stay, and State and local governments must take a much stronger leadership role to help reduce damage caused by all types of natural hazards. It is hoped that the contents of this Phase II study will assist local planners and decision makers with preparing local mitigation plans for their areas so that future damages to public and private property can be greatly reduced.

The Tri-State Hurricane Loss and Contingency Planning Study was undertaken to demonstrate the potential for property damages from the five levels of severity of hurricanes, and to demonstrate the effectiveness of several actions that could be taken to reduce or avoid those property damages. Some background on past efforts is in order to place this phase of study in its proper perspective.

TRI-STATE HURRICANE EVACUATION STUDY

The initial effort of the Tri-State study was to provide information to emergency management officials for the safe and orderly evacuation of residents and tourists in the event of a hurricane threat. That study area was comprised of the three coastal counties in Mississippi, the two coastal counties in Alabama, and the five westernmost coastal counties in Florida. The information provided in that study centered around estimates of the hurricane tidal surge heights at various points along the coast, estimates about the behavior of people when evacuation warnings were issued, the availability of shelters, a transportation analysis showing major arteries used and an estimate of the length of time it would take to safely evacuate specific areas, and an estimate of when gale force winds would arrive at the coast given the size, strength, and forward speed and direction of the storm. Briefly, this information can be used to determine when an evacuation warning should be issued based on the characteristics of the approaching storm. The information can be used to devise the emergency evacuation plans for a community or county.

TRI-STATE HURRICANE LOSS AND CONTINGENCY PLANNING STUDY

The Phase I efforts of the current study were directed at estimating the amount of property damage that can be expected in the event of a hurricane. The study area was limited to the coastal counties in Mississippi and Alabama -- specifically those areas subject to hurricane tidal surges. Thus, the expected damages estimated for the study are for the higher hazard areas and do not include estimates of damages due to wind in areas that are not expected to be flooded. These are essentially the same areas used in the evacuation study. Florida was not included in this phase because of studies previously conducted by Florida which addressed this issue.

A generalized approach was used in Phase I to estimate potential damages in the study areas. The objective of that effort was to estimate the property damages that could occur from potential hurricanes striking the most vulnerable areas of the central Gulf coast. The estimates are needed to form the basis for hurricane recovery plans prepared at the State and local levels. In order to plan for recovery or to determine potential future mitigation measures against potential losses for hurricanes, governmental agencies should have an awareness of the likely location and magnitudes of hurricane hazards. The study identified the locations within each county that are highly vulnerable to the destructive forces of hurricanes and provided quantitative estimates of potential damages within those locations. The following table displays the potential for damage to all types of property in the surge areas of the coastal counties of Mississippi and Alabama. A comparable study was also made for the West Florida portion of the study area. The potential damages from each category of hurricane are also shown on Table ES-1 below.

TABLE ES-1

Estimated Damages from Hurricanes
Mississippi and Alabama
Surge Areas Only
($ Millions)

COUNTY	CATEGORY 1	CATEGORY 2	CATEGORY 3	CATEGORY 4	CATEGORY 5
MISSISSIPPI					
HANCOCK	$ 16.8	$ 20.6	$ 178.1	$ 309.4	$ 440.4
HARRISON	90.3	113.0	336.1	874.5	1,583.3
JACKSON	124.2	275.0	1,023.7	2,079.4	2,657.3
ALABAMA					
MOBILE	$ 54.1	$ 63.3	$ 78.9	$ 321.3	$ 290.7
BALDWIN	17.9	23.2	64.0	143.8	173.2
FLORIDA					
ESCAMBIA	$ 20.8	$ 64.9	$ 102.0	$ 168.6	$ 349.0
SANTA ROSA	1.8	3.3	4.8	6.7	28.9
OKALOOSA	12.9	20.7	28.9	44.9	73.9
WALTON	2.9	5.1	7.4	10.6	23.3
BAY	3.2	5.3	7.7	9.7	27.4

Note: The price level for the data for Mississippi and Alabama is 1987. The price level for the Florida data is 1985.

PHASE II STUDY

Study Objective. The main objective of the Phase II report is to compile a list of appropriate and effective mitigation measures that communities can adopt to lessen the probable property damages that will result from a hurricane striking the area. The second objective is to outline a process that communities can use to decide which mitigation measures would best suit the unique circumstances faced by each community. The third objective is to demonstrate techniques useful in quantifying the beneficial effects of various mitigation measures.

Mitigation is defined in this study as reducing or avoiding the harm or losses suffered from a hurricane. In Chapter 2 of the main report, the nature of each item on the list of mitigation measures is briefly discussed along with some qualitative indications of the circumstances under which the measure would be effective or appropriate for consideration by local government.

Mitigation Measures. The list of mitigation measures is summarized in Table ES-2 below. These measures fall into three general categories of Strengthening the Coast or Shore, Strengthening Buildings and Facilities, and Development Management. The desired effect of the Strengthening the Coast mitigation measures is to prevent hurricane storm surge from reaching vulnerable property. The concept of Strengthening Buildings requires the use of construction methods that enable structures to survive a hurricane essentially intact. Development Management mitigation measures, on the other hand, attempts to avoid unwise development or relocate people and structures away from the areas subject to hurricane storm surges, while simultaneously achieving other community goals and objectives such as economic growth, environmental preservation, or public recreation.

Table ES-2

Property Damage Mitigation Measures

A. STRENGTHENING THE COAST OR SHORE

1. Seawalls - Bulkheads - Revetments
2. Sand Traps - Groin Fields - Sand Bypass Systems
3. Beach Nourishment - Sand Scraping
4. Flood Control Levees - Tidal Gates
5. Dune Protection Restoration Revegetation and Sand Fencing

B. STRENGTHENING BUILDINGS AND FACILITIES

1. Building Codes and Construction Standards
2. National Flood Insurance Program Requirements
3. Floodproofing
4. Burying Aerial Utilities
5. Backup Generators for Utilities
6. Elevating Roadways and Bridges
7. Retrofitting Existing Structures

C. DEVELOPMENT MANAGEMENT

1. Planning
2. Capital Facilities Policy
3. Taxation, Fiscal and other Incentives
4. Development Regulations
5. Land and Property Acquisition
6. Information Dissemination

Strengthening the Coast or Shore. These mitigation measures are generally very expensive to construct and maintain. Once they have been started, it is difficult to abandon them because of the large investment that has already been made. They can be very effective in halting tidal surge from damaging the property they protect. They have no effect on hurricane force winds since they do not address that hazard. All of these measures consist of complex structures that will be placed in a very sensitive and dynamic environment and should be planned, designed, and constructed by professionals. Despite their drawbacks these measures have their rightful place in the tool box available to communities considering mitigating property damage from hurricanes. In certain situations, they may be the only alternative that is available to the community. In some States, erecting hard coastal works is prohibited as well as the repair of substantially damaged works.

Strengthening Buildings and Facilities. The building and facility strengthening measures are best applied before or during initial construction when their cost would be least. These measures have their own complexities, and a thorough understanding of them can be crucial in the decision to adopt, revise, or discard them. The National Flood Insurance Program (NFIP) standards, for example, are generally thought of as minimum elevation standards. Structures elevated above the minimum elevation standards will be eligible for reduced flood insurance rates. The NFIP standards and flood insurance policies also need to be fully understood with respect to claims and reconstruction in the event of substantial damage due to a storm. The NFIP's new community rating system should be fully investigated so that the entire community can receive reduced premiums based upon the efforts of the community to mitigate property damages.

Retrofitting structures to make them more resistant to damage from storms can be accomplished in some cases at reasonable costs. Adding storm shutters or hurricane clips in exposed areas are examples of retrofitting that can be done inexpensively. Raising a structure is relatively expensive. In South Carolina following Hurricane Hugo, it is estimated that the average per house cost of elevating structures 4 to 8 feet above grade will average nearly $16,000. (see table 6)

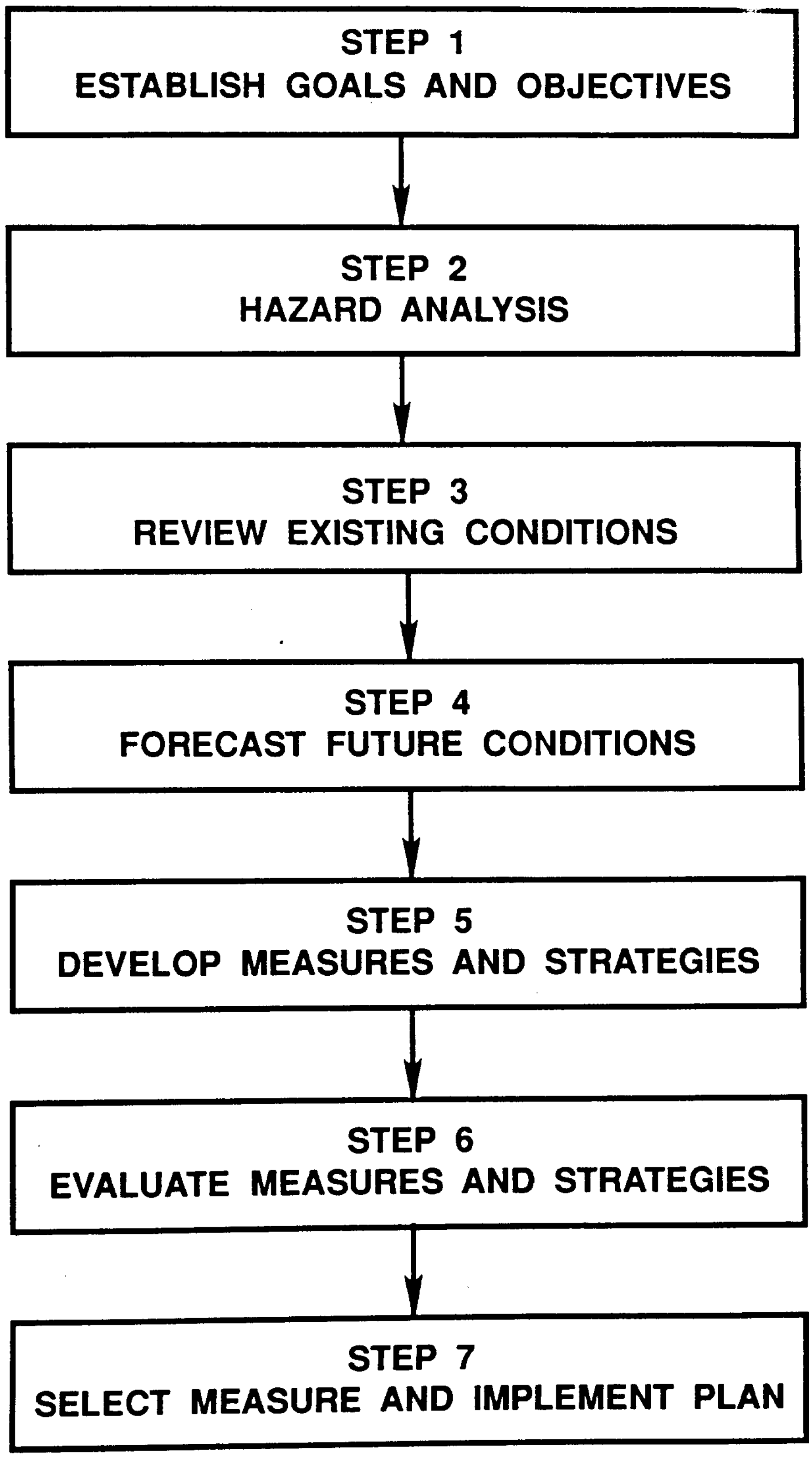
Development Management. The third basic type of mitigation measure, development management, seeks to minimize future damages by controlling the building in the hazard area. These measures are used to prevent damage to future development. A principle responsibility of government is to protect the safety and welfare of the citizenry. The cost, however, of implementing these measures is extremely variable. The political acceptability of many of these measures may be harder to determine than the economic costs. Generating political support for these measures, however, may be easier than is commonly believed. That support could be generated through the use of a citizens advisory group to a planning team that is developing a mitigation plan for the community. With the advisory group's participation in all of the steps of the planning process, that support could naturally result from their "ownership" of the plan and its various components.

There is nothing new about the development management measures. In fact, many of them are being used by communities to accomplish other goals. The legal precedence for zoning and subdivision regulations has long since been established. Property damage mitigation could be added as one of the criteria used in granting building permits. A capital facilities program can be used to guide development away from high hazard areas into lower hazard areas. The array of public services for undeveloped areas can be used to achieve the maximum amount of development limited only by the extent that property risk will be minimized. Educational programs and information dissemination can be used to influence how and where structures are built. Tax and other fiscal policies can be used to reduce the market demand for uses of high hazard areas or alternatively to increase the market demand for the use of lower hazard areas.

Research into the perceptions of local officials who deal with emergency management and planning has found that they believe the more expensive measures such as seawalls or beach nourishment are the least effective at mitigating damages, while the least expensive mitigation measures such as development management are among the most effective tools that can be used to mitigate damages. Strengthening buildings or facilities falls between the two extremes in both cost and effectiveness.

<u>General Planning Process</u>. A description of a general planning process that can be followed to determine which of the mitigation measures would be appropriate for them is given in Chapter 3 of the main report. Seven general steps in the planning process are discussed. Briefly, these steps are: (1) Establish Goals and Objectives, (2) Conduct a Hazard Analysis, (3) Review Existing Conditions, (4) Forecast Future Conditions, (5) Develop Plans and Strategies, (6) Evaluate Plans and Strategies, and (7) Select and Implement the chosen plan. A flow chart of the planning process is shown on Figure ES-1.

The general planning process outlined in the report is one that can be found in a standard text on planning. The planning process begins with organizing a planning team and selecting a manager to be responsible for development of the plan. It is suggested that most of the departments of local government will have a role to play in the development of the plan. At the very least, most departments will have expertise that will be needed at some point in the development of the mitigation plan. From the organization of a planning team, the next steps are to establish the community's goals and objectives in enough detail to provide direction to the remainder of the planning effort. An inventory of the areas at risk needs to be accomplished so the planning team will know the nature of the risks and the property vulnerable to those risks. It is suggested that the planning



GENERAL PLANNING PROCESS

Figure ES-1

team review past mitigation efforts to see how well they have worked and what, if any, modifications need to be made to them. It is entirely likely that many communities have taken mitigation measures without consciously knowing that they were attempting to mitigate future losses from hurricanes. The planning process continues by forecasting the future. Planning by its very nature looks to the future. Mitigation measures are generally more effective if implemented prior to construction. Once the frame work in which the planning will take place is identified and understood, the planning team will start to develop the plan by examining the various mitigation measures. Initially, this examination could be more qualitative than quantitative since it may not be desirable or possible to analyze each measure in great detail. The development of the mitigation plan at this juncture is to choose the measures that will be examined in further detail. Once the alternative mitigation measures have been thoroughly examined, the political decision making process can begin to select those alternative measures that are appropriate for the community. That does not signal the end of the planning process. The last step in the planning process is the periodic review and updating of the original plan to meet the needs of changed circumstances.

Estimating Potential Property Losses. Central to the planning process are evaluation techniques to estimate quantitatively the reduction in potential property damages that can be expected from the implementation of the various mitigating actions. Chapter 4 covers techniques that can be used in estimating the effectiveness of the mitigation measures.

Test Sites. To demonstrate the effectiveness of many of the proposed mitigation measures, three test sites were selected for detailed analysis. Each site concentrated on different kinds of property development from residential to commercial to public or institutional. Chapter 5 is devoted to the analysis of the effectiveness of various mitigation measures in the three test sites.

The effectiveness of several of the suggested mitigation measures was tested in three separate sites in the study area. A primarily commercial area was selected in Gulfport, Mississippi, a residential area was selected in Gulf Shores, Alabama, and an area with primarily public and institutional development was selected in Fort Walton Beach, Florida. Mitigation measures selected for testing include changing the elevation at which structures are built, adopting windspeed building codes, undertaking a dune restoration and preservation scheme, and changing the density of use in a velocity zone.

Within each test site, detailed data were collected and analyzed to estimate the current vulnerability to damage from hurricanes. Mitigation measures were selected for testing in each area to show the savings in potential damages if the measure had been adopted prior to construction. To conduct the tests, a computer spreadsheet program was devised to handle the large number of calculations needed in the analysis. That spreadsheet program is contained in Appendix B to the main report.

Test Results. By far, the most effective mitigation measure was raising the elevation at which structures are built using an appropriate foundation design. In Gulfport, the potential property damages from a category 3 size storm could be 78% less than expected if all of the structures in the test area had been built 4 feet higher than they were. In Gulf Shores, the structures have been elevated by substantial amounts. Comparing the potential damages between structures built to the base flood elevation to their actual elevations shows that potential damages are reduced by more than $1.8 million, or from $3.1 to $1.3 million. In Fort Walton Beach, if the structures in the test area were raised between 0.5 and 2.0 feet to be at the base flood elevation plus 4 feet, damages in a category 3 storm would be reduced by 20%. Raising all structures by 2.5 to 3.0 feet to be at the expected surge height of a category 3 storm would eliminate the potential damages from water which are expected to be $2.7 million.

Adoption of building codes for windspeeds was also examined in Gulfport and Gulf Shores. A 120 mph windspeed standard was selected for analysis. It was assumed that damages from winds less than the standard would be eliminated and that damages from windspeed greater than the standard would be diminished to some small extent. Damages from 130 mph winds would be reduced by 25% and damages from 140 mph would be reduced by 5%. The model used to compute the potential damages does not consider the effects of windblown debris or falling objects such as trees.

A dune restoration and preservation scheme was tested in Gulf Shores. It was assumed that the presence of a dune system would be enough to change the designation of part of the test area from a velocity zone to an "A" zone. Under these conditions, the potential damages from a category 3 storm would be reduced by $750,000 or nearly 60%.

Changing the density of development was examined in the Gulf Shores test area. All of the structures in the test area were kept in the test area. The test was to see the effects of reducing the number of structures in the velocity zone portion of the area. It was assumed that if the number of structures allowed in the velocity zone were limited, that the structures deleted from that area would be built in the "A" zone portion of the test area. The results of shifting some structures from the velocity zone to the "A" zone portion of the test area show that potential total damages would be reduced by 20 to 25% for category 3 through 5 storms. Since the structures built in the velocity zone have first floors at a greater average elevation than in the "A" zone, the floor elevation of the structures that were moved was reduced to the average floor elevation for the "A" zone, a reduction of 2 feet. The results from this change still showed positive results. Instead of savings of $400,000 to $800,000, the savings were $200,000 to $450,000.

Education was another item discussed in the test section of the report. It is one thing to have a knowledgeable staff of inspectors and local developers and contractors, but it is quite another matter with owners who have never owned property near the coast. For the educational seminars on how to build in the coastal environment to reduce the risk of damage from hurricanes and to meet the requirements of flood insurance to be fully successful, the potential owner must be convinced of the wisdom that building practices with which they may have no familiarity are necessary. It is the new owners who must pay the added costs to exceed the minimum elevation standards which may be a few hundred dollars. They must also pay the added 2 to 4% of construction costs to "windproof" the structure. They also need to be shown the potential savings in insurance premiums that accompany exceeding the minimum standards as well as the potential savings in damages from the construction practices.

Conclusions. As more and more Americans move to the coastlines, the total structural damage from severe storms increases. By the turn of the century, it is estimated that 70% of our population will live or own property within 50 miles of a shore. Over the past two decades, the growth rate for coastal areas has been 3 to 4 times faster than the national average. At the same time, the sea-level is now believed by some scientists to be rising at an increasing rate. This means that future hurricanes will place more property at risk.

Mitigating coastal property losses is a public policy issue that challenges all levels of government. That challenge lies in finding the appropriate balance between the economic growth of communities, public safety, and private property rights. Being closer to the problem, it is incumbent on local officials to take a stronger lead in resolving the issue for their areas. In the Federal disaster assistance program, State and local governments are being required to implement actions to reduce recurring damages as a condition of receiving future disaster assistance.

In terms of deaths and dollar losses, hurricanes are expected to become the worst natural disasters we will have to deal with by the turn of the century. Hurricanes are expected to be the leading cause of per capita and annual dollar losses by the year 2000, $5.9 billion annually. In 1970, both hurricane and tornado property losses were less than riverine flooding. By 2000, both tornado and hurricane annual property losses are expected to be greater than riverine flooding property losses by substantial margins. The number of deaths annually is expected to increase more than 150% over the annual average in 1970 of 99 per year to 256 deaths. While this number ranks third behind tornadoes and earthquakes, the increase is substantial. Hurricanes also hold the top spot in number of housing units lost. It is expected that the number of housing units lost, 56,000 in 1970, will increase to 96,000 by the turn of the century. (ref. 4)

The major recommendations of this report are to assist local governments in making property damage mitigation explicit in their daily functioning. Take small steps. Fine tune existing programs that are working well. Become thoroughly familiar with the National Flood Insurance Program, the new Community Rating System and the Stafford Act amendments of the Disaster Assistance Act. State laws may also require local governments to make provisions in preparation for future hurricanes. Plans need to be developed for recovery of the community immediately following a hurricane. Those plans should cover provision of essential services such as water, electricity, communications and sewage. Secondarily, preparations should be developed for the reconstruction of vulnerable areas that may be devastated. Plans to mitigate property damages to future development should also be developed, but they may not have the same priority. The hazard analyses for the community should demonstrate which areas face the greater degree of risk. The priority of developing plans for areas of existing development versus areas to be developed could be determined by those analyses. The strength of existing measures and other considerations will also have a bearing on the priority given to development of plans for mitigation of property damages in different areas of the community. What is required is to take the time and commit the resources to begin the process of planning for hurricane hazard mitigation.

Those of us who have been involved in the Tri-State study offer our congratulations for your past efforts to mitigate property damages and applaud your decision to initiate a planning effort to do even more along those lines.

TRI-STATE HURRICANE LOSS AND CONTINGENCY PLANNING STUDY PHASE II

TECHNICAL DATA REPORT

JUNE 1990

ALABAMA **FLORIDA** **MISSISSIPPI**

US Army Corps of Engineers
Mobile District

TABLE OF CONTENTS

TITLE	PAGE
CHAPTER 1 - INTRODUCTION	1
Purpose	1
Previous Studies	1
Hurricane Evacuation Study	1
Loss and Mitigation Study	1
Description of the Study Area	2
Demographics of the Study Area	2
Categories of Hurricanes	4
Policy Considerations of Mitigation	5
Trends in Damages from Natural Disasters	5
State and Federal Programs	5
Report Organization	6
CHAPTER 2 - MITIGATION MEASURES	8
Introduction	8
List of Mitigation Measures	8
Measures for Different Types of Development	12
Timing of Implementation	12
Strengthening the Coast or Shore	16
General Discussion	16
Seawalls - Bulkheads - Revetments	18
Sand Traps - Groin Fields - Sand Bypass Systems - Offshore Breakwaters	19
Beach Nourishment - Sand Scraping	20
Flood Control	20
Dune Protection	20
Strengthening Buildings and Facilities	21
General Discussion	21
Building Codes and Construction Standards	23
National Flood Insurance Program Requirements	24
Floodproofing	25
Burying Aerial Utilities	25
Backup Generators for Utilities	26
Elevating Roadways and Bridges	26
Retrofitting Existing Structures	26
Development Management	33
General Discussion	33
Planning	35
Capital Facilities Program	38
Taxation - Fiscal - Other Incentives	39
Development Regulations	40
Land and Property Acquisition	45
Information Dissemination	46
CHAPTER 3 - PLANNING PROCESS	49
Step 1: Establish Goals and Objectives	49
Step 2: Hazard Analysis	51
Step 3: Review Existing Conditions	52
Step 4: Forecast Future Conditions	52
Step 5: Develop Measures and Strategies	52
Step 6: Evaluate Measures and Strategies	53
Step 7: Select Measures and Implement Plan	54

TABLE OF CONTENTS (Cont)

TITLE	PAGE
CHAPTER 4 - MEASURING EFFECTIVENESS	55
Introduction	55
Estimating Potential Property Damages	55
Property Values	55
Elevation Data	55
Surge Heights	56
Damage Susceptibility	56
Reducing or Avoiding Potential Property Losses	58
Rising Stillwater Surge	58
Structure Elevation	59
Number and Value of Buildings	63
Susceptibility to Damage	64
Current Versus Future Development	66
Mitigation as an Investment	68
Public Expenditures and Tax Revenues	69
CHAPTER 5 - TEST AREAS	73
Introduction	73
Gulfport, Mississippi	74
Existing Conditions	76
Benefits for Elevating Structures	77
Benefits for Wind Resistant Construction	79
Combination of Mitigation Measures	80
Gulf Shores, Alabama	82
Existing Conditions	84
Benefits for Dune Preservation and Restoration	84
Benefits for Elevating Structures	86
Benefits for Wind Resistant Construction	88
Benefits for Density Restrictions	89
Combination of Mitigation Measures	90
Fort Walton Beach, Florida	92
Existing Conditions	92
Benefits for Floodproofing	94
Benefits for Relocation	94
Benefits for Elevating Structures	95
Combination of Mitigation Measures	97
CHAPTER 6 - SUMMARY AND CONCLUSIONS	98
Mitigation Measures	98
Planning Process	99
Estimating Effectiveness	100
Test Sites	100
Appendix A	102
Appendix B	102
Appendix C	102
Recommendations	103

LIST OF APPENDICES

TITLE	PAGE
APPENDIX A - BIBLIOGRAPHY AND PERSONS CONSULTED	
APPENDIX B - SPREADSHEET FOR ESTIMATING PROPERTY DAMAGES	
APPENDIX C - MITIGATION MEASURES IN EFFECT ACROSS THE STUDY AREA AND PERTINENT STATE LAWS ON EROSION SETBACK LINES - STATEWIDE BUILDING CODES - GROWTH MANAGEMENT	

LIST OF TABLES

No.	TITLE	PAGE
1	Saffir/Simpson Hurricane Scale	4
2	Property Damage Mitigation Measures	10
3	Mitigation Measures Compared to Type of Development and Timing of Implementation	14
4	Unit Cost Estimating for Elevation Projects	28
5	Unit Cost Estimating for Relocation Projects	29
6	Four Case Studies from South Carolina, 11/02/89 Estimated Costs to Elevate Structures In-place	31
7	Costs and Savings in Annual Flood Insurance Premiums for Buildings Above Minimum Elevation in "A" Zones with Elevation Certificates	61
8	Costs and Savings in Annual Flood Insurance Premiums for Buildings Above Minimum Elevation in "V" Zones with Elevation Certificates, Post 1981 Construction	62
9	Estimated Damages from Hurricanes - Selected Area of Gulfport, MS - Existing Conditions	76
10	Estimated Damages from Hurricanes - Selected Area of Gulfport, MS - All Structures Minimum Elevation of 17 Feet	78
11	Estimated Damages from Hurricanes - Selected Area of Gulfport, MS - All Structure Elevation Increased 4 Feet	78
12	Estimated Damages from Hurricanes - Selected Area of Gulfport, MS - Adoption of 120 mph Windspeed Building Codes	80

LIST OF TABLES (Cont)

No.	TITLE	PAGE
13	Estimated Damages from Hurricanes - Selected Area of Gulfport, MS - Elevating All Structures by 4 Feet and Adoption of 120 mph Windspeed Building Codes	81
14	Estimated Damages from Hurricanes - Selected Area of Gulf Shores, AL - Existing Condition	84
15	Estimated Damages from Hurricanes - Selected Area of Gulf Shores, AL - Dune Restoration and Preservation	86
16	Estimated Damages from Hurricanes - Selected Area of Gulf Shores, AL - Artificial Existing Conditions All Lowest Floors Set to Base Flood Elevation of 10 Feet	87
17	Estimated Damages from Hurricanes - Selected Area of Gulf Shores, AL - Artificial Existing Conditions All First Floors Elevated 4 Feet Above BFE	88
18	Estimated Damages from Hurricanes - Selected Area of Gulf Shores, AL - Adoption of 120 mph Windspeed Building Codes	89
19	Estimated Damages from Hurricanes - Selected Area of Gulf Shores, AL - Adoption of Density Restrictions	90
20	Estimated Damages from Hurricanes - Selected Area Gulf Shores, AL - Adoption of Selected Measures	91
21	Estimated Damages from Hurricanes - Selected Area of Fort Walton Beach, FL - Existing Conditions	92
22	Estimated Damages from Hurricanes - Selected Area of Fort Walton Beach, FL - Floodproofing All Buildings to 3 Feet	94
23	Estimated Damages from Hurricanes - Selected Area of Fort Walton Beach, FL - Relocating the Auditorium	95
24	Estimated Damages from Hurricanes - Selected Area of Fort Walton Beach, FL - Raising All Structures to Base Flood Elevation of 6 Feet Plus 4 Feet	96
25	Estimated Damages from Hurricanes - Selected Area of Fort Walton Beach, FL - Raising All Structures to Category 3 Surge Height of 11.6 Feet	96
26	Estimated Damages from Hurricanes - Selected Area of Fort Walton Beach, FL - Relocating the Auditorium and Raising All Structures to 11.6 Feet	97

LIST OF TABLES (Cont)

No.	TITLE	PAGE
B-1	Tabular Data for Lotus 1-2-3 Spreadsheet - Windspeeds, Surge Heights, and Value of Contents	B-2
B-2	Tabular Data for Lotus 1-2-3 Spreadsheet - Percent of Structure Value Damaged by Hurricane Generated Stillwater Surge	B-3
B-3	Tabular Data for Lotus 1-2-3 Spreadsheet - Percent of Content Value Damaged by Hurricane Generated Stillwater Surge	B-4
B-4	Tabular Data for Lotus 1-2-3 Spreadsheet - Percent of Structure Value Damaged by Hurricane Generated Waves	B-5
B-5	Tabular Data for Lotus 1-2-3 Spreadsheet - Percent of Structure Value Damaged by Hurricane Generated Winds	B-6
B-6	Lotus 1-2-3 Spreadsheet for Estimating Property Damages	B-11
B-7	Finished Spreadsheet for Gulfport Test Site Category 3 Storm	B-14
B-8	Finished Spreadsheet for Gulfport Test Site Category 5 Storm	B-15
B-9	Finished Spreadsheet for Gulf Shores Test Site Category 3 Storm	B-16
B-10	Finished Spreadsheet for Gulf Shores Test Site Category 5 Storm	B-19
B-11	Finished Spreadsheet for Fort Walton Beach Test Site Category 3 Storm	B-22
B-12	Finished Spreadsheet for Fort Walton Beach Test Site Category 5 Storm	B-23
C-1	Mitigation Measures in Effect Across the Study Area Alabama - Mobile County	C-2
C-2	Mitigation Measures in Effect Across the Study Area Alabama - Baldwin County	C-3
C-3	Mitigation Measures in Effect Across the Study Area Mississippi	C-4
C-4	Mitigation Measures in Effect Across the Study Area Florida	C-5

LIST OF FIGURES

No.	TITLE	PAGE
1	Map of Study Area	3
2	General Planning Process	50
3	Wind Damage Curve	67
4	Map of Gulfport, Mississippi Test Site	75
5	Map of Gulf Shores, Alabama Test Site	83
6	Map of Fort Walton Beach, Florida Test Site	93
B-1	Computations of Water Heights at Structure	B-9

CHAPTER 1

INTRODUCTION

PURPOSE

The purpose of the Tri-State Hurricane Loss and Contingency Planning Study, Phase II is to provide a list of practical measures which local governments can adopt to mitigate property damages in the event of a hurricane. This report also provides a planning process that can be followed in the selection of the most effective and appropriate mitigation measures for individual communities in its development of a hurricane hazard mitigation plan. In choosing mitigation measures, one of the more difficult tasks is evaluating the effectiveness of particular measures. This report provides a technique to estimate the potential savings in property losses that can be expected from the next hurricane.

PREVIOUS STUDIES

The Federal Emergency Management Agency's Hurricane Preparedness Program involves two activities - first the protection of people from hurricane surge flooding through the evacuation of the hazardous areas and second the protection of property through the application of mitigation measures. FEMA's policy is to assist with population preparedness projects before dealing with property protection projects.

<u>Hurricane Evacuation Study</u>: The Tri-State Hurricane Evacuation Study was jointly funded by FEMA, the U.S. Army Corps of Engineers, and the Office of Ocean and Coastal Resource Management of the National Oceanic and Atmospheric Administration. The study was an effort to provide State and local emergency management agencies with realistic, quantitative data pertaining to the major factors affecting decision-making for evacuation under hurricane threats. The data do not replace the detailed operations plans developed by each of the States and counties within the study area. These data are intended to provide a framework within which each State and county can update and revise existing hurricane evacuation plans and from which operational procedures and decision guides for future hurricane threats can be developed.

<u>Loss and Mitigation Study</u>: With the completion of the evacuation study, a property loss and mitigation study was initiated to complement the evacuation study. This effort was to be a prototype study, not to develop mitigation plans for local governments, but to research and summarize mitigation measures and to demonstrate to interested local governments how to develop and implement a plan to reduce future hurricane losses.

Phase I of the study process was to determine the potential for loss from future hurricane events. Using calculated surge heights and applying depth versus damage curves, the Phase I report summarized potential flood and wind losses in the surge zones for varying categories of storms. The area where potential damages were estimated was limited to the area that could be inundated by storm surge. Additional damages, primarily from wind, could occur outside of this area. Potential damages in these areas, however, were not estimated. This document demonstrated to local officials the massive damage potential from hurricane surges in the coastal portions of the Tri-State study area. The Phase I study was completed in 1988.

Mitigation is here to stay, and State and local governments must take a much stronger leadership role to help reduce damage caused by all types of natural hazards. It is hoped that the contents of this Phase II study will assist local planners and decision makers with preparing local hurricane mitigation plans for their areas so that future damages to public and private property can be greatly reduced.

The results of the Phase II study are intended to be used as an educational tool. While the study is based in the Tri-State study area, the list of practical mitigation measures, the process that can be followed in selecting appropriate measures for individual communities, and the techniques for estimating potential savings from the adoption of one or more of these measures should have applicability to other areas along the Gulf and Atlantic coasts. In demonstrating the potential savings in property losses, the intended transportability of the study results was considered in the selection of the test sites and the selection of the mitigation measures to test.

DESCRIPTION OF THE STUDY AREA

The study area for Phase II of the Hurricane Loss and Contingency Planning Study is the same as that for the Evacuation Study. The study area is comprised of the three coastal counties in Mississippi, the two coastal counties in Alabama, and the five westernmost coastal counties in Florida. A map of the study area is provided in Figure 1. It should be noted that only the coastal portion of the coastal counties is included in the study area; i.e., those areas that are subject to surge flooding from hurricanes. Within each State, a small test site was selected to demonstrate the effectiveness of various mitigation measures. A test site was selected in Gulfport, Mississippi, which featured commercial development. In Alabama, a test site representing residential development was selected in Gulf Shores. Public and institutional property is featured in the Fort Walton Beach, Florida, test site.

DEMOGRAPHICS OF THE STUDY AREA

The permanent resident population of the Tri-State area increased by significant amounts during the 1960's and 1970's. While the population of the United States was increasing at a rate of 25% between 1960 and 1980, the study area population was increasing at a 40% rate. This increase has occurred primarily

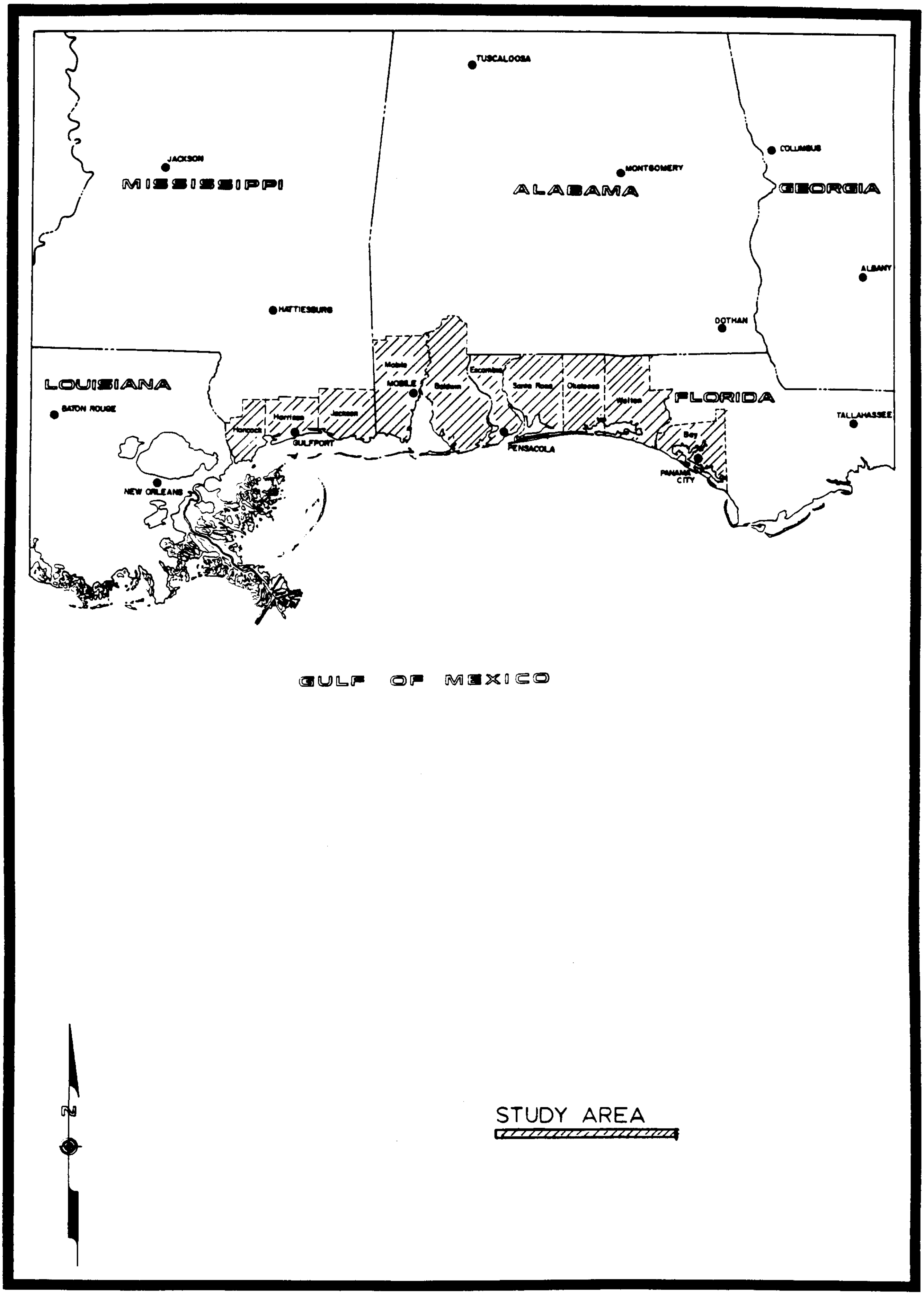

TUSCALOOSA
JACKSON
MISSISSIPPI
MONTGOMERY
ALABAMA
COLUMBUS
GEORGIA
ALBANY
HATTIESBURG
DOTHAN
LOUISIANA
BATON ROUGE
Mobile
MOBILE
Baldwin
Escambia
Santa Rosa
Okaloosa
Walton
FLORIDA
Hancock
Harrison
Jackson
GULFPORT
PENSACOLA
Bay
PANAMA CITY
TALLAHASSEE
NEW ORLEANS
GULF OF MEXICO
N
STUDY AREA

FIGURE I

at or near the coastline and bay shorelines in the study area. This increase in population has severe implications for both the evacuation of vulnerable populations in the event of a hurricane and the potential for increased property damages.

As more and more Americans move to the coastlines, the damage to property from severe storms increases. By the turn of the century, it is estimated that 70% of our population will live or own property within 50 miles of a shore. Over the past two decades, the growth rate for coastal areas has been 3 to 4 times faster than the national average. At the same time, there is evidence of a relative sea-level rise that could be occurring at an increasing rate. This means that future hurricane surges could put ever more property at risk.

CATEGORIES OF HURRICANES

Numerous methods and models have been utilized to quantify the potential storm surge generated by hurricanes. One of the earlier guides developed for that purpose is the Saffir/Simpson Hurricane Scale. This scale, shown in Table 2, is a descriptive scale which categorizes hurricanes based upon intensity and relates hurricane intensity to damage potential. The scale also provides a range of windspeeds and potential surge heights associated with the five categories of hurricanes. The Saffir-Simpson is intended as a general guide for use by public safety officials during hurricane emergencies. The scale assumes an average, uniform coastline for the continental United States and does not reflect the effects of varying localized bathymetry, coastline configuration, barriers or other factors which can greatly influence the surge heights that occur at differing locations during a single hurricane event. The National Hurricane Center has added a range of central barometric pressures associated with each category of hurricane described by the Saffir/Simpson Hurricane Scale.

TABLE 1

Saffir/Simpson Hurricane Scale with
Central Barometric Pressure Ranges

SCALE NUMBER	CENTRAL PRESSURES MILLIBARS	INCHES	WINDS (mph)	SURGE (feet)	DAMAGES
1	980	28.94	74-95	4-5	MINIMAL
2	965-979	28.50-28.91	96-110	6-8	MODERATE
3	945-964	27.91-28.47	111-130	9-12	EXTENSIVE
4	920-944	27.17-27.88	131-155	13-18	EXTREME
5	<920	<27.17	>155	>18	CATASTROPHIC

POLICY CONSIDERATIONS OF MITIGATION

Mitigating coastal property losses is a public policy issue that challenges all levels of government. That challenge lies in finding the appropriate balance between the economic growth of communities, public safety, and private property rights. Being closer to the problem, it is incumbent on local officials to take a stronger lead in resolving the issue for their areas. To obtain Federal disaster assistance, the State and local governments, through Section 409 of the Stafford Act, are being required to plan for the actions they intend to take to reduce recurring damages, particularly to public property.

TRENDS IN DAMAGES FROM NATURAL DISASTERS

In terms of deaths and dollar losses, hurricanes are expected to become the worst natural disasters we will have to deal with by the turn of the century. Hurricanes are expected to be the leading cause of per capita and annual dollar losses by the year 2000, $5.9 billion annually. In 1970, both hurricane and tornado property losses were less than riverine flooding. By 2000, both tornado and hurricane annual property losses are expected to be greater than riverine flooding property losses by substantial margins. The number of deaths annually is expected to increase more than 150% over the annual average in 1970 of 99 per year to 256 deaths. While this number ranks third behind tornadoes and earthquakes, the increase is substantial. Hurricanes also hold the top spot in number of housing units lost. It is expected that the number of housing units lost, 56,000 in 1970, will increase to 96,000 by the turn of the century. (ref. 4)

STATE AND FEDERAL PROGRAMS

The focus of this report is on the leadership role that local governments can and should take to reduce the amounts of property damage from hurricanes. There are, of course, many opportunities that States and the Federal government have to assist in these endeavors. Regardless of State and Federal programs, it is the local governments that must take the lead and make their communities safer places to live and work.

Some States are aggressively pursuing property mitigation measures. They are requiring construction setbacks in an attempt to accommodate long-term erosion of the shoreline. Through these measures, they are attempting to strike a balance between the development of coastal areas and public health and safety as well as some degree of environmental protection.

The Federal government is also trying to reduce property damages. The recently enacted Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 (P.L. 100-107), which amended the Disaster Relief Act of 1974 (P.L. 93-288), incorporates many changes in response to the criticisms of those programs. These new statutes provide for partial funding of identified mitigation projects in the wake of a disaster. The disaster assistance is now contracted with the governor of each State. Immediately following a presidential disaster declaration, an agreement is signed with the governor who requested the declaration specifying the responsibilities of the parties. Several types of costs to local governments not eligible previously for assistance are now eligible. For example, according to the Stafford Act there are administrative cost allowances for both the applicant community and the State, fringe benefits on force account labor are eligible, and hazard mitigation measures required by FEMA are also eligible.

The National Flood Insurance Program (NFIP) has a new program, the Community Rating System. This program is fashioned much like the rating system for communities for fire insurance. Under the Community Rating System, a community can reduce its flood insurance policy rates throughout the community by as much as 45%. There are several categories of activities that communities can undertake that will give them credits towards reduced insurance premiums. This program recognizes that uniform rates do not reward communities that exceed the minimum requirements. Many of the measures mentioned in this report are among the activities that communities can adopt to receive reduced insurance premiums. The FEMA regional office should be consulted for additional information on the Community Rating System.

REPORT ORGANIZATION

The report is organized into four major parts. The first portion is a listing and discussion of mitigation measures. The discussion briefly outlines the nature of the measures and the circumstances where they might be appropriate. A general idea of the cost of some of these measures is also included. The second portion of the report covers the general planning process that a community can follow in choosing the mitigation measures that are most effective and appropriate for them. The third section of the report is devoted to describing measurement techniques that can be used in a hazard analysis for an area of the community and in estimating the potential savings in property losses attributable to the mitigation measure. Additionally, some discussion on the effects of mitigation measures on public expenditures and tax revenues is included in the third portion of the report. The fourth section of the report covers the testing of selected mitigation measures in three separate sites. Among the measures tested are elevating structures, dune preservation, and adoption of windspeed building codes.

A bibliography of the published works and persons consulted during the preparation of this report is included in Appendix A. These publications give more detail on the nature of coastal processes, prudent construction practices in the coastal zone, development management as a means to mitigating property losses, and other coastal development issues. Additionally, a list of professionals in the field of damage mitigation measures that were consulted during the course of this study is also presented.

A <u>computer spreadsheet</u> was developed to assist in the calculations of potential property damages due to the destructive forces of a hurricane. A complete listing of the spreadsheet is contained in Appendix B to the report. This spreadsheet is only an example of how such calculations can be made. Users should feel free to rearrange it to suit their own particular needs.

Appendix C to the report contains information on the <u>mitigation measures</u> that are already being used across the study area. A brief discussion of some <u>pertinent State laws</u> is also included.

CHAPTER 2

MITIGATION MEASURES

INTRODUCTION

Any measure that a community could adopt to reduce or eliminate damages to property from hurricane or other storm events can be considered to be appropriate and effective. The degree of appropriateness or effectiveness will depend on the characteristics unique to the community. For example, constructing a seawall or nourishing a beach may be less appropriate than development management if the coastal area is sparsely developed and vice versa. Interestingly, research into the perceptions of community officials principally involved with planning and community development has found that the more expensive options such as stabilizing the shoreline are considered to be among the least effective while the less expensive options such as development management are perceived as being more effective. Strengthening structures falls between the two in both expense and effectiveness. (ref. 30)

The appropriateness of the various measures is somewhat more difficult to estimate than the effectiveness of a measure, since the estimate of appropriateness may be based on more subjective analyses. However, the antecedent conditions may to some extent dictate the choice as in the case of existing seawalls or groin fields. The degree of development in the coastal area may preclude the use of development management techniques, particularly if that development is of very recent vintage. Such recent development may also signal the prior use of development management techniques. In this case, further efforts at storm damage mitigation may of necessity have to be somewhat more sophisticated if further reduction of property damage is to be achieved over and above that which will be achieved by past implementation of mitigation measures. Reconstruction in the aftermath of a storm may then become more important than preparing for the next storm event. Appendix C is a compilation of mitigation efforts that have been instituted across the study area. Applicable state laws are also briefly summarized in this appendix.

LIST OF MITIGATION MEASURES

The initiation of storm damage mitigation planning begins with the decision that something must be done and proceeds to the question of deciding what should be done. The choices are varied and not at all obvious. The community would be well advised to begin by deciding what is desirable for their community from many perspectives by setting goals and objectives. It should be noted that much has probably already been done. Then the choices of what to do become more apparent, but they are still not crystal clear. In many cases it may be a simple matter of adding hazard mitigation planning as a consideration to other types of planning or regulating activities such as zoning or subdivision regulations. Certainly, only those options which directly support the community goals and objectives should be chosen, but there are some options that indirectly support those goals which can also be quite appropriate. It is instructive to remember that the choices will be made more from a political perspective than from a purely professional planning perspective. However, since the useful life of new construction can be 70 years or more, and since it is quite likely that those structures will have to withstand the forces of more than one large storm during that period, it would be prudent to think in terms of the next several storms rather than just the next single storm.

The list of mitigation measures provided below is subdivided into three general classes. The effectiveness and appropriateness of the three classes will be discussed in generic terms, and then each measure will be considered in turn.

TABLE 2

PROPERTY DAMAGE MITIGATION MEASURES

A. STRENGTHENING THE COAST OR SHORE
   1. SEAWALLS - BULKHEADS - REVETMENTS
   2. SAND TRAPS - GROIN FIELDS - SAND BYPASS SYSTEMS
   3. BEACH NOURISHMENT - SAND SCRAPING
   4. FLOOD CONTROL
      LEVEES - TIDAL GATES
   5. DUNE PROTECTION
      RESTORATION - REVEGETATION - SAND FENCING

B. STRENGTHENING BUILDINGS AND FACILITIES
   1. BUILDING CODES - CONSTRUCTION STANDARDS
   2. NATIONAL FLOOD INSURANCE PROGRAM REQUIREMENTS
   3. FLOODPROOFING
   4. BURYING AERIAL UTILITIES
   5. BACKUP GENERATORS FOR UTILITIES
   6. ELEVATING ROADWAYS/BRIDGES
   7. RETROFITTING EXISTING STRUCTURES
      CLIPS - BRACES - SHUTTERS & ELEVATING UTILITIES

C. DEVELOPMENT MANAGEMENT
   1. PLANNING
      BROAD POLICY STATEMENTS OF COMMUNITY GOALS AND OBJECTIVES
      GUIDING/FRAMEWORK FOR FUTURE DECISIONS
      EXPLICIT RECOGNITION OF HAZARD MITIGATION
      REDEVELOPMENT/RECONSTRUCTION POLICIES
      EVACUATION/SHELTERING
      MAPPING
         IDENTIFY AREAS AT RISK
         INVENTORY DEVELOPMENT
         ANALYSIS OF VULNERABILITY
   2. CAPITAL FACILITIES POLICY
      DEVELOPMENT ORIENTATION
      DEVELOPMENT DEPENDENCE ON WATER/SEWER, FIRE/POLICE, SCHOOLS, HOSPITALS
   3. TAXATION, FISCAL AND OTHER INCENTIVES
      PREFERENTIAL TAXATION
      PUBLIC SERVICE/FACILITY PRICING SYSTEMS
      IMPACT FEES
      SITE VALUE TAXATION
      MORTGAGE STANDARDS - REQUIRED HAZARD INSURANCE

TABLE 2 (Con't)

PROPERTY DAMAGE MITIGATION MEASURES

C. DEVELOPMENT MANAGEMENT (Con't)
- 4. DEVELOPMENT REGULATION
    - ZONING
    - SUBDIVISION REGULATIONS
    - INCENTIVE ZONING
    - CONDITIONAL/CONTRACT ZONING
    - FLOATING - SLIDING SCALE ZONING
    - SETBACKS
        - COASTAL
        - SIDE YARD
        - STREET FRONTAGE
    - DENSITY
    - INTENSITY
    - SITE REVIEW
    - BUILDING ORIENTATION
    - BEACH/DUNE PROTECTION
        - CROSSOVERS, ETC.
    - PLANNED UNIT DEVELOPMENTS
    - CLUSTERING
    - DEVELOPMENT/REDEVELOPMENT MORATORIA
- 5. LAND AND PROPERTY ACQUISITION
    - FEE SIMPLE
    - LESS-THAN-FEE SIMPLE
    - TRANSFER OF DEVELOPMENT RIGHTS
    - RESALE WITH RESTRICTIVE COVENANTS
    - SCENIC EASEMENTS
    - RELOCATIONS
    - DONATIONS WITH OR WITHOUT TAX ADVANTAGES
    - EXCHANGE
    - FORECLOSURE ON TAX DELINQUENT PROPERTY
- 6. INFORMATION DISSEMINATION
    - HAZARD DISCLOSURE DURING REAL ESTATE TRANSACTIONS
    - HAZARD INFORMATION RECORDED ON DEEDS, SUBDIVISION PLATS, PUBLIC SIGNS
    - COOPERATIVE PROGRAMS WITH LOCAL MEDIA
    - SCHOOL - PUBLIC EDUCATION FORUMS
    - TRAINING/CERTIFYING BUILDING INSPECTORS
    - TRAINING DEVELOPERS, CONTRACTORS, REGULATORS, ETC.
    - PEER REVIEW PROGRAMS
    - HOMEOWNER ASSOCIATION PROGRAMS

MEASURES FOR DIFFERENT TYPES OF DEVELOPMENT

In the search for effective and appropriate mitigation measures, two questions were posed: are there mitigation measures that are uniquely effective or appropriate for different types of development such as residential, commercial, industrial or public; and when in the cycle of build-damage-rebuild should these mitigation measures be imposed if the cycle of build-damage-rebuild is to be broken? The mitigation measures that were found to be effective and appropriate are shown in Table 2. The two questions about types of development and the timing of implementation are shown in Table 3.

As shown in Table 3, all of the items listed under Strengthening the Coast or Shore would be effective in mitigating property damages regardless of the type of development. Since these measures function by reducing the storm surge and waves, thereby diminishing their ability to cause damage, then the type of development these measures protect is unimportant - these measures protect all types of development. Additionally, undeveloped property can also be protected by these measures, though it is rarely economical to protect extensive sections of undeveloped property in this manner. Since these measures protect against water damages, some other mitigation measure must be employed to combat the storm's damaging winds.

TIMING OF IMPLEMENTATION

The timing of the implementation of Strengthening the Coast or Shore is not critical in breaking the cycle of build-damage-rebuild. Certainly, the sooner these measures are constructed, the sooner they are available to protect against the next severe storm.

Much the same can be said of the items listed in Table 3 under the heading of Strengthening Buildings and Facilities. These measures function by improving the structure's ability to withstand the damaging forces of severe storms. It makes no difference whether the structures are for residential, commercial, industrial or public purposes. Three of the items - burying aerial utilities, backup generators for utilities, and elevating roads and bridges - are measures for specific types of public property. While mitigating the potential damages to these community lifelines is useful in and of itself, there are additional benefits since the improvement of these structures to withstand the forces of hurricanes impacts the whole of the community's fabric. These public structures or lifelines are vital to post-hurricane cleanup efforts and in the efforts to return to normal. Floodproofing residential buildings should not be considered a mitigation measure for the velocity zone. Since loss of life is still a possibility, FEMA does not allow the floodproofing of residential structures in this area.

As with the Strengthening the Coast or Shore mitigation measures, the timing of the implementation of the Strengthening

Building and Facilities is not critical in breaking the cycle of build-damage-rebuild. The sooner they are implemented, the sooner they are available to mitigate property damage.

The mitigation measures listed under Development Management in Table 3 present a mixture of answers to the question of type of development. On the whole, they are effective in avoiding or reducing damages to any type of development. Some items are more associated with residential development such as subdivision regulations, transfer of development rights or homeowners associations. Most of the items listed under the subheading of Land and Property Acquisition are associated with all types of development, except public.

The question of the timing of the implementation of these measures is also answered in the same manner for these mitigation measures as for the other mitigation measures - the sooner the better. There are some mitigation measures that by their very nature cannot be implemented until after the storm. Such a case could be made for redevelopment and reconstruction policies. To make effective use of these policies, they should be planned before the next storm so they are available for use afterwards. Hurricanes are not the only means by which structures are destroyed. Redevelopment or reconstruction policies can also be useful in cases of fire damage, old age or neglect.

TABLE 3

MITIGATION MEASURES COMPARED TO TYPE OF DEVELOPMENT
AND TIMING OF IMPLEMENTATION

PROPERTY DAMAGE MITIGATION MEASURE	TYPE OF DEVELOPMENT				TIMING	
	RES	COM	IND	PUB	PRE	POST
A. STRENGTHENING COAST OR SHORE						
1. SEAWALLS - BULKHEADS - REVETMENTS	x	x	x	x	x	x
2. SAND TRAPS - GROIN FIELDS - SAND BYPASS SYSTEMS	x	x	x	x	x	x
3. BEACH NOURISHMENT - SAND SCRAPING	x	x	x	x	x	x
4. FLOOD CONTROL						
LEVEES - TIDAL GATES	x	x	x	x	x	x
5. DUNE PROTECTION						
RESTORATION - REVEGETATION - SAND FENCING	x	x	x	x	x	x
B. STRENGTHENING BUILDINGS AND FACILITIES						
1. BUILDING CODES - CONSTRUCTION STANDARDS	x	x	x	x	x	x
2. NATIONAL FLOOD INSURANCE PROGRAM REQUIREMENTS	x	x	x	x	x	x
3. FLOODPROOFING		x	x	x	x	x
4. BURYING AERIAL UTILITIES	x	x	x	x	x	x
5. BACKUP GENERATORS FOR UTILITIES		x	x	x	x	x
6. ELEVATING ROADWAYS/BRIDGES				x	x	x
7. RETROFITTING EXISTING STRUCTURES						
CLIPS - BRACES - SHUTTERS & ELEVATE UTILITIES . .	x	x	x	x	x	x
C. DEVELOPMENT MANAGEMENT						
1. PLANNING						
BROAD POLICY STATEMENTS OF COMMUNITY GOALS AND OBJECTIVES	x	x	x	x	x	x
GUIDING/FRAMEWORK FOR FUTURE DECISIONS	x	x	x	x	x	x
EXPLICIT RECOGNITION OF HAZARD MITIGATION	x	x	x	x	x	x
REDEVELOPMENT/RECONSTRUCTION POLICIES	x	x	x	x	x	x
EVACUATION/SHELTERING				x	x	x
MAPPING						
IDENTIFY AREAS AT RISK	x	x	x	x	x	x
INVENTORY DEVELOPMENT	x	x	x	x	x	x
ANALYSIS OF VULNERABILITY	x	x	x	x	x	x
2. CAPITAL FACILITIES POLICY						
DEVELOPMENT ORIENTATION	x	x	x	x	x	x
DEVELOPMENT DEPENDENCE ON WATER/SEWER, FIRE/POLICE, SCHOOLS, HOSPITALS				x	x	x
3. TAXATION, FISCAL AND OTHER INCENTIVES						
PREFERENTIAL TAXATION	x	x	x	x	x	x
PUBLIC SERVICE/FACILITY PRICING SYSTEMS	x	x	x	x	x	x
IMPACT FEES	x	x	x	x	x	x
SITE VALUE TAXATION	x	x	x	x	x	x
MORTGAGE STANDARDS - REQUIRE HAZARD INSURANCE . . .	x	x	x	x	x	x

COLUMN HEADINGS:

RES - Residential; COM - Commercial; IND - Industrial; PUB - Public; PRE - Pre-storm; POST - Post-storm

TABLE 3 (Cont)

MITIGATION MEASURES COMPARED TO TYPE OF DEVELOPMENT
AND TIMING OF IMPLEMENTATION

PROPERTY DAMAGE MITIGATION MEASURE	TYPE OF DEVELOPMENT				TIMING	
	RES	COM	IND	PUB	PRE	POST
C. DEVELOPMENT MANAGEMENT (Con't)						
4. DEVELOPMENT REGULATION						
ZONING	x	x	x	x	x	x
SUBDIVISION REGULATIONS	x				x	x
INCENTIVE ZONING	x	x	x	x	x	x
CONDITIONAL/CONTRACT ZONING	x	x	x	x	x	x
FLOATING - SLIDING SCALE ZONING	x	x	x	x	x	x
SETBACKS						
COASTAL	x	x	x	x	x	x
SIDE YARD	x	x	x	x	x	x
STREET FRONTAGE	x	x	x	x	x	x
DENSITY	x	x		x	x	x
INTENSITY	x	x		x	x	x
SITE REVIEW	x	x	x	x	x	x
BUILDING ORIENTATION	x	x	x	x	x	x
BEACH/DUNE PROTECTION						
CROSSOVERS, ETC.	x	x	x	x	x	x
PLANNED UNIT DEVELOPMENTS	x	x			x	x
CLUSTERING	x	x	x	x	x	x
DEVELOPMENT/REDEVELOPMENT MORATORIA	x	x	x	x	x	x
5. LAND AND PROPERTY ACQUISITION						
FEE SIMPLE	x	x	x	x	x	x
LESS-THAN-FEE SIMPLE	x	x	x	x	x	x
TRANSFER OF DEVELOPMENT RIGHTS	x	x	x		x	x
RESALE WITH RESTRICTIVE COVENANTS	x	x	x		x	x
SCENIC EASEMENTS	x	x	x		x	x
RELOCATIONS	x	x	x		x	x
DONATIONS WITH OR WITHOUT TAX ADVANTAGES	x	x	x		x	x
EXCHANGE	x	x	x	x	x	x
FORECLOSURE ON TAX DELINQUENT PROPERTY	x	x	x		x	x
6. INFORMATION DISSEMINATION						
HAZARD DISCLOSURE - REAL ESTATE TRANSACTIONS	x	x	x		x	x
HAZARD INFORMATION RECORDED ON DEEDS, SUBDIVISION PLATS, PUBLIC SIGNS	x	x	x	x	x	x
COOPERATIVE PROGRAMS WITH LOCAL MEDIA	x	x	x		x	x
SCHOOL - PUBLIC EDUCATION FORUMS	x	x	x	x	x	x
TRAINING/CERTIFYING BUILDING INSPECTORS	x	x	x	x	x	x
TRAINING DEVELOPERS, CONTRACTORS, REGULATORS	x	x	x	x	x	x
PEER REVIEW PROGRAMS	x	x	x	x	x	x
HOMEOWNER ASSOCIATION PROGRAMS	x				x	x

COLUMN HEADINGS:

RES - Residential; COM - Commercial; IND - Industrial; PUB - Public; PRE - Pre-storm; POST - Post-storm

STRENGTHENING THE COAST OR SHORE

General Discussion: The measures listed in Table 2 under the heading of strengthening the coast or shore can be effective at reducing or avoiding the damages to both present and future development from storm surge and waves. Since these measures provide a barrier to the flow of water or the energy stored in water, they would be effective and appropriate for some types of development. Industrial structures or recreational facilities that must be situated adjacent to the water or in high energy zones such as a surf zone would need to be protected from surge and wave energy by seawalls, bulkheads, breakwaters, or jetties. Examples of this situation are industries that depend on water transportation, commercial fishing operations, and recreational marinas.

The effectiveness of coastal strengthening mitigation measures is the extent they prevent water from damaging the property behind them. This can be evaluated by calculating the expected damages without the protective measure in place and figuring the expected damages after the protective measure is in place. The difference between these two conditions is the measure of the effectiveness of the protective works. Since these mitigation measures protect against surge and wave damages only, damage from winds can still be expected to be the same whether the protective works are constructed. Other mitigation measures in conjunction with these measures would have to be adopted to avoid or reduce wind damage.

The cost of these measures should also be considered in estimating their effectiveness. The cost of shore strengthening measures is generally in the millions of dollars. Once started, these measures require continuous maintenance and occasional rehabilitation. There are other less expensive mitigation measures that would effectively protect new development from water related damage.

While coast or shore strengthening measures will prevent damages to any new development as well as existing buildings, the choice of implementing a shore or coastal strengthening measure may be more appropriate in those situations where the area to be protected is already heavily developed. In such a situation, a substantial investment has already taken place and it may not be desirable to allow the forces of nature to destroy that investment. Other circumstances where these measures may be appropriate are where these measures have been employed in the past. Beach nourishment may be the least expensive means of protecting a seawall that is in danger of being undermined. This situation can happen since the seawall interrupts the natural shore processes. Seawalls, bulkheads, and revetments tend to protect property development behind them at the expense of the beach. Other coastal works are designed to stabilize the shoreline and protect the beach. The nature of the community's economy should be considered in deciding to invest in a shore stabilization mitigation measure. If the community relies on the beach environment for much of its economic well-being, then the loss of that beach due to the construction of a seawall, bulkhead or revetment would have the opposite result from what was intended.

The coastal areas are among the most dynamic environments to be found anywhere. The shore is in constant motion. This motion is dramatic during a severe storm or hurricane. However, the normal motion on a daily basis is so gradual that it is imperceptible.

The beach is continuously seeking an equilibrium condition. There are five interrelated factors that effect this equilibrium: wave condition (height, period,and direction), sand size, water level fluctuation, sand supply, and the slope of the beach. A change to any factor will have a predictable change in the others as the shore tries to return to an equilibrium state. While these factors are the same for any beach, each beach has its own uniqueness that must be considered.

Beaches tend to flatten during storms so the wave energy is distributed over a greater area. During the storm, sand may form an offshore ridge. After the storm, the sand in these ridges gradually moves back to the shore and the beach profile steepens.

With seawalls, bulkheads or revetments, often the beach is lost or greatly diminished in front of the structure. The shoreline steepens, which increases the size of waves, and erosion accelerates. However, seawalls have, in general, been quite effective at protecting the property behind them.

Beach nourishment is a shore protection measure that is designed to be accomplished several times over the life of the project as a more cost effective and compatible solution than hard structures. Often the size of the sand grains used in beach nourishment is smaller than would occur naturally. The smaller size will tend to erode at a faster rate, but that phenomenon is taken into account in the design. The source of the sand for beach nourishment is also a serious concern as sand supplies are exhaustible. Over time, additional sand supplies may be required that come from farther away which means additional costs.

Dune protection is another means of stabilizing the shore. While it can oftentimes be accomplished at a relatively small expense in comparison to other shoreline strengthening measures, there are detrimental aspects of this measure that need to be considered. Recreating a protective dune system in previous overwash areas may prevent the movement of sand to the backside of a barrier island which in turn increases the erosion to that side of the island.

Since the natural processes of the shore are complex and since the coastal or shore strengthening mitigation measures are themselves very complex structures, the decision to implement any of them should rest on a knowledge of coastal processes and detailed engineering investigations of each site. These measures all interrupt the natural processes in one way or another. It is the long term effects of preventing the beach from reaching a state of near equilibrium that can mean the ultimate failure of these measures from performing their intended function.

Several sources of information are available to assist in understanding the natural coastal processes. The Federal Emergency Management Agency has several publications that deal with construction in coastal areas. Many of these publications provide very useful general information about coastal processes and coastal works that should be consulted before engaging in the necessary, lengthy and expensive investigations.

If more detailed information is needed, many universities have courses of study in coastal geology and coastal engineering. Some State governments have departments that deal with coastal issues and can also provide information on coastal processes and engineered coastal structures. The U.S. Army Corps of Engineers deals with coastal erosion problems and can provide information on strengthening the shore or coast. There are regional planning and development commissions and coastal research laboratories that can help communities in their planning efforts. There are engineering firms in the private sector that have the necessary expertise in coastal processes.

While it is not within the purview of this report to delve into the debate concerning the "greenhouse" effect, attention to the issue of long term global climate changes needs to be considered when deciding which of the mitigation measures would best suit the community's needs. One of the items in the debate seems to be centered around how much of a sea level rise can be expected in the next century. The implications of a gradual warming for coastal areas are twofold. First is the sea level rise and second is the increase in storm activity from warmer waters.

Recent research indicates that coastal engineering solutions to the potential for damage from severe storms will be even more expensive than in the past and that existing structures will be less effective in the future as their design conditions are exceeded. A gradual rise in sea level can also mean increased erosion rates. This may mean that the coastal environment will become a more threatening and dynamic environment.

<u>Seawalls - Bulkheads - Revetments</u>: Seawalls, bulkheads and revetments are protective structures that function in essentially the same manner, but are constructed of different materials or in different configurations. They reflect and dissipate wave energy and keep the surge and waves away from the land behind them. In reflecting the wave energy, the beach in front of them is sometimes eroded. The intensity of the longshore currents can also be increased, thereby accelerating the removal of the beach. These shore stabilizing structures can also prevent the exchange of sand between the dunes and the beach so that the

beach cannot flatten in response to a storm. Wave and current energy are also concentrated at the ends of these structures, which increases the erosion rate at these critical points. Seawalls and bulkheads can also trap flood water behind them if they are not tall enough to prevent overwash during severe storms.

In order to prevent hurricane storm surge and waves from reaching the land behind them, these structures must be extensive in size. Storm surge from a moderate hurricane such as a category 3 storm can reach from 9 to 12 feet or more with waves added to the storm surge. Normal tide ranges are in addition to storm surge and waves. Experience has shown that if structures are well constructed they will work quite well. Experience has also shown that these structures require substantial investment for original construction and for maintenance, that they must be extended at one or both ends, and that they are frequently reconstructed landward to even larger dimensions. Once started, their care is perpetual.

<u>Sand Traps - Groin Fields - Sand Bypass Systems - Offshore Breakwaters</u>: Sand traps such as groin fields, jetties or offshore breakwaters or sand bypass systems attempt to stop the loss of sand. Groins are constructed perpendicular to the beach and are made of a variety of materials. Groins trap enough of the longshore transport to stabilize the position of the shoreline. Frequently the beach downdrift of the last groin in the field experiences erosion unless the groin field is properly designed.

Jetties are usually very long in comparison to groins and are constructed to prevent sand from filling a navigation channel. These structures function by trapping sand on one side and preventing it from flowing into the channel. If these structures are working properly, they can be causing erosion downdrift by intercepting the sand that would naturally be flowing to them.

Sand bypass systems are generally constructed in conjunction with jetties to help correct the downdrift erosion. The sand that would fill a ship channel is collected and then pumped or trucked to the downdrift side of the channel and placed so it can continue its journey along the beach.

Offshore breakwater structures are constructed parallel to the shore and also interrupt the longshore currents. The sand settles on the shore behind the breakwater.

The decision to invest in these types of projects should also be based on a firm knowledge of the natural processes peculiar to the location. These projects are usually very expensive to construct and they require a long term commitment of monetary resources for maintenance and rehabilitation. A stabilized shoreline is effective in combating damage from breaking waves and storm surge, but not against wind damage.

Beach Nourishment - Sand Scraping: Beach nourishment and sand scraping are perhaps the least intrusive measures into the natural shoreline processes. To be effective against hurricane surge and wave action, the berm must be constructed to a height that will prevent the storm surge from penetrating to the land behind it. In addition, a nourished beach may need to reach into water 30 to 40 feet deep offshore if it is to be fully effective or reduce some of the long term commitment to maintenance. The cost of nourishing a beach with the volumes of sand required to reach deep water may be prohibitive in most instances. Sand scraping is simply moving the sand that naturally accumulates during periods of accretion and spreading it smoothly to create a summer recreation beach. Sources of sand for nourishment can come from offshore or from upland sites.

Flood Control: The next two measures listed in Table 2 under the heading of strengthening the coast or shore are both flood control measures and are effective in mitigating damages from surge and waves. Levees are constructed on dry land while tidal gates are generally constructed across inlets. Both are complicated structures that require extensive planning, design and construction engineering. The physical characteristics of the land and water may preclude their construction or increase the cost of their construction beyond practical limits.

Dune Protection: Dune protection could act in much the same way as a levee. The cost of restoration and revegetation is considerably less since there is not as much foundation work that would have to be accomplished. Dunes are natural structures that absorb the wave energy. Dune protection does require the long term commitment of not developing the land on which they rest. The restoration and revegetation of a dune can be accomplished at a relatively small cost if the community is willing to proceed at nature's pace. There are several publications on the design of sand fencing and there are vendors of suitable plants for revegetation. Irrigation and fertilization could be major cost items in some instances. While the dune restoration and revegetation measure may be somewhat less expensive than any of the other shore strengthening measures, the complexity of this measure is such that professional assistance in the planning and design of the measure should be seriously considered as an appropriate cost. It is possible that land costs for a dune system could increase the cost of this measure to nearly the same relative level as the other alternatives in this category of mitigation measures. The implementation and enforcement of prohibitions against activities harmful to the dune system, such as driving and walking, could also be a cost that should be considered in the decision to adopt a dune preservation program. Dune systems might not be as effective as the above measures in combating damages from surge and wave energy since they are not intended to completely prevent the intrusion of storm surge but to halt the penetration of waves to damageable property. The more extensive the dune system, the more effectively it will prevent this penetration. The preservation of dune systems can also be a part of other community goals and objectives for reasons other than mitigation of property damage from tropical storms.

STRENGTHENING BUILDINGS AND FACILITIES

General Discussion: The second category of available mitigation measures listed in Table 2 is strengthening buildings and facilities. These measures are used to minimize the damage to facilities for the more frequent storms in high hazard zones. What is intended by their adoption is the use of the high hazard areas for human enjoyment while simultaneously reducing the likelihood of substantial loss to facilities as a result of a severe storm or hurricane. An additional benefit of a well designed and built structure is the prevention of the structure from becoming part of the forces that damage adjacent buildings. The freedom for individual acceptance of risk is preserved for all, but no building or facility should be allowed to be built in such a manner that parts of the structure become waterborne or wind blown debris that batters the windows of other buildings, thereby increasing the damages.

The structural integrity of buildings and facilities can be maintained from the attack of surge, wave and wind. Building codes and regulated construction practices can be adopted by communities to mitigate all three damaging effects of hurricanes.

The effectiveness of these measures would be estimated in the same manner as those in the preceding category. That is, an estimate of potential damages is made for existing conditions. Then an estimate of potential damages is made assuming that one or more of these measures have been adopted. The difference between the two estimates is the measure of the effectiveness of having adopted the measures.

Strengthening buildings and facilities is appropriate in almost all cases. The cost of these measures is generally small, particularly when they are incorporated in the original construction. Their costs can become quite large in retrofitting situations. In those instances where some substantial reconstruction is required, the costs of providing some building strengthening measures would be comparable to new construction costs. While these measures should be applied in an even handed manner, the standards can be modified to fit the circumstances. For example, the National Flood Insurance Program requirements vary depending upon the degree of risk associated with the proximity to streams or the coast. The further inland the property is situated, the less damaging the winds from hurricanes can be. However, great care should be exercised in adjusting the construction standards for differing circumstances because the damaging effects of hurricane winds can be felt for great distances inland. The City of Birmingham had serious wind damage from Hurricane Frederic in 1979. Hurricane Hugo also caused major wind damages hundreds of miles inland.

Strengthening buildings and facilities is generally more valuable for future developments or redevelopments than for present structures. The circumstances peculiar to each community will in large part determine the appropriateness of many of these measures. On occasion it may be argued that imposition of building codes or construction standards by a single community will drive developers to areas outside of the community where these standards are not imposed, thereby losing valuable community economic development. While that may be true in some instances, the community may want to consider whether that is the kind of economic development it truly desires. Since the life expectancy of most buildings or facilities is counted in decades, the longer term perspective may have a critical bearing on the decision to adopt sound building codes and construction standards.

Strengthening buildings and facilities can have more utility when used in conjunction with other mitigation measures. For example, up to date building codes are needed if a community decides to adopt a reconstruction policy that will be followed in the event of a hurricane. The training and education of building inspectors as well as contractors and developers also assumes that the community has or will adopt building codes.

The property insurance industry is very concerned about its ability to withstand the financial strain that would be caused by two $7 billion storms occurring in heavily populated areas within a short period of time. The industry strongly encourages the adoption and enforcement of building codes and construction standards. (ref. 22)

By way of illustration, in 1983 Hurricane Alicia struck the Texas coast. In 1984 Hurricane Diana struck the North Carolina coast. These two storms were fairly similar in their composition, however the destruction in their wakes was very different. The number of homes, their age and type of construction were similar, as well as the existence of similar building codes. In Texas, these codes were inadequately followed, which resulted in wide spread destruction, while in North Carolina the codes were effectively used. Thus, the damage in North Carolina was small in comparison. In Texas, an example of an inspection/compliance/enforcement problem was the fact that supplies of hurricane clips were found in the attics of structures that had their roofs torn away. All of the differences in the resulting damages, however, can not be described as simply as the above example. (ref. 22)

As shown on the coast of South Carolina following Hurricane Hugo and elsewhere in the United States, good code enforcement can make a significant difference in reducing damages and permitting families and communities to resume their normal lives soon after a disaster. But code enforcement alone is not sufficient, nor does it work in a vacuum. It is part of a total system in which the market component of owners, builders, materialmen, lenders, and insurers have a greater responsibility than building officials for the success or failure of buildings in natural disasters. Where it succeeds, the market component perceives and assumes its responsibility; the building official encourages, educates, cajoles, insists, and applies the codes firmly and fairly. Ultimately good code enforcement has a small part in the total process, yet can make a significant difference in the losses incurred in a disaster. (ref. 24)

Building Codes and Construction Standards: Most of the building and facility strengthening measures entail doing something to or for an existing building or structure. Obviously, construction necessary to withstand the forces incurred during a hurricane is far less expensive if done during the original construction than after the building or facility is completed. A thorough review of adopted building codes and construction standards need not wait until the next storm to see if they are adequate. Many of these standards are continuously updated by the code developers. Some of them are also developing "Deemed to Comply" addendum for their codes. For a community that has already adopted one of the standard building codes, it could be a relatively simple matter of adopting an updated version. Some building code organizations are also doing research into the types of damage that occur during hurricanes and the adequacy of the codes that they have developed. This information may be generally available to a subscriber of these codes. Such information can help point out the areas of buildings most subject to damage and where a community may want to amend its regulations. Some of these areas are the corners of roofs and porches or decks that are added after the original structure is built. These additions may not be adequately tied to the main structure and can become wind blown debris that further damages the main structure.

Hurricane-resistant construction is significantly different than conventional construction. Substantial attention must be given to details, particularly connections that are rarely considered in conventional construction. Many coastal builders and inspectors do not clearly understand the differences between the two types of construction. Through providing educational opportunities, inspectors and builders can develop a clear understanding of the important details of hurricane-resistant construction.

Building codes and construction standards should be geared to protecting the structures or facilities from the forces of nature with which the structures will have to contend. These forces are wind, surge, wave and erosion. Retrofitting structures can be accomplished, but often at fairly large expense. Any retrofitting that can be accomplished at minimal cost such as replacing a missing brace or adding clips or hangers in exposed areas is well worth the effort. Strengthening buildings and facilities can be either very expensive or relatively inexpensive. Retrofitting structures to be resistant to flood damages or wind damages could be very expensive, whereas construction to these standards originally would be relatively inexpensive. For example, a recent study done by the National

Association of Home Builders for the All-Industry Research Advisory Council shows that the costs of construction to meet Deemed to Comply standards for 100 mph wind design adds 2.1 to 4.4 percent to the total direct construction costs. The same study also estimates that meeting the Deemed to Comply standards would add 1.8 to 3.7 percent to the total sales price. (ref. 10)

National Flood Insurance Program Requirements: Of a more general concern are standards which are imposed by participation in the National Flood Insurance Program. Such participation should be considered as one of the best mitigation measures available, since its adoption will greatly reduce or avoid property damages. It should be stressed, however, that the standards imposed by this program are minimum standards. These standards are effective means of mitigating property damages by trying to avoid unwise development in areas subject to storms. It should also be noted that the flood insurance program does not cover wind damages. Other measures, such as building codes, need to be employed to mitigate for these damages.

There are two high hazard areas of particular interest. Both the "A" zone and the "V" or velocity zone are subject to flooding while the "V" zone is also subject to wave action. (The "A" zone is the area that would be inundated by the 100 year storm.) The same standards apply in both zones with additional standards for the velocity zone. An area is included in the velocity zone if a three foot wave over and above the storm surge is considered possible in that area. The area adjacent to the velocity zone may be at a high enough elevation that a three foot wave is improbable, but the area immediately adjacent to the velocity zone is still subject to waves smaller than three feet. A possible mitigation measure would be to adopt a coastal "A" zone where the "V" zone standards would be applied in areas subject to wind driven water.

There can be substantial savings to property owners, both private and public, in insurance premiums alone by exceeding these elevation standards. The annual flood insurance premium for a building in the velocity zone can be reduced substantially by exceeding the minimum standard by three or four feet. The additional cost of longer pilings, longer stairs, and longer lateral braces can be recouped by the savings in insurance premiums in one to three years. The same kind of annual insurance premium savings is also possible in areas adjacent to the velocity zone, but it may take a little more time for the savings to outweigh the costs of exceeding the minimum standards. Additionally, the Federal Insurance Administration (FIA) of the Federal Emergency Management Agency (FEMA) is preparing a community rating system whereby each community can reduce its flood insurance premiums based upon the extent they exceed the minimum standards imposed by participation in the flood insurance program as well as by adopting and enforcing other flood hazard mitigation measures. The community rating system is envisioned as being similar in nature to the community rating system for fire insurance. All policy holders would benefit under such a community rating system.

Each community should understand what went into the determination of the flood heights and wave heights that are presented on the Flood Insurance Rate Maps (FIRMs) that are provided by FIA. Particular attention should be paid to the provisions made for erosion and resulting changes in flood or wave heights. Considerations for wave height have been included in all recent coastal studies, and considerations for erosion are being incorporated as rapidly as possible.

In conjunction with the FIRMs, communities should understand how flood insurance premiums are computed. It is a rather complex issue that can have some unpleasant ramifications for property owners. As the FIRM's are updated to account for recent events and additional information, the base flood elevation may change as well as the extent of the velocity zones. If a building was in compliance with the regulations when it was constructed, then the insurance premium for that building is computed according to the map that was in effect at the time of construction. If the building was not in compliance with the regulations when it was built, then the insurance premium would be computed according to the new map.

Prior planning for strengthening buildings or facilities can also pay benefits in the aftermath of a devastating storm. Under the Stafford Act, it is now possible to qualify for funding to reconstruct damaged public property to higher standards, but only if plans to do so are identified beforehand. Time and effort is usually required to develop such plans. In the aftermath of a storm, that time and effort could be spent for better purposes.

<u>Floodproofing</u>: FEMA and the Corps have some excellent publications that deal with floodproofing structures. Because of the complexity of floodproofing a structure, engineering expertise is required in the planning, design and implementation of floodproofing measures. Essentially, floodproofing is keeping the structure watertight or raising it above flood height.

<u>Burying Aerial Utilities</u>: For this study, we are principally concerned with what a community can do for itself and secondarily concerned with what individual property owners can do for themselves. For communities, it may be the aerial utilities that are of primary concern. The community can adopt a program of burying aerial utilities, but then the environment in which these facilities are to buried needs to be considered. The presence of high ground water tables, mineral salts and saltwater may make the continuing cost of maintenance of buried utilities more expensive than it would at first seem to be. Burying utilities may be feasible to do in reconstruction or new construction situations. Replacing wooden poles with more wind or erosion resistant concrete poles as a matter of routine maintenance may be the alternative that is most feasible. Again, engineering expertise may be required. The utility companies have such expertise and can be of service to the community since they are also interested in reducing storm damage to their facilities.

Backup Generators for Utilities: While backup generators for utilities are not mitigation measures in the sense that they avoid or reduce property damage directly attributable to a storm, they are mitigation measures that can lessen losses that are indirectly associated with a storm. Examples of indirect losses include being out of business due to lack of water or sanitary services with the resulting loss of income to the owner and loss of tax revenue to the community. Loss of water and sanitary service can create health problems for the community that would otherwise not occur.

One of the more serious problems a community faces in the immediate aftermath of a hurricane is the loss of water, sewer, and communication systems. These utilities need to be back in operation so that other cleanup work can proceed. The provision of backup generators for water and sewer systems can lessen this problem by providing the electrical power to keep the required pressure in the main lines so that these systems are usable immediately following the storm. Backup generators provide the added benefit of keeping communication systems viable during the storm event itself. Such generators are not cheap. An order of priority based on costs may need to be assigned such as emergency communications, then fresh water supply and finally sanitary sewer system. All environmental issues need to be taken into consideration as well. The community water and sewer boards should have the necessary expertise. If such expertise is not available, the State or Federal environmental agencies are available to advise the community on any such issues.

Elevating Roadways and Bridges: Elevating roadways and bridges or otherwise protecting the viability of these facilities can guard these structures from damage as well as aid in the evacuation problems in the face of a hurricane. Similar to protecting utilities, these measures have benefits during and immediately following a hurricane. A constraint to the community's growth could be the ability to evacuate residents from new development. The elevation and/or protection of roadways and bridges could be of considerable effectiveness in eliminating such a constraint. Additionally, the non-federal share of disaster assistance is an amount up to 25 percent. Protecting roads and bridges from damage will reduce the costs to a community from a hurricane since the road or bridge will no longer need to be repaired, or if repair is required, it should not be as extensive.

Retrofitting Existing Structures: As stated previously, some retrofitting of structures can be relatively inexpensive, and well worth the effort. For structures on pilings, it may be possible to add clips and braces to prevent loss of the structure. This may also be true in the reconstruction of damaged portions of structures. The addition of shutters to glassed areas could prevent damage from wind blown debris. Once the structure has been breached, both wind and rain can damage the structure further. Elevating utilities can also prevent their loss due to flooding. These measures are things that individual property owners can do for themselves or contract for if a licensed contractor is required by local ordinance. They are items that can be made a part of building codes and construction standards for reconstructed structures and facilities.

The Design Manual for Retrofitting Flood-prone Residential Structures contains some unit cost considerations for several options that could be contemplated in the choice of which mitigation measures would be appropriate for coastal communities. Of particular concern for this study are the unit cost numbers for elevating structures in-place and the unit costs for relocating structures. This information is shown in Tables 4 and 5. By way of comparison, four case studies in South Carolina are also shown in Table 6. These case studies are for elevating structures in-place. Of note in the four case studies is the preponderance of costs for four items: Mobilization; Jacking and Moving; Move, Lower and Secure; and, Cleanup. These $13,000 costs would not be incurred in original construction. Additionally, only a portion of the remaining costs would be incurred in original construction. The cost of the slab could be incurred if the slab is to be used for parking or similar purposes.

The implications of the retrofitting costs are that they can be avoided, for the most part, by adhering to greater standards during original construction. They also have a bearing on post disaster reconstruction policies. These greater construction standards need to be in effect prior to the next storm for implementation in cases of substantial destruction, i.e., 50+ percent of market value, as well as for any new development.

Mitigating the potential damages to existing utilities, while in many cases expensive, could be budgeted to coincide with routine maintenance. When new utilities are being considered, the time to mitigate for potential damage is, of course, during construction. It is also important to have plans ready for implementation in the event of a hurricane. With such plans, it may be possible to obtain financial assistance through the provisions of the Stafford Act to reconstruct public utilities.

TABLE 4

Unit Cost Estimating for Elevation Projects
(1985 Dollars)

Item	Units	Unit Cost
1. Excavation	Cu. Yd.	\$3.00 - \$8.00
2. Boring for Lift Beams (Under Slab)	L. F.	\$125 - \$175
3. Jacking - Hydraulic	Ft.	\$300 - \$500
4. Cribbing Timber	Thousand Board - Ft.	\$800 - \$1,000
5. Concrete Reinforced in Place	Cu. Yd.	\$225 - \$300
6. 8" Concrete Masonry Units (CMU) Reinforced, in Place	Thousand (880 Sq. Ft.)	\$2,000 - \$2,500
7. 8" CMU - Unreinforced, in Place	Thousand (880 Sq. Ft.)	\$1,800 - \$2,200
8. Driving Pile (Timber)	Ft.	\$15 - \$20
9. Driving Pile (Concrete)	Ft.	\$20 - \$30
10. Steel Beams - Material Only	lb.	\$.50 - \$1.00
11. Sanitary Sewer Line 4"-6" in Place, buried or strapped to foundation	L. F.	\$4.00 - \$8.00
12. Water Service Line 3/4" - 1", Copper or PVC, in place, buried or strapped	L. F.	\$3.00 - \$6.00
13. Backfill	Cu. Yd.	\$3.00 - \$8.00
14. Seeding	Sq Yd.	\$1.25 - \$1.50

Source: Design Manual for Retrofitting Flood-prone Residential Structures, Federal Emergency Management Agency, September 1986.

TABLE 5

Unit Cost Estimating for Relocation Project
(1985 Dollars)

Item	Units	Unit Cost
1. Excavation	Cu. Yd.	$3.00 - $8.00
2. Boring for Lift Beams (Under Slab)	L. F.	$125 - $175
3. Jacking - Hydraulic	Ft.	$300 - $500
4. Steel Beams - Material Only	lb.	$.50 - $1.00
5. Moving Operation	Lump Sum $7,000 flat fee plus an apx fee of $500 - $1,500 for each mile over the first	Apx $5,000 -
6. Concrete Reinforced in Place	Cu. Yd.	$150 - $250
7. 8" Concrete Masonry Units (CMU) Reinforced, in Place	Thousand	$2,000 - $2,500
8. 8" CMU - Unreinforced, in Place	Thousand	$1,800 - $2,200
9. Brick, in place	Thousand	$120 - $180
10. New Lot (.2 - 6.0 acres)	Lump Sum upon local real estate market, conditions, lot size, and lot location	$2,000 - $22,000 depends
11. Water Supply (high range for individual well)	Lump Sum	$500 - $5,000
12. Sewer Hook-up (high range for septic tank	Lump Sum	$500 - $5,000

TABLE 5 (Cont)

Unit Cost Estimating for Relocation Project
(1985 Dollars)

Item	Units	Unit Cost
13. Sanitary Sewer Line 4"-6" in Place, buried or strapped to foundation	L. F.	$4.00 - $8.00
14. Service Water Line 3/4" - 1", Copper or PVC, in place, buried or strapped	L. F.	$3.00 - $6.00
15. Internal/External repair flooring, painting, etc. houses to 1,000 Sq. Ft.	Lump Sum	$3,000 - $5,000
16. Internal/External repair flooring, painting, etc. houses from 1,000 to 2,500 Sq. Ft.	Lump Sum	$5,000 - $15,000
17. Grading	Sq. Yd.	$150 - $250
18. Seeding	Sq. Yd.	$1.25 - $1.50

Source: Design Manual for Retrofitting Flood-prone Residential Structures, Federal Emergency Management Agency, September 1986.

TABLE 6

Four Case Studies from South Carolina, 11/02/89
Estimated Costs to Elevate Structure In-place

Item	Units	Unit Cost	Quantity	Amount
Items applicable to <u>all</u> case studies				
1. Mobilization	Lump Sum	$1,000	-	$ 1,000
2. Jacking and Moving	Lump Sum	$5,000	-	$ 5,000
3. Move, Lower and Secure	Lump sum	$6,000	-	$ 6,000
4. Cleanup	Days	$1,000	1	$ 1,000
		Sub-total		$13,000
<u>Case 1</u>: Jackings + Piles 8' above grade with 12' penetration into grade.				
1. Piles, Material	L. F.	$3.50	480	$ 1,680
2. Piles, by Jetting	L. F.	$2.50	288	$ 720
3. Misc. Bracing	MBF	$1,000	1	$ 1,000
		Sub-total		$ 3,400
		Total Case 1		$16,400
<u>Case 2</u>: Jacking + Masonry Piers 8' above grade and 4' below grade.				
1. Excavation	Cu. Yd.	$25	14	$ 350
2. Footings	Cu. Yd.	$210	4	$ 840
3. Masonry	Sq. Ft.	$3.50	768	$ 2,688
		Sub-total		$ 3,878
		Total for Case 2		$16,878

TABLE 6 (Cont)

Four Case Studies from South Carolina, 11/02/89
Estimated Costs to Elevate Structure In-place

Item	Units	Unit Cost	Quantity	Amount
Case 3: Jacking + Masonry Piers 4' above grade and 2' below grade.				
1. Excavation	Cu. Yd.	$25	7	$ 175
2. Footings	Cu. Yd.	$210	4	$ 840
3. Masonry	Sq. Ft.	$3.50	384	$ 1,344
		Sub-total		$ 2,359
		Total Case 3		$15,359
Case 4: Jacking + Masonry Piers 4' above grade and resting on existing slab.				
1. Additional Mobilization	Lump Sum	$500	-	$ 500
2. Masonry	Sq. Ft.	$3.500	256	$ 896
		Sub-total		$ 1,396
		Total Case 4		$14,396

SOURCES: Means Construction Cost Data, 1989

Wayne Overton, Pres. C. G. Leary and Sons,
Re: Jacking and Moving costs.

Ronald T. Strachan, P. E., Quible and Associates,
Re; Jacking, Piling and Moving costs.

Coastal Residential Construction Workshop
Construction Costs in Coastal High Hazard Areas
by James C. Patterson.

DEVELOPMENT MANAGEMENT

General Discussion: The development management mitigation measures are essentially nonstructural in nature. With these measures, the emphasis is on avoiding or reducing property damage by lessening the amount of property at risk. With the other two general types of mitigation measures, the emphasis was placed on reducing the risk of damage from severe storms or hurricanes by altering the coast so that the storm's ability to cause damage is lessened, or altering a structure's ability to withstand damaging forces.

Sometimes development management mitigation measures are referred to as "land use". These land use measures are meant to allow safe and sane use of high hazard areas. Some of the measures are aimed at having the user pay for the additional costs of providing public services in areas where the maintenance costs are more expensive than in the majority of the service area. Land use measures are criticized as increasing the costs of development. While there is some validity to such criticism, what generally occurs is that the cost of development is simply transferred from one parcel to another.

On the positive side of the ledger, development management measures frequently serve more than one objective. For example, areas of particular scenic beauty, wildlife habitat, or other special interest could be preserved through donation or purchase, some passive recreation could be developed if the area could withstand such pressures, and an area that was only marginally suitable for development due to soil conditions is left in its natural state for the enjoyment of the community and its visitors. With no development on the site, the next hurricane cannot cause much damage. Preserved areas may also be the reason that visitors to the community decide to return to the area, or decide that this is the kind of community in which they want to live in the future. Many of these development management measures can pay for themselves in terms of reduced long term maintenance costs associated with a specific capital improvements program, or the beneficial resale of property with restrictive covenants.

The effectiveness of these measures is estimated by the same method as the other two types of measures. In addition, some estimate of the impact on tax revenues and the tax base can also be usefully considered for these measures. The full range of the ramifications of these measures needs to be considered so that all of the impacts, both positive and negative, are fully considered. Interestingly, community planners and others who deal with coastal issues feel that development management mitigation measures are among the most effective ways to reduce or avoid property damage while simultaneously being among the least expensive. (ref. 30)

Since coastal communities are growing at three to four times the national average, it is forecast that by the turn of the century nearly 70 percent of the population will live or own property within 50 miles of the coast. People are moving to the shores, and no area of the coast can consider itself immune from severe storms or hurricanes. It is not a matter of "if" a storm strikes, but "when" a storm strikes.

Recently, the disaster assistance laws were amended. The non-federal share of disaster relief was held at 25 percent, but an attempt was made to increase that non-federal share to 50 percent. There simply is not enough money in the Federal treasury to pay for recurring damages. The general thrust of the changes in disaster assistance is to be generous to those communities that are trying to help themselves, and to be less generous to those communities which do not seem willing or able to mitigate their recurring damages.

For the past few years, one of the requirements of disaster assistance has been the preparation of a plan to mitigate future property damages. Funds are now available to help communities implement those plans. Future disaster assistance may be conditioned on the extent to which the community has implemented these hazard mitigation plans.

While the items listed under development management are generally of more value in preventing or avoiding damages to future structures than to present structures, there are benefits that can accrue to present structures in the form of minimizing recurring damages to those structures. The appropriateness of these measures for any community is determined by the circumstances with which the community is faced. The use of these measures should be to effect small specific changes that are tailored to meet specific goals or objectives. Since the community will face a wide range of different conditions, the community needs a great deal of flexibility in dealing with similar, yet subtly different, problems.

Development management mitigation measures offer that flexibility to a far greater extent than strengthening the coast or shore. They also offer the ability to alter the measures as conditions change, something that cannot be done with a seawall. Combinations of these measures will usually be more effective than using them in isolation from other measures. With planning, it is possible to combine the use of these measures with other community goals and objectives such as economic growth of the community, recreation development, and conservation or preservation of sensitive environmental areas of the community. Many of these measures could be used in combination with the other two categories of measures.

Of signal importance in the use of these type measures is the consistency with which they are applied. It is entirely possible to develop the use of these techniques so that potential opponents to their use actively support them. Of concern to many developers is the uncertainty associated with the application of development management measures. They are rightly concerned that an unfair advantage is not given to their competitors. When considering the adoption of these kinds of mitigation techniques, the long term viability of the community is more important than the near term. For many communities, many of these measures are already in use for other reasons. It then becomes a matter of adding storm hazard mitigation as one of the items that is considered in the decision to invest public monies in some project such as the extension of water/wastewater services.

Planning: Planning is the first item listed under development management. Chapter 3 is devoted to the general planning process. The importance of planning, however, is such that it is also listed as a mitigation measure in and of itself.

The decision to use any of the hurricane mitigation measures should be based in large part upon planning. Planning or preparation begins with the formulation of goals and objectives. As a part of establishing a community's goals and objectives, a careful review of existing programs and policies should be made. It may be much easier to adjust existing programs that may not be working quite as well as desired than to institute new policies or programs. In addition, the existing policies and programs are expressions of important historic community goals and objectives. When formulating community goals and objectives, it is important to keep in mind the interrelatedness of natural hazard mitigation planning and other governmental actions. Through the effort of establishing goals and objectives, it should become apparent that natural hazard mitigation planning is related to many of the endeavors that any community undertakes. While the planning department may take a lead role in the effort, there is much that all departments of a community's government can do to contribute to the effort. It is also important to remember that the actions of one governmental department probably have some bearing on the actions or responsibilities of other departments. Thus, coordination between departments can become crucial to achieving the established goals or objectives.

Depending upon the nature of the community goals and objectives, consideration should be given to establishing a public involvement program. Most hurricane property damage mitigation measures revolve around some form of land use planning. General community consensus on the goals and objectives that a community decides to adopt could enhance the ability to adopt particular land use measures which achieve those goals and objectives. As an example, it may be an objective to create a public park near the beach. Public acquisition of the property in a high hazard zone would prevent future property damages in that area since some other use such as residential or commercial is precluded. The land use of a public park in this high hazard zone would be more compatible with the hazard than other land uses would be.

A community's future economic well-being is certainly a serious concern that should be jealously guarded. Hazard mitigation planning is one way of preserving the attractiveness of the community while simultaneously planning for the orderly growth of the community's economic health.

The point of establishing community goals and objectives is the recognition that natural hazard mitigation planning need not be a stand alone issue, but that the benefits of reducing property damages from natural hazards in the future can be achieved in concert with other worthwhile community endeavors.

The City of Nags Head, North Carolina, found itself growing in ways that were not exactly as wished. So it surveyed the residents to find out what kind of community was really desired. It found that 90 percent of the residents wanted the town to retain the family oriented recreation resort atmosphere that it had always had. Armed with that information, it was a relatively simple matter to adopt a package of mitigation measures that are accomplishing the goals and desires of the community. One of the center pieces of its mitigation package was not allowing multiple family dwellings to front the beach. That area was reserved for single family structures. There were other problems that were also addressed, such as adequate evacuation routes and the siting of other public facilities. The point is that the community took the time and trouble to find out what was really desirable and then acted upon those desires.

This investigation of the wishes and desires of the residents of the community accomplished several things for the community. It ensured broad acceptance of the package of mitigation measures before they were proposed. The community took control of its own future by deciding what kind of future was desired. Since it is not practical to accomplish everything all at once, future decisions can be guided by the framework of the long term goals and objectives.

It is axiomatic that the future will occur regardless of the amount or degree of planning that takes place. With planning, the community is prepared to take advantage of opportunities as they occur and even to "create" opportunities. Elected community officials are responsible for protecting the community's health and welfare. For these reasons, planning to reduce or avoid the damaging effects of tropical storms is an appropriate undertaking.

The explicit recognition of any or all hazard mitigation can be made a part of the community's long range goals and desires. Any community that has suffered a devastating storm knows the difficulties that follow on the heels of such storms. Yet, there are opportunities to improve the community's ability to respond to the damaging effects of storms that can very easily be lost because the community was not prepared to take advantage of them as they occur, the so-called windows of opportunity. In the rush to "return to normal" the community may find itself rebuilding in exactly the same fashion that it was built in the first place. It may well be that these patterns of development were in large part responsible for much of the damage. Policies for the redevelopment or reconstruction of the community need to be prepared before the next storm. Those windows of opportunity are open for a very short period of time, and the time to plan the redevelopment of a community is generally not adequate immediately following a hurricane.

The redevelopment and reconstruction of a community following a storm can be one of the most trying times a community can face. There are a wide variety of issues that must be faced. The prior establishment of policies, standards, and rules that will be followed will help the community find its way through this period. A program of public debate on the policies, standards, and rules that will be followed is indispensable. Most citizens will respond well in such situations when they know what the rules are and particularly when they were afforded the opportunity to help shape those rules and standards.

Some reconstruction and redevelopment policies are based on the amount of damage that was sustained in the storm. The determination of the amount of damage can be a most difficult task to perform. Policies on the reconstruction and redevelopment of damaged areas of the community will be far more palatable and easier to administer if the policies receive wide community support before adoption and if provisions are made to have the expertise available to make the necessary decisions. A cooperative arrangement with other communities to share qualified staff can aid in making these decisions. Prior arrangements with local architecture and engineering firms are another way of insuring that the community will have the necessary expertise when the need arises.

Rules about the priority that is placed on the permitting of reconstructing damaged structures could be minor damage first, moderate damage next, and a longer waiting period for structures that received major damage. Other criteria could be imposed on reconstructing buildings that received major damage such as reconstructing to current code, or reconstructing to the same or lesser density or intensity of use. Such policies should be of a general nature that apply to some area of the community and not to individual structures so that legal battles over uncompensated taking of property can be avoided.

In hurricane mitigation, the first priority should be given to the protection of life. Preparations for the safe and orderly evacuation and sheltering of the citizenry are necessary since this process will not occur of its own volition. The future must also be considered. Development management measures are intended to place a community in a posture so that the protection of life is always assured to the extent that it can be.

Uncontrolled growth can jeopardize the best laid plans by overloading the systems. There are mitigation measures that can help to defray the costs of keeping those systems from becoming overloaded, such as impact fees or a capital facilities program. Foresight in the acquisition of property for public thoroughfares or the placement of public utilities can save tremendous expenditures of public funds in the future when expansion of the facilities is required to accommodate growth. In the planning stages for community growth, a mapping program is indispensable.

Once the community's goals and objectives are established, the next step is to decide how they will be accomplished. An indispensable aid in making those decisions is a good mapping program. Before most planning can begin in earnest, the planners must have a clear picture of the physical environment with which they will be dealing. Without such a picture, it is possible that well intended efforts will become mistakes.

Maps should cover the areas of concern at a scale that is usable. Maps should include topographic data. Contour lines at one foot intervals should be considered. A beach profile should be made. Maps could show the locations of all major structures. Such data as water and sewer lines could be added to a base map as an overlay. In addition to mapping the existing condition of the near shore environment, the community archives should be consulted to obtain information about historic shorelines and how the shoreline has changed in response to storm events. Resources permitting, offshore conditions should be researched. A map maintenance program should also be instituted. Such a program could include a high school class project to measure the beach after particular events. These events should not be restricted to hurricanes, since any severe weather event has an effect on shore processes. If it is not already available, it may be prudent for the community to hire specific expert advice, such as a coastal geologist or engineer with experience in coastal processes.

A good mapping program could entail identifying areas of risk, an inventory of existing development and an analysis of the vulnerability of existing and future development to various risks. It is this knowledge that can demonstrate where and which development management measures will be most effective. The lack of such detailed knowledge can lead to inappropriate imposition of development management measures even with the best of intentions. For many communities, the services of consultants for a mapping program will be necessary. Such assistance may be available from State government or regional planning agencies. In other cases, communities can join forces with their neighbors and the county to accomplish these ends. Cooperative arrangements among communities and counties for a mapping program can also foster cooperative arrangements in other areas such as sharing resources in the aftermath of a storm.

Capital Facilities Program: A capital facilities program can also mitigate damages to future development by encouraging the orientation of that development into areas of least hazard. Such programs will be less effective in situations where the development is not dependent on the provision of public utilities such as water. But the amenities of an area such as schools, hospitals, and shopping are important considerations in the selection of a new home. To the extent that a community can encourage new development into areas of least hazard, the damages sustained in the next storm will be minimized.

In situations where extensive damage has been suffered in a relatively large area of the community, the capital facilities can be reoriented so that the redevelopment of the area can occur in a manner that will render the area less susceptible to recurring damages. Under the new disaster assistance laws, there are funds available that can help the community accomplish these ends.

Taxation - Fiscal - and Other Incentives: Taxation, fiscal policy and other incentives can be used to encourage or discourage development in high hazard areas. They can be combined with other measures such as a capital facilities program to help encourage development into less hazardous areas. Variable taxation rates are established in most communities based upon the type of development such as residential, commercial or industrial. This highest and best use principle or preferential taxation can be extended to include consideration of the hazard of storm damage.

The community is responsible for the protection of the welfare of the citizens. High hazard areas require a greater public expenditure for that protection than other areas where the dangers to life and property are not as great. These kinds of measures can be used to fund community services such as evacuation planning and sheltering. For example, in Lee County, Florida, State law provides that the county may levy up to 1/2 mil to fund programs for hazard mitigation or emergency preparedness. The issue should go before the county commission this year. The proposed program has four main objectives. The first is to provide for hazardous material response. Funds would be used for personnel, equipment and training. The second objective is to upgrade shelters for the frail and elderly as well as upgrading shelters for the general public. Included in this objective are generators for shelters, bus transportation and public education. The third objective is to establish an emergency contingency fund. These monies would be used to match State and Federal disaster assistance. The fourth objective is to establish a fund to be used to acquire property that is damaged by a storm from willing sellers.

The community can decide to impose differential impact fees for utility service based upon the likelihood of damage to those utilities from storms and the resultant costs of repair. These incentives can also have the benefit of preserving high hazard areas in their natural states by establishing a value of the site to the community and then taxing that site accordingly. Where the market price of undeveloped land is high, the use of differential taxation may not be particularly effective at keeping undeveloped property in its natural state. Taxation policies would need to be used in conjunction with other development management measures to be effective. Programs such as these can also be a source of revenue to fund other programs such as additional staff or training for the building inspection department.

The community can adopt mortgage standards that are administered by lending institutions. These mortgage standards can require that hazard insurance be maintained for the duration of the mortgage. The National Flood Insurance Program has such requirements, which can be supplemented by the community.

There are costs to the community associated with these mitigation measures that need to be considered before such measures are adopted. The availability of less hazardous property within the jurisdiction that can be developed is of paramount importance. The ability to leave the jurisdiction where such taxation policies are not in effect may also impact the effectiveness of such programs. Such arguments are important in the decision to adopt these mitigation measures. But the temporal nature of such arguments also needs to be considered.

While it may be true that such taxation policies may drive some development away from the community, it may also be true that sufficient pressure for development exists so that these policies can encourage the kind of development that is "right" for the community. The establishment of long term community goals and objectives together with a good mapping program should help a community decide whether taxation or other fiscal policies will be of benefit to the community in achieving those goals and objectives. The growth of a community means that the complexion of the community will change with the passage of time. The real question may be the willingness of the community to wait for the desired development to occur.

Development Regulations: Development regulations are among the most effective of the development management mitigation tools that a community can adopt. These tools are a natural extension of programs to determine the long term goals and objectives of a community and of mapping programs that determine where the more vulnerable areas of the community are located. The employment of development regulations is intended to allow the wise development of land and not the prohibition of development.

There is nothing new about zoning or subdivision regulations. They are used by communities to determine what kinds of development are compatible with each other. In many communities it is not possible to erect a store or factory anywhere an individual may desire. There are any number of tools that can be used to prohibit particular types of development in various locations such as permit requirements for water and sewer connections or mandated provision of adequate parking. These tools are nothing more than land use controls for the general welfare of the community.

Subdivision regulations are in the same vein. It is not uncommon for subdivision regulations to require that all of the houses in the subdivision be of a certain size or setback from the street by some distance. These regulations are intended to support the general value of all of the parcels in the subdivision. For reasons of traffic control, apartment complexes can only be developed where the street system can withstand the increased amounts of traffic that would be generated by an apartment complex at that location. Hazard mitigation can be made one of the important considerations in the determination of what types of development are appropriate in specific areas of the community, such as the location of shopping centers, industrial property, recreation facilities, community centers, schools, hospitals and residential neighborhoods. The appropriate configuration of these structures can be predetermined in subdivision regulations that accompany zoning ordinances. These tools can be tailored to fit the peculiar circumstances of geography or soil conditions.

Other considerations can include the physical ability to expand the street system to handle the traffic loads if and when a general evacuation is required. The degree of development and consideration for the long term will in large part dictate the degree of sophistication a community may feel is necessary or appropriate for their situation. Some of these tools can be quite sophisticated such as incentive zoning or conditional/contract zoning, or floating/sliding scale zoning. The three special types of zoning mentioned above are modifications to conventional zoning ordinances. They entail negotiating with developers for an allowable variance to conventional zoning provided the developer performs some service to the community. Extreme care should be exercised before any of these measures are adopted due to the legal ramifications that can occur with their use. Some of the forms that these zoning techniques take have been judged to be spot zoning which usually will not stand the test of a legal challenge.

In Lee County, Florida, a recent case concerning a rezoning of property on a barrier island from commercial to single family residential was decided in the county's favor. The court found that the zoning board was appropriately concerned with limiting the effects of future commercial development on the island in view of legitimate environmental concerns, public safety concerns, and concern for preserving the island's aesthetic, historical, and archeological characteristics.

Site review of proposed developments can be very valuable in avoiding or minimizing damage to existing and future developments. How a building is oriented on a piece of property can make a difference in its ability to resist the forces of a hurricane. A limited surface area exposed to the direct onslaught of the wind could make a small difference in the degree of damage that could be expected. The shape of the roof can also play a role in reducing damage to buildings.

Post storm damage surveys have shown that such developments as finger canals or road ends where dunes are not protected by crossovers are responsible for considerable damage to adjacent properties. Surge overwash can become concentrated in these areas because they are paths of least resistance. These kinds of development were initially constructed as amenities to induce investment in adjacent properties. Site review of such developments can be very useful in avoiding the worst of these mistakes. In some cases, all that may be needed are slight modifications in the orientation of finger canals to lessen the likelihood of increased damages.

Density and intensity regulations can be used to avoid damage to future developments. Density refers to the number of structures that will be permitted to the acre, while intensity refers to the number of dwelling units allowed per building. Obviously, the lower the number of buildings per acre and the lower the number of dwelling units per building, the lower the total damages that can be expected in the area. While these regulations would be immediately available for undeveloped property, they can also be very useful in redevelopment situations. A reconstruction policy for areas following a hurricane should not overlook the value of including this useful tool. The entire character of a community can be altered following a storm if an area of single family houses is destroyed by a storm, purchased by a developer, and redeveloped with multiple family apartment or condominiums. There is nothing to say that such a situation is necessarily undesirable. A community should be aware that such redevelopment does happen.

Local or State sponsored construction setback requirements can be used to mitigate property damage. Most State sponsored setback requirements are for the water side of a piece of property, while locally sponsored setbacks normally deal with side yard distances and street front distances. The water side setbacks are instituted to deal with the naturally occurring coastal erosion problems. The side yard setbacks are designed to create space between buildings. The street front setbacks allow for safe entering and exiting the street as well as utility rights-of-way.

For property damage mitigation purposes, the coastal setbacks are the more important of the three. These coastal setbacks take the naturally occurring erosion rates, and mandate that no structures can be built forward of some line. This in turn means that structures will not succumb to erosion damage in their useful life as well as providing the land area that may be needed to restore a protective dune system. Most coastal States have some form of a setback law governing construction in beach areas. These laws generally take one of two approaches to establishing the setback requirements. One method is to multiply the annual erosion rate by some number of years. The second method is to move back some number of feet from a benchmark such as mean high tide or a dune line. South Carolina is one of the most recent States to adopt a coastal setback law. Its setback law has come under legal attack as an inverse condemnation. The courts have, as yet, to fully decide the issue.

Provisions of the Housing and Community Development Act of 1987 amended the National Flood Insurance Act of 1968. These provisions, known as the Upton/Jones Amendment, expand coverage under the NFIP to include payment of claims from owners of buildings that are subject to "imminent collapse or subsidence as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels" so that the building can be relocated or demolished, at the policyholder's option, before the damage occurs. Ownership of the land on which the demolished or relocated structure was located remains with the owner of the structure, and it is not transferred to the local government for public open space usage. Structures can be erected on this property, and they can be insured if they are sited behind an erosion setback line acceptable to FEMA. This program is intended to get development out of high hazard areas before it is damaged by a flood.

Another development regulation that is most useful in mitigating property damage is protection of the dune system. The coastal setback criteria provide the land area for dune systems, while protection of the dunes does not permit construction in the dune area that would be harmful to the longevity of the dune system. Dune protection regulations can set standards for crossover walkways so that beach users can reach the beach without trampling the very fragile vegetation that holds the dunes together. These regulations can also specify vegetation species, how sand fencing and other measures that aid in the restoration of dunes should be planted, built, and maintained.

A community may find that dune protection measures are more usefully applied to commercial property that depends upon tourists rather than for permanent residents, since the latter group may be more aware of the fragile nature of the dunes.

Planned unit developments offer a great deal of flexibility to both the community and the developer. These projects are usually sizable projects that encompass several acres. The normal zoning and subdivision regulations are followed in the generic sense, but some flexibility can be built into the design of the overall development, such as allowing the clustering of dwelling units on the more suitable sections of the parcel. Mixed uses can also be permitted. The design is negotiated with the developer and the final design is reviewed by the community. For the community, the provision of public services may be less expensive than it would be if the entire area was developed in a piece meal fashion.

As can be seen from the discussion of these development regulations, the majority of the benefit to the community for property damage mitigation will be for future development. These strategies would have little or no effect on existing development. However, the same strategies for future development can also be made to apply to areas that receive substantial damage from the next storm. These areas will need to be redeveloped or reconstructed. Zoning ordinances and subdivision regulations can be adopted that would become applicable in the event of substantial damage or destruction. Such strategies would need to be planned and developed before the next storm so they are available for use in the immediate aftermath of the next hurricane.

A temporary moratorium for reconstruction could be imposed which would give the community the necessary time to make damage surveys to determine which areas should be redeveloped in priority order. The medical concept of triage can be very valuable in establishing an order of priority for redevelopment. Some of the strictures contained in the National Flood Insurance Program could be used as a guide in establishing a triage program. Basically, the triage concept means that minor damage that amounts to less than 25 percent of the structure's market value will be permitted to be repaired first, moderate damage that amounts to more than 25 percent but less than 50 percent of market value would be permitted next and major damage that amounts to more than 50 percent of market value would be permitted to be repaired last.

Reconstruction of moderate or major damage could be permitted only if certain standards are met, such as current building codes or setback lines. Density restrictions could also be imposed in redevelopment areas as well as any other restrictions that would preserve or desirably alter the character of those portions of the community.

Redevelopment policies will be extremely difficult to administer if they are not designed and adopted with broad public support before the next storm. The intention of redevelopment strategies is to ease the administrative burden of permitting the repair or replacement of damaged structures following a storm at a pace that the community can manage.

Broad public support of redevelopment strategies would greatly reduce the conflicts that would arise where residents might feel that they were being treated in some arbitrary fashion. Engendering a feeling of having had a part to play in the planning and design of the rules that will be followed in the aftermath of a severe storm could substantially reduce the feelings of arbitrary treatment on the part of the impacted residents. This in turn, makes the administration of redevelopment strategies or the "return to normal" that much easier, smoother, and faster. Everyone involved with the reconstruction of devastated areas of the community can feel good about a job well done.

There are costs associated with the employment of these tools such as hiring the staff to plan, design, implement and enforce the development regulations. The argument of increased costs of development may not be as persuasive as it seems at first blush. What may occur, however, is the shifting of costs of development from one parcel to another. There can be some thorny legal issues involved in the employment of development regulations that center around the issue of acquisition of property rights without just compensation.

Carefully crafted development regulations that consider these difficulties need not encounter such problems. If the adoption of development regulations is a new undertaking for a community, the budgetary provision of funds to defend such development regulations may prove to be a prudent safeguard.

Land and Property Acquisition: The acquisition of a real estate interest in property is a mitigation measure in itself. There is a wide variety of real estate interests that a community can acquire which presents the community with a great deal of flexibility in using this mitigation tool to avoid or reduce damages to property. Hurricane damage mitigation can be one of many reasons for acquiring an interest in a piece of property. Just as there are many types of interests that can be acquired, there are a variety of means that can be used to acquire those interests.

Property in high hazard areas can be purchased in fee simple. The community is then in the position of using this property for public uses such as parks or access to the beach. Easements or less-than-fee-simple acquisition can also be used for public access to the beach. The high hazard areas can be purchased, resold with restrictive covenants and still achieve the mitigation goals. A system of development rights can be established so that restrictions can be placed on the development of the property, yet the property can still retain a marketable value.

The value of relocating structures from high hazard areas should not be overlooked. While there is some expense involved in the relocation process, the community may find itself in an advantageous position in the sense that property will not be damaged by severe storms, the vacated land can be used for other purposes which may have some value to the community's tax base, and the land to which the structure is relocated may shift from a lower to a higher use which could also increase the tax base and tax revenue of the community. The previously mentioned Upton Jones amendment is another method that can be employed by individuals to help defray the costs of relocating structures that are in imminent danger of collapse.

Other forms of land and property acquisition are donations, exchanges or foreclosures on tax delinquent property. As with any of these acquisition programs, the prime objective does not have to be mitigating property damage from storms. Estimating the effects of property acquisition on the community's tax base and tax revenues should be a relatively simple task.

The appropriateness of such measures will depend upon circumstances such as the degree of existing development or the amount of existing public parking and beach access. Designing a system for the transfer of development rights may resolve some difficult problems associated with taxation or other fiscal incentives, but it can create difficulties of its own. Such a program would require extensive preparation and knowledge of local land development trends so that the market can establish appropriate prices for the development rights and so that property buyers and sellers are fully familiar with what they are buying and selling.

Some property may become available for purchase immediately following a storm at lower than normal prices. These situations may present some opportunities that a prepared community could use to its advantage.

Information Dissemination: One of the principle assumptions upon which modern economic theory rests is that of knowledgeable buyers and sellers. The provision of knowledge concerning the risks of damage from natural events associated with living in close approximation to the coast can help mitigate those risks. Requiring the disclosure of hazard information during real estate transactions helps to create knowledgeable buyers and sellers.

When that information is provided can be critical in a decision to consummate a real estate transaction. Information about hazardous conditions associated with particular parcels of land could be recorded on deeds or subdivision plats. In Florida, rule 9J-2.0562 of the Florida Administrative Code requires the recording of hazard information on deeds for property that is included in Developments of Regional Impacts. The prospective buyer is entitled to know, before purchase, that the property is located in a hurricane hazard area.

Some hazard information could be posted on public signs in high hazard areas, such as a small sign which states how high the surge from a specific category of hurricane is expected to reach at the sign's location. Such signs are being posted in the Gulfport, Mississippi area.

Knowing where that kind of information is readily available is also an important consideration if it is to be used in a prudent manner. The dissemination of timely and accurate information can make a critical difference in emergency situations. In many coastal communities, the local press, radio and television media actively disseminate information about the dangers of hurricanes and provide much useful information about the course of action residents and visitors should take if a hurricane strike is imminent. Most of these programs are aimed at the preservation of life, but could be expanded to include information that property owners and prospective property owners would find useful in preventing damages to their property.

Education is an area where many opportunities exist for communities. The community's building inspection department could establish a program for the local grade school where officials go to the school and talk to the children about the kinds of things that homeowners could do to make their homes more wind or water resistant. Such a program could be patterned after similar programs put on by the fire marshal to teach children about fire safety.

Once a building has been inspected, the community may have exhausted its authority. Minor modifications can be made to the structure, such as removing a brace or two to accommodate some useful addition, or hurricane straps can become corroded. Children can be very helpful in looking for such minor changes. If a child can spot such things, it may be very likely that they can be repaired at a very modest cost.

In the event of a severe storm, however, the claims adjustor will take into account all additions to the structure since it was inspected and certified to be in compliance with the National Flood Insurance Program. If some of the modifications alter the structure so that the lowest elevated floor has changed, e.g., there is more than 300 square feet of enclosed space below the lowest elevated floor, then the claim can be adjusted to reflect higher premiums that should have been paid based on a lower elevation for the lowest elevated floor.

Training of building inspectors, developers, contractors, and other community officials who deal with planning and regulations can be a very effective adjunct to adoption of building codes and construction standards. This is a means of keeping these people abreast of the changes and improvements in codes and standards, and aiding in the design of buildings that are more storm resistant. Hurricane resistant construction is significantly different than conventional construction. Substantial attention must be given to details, particularly connections that are rarely considered in conventional construction. Many coastal builders and inspectors do not clearly understand the differences between the two types of construction. Through educational opportunities inspectors, builders and others can develop a clear understanding of the details of hurricane resistant construction.

One of the lessons that can be learned from our experiences with Hurricane Hugo is the need to fully understand the flood plain management regulations that communities must adopt to be eligible for the benefits of the National Flood Insurance Program. An educational mitigation measure that was employed in the South Carolina coastal area devastated by the storm was a series of workshops for architects, engineers, contractors, building officials, homeowners, and other interested parties. The workshops were designed to provide information on the intricacies of the program's requirements. There were a tremendous number of buildings which were substantially damaged, i.e., more than 50% of their market value. These buildings must be reconstructed in compliance with current standards to meet flood plain management regulations. The workshops were designed to provide that information to all involved parties so that the requirements of the current standards could be met.

While these workshops were hosted by a local home builders association, a community could establish a program on an annual basis to provide the same information for its building officials, general contractors, and other interested parties. These workshops could be done in conjunction with a Community Assistance Program visit from the Federal Emergency Management Agency or by requesting FEMA to participate in a special session. The majority of the speakers at the South Carolina workshops were from that agency. Both the insurance and the mitigation aspects of FEMA's program should be covered in workshops of this nature.

The community could adopt a program to provide property owners with an inspection of their building to help them improve the wind resistance of the structure. This kind of program could be expanded to include certifying and endorsing contractors who practice good building standards much like some utility companies certify and endorse contractors who build energy efficient structures. A peer review of new developments can also aid in designing stronger buildings while it shares knowledge about such designs. The peer review should cover both the structural engineering and the architectural aspects of the design, particularly where the foundation and frame of the building are designed by one group and the roof, windows, and cladding are designed by another group. The cost of peer review could be included in the cost of a permit to build.

A community could also adopt homeowner association programs where these groups take some responsibility for informing themselves and new residents about preparing for tropical storms, evacuation routes, ways of strengthening their structures so they are more wind resistant, and other self-help measures. These groups can also render valuable assistance in formulating community goals and objectives and in choosing mitigation measures that will achieve those goals and objectives.

CHAPTER 3

PLANNING PROCESS

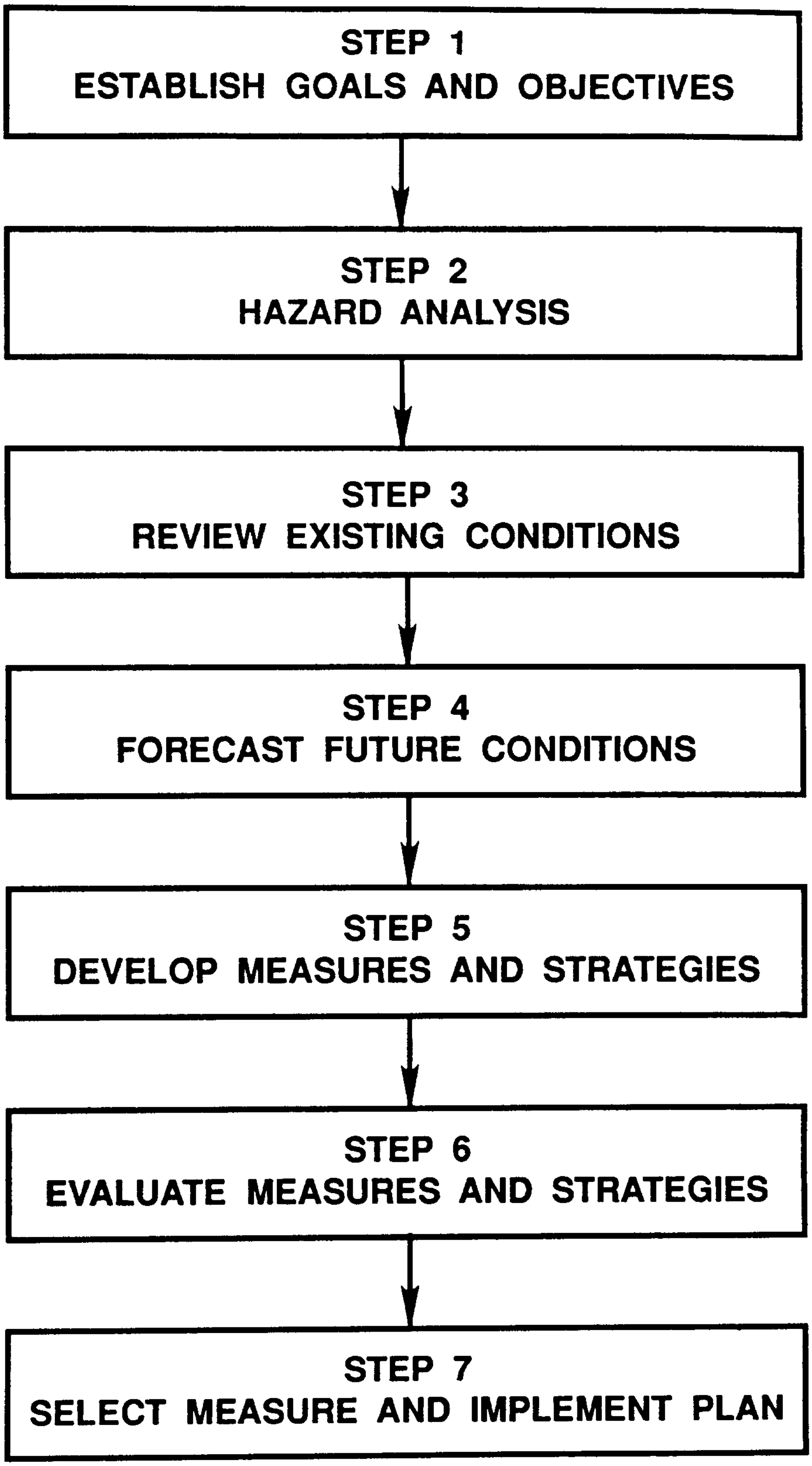
This section of the report deals with the general planning process that any community can follow in its deliberations on selecting mitigation measures appropriate for it. From the discussion of the mitigation measures, it should become evident that many departments within the local government and the general public have contributions to make for the successful development of a property loss mitigation plan. A flow chart showing the seven steps of the general planning process is provided at Figure 2.

Perhaps the first decision to be made is the selection of some individual to be responsible for developing the mitigation plan. Timetables for completion of the plan need to be established as well as a budget. The manager will also need technical support from several departments such as engineering, public works, finance, community development, recreation and legal. The person given the responsibility for the plan may be from existing staff or a consultant.

There are seven steps in the general planning process. Each step has some dependence on the preceding step. The entire process is sometimes referred to as the iterative planning process, since results in the latter steps may necessitate revisions or additions to the earlier steps. The beginning two steps can be interchanged. Some have suggested that a hazard analysis be the first step performed while others suggest that the community's goals and objectives be established first. Both steps are vital, but the order is not particularly important. In many cases, both steps are performed several times before they are finished.

STEP 1: ESTABLISH GOALS AND OBJECTIVES

The process can begin by deciding what is to be accomplished by the undertaking. Establishing the community's goals and objectives is one of the major items of work that must be done. The eventual acceptance and success of the plan largely depends upon clearly defining the desires of the community. Many communities have already completed this task as part of their comprehensive development plan or it can be done as part of this planning process. In defining the community's goals and objectives, it would be helpful to include the general public in the discussions. This can be done by holding public meetings, household questionnaire surveys, or selecting a citizens advisory group. The goals and objectives need not be confined solely to mitigation of property losses from hurricanes. Other areas such as the community's economic well-being, provision of parks and recreational facilities, protection and enhancement of the natural environment, and extension of public services to undeveloped areas can all be subjects for discussion. At first, the goals and objectives should be fairly broad, but not so broad



GENERAL PLANNING PROCESS

Figure 2

that they do not provide direction for the remainder of the planning process. As the plans are being developed, the broad goals and objectives can be refined into more specific desires. Some goals and objectives may be in conflict with other goals and objectives. For example, development along the beach road may exceed the capacity to evacuate within reasonable times. Limiting such development to achieve reasonable evacuation times may conflict with economic development and the additional tax base derived by such development. However, the developer could be required to expand the capacity of the roadway to accommodate increased traffic generated by the development.

Some definitions may need to be established so that meaningful measurements can be made. For instance, how safe is safe enough? Care should be taken, however, that some options of mitigation are not automatically discarded because of the definition of the problems to be resolved.

STEP 2: HAZARD ANALYSIS

The second step in the planning process is to conduct a hazard analysis. The previously completed evacuation studies have maps depicting the areas subject to tidal surge inundation. The Flood Insurance Rate Maps show areas subject to coastal and riverine flooding. The hazard analysis need not be confined to coastal areas. Hurricane force winds extend many miles inland and can do extensive property damage. Strategies to mitigate coastal flooding could be just as effective mitigating riverine flooding. Strategies to reduce wind damages in areas subject to hurricane surge tides could be just as effective combating wind damages in other areas. Planning safe development in coastal areas may mean that some development should be located in noncoastal areas. Other hazards can be considered as well since the allowable locations of those sites can have a bearing on development in coastal areas.

Understanding the coastal processes is also very important. Most development will have a long life. Currently, residential buildings are expected to last at least 70 years. That means a building will probably be faced with a hurricane one or more times in its lifetime. More importantly, long term erosion could result in the eventual loss of some developments that may appear to be quite safe today. The NFIP standards are incorporating consideration of erosion in coastal areas as rapidly as possible. The loss of the beaches also means that development closest to the water will be even more vulnerable to tidal surge with the passage of time. Regardless of the kind of mitigation measure adopted for these areas, they should be tempered with a knowledge of the dynamic nature of the coastal environment and a view toward the long term.

The hazard analysis should include consideration of the number of people that are at risk from various hazards. The analysis should also concentrate on the amount, type, and location of property at risk and the kinds of damage to each that can be expected from various scenarios.

STEP 3: REVIEW EXISTING CONDITIONS

Once the hazard analysis is complete, a review of mitigation measures taken in the past should be made. This should be done for two reasons. First and foremost is an examination of the effectiveness of the measure. Perhaps that examination will show that the past efforts have been very effective or that only small alterations need to be made to make them even more effective. Politically, it could be far easier to modify some measure that has worked well in the past than it is to adopt a new strategy. Additionally, the existence of past mitigation measures could indicate what the past goals and objectives of the community were so that a sense of continuity can be preserved. It is also possible that the examination will show that past measures did not work or that the goals and objectives they represented are no longer appropriate to the community.

The second reason to examine past mitigation measures is to establish some baseline against which to measure the probable effectiveness of additional mitigation measures. It is possible that several mitigation measures have been taken in the past that were not recognized as being mitigation measures. This examination can also have beneficial effects in connection with the new community rating system being implemented by the Federal Insurance Administration as an integral part of the National Flood Insurance Program.

STEP 4: FORECAST FUTURE CONDITIONS

The fourth step in the planning process is to forecast future conditions. Again, it should be noted that the end result of this planning is a set of development management guidelines to follow in the long term development of the community. In analyzing the effectiveness of some of the possible mitigation measures, it may be important to "know" what the future will be. Some assumptions may have to be made concerning the amount of development and/or the rate at which it is likely to take place.

One of the arguments that is made against the development management type of mitigation measures is that if some control of the type of development is exercised, that development will take place in areas where control is not exercised. One of the reasons cited is the increased cost of development, so profits earned are reduced or zero. Such arguments are only partially true. The legitimate concern of developers is the arbitrary nature of the imposition of some measures that control the nature of development. What is desired by developers is that an economic advantage not be granted to one developer at the expense of another.

STEP 5: DEVELOP MEASURES AND STRATEGIES

Deciding what the future is likely to be naturally leads to the fifth step of developing plans or strategies to mitigate the potential for property damage. One of the main objectives of this report is to outline the various mitigation measures that are available to the community. Each of the mitigation measures should be seriously considered. Some can be quickly discarded as they clearly do not address the particular hazard, or are obviously too expensive, or are otherwise inappropriate for the community. Other mitigation measures are complex and may need to be researched further to understand fully how they would work or how they should be implemented. None of the measures should be discarded until the community understands what is involved with that measure. At the very least, some qualitative estimate of the effectiveness and/or appropriateness of each mitigation tool should be made.

At this stage it should be decided which mitigation measures are to be analyzed in greater detail. The selection of a measure or measures to implement will be made after detailed analyses. The views of the general public would be helpful in focusing on those mitigation measures which will be subjected to closer scrutiny. Without such involvement from the general public, it may be difficult to generate the needed support or acceptance of the plan in order to get it implemented. With a citizen's advisory committee, this vital information is being furnished to the planning staff on a routine basis.

STEP 6: EVALUATE MEASURES AND STRATEGIES

The sixth step in the planning process is to evaluate the various strategies that the community is considering to reduce the potential for property damages from hurricanes. Evaluating the effectiveness of the mitigation measures can be a difficult task. A second major objective of this report is to demonstrate how to estimate the effectiveness of various mitigation measures. A computer spreadsheet has been developed to enable communities to estimate the potential for property losses. That spreadsheet program can make those estimates based upon several different sets of circumstances. With that capability, an analyst can estimate the difference between existing conditions and some future condition and thereby estimate the effectiveness of the various mitigation measures. If the criteria for the measurement of the mitigation measures are not fully established in the previous steps, that will have to be done in this step.

In Chapter 4, the report also briefly discusses the impacts on public expenditures and tax revenues for the adoption of various mitigation measures. Since circumstances can vary greatly between communities, it was not possible to address these issues in any quantitative sense. That is another reason for including such departments as community development, engineering, finance and legal in the discussions and planning of a property damage mitigation plan for the community. These people should be able to provide information relative to the probable impacts to the local treasury from adopting particular mitigation measures. These departments can also provide insight into the organization and resources that will be needed to initiate and implement the overall plan.

STEP 7: SELECT MEASURES AND IMPLEMENT PLAN

The last step in the process is to select the measures and strategies that will comprise the mitigation plan, and then implement them. But good planning does not stop at this point. After a period of time, some review of the hurricane hazard mitigation plan should be made to see if the desired results are actually occurring. Any problems can then be addressed and corrected. The plan will need to be updated periodically as circumstances change. Depending upon the nature and magnitude of those changed circumstances, the planning process can be abbreviated or it can start over again with a new plan.

These planning efforts need to be accomplished prior to the next storm so that the results of the planning will be available for use. Plans need to be developed for the immediate recovery of the community following a hurricane. Those plans should cover provision of essential services such as water, electricity, communications and sewage. Preparations should be made for the redevelopment of areas that are most vulnerable and that may be devastated. Such contingency planning needs to be relatively flexible since in may not be possible to anticipate all of the needs that will be created by a major hurricane. Major hurricanes may also present the community with opportunities to provide public amenities such as recreational parks through property acquisition that might not be possible prior to the next storm.

Similarly, planning for the mitigation of property damages in undeveloped areas needs to precede the development of those areas. The costs of retrofitting or reconstruction can be avoided if appropriate development management or construction practices are adopted.

CHAPTER 4

MEASURING EFFECTIVENESS

INTRODUCTION

Two methods of measuring the effectiveness of various mitigation measures will be presented in this report. One method estimates the potential property damages before any mitigating action is taken and then estimates the potential property damages after the mitigating action is accomplished. The difference between the before and after estimates indicates the effectiveness of the action. The other method entails measuring the impacts of adopting mitigation measures on tax revenues and public expenditures.

ESTIMATING POTENTIAL PROPERTY DAMAGES

There are several data that are needed to perform this type of estimate. They are: (1) separate appraisals of the value of the structure and its contents, (2) the elevation of the ground surrounding the structure, (3) the elevation of the lowest horizontal member supporting the structure, (4) estimates of the expected stillwater surge heights, wave heights and wind speeds from various categories of hurricanes, and (5) the relationship between the value of a structure and its contents and of the degree of damage caused by the natural forces of a hurricane.

Property Values: The property tax rolls contain much useful information about the value of property. The appraised value should be used with this method of measuring the effectiveness of mitigation measures since it bears a relationship to the cost of constructing the building. The assessed value of property is useful in estimating the effects that hurricanes and mitigation measures can have on the local treasury. Occasionally, the appraised value of property may need to be adjusted for the passage of time or some other reason. The assistance of local realty boards can be most helpful in updating appraised values of property to reflect current market conditions.

For residential buildings, the value of the contents can conveniently be estimated to be 50 percent of the value of the building since most homeowner policies insure personal property to that amount. The value of the contents for other types of development can be collected by interview or survey. For convenience, percentages for the value of contents are presented for many types of development in addition to residential buildings.

Elevation Data: The elevation data for the building and the surrounding ground is used in this estimating technique to determine the amount of stillwater surge and wave damage to which the building will be subjected. An algorithm using the ground elevation data and expected surge heights is needed to compute the wave heights that can be expected at the location of the structure. The elevation data may be available from existing maps of the area, they may be recorded on building permits or flood insurance papers, or they can be collected by actual field investigations. For purposes of estimating the potential property damages, elevation data to the nearest 0.1 foot are adequate. Formulas used to compute damages will eventually round the elevation values to the nearest whole foot.

Surge Heights: The information on the expected stillwater surge heights and wind speeds that are expected from the different categories of hurricanes can be obtained from the Sea Lake and Overland Surge from Hurricanes (SLOSH) model for the area. This information is provided for the "test" areas in this report. For the remainder of the study area, these surge heights can be found in Appendix A of the Technical Data Report for the Tri-State Hurricane Evacuation Study.

The surge heights displayed in the evacuation study are those that can occur in a worst case scenario. They have been adjusted to account for any discrepancies in the SLOSH model outputs, the anomalous tidal increase that accompanies every storm, and for one foot of astronomical tide. It should be recognized that no single storm will produce the maximum possible surge heights that can occur in all parts of a coastal county. For this report, however, the worst case scenario data are used.

Damage Susceptibility: This report also provides the information on the relationship between the natural forces encountered in hurricanes and the degree of damages that can be expected. This relationship is presented as a percent of the value of the structure or its contents that would be lost as a result of the varying degrees of the natural forces. For example, three feet of stillwater surge is expected to do 38 percent damage to a single family dwelling, a wave height of three feet is expected to do 50 percent damage to a single family dwelling, and a peak gust at the surface of 100 miles per hour is expected to do 8 percent damage to a single family dwelling. There are several curves which show this damage relationship with natural forces for many different types of buildings. These curves are converted to tabular form and used in the damage estimates. The curves, in tabular form, are presented at Tables B-1 through B-5 in Appendix B.

The damage done to the contents of a building is computed in the same manner as the damage done to the structure, with one exception. Where a three foot surge and a three foot wave would do different amounts of damage to the structure, it is expected that there would also be different amounts of damage to the contents. Damage to the contents from the wave is expected to be less than the damage caused by rising stillwater surge because of the protection to the contents afforded by the walls of the structure. The structure behaves in much the same fashion as a stilling basin. Therefore, the water level inside of the structure from a three foot wave would be less deep than the water level from a three foot stillwater surge. It is assumed, however, that if the structure is totally destroyed by a wave, then the contents would also be a total loss.

Water damages to a structure and its contents are computed for either stillwater surge or wave height but not from both. Damages from wind are added to either surge damage or wave damage. Wind damage to contents is not calculated unless the total damages by water and wind exceed the total structure value. In this case, contents are also assumed to be a total loss.

Whether a structure is damaged by stillwater surge or waves depends upon the surge height generated by a hurricane, the ground elevation surrounding the structure, and the elevation of the lowest horizontal member supporting the structure. The first calculation is to determine the wave crest elevation. That is done by subtracting the ground elevation from the surge height and multiplying the result by a factor of 1.55. This is done only when the difference between the surge height and the ground is at least 4 feet or more. Where that difference is less than 4 feet, only surge damages will be calculated and then only if the elevation of the structure is less than the surge height. Where the difference between surge height and the ground elevation is 4 feet or more, then wave damages will be calculated when the elevation of the structure is less than the elevation of the wave crest.

Before wind damages can be computed, the appropriate windspeeds must be obtained. The SLOSH model windspeeds, calculated to represent expected windspeeds at 30 meters altitude, need to be converted to peak gusts overland. This is accomplished by reducing sustained winds at 30 meters by a factor of 0.66 to get sustained winds at the surface. Peak gusts are obtained by increasing the surface sustained winds by a factor of 1.3. The windfield calculated by the SLOSH model is a quasi-symmetrical windfield which serves well for the purpose of generating surge heights over open water. This windfield, however, is not a reliable indicator of the actions of hurricane winds overland and near the surface where structural and terrain factors have great influence on the winds through buffering or channelization. Because of these effects, it is necessary to modify the windspeeds from the SLOSH model to approximate the potential effects near the surface.

Wind damages are added to water damages. The total of water and wind damages cannot exceed the total value of the structure. If the water damages and the wind damages are estimated to exceed the total value of the structure, wind damages are limited to an amount equal to the remainder of total value less water damages. Damages to contents from wind are not computed unless the structure damages equal the total value of the structure. In this case, the total value of the contents is also considered to be a total loss. The reason for treating content damage from wind in this manner is much the same as the reason used in determining the content damage from waves. So long as the structure is considered to remain essentially intact, the contents are considered to be protected.

For some types of development such as roads, bridges and certain utilities, wind is not expected to cause any damage, and wind damages are not computed in these situations.

To facilitate the large number of calculations that would need to be made even for a small community, a computer spreadsheet is utilized. For the Phase I study a Lotus 1-2-3 spreadsheet was used. A modified version of that spreadsheet is used for the Phase II study. The layout of the spreadsheet is presented in Appendix B. A listing of the formulas and the row and column headings is also provided in Appendix B.

REDUCING OR AVOIDING POTENTIAL PROPERTY LOSSES

Once the potential damages from various categories of storms have been estimated, the impact of adopting a particular mitigation measure can be determined. From estimating the potential damages, it should be clear that there are five critical components that can be altered by a mitigation measure. It is possible to affect: (1) the height to which the water will rise, (2) the height of a building above the surrounding terrain, (3) the number of buildings subject to damaging forces, (4) the value of buildings subject to damage, and (5) the susceptibility of buildings to being damaged. The first step in the analysis of the effectiveness of any of the mitigation measures is to decide what direction the impacts will take.

Rising Stillwater Surge: The shoreline strengthening measures such as seawalls, bulkheads, breakwaters or beach nourishment can be employed to reduce the height to which storm waters would rise. In some cases, they might even completely halt surge and waves from reaching damageable property. Additional development management measures may also have to be taken in conjunction with these measures. For example, a dune restoration program would require the land area for the dune system. Setbacks may be needed to ensure that the necessary land area is available and to ensure that the integrity of the restored dune system is not breached. Dune crossovers also protect the integrity of a dune system.

The spreadsheet can easily compute the reduction in potential damages for these types of measures in two ways. If the mitigation measure would have the effect of tripping a wave before it can reach developed property, then specify in the model that the area is not a velocity zone. The spreadsheet will not compute damages due to waves, but will compute damages caused by stillwater surge at a lower level of inundation. Potential damages are reduced since the damages computed for wave energy are greater than those for rising stillwater surge in all instances.

The other way to estimate the reduction in potential damages is to reduce the value of the surge height by simply subtracting some amount from the surge height that the model produces. This has the effect of reducing the amount of surge in each structure which is used in the damage computations. Both changes to the spreadsheet can be made simultaneously for a mitigation measure that could have both effects such as a dune restoration and protection scheme.

Structure Elevation: There are several measures which can be employed that will alter the elevation of damageable property. Chief among these measures is the adoption of the National Flood Insurance Program's minimum elevation standards. But other measures such as building codes, subdivision regulations and information dissemination programs can also be used to effect the same changes. The difference between the various measures is in the degree to which the measure's success depends upon the voluntary actions of others.

The analysis of the potential reduction in property losses can be accomplished by altering the value used for the structure's elevation. The analyst should note that the data for this value are physical data that should not be lost. One precaution is to copy the physical data to another area of the spreadsheet and manipulate that copy. The spreadsheet could be instructed to go and get the structure elevation and add some amount to it before it is used in the computations of potential damages.

In the analysis of a reconstruction policy, for example, it could be important to know what the potential for damage reduction would be had all or some of the buildings been built to some minimum elevation or if they had all been built at a greater elevation. In the first case, that desired minimum elevation can be specified for all of the buildings under investigation. For the second case, an amount can be added to the actual value of each structure's elevation. This kind of information could be of great value in information dissemination programs. Not only can it be shown what the potential avoidance or reductions in property losses could be from various size storms, but it can also be shown how the annual flood insurance premiums can be substantially lowered by exceeding minimum elevation standards.

Determining the exact annual flood insurance premiums for each structure under investigation can be an extremely difficult job because of all the variables that must be considered. An example of the savings that can be achieved by exceeding minimum standards is displayed in Tables 7 and 8. The example is for a single family residence valued at $50,000 with contents valued at $10,000. Notes following the tables also explain some of the variables used in constructing the examples. Premiums can vary widely depending upon the amount of the deductible selected by the owner. The standard policy carries a deductible for the first $500 worth of damage to both the structure and its contents for a total deductible of $1,000. The larger the deductible, the lower the premium. The rates vary depending upon the ratio of the amount of insurance coverage versus the cost of replacement. When the structure was built or substantially improved also has a bearing on which set of rates are applicable. An elevation certificate completed by an engineer, land surveyor, or architect is required to determine the insurance rates. In a velocity zone, the amount, if any, of obstructions to the flow of water makes a substantial difference in the rates used to determine the annual premium. Fortunately, the rates are set by FEMA and are the same for similar structures regardless of the company that writes the policy.

While there are many variables to consider in computing the premium for a specific structure, with any combination of the variables the rates per $100 of coverage decrease as the elevation of the structure increases over the minimum required. The rates increase dramatically for elevations below the minimum required. In fact, any policy application where the elevation is more than one foot below the minimum requirement must be sent to Washington to be rated. Tables 7 and 8 display annual insurance premiums in the "A" zone and in the "V" zone as well as the savings for exceeding minimum elevation standards.

Elevating a structure during construction is generally easy and relatively inexpensive. For example, assume a structure is being elevated on 20 pilings and that pilings cost $5 per foot. The cost of elevating the building by an additional 3 feet is 20 x $5 x 3 = $300. From Tables 7 and 8, it can be seen that it takes 3 years of premiums in the "A" zone and 1 year in the "V" zone to match this cost. It is not unusual to see piles being driven and then cut off to some desired height. The amount being cut off is frequently more than 2 or 3 feet. Thus, there may be no additional cost in elevating the structure except incidentals.

TABLE 7

Costs and Savings
in Annual Flood Insurance Premiums
for Buildings Above Minimum Elevation
in "A" Zones
with Elevation Certificates

AMOUNT ABOVE MINIMUM ELEVATION	TYPE OF COVERAGE	AMOUNT OF COVERAGE	RATE	ANNUAL COSTS	ANNUAL SAVINGS
+3 FT	BUILDING	$40,000	.12	$48.00	
		10,000	.06	6.00	
	CONTENTS	10,000	.17	17.00	
				$71.00	$115.00
+2 FT	BUILDING	$40,000	.14	$56.00	
		10,000	.06	6.00	
	CONTENTS	10,000	.17	17.00	
				$79.00	$107.00
+1 FT	BUILDING	$40,000	.19	$76.00	
		10,000	.06	6.00	
	CONTENTS	10,000	.30	30.00	
				$112.00	$ 74.00
0 FT	BUILDING	$40,000	.30	$120.00	
		10,000	.06	6.00	
	CONTENTS	10,000	.60	60.00	
				$186.00	-0-
-1 FT	BUILDING	$40,000	.78	$312.00	
		10,000	.50	50.00	
	CONTENTS	10,000	1.50	150.00	
				$512.00	- $326.00*

* Indicates additional costs and is not a savings.

Notes: The minimum standard elevation is referred to as the Base Flood Elevation or BFE. This analysis is based on single family dwellings. The types of coverage are the basic coverage which has a limit of $40,000 in the regular program, and additional coverage, which has a limit of $145,000 in the regular program. The annual premiums also include an expense constant of $45.00 which is not included in the costs or savings.

TABLE 8

Costs and Savings
in Annual Flood Insurance Premiums
for Buildings Above Minimum Elevation
in "V" Zones
with Elevation Certificates
Post 1981 Construction

AMOUNT ABOVE MINIMUM ELEVATION	TYPE OF COVERAGE	AMOUNT OF COVERAGE	RATE	ANNUAL COSTS	ANNUAL SAVINGS
+4 FT	BUILDING	$50,000	.36	$180.00	
	CONTENTS	10,000	.19	19.00	
				$199.00	$340.00
+3 FT	BUILDING	$50,000	.41	$205.00	
	CONTENTS	10,000	.19	19.00	
				$224.00	$315.00
+2 FT	BUILDING	$50,000	.53	$265.00	
	CONTENTS	10,000	.27	27.00	
				$292.00	$247.00
+1 FT	BUILDING	$50,000	.71	$355.00	
	CONTENTS	10,000	.49	49.00	
				$404.00	$135.00
0 FT	BUILDING	$50,000	.93	$465.00	
	CONTENTS	10,000	.74	74.00	
				$539.00	-0-
-1 FT	BUILDING	$50,000	1.23	$615.00	
	CONTENTS	10,000	1.07	107.00	
				$722.00	- $183.00*

* Indicates additional costs and is not a savings

Notes: This analysis is based on single family dwellings. It is assumed that there are no obstructions to flow below the lowest supporting horizontal member. The rates are for the ratio of 75% insurance coverage to replacement cost with the standard deductible of $500 for structure and $500 for contents. There is only one type of coverage for buildings in the velocity zones, thus the additional coverage as shown in the analysis for the "A" zone is not used. The annual premiums also include an expense constant of $45.00 which is not included in the costs or savings.

A small difference in elevation can also occur between types of flood zones, such as between velocity zones and the "A" zone. For the "A" zones, the minimum elevation is measured at the top of the lowest elevated floor, and for the "V" zones, the minimum elevation is measured from the bottom of the lowest supporting member. That difference can be up to two feet. Two feet of wave damage can amount to thirty-seven percent of the value of a single family dwelling. It should be remembered that the definitional differences between velocity zones and the "A" zones revolve around the potential for the generation of a wave, and that the wave is added to the top of the stillwater surge. Therefore, it is reasonable to compare two or three feet of wave damage to zero or only one foot of stillwater surge damage.

That definitional difference points out another opportunity for the adoption of a local mitigation measure. Nature rarely pays much attention to lines drawn on paper. The transition between a velocity zone and an "A" zone is one such line on paper. The statutory flood plain requirement may be different on either side of the line, but the potential for the generation of a small wave still exists. The difference between two feet of wave damage and two feet of stillwater surge damage is approximately eight percent of the value of the structure for a single family dwelling. With this in mind, the community might want to consider increasing the minimum standards for elevation in the "A" zones immediately adjacent to velocity zones.

<u>Number and Value of Buildings</u>: The next two items, changing the number or value of buildings at risk, goes to the heart of the development management mitigation measures. By altering the value of buildings at risk, it is not suggested that cheaper structures be built. The suggestion is that smaller structures be built or that less intense use be made of high hazard areas.

The list of mitigation measures can be examined for those measures which would be useful in lowering either the number or value of buildings that could be subjected to varying degrees of natural forces. A capital facilities policy, to the extent it can be used, would tend to guide development away from high hazard areas and into lower hazard areas. The fewer buildings in the high hazard areas, the lower the potential loss of property for the community from the next storm. It is possible that the differences in a structure's elevation and the surrounding ground elevation could make a difference between a couple of feet of wave damage and no damages from stillwater surge. Relocations would also have the same effect of reducing the number of buildings in the higher hazard areas. These beneficial effects would be in addition to reduced damages to public streets and utilities. The impacts on the treasury would also be positive since the construction costs would be the same, but maintenance and extraordinary costs for repairs would be reduced.

Taxation and other financial incentives will also tend to avoid or reduce potential property losses in the future from damaging storms by reducing the number of buildings in high hazard areas. Such schemes as impact fees have the added advantage of raising revenues to help defray the additional costs of maintaining public properties that service these areas such as evacuation shelters or normal water and sewer facilities. The difficulty in measuring the effectiveness of these measures lies in the assumptions concerning the extent to which these incentives convince people not to build in these areas. If the amount of development is the same with and without these incentives, the the potential for reducing property damages will not be realized.

The development regulation mitigation measures are somewhat more direct and thus it is easier to measure their effectiveness. The circumstances under which the analysis of the effectiveness of these measures will be done can largely be known in advance, since the adoption of several of these measures dictate what those circumstances will be by ordinance or regulation. Such matters are not quite as clear with some of these measures such as planned unit developments or clustering. The flexibility that can be achieved with these measures is part of their attractiveness. There is room for negotiations which can best serve the legitimate interests of developer and regulator.

Also among the measures for which the potential to reduce property damages can be readily estimated are the land and property acquisition measures. With ownership comes the ability to decide the number and value of structures that will be erected on these properties.

Information dissemination, the last of the development management mitigation measures, is also difficult to analyze since its success depends upon voluntary actions. This measure may be more effective at influencing how structures are built rather than whether or where structures are built. Nonetheless, it can be considered among the measures that have, as a result of its adoption, a lessening in the number or value of structures placed in areas subject to the damaging effects of severe storms.

The methods that can be used to measure the effectiveness of these mitigation actions would be to decrease artificially the number or value of structures in existing areas of development. For example, an area of development has one hundred dwellings. If it is believed that the appropriate or desired density in this area should be fifty dwellings, then the analyst could simply subtract every other dwelling. That would preserve, to some extent, the mixture of ground elevations and first floor elevations as well as some of the age and value mixture. Selecting either the structures at the highest or lowest elevations or the least or most expensive structures would introduce an unnecessary bias in the estimate of effectiveness.

Susceptibility to Damage: The fifth area of changes that can be made in evaluating the effectiveness of a mitigation measure is to alter the susceptibility of the structure to damage. The measures that would be analyzed in this manner are those listed under the heading of strengthening buildings and facilities on Table 2. If a structure were built to withstand windspeeds of 120 mph, then it would not be expected to sustain major damages from any storm that produced windspeeds of that amount or less. To analyze these situations, the damage curves provided with the spreadsheet must be altered.

The set of curves which must be modified are the ones associated with wind damages. Constructing more solid buildings would have little effect on their ability to withstand damage from rising stillwater and even less from the pounding of waves. The building codes contained in the National Flood Insurance Program regulations have the tendency to raise the structures out of harm's way. The use of flood resistant materials is generally mandated for those areas below the lowest floor or lowest supporting horizontal member. The damage curves for surge or wave used in this spreadsheet do not compute damages in this area of the structure.

Floodproofing nonresidential buildings can be accomplished. In these instances, the damage curves for surge and wave can be modified to reflect the lower degrees of susceptibility to damage achieved by the floodproofing. Floodproofing can only be done to a relatively small extent. The forces of nature can be so great, that attempting to floodproof a nonresidential building by more than three or four feet may not be possible or prohibitively expensive. If the structure is located so that it is only subject to a small amount of flooding, then it may be feasible to undertake floodproofing. It should be remembered, though, that a structure floodproofed to three feet that receives four feet of water would be expected to suffer as much damage as it would without the three feet of floodproofing. Such a case could occur if a structure were floodproofed against a category 3 storm and were struck by a category 4 storm.

The curves showing the relationship between windspeed and expected damage need to be modified to account for the structure strengthening measures. These curves can be adjusted to account for partial or complete elimination of damages from specific windspeeds. For example, the addition of shutters would only partially reduce the potential for wind damages, and then only up to some upper limit of wind speeds. The percentages for wind damages should not be reduced to zero, however, since windows are not the only portion of the structure that would be damaged by high winds. Adding hurricane clips or strengthening the connections between the various parts of a structure are other methods of reducing the likelihood of wind damage.

Constructing a building completely to some windspeed standard, such as 120 mph, should practically eliminate wind damages up to that standard and decrease probable damages from windspeeds up to 140 mph. In adjusting the windspeed damage curves, it should be remembered that the adjustment is for constructing to some specific standard and not doing so. The shape of the damage curves should approximately parallel each other. It is reasonable to expect that the damage curve for constructing to some standard, say 120 mph, would not revert to the curve for not constructing to some standard for a windspeed of 121 mph. For that reason, a reduction in potential damages can be expected for windspeeds slightly greater than the standard. Figure 3 shows graphically how a wind damage curve might be altered to account for constructing to some specific windspeed standard.

CURRENT VERSUS FUTURE DEVELOPMENT

Estimating the effectiveness of mitigation measures for future development can be difficult since both the before and after conditions must be created. Some of this creating is not very difficult, such as density restrictions. First, estimate the total potential damages for a developed area. Next, subtract a number of structures so that the desired density level is reached. The difference can then be imagined to occur in other currently undeveloped areas.

The real difficulties lie in transferring all of the other conditions from a developed area into an undeveloped area. Further adjustments can be made to account for differences in ground elevation, for instances, so that a truer comparison can be made. In the analysts' favor is the fact that if nothing is done, then undeveloped areas will probably come to resemble currently developed areas. That means that the conditions that are being transferred are more likely to be true than false. To test this assumption, look closely at some of the newest developments in the community and see if they are similar in nature. The examination should concentrate on such things as how the foundation is created, what kinds of building materials are used, what size and shape lots are used, and other general construction practices.

Estimating the value of some of the other mitigation measures is more subjective, since there is no hard evidence of the actual impacts of these measures. Information dissemination could be very valuable in educating all concerned parties about the potential for property damage and some of the actions that can be taken to avoid or reduce that potential. But it would be pure speculation to estimate the good that can be done by teaching developers, contractors, builders and inspection officials what constitutes a properly built structure that can be subjected to the forces of a hurricane. However, some conservative estimates of the value of education can be made. For example, it could be estimated that a quarter of all new buildings will only suffer half of the damages that the same buildings are currently expected to suffer. (This assumption could vary depending upon the category of storm that is being considered.) The only remaining assumption is an estimate of the number of new buildings that are expected to be built over some period of time. These percentages could be increased if the community insisted that buildings be constructed to be more hurricane

WIND DAMAGE CURVE, STRUCTURE
Single-Family Residential

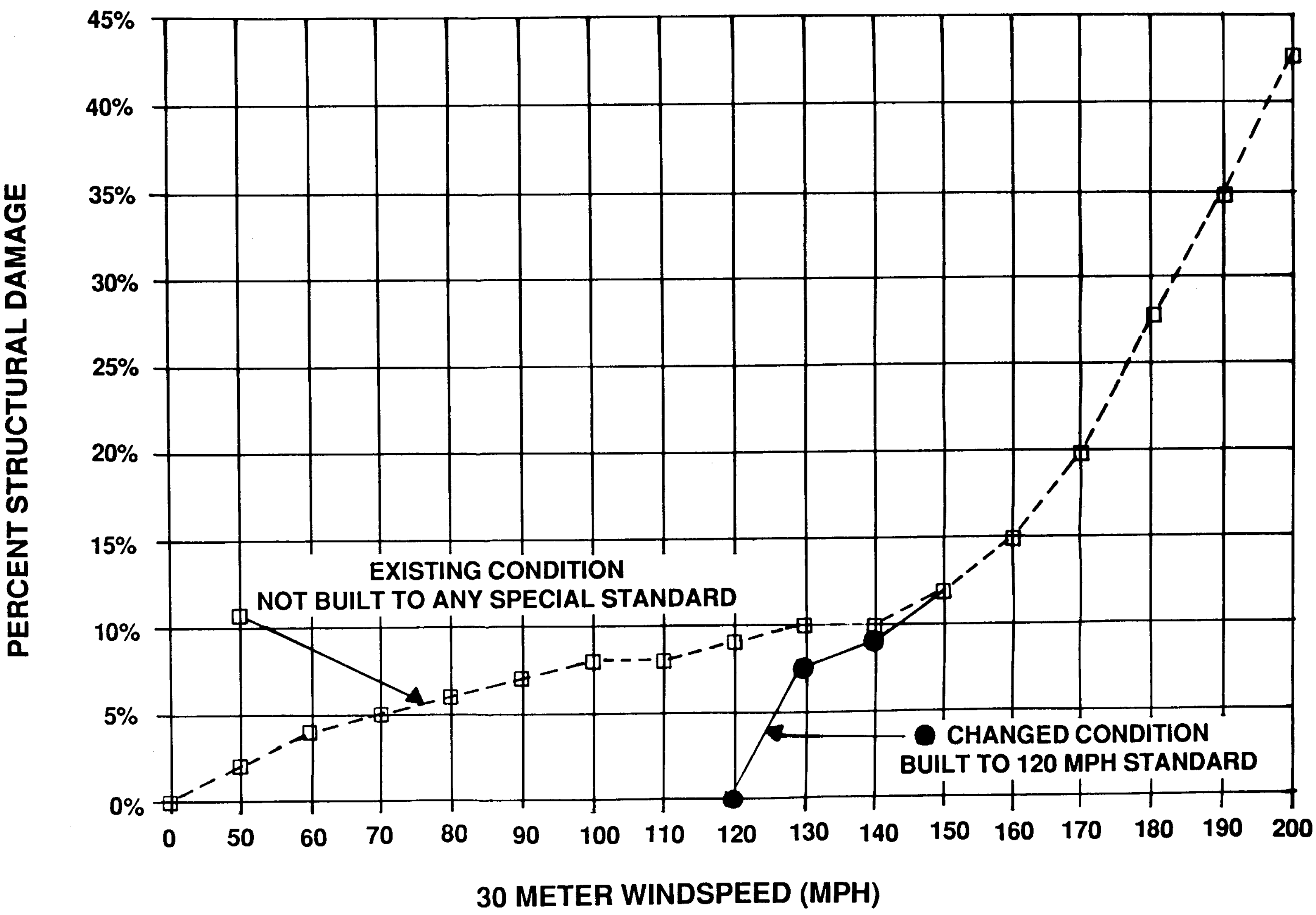


FIGURE 3

resistant by adopting and enforcing stringent building codes and construction practices. Otherwise, the measure must depend upon the voluntary cooperation of many people to be effective.

There is another unquantifiable benefit to adoption and enforcement of codes. Constructing to standards appropriate to the hazard does have a cost associated with it. If there is no differentiation in the selling price for structures that have been built to an appropriate standard and those that have not, then the builder will have little incentive to incur additional costs that can not be recouped in the sale of his product. Builders who voluntarily construct to appropriate standards are "penalized" by a lower profit margin than would otherwise be possible.

If history is a cogent teacher, it should be pointed out that along the South Carolina coast there are numerous examples of how well constructed buildings survived hurricane Hugo with only minor damage, while buildings on adjacent lots that were not well constructed were severely damaged or destroyed. Some of the differences in the construction techniques were very minor, such as reinforcing steel that did not travel the entire length of supporting columns, which were subsequently broken near the point where the reinforcing steel stopped, or examples where the supporting pilings were not embedded to a sufficient depth and the structure was lifted out of the ground with the pilings still attached. That is not to say that these particular structures would have survived intact were it not for these problems. Some other flaw or weakness in their construction could have caused their destruction. The lesson to be learned is that good construction practices work well, yet they need to be followed in full during construction.

The effectiveness of enforced building practices can also be seen in a comparison of the costs to fully embed the pilings during initial construction as opposed to completely replacing the structure and its contents. The comparison is not to the cost of retrofitting the structure because the structure will face a storm during its lifetime, and because the flaws will probably not manifest themselves until a storm strikes.

MITIGATION AS AN INVESTMENT

Without knowing exactly what the additional costs would be to set the pilings to a proper depth, an examination of the effectiveness can still be made. To set the stage, let's assume that we are constructing a $100,000 building. Further, let us assume that we can invest at 8% net of taxes, and that we are going to invest in something that will assure us of having the $100,000 it costs to build our building at the end of some period of time. If we think that a storm will destroy our building in 10 years, how much money would we have to invest today so that we will have the $100,000 building in 10 years? If we invest $46,319.35 today at 8%, we will have $100,000 in 10 years. In 25 years, an investment of $14,601.79 at 8% will yield $100,000.

The same yield can be realized by an initial investment of $2,132.12 for 50 years or an initial investment of $311.33 for 75 years. Now then, when will the next storm come? Since we cannot know that with any precision, we will guess that it will be 25 years before the next hurricane hits our area. How many pilings can we set to keep our building from being blown over or floated away for $14,601.79? Properly embedding the pilings is equivalent to investing the $14,601.79, because at the end of the 25 years when we have assumed the hurricane will come, we will still have the $100,000 building. The formula for making these calculations is 1 divided by 1 plus the interest rate raised to the number of years, and this result is multiplied by the $100,000: $(1/(1+i)^n) \times \$100,000$.

PUBLIC EXPENDITURES AND TAX REVENUES

Another means of measuring the effectiveness of taking some property damage mitigation action is to examine the impacts that action may have on public expenditures and tax revenues. To begin with, there is the expense of planning to take the mitigating action regardless of whether that planning is done by existing staff, newly hired staff, or by contract. To that must be added the costs of implementing the mitigating action. A third item is the cost of maintaining or enforcing the mitigating action.

In the case of shoreline strengthening measures, these expenses can be on the order of millions of dollars. For the strengthening of building measures, the cost would be substantially less. For example, adopting building codes for hurricane resistant construction could be as simple as supplementing existing requirements for fire safety or supplementing the construction standards under the National Flood Insurance Program. Implementation and maintenance costs could include additional staff, appropriate office space and equipment, and training or certification expenses. Much the same would be true for adopting land use measures, although some of the planning could be accomplished by contract with private enterprise or with regional planning councils.

Beyond these initial and annual costs are the public expenditures in the event of a hurricane. Many of these expenses are at least partially predictable. They could include the deductible portion of a loss claim, any uninsured losses, damage to property that is eligible for insurance coverage but which is not insured, and up to 25 percent of disaster assistance and the costs of debris removal. In addition, there could be costs for providing food and/or shelter for victims of a storm and other types of public assistance. There could be many requests for inspection of business property to certify that the structure is safe to be reopened for business. There will be costs to repair or restore damaged transportation systems including roads and streets, traffic signs and control devices, and drainage systems. The community's water and sewer system will at least require some testing to be sure it is safe for use.

These are only a sample of extra public expenses that are necessitated by a hurricane. It is entirely likely that most functions of local government will be affected in some fashion by a storm. Normal operating expenses will increase for a variety of reasons. Additional office space may have to be found if the existing locations need to be repaired, or because temporary "branch" offices will accommodate a temporary increase in demand for specific services in particular segments of the community. Normal operating expenses will increase for overtime hours worked by current employees and for temporary employees needed for a variety of reasons. Some of these expenses can be recouped under current Federal disaster assistance laws, if the proper paper work is done. Under the Stafford Act, some of these expenses can be covered by advances or loans. Any interest on these loans represents an additional abnormal expense.

Another area of extraordinary public expenditure which is necessitated by a storm event but which is extremely difficult to quantify, is the area sometimes referred to as the hassle factor. Any community official who has lived through the aftermath of a major disaster is well aware of these expenses. There will be press conferences and other public forums to disseminate needed information. There will be complaints over the rapidity or priority of performing some governmental functions or services which must be dealt with. The expense of these items is the abnormal amount of time that must be devoted to these functions. There is also the stress and strain of working longer and harder hours, which can result in costly mistakes that would not happen under normal circumstances.

One of the suggested mitigation measures is pre-storm planning of post-storm reconstruction policies. It is this preparation that is intended to minimize public expenditures to the extent possible. Such planning could be added to the existing management plans for other emergencies with input from other departments. An assessment of the probable damages would help by suggesting where the most serious problems are likely to occur. Such planning needs to be relatively flexible since it may not be possible to anticipate all of the needs that will be created by a major hurricane.

While not strictly a property damage mitigation measure, the preparation of the organizational structure that will manage the aftermath of a major disaster can reduce public expenditures for this task. It is reported that there was a drill within two months prior to the earthquake that struck the San Francisco Bay area in 1989. The relative ease with which the disaster was managed was attributed to the drill, since most of the community officials knew in advance what their roles and responsibilities would be. Evacuations in Georgia and South Carolina for Hurricane Hugo also went very smoothly due to prior planning and exercises conducted by the States. The most recent exercise was held in June 1989. Such testing of emergency preparations can be very helpful in returning the community to normal in as short a period of time as possible.

At this point, a word or two about the problems associated with exactness of estimates would be appropriate. To begin with, it should be remembered that we are dealing with estimates. Estimates by their very nature are not meant to be exact, but rather to be of sufficient accuracy that sound and reasonable decisions can be made on the strength of them. It should be pointed out that in construction cost estimates a fairly sizeable contingency factor is often added. Sometimes this factor is as much as 25 percent. That contingency factor is not to cover some major item that has been omitted, but to cover the inexact nature of the estimating. As the accuracy of the estimating is increased, the value of the contingency factor is decreased.

Another way of looking at the problem is to consider a common practice in accounting. In listings of expenses or liabilities each major item is treated separately, while an amalgam of minor items is treated as "other" or "miscellaneous". Frequently, these categories amount to a substantial percentage of the total. Either of the above techniques can be useful in estimating probable total public expenditures that will result from a hurricane striking the community.

On the other side of the ledger are tax revenues. The major categories of tax revenues that will probably be impacted by a mitigation measure are property taxes, sales taxes, various business taxes, licences and permits, use taxes or impact fees of various kinds and possibly some ad valorem taxes.

With public expenditures, the analysis of the impacts should be an examination of present expenses to avoid or reduce future expenses that would result from a storm. The analysis of the impacts on tax revenues should concentrate on the differences in revenues that result from adopting a particular mitigation measure. Otherwise, it is possible to conclude that from the standpoint of tax revenues only, a hurricane is a fortunate occurrence for the community. Older property is damaged or destroyed and replaced with more expensive property which results in larger property tax revenues. A substantial number of permits to reconstruct damaged property could swell the revenue from that source, at least in the short term following a storm. Sales taxes would increase from the purchases of building materials, household furnishings, and other personal property that is being replaced.

With any of the analyses of the effectiveness of a mitigating action, it must first be decided what the impact will be. What would the impacts be on property taxes as a result of imposing some density restrictions on property close to the beach? Would such a restriction tend to increase the value of the dwellings that could be constructed in that area and thereby offset to some extent the revenue from more but less valuable development? Would density restrictions in a high hazard area tend to increase the development potential of other less hazardous sites and thereby increase total property tax revenues since additional idle land would be required to accommodate the same number of dwelling units?

A shoreline strengthening measure might increase tax revenues, since the property behind a seawall might be considered to be more valuable because it is protected from damage. Tax incentives to develop in less hazardous areas could decrease total revenue if they are not offset by tax disincentives in the higher hazard areas. Impact fees can be considered to be neutral, since the extra revenue may be earmarked to cover public expenditures for increased evacuation efforts and/or sheltering. Zoning and subdivision regulations may have little or no positive effects on revenues, since the development will take place regardless. It will simply take place in less hazardous areas, which could mean savings in public expenditures.

CHAPTER 5

TEST AREAS

INTRODUCTION

Three test areas were chosen in the study area to demonstrate the techniques for estimating potential damages and the effectiveness of various mitigation measures. In Mississippi, a section of Gulfport that faces the Mississippi Sound was selected. The development in this area is essentially commercial, although some residential property is interspersed along the second tier from the water. The area is fronted by a nourished beach, a seawall and a highway, with all development located landward of the highway.

In Alabama, a section of residential Gulf Shores was selected. Most of the homes and apartments in this area are generally new, having been built following Hurricane Frederic in 1979. The development faces the Gulf of Mexico with one tier of buildings seaward of the main road.

The third area selected is in Fort Walton Beach, Florida. The type of development selected for analysis in this area is public property and churches. The area is on the mainland behind a heavily developed barrier island. There are shops, restaurants and marinas that line the north shore of the sound, or the south side of the main highway. The city property being studied lies on the north side of the main highway, and consists of the city hall, a city library, the council chambers and the city auditorium. There are four churches nearby, one of which also has a substantial school.

Location maps of the three areas are provided in Figures 4 through 6. Field surveys were performed to gather the ground and structure elevations. The value of the property was estimated from property tax data or experience. The surge and wind data were extracted from the SLOSH models for the areas. All of the collected data were input to the Lotus 1-2-3 model developed for this study.

GULFPORT, MISSISSIPPI

In the Gulfport area, a four block area with fifteen varied commercial ventures was surveyed. Ground elevations ranged from 13.6 feet to 19.2 feet. Structure elevations ranged from 14.3 feet to 20.5 feet. The total value for structures and contents was estimated to be nearly $10 million. The commercial ventures represented in the area included office buildings, restaurants, motels, banks, food stores, gift shops, and medical offices. Some of the buildings predate Hurricane Camille in 1969, while most were constructed since then. The current Flood Insurance Rate Maps show that none of the development in this test area is located in a velocity zone. It is, however, immediately adjacent to a velocity zone. The rate maps also show a minimum elevation for the 100-year storm of 13 feet. Figure 4 displays this test site.

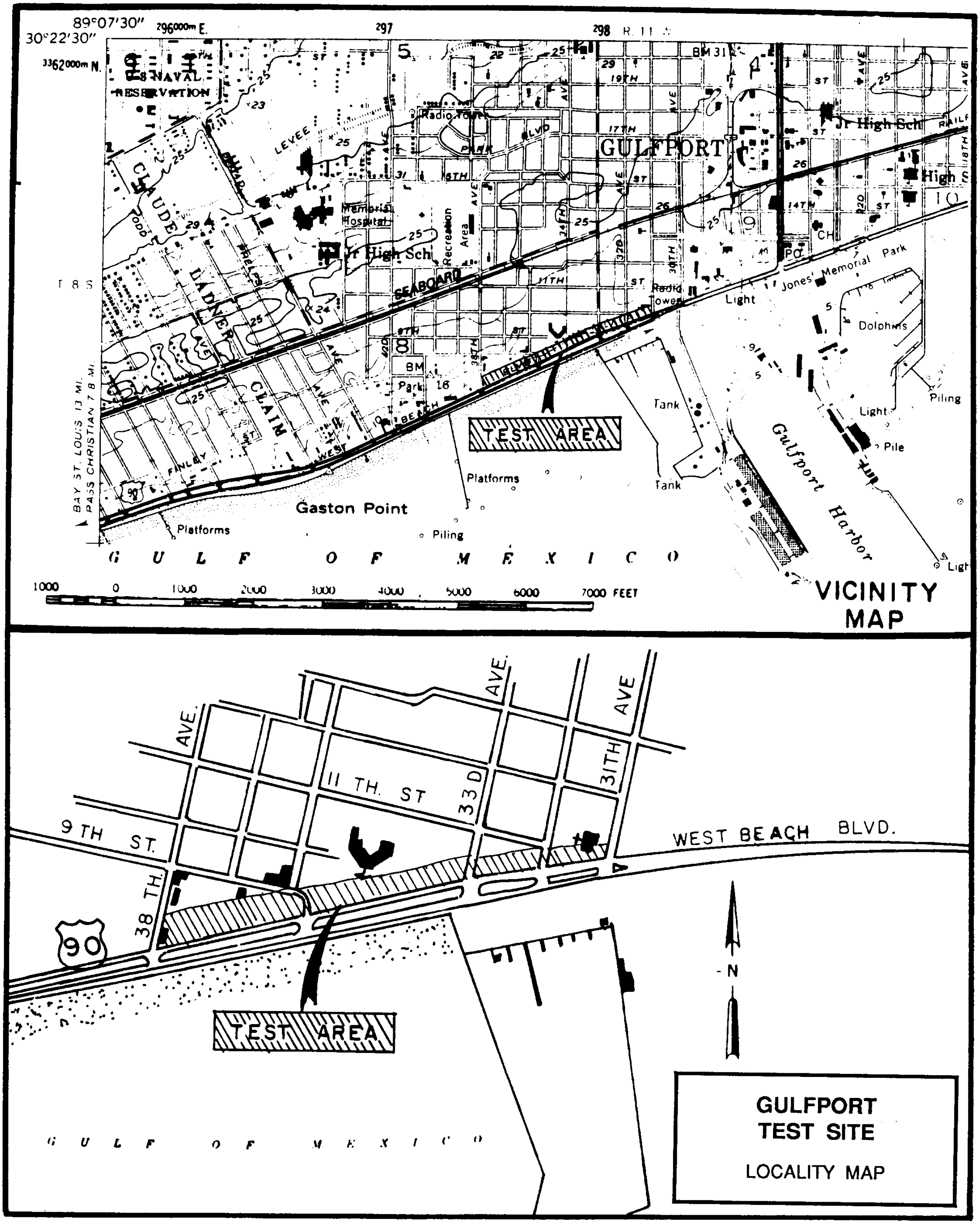

89°07'30"
30°22'30"
296000m E.
297
298
3362000m N.
NAVAL RESERVATION
GULFPORT
Radio Tower
Memorial Hospital
Jr High Sch
Recreation Area
SEABOARD
LADNER
CLAIM
CLAUDE
LEVEE
Jr High Sch
High
Jones' Memorial Park
Light
Dolphins
Radio Tower
Park
Tank
Platforms
Piling
Light
Pile
Gulfport Harbor
Gaston Point
TEST AREA
FINLEY
WEST BEACH
G U L F O F M E X I C O
BAY ST. LOUIS 13 MI.
PASS CHRISTIAN 7.8 MI.
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
VICINITY MAP
AVE.
AVE.
AVE
11 TH. ST
33 D
31TH
9 TH ST.
38 TH.
WEST BEACH BLVD.
90
TEST AREA
N
G U L F O F M E X I C O
GULFPORT
TEST SITE
LOCALITY MAP

FIGURE 4

Existing Conditions: The estimated potential property losses for the area from all five categories of storms are shown in Table 9. Using the spreadsheet model, it is estimated that this area is relatively immune to serious damage from category 1 and 2 hurricanes. It is estimated that the damage would be $90,000 to $350,000 from these storms, respectively. For a category 3 storm, the estimated damages are $3,500,000, or approximately 35% of total property value. Estimated damages for category 4 and 5 storms range from $6,638,000 to $7,842,000.

TABLE 9

Estimated Damages from Hurricanes
Selected Area of Gulfport, Mississippi
Existing Conditions
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Height	9.0	15.5	21.4	26.6	30.0
Peak Gusts @ Surface	80	90	110	130	170
Total Property Value	$9,975.0	$9,975.0	$9,975.0	$9,975.0	$9,975.0
Surge Only Damages	-0-	241.1	3,368.5	6,453.1	7,272.2
Wave & Surge Damages	-0-	-0-	-0-	-0-	-0-
Wind Damages	92.3	99.1	141.9	184.6	569.4
Total Damages	$92.3	$340.2	$3,510.4	$6,637.7	$7,841.6
% of Property Value	0.9%	3.4%	35.2%	66.6%	78.6%

Notes: Surge Only Damages are for the "A" zone portion of the test area. Wave and Surge Damages are for the "V" zone portion of the test area. Together, the two categories represent the damages caused by water.

While it is dangerous to extrapolate from such a small sample of the city, it does appear that there may be some further mitigation measures that might be warranted. The city has already done much to mitigate potential property damages and is continuing to do so.

A seawall was constructed in 1927. The beach in front of the seawall was nourished in 1951. Since then, the beach has been nourished several times. A study is being conducted to determine what types of vegetation should be used to stabilize some low dunes to help prevent sand from accumulating on the highway, which necessitates expensive removal on an annual basis. Signs which display the elevation of potential surge heights are being installed on existing poles at street corners in the areas subject to coastal flooding. All of these measures indicate an acute awareness of the potential problems that can accompany severe storms. Much of this awareness comes from practical experience with severe storms in the past.

Since much of the coastline has already been developed, and since shoreline strengthening measures have already been taken, little in the way of land use planning would be of immediate benefit. What may be of most benefit for the area is a reconstruction policy that includes some land use planning. Building codes can be examined for possible updating and improvements. NFIP minimum standards could be supplemented, particularly for the flood zones immediately adjacent to the velocity zones. These standards could be made to apply to the pockets of currently undeveloped land and to those developed areas in the event of substantial damage from a future storm. A reconstruction policy could include cooperative agreements with other counties or communities to provide personnel to help make the determinations of degree of damage and therefore the priority that is placed on repair or reconstruction of the damaged structures.

Two of these suggestions will be evaluated for their potential to reduce future property damages. These suggestions are increasing minimum elevation standards recommended by the National Flood Insurance Program, and an educational program that could be used to train and/or certify builders, developers, contractors, inspectors and others in the arts and science of flood and hurricane resistant construction. Since an educational program for NFIP standards could include discussions of construction practices for combating wind damages, the effects of building to a minimum windspeed standard will also be examined.

Benefits of Elevating Structures: The potential benefit for a reconstruction policy that includes increasing the NFIP minimum elevation standards can be seen from Table 10. The difference between the existing structure elevations and increasing those elevations so that all structures have a minimum elevation of 17 feet are $240,000 for a category 2 storm. Only seven structure's elevation was changed. These structures have a combined total value of $1.9 million dollars or approximately 20% of the total value for the test area. They are located on some of the lowest ground elevations in the test area. They also account for all of the surge damage for a category 2 storm. Raising them to a minimum elevation of 17 feet completely eliminates those damages. The costs of raising structures in-place, and by extension, of raising them during original construction is discussed in Chapter 2 under Retrofitting Existing Structures. Additional benefits to owners for exceeding NFIP minimum standards is discussed in Chapter 4 and on Tables 7 and 8.

TABLE 10

Estimated Damages from Hurricanes
Selected Area of Gulfport, Mississippi
All Structures Minimum Elevation of 17 Feet
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	-0-	$3,111.0	$6,398.6	$7,192.3
Wave & Surge Damages	-0-	-0-	-0-	-0-	-0-
Wind Damages	92.3	99.1	141.9	184.6	569.4
Total Damages	$92.3	$99.1	$3,252.9	$6,583.2	$7,761.7
Savings	-0-	$241.1	$257.5	$54.5	$79.9
% of Damages Reduced 1/	-0-	71%	7%	0.8%	1%

1/ Savings as a percent of Existing Total Damages shown on Table 9.

In comparison, raising all structures by 4 feet would reduce potential damages from all categories of storms by substantial amounts. These differences are shown in Table 11. For a category 3 storm, the potential property damages are reduced from 35% to less than 8% of total property value, with substantial reductions for category 4 and 5 storms.

TABLE 11

Estimated Damages from Hurricanes
Selected Area of Gulfport, Mississippi
All Structure Elevation Increased 4 Feet
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	-0-	$638.2	$4,430.7	$6,149.8
Wave & Surge Damages	-0-	-0-	-0-	-0-	-0-
Wind Damages	92.3	99.1	141.9	184.6	569.4
Total Damages	$92.3	$99.1	$780.1	$4,615.3	$6,719.2
Savings	-0-	$241.1	$2,730.3	$2,022.4	$1,122.4
% of Damages Reduced 1/	-0-	71%	78%	30%	14%

1/ Savings as a percent of Existing Total Damages shown on Table 9.

These two analyses, raising selected structures to a minimum elevation of 17 feet and raising all structures by 4 feet, show the potential for reducing property damages by changing the elevation of structures. Changing the elevation of future development through flood plain management ordinances adopted for eligibility in the National Flood Insurance Program virtually assures the reduction in property damages. Changing the elevation of future structures through a program of training and certifying contractors depends for its success upon convincing the owners of the future structures through the efforts of their contractors, or amending the flood plain management regulations to require a higher elevation than FEMA's minimum elevation.

This mitigation measure could have significant benefits for the entire community. The training could be accomplished by offering seminars on the requirements for eligibility for insurance and reduced insurance premiums under the NFIP to any interested party. Some suggested topics to include are the following: the standards and criteria to be eligible for flood insurance; the ramifications of exceeding or not meeting minimum standards on annual insurance premiums; the meaning of the term substantial damage and how it is determined; the elements of flood resistant construction and what construction practices meet that definition; and the distinctions made between flood zones.

Such seminars could be conducted under the auspices of the community building inspection department, county emergency management department, or local home builders association. Representatives from FEMA could be invited to make many of the presentations in conjunction with one of their community visits. Interested parties could include building inspections officials, developers, architects, contractors and foremen. Attendance at such seminars could be enhanced if a program of certification for designers, developers and contractors were instituted. Holders of certificates could then advertise that they were qualified in the art of flood resistant construction.

These seminars would accumulate additional benefits in other areas of the community that are subject to riverine flooding, since the techniques would be generally applicable in that hazard area too.

Benefits for Wind Resistant Construction: Wind resistant building codes and construction practices could also be discussed, and thereby the educational programs could be expected to have positive results in mitigating that hazard as well. Adoption of building codes for a 120 mph windspeed standard would assure greater reduction in potential wind damages than an educational program. If such a standard were instituted, there would be no wind damages from category 1, 2, or 3 storms. The wind damages from a category 4 storm would be reduced by 25%. These savings are shown in Table 12. It should be noted that construction standards for wind loads do not include wind blown debris or falling objects. The model used in these analyses of potential damages does not include estimates for wind blown or waterborne debris damages. A discussion on the costs of meeting Deemed-to-Comply construction standards for wind resistant buildings can be found in Chapter 2 under Building Codes and Construction Standards.

TABLE 12

Estimated Damages from Hurricanes
Selected Area of Gulfport, Mississippi
Adoption of 120 mph Windspeed Building Codes
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	$241.1	$3,368.5	$6,453.1	$7,272.2
Wave & Surge Damages	-0-	-0-	-0-	-0-	-0-
Wind Damages	-0-	-0-	-0-	138.4	569.4
Total Damages	-0-	$241.1	$3,368.5	$6,591.5	$7,841.6
Savings	$92.3	$99.1	$141.9	$46.2	-0-
% of Damages Reduced 1/	100%	29%	4%	1%	-0-

1/ Savings as a percent of Existing Total Damages shown on Table 9.

Combination of Mitigation Measures: The analyses for this test site are completed by combining the results of elevating all structures 4 feet over their existing elevation and adoption of a 120 mph windspeed construction standard. As shown in Table 13, the expected damages from category 1, 2, and 3 storms are virtually eliminated. Damages from category 4 and 5 storms would be reduced by 15 to 30 percent.

TABLE 13

Estimated Damages from Hurricanes
Selected Area of Gulfport, Mississippi
Elevating All Structures by 4 Feet and
Adoption of 120 mph Windspeed Building Codes
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	-0-	$638.3	$4,430.7	$6,149.8
Wave & Surge Damages	-0-	-0-	-0-	-0-	-0-
Wind Damages	-0-	-0-	-0-	138.4	569.4
Total Damages	-0-	-0-	$638.3	$4,569.1	$6,719.2
Savings	$92.3	$340.2	$2,872.1	$2,068.5	$1,122.4
% of Damages Reduced 1/	100%	100%	82%	31%	14%

1/ Savings as a percent of Existing Total Damages shown on Table 9.

GULF SHORES, ALABAMA

In the Gulf Shores area, residential development is featured. All of the homes are of wood frame construction supported by a wood piling foundation. Most of the space under the buildings is used for parking. The area south of Beach Boulevard is in a velocity zone, while the area north of the road is an "A" zone. The velocity zone area is zoned for medium density single family residential development, while the remainder of the study area is zoned for tourist accommodations. Much of the development is relatively new, being constructed after Hurricane Frederic in 1979. Some of the development did survive that storm. In the velocity zone there are 27 single family dwellings with a total estimated value of $3,640,000, while there are 16 single family dwellings and 2 condominiums with a total estimated value of $5,080,000 in the adjacent "A" zone.

The Flood Insurance Rate Maps for this test site show a 100-year elevation of 11.0 feet for the area between the water's edge and the dune line, a 10.0 foot minimum elevation for the area between the dune line and West Beach Boulevard, a 9.0 foot minimum elevation for the next 100+ feet including the road, and an 8.0 foot minimum elevation for the remainder of the area northward to Little Lagoon. The test site is displayed on Figure 5.

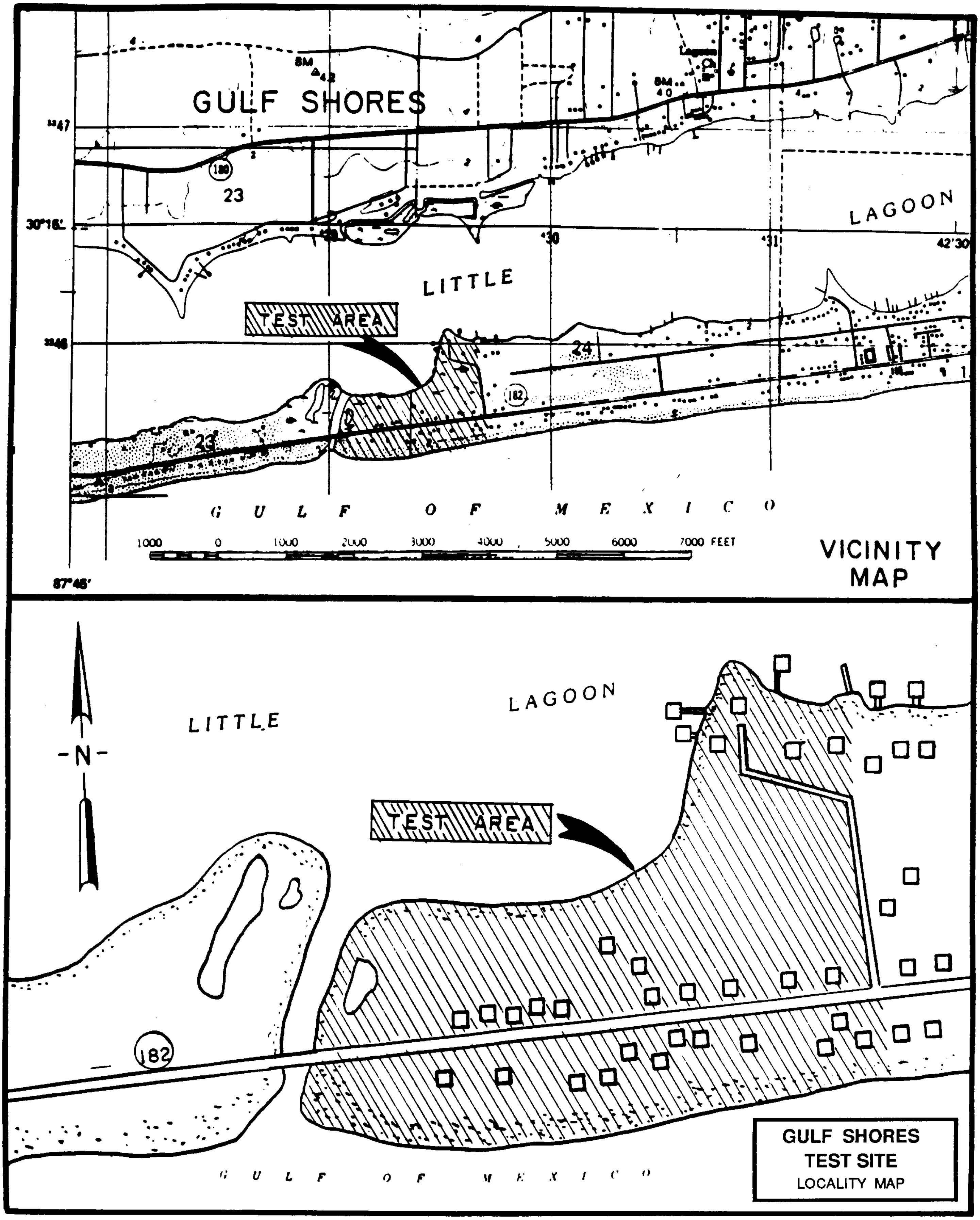

GULF SHORES
LITTLE
LAGOON
TEST AREA
GULF OF MEXICO
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
VICINITY MAP
87°46'
30°15'
42'30"
LITTLE
LAGOON
TEST AREA
N
182
GULF OF MEXICO
GULF SHORES
TEST SITE
LOCALITY MAP

FIGURE 5

Existing Conditions: Table 14 displays the existing conditions for the Gulf Shores test site. The data show that the test site is relatively safe from damage from a category 1 or 2 storm, with only wind damages amounting to less than 4% of total value. With the larger storms, the potential for property damage increases significantly. A category 3 storm could produce nearly $1.0 million more damages than a category 2 storm. A category 4 storm could increase damages from 15% of total value to 42%. Since the surge height difference between a category 4 and 5 storm is quite small for this area, the potential property damage from the two water categories - Surge Only Damages plus Wave & Surge Damages - only increases approximately $120,000 for the larger storm. There is a large increase, however, in potential damages due to the increase in windspeeds for a category 5 storm. A category 5 storm would sustain nearly $1.1 million in wind damages, or $600,000 more than a category 4 storm.

TABLE 14

Estimated Damages from Hurricanes
Selected Area of Gulf Shores, Alabama
Existing Conditions
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Height	4.0	8.7	13.6	17.1	17.3
Peak Gusts @ Surface	80	90	110	130	170
Total Property Value	$8,723.5	$8,723.5	$8,723.5	$8,723.5	$8,723.5
Surge Only Damages	-0-	-0-	130.8	728.4	767.8
Wave & Surge Damages	-0-	-0-	754.1	2,450.6	2,533.9
Wind Damages	271.9	330.1	420.7	478.9	1,081.3
Total Damages	$271.9	$330.1	$1,305.6	$3,657.9	$4,383.0
% of Property Value	3.1%	3.8%	15.0%	41.9%	50.2%

For this test site, an examination will be made of a dune restoration and preservation plan, changed first floor elevations, windspeed construction standards and density restrictions.

Benefits for Dune Preservation or Restoration: A dune restoration and preservation plan could reduce potential property damages by preventing the penetration of waves into developed areas. Such a project can be a very complicated undertaking. Professional assistance may be necessary to balance the beneficial effects of the height of the dune system and the slope and width of the beach to reach the optimum scale of the project. Since these determinations are beyond the scope of this report, it is assumed for the following example of the effectiveness of dune systems that the restoration and preservation is great enough to halt the penetration of waves for all categories of storms. Effectively, this assumption removes all development from the velocity zone.

One of the limitations of a restoration plan is the needed land area for the dune field. If structures cannot be relocated to allow sufficient room for the dune field, the plan may have only marginal effectiveness. Building setbacks may be necessary to assure that the dune field has sufficient room to establish itself. Such setback could be included in a reconstruction plan for currently developed areas. Obviously, in undeveloped areas, the plan for the utilities, streets and subdivision of the area can be drawn to accommodate the protection or creation of a dune field. Since many factors need to be taken into account in establishing a setback line for dune establishment, it is suggested that professional assistance be obtained.

Another limitation is the time it takes for dunes to naturally accumulate and vegetate. With sand fencing, planting vegetation, irrigation and fertilization, that time can be reduced. Because of the fragile nature of dunes, they need to be protected by crossovers, or other means of transiting the dune field without damage.

While several of the mitigation measures can have a bearing on the degree of success that a dune restoration and preservation scheme will have, the analysis of the potential reduction of property damages is the same for any combination of measures that prevents wave damages and/or reduces stillwater surge heights. For measures that prevent wave damages, the model for the Gulf Shores test site shows that damages can be reduced in the velocity zone by $750,000 for a category 3 storm. Table 15 displays the potential reduction in property damages for all categories of storms for a dune restoration plan. Even though no wave damages are computed for the area, there is still the potential for surge damages. This analysis is accomplished by changing the designation of property in a "V" zone to being in an "A" zone. Simply removing the threat of wave damages in the velocity zone reduces potential storm damages from water by $1.7 million for category 4 and 5 storms.

TABLE 15

Estimated Damages from Hurricanes
Selected Area of Gulf Shores, Alabama
Dune Restoration and Preservation
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	-0-	$130.8	$1,536.4	$1,627.9
Wave & Surge Damages	-0-	-0-	-0-	-0-	-0-
Wind Damages	271.9	330.1	420.7	478.9	1,034.9
Total Damages	$271.9	$330.1	$551.5	$2,015.3	$2,662.8
Savings	-0-	-0-	$754.1	$1,642.6	$1,720.2
% of Damages Reduced 1/	-0-	-0-	58%	45%	39%

1/ Savings as a percent of Existing Total Damages shown on Table 14.

Benefits for Elevating Structures: The next type of mitigation measure to be analyzed at this site is changing the elevation of the structures built in the area. It was decided that only the elevation of structures in the velocity zone would be changed. This decision was made since the analysis will be to reduce artificially the elevation of the structures. To demonstrate the effects of raising a structure's lowest floor elevation above the minimum required by NFIP, it is necessary to establish a new base condition. This is done by setting the lowest floor elevation of all of the structures in the velocity zone to the base flood elevation of 10 feet. The results of these artificial changes can be seen in Table 16. A comparison of the two "existing" conditions demonstrates the value that has already been accomplished by elevating the lowest floor above the base flood elevation. The change of elevation of structures in the velocity zone only has a dramatic effect on the potential for property damages from Wave and Surge Damages for the three largest storm events.

TABLE 16

Estimated Damages from Hurricanes
Selected Area of Gulf Shores, Alabama
Artificial Existing Conditions
All Lowest Floors Set to Base Flood Elevation of 10 Feet
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	-0-	$ 294.7	$ 728.4	$ 767.8
Wave & Surge Damages	-0-	-0-	2,395.9	3,642.0	3,642.0
Wind Damages	$271.9	$330.1	420.7	236.1	549.3
Total Damages	$271.9	$330.1	$3,111.3	$4,606.5	$4,959.1

The value of raising the structures 4 feet above the required base flood elevation can be seen in Table 17. While there is a tremendous reduction in Wave and Surge Damage for category 3, 4 and 5 storms, many of those benefits are offset by increased wind damages. It is very difficult to see the full reduction in the potential losses since it is masked by the tremendous potential for losses from water in the artificial existing condition. Notice in Table 16 that the Wave and Surge Damages for categories 4 and 5 storms show no difference. In this instance, the property in the velocity zone is completely destroyed by water which leaves no value to be lost due to wind. In Table 17, the Wave and Surge Damage is reduced, but there is value remaining to be damaged by wind. Since no changes were made to structures outside of the velocity zone, no changes will occur in Surge Only Damages between Tables 16 and 17.

TABLE 17

Estimated Damages from Hurricanes
Selected Area of Gulf Shores, Alabama
Artificial Existing Conditions
All Lowest Floors Elevated 4 Feet Above Base Flood Elevation
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	-0-	$ 130.8	$ 728.4	$ 767.8
Wave & Surge Damages	-0-	-0-	1,362.0	2,784.7	2,841.7
Wind Damages	$271.9	$330.1	420.7	478.9	1,126.5
Total Damages	$271.9	$330.1	$1,913.5	$3,992.0	$4,736.0
Savings	-0-	-0-	$1,197.8	$614.5	$223.1
% of Damages Reduced 1/	-0-	-0-	38%	13%	4%

1/ Savings as a percent of the Artificial Existing Total Damages shown on Table 16.

A comparison with the actual conditions reveals some startling results. The potential damages from wind for category 4 and 5 storms are substantially different. This is due to the manner in which these losses are computed. The damages from wind cannot result in total damages exceeding the total value of the structure and its contents. With the lower first floor elevations in the new base condition, the water damages to the structure and its contents are far more extensive, leaving less value to be damaged by wind. In fact, with the new base condition, the model returns a zero for wind damages in the velocity zone, because the structure and its contents are totally destroyed by waves. The wind damage that is shown in Table 16 is all attributable to the area behind the velocity zone.

The actual savings in potential damages can be seen in a comparison of the real conditions and the artificially created base condition. Since the first floors of most of the structures exceed the minimum requirements by more than 4 feet, the structures' ability to withstand greater surge heights and probable wave damages are better.

Benefits for Wind Resistant Construction: From Table 14, it can be seen that the potential for wind damages is particularly acute, especially for the category 5 storm which could produce surface gusts of 170 mph. Adopting building codes for 120 mph windspeeds would probably have little effect for such a storm, but it would have considerable effect for all other categories of storms. In this test, it was assumed that wind damages would be zero for all windspeeds including 120 mph. It was further assumed that only 75 percent of expected damages from 130 mph windspeeds would occur as a result of constructing to a 120 mph standard. For 140 mph windspeeds, it was assumed that 95 percent of expected damages would occur. Expected damages for windspeeds in excess of 140 mph would remain unchanged. As shown in Table 18, wind damages for categories 1, 2 and 3 storms could be eliminated, and wind damages for a category 4 storm could be reduced by 25 percent. (See Chapter 2, Building Codes and construction Standards for a discussion of costs associated with this measure).

TABLE 18

Estimated Damages from Hurricanes
Selected Area of Gulf Shores, Alabama
Adoption of 120 mph Windspeed Building Codes
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	-0-	130.8	728.4	767.8
Wave & Surge Damages	-0-	-0-	754.1	2,450.6	2,533.9
Wind Damages	-0-	-0-	-0-	359.2	1,081.3
Total Damages	-0-	-0-	$884.9	$3,538.2	$4,383.0
Savings	$271.9	$330.1	$420.7	119.7	-0-
% of Damages Reduced 1/	100%	100%	32%	3%	-0-

1/ Savings as a percent of Existing Total Damages shown on Table 14.

Benefits for Density Restrictions: A fourth mitigation measure that is analyzed in this area is the consequence of reducing the density of structures in the velocity zone. To accomplish this analysis, every other structure seaward of the beach road was subtracted from the velocity zone area, but not from the total amount of property at risk. This allows some degree of realism to the analysis, since the demand for developable property must still be met by some means. With density restrictions, the total demand for property is met in both higher and lower hazard areas, rather than primarily in the higher hazard areas. Table 19 displays the results of this manipulation. Costs associated with Development Regulations such as density restrictions are discussed in Chapter 2.

TABLE 19

Estimated Damages from Hurricanes
Selected Area of Gulf Shores, Alabama
Adoption of Density Restrictions
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	-0-	130.8	1,054.4	1,132.1
Wave & Surge Damages	-0-	-0-	436.4	1,322.7	1,362.1
Wind Damages	271.9	330.1	420.7	478.9	1,076.5
Total Damages	$271.9	$330.1	$987.9	$2,856.0	$3,570.7
Savings	-0-	-0-	$317.7	$801.9	$812.3
% of Damages Reduced 1/	-0-	-0-	24%	22%	19%

1/ Savings as a percent of Existing Total Damages shown on Table 14.

One of the hidden assumptions that is made in this example is that the structures that were deleted from the velocity zone would have the same ground and floor elevations. Accordingly, the potential reduction in damages for a category 3 storm is for reductions in wave damage. The ground and floor elevations of the structures that were deleted from the velocity zone are such that they would not suffer surge damages. The difference in potential damage for category 4 and 5 storms is the result of reduced wave damage net of the increase in surge damage. This net difference is nearly $800,000 for the larger two storms.

The assumption about floor elevations can also be tested. Since the minimum floor elevations are two feet less in the area where these structures would probably be built if they could not be built next to the beach, it may be reasonable to assume that the floor elevations would be two feet less than they are. If this is the case, then the potential savings from category 3, 4 and 5 storms would be $202,900, $437,100, and $462,000 respectively. The savings that could be made by reducing the density in the higher hazard area are reduced because the minimum elevations of the higher hazard area are not maintained in the lower hazard area.

Combination of Mitigation Measures: The last (fifth) analysis made for the Gulf Shores test site is a combination of the dune restoration and preservation plan, constructing to a 120 mph windspeed standard, and density restrictions, including maintaining the floor elevations mentioned above. Table 20 displays the results of these computations. If all of the measures were adopted, then the area would suffer no damage from category 1, 2 and 3 storms. Potential damages for categories 4 and 5 would be reduced by $2.8 million.

TABLE 20

Estimated Damages from Hurricanes
Selected Area of Gulf Shores, Alabama
Adoption of Selected Measures
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	-0-	-0-	$ 525.7	$ 548.0
Wave & Surge Damages	-0-	-0-	-0-	-0-	-0-
Wind Damages	-0-	-0-	-0-	359.2	1,034.9
Total Damages	-0-	-0-	-0-	$ 884.9	$1,582.9
Savings	$271.9	$330.1	$1,305.6	$2,773.0	$2,800.1
% of Damages Reduced 1/	100%	100%	100%	76%	64%

1/ Savings as a percent of Existing Total Damages shown on Table 14.

FORT WALTON BEACH, FLORIDA

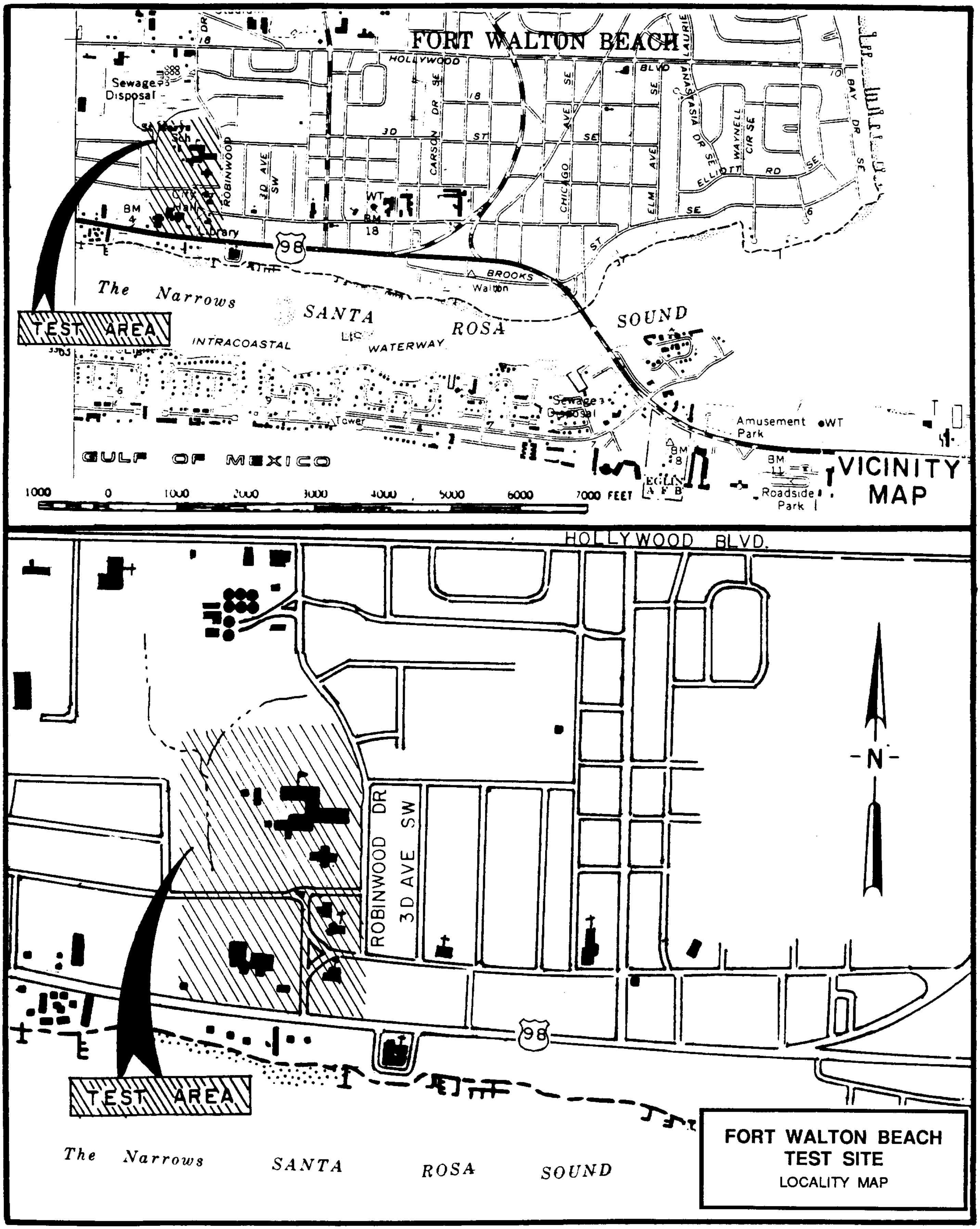
The third test site is in Fort Walton Beach and is centered around the city hall complex. In this test site are 4 churches and a church school. The total value of the property is estimated at $9.2 million. The Flood Insurance Rate Map for the area shows the test site to be in an "A" zone with a 100-year minimum elevation of 6 feet. Figure 6 displays this test site.

Existing Conditions: Table 21 displays the existing conditions for the area. Of note is the lower surge height for a category 5 storm over a category 4 storm. Much of this is due to the smaller but more intense eye of a category 5 storm as compared to the category 4 storm. Being on the mainland behind a barrier island also plays a part in the difference in the surge heights between the two largest storms. Although the damages from surge are less, the damage from increased winds provides for a greater total with a category 5 storm. The surge damages for a category 2 storm are all attributable to the auditorium. This is due to the lower elevation of the back door. The main entrance is at the same elevation as the remainder of the city complex.

TABLE 21

Estimated Damages from Hurricanes
Selected Area of Fort Walton Beach, Florida
Existing Conditions
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Height	5.3	8.5	11.6	14.8	13.8
Peak Gusts @ Surface	80	90	110	130	170
Total Property Value	$9,180.0	$9,180.0	$9,180.0	$9,180.0	$9,180.0
Surge Only Damages	-0-	$708.0	$2,665.4	$3,776.1	$3,531.4
Wave & Surge Damages	-0-	-0-	-0-	-0-	-0-
Wind Damages	102.0	102.0	153.0	204.0	663.0
Total Damages	$102.0	$810.0	$2,818.4	$3,980.1	$4,194.4
% of Property Value	1.1%	8.8%	30.7%	43.4%	45.7%



FORT WALTON BEACH
HOLLYWOOD
Sewage Disposal
ROBINWOOD
3D AVE SW
CARSON DR SE
3D ST SE
CHICAGO AVE SE
ELM AVE SE
ANASTASIA DR SE
WAYNELL CIR SE
ELLIOTT RD SE
BAY DR SE
BLVD
Library
98
BROOKS
Walton
The Narrows
SANTA ROSA SOUND
INTRACOASTAL WATERWAY
TEST AREA
Sewage Disposal
Tower
Amusement Park
WT
GULF OF MEXICO
EGLIN A F B
Roadside Park
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
VICINITY MAP
HOLLYWOOD BLVD.
ROBINWOOD DR
3D AVE SW
N
98
TEST AREA
The Narrows SANTA ROSA SOUND
FORT WALTON BEACH
TEST SITE
LOCALITY MAP

FIGURE 6

Benefits for Floodproofing: The first mitigation measure tested in this site is floodproofing. This entails modifying the damage susceptibility curves. Because floodproofing a building in-place is difficult and expensive, it was assumed that each building would be floodproofed to 3 feet only. This would consist of sealing the walls and providing watertight closures for the doors and other openings. Costs for floodproofing unique buildings such as auditoriums should be professionally estimated.

By floodproofing the auditorium to 3 feet, all of the surge damages from a category 2 storm are eliminated. Floodproofing all of the buildings to 3 feet, eliminates all of the surge damages to all of the buildings from a category 3 storm except the auditorium. Due to the lower elevation of the back door, the surge height in the auditorium in a category 3 storm is estimated to be 5 feet. Surge heights in all buildings are estimated to be greater than 3 feet in category 4 and 5 storms. Floodproofing to three feet would have no effect for these buildings in the event of a storm of those magnitudes. Table 22 displays the effects of the floodproofing mitigation measure.

TABLE 22

Estimated Damages from Hurricanes
Selected Area of Fort Walton Beach, Florida
Floodproofing All Buildings to 3 Feet
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	-0-	$1,168.0	$3,776.1	$3,531.4
Wave & Surge Damages	-0-	-0-	-0-	-0-	-0-
Wind Damages	102.0	102.0	153.0	204.0	663.0
Total Damages	$102.0	$102.0	$1,321.0	$3,980.1	$4,194.4
Savings	-0-	$708.0	$1,497.4	-0-	-0-
% of Damages Reduced 1/	-0-	87%	53%	-0-	-0-

1/ Savings as a percent of Existing Total Damages shown on Table 21.

Benefits for Relocations: Another mitigation measure to be tested in this site is relocations. Since the auditorium cannot be fully floodproofed against category 4 and 5 storms, relocating the building after one of these storms may be the appropriate solution. The relocation of the auditorium could be made part of a general reconstruction plan for the community. Table 23 displays the potential reductions in property damages from relocating the auditorium.

TABLE 23

Estimated Damages from Hurricanes
Selected Area of Fort Walton Beach, Florida
Relocating the Auditorium
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	-0-	$1,497.4	$2,388.1	$2,195.4
Wave & Surge Damages	-0-	-0-	-0-	-0-	-0-
Wind Damages	62.0	62.0	93.0	124.0	403.0
Total Damages	$62.0	$62.0	$1,590.4	$2,512.1	$2,598.4
Savings	$40.0	$748.0	$1,228.0	$1,468.0	$1,596.0
% of Damages Reduced 1/	39%	92%	44%	37%	38%

1/ Savings as a percent of Existing Total Damages shown on Table 21.

Benefits for Elevating Structures: Changing the elevation of the structures was also tested in this area. The first change was to determine what the potential damages would be if all of the structures had been built to the base flood elevation plus 4 feet. Table 24 displays these results. Most of the structures were built well above the base flood elevation of 6 feet. In this analysis, structures were artificially raised between 0.5 and 2 feet to get them to the desired height of 10 feet. (See Chapter 2, Retrofitting Existing Structures, for a discussion of costs).

TABLE 24

Estimated Damages from Hurricanes
Selected Area of Fort Walton Beach, Florida
Raising All Structures to Base Flood Elevation of 6 Feet Plus 4 Feet
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	-0-	$2,091.4	$3,396.4	$3,078.6
Wave & Surge Damages	-0-	-0-	-0-	-0-	-0-
Wind Damages	$102.0	$102.0	153.0	204.0	663.0
Total Damages	$102.0	$102.0	$2,244.4	$3,600.4	$3,741.6
Savings	-0-	$708.0	$574.0	$379.7	$452.8
% of Damages Reduced 1/	-0-	87%	20%	10%	11%

1/ Savings as a percent of Existing Total Damages shown on Table 21.

The second change was to determine what the potential damages would be if the structures had been built to the category 3 surge height of 11.6 feet. This has the effect of raising all of the structures by 2 to 3.5 feet. Table 25 displays the results of this test.

TABLE 25

Estimated Damages from Hurricanes
Selected Area of Fort Walton Beach, Florida
Raising All structures to Category 3 Surge Height of 11.6 Feet
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	-0-	-0-	$2,594.4	$2,091.4
Wave & Surge Damages	-0-	-0-	-0-	-0-	-0-
Wind Damages	$102.0	$102.0	$153.0	204.0	663.0
Total Damages	$102.0	$102.0	$153.0	$2,798.4	$2,754.4
Savings	-0-	$708.0	$2,665.4	$1,181.7	$1,440.0
% of Damages Reduced 1/	-0-	87%	95%	30%	34%

1/ Savings as a percent of Existing Total Damages shown on Table 21.

Combination of Mitigation Measures: A final test was performed for this area. Relocating the auditorium and elevating all remaining structures to 11.6 feet were combined. Table 26 displays the results of combining these measures.

TABLE 26

Estimated Damages from Hurricanes
Selected Area of Fort Walton Beach, Florida
Relocating Auditorium and Raising All Structures to 11.6 Feet
($1,000)

	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
Surge Only Damages	-0-	-0-	-0-	$1,706.4	$1,383.4
Wave & Surge Damages	-0-	-0-	-0-	-0-	-0-
Wind Damages	$62.0	$62.0	$93.0	124.0	403.0
Total Damages	$62.0	$62.0	$93.0	$1,830.4	$1,786.4
Savings	$40.0	$748.0	$2,725.4	$2,149.7	$2,408.0
% of Damages Reduced 1/	39%	92%	97%	54%	57%

1/ Savings as a percent of Existing Total Damages shown on Table 21.

CHAPTER 6

SUMMARY AND CONCLUSIONS

The main objective of this report is to compile a list of appropriate and effective mitigation measures that communities can adopt to lessen the probable property damages that will result from a hurricane striking the area. The second objective is to outline a process that communities can use to decide which mitigation measures would best suit the unique circumstances faced by each community. The third objective is to demonstrate techniques useful in quantifying the beneficial effects of various mitigation measures.

MITIGATION MEASURES

A list of mitigation measures available to communities is included in Chapter 2, Table 2. The list is subdivided into three sections, Strengthening the Coast or Shore, Strengthening Buildings and Facilities, and Development Management. This categorization follows the ways measures tend to mitigate property damages. The measures in the first category tend to mitigate damages by reducing the storm surge's ability to harm property. The measures in the second category strive to make property resistant to the natural forces of hurricanes. Avoiding hazardous areas is the means used by measures in the third category to mitigate property damages.

A brief discussion of specific measures follows a general discussion of all mitigation measures. The report attempts to indicate the circumstances where each measure would be appropriate. Where possible, costs of each measure are discussed. Examples of where some measures have been tried are also given in the discussion of each measure.

Most of the mitigation measures have been around for a long time. Unfortunately, there is very little new about any of them. Many communities have instituted a number of the measures over the years. With more and more people moving to coastal areas, and with rapidly increasing amounts of investments being made in coastal areas, it is becoming more imperative that mitigating probable damages from hurricanes become a priority issue in coastal communities. While much has been done, much remains to be done.

Of the three types of measures listed, the Development Management measures are among the least expensive to implement. They may be, however, the more politically difficult to institute because they require some measure of control of land uses. In some States, local communities are required by State law to perform land use planning with mitigation of damages in hazardous areas as a specific requirement.

One of the myths about hurricanes is the fatalistic attitude that nothing can be done to lessen the damages from a category 4 or 5 storm. While it may be true that effective coastal works such as a seawall or nourished beach cannot be afforded or that construction of a building to withstand any hurricane force winds would be prohibitively expensive, avoiding the hazard area altogether would be just as effective regardless of the size of the storm.

For both communities and individuals, the NFIP can be of enormous benefit in mitigating damages, particularly where minimum standards are exceeded. The NFIP standards are based upon the 100-year storm, or the storm with a 1 percent chance of being equalled or exceeded in any given year. It should be noted, however, that greater magnitude storms are a real possibility. Hurricane Hugo in South Carolina is the most recent example of a storm that exceeds the 100-year classification. By exceeding the minimum NFIP standards, communities and individuals can achieve a greater degree of safety and simultaneously reduce insurance premiums. The savings in premiums is one source of funding to pay the extra costs of exceeding the minimum standards. In South Carolina, buildings that were constructed in compliance with the NFIP standards were among those that weathered the storm the best.

Wind resistant building codes and construction practices are also very important tools to use in mitigating storm damages. It needs to be emphasized that building practices in hurricane hazard areas needs to be significantly different than for conventional construction. Where practiced, the value of these measures is evident in the structures that survived the onslaught of a storm virtually intact. When practiced during original construction, they add between 2 to 4 percent to the total sales price of a single family residence.

Coastal works can be effective mitigation measures for combating damage caused by storm surge. In some States, however, new coastal works such as seawalls and bulkheads and the repair of substantially damaged coastal works is prohibited. Dune preservation or beach nourishment are coastal works that are available. While these can be expensive measures to both construct and maintain, they do have their rightful place among hurricane damage mitigation measures. Because of the complexities of both the measure itself and the environment in which they are built, it is recommended that they be planned, designed, and constructed by professionals.

PLANNING PROCESS

Deciding which mitigation measures to adopt can be a very difficult undertaking for many communities. Chapter 3 outlines a planning process that can be used to assist in the decision making process. The seven steps in the process are establishing the community's goals and objectives to provide guidance and a framework to the remainder of the planning process, performing a hazard analysis so that the amount of property at risk and the extent of the risks are fully understood, reviewing existing conditions to account for the successful measures that are already in existence and to establish a baseline against which the effectiveness of additional mitigation measures can be estimated, forecasting future conditions to provide direction for consideration of which mitigation measures would be appropriate for the community, developing plans and strategies to best meet as many of the future needs of the community as possible, evaluating those plans and strategies so that the real potential effectiveness of various mitigation measures can be fully understood, and, finally, selecting and implementing mitigation measures which have the support of the community.

It is suggested that a planning team be organized and that a manager be selected. Team members could come from most governmental departments, since they will have valuable contributions to make sometime during the planning process. If the general public and civic leaders are not included on the planning team, a citizen advisory committee could be formed to help generate the political support that will be needed to choose and implement the mitigation measures that are most appropriate for the community.

ESTIMATING EFFECTIVENESS

Within the planning process is the step of evaluating the potential effectiveness of various measures. Chapter 4 is devoted to explaining two techniques that can be used to evaluate analytically the effectiveness of selected measures. These two techniques are centered around estimating the potential savings in property damages directly attributable to a mitigation measure and estimating the impacts on tax revenues and public expenditures as a direct result of adopting some measure.

TEST SITES

To demonstrate how the estimation of savings in potential property damages technique works, three test site were chosen. A site in Gulfport, Mississippi, which features commercial establishments, a site in Gulf Shores, Alabama, which features residential construction, and a site in Fort Walton Beach, Florida, which features public buildings were selected. The measures picked for testing were elevating structures, adopting wind resistant building codes, dune restoration, density restrictions, floodproofing, and relocating.

By far, the most effective measure is elevating structures. In the Gulfport test site, elevating all of the structures four feet above the base flood elevation would result in savings of 70 percent of damages in a category 2 storm. Elevating all structures 4 feet above their existing elevation would also save 70 percent of category 2 damages, nearly 80 percent of category 3 damages, and 30 to 14 percent of category 4 and 5 storm damages.

In the Gulf Shores test area, savings for elevating were analyzed in a slightly different manner. In this instance, the structures are already substantially elevated. The analysis of elevating structures was to show the effectiveness of having built to higher elevations. Assuming that structures could have been built to the base flood elevation, the savings of having built to higher elevations are $2.8 million for a category 3 storm, $950,000 for a category 4 storm, and $600,000 for a category 5 storm.

In the Fort Walton Beach test site, raising structures to the expected surge height of a category 3 storm would eliminate flooding damages of $2.7 million for that size storm and reduce category 4 and 5 storm flooding damages by 30 to 35 percent.

Dune restoration was tested in the Gulf Shores test area. Assuming that a dune system would prevent waves from damaging property, the savings in potential damages are estimated to range from 60 to 45 to 40 percent for category 3, 4, and 5 storms, respectively.

Adoption of wind resistant building codes was tested in the Gulfport and Gulf Shores areas. The test assumed that a building code standard of 120 mph was instituted, and that all components of all structures would meet the standard. Adoption of this standard would completely eliminate wind damages for categories 1, 2, and 3 storms. Wind damages for category 4 storms would also be reduced by 25 percent. The analysis of wind damages considers only the damage that is caused by the wind itself, and does not include damages caused by wind blown debris.

Density restrictions were tested in the Gulf Shores test area. In this test, half of the structures in the "V" zone were moved to the adjacent "A" zone. The effects of this alteration are to reduce the damages caused by Wave & Surge and to increase the damages caused by Surge Only. Because the elevation of the lowest floor of all of the structures moved is great enough, the $750,000 damages in a category 3 storm from Wave & Surge in the "V" zone are reduced to $436,000 with no corresponding increase in the "A" zone. For category 4 and 5 storms, the damages in the "V" zone are decreased from $2.5 million to $1.3 million while the damages in the "A" zone are increased by $300,000 to $400,000. If the elevation of the lowest floor of the structures that are "moved" from the "V" zone to the "A" zone is also lowered to the average of the lowest floor in the "A" zone, an adjustment of 2 feet, the savings in potential damages is reduced by half. This test again demonstrates the value of elevating the lowest floor above the expected height of the storm surge.

In the Fort Walton Beach test site, floodproofing all buildings and relocation of the civic auditorium were tested. Floodproofing a building can be a complex undertaking. For the test it was assumed that each building was floodproofed only 3 feet. This means that no flood damages would occur so long as the height of the water surrounding the building is less than 3 feet. Should the surrounding water be higher than 3 feet, the building and its contents would be damaged to the same extent as if no floodproofing had taken place. If all of the buildings in the test area are floodproofed by 3 feet, the damages from category 2 and 3 storms would be reduced by 87 and 53 percent. Damages from category 4 and 5 storms would be unaffected.

Because the civic auditorium has the lowest floor elevation of all buildings in the test area, and because of its value, it represents a large portion of the total potential damages in all categories of storms. Relocating this structure to an area that is not subject to flooding would significantly reduce the potential damages to public property in the event of a hurricane. Damages attributable to storm surge and winds would both be reduced for the test area. It should be recognized, however, that wind damages could still occur to a relocated auditorium.

It is not the intention of this report to recommend specific measures for any of the test sites. The analysis of savings in potential damages in the test areas is to demonstrate the possibilities for saving potential damages in high hazard areas throughout the community. Far more extensive data collection and analysis would be needed to demonstrate the effectiveness of any of the mitigation measures for the entire community.

APPENDIX A

The bibliography and the list of persons consulted during the course of this study also provides a source for detailed information on each of the mitigation measures discussed in the report. This report is meant to be a starting point for the adoption of the mitigation measures mentioned in the report.

APPENDIX B

A computer spreadsheet was developed to accommodate the many computations that were needed to estimate the savings in potential property damages. A listing of tabular data used in the spreadsheet and examples of completed spreadsheets for the three test areas are included in Appendix B. Users of the spreadsheet may modify it to suit individual preferences or applications.

APPENDIX C

As part of the investigations for this report, information was collected on mitigation measures that are being used across the study area. A compilation of that information is contained in Appendix C. A brief summary of some of the pertinent State laws concerning statewide building codes, erosion setback requirements, and mandatory growth management is also included in the appendix. This information is intended to provide a source for those who are interested in a specific mitigation measure and learning from the experiences of those who are using that measure.

RECOMMENDATIONS

The major recommendations of this report are for local governments to make considerations of property damage mitigation explicit in their daily functioning. Take small steps. Fine tune existing programs that are working well. Become thoroughly familiar with the National Flood Insurance Program, the new Community Rating System and the Stafford Act amendments of the Disaster Assistance Act. State laws may also require local governments to make provisions in preparation for future hurricanes. Develop plans for the immediate recovery of the community following a hurricane. Those plans should cover provision of essential services such as water, electricity, communications and sewage. Secondarily, preparations should be developed for the reconstruction of areas that are most vulnerable and that may be devastated. Plans to mitigate property damages to future development should also be developed, but they may not have the same priority. The hazard analyses for the community should demonstrate which areas face the greatest degree of risk. The priority of developing plans for areas of existing development versus areas to be developed could be determined by those analyses. The strength of existing measures and other considerations will also have a bearing on the priority given to development of plans for mitigation of property damages to different areas of the community. What is required is to take the time and commit the resources to begin the process of planning for hazard mitigation.

APPENDIX A

BIBLIOGRAPHY

AND

PERSONS CONSULTED DURING STUDY

BIBLIOGRAPHY

1. Living with the West Florida shore (sic), by Larry J. Doyle, Dinesh C. Sharma, Albert C. Hines, Orrin H. Pilkey, Jr., William J. Neal, Orrin H. Pilkey, Sr., David Martin, and Daniel F. Belknap. Durham, N.C.: Duke University Press, 1984. 222 pp. ISBN No. 0-8223-0517-8(pbk).

2. Living with the Alabama-Mississippi shore (sic), by Wayne F. Canis, William J. Neal, Orrin H. Pilkey, Jr., Orrin H. Pilkey, Sr. Durham, N.C.: Duke University Press, 1985. 215 pp. ISBN No. 0-8223-0511-9(pbk).

3. Coastal Design: A Guide For Builders, Planners, And Home Owners, by Orrin H Pilkey, Sr., Walter D. Pilkey, Orrin H. Pilkey, Jr. New York City: Van Nostrand Reinhold Company, 1983. 224 pp. ISBN No. 0-442-27718-0.

4. Catastrophic Coastal Storms: Hazard Mitigation and Development Management, by David R. Godschalk, David J. Brower, and Timothy Beatley. Durham N.C.: Duke University Press, 1989. 275 pp. ISBN (invalid) 0-8223-0558-X.

5. Design and Construction Manual for Residential Buildings in Coastal High Hazard Areas (Coastal Construction Manual), prepared for Federal Emergency Management Agency by Dames and Moore and Bliss and Nyitray, Inc. Washington, D.C.: U.S. Government Printing Office, 1986.

6. Design Manual for Retrofitting Flood-prone Residential Structures, prepared for Federal Management Agency by Dewberry and Davis, Washington, D.C.: U.S. Government Printing Office, 1986.

7. Reducing Hurricane And Coastal Hazards Through Growth Management: A Guidebook for North Carolina Coastal Localities, by David J. Brower, Timothy Beatley, and David J.L. Blatt. Center for Urban and Regional Studies, University of North Carolina at Chapel Hill: 1987. 317 pp.

8. Amendment No. 1 to the South Carolina Coastal Management Program, Inclusion of the 1988 Beach Management Act, Environmental Assessment and Preliminary Findings of Approvability, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Office of Ocean and Coastal Resource Management, 1988.

9. "Coastal Infrastructure Policy Implementation Update", Florida Department of Community Affairs, Division of Resource Planning and Management, Tallahassee, March 1990.

10. "Surviving the Storm: Building Codes, Compliance and Mitigation of Hurricane Damage", All-Industry Research Advisory Council, Oak Brook, Illinois, 1990.

11. "Low Cost Shore Protection", prepared by Rogers, Golden and Halpern, Inc., for U.S. Army Corps of Engineers, Washington, D.C. 1981. 36 pp.

12. "Restless Ribbons of Sand: Atlantic and Gulf Coastal Barriers", by John T. Wells and Charles H. Peterson, Institute of Marine Sciences, University of North Carolina at Chapel Hill, Morehead City, North Carolina, in cooperation with U.S. Department of the Interior, Fish and Wildlife Service, National Wetlands Research Center, Slidell, Louisiana, Graphics and Production by Louisiana Sea Grant College Program, Louisiana State University, Baton Rouge, Louisiana. 19 pp.

13. "Florida Hurricane Resistant Construction Manual", Developed by Southern Building Code Congress International, Inc., Birmingham, Alabama. for The Department of Community Affairs, State of Florida.

14. "A Deemed-To-Comply Standard for Single and Multifamily Dwellings in High Wind Regions", public review draft. Southern Building Code Congress International, Inc., Birmingham, Alabama. 1989.

15. "Making Mitigation Work: A Handbook for State Officials", Federal Emergency Management Agency, Disaster Assistance Programs, DAP 12, Washington, D.C., U.S. Government Printing Office. 1986.

16. "Robert T. Stafford Disaster Relief and Emergency Assistance Act". 1988.

17. "The Strange Life of Hurricane Gilbert September 11-19, 1988", by Dale C. Perry, James R. McDonald and Richard E. Peterson, from Southern Building, January/February 1989, Rick Moore, Manager of Publications, Birmingham, Alabama. Southern Building Code Congress International, Inc.

18. "Coastal Erosion Issues In Flood Hazard Mapping", by Spencer M. Rogers, Jr. Department of Civil Engineering, North Carolina State University and UNC Sea Grant, Marine Advisory Service, Kure Beach, North Carolina.

19. "A Study of the Effectiveness of Building Legislation in Improving the Wind Resistance of Residential Structures", by Spencer M. Rogers, Jr., Peter R. Sparks and Katharine M. Sparks. 1986

20. "Hurricane Diana: Impact on Coastal Development" by Spencer M. Rogers, Jr. Coastal Zone '85 Volume 2. pp 2468-2486.

21. "Saving Money on Flood Insurance for Coastal Property Owners", by Spencer M. Rogers. draft 1989.

22. "America's Vanishing Coastlines: A New Concern For The Voluntary And Residual Property Insurance Markets", The National Committee on Property Insurance, 1988.

23. "Catastrophic Losses: How the Insurance System Would Handle Two $7 Billion Hurricanes", All-Industry Research Advisory Council, 1986.

24. "Hurricane Hugo: learning from South Carolina", by H. Crane Miller., for the Office of Ocean and Coastal Resources Management, National Ocean Survey, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, DC, March 1990.

25. "Natural Hazard Risk Assessment for an Insurance Program", by Don G. Friedman, The Geneva Papers on Risk and Insurance, Vol. 9, No. 30. 1984.

26. Memorandum to: Coastal Management Program Managers, from: John Crew, Subject: "Preparing for the Next Hurricane: The North Carolina Experience", Pre/Post-storm Planning in Local Land Use Plans in Coastal North Carolina, September 28, 1987. North Carolina Department of Natural Resources and Community Development, Division of Coastal Management.

27. "The Town of Nags Head (North Carolina) Hurricane and Storm Mitigation and Reconstruction Plan", Adopted October 10, 1988.

28. "Hurricane Hazard Mitigation and Post-Storm Reconstruction Plan for Nags Head, North Carolina, by David J. Brower, William E. Collins, and Timothy Beatley. Chapel Hill, North Carolina. 1984.

29. "Federal Programs Providing Disaster Assistance to Coastal Local Governments Following A Hurricane: A Handbook For Local Government Officials", by Luther Propst, (second edition by Christine Kentoop). Ocean and Coastal Policy Program, Center for Urban and Regional Studies, University of North Carolina at Chapel Hill. 1987.

30. "Influences on the Priority, Adoption, and Effectiveness of Local Coastal Storm Hazard Mitigation", by Timothy Beatley, (under the direction of David R. Godschalk). Hazard Mitigation Research Program, Center for Urban and Regional Studies, University of North Carolina at Chapel Hill. 1986.

31. North Carolina Administrative Code, NR&CD - Coastal Management, Subchapter 7B - Land Use Planning Guidelines. 1988.

32. Interagency Flood Hazard Mitigation Report: In Response to the April 12, 1984 Disaster Declaration, State of New Jersey, (FEMA-701-DR-NJ), Covering: Monmouth, Ocean, Atlantic, Cape May, Bergen, Passaic, Morris and Essex Counties, N.J. prepared by the Region II Interagency Hazard Mitigation Team. April 27, 1984.

33. Interagency Hazard Mitigation Report: In Response to the April 17, 1984 Disaster Declaration, (FEMA-702-DR-NY), State of New York, prepared by the Region II Hazard Mitigation Team.

34. Interagency Hazard Mitigation Report: In Response to the September 12, 1985 Disaster Declaration, (FEMA-743-DR-FL), Covering Franklin, Wakulla, Dixie, Levy, Hillsborough, Pinellas and Manatee Counties. October 2, 1985.

35. "Hazard Mitigation in Brownwood Subdivision", by Robert C. Freitag, presented at the Tenth Annual Oregon Planning Institute, September 28, 1984.

36. Interagency Flood Hazard Mitigation Report: In response to the August 19, 1983 Disaster Declaration, State of Texas, (FEMA-689-DR), prepared by the Region 6 Interagency Hazard Mitigation Team. September 2, 1983.

37. One-Year Interagency Post-Flood Recovery Progress Report, "Alicia", In Response to the August 19, 1983 Disaster Declaration, State of Texas, (FEMA-689-DR)

38. "Mitigation Approaches and Tools in Coastal Areas" by Timothy Beatley, Division of Urban and Environmental Planning, School of Architecture, University of Virginia, Charlottesville, Virginia.

39. "Local Government Adoption of Innovative Measures to Mitigate Urban Flood Hazards: The U.S. Experience" by Raymond J. Burby for presentation at the World Planning and Housing Congress "Innovation in Planning and Housing", Adelaide, South Australia. 1986.

40. "NFIP Community Rating System Community Credit Activities", prepared for Federal Emergency Management Agency, Federal Insurance Administration by The Association of State Floodplain Managers. June 25, 1988.

41. "Probable Property Damage Losses from Natural Hazards to Present and Future Development on Florida's Barrier Islands: Development of a Method", by Bruce Stiftel, Andrew Dzurik and Anita Tallarico, Environmental Hazards Center, Institute for Science and Public Affairs, Florida State University, Tallahassee. prepared for presentation at the Fifth Symposium on Coastal and Ocean Management, May 27, 1987, Seattle, Washington.

42. "Estimating Probable Storm Damage on Barrier Islands", by Andrew A. Dzurik, Bruce Stiftel and Anita Tallarico, Florida State University, Tallahassee.

43. Hurricane Alicia: Galveston and Houston, Texas August 17-18, 1983, by Rudolph P. Savage, Jay Baker, Joseph H. Golden, Ahsan Kareem and Billy R. Manning, Committee on Natural Disasters, Commission on Engineering and Technical Systems, National Research Council, National Academy Press, Washington D.C. 1984.

44. "America's Eroding Beaches--NOS Data May Hold the Key" by Stephen P. Leatherman and John J. McDonough, III, The Military Engineer, No. 520, March/April 1988. pp 143-144.

45. "Coasts and Beaches" by Stephen P. Leatherman, Geological Society of America, Centennial Special Vol. 3. 1988.

46. "War of the Waves: Tirelessly, Sometimes Violently, the Sea Tears at Ocean City", by Jeffrey W. Peters, The Evening Sun, Baltimore, Maryland. A reprint of articles published June 3, 10, 17, 24, 1985.

47. West Florida Region Hurricane Loss and Contingency Planning Study, West Florida Regional Planning Council, Pensacola, Florida, December 1985.

48. "Barrier Island Handbook", by Stephen P. Leatherman, Coastal Publications Series, Laboratory for Coastal Research, The University of Maryland, College Park, Maryland. 1988.

49. "Summaries of State CZM Policies on Erosion Control and Beach Access", by Anthonette B. Touart and Amanda S. Dent, Coastal Zone Studies Department, The University of West Florida. 1980.

50. "National Strategy for Beach Preservation", Second Skidaway Institute of Oceanography Conference on America's Eroding Shoreline, Savannah, Georgia. June 1985.

51. "A "Thumbnail Method" for Beach Communities: Estimation of Long-Term Beach Replenishment Requirements" by Orrin H. Pilkey. Shore and Beach. pp 23-31. July 1988.

52. "Saving the American Beach: A Position Paper by Concerned Coastal Geologists" Results of the Skidaway Institute of Oceanography Conference on America's Eroding Shoreline: The Need for Geologic Input into Shoreline Management, Decisions and Strategy. Savannah, Georgia. March 25-27, 1981.

53. "Hurricane-Related Morphodynamics and Implications for Hazard Mitigation, Perdido Key, Florida, U.S.A.", by Gregory W. Stone and Jack D. Salmon. Coastal Management, Vol. 16 pp 245-270. 1988.

54. "Public Perception of Hurricane Hazards: Examining the Differential Effects of Hurricane Diana" by Timothy Beatley and David J. Brower. Coastal Zone Management Journal, Vol. 14, No. 3. pp 241-269. 1986.

55. "Hurricane Loss Study Analysis", Florida Department of Community Affairs, Division of Emergency Management. 1988.

56. "A Dune Restoration and Protection Program for Escambia County Florida", by James P. Morgan and Gregory W. Stone. Center for State and Local Government, The University of West Florida. Vol. 1 of 2. 1987.

57. "Summary of Beach Replenishment Experience on U.S. East Coast Barrier Islands", by Orrin H. Pilkey and Tonya D. Clayton. Journal of Coastal Research, Vol. 5, No. 1, 1989.

58. "Seawalls Versus Beaches" by Orrin H. Pilkey and Howard L. Wright III. Journal of Coastal Research, Vol. 4, No. 4, Fall 1988.

59. "An Analysis of Coastal Recession Models: North Carolina Coast" by Orrin H. Pilkey and Thomas W. Davis. Department of Geology and Marine Laboratory, Duke University, Durham, North Carolina. pp 59-68.

60. "Beach Replenishment: The National Solution?" by Orrin H. Pilkey and Tonya D. Clayton. Coastal Zone '87. pp 1408-1419.

61. "An Assessment of Beach Replenishment Parameters", by Orrin H. Pilkey and Tonya D. Clayton. Department of Geology, Duke University, Durham, North Carolina.

62. "Hurricane Preparedness Policy Rule, 9J-2.0256" Florida Department of Community Affairs, Division of Resource Planning and Management.

63. "Special Hurricane Preparedness Districts for Development of Regional Impact, 9J-2.0257" Florida Department of Community Affairs, Division of Resource Planning and Management.

64. Lee County Comprehensive Plan: "The Lee Plan", adopted by the Lee County (Florida) Board of County Commissioners on November, 16, 1984. Chapter VII, Disaster Preparedness Sub-Element.

65. Summary of Proposed Changes to the Lee Plan (Currently Chapter IX), "Conservation and Coastal Management", 1988. (see item No. 63)

66. Lee County (Florida) Comprehensive Plan: Selected Goals, Objectives and Policies Relevant to the Department of Public Safety. Lee County Department of Public Safety, Disaster Preparedness Agency. 1986.

67. Lee County (Florida) Development Standards Ordinance, adopted by the Lee County Board of County Commissioners on September 3, 1986. pp i-ii and 88.

68. Lee County (Florida) Ordinance No. 86-17, pp i and 115-116.

PERSONS CONSULTED DURING STUDY

The following is a list of persons consulted during the course of the Phase II study. Each person provided valuable insight into the issues surrounding the mitigation of potential property damages caused by severe storms and hurricanes. It is with gratitude that we acknowledge the contributions made by these individuals.

Dr. David Brower
Center for Urban and Regional Studies
University of North Carolina

Mr. Bruce Bortz
City Planner
City of Nags Head, North Carolina

Dr. Ray Fox
Department of Civil, Mechanical
and Environmental Engineering
George Washington University

Mr. John Gamble
Federal Emergency Management Agency
Washington, D.C.

Dr. David Godschalk
Department of City and Regional Planning
University of North Carolina

Mr. John Housley
Mr. Jay Lockhart
Mr. Lim Vallianos
U.S. Army Corps of Engineers
Washington, D.C.

Dr. Steve Leatherman
Department of Geography
University of Maryland

Mr. Billy Manning
Director of Engineering and Education
Southern Building Code Congress International
Birmingham, Alabama

Mr. Ben Mieremet
Office of Coastal Resource Management
National Oceanic and Atmospheric Administration
Washington, D.C.

Dr. James Morgan
Dr. Jack Salmon
Dr. Gregory Stone
Department of Political Science
University of West Florida

Dr. Orrin Pilkey, Jr.
Mr. David Bush
Department of Geology
Duke University

Mr. Gary Price
City Manager
Mr. Fred Voutin
Mayor
Sanibel Island, Florida

Dr. Spencer Rogers
North Carolina Sea Grant Program
Kure Beach, North Carolina

Dr. Bruce Stiftel
Department of Urban and Regional Studies
Florida State University

Mr. Stan Tait
Florida Shore and Beach Preservation Association
Tallahassee, Florida

Mr. David Unnewehr
Research Manager
All-Industry Research Advisory Council
Oak Brook, Illinois

Mr. John Wilson, Director
Mr. David Sanitor
Division of Emergency Management
Lee County, Florida

Mr. Larry Zenzinger
Federal Emergency Management Agency
Washington D.C.

APPENDIX B

SPREADSHEET

FOR

ESTIMATING PROPERTY DAMAGES

SPREADSHEET FOR ESTIMATING PROPERTY DAMAGES

Some of the data used in the spreadsheet are input directly and some of the data are computed based upon tabular data and/or other directly input data. Tables B-1 through B-5 present the tabular data that the spreadsheet uses with several of the formulas.

The spreadsheet is designed so that the estimate of potential damages can be made for each of the five categories of hurricanes. The selection of a storm category is directly input and used with other directly input data and tabular data. Surge height is an example of a computed answer which is dependent on tabular data. For this spreadsheet, the formula for SURGE HEIGHT directs the spreadsheet to a table labelled SURGEHEIGHT and asks for the value that corresponds to the category of storm which was previously selected and for LOSS ZONE since the surge heights vary for location and storm category.

The formula for SUSTAINED WINDS AT 30 METERS also directs the computer model to go to a table named STORMS and find the answer that corresponds to the category of storm that is being analyzed.

The formula for SUSTAINED SURFACE WINDS depends upon the preceding answer. The formula instructs the model to multiply the SUSTAINED WINDS at 30 METERS by a factor of 0.66.

The formula for PEAK GUSTS at the SURFACE tells the model to multiply the SUSTAINED SURFACE WINDS by a factor of 1.3 and round the answer to the nearest 10 mph. This answer is rounded to the nearest 10 mph because it is used in the computation of wind damages. If it were not rounded, then the damages from a 109-mph windspeed would be treated by the spreadsheet in its search for a value in a table as if it were a 100-mph windspeed. In the search, the spreadsheet will not look for a value greater than the target value, and failing to find the target, will revert to the next lowest value in the table. The values in the windspeed table are in increments of 10 mph. Therefore, for any value between 101 and 109, the spreadsheet will "find" the value in the table corresponding to 100.

The next two items, VELOCITY ZONE and LOSS ZONE are input to the spreadsheet by the analyst. They are used in other computations. VELOCITY ZONE is used in the computation of WAVE HEIGHT AT STRUCTURE. By setting the VELOCITY ZONE to anything other than 1, the WAVE HEIGHT AT STRUCTURE will always return an answer of zero. This means that no damages due to wave action will be computed. This is useful in those cases where the SURGE DEPTH AT STRUCTURE could be greater than 4 feet, but there are other factors that would not allow the generation of a wave. Such a case could be behind a dune system or the second or third row of structures from the beach. In these cases, the wave could crest and not have enough fetch to regenerate. The LOSS ZONE value is used to find the appropriate value for SURGE HEIGHT.

TABLE B-1

TABULAR DATA FOR LOTUS 1-2-3 SPREADSHEET
WINDSPEEDS, SURGE HEIGHTS, AND VALUE OF CONTENTS

STORMS

CATEGORY	WINDSPEED
1	90
2	105
3	125
4	150
5	200

These values are in the upper end of the Saffir-Simpson scale. They can be adjusted to suit the user.

SURGEHEIGHTS

CATEGORY	GP MS	GS AL	FWB FL
1	9.0	4.0	5.3
2	15.5	8.7	8.5
3	21.4	13.6	11.6
4	26.6	17.1	14.8
5	30.0	17.3	13.8

CONTENTVALUE

TYPE	ID	PERCENT
RESIDENTIAL	1	50
MOBILE HOME	2	80
COMMERCIAL	3	144
INDUSTRIAL	4	280
MEDICAL	5	280
PUBLIC BLDG	6	80
MAINT/STORG	7	150
RD & BRDG	8	0
UTILITIES	9	0
CHURCH	10	80
OVHD UTIL	11	0

These values must be converted to decimal format before inserting into the spread-sheet.

SOURCE: The values shown above have been taken from the Tri-State Hurricane Evacuation Study, the Tri-State Hurricane Property Loss Study, Phase I, and from experience with this type of analysis.

TABLE B-2

TABULAR DATA FOR LOTUS 1-2-3 SPREADSHEET

PERCENT OF STRUCTURE VALUE DAMAGED BY HURRICANE GENERATED STILLWATER SURGE

(Decimal Format 0.15 = 15%)

SURGECURVES

FT	SINGLE	MULTI	MOBILE	COMMERCIAL	INDUSTRIAL	MEDICAL	PUBLIC	RDS & BRDG	UTILITIES	CHURCHES	OVHD UTL
	1	2	3	4	5	6	7	8	9	10	11
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.15	0.08	0.30	0.12	0.03	0.03	0.03	0.05	0.05	0.12	0.05
2	0.29	0.16	0.77	0.18	0.05	0.05	0.05	0.06	0.06	0.18	0.06
3	0.38	0.21	0.92	0.21	0.06	0.06	0.06	0.07	0.07	0.21	0.07
4	0.44	0.24	0.98	0.25	0.07	0.07	0.07	0.08	0.08	0.25	0.08
5	0.49	0.27	1.00	0.27	0.08	0.08	0.08	0.09	0.09	0.27	0.09
6	0.53	0.29	1.00	0.30	0.09	0.09	0.09	0.10	0.10	0.30	0.10
7	0.56	0.30	1.00	0.33	0.10	0.10	0.10	0.10	0.10	0.33	0.10
8	0.58	0.30	1.00	0.36	0.11	0.11	0.11	0.11	0.11	0.36	0.11
9	0.60	0.31	1.00	0.38	0.12	0.12	0.12	0.12	0.12	0.38	0.12
10	0.61	0.37	1.00	0.40	0.13	0.13	0.13	0.13	0.13	0.40	0.13
11	0.62	0.42	1.00	0.43	0.15	0.15	0.15	0.14	0.14	0.43	0.14
12	0.63	0.46	1.00	0.48	0.17	0.17	0.17	0.15	0.15	0.48	0.15
13	0.63	0.48	1.00	0.52	0.18	0.18	0.18	0.15	0.15	0.52	0.15
14	0.63	0.50	1.00	0.60	0.19	0.19	0.19	0.16	0.16	0.60	0.16
15	0.63	0.51	1.00	0.67	0.20	0.20	0.20	0.17	0.17	0.67	0.17
16	0.63	0.51	1.00	0.75	0.22	0.22	0.22	0.18	0.18	0.75	0.18
17	0.63	0.51	1.00	0.82	0.24	0.24	0.24	0.19	0.19	0.82	0.19
18	0.63	0.51	1.00	0.90	0.25	0.25	0.25	0.20	0.20	0.90	0.20
19	0.63	0.51	1.00	0.95	0.26	0.26	0.26	0.20	0.20	0.95	0.20
20	0.63	0.51	1.00	1.00	0.27	0.27	0.27	0.21	0.21	1.00	0.21
21	0.63	0.51	1.00	1.00	0.28	0.28	0.28	0.22	0.22	1.00	0.22
22	0.63	0.51	1.00	1.00	0.30	0.30	0.30	0.23	0.23	1.00	0.23
23	0.63	0.51	1.00	1.00	0.32	0.32	0.32	0.24	0.24	1.00	0.24
24	0.63	0.51	1.00	1.00	0.34	0.34	0.34	0.25	0.25	1.00	0.25
25	0.63	0.51	1.00	1.00	0.35	0.35	0.35	0.25	0.25	1.00	0.25
26	0.63	0.51	1.00	1.00	0.36	0.36	0.36	0.25	0.25	1.00	0.25
27	0.63	0.51	1.00	1.00	0.38	0.38	0.38	0.25	0.25	1.00	0.25
28	0.63	0.51	1.00	1.00	0.40	0.40	0.40	0.25	0.25	1.00	0.25
29	0.63	0.51	1.00	1.00	0.43	0.43	0.43	0.25	0.25	1.00	0.25
30	0.63	0.51	1.00	1.00	0.45	0.45	0.45	0.25	0.25	1.00	0.25

Source: Tri-State Hurricane Property Loss Study, U.S. Army Corps of Engineers, Mobile District, July 1989.

TABLE B-3

TABULAR DATA FOR LOTUS 1-2-3 SPREADSHEET

PERCENT OF CONTENT VALUE DAMAGED BY HURRICANE GENERATED STILLWATER SURGE

(Decimal Format 0.21 = 21%)

CONTENTCURVES

FT	SINGLE	MULTI	MOBILE	COMMERCIAL	INDUSTRIAL	MEDICAL	PUBLIC	RDS & BRDG	UTILITIES	CHURCHES	OVHD UTL
	1	2	3	4	5	6	7	8	9	10	11
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.21	0.16	0.28	0.21	0.07	0.24	0.24	0.00	0.00	0.24	0.00
2	0.39	0.23	0.52	0.39	0.13	0.38	0.38	0.00	0.00	0.38	0.00
3	0.52	0.28	0.72	0.52	0.17	0.48	0.48	0.00	0.00	0.48	0.00
4	0.61	0.30	0.88	0.61	0.20	0.57	0.57	0.00	0.00	0.57	0.00
5	0.67	0.33	1.00	0.72	0.23	0.63	0.63	0.00	0.00	0.63	0.00
6	0.70	0.35	1.00	0.81	0.25	0.68	0.68	0.00	0.00	0.68	0.00
7	0.72	0.36	1.00	0.88	0.27	0.71	0.71	0.00	0.00	0.71	0.00
8	0.74	0.37	1.00	0.93	0.29	0.73	0.73	0.00	0.00	0.73	0.00
9	0.75	0.38	1.00	0.97	0.31	0.75	0.75	0.00	0.00	0.75	0.00
10	0.76	0.39	1.00	1.00	0.33	0.76	0.76	0.00	0.00	0.76	0.00
11	0.77	0.44	1.00	1.00	0.34	0.77	0.77	0.00	0.00	0.77	0.00
12	0.77	0.50	1.00	1.00	0.35	0.78	0.78	0.00	0.00	0.78	0.00
13	0.78	0.55	1.00	1.00	0.36	0.78	0.78	0.00	0.00	0.78	0.00
14	0.78	0.62	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
15	0.79	0.66	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
16	0.79	0.70	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
17	0.79	0.72	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
18	0.79	0.74	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
19	0.79	0.75	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
20	0.79	0.76	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
21	0.79	0.77	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
22	0.79	0.78	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
23	0.79	0.78	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
24	0.79	0.79	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
25	0.79	0.79	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
26	0.79	0.79	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
27	0.79	0.79	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
28	0.79	0.79	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
29	0.79	0.79	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00
30	0.79	0.79	1.00	1.00	0.36	0.79	0.79	0.00	0.00	0.79	0.00

Source: Tri-State Hurricane Property Loss Study, U.S. Army Corps of Engineers, Mobile District, July 1989.

TABLE B-4

TABULAR DATA FOR LOTUS 1-2-3 SPREADSHEET

PERCENT OF STRUCTURE VALUE DAMAGED BY HURRICANE GENERATED WAVES

(Decimal Format 0.22 = 22%)

WAVECURVES

FT	SINGLE	MULTI	MOBILE	COMMERCIAL	INDUSTRIAL	MEDICAL	PUBLIC	RDS & BRDG	UTILITIES	CHURCHES	OVHD UTL
	1	2	3	4	5	6	7	8	9	10	11
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.22	0.14	0.75	0.15	0.04	0.04	0.04	0.04	0.04	0.15	0.04
2	0.37	0.20	1.00	0.22	0.06	0.06	0.06	0.06	0.06	0.22	0.06
3	0.50	0.26	1.00	0.27	0.09	0.09	0.09	0.09	0.09	0.27	0.09
4	0.60	0.29	1.00	0.30	0.10	0.10	0.10	0.10	0.10	0.30	0.10
5	0.65	0.32	1.00	0.32	0.11	0.11	0.11	0.11	0.11	0.32	0.11
6	0.69	0.35	1.00	0.35	0.11	0.11	0.11	0.11	0.11	0.35	0.11
7	0.72	0.38	1.00	0.39	0.12	0.12	0.12	0.12	0.12	0.39	0.12
8	0.78	0.41	1.00	0.43	0.13	0.13	0.13	0.13	0.13	0.43	0.13
9	0.83	0.45	1.00	0.46	0.14	0.14	0.14	0.14	0.14	0.46	0.14
10	0.94	0.48	1.00	0.49	0.15	0.15	0.15	0.15	0.15	0.49	0.15
11	1.00	0.53	1.00	0.54	0.16	0.16	0.16	0.16	0.16	0.54	0.16
12	1.00	0.60	1.00	0.60	0.18	0.18	0.18	0.18	0.18	0.60	0.18
13	1.00	0.65	1.00	0.68	0.20	0.20	0.20	0.20	0.20	0.68	0.20
14	1.00	0.79	1.00	0.85	0.24	0.24	0.24	0.24	0.24	0.85	0.24
15	1.00	0.95	1.00	1.00	0.28	0.28	0.28	0.28	0.28	1.00	0.28
16	1.00	1.00	1.00	1.00	0.32	0.32	0.32	0.32	0.32	1.00	0.32
17	1.00	1.00	1.00	1.00	0.38	0.38	0.38	0.38	0.38	1.00	0.38
18	1.00	1.00	1.00	1.00	0.42	0.42	0.42	0.42	0.42	1.00	0.42
19	1.00	1.00	1.00	1.00	0.46	0.46	0.46	0.46	0.46	1.00	0.46
20	1.00	1.00	1.00	1.00	0.50	0.50	0.50	0.50	0.50	1.00	0.50
21	1.00	1.00	1.00	1.00	0.54	0.54	0.54	0.54	0.54	1.00	0.54
22	1.00	1.00	1.00	1.00	0.58	0.58	0.58	0.58	0.58	1.00	0.58
23	1.00	1.00	1.00	1.00	0.62	0.62	0.62	0.62	0.62	1.00	0.62
24	1.00	1.00	1.00	1.00	0.66	0.66	0.66	0.66	0.66	1.00	0.66
25	1.00	1.00	1.00	1.00	0.70	0.70	0.70	0.70	0.70	1.00	0.70
26	1.00	1.00	1.00	1.00	0.74	0.74	0.74	0.74	0.74	1.00	0.74
27	1.00	1.00	1.00	1.00	0.78	0.78	0.78	0.78	0.78	1.00	0.78
28	1.00	1.00	1.00	1.00	0.82	0.82	0.82	0.82	0.82	1.00	0.82
29	1.00	1.00	1.00	1.00	0.86	0.86	0.86	0.86	0.86	1.00	0.86
30	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	1.00	0.90

Source: Tri-State Hurricane Property Loss Study, U.S. Army Corps of Engineers, Mobile District, July 1989.

TABLE B-5

TABULAR DATA FOR LOTUS 1-2-3 SPREADSHEET
PERCENT OF STRUCTURE VALUE DAMAGED BY HURRICANE GENERATED WINDS
(Decimal Format 0.02 = 2%)

WINDCURVES

MPH	SINGLE	MULTI	MOBILE	COMMERCIAL	INDUSTRIAL	MEDICAL	PUBLIC	RDS & BRDG	UTILITIES	CHURCHES	OVHD UTL
	1	2	3	4	5	6	7	8	9	10	11
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.02
60	0.04	0.02	0.04	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.04
70	0.05	0.02	0.06	0.02	0.02	0.02	0.02	0.00	0.02	0.02	0.05
80	0.06	0.03	0.12	0.02	0.02	0.02	0.02	0.00	0.02	0.02	0.06
90	0.07	0.04	0.28	0.02	0.02	0.02	0.02	0.00	0.02	0.02	0.07
100	0.08	0.04	0.60	0.03	0.03	0.03	0.03	0.00	0.03	0.03	0.08
110	0.09	0.05	1.00	0.03	0.03	0.03	0.03	0.00	0.03	0.03	0.08
120	0.09	0.05	1.00	0.04	0.04	0.04	0.04	0.00	0.04	0.04	0.09
130	0.10	0.06	1.00	0.04	0.04	0.04	0.04	0.00	0.04	0.04	0.10
140	0.10	0.07	1.00	0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.10
150	0.12	0.08	1.00	0.06	0.06	0.06	0.06	0.00	0.06	0.06	0.12
160	0.15	0.10	1.00	0.08	0.08	0.08	0.08	0.00	0.08	0.08	0.15
170	0.20	0.15	1.00	0.13	0.13	0.13	0.13	0.00	0.13	0.13	0.20
180	0.28	0.20	1.00	0.17	0.17	0.17	0.17	0.00	0.17	0.17	0.28
190	0.35	0.27	1.00	0.24	0.24	0.24	0.24	0.00	0.24	0.24	0.35
200	0.43	0.33	1.00	0.31	0.31	0.31	0.31	0.00	0.31	0.31	0.43

Source: Tri-State Hurricane Property Loss Study, U.S. Army Corps of Engineers, Mobile District, July 1989.

The column labelled ADDRESS is self-explanatory. It could be used for the name of an establishment or any other identifying remark.

The value of the structure must always be input by the analyst.

The column labelled ID is meant to be used to compute the value of the contents of a structure. The formula used here instructs the model to find the appropriate percentage value in the CONTENTVALUE table and multiply it by the value of the structure. A table of percentages of structure value that can be used to estimate the value of the contents is provided. These percentages can be used or the analyst can directly input the value of the contents instead of using the formula provided at the column labeled CONTENTS VALUE.

The column for TOTAL VALUE is the simple sum of structure and content value.

The ground elevation and structure elevation are also input by the analyst in their respective columns.

The value for the FAMILY OF CURVES is directly input. It is used by the spreadsheet to find the appropriate damage curves. There are several members of the family with each member representing a different type of development. There is a member that represents single family dwellings, multiple family dwellings, mobile homes, commercial establishments, industrial buildings, medical facilities, churches, public buildings, and utilities. If a particular type of development is not specifically represented, the analyst must choose the family member that best represents that development or the analyst must create a new family member. Each family member represents a series of curves that apply to the type of development the member represents. Each member represents the curve for damage due to stillwater surge, wave action, windspeed action, and damage to the contents.

The answer to the formula for SURGE DEPTH IN STRUCTURE will be used in finding the appropriate percentage to use in computing damages. The formula reads: if SURGE HEIGHT is less than STRUCTURE ELEVATION, then return an answer of zero, otherwise return the answer of SURGE HEIGHT minus STRUCTURE ELEVATION rounded to the nearest whole foot. Figure B-1 is provided to help visualize the computations that are being made for both SURGE DEPTH IN STRUCTURE and WAVE HEIGHT AT STRUCTURE.

The formula for WAVE HEIGHT AT STRUCTURE is a simplified approximation of some very complex interactions involving wind, water and terrain. In this formula, it is assumed that the controlling factor is the difference between the surge height and the elevation surrounding the structure. The formula will compute a wave height only if the surge height is 4 feet or more above the terrain. It is possible for a structure to be elevated above the height a wave might reach. Thus, the formula computes the elevation of the potential wave height and then subtracts the elevation of the structure and returns that value only if it is greater than zero. This value is then used to find the appropriate percent of value damaged in later formulas.

The formula for WAVE HEIGHT AT STRUCTURE begins by checking to see if the structure is located in a velocity zone. If it is not, then the model returns an answer of zero. If it is, then the model continues to compute a wave height by checking to see if the SURGE HEIGHT less the GROUND ELEVATION is equal to or greater than 4, and if that value when multiplied by a factor of 1.55, added to the GROUND ELEVATION less the STRUCTURE ELEVATION is greater than zero. If this is true, then the answer is rounded to the nearest whole number. If either or both of these conditions are not met, the formula will return a value of zero.

As stated earlier, either stillwater surge damages or wave action damages are computed for each structure but not both. The formula for SURGE ONLY DAMAGES TO STRUCTURE is written to reflect this dichotomy. The formula reads: if WAVE HEIGHT AT STRUCTURE is equal to zero, then compute damages to the structure, otherwise return an answer of zero. To compute the damages to the structure, the spreadsheet is instructed to find the percent of value damaged from the table named SURGECURVES that corresponds to the value in SURGE DEPTH IN STRUCTURE and for the type of development specified at FAMILY OF CURVES. That percentage is multiplied by the value given at STRUCTURE VALUE.

The formula for SURGE ONLY DAMAGES TO CONTENTS is conditioned by the results of SURGE ONLY DAMAGES TO STRUCTURE. Here the formula reads: if SURGE ONLY DAMAGES TO STRUCTURE is not equal to zero, then compute damages to the contents in the same manner as the damages to the structure were computed. A different table of percentages is used. The formula also says that if no damages to the structure were computed, then no damages to the contents will be computed.

The formula for WAVE & SURGE DAMAGES TO STRUCTURE reflects the branch not taken by the formula for SURGE ONLY DAMAGES TO STRUCTURE. In this case, the formula reads: if WAVE HEIGHT AT STRUCTURE is not equal to zero, then compute damages to the structure, otherwise return an answer of zero. A comparison of the two structure damage formulas reveals other differences. The table of percentages is different and the value for the depth of water is based on WAVE HEIGHT AT STRUCTURE rather than the value for SURGE HEIGHT IN STRUCTURE. This is an important distinction as will be seen in the formula for WAVE & SURGE DAMAGES TO CONTENTS.

The formula for WAVE & SURGE DAMAGES TO CONTENT is a little more complex than any of the preceding formulas. There is an additional condition that the formula must take into consideration. The formula reads: if no damages were computed for WAVE & SURGE DAMAGES TO STRUCTURE, then do not compute

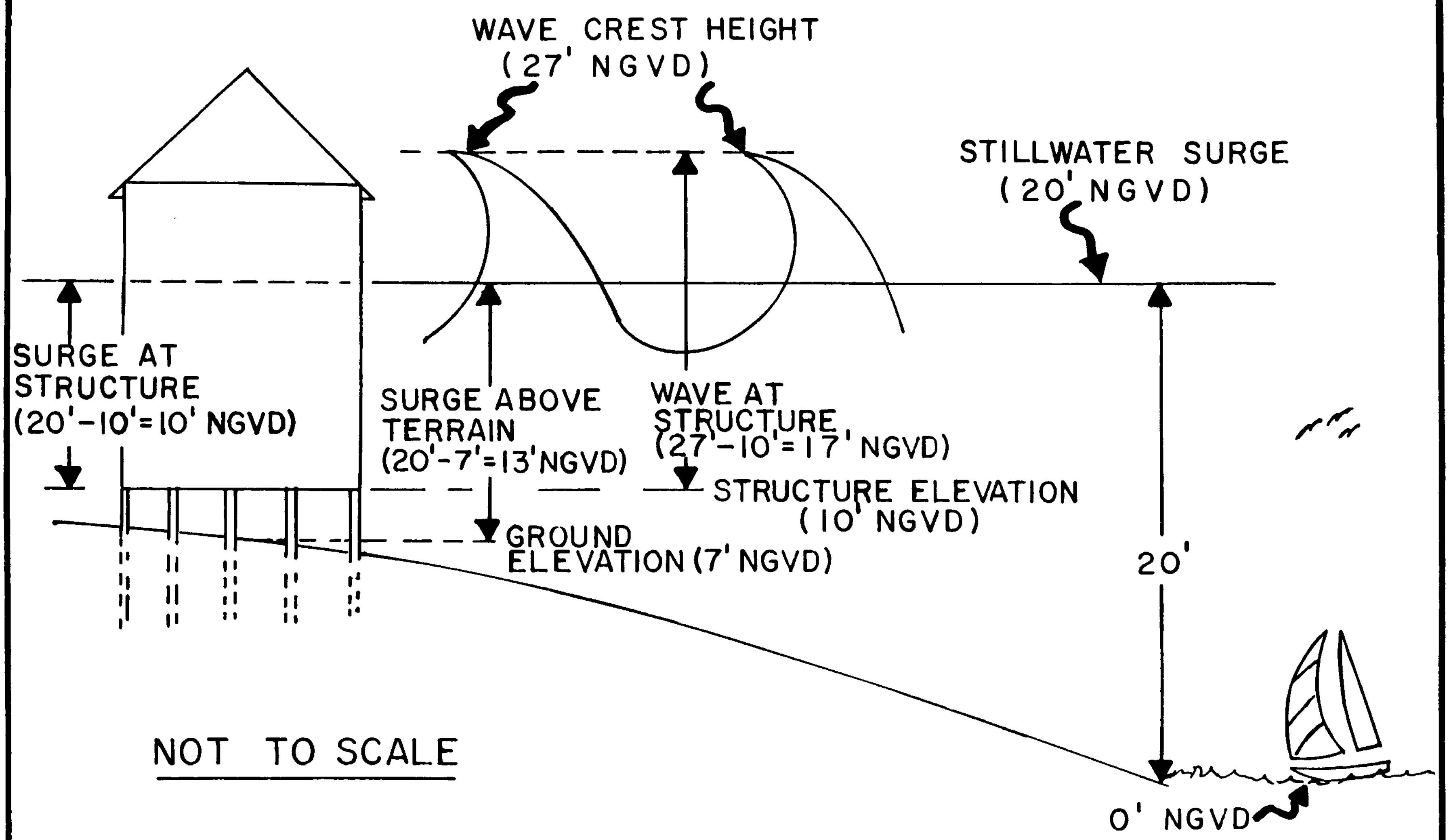


FIGURE B-1

COMPUTATIONS OF WATER HEIGHTS AT STRUCTURE damages to the contents; otherwise, if the structure is totally damaged, then reflect total loss of the contents, otherwise compute damages to the contents in much the same manner as WAVE & SURGE DAMAGES TO STRUCTURE with one significant difference. That difference is the determination of the depth of water that is used in selecting the percent of the contents that would be damaged. Since the structure will behave to some extent much like a stilling basin, the water level in the structure will be less than the WAVE HEIGHT AT STRUCTURE, but greater than the stillwater SURGE HEIGHT IN STRUCTURE. For purposes of estimating the potential content damages from waves, the spreadsheet is instructed to use a water level which is two-thirds of the difference between WAVE HEIGHT AT STRUCTURE minus the SURGE DEPTH IN STRUCTURE, rounded to the nearest whole foot.

The formula for wind damages is relatively straight forward. One of the assumptions used in estimating damages from both water and wind is that water causes the first damage and then wind damage is added. Certainly total damage can not exceed total value. The formula for WIND DAMAGES reads: if SURGE ONLY DAMAGES TO STRUCTURE plus WAVE & SURGE DAMAGES TO STRUCTURE plus WIND DAMAGE is less than the STRUCTURE VALUE, then compute WIND DAMAGES using PEAK GUSTS at SURFACE and the table of percent of value named WINDCURVES, otherwise compute WIND DAMAGES so that the total of water and wind damage is equal to the total value of both structure and content. Unfortunately, there are no curves that can be used to compute damage from winds to contents alone. An examination of the table of the percent of expected damage from wind, however, reveals that only modest damage to the structure is expected until the windspeeds exceed 130 mph. Those windspeeds are peak gusts at the surface which are less than peak gusts at 30 meters. The latter figures are the ones which are normally reported during the period prior to landfall of a storm. With such modest amounts of expected structural damage, the lack of specific damages to contents from wind does not represent a serious problem in the overall technique of estimating potential storm damages.

The last formula is for TOTAL DAMAGES and is a simple sum of the water and wind damages to both the structure and the contents.

The following Table B-6 contains a listing of the contents for each cell address for a Lotus 1-2-3 spreadsheet that can be used to estimate the potential property damages from the five categories of hurricane events. Tables B-7 through B-12 are examples of finished spreadsheets for the three test sites using category 3 and 5 storms. They also represent existing conditions.

TABLE B-6

LOTUS 1-2-3 SPREADSHEET FOR ESTIMATING PROPERTY DAMAGES

```
A3: [W30] 'STORM CATEGORY
A4: [W30] 'SURGE HEIGHT
A5: [W30] 'SUSTAINED WINDS (30m)
A6: [W30] 'SUSTAINED SURFACE WINDS
A7: [W30] 'PEAK GUSTS @ SURFACE
A8: [W30] 'VELOCITY ZONE
A9: [W30] 'LOSS ZONE

B3: [W5] 5   (This item is directly input by the analyst)
B4: [W5] @VLOOKUP($B$3,$SURGEHEIGHTS,B9)
B5: [W5] @VLOOKUP($B$3,$STORMS,1)
B6: [W5] @ROUND(B5*0.66,-1)
B7: [W5] @ROUND((B6*1.3),-1)
B8: [W5] 1  (This is directly input by the analyst)
B9: [W5] 1  (This is directly input by the analyst)

A15: [W30] ^ADDRESS
A17: [W30] \=

B15: [W5] ^ID
B17: [W5] \=
B21: [W5] 1  (This is directly input by the analyst)

C14: [W11] ^STRUCTURE
C15: [W11] ^VALUE
C17: [W11] \=
C21: (C0) [W11] 100000  (This is directly input by the analyst)

D14: [W11] ^CONTENTS
D15: [W11] ^VALUE
D17: [W11] \=
D21: (C0) [W11] @VLOOKUP(B21,$CONTENTVALUE,1)*C21

E14: [W11] ^TOTAL
E15: [W11] ^VALUE
E17: [W11] \=
E21: (C0) [W11] (C21+D21)
```

TABLE B-6 (Con't)

LOTUS 1-2-3 SPREADSHEET FOR ESTIMATING PROPERTY DAMAGES

```
F14: [W11] ^GROUND
F15: [W11] ^ELEVATION
F17: [W11] \=
F21: (F1) [W11] 7.4  (This is directly input by the analyst)


G14: [W11] ^STRUCTURE
G15: [W11] ^ELEVATION
G17: [W11] \=
G21: (F1) [W11] 16.3  (This is directly input by the analyst)


H13: [W11] ^FAMILY
H14: [W11] ^OF
H15: [W11] ^CURVES
H17: [W11] \=
H21: [W11] 1  (This is directly input by the analyst)


I12: [W11] ^SURGE
I13: [W11] ^DEPTH
I14: [W11] ^IN
I15: [W11] ^STRUCTURE
I17: [W11] \=
I21: (F0) [W11] @IF($B$4-$G21<0,0,@ROUND($B$4-$G21,0))


J12: [W11] ^WAVE
J13: [W11] ^HEIGHT
J14: [W11] ^AT
J15: [W11] ^STRUCTURE
J17: [W11] \=
J21: (F0) [W11] @IF($B$8=1,(@IF(($B$4-$F21)>=4#AND#
                (1.55*($B$4-$F21)+$F21-$G21)>0,@ROUND
                (((1.55*($B$4-$F21))+$F21-$G21),0),0)


K10: [W11] \-
K11: [W11] ^SURGE
K12: [W11] ^ONLY
K13: [W11] ^DAMAGES
K14: [W11] ^TO
K15: [W11] ^STRUCTURE
K17: [W11] \=
K21: (C0) [W11] @IF(J21=0,(@VLOOKUP(I21,$SURGECURVES,$H21)
                *$C21),0)
```

TABLE B-6 (Con't)

LOTUS 1-2-3 SPREADSHEET FOR ESTIMATING PROPERTY DAMAGES

```
L9: [W11] "WATER DAMAGES
L10: [W11] \-
L11: [W11] ^SURGE
L12: [W11] ^ONLY
L13: [W11] ^DAMAGES
L14: [W11] ^TO
L15: [W11] ^CONTENTS
L17: [W11] \=
L21: (C0) [W11] @IF(K21<>0,(@VLOOKUP(I21,$CONTENTCURVES,$H21)
                *$D21),0)

M10: [W11] \-
M11: [W11] ^WAVE &
M12: [W11] ^SURGE
M13: [W11] ^DAMAGES
M14: [W11] ^TO
M15: [W11] ^STRUCTURE
M17: [W11] \=
M21: (C0) [W11] @IF(J21<>0,(@VLOOKUP(J21,$WAVECURVES,$H21)
                *C21),0)

N10: [W11] \-
N11: [W11] ^WAVE &
N12: [W11] ^SURGE
N13: [W11] ^DAMAGES
N14: [W11] ^TO
N15: [W11] ^CONTENTS
N17: [W11] \=
N21: (C0) [W11] @IF(M21=0,0,(@IF(M21=$C21,$D21,(@VLOOKUP((@ROUND
                ((I21+J21*0.67),0)),$CONTENTCURVES,$H21)*$D21))))

O14: [W11] ^WIND
O15: [W11] ^DAMAGES
O17: [W11] \=
O21: (C0) [W11] @IF((K21+M21+(@VLOOKUP($B$7,$WINDCURVES,$H21)
                *$C21))<$C21,(@VLOOKUP($B$7,$WINDCURVES,$H21)
                *$C21),(($C21-K21-M21)+($D21-L21-N21)))

P14: [W11] ^TOTAL
P15: [W11] ^DAMAGES
P17: [W11] \=
P21: (C0) [W11] @SUM(K21..O21)
```

TABLE B-7

FINISHED SPREADSHEET FOR GULFPORT TEST SITE
CATEGORY 3 STORM

STORM CATEGORY	3
SURGE HEIGHT	21.4
SUSTAINED WINDS (30m)	125
SUSTAINED SURFACE WINDS	83
PEAK GUSTS @ SURFACE	110
VELOCITY ZONE	0
LOSS ZONE	1

										WATER DAMAGES					
ADDRESS	ID	STRUCTURE VALUE	CONTENTS VALUE	TOTAL VALUE	GROUND ELEVATION	STRUCTURE ELEVATION	FAMILY OF CURVES	SURGE DEPTH IN STRUCTURE	WAVE HEIGHT AT STRUCTURE	SURGE ONLY DAMAGES TO STRUCTURE	SURGE ONLY DAMAGES TO CONTENTS	WAVE & SURGE DAMAGES TO STRUCTURE	WAVE & SURGE DAMAGES TO CONTENTS	WIND DAMAGES	TOTAL DAMAGES
Gulfport, Mississippi															
Office Bldg	3	$250,000	$360,000	$610,000	18.3	19.6	4	2	0	$45,000	$140,400	$0	$0	$7,500	$192,900
Apartments	1	$80,000	$40,000	$120,000	18.3	18.6	2	3	0	$16,800	$11,200	$0	$0	$4,000	$32,000
Office Bldg	3	$150,000	$216,000	$366,000	18.2	19.7	4	2	0	$27,000	$84,240	$0	$0	$4,500	$115,740
Restaurant	3	$250,000	$360,000	$610,000	18.9	20.5	4	1	0	$30,000	$75,600	$0	$0	$7,500	$113,100
Office Bldg	7	$25,000	$37,500	$62,500	19.2	20.1	4	1	0	$3,000	$7,875	$0	$0	$750	$11,625
Office Bldg	3	$500,000	$720,000	$1,220,000	17.4	19.3	4	2	0	$90,000	$280,800	$0	$0	$15,000	$385,800
Office Bldg	3	$1,700,000	$2,448,000	$4,148,000	17.7	19.0	4	2	0	$306,000	$954,720	$0	$0	$51,000	$1,311,720
Office Bldg	3	$70,000	$100,800	$170,800	15.1	18.3	4	3	0	$14,700	$52,416	$0	$0	$2,100	$69,216
Vacant Office Bldg	9	$40,000	$0	$40,000	15.1	17.3	4	4	0	$10,000	$0	$0	$0	$1,200	$11,200
Office Bldg	3	$20,000	$28,800	$48,800	15.5	17.9	4	3	0	$4,200	$14,976	$0	$0	$600	$19,776
Motel	1	$150,000	$75,000	$225,000	15.3	16.0	2	5	0	$40,500	$24,750	$0	$0	$7,500	$72,750
Motel	1	$150,000	$75,000	$225,000	18.2	19.3	2	2	0	$24,000	$17,250	$0	$0	$7,500	$48,750
Motel	1	$300,000	$150,000	$450,000	18.4	19.6	2	2	0	$48,000	$34,500	$0	$0	$15,000	$97,500
Restaurant	3	$135,000	$194,400	$329,400	14.6	15.9	4	6	0	$40,500	$157,464	$0	$0	$4,050	$202,014
Food Store	3	$50,000	$72,000	$122,000	14.1	14.4	4	7	0	$16,500	$63,360	$0	$0	$1,500	$81,360
Medical Office Bldg	5	$175,000	$490,000	$665,000	13.8	14.6	6	7	0	$17,500	$347,900	$0	$0	$5,250	$370,650
Restaurant	3	$120,000	$172,800	$292,800	14.4	14.8	4	7	0	$39,600	$152,064	$0	$0	$3,600	$195,264
Shop	3	$30,000	$43,200	$73,200	13.6	14.6	4	7	0	$9,900	$38,016	$0	$0	$900	$48,816
Restaurant	3	$80,000	$115,200	$195,200	13.9	14.3	4	7	0	$26,400	$101,376	$0	$0	$2,400	$130,176
		$4,275,000	$5,698,700	$9,973,700						$809,600	$2,558,907	$0	$0	$141,850	$3,510,357

TABLE B-8

FINISHED SPREADSHEET FOR GULFPORT TEST SITE
CATEGORY 5 STORM

STORM CATEGORY	5
SURGE HEIGHT	30.0
SUSTAINED WINDS (30m)	200
SUSTAINED SURFACE WINDS	132
PEAK GUSTS @ SURFACE	170
VELOCITY ZONE	0
LOSS ZONE	1

ADDRESS	ID	STRUCTURE VALUE	CONTENTS VALUE	TOTAL VALUE	GROUND ELEVATION	STRUCTURE ELEVATION	FAMILY OF CURVES	SURGE DEPTH IN STRUCTURE	WAVE HEIGHT AT STRUCTURE	WATER DAMAGES: SURGE ONLY DAMAGES TO STRUCTURE	WATER DAMAGES: SURGE ONLY DAMAGES TO CONTENTS	WATER DAMAGES: WAVE & SURGE DAMAGES TO STRUCTURE	WATER DAMAGES: WAVE & SURGE DAMAGES TO CONTENTS	WIND DAMAGES	TOTAL DAMAGES
Gulfport, Mississippi															
Office Bldg	3	$250,000	$360,000	$610,000	18.3	19.6	4	10	0	$100,000	$360,000	$0	$0	$32,500	$492,500
Apartments	1	$80,000	$40,000	$120,000	18.3	18.6	2	11	0	$33,600	$17,600	$0	$0	$12,000	$63,200
Office Bldg	3	$150,000	$216,000	$366,000	18.2	19.7	4	10	0	$60,000	$216,000	$0	$0	$19,500	$295,500
Restaurant	3	$250,000	$360,000	$610,000	18.9	20.5	4	9	0	$95,000	$349,200	$0	$0	$32,500	$476,700
Office Bldg	7	$25,000	$37,500	$62,500	19.2	20.1	4	10	0	$10,000	$37,500	$0	$0	$3,250	$50,750
Office Bldg	3	$500,000	$720,000	$1,220,000	17.4	19.3	4	11	0	$215,000	$720,000	$0	$0	$65,000	$1,000,000
Office Bldg	3	$1,700,000	$2,448,000	$4,148,000	17.7	19.0	4	11	0	$731,000	$2,448,000	$0	$0	$221,000	$3,400,000
Office Bldg	3	$70,000	$100,800	$170,800	15.1	18.3	4	12	0	$33,600	$100,800	$0	$0	$9,100	$143,500
Vacant Office Bldg	9	$40,000	$0	$40,000	15.1	17.3	4	13	0	$20,800	$0	$0	$0	$5,200	$26,000
Office Bldg	3	$20,000	$28,800	$48,800	15.5	17.9	4	12	0	$9,600	$28,800	$0	$0	$2,600	$41,000
Motel	1	$150,000	$75,000	$225,000	15.3	16.0	2	14	0	$75,000	$46,500	$0	$0	$22,500	$144,000
Motel	1	$150,000	$75,000	$225,000	18.2	19.3	2	11	0	$63,000	$33,000	$0	$0	$22,500	$118,500
Motel	1	$300,000	$150,000	$450,000	18.4	19.6	2	10	0	$111,000	$58,500	$0	$0	$45,000	$214,500
Restaurant	3	$135,000	$194,400	$329,400	14.6	15.9	4	14	0	$81,000	$194,400	$0	$0	$17,550	$292,950
Food Store	3	$50,000	$72,000	$122,000	14.1	14.4	4	16	0	$37,500	$72,000	$0	$0	$6,500	$116,000
Medical Office Bldg	5	$175,000	$490,000	$665,000	13.8	14.6	6	15	0	$35,000	$387,100	$0	$0	$22,750	$444,850
Restaurant	3	$120,000	$172,800	$292,800	14.4	14.8	4	15	0	$80,400	$172,800	$0	$0	$15,600	$268,800
Shop	3	$30,000	$43,200	$73,200	13.6	14.6	4	15	0	$20,100	$43,200	$0	$0	$3,900	$67,200
Restaurant	3	$80,000	$115,200	$195,200	13.9	14.3	4	16	0	$60,000	$115,200	$0	$0	$10,400	$185,600
		$4,275,000	$5,698,700	$9,973,700						$1,871,600	$5,400,600	$0	$0	$569,350	$7,841,550

TABLE B-9

FINISHED SPREADSHEET FOR GULF SHORES TEST SITE
CATEGORY 3 STORM

STORM CATEGORY	3
SURGE HEIGHT	13.6
SUSTAINED WINDS (30m)	125
SUSTAINED SURFACE WINDS	83
PEAK GUSTS @ SURFACE	110
VELOCITY ZONE	1
LOSS ZONE	2

										WATER DAMAGES					
ADDRESS	ID	STRUCTURE VALUE	CONTENTS VALUE	TOTAL VALUE	GROUND ELEVATION	STRUCTURE ELEVATION	FAMILY OF CURVES	SURGE DEPTH IN STRUCTURE	WAVE HEIGHT AT STRUCTURE	SURGE ONLY DAMAGES TO STRUCTURE	SURGE ONLY DAMAGES TO CONTENTS	WAVE & SURGE DAMAGES TO STRUCTURE	WAVE & SURGE DAMAGES TO CONTENTS	WIND DAMAGES	TOTAL DAMAGES
Gulf Shores, Alabama															
West Beach Blvd	1	$150,000	$75,000	$225,000	8.8	16.4	1	0	0	$0	$0	$0	$0	$13,500	$13,500
West Beach Blvd	1	$110,000	$55,000	$165,000	8.7	16.4	1	0	0	$0	$0	$0	$0	$9,900	$9,900
West Beach Blvd	1	$188,000	$94,000	$282,000	9.4	16.9	1	0	0	$0	$0	$0	$0	$16,920	$16,920
West Beach Blvd	1	$60,000	$30,000	$90,000	7.9	15.6	1	0	1	$0	$0	$13,200	$6,300	$5,400	$24,900
West Beach Blvd	1	$110,000	$55,000	$165,000	6.9	14.0	1	0	3	$0	$0	$55,000	$21,450	$9,900	$86,350
West Beach Blvd	1	$60,000	$30,000	$90,000	7.1	14.4	1	0	3	$0	$0	$30,000	$11,700	$5,400	$47,100
West Beach Blvd	1	$70,000	$35,000	$105,000	7.0	14.0	1	0	3	$0	$0	$35,000	$13,650	$6,300	$54,950
West Beach Blvd	1	$50,000	$25,000	$75,000	6.5	15.0	1	0	3	$0	$0	$25,000	$9,750	$4,500	$39,250
West Beach Blvd	1	$50,000	$25,000	$75,000	7.5	16.4	1	0	1	$0	$0	$11,000	$5,250	$4,500	$20,750
West Beach Blvd	1	$125,000	$62,500	$187,500	7.9	13.3	1	0	3	$0	$0	$62,500	$24,375	$11,250	$98,125
West Beach Blvd	1	$70,000	$35,000	$105,000	9.6	16.9	1	0	0	$0	$0	$0	$0	$6,300	$6,300
West Beach Blvd	1	$50,000	$25,000	$75,000	7.3	15.6	1	0	1	$0	$0	$11,000	$5,250	$4,500	$20,750
West Beach Blvd	1	$85,000	$42,500	$127,500	6.3	15.2	1	0	2	$0	$0	$31,450	$8,925	$7,650	$48,025
West Beach Blvd	1	$80,000	$40,000	$120,000	7.1	14.2	1	0	3	$0	$0	$40,000	$15,600	$7,200	$62,800
SUB-TOTALS		$1,258,000	$629,000	$1,887,000						$0	$0	$314,150	$122,250	$113,220	$549,620

TABLE B-9 (Cont)

FINISHED SPREADSHEET FOR GULF SHORES TEST SITE
CATEGORY 3 STORM

ADDRESS	ID	STRUCTURE VALUE	CONTENTS VALUE	TOTAL VALUE	GROUND ELEVATION	STRUCTURE ELEVATION	FAMILY OF CURVES	SURGE DEPTH IN STRUCTURE	WAVE HEIGHT AT STRUCTURE	WATER DAMAGES: SURGE ONLY DAMAGES TO STRUCTURE	WATER DAMAGES: SURGE ONLY DAMAGES TO CONTENTS	WATER DAMAGES: WAVE & SURGE DAMAGES TO STRUCTURE	WATER DAMAGES: WAVE & SURGE DAMAGES TO CONTENTS	WIND DAMAGES	TOTAL DAMAGES
VELOCITY ZONE	1														
West Beach Blvd	1	$150,000	$75,000	$225,000	10.0	18.3	1	0	0	$0	$0	$0	$0	$13,500	$13,500
West Beach Blvd	1	$110,000	$55,000	$165,000	8.8	16.3	1	0	0	$0	$0	$0	$0	$9,900	$9,900
West Beach Blvd	1	$150,000	$75,000	$225,000	9.4	16.7	1	0	0	$0	$0	$0	$0	$13,500	$13,500
West Beach Blvd	1	$30,000	$15,000	$45,000	6.0	15.1	1	0	3	$0	$0	$15,000	$5,850	$2,700	$23,550
West Beach Blvd	1	$120,000	$60,000	$180,000	7.3	15.0	1	0	2	$0	$0	$44,400	$12,600	$10,800	$67,800
West Beach Blvd	1	$120,000	$60,000	$180,000	7.1	14.4	1	0	3	$0	$0	$60,000	$23,400	$10,800	$94,200
West Beach Blvd	1	$50,000	$25,000	$75,000	7.0	14.0	1	0	3	$0	$0	$25,000	$9,750	$4,500	$39,250
West Beach Blvd	1	$65,000	$32,500	$97,500	7.9	15.2	1	0	2	$0	$0	$24,050	$6,825	$5,850	$36,725
West Beach Blvd	1	$80,000	$40,000	$120,000	9.5	18.1	1	0	0	$0	$0	$0	$0	$7,200	$7,200
West Beach Blvd	1	$120,000	$60,000	$180,000	9.6	16.9	1	0	0	$0	$0	$0	$0	$10,800	$10,800
West Beach Blvd	1	$90,000	$45,000	$135,000	7.3	15.5	1	0	2	$0	$0	$33,300	$9,450	$8,100	$50,850
West Beach Blvd	1	$50,000	$25,000	$75,000	8.1	14.8	1	0	2	$0	$0	$18,500	$5,250	$4,500	$28,250
West Beach Blvd	1	$35,000	$17,500	$52,500	6.5	14.9	1	0	3	$0	$0	$17,500	$6,825	$3,150	$27,475
SUB-TOTALS		$1,170,000	$585,000	$1,755,000						$0	$0	$237,750	$79,950	$105,300	$423,000

TABLE B-9 (Cont)

FINISHED SPREADSHEET FOR GULF SHORES TEST SITE
CATEGORY 3 STORM

ADDRESS	ID	STRUCTURE VALUE	CONTENTS VALUE	TOTAL VALUE	GROUND ELEVATION	STRUCTURE ELEVATION	FAMILY OF CURVES	SURGE DEPTH IN STRUCTURE	WAVE HEIGHT AT STRUCTURE	WATER DAMAGES: SURGE ONLY DAMAGES TO STRUCTURE	WATER DAMAGES: SURGE ONLY DAMAGES TO CONTENTS	WATER DAMAGES: WAVE & SURGE DAMAGES TO STRUCTURE	WATER DAMAGES: WAVE & SURGE DAMAGES TO CONTENTS	WIND DAMAGES	TOTAL DAMAGES
VELOCITY ZONE	0														
West Beach Blvd	1	$25,000	$12,500	$37,500	6.7	13.5	1	0	0	$0	$0	$0	$0	$2,250	$2,250
West Beach Blvd	1	$20,000	$10,000	$30,000	8.6	15.1	1	0	0	$0	$0	$0	$0	$1,800	$1,800
West Beach Blvd	1	$30,000	$15,000	$45,000	7.4	14.8	1	0	0	$0	$0	$0	$0	$2,700	$2,700
West Beach Blvd	1	$30,000	$15,000	$45,000	7.1	13.8	1	0	0	$0	$0	$0	$0	$2,700	$2,700
West Beach Blvd	1	$30,000	$15,000	$45,000	7.4	14.4	1	0	0	$0	$0	$0	$0	$2,700	$2,700
West Beach Blvd	1	$55,000	$27,500	$82,500	6.7	15.3	1	0	0	$0	$0	$0	$0	$4,950	$4,950
West Beach Blvd	1	$200,000	$100,000	$300,000	7.6	16.5	1	0	0	$0	$0	$0	$0	$18,000	$18,000
West Beach Blvd	1	$50,000	$25,000	$75,000	6.9	14.2	1	0	0	$0	$0	$0	$0	$4,500	$4,500
West Beach Blvd	1	$50,000	$25,000	$75,000	7.8	14.9	1	0	0	$0	$0	$0	$0	$4,500	$4,500
West Beach Blvd	1	$50,000	$25,000	$75,000	7.0	12.7	1	1	0	$7,500	$5,250	$0	$0	$4,500	$17,250
West Beach Blvd	1	$40,000	$20,000	$60,000	6.6	13.2	1	0	0	$0	$0	$0	$0	$3,600	$3,600
West Beach Blvd	1	$40,000	$20,000	$60,000	5.7	13.9	1	0	0	$0	$0	$0	$0	$3,600	$3,600
West Beach Blvd	1	$120,000	$60,000	$180,000	7.5	15.6	1	0	0	$0	$0	$0	$0	$10,800	$10,800
West Beach Blvd	1	$4,000	$0	$4,000	6.5	12.9	1	1	0	$600	$0	$0	$0	$360	$960
West Beach Blvd	1	$25,000	$12,500	$37,500	6.3	12.6	1	1	0	$3,750	$2,625	$0	$0	$2,250	$8,625
West Beach Blvd	1	$50,000	$25,000	$75,000	5.4	11.9	1	2	0	$14,500	$9,750	$0	$0	$4,500	$28,750
West 13th Street	1	$360,000	$180,000	$540,000	7.3	14.1	2	0	0	$0	$0	$0	$0	$18,000	$18,000
Condos	1	$2,210,000	$1,105,000	$3,315,000	3.4	12.0	2	2	0	$50,514	$36,307	$0	$0	$110,500	$197,321
SUB-TOTALS		$3,389,000	$1,692,500	$5,081,500						$76,864	$53,932	$0	$0	$202,210	$333,006
TOTALS		$4,647,000	$2,321,500	$6,968,500						$76,864	$53,932	$551,900	$202,200	$420,730	$1,305,626

TABLE B-10

FINISHED SPREADSHEET FOR GULF SHORES TEST SITE
CATEGORY 5 STORM

STORM CATEGORY	5
SURGE HEIGHT	17.3
SUSTAINED WINDS (30m)	200
SUSTAINED SURFACE WINDS	132
PEAK GUSTS @ SURFACE	170
VELOCITY ZONE	1
LOSS ZONE	2

										WATER DAMAGES					
ADDRESS	ID	STRUCTURE VALUE	CONTENTS VALUE	TOTAL VALUE	GROUND ELEVATION	STRUCTURE ELEVATION	FAMILY OF CURVES	SURGE DEPTH IN STRUCTURE	WAVE HEIGHT AT STRUCTURE	SURGE ONLY DAMAGES TO STRUCTURE	SURGE ONLY DAMAGES TO CONTENTS	WAVE & SURGE DAMAGES TO STRUCTURE	WAVE & SURGE DAMAGES TO CONTENTS	WIND DAMAGES	TOTAL DAMAGES
Gulf Shores, Alabama															
West Beach Blvd	1	$150,000	$75,000	$225,000	8.8	16.4	1	1	6	$0	$0	$103,500	$50,250	$30,000	$183,750
West Beach Blvd	1	$110,000	$55,000	$165,000	8.7	16.4	1	1	6	$0	$0	$75,900	$36,850	$22,000	$134,750
West Beach Blvd	1	$188,000	$94,000	$282,000	9.4	16.9	1	0	5	$0	$0	$122,200	$48,880	$37,600	$208,680
West Beach Blvd	1	$60,000	$30,000	$90,000	7.9	15.6	1	2	7	$0	$0	$43,200	$21,600	$12,000	$76,800
West Beach Blvd	1	$110,000	$55,000	$165,000	6.9	14.0	1	3	9	$0	$0	$91,300	$41,250	$32,450	$165,000
West Beach Blvd	1	$60,000	$30,000	$90,000	7.1	14.4	1	3	9	$0	$0	$49,800	$22,500	$17,700	$90,000
West Beach Blvd	1	$70,000	$35,000	$105,000	7.0	14.0	1	3	9	$0	$0	$58,100	$26,250	$20,650	$105,000
West Beach Blvd	1	$50,000	$25,000	$75,000	6.5	15.0	1	2	8	$0	$0	$39,000	$18,000	$10,000	$67,000
West Beach Blvd	1	$50,000	$25,000	$75,000	7.5	16.4	1	1	6	$0	$0	$34,500	$16,750	$10,000	$61,250
West Beach Blvd	1	$125,000	$62,500	$187,500	7.9	13.3	1	4	9	$0	$0	$103,750	$47,500	$36,250	$187,500
West Beach Blvd	1	$70,000	$35,000	$105,000	9.6	16.9	1	0	5	$0	$0	$45,500	$18,200	$14,000	$77,700
West Beach Blvd	1	$50,000	$25,000	$75,000	7.3	15.6	1	2	7	$0	$0	$36,000	$18,000	$10,000	$64,000
West Beach Blvd	1	$85,000	$42,500	$127,500	6.3	15.2	1	2	8	$0	$0	$66,300	$30,600	$17,000	$113,900
West Beach Blvd	1	$80,000	$40,000	$120,000	7.1	14.2	1	3	9	$0	$0	$66,400	$30,000	$23,600	$120,000
SUB-TOTALS		$1,258,000	$629,000	$1,887,000						$0	$0	$935,450	$426,630	$293,250	$1,655,330

TABLE B-10 (Cont)

FINISHED SPREADSHEET FOR GULF SHORES TEST SITE
CATEGORY 5 STORM

										WATER DAMAGES					
ADDRESS	ID	STRUCTURE VALUE	CONTENTS VALUE	TOTAL VALUE	GROUND ELEVATION	STRUCTURE ELEVATION	FAMILY OF CURVES	SURGE DEPTH IN STRUCTURE	WAVE HEIGHT AT STRUCTURE	SURGE ONLY DAMAGES TO STRUCTURE	SURGE ONLY DAMAGES TO CONTENTS	WAVE & SURGE DAMAGES TO STRUCTURE	WAVE & SURGE DAMAGES TO CONTENTS	WIND DAMAGES	TOTAL DAMAGES
VELOCITY ZONE	1														
West Beach Blvd	1	$150,000	$75,000	$225,000	10.0	18.3	1	0	3	$0	$0	$75,000	$29,250	$30,000	$134,250
West Beach Blvd	1	$110,000	$55,000	$165,000	8.8	16.3	1	1	6	$0	$0	$75,900	$36,850	$22,000	$134,750
West Beach Blvd	1	$150,000	$75,000	$225,000	9.4	16.7	1	1	5	$0	$0	$97,500	$45,750	$30,000	$173,250
West Beach Blvd	1	$30,000	$15,000	$45,000	6.0	15.1	1	2	8	$0	$0	$23,400	$10,800	$6,000	$40,200
West Beach Blvd	1	$120,000	$60,000	$180,000	7.3	15.0	1	2	8	$0	$0	$93,600	$43,200	$24,000	$160,800
West Beach Blvd	1	$120,000	$60,000	$180,000	7.1	14.4	1	3	8	$0	$0	$93,600	$44,400	$24,000	$162,000
West Beach Blvd	1	$50,000	$25,000	$75,000	7.0	14.0	1	3	9	$0	$0	$41,500	$18,750	$14,750	$75,000
West Beach Blvd	1	$65,000	$32,500	$97,500	7.9	15.2	1	2	7	$0	$0	$46,800	$23,400	$13,000	$83,200
West Beach Blvd	1	$80,000	$40,000	$120,000	9.5	18.1	1	0	4	$0	$0	$48,000	$20,800	$16,000	$84,800
West Beach Blvd	1	$120,000	$60,000	$180,000	9.6	16.9	1	0	5	$0	$0	$78,000	$31,200	$24,000	$133,200
West Beach Blvd	1	$90,000	$45,000	$135,000	7.3	15.5	1	2	7	$0	$0	$64,800	$32,400	$18,000	$115,200
West Beach Blvd	1	$50,000	$25,000	$75,000	8.1	14.8	1	2	8	$0	$0	$39,000	$18,000	$10,000	$67,000
West Beach Blvd	1	$35,000	$17,500	$52,500	6.5	14.9	1	2	8	$0	$0	$27,300	$12,600	$7,000	$46,900
SUB-TOTALS		$1,170,000	$585,000	$1,755,000						$0	$0	$804,400	$367,400	$238,750	$1,410,550

TABLE B-10 (Cont)

FINISHED SPREADSHEET FOR GULF SHORES TEST SITE
CATEGORY 5 STORM

										WATER DAMAGES					
ADDRESS	ID	STRUCTURE VALUE	CONTENTS VALUE	TOTAL VALUE	GROUND ELEVATION	STRUCTURE ELEVATION	FAMILY OF CURVES	SURGE DEPTH IN STRUCTURE	WAVE HEIGHT AT STRUCTURE	SURGE ONLY DAMAGES TO STRUCTURE	SURGE ONLY DAMAGES TO CONTENTS	WAVE & SURGE DAMAGES TO STRUCTURE	WAVE & SURGE DAMAGES TO CONTENTS	WIND DAMAGES	TOTAL DAMAGES
VELOCITY ZONE	0														
West Beach Blvd	1	$25,000	$12,500	$37,500	6.7	13.5	1	4	0	$11,000	$7,625	$0	$0	$5,000	$23,625
West Beach Blvd	1	$20,000	$10,000	$30,000	8.6	15.1	1	2	0	$5,800	$3,900	$0	$0	$4,000	$13,700
West Beach Blvd	1	$30,000	$15,000	$45,000	7.4	14.8	1	3	0	$11,400	$7,800	$0	$0	$6,000	$25,200
West Beach Blvd	1	$30,000	$15,000	$45,000	7.1	13.8	1	4	0	$13,200	$9,150	$0	$0	$6,000	$28,350
West Beach Blvd	1	$30,000	$15,000	$45,000	7.4	14.4	1	3	0	$11,400	$7,800	$0	$0	$6,000	$25,200
West Beach Blvd	1	$55,000	$27,500	$82,500	6.7	15.3	1	2	0	$15,950	$10,725	$0	$0	$11,000	$37,675
West Beach Blvd	1	$200,000	$100,000	$300,000	7.6	16.5	1	1	0	$30,000	$21,000	$0	$0	$40,000	$91,000
West Beach Blvd	1	$50,000	$25,000	$75,000	6.9	14.2	1	3	0	$19,000	$13,000	$0	$0	$10,000	$42,000
West Beach Blvd	1	$50,000	$25,000	$75,000	7.8	14.9	1	2	0	$14,500	$9,750	$0	$0	$10,000	$34,250
West Beach Blvd	1	$50,000	$25,000	$75,000	7.0	12.7	1	5	0	$24,500	$16,750	$0	$0	$10,000	$51,250
West Beach Blvd	1	$40,000	$20,000	$60,000	6.6	13.2	1	4	0	$17,600	$12,200	$0	$0	$8,000	$37,800
West Beach Blvd	1	$40,000	$20,000	$60,000	5.7	13.9	1	3	0	$15,200	$10,400	$0	$0	$8,000	$33,600
West Beach Blvd	1	$120,000	$60,000	$180,000	7.5	15.6	1	2	0	$34,800	$23,400	$0	$0	$24,000	$82,200
West Beach Blvd	1	$4,000	$0	$4,000	6.5	12.9	1	4	0	$1,760	$0	$0	$0	$800	$2,560
West Beach Blvd	1	$25,000	$12,500	$37,500	6.3	12.6	1	5	0	$12,250	$8,375	$0	$0	$5,000	$25,625
West Beach Blvd	1	$50,000	$25,000	$75,000	5.4	11.9	1	5	0	$24,500	$16,750	$0	$0	$10,000	$51,250
West 13th Street	1	$360,000	$180,000	$540,000	7.3	14.1	2	3	0	$113,400	$75,600	$0	$0	$54,000	$243,000
Condos	1	$2,210,000	$1,105,000	$3,315,000	3.4	12.0	2	5	0	$85,243	$52,093	$0	$0	$331,500	$468,836
SUB-TOTALS		$3,389,000	$1,692,500	$5,081,500						$461,503	$306,318	$0	$0	$549,300	$1,317,121
TOTALS		$4,647,000	$2,321,500	$6,968,500						$461,503	$306,318	$1,739,850	$794,030	$1,081,300	$4,383,001

TABLE B-11

FINISHED SPREADSHEET FOR FORT WALTON BEACH TEST SITE
CATEGORY 3 STORM

STORM CATEGORY	3
SURGE HEIGHT	11.6
SUSTAINED WINDS (30m)	125
SUSTAINED SURFACE WINDS	83
PEAK GUSTS @ SURFACE	110
VELOCITY ZONE	0
LOSS ZONE	3

										WATER DAMAGES					
ADDRESS	ID	STRUCTURE VALUE	CONTENTS VALUE	TOTAL VALUE	GROUND ELEVATION	STRUCTURE ELEVATION	FAMILY OF CURVES	SURGE DEPTH IN STRUCTURE	WAVE HEIGHT AT STRUCTURE	SURGE ONLY DAMAGES TO STRUCTURE	SURGE ONLY DAMAGES TO CONTENTS	WAVE & SURGE DAMAGES TO STRUCTURE	WAVE & SURGE DAMAGES TO CONTENTS	WIND DAMAGES	TOTAL DAMAGES
Ft. Walton Beach, Florida															
Auditorium	6	$2,000,000	$1,600,000	$3,600,000	5.7	6.5	7	5	0	$160,000	$1,008,000	$0	$0	$60,000	$1,228,000
Office Bldg	6	$500,000	$400,000	$900,000	6.7	8.6	7	3	0	$30,000	$192,000	$0	$0	$15,000	$237,000
Office Bldg	6	$250,000	$200,000	$450,000	6.7	8.8	7	3	0	$15,000	$96,000	$0	$0	$7,500	$118,500
Library	6	$150,000	$120,000	$270,000	8.0	8.3	7	3	0	$9,000	$57,600	$0	$0	$4,500	$71,100
Church	10	$150,000	$120,000	$270,000	8.6	9.3	10	2	0	$27,000	$45,600	$0	$0	$4,500	$77,100
Church	10	$150,000	$120,000	$270,000	8.8	9.0	10	3	0	$31,500	$57,600	$0	$0	$4,500	$93,600
Church	10	$150,000	$120,000	$270,000	7.4	8.2	10	3	0	$31,500	$57,600	$0	$0	$4,500	$93,600
Church	10	$200,000	$160,000	$360,000	7.4	9.4	10	2	0	$36,000	$60,800	$0	$0	$6,000	$102,800
Church	10	$1,000,000	$800,000	$1,800,000	8.7	9.2	10	2	0	$180,000	$304,000	$0	$0	$30,000	$514,000
Church	10	$250,000	$200,000	$450,000	9.0	9.4	10	2	0	$45,000	$76,000	$0	$0	$7,500	$128,500
School	6	$150,000	$120,000	$270,000	9.0	9.4	10	2	0	$27,000	$45,600	$0	$0	$4,500	$77,100
School	6	$150,000	$120,000	$270,000	8.9	9.6	10	2	0	$27,000	$45,600	$0	$0	$4,500	$77,100
		$5,100,000	$4,080,000	$9,180,000						$619,000	$2,046,400	$0	$0	$153,000	$2,818,400

TABLE B-12

FINISHED SPREADSHEET FOR FORT WALTON BEACH TEST SITE
CATEGORY 5 STORM

STORM CATEGORY	5
SURGE HEIGHT	11.6
SUSTAINED WINDS (30m)	125
SUSTAINED SURFACE WINDS	83
PEAK GUSTS @ SURFACE	110
VELOCITY ZONE	0
LOSS ZONE	3

										WATER DAMAGES					
ADDRESS	ID	STRUCTURE VALUE	CONTENTS VALUE	TOTAL VALUE	GROUND ELEVATION	STRUCTURE ELEVATION	FAMILY OF CURVES	SURGE DEPTH IN STRUCTURE	WAVE HEIGHT AT STRUCTURE	SURGE ONLY DAMAGES TO STRUCTURE	SURGE ONLY DAMAGES TO CONTENTS	WAVE & SURGE DAMAGES TO STRUCTURE	WAVE & SURGE DAMAGES TO CONTENTS	WIND DAMAGES	TOTAL DAMAGES
Ft. Walton Beach, Florida															
Auditorium	6	$2,000,000	$1,600,000	$3,600,000	5.7	6.5	7	5	0	$160,000	$1,008,000	$0	$0	$60,000	$1,228,000
Office Bldg	6	$500,000	$400,000	$900,000	6.7	8.6	7	3	0	$30,000	$192,000	$0	$0	$15,000	$237,000
Office Bldg	6	$250,000	$200,000	$450,000	6.7	8.8	7	3	0	$15,000	$96,000	$0	$0	$7,500	$118,500
Library	6	$150,000	$120,000	$270,000	8.0	8.3	7	3	0	$9,000	$57,600	$0	$0	$4,500	$71,100
Church	10	$150,000	$120,000	$270,000	8.6	9.3	10	2	0	$27,000	$45,600	$0	$0	$4,500	$77,100
Church	10	$150,000	$120,000	$270,000	8.8	9.0	10	3	0	$31,500	$57,600	$0	$0	$4,500	$93,600
Church	10	$150,000	$120,000	$270,000	7.4	8.2	10	3	0	$31,500	$57,600	$0	$0	$4,500	$93,600
Church	10	$200,000	$160,000	$360,000	7.4	9.4	10	2	0	$36,000	$60,800	$0	$0	$6,000	$102,800
Church	10	$1,000,000	$800,000	$1,800,000	8.7	9.2	10	2	0	$180,000	$304,000	$0	$0	$30,000	$514,000
Church	10	$250,000	$200,000	$450,000	9.0	9.4	10	2	0	$45,000	$76,000	$0	$0	$7,500	$128,500
School	6	$150,000	$120,000	$270,000	9.0	9.4	10	2	0	$27,000	$45,600	$0	$0	$4,500	$77,100
School	6	$150,000	$120,000	$270,000	8.9	9.6	10	2	0	$27,000	$45,600	$0	$0	$4,500	$77,100
		$5,100,000	$4,080,000	$9,180,000						$619,000	$2,046,400	$0	$0	$153,000	$2,818,400

APPENDIX C

MITIGATION MEASURES IN EFFECT

ACROSS THE STUDY AREA

AND

PERTINENT STATE LAWS

ON

EROSION SETBACK LINES

STATEWIDE BUILDING CODES

GROWTH MANAGEMENT

MITIGATION MEASURES IN EFFECT ACROSS THE STUDY AREA

The participating States collected information from local officials concerning the hurricane property damage mitigation measures that are currently in effect as well as information about their communities' responses to past hurricanes. The following tables summarize that information. The questions asked of the local officials are listed below and accompany the tables. Underlining is used in the list of questions for ease in reading the tables.

QUESTIONS ASKED OF LOCAL OFFICIALS

1. Does the community participate in the National Flood Insurance Program, and if so, does the community enforce standards stricter than those required by the NFIP?

2. Does the community have a Coastal Construction Control Line, and if so, does the community enforce a stricter standard than that required by the state?

3. Does the community practice land use planning with mitigation of hurricane caused property damages as a goal?

4. Is the community required to perform land use planning?

5. Does the community use any of the following land use planning tools?
   - Property Acquisition
   - Zoning
   - Building Codes
   - Building Permits
   - Subdivision Regulations
   - Density Restrictions
   - Transfer of Development Rights
   - Other

6. Has the community made any changes to any of the land use planning regulations due to the last hurricane that are directly or indirectly associated with the mitigation of property damage?

7. What current hurricane damage mitigation measures or plans has the community enacted?

8. What hurricane damage measures has the community considered but not enacted?

TABLE C-1

Mitigation Measures In Effect Across the Study Area

	N F I P STRICTER	C C C L STRICTER	MITIGATION AS A GOAL	REQUIRED LAND USE	LAND USE TOOLS	PROPERTY ACQUISITION	ZONING	BUILDING CODES	BUILDING PERMITS	SUBDIVISION REGULATIONS	DENSITY RESTRICTIONS	TRANSFER OF DEVELOPMENT RIGHTS	OTHER	CHANGES DUE HURRICANE	ENACTED MEASURES	NOT ENACTED MEASURES
<u>ALABAMA</u>																
MOBILE COUNTY	Y N	Y N	Y	Y	Y				Y	Y			N	N	1	N
BAYOU LA BATRE	Y N	N	Y	Y	Y		Y	Y	Y				N	N	N	N
DAUPHIN ISLAND	Y N	Y N	Y	Y	Y								N	2	N	N
CITY OF MOBILE	Y 3	Y 4	Y	Y	Y	Y	Y	Y	Y	Y			N	5	6	7
CHICKASAW	Y N	N/A	N	N	Y								N	N	N	N
CREOLA	Y N	Y N	N	N	Y								N	8	N	N
PRICHARD	Y N	N	N	N	Y								N	N	N	N
WILMER		N/A	N	N	Y	Y	Y	Y	Y				N	9	N	N

1. Inventory of personnel and equipment
2. Town was incorporated on January 15, 1988.
3. Stricter standards for construction in floodway.
4. City zoning ordinance also requires a setback from the front edge of the property.
5. City flood plain ordinance now requires that stormwater runoff rate be the same before and after development. Wind resistivity increased from 100 mph to 120 mph.
6. Flood plain ordinance revised in 1982.
7. City is considering wind resistivity standards for interior walls to be equal to exterior walls.
8. Continually update building codes, most recently in 1988.
9. Increased enforcement of building codes.

TABLE C-2

Mitigation Measures In Effect Across the Study Area

	N F I P STRICTER	C C C L STRICTER	MITIGATION AS A GOAL	REQUIRED LAND USE	LAND USE TOOLS	PROPERTY ACQUISITION	ZONING	BUILDING CODES	BUILDING PERMITS	SUBDIVISION REGULATIONS	DENSITY RESTRICTIONS	TRANSFER OF DEVELOPMENT RIGHTS	OTHER	CHANGES DUE HURRICANE	ENACTED MEASURES	NOT ENACTED MEASURES
<u>ALABAMA</u>																
BALDWIN COUNTY	Y Y	Y N	Y	N	Y		Y	Y					N	1	N	N
ORANGE BEACH	Y N	Y N	Y	N	Y		Y	Y					N	2	N	3
GULF SHORES	Y N	Y N	Y	N	Y			Y					N	4	5	N
FAIRHOPE	Y N	Y Y	Y	Y	Y		Y	Y	Y	Y			N	6	N	N
DAPHNE	Y N	Y N	Y	Y	Y								N	N	7	N
BAY MINETE	Y N	N/A	N	N	Y								N	N	N	N
ELBERTA	N	N/A	N	N	Y		Y						N	N	N	N
FOLEY	Y N	N/A	Y	N	Y		Y	Y		Y	Y		N	N	N	8
LOXLEY	Y N	N/A	N	N	Y			Y					N	N	N	N
ROBERTSDALE	Y N	N/A	N	N	Y			Y					N	N	N	N
SILVERHILL	Y N	N/A	N	N	N								N	N	N	N
SUMMERDALE	N	N/A	Y	Y	Y		Y	Y					N	N	N	N

1. High hazard building codes developed, coastal setback implemented, dune protection initiated, and zoning requirements enacted.
2. City was incorporated in 1984.
3. Currently planning Emergency Operations Plan to include pre and post disaster actions.
4. Adopted supplemental building codes for coastal construction in high hazard areas.
5. Enacted regulations and procedures to minimize public and private losses due to flood conditions in specific areas.
6. Revision of flood damage prevention ordinance to restrict and/or control construction or placement of fill in hurricane and flood prone areas.
7. Flood plain, land use and development ordinances.
8. Currently planning Emergency Operations Plan to include pre and post disaster actions.

TABLE C-3

Mitigation Measures In Effect Across the Study Area

	N F I P STRICTER	C C C L STRICTER	MITIGATION AS A GOAL	REQUIRED LAND USE	LAND USE TOOLS	PROPERTY ACQUISITION	ZONING	BUILDING CODES	BUILDING PERMITS	SUBDIVISION REGULATIONS	DENSITY RESTRICTIONS	TRANSFER OF DEVELOPMENT RIGHTS	OTHER	CHANGES DUE HURRICANE	ENACTED MEASURES	NOT ENACTED MEASURES
MISSISSIPPI																
HANCOCK COUNTY	Y Y	Y N	Y	N	Y				Y				N	1	2	N
WAVELAND	Y N	Y N	Y	N	Y		Y	Y					N	3	N	N
BAY SAINT LOUIS	Y Y	N	Y	N	Y				Y				N	4	N	N
HARRISON COUNTY	Y Y	Y N	Y	Y	Y		Y	Y	Y	Y	Y		N	5	6	N
PASS CHRISTIAN	Y Y	Y N	Y	Y	Y		Y	Y	Y	Y	Y		N	5	6	N
LONG BEACH	Y Y	Y N	Y	Y	Y		Y	Y	Y	Y	Y		N	5	6	N
GULFPORT	Y Y	Y N	Y	Y	Y		Y	Y	Y	Y	Y		N	5	6	N
BILOXI	Y Y	Y N	Y	Y	Y		Y	Y	Y	Y	Y		N	5	6	N
D'IBERVILLE	Y Y	Y N	Y	Y	Y		Y	Y	Y	Y	Y		N	5	6	N
JACKSON COUNTY	Y N	N	N	Y				Y					N	N	N	N
OCEAN SPRINGS	Y N	Y Y	N	N	Y								N	N	N	N
PASCAGOULA	Y N	N	Y	Y	Y			Y					7	N	N	N
MOSS POINT	Y N	Y 8	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	9	10	11	12

1. Updated flood plain ordinances to meet new FEMA requirements.
2. Civil defense pre-hurricane plans.
3. Flood plain management ordinance is periodically updated.
4. Update the existing flood damage prevention ordinance in January 1988.
5. Adopted floodway plans, enacted mobile home tie-down regulation and increased inspections.
6. Hurricane evacuation plans
7. Planning board and city council.
8. 40-foot minimum setback on front and 40% minimum open space on lot.
9. Permit required for improvements that exceed $100 in value.
10. Upgraded minimum elevations from 15 feet to 18 feet.
11. Hired 2 full-time building inspectors at $75,000 annual salary. Funds were obtained from General Funds.
12. Public warning and public address system was not adopted due to lack of funds.

TABLE C-4

Mitigation Measures In Effect Across the Study Area

	N F I P	STRICTER	C C C L	STRICTER	MITIGATION AS A GOAL	REQUIRED LAND USE	LAND USE TOOLS	PROPERTY ACQUISITION	ZONING	BUILDING CODES	BUILDING PERMITS	SUBDIVISION REGULATIONS	DENSITY RESTRICTIONS	TRANSFER OF DEVELOPMENT RIGHTS	OTHER	CHANGES DUE HURRICANE	ENACTED MEASURES	NOT ENACTED MEASURES
<u>FLORIDA</u>																		
ESCAMBIA COUNTY	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N
PENSACOLA	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	1	N	N	N
SANTA ROSA ISLAND	Y	Y	Y	2	Y	Y	Y			Y	Y	Y	Y	Y	3	4	5	N
SANTA ROSA COUNTY	Y	N	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	N	N	N	N	N
MILTON	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	6	N
GULF BREEZE	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	7	N
OKALOOSA COUNTY	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N
FORT WALTON BEACH	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	8	N	9	N	N	N
VALPARISO	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N
WALTON COUNTY	Y	N	Y	10	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	11	Y	N	N
BAY COUNTY	Y	12	Y	N	Y	Y	Y	N	N	Y	Y	Y	N	N	13	14	N	15
PANAMA CITY	Y	N	N	N	Y	Y	Y	N	Y	Y	Y	Y	Y	N	N	N	N	N

1. Special ordinance restricting developments along the shoreline. The ordinance requires several yards of setback from the shore.
2. The state CCCL on the gulf side of the island is used as a line of prohibition of permanent construction rather than a line of jurisdiction. Additionally, a 100 foot setback line governs construction on the Santa Rosa Sound side of the island.
3. All of the land within the jurisdiction is owned by Escambia County. Other means of mitigating hurricane damages include lease agreements, development codes and general covenants and restrictions.

4. Require break-away wall construction below the base flood elevation in all flood zones, increased the base flood elevation in most flood zones beyond FEMA requirements, require construction in "V" zones to be wind resistant to 120 mph and use of break-away walls in "V" zones is limited to 299 square feet. Have successfully challenged the preliminary flood insurance rate map to exclude any "C" zones within the jurisdiction and to increase the base flood elevation.
5. Revised and adopted comprehensive land use plan in 1988.
6. More stringent setback requirements for construction along the shores.
7. More stringent setback requirements along the coasts.
8. No direct density restriction but indirectly in the form of lot coverage restrictions
9. Landscape requirements.
10. Windload requirements.
11. Planned Unit Development.
12. In the process of developing a stricter ordinance. Expect accomplishment after completion of mapping of the area.
13. Deed restrictions.
14. In the process of preparing land development regulations which will include hurricane damage mitigation measures.
15. A more stringent subdivision regulation was proposed but not enacted.

PERTINENT STATE LAWS

Information was also assembled on State laws that are useful in mitigating potential property loss from hurricanes. Three subject areas were considered. They are development or growth management, building codes, and coastal setback requirements. The following briefly summarizes some of the more important statutes in each state.

ALABAMA

There are no State laws that mandate land use planning or enforcement of a building code. State law does, however, permit local governments to impose building codes and land use planning.

The State's Coastal Zone Management program contains setback provisions for construction in coastal areas. These setbacks range from 120 to 450 feet with no development allowed seaward of the setback line. The Alabama Department of Environmental Management is responsible for establishing the setback line. If the local community accepts the determination of the setback line, it is allowed to administer the program, otherwise ADEM is responsible for the administration of the program. The program is intended to manage the coastal area so that construction can occur, but the dune system is preserved.

MISSISSIPPI

There are no state laws that pertain to statewide building codes, erosion setback requirements, or land use planning. Each community is empowered to enact such legislation for its own use. Mississippi does have a Coastal Zone Management program. It should be noted that much of the Mississippi coast is fronted by US Highway 90 with development landward of the road, that there is a 28-mile long seawall fronted by a nourished beach, and that much of the coast has been developed for a considerable number of years.

FLORIDA

The State of Florida has been very aggressive in its pursuit of reducing the damaging effects of hurricanes and other severe storms. There are several state policies and statutes that outline the efforts they are making to accomplish storm damage mitigation through development management. Listed below are some of the more important actions that the state has taken and a brief explanation of each.

A. Executive Order 81-105, September 4, 1981, reads in part:

"1. Give coastal barriers, which include barrier islands, beaches and related lands, high consideration in existing state land acquisition programs and priority in the development of future acquisition programs.

2. Direct state funds and federal grants for coastal barrier projects only in those coastal areas which can accommodate growth, where there is need and desire for economic development, or where potential danger to human life and property from natural hazards is minimal. Such funds shall not be used to subsidize growth or post disaster redevelopment in hazardous coastal barrier areas. Specific consideration shall be given to the impacts of proposed development or redevelopment with respect to hazard mitigation.

3. Encourages, in cooperation with local governments, appropriate growth management so that population and property in coastal barrier areas are consistent with evacuation capabilities and hazard mitigation standards."

B. A letter to agency heads, signed by Governor Bob Graham on August 8, 1986, updated and clarified the Executive Order. The following summarizes provisions in the letter:

No state funds for infrastructure and economic development for any barrier island without a bridge or causeway.

No state funds for infrastructure expansion or economic development in any designated unit of the federal Coastal Barrier Resource System.

No state funds for new or expanded infrastructure projects seaward of the coastal construction control line, in Federal Emergency Management Agency designated "V" zones, in areas damaged or undermined by coastal storms, or at inlets without structural controls. Exceptions: Allow state funds where a crucial need is found to alleviate dangerously overcrowded roads or replace defective wastewater facilities violating water quality standards.

Allow state funds for justifiable repair or replacement of storm damaged facilities in Coastal High Hazard Areas. Justification: If repair or replacement is in the overall long term public interest and hazard mitigation, including relocation alternatives, are fully evaluated. Justifiable replacement must be at the same or less capacity than the original facility.

Allow state funds in coastal areas if consistent with approved resource planning and management plans pursuant to Sec. 380.045, Florida Statutes, and comprehensive plans approved pursuant to Sec. 380.05, Florida Statutes.

C. The Executive Order and the letter to agency heads does not carry the weight of law. The Coastal Infrastructure Policy of 1985 is a state law and provides that:

(1) No state funds shall be used for the purpose of constructing bridges or causeways to coastal barrier islands, as defined in s. 161.54(2), which are not accessible by bridges or causeways on October 1, 1985.

(2) After a local government has an approved coastal management element pursuant to s. 163.3178, no state funds which are unobligated at the time the element is approved shall be expended for the purpose of planning, designing, excavating for, preparing foundations for, or constructing projects which increase the capacity of infrastructure unless such expenditure is consistent with the approved coastal management element.

(3) The state land planning agency shall, by March 1 of each year, prepare and transmit to the Governor, the President of the Senate, and the Speaker of the House of Representatives a report on the state's coastal barrier areas. The report shall assess the effectiveness of the state's coastal barrier area infrastructure policy on growth and development.

D. The State Comprehensive Plan, enacted in 1985, amends the State and Regional Planning Act. The coastal policies in the State Comprehensive Plan include the following:

"Avoid the expenditure of state funds that subsidize development in high hazard coastal areas"
(s. 187.201(9)(b)3., F.S.).

"Avoid transportation improvements which encourage or subsidize increased development in coastal high hazard areas or in identified environmentally sensitive areas such as wetlands, floodways, or productive marine areas"
(s. 187.201(20)(b)., F.S.).

Promote natural resource protection and restoration
(s. 187.201(9)(b)4., 5., and 9., F.S.).

"require local governments, in cooperation with regional and state agencies, to adopt plans and policies to protect public and private property and human lives from the effects of natural disasters" (s. 187.201(7)(b)25., F.S.).

E. In response to the State and regional Planning Act of 1984, Florida's eleven regional planning councils adopted comprehensive regional policy plans intended to further the entire state comprehensive plan. Each regional policy plan must contain goals and policies that are consistent with the state comprehensive plan. Local government plans must be consistent with the regional plans. The regional plans form a basis for improving the coordination of local governments and local plans that share common natural resources, issues and concerns.

F. Also enacted in 1985, the Local Government Comprehensive Planning and Land Development Regulation Act furthers the state's aims of hazard mitigation. The provisions of this statute specifically require certain local governments to adopt coastal management elements as part of their comprehensive plans. The statute also outlines the legislative intent regarding the preparation of local comprehensive plans and provides minimum standards with which all plans must comply. The Act states that "...it is the intent of the Legislature that local government comprehensive plans restrict development activities where such activities would damage or destroy coastal resources, and that such plans protect human life and limit public expenditures in areas that are subject to destruction by natural disaster." The Act also specifically requires local comprehensive plans to have policies which address the "...limitation of public expenditures that subsidize development in high hazard coastal areas."

The minimum criteria by which local comprehensive plans will be prepared and reviewed is promulgated in the Florida Administrative Code, Chapter 9J-5. Pursuant to the coastal management element requirements contained in Rule 9J-5.012 of the Florida Administrative Code, the local governments must provide objectives which:

(3)(b)5. Limit public expenditures that subsidize development permitted in coastal high hazard areas subsequent to the elements's adoption except for restoration or enhancement of natural resources.

(3)(b)6. Direct population concentrations away from known or predicted coastal high hazard areas.

(3)(b)8. Prepare post-disaster redevelopment plans which will reduce or eliminate the exposure of human life and public and private property to natural hazards.

(3)(b)11. Establish level of service standards, areas of service and phasing of infrastructure in the coastal area.

In addition, policies which identify regulatory or management techniques must be provided for each objective and for:

(3)(c)3. General hazard mitigation including regulation of building practices, flood plains, beach and dune alteration, stormwater management, sanitary sewer and septic tanks, and land use to reduce the exposure of human life and public and private property to natural hazards.

(3)(c)5. Post-disaster redevelopment including the removal, relocation, or structural modification of damaged infrastructure and unsafe structures; limiting redevelopment in areas of repeated damage.

(3)(c)7. Designating coastal high hazard areas, limiting development in these areas, and relocating infrastructure away from these areas.

The State of Florida enacted the Coastal Zone Protection Act in 1985. This Act created a protected coastal building zone in which structural standards are imposed on most constructions. The Act imposes structural requirements on different types of constructions within the coastal building zone, but does not address the siting policies or site coverage concerns of other similar Florida programs. The Act requires each affected local government to adopt a building code and enforce the structural requirements of the Act. All major structures with the potential for substantial impact on the coastal zone must conform to the state minimum building code; must be designed, constructed and located in compliance with the National Flood Insurance Program, or local flood damage prevention ordinance, whichever is more restrictive; and must meet the 1986 revisions to the 1985 Standard Building Code using a wind load of 110 mph.

One of the notable measures which the State of Florida has adopted to regulate developments along the coast is the Coastal Construction Control Line (CCCL) program which was authorized by the Florida Beach and Shore Protection Act of 1975. The purpose of the program is to identify the coastal areas of Florida most likely to be impacted by the 100-year storm event, and to regulate developments in those areas so as to mitigate or eliminate structural damage and erosion within those areas. The program has the potential to drastically reduce storm related damages in coastal areas subject to high velocity waves and storm surge.

The Division of Beaches and Shores of the Department of Natural Resources is responsible for the implementation of the program. The CCCL program is only applicable to counties with sandy beaches along the Atlantic and Gulf coasts. The delineation of the CCCL is based on engineering and scientific analysis of coastal dynamics; and it shows that portion of the beach and dune system which is subject to severe fluctuation based on a 100-year storm surge, storm waves, and other predictable weather conditions. The DNR reviews permit applications for all construction and excavation activities seaward of the CCCL based on special design and siting criteria established in the Section 16B-33 of the Florida Administrative Code. In reviewing the permits, DNR makes reference to local zoning and building codes for stricter setback requirements that are consistent with the purpose of CCCL.

Another section of the Florida Beach and Shore Protection Act prohibits the DNR from issuing permits for construction activities proposed in any area which, based on the Department's erosion projection, will be seaward of the seasonal high water line within thirty years of the date of application. Detailed procedures for implementing the Thirty-Year Erosion Line are also contained in the Florida Administrative Code.

Evaluation for the Thirty-Year Erosion Line is done on a site specific basis, projecting the erosion rate from the date of the field work for the topographic survey submitted as part of the permit application process. Determination of the line takes into consideration historical shoreline erosion measurements for an along shore segment approximately 3,000 feet on either side of the center line of the project site.