Hazard Mitigation Research Program

The Center for Urban and Regional Studies
The University of North Carolina
Chapel Hill, North Carolina 27514

Report No. 85-07

DEVELOPMENT MANAGEMENT TO REDUCE COASTAL STORM HAZARDS: POLICIES AND PROCESSES

Timothy Beatley

The information presented in this report is based upon research funded by the National Science Foundation under Grant No. CEE-8217115, Hurricane Hazard Reduction Through Development Management. The findings and opinions are solely those of the authors and do not necessarily reflect the views of the National Science Foundation.

June 1985

Contents

Section	Page
I. Introduction: Planning for Coastal Storm Hazards	1
II. Storm Hazard Reduction Goals	3
III. Assessing the Local Storm Threat: Hazard Mapping and Risk Analysis	5
IV. Alternative Storm Hazard Mitigation Options	14
V. Development Management Tools and Concepts	20
A. Development Regulation	21
B. Land and Property Acquisition	41
C. Taxation, Fiscal and Other Incentives	59
D. Capital Facilities Policies	65
E. Information Dissemination	71
VI. Institutional Approaches to Recovery and Reconstruction	74
VII. Conclusions	85
VIII. References	87

I. Introduction: The Need to Plan for Coastal Storm Hazards

When this nation's coastal areas were sparsely populated, the need to plan for hurricanes and coastal storms was not great. In recent decades, however, barrier islands and vulnerable coastal areas have experienced unprecedented growth (e.g., Baker 1979). The aesthetic and other amentities of the coast have attracted many to the water's edge. These natural attractions and amenities of the coast are accompanied by natural hazards, most importantly hurricanes and severe coastal storms. The lives and property at risk in coastal areas are substantial, and states and localities must begin to seriously deal with and plan for these eventual natural phenomena.

A number of hazards are usually associated with a hurricane or severe coastal storm. Ocean surge and waves can create tremendous hydrodynamic forces which destroy or undermine shoreline buildings, public facilities, and protective works. Stillwater flooding, from surge and storm rains, can cause substantial property damages, as well as obstruct the evacuation of coastal residents to safer areas. High winds create similar threats to life and property, destroying homes and blowing down trees and utility lines. A more extensive catalog of the threats to life and property can be found elsewhere (Beatley, Brower, and Godschalk 1984). These brief comments are meant only to identify in a general way the danger of hurricanes and severe coastal storms.

This paper is designed to assist local, regional, and state officials in planning for storm risks and is specifically focused on the concept of mitigation. Mitigation can be defined as actions taken in advance of a disaster which reduce the damages and loss of life resulting from such an event should it occur. Mitigation is, of course, not the only area where local and state planning is needed. Disaster planning is typically conceptualized in terms of four phases or stages. They are: 1) pre-storm

preparedness (mitigation), 2) preparedness, 3) emergency response, and 4) recovery and reconstruction. It is clear that this is a circular process with recovery and reconstruction feeding into preparation and mitigation for the next storm. The mitigation options and process described in this report

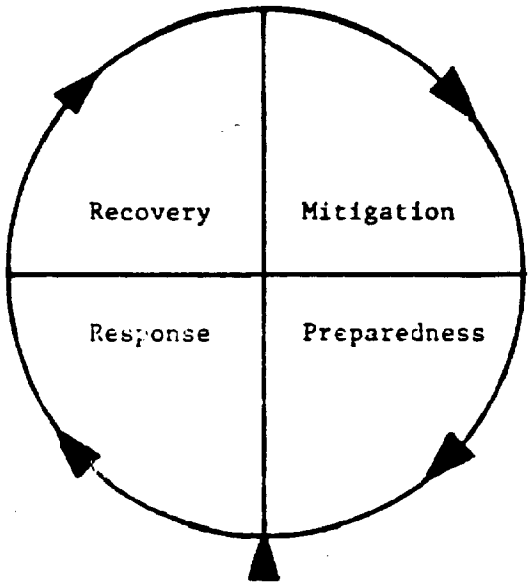


Diagram 1: The Four Phases of Disaster-related Activity

are relevant to stages 1 and 2 of this sequence. Policies and processes of planning for the immediate storm emergency, such as evacuation planning or search and rescue functions, will not be discussed in this paper. This, however, does not imply that these activities do not influence or have a bearing on mitigation. For example, certain pre-storm mitigation programs may have as their main objectives the facilitating of evacuation should a storm threaten. While mitigation is not concerned with the immediate actions and management tasks associated with evacuation, it may be concerned with creating a physical environment in which evacuation is relatively easy.

While a number of mitigation options are reviewed in this paper, the primary focus is on the use of development management techniques. Other major mitigation options, such as structural improvements and building codes, have been examined at length elsewhere, while development management remains an approach little discussed in hurricane hazard mitigation. Moreover, the focus on development management is an acknowledgement of the limitations of these other approaches. Coastal protection structural improvements, such as the construction of seawalls and groins, tend to be very expensive, and it is often difficult for local governments to modify existing national or statewide building codes and construction standards to enhance their storm protection requirements.

Development management refers to programs and policies which control or influence the location, density, timing and/or type of urban development (Godschalk, Brower 1979). While these techniques have been used extensively to advance numerous other community goals in coastal and non-coastal settings, their explicit use in reducing storm hazards has thus far been limited. This report presents alternative development management strategies, potential problems in their application, and general approaches to effectively apply these techniques to mitigate the impacts of hurricane and coastal storms.

II. Hazard Reduction Goals

The general goal of reduction of storm hazards is not specific enough to guide mitigation programs and policies. There are several basic objectives, however, within this overall goal which can be identified and among which priorities can be assigned. Decisions concerning which of these objectives are important, and the extent of their importance are essential to choosing between different hazard mitigation strategies. Potential objectives within storm hazard reduction are the following:

1. reduction of damages to existing development;
2. reduction of damages to future development;
3. reduction of damages to existing public facilities and structures;
4. reduction of damages to future public facilities and structures.
5. reduction of injury and loss of life;
6. protection of the natural environment;
7. other community goals.

The relative importance of each of these objectives will in turn influence the types of hazard reduction programs and policies which are chosen by the locality. For instance, many of the development management strategies suggested below are oriented toward reducing damages to future development and can do little in the case of existing development. Shoreline protection works, such as seawalls and bulkheads are designed primarily to reduce damages to property already existing in the storm hazard area. On the other hand, protecting human life may call for the construction of additional infrastructure, e.g., the construction of roads and bridges to facilitate evacuation, and the construction of storm shelters.

The relation of storm hazard reduction goals, and the programs designed to advance them, to other community objectives should always be considered. Among these non-mitigation goals might be some of the following:

- the protection and enhancement of the natural environment and ecosystem;
- the enhancement and improvement of the local economy and the adequate provision of employment and income for residents;
- the availability of sufficient and affordable housing stock for existing and future residents;
- the protection of aesthetic and scenic characteristics of the coastal environment.

- the preservation of the high quality-of-life and small town atmosphere of the community;
- the achievement of efficiency in the provision of public services and facilities.

If, for instance, the protection of coastal wildlife areas is an important local goal, this may be accomplished through the public acquisition of such lands, which are likely also to be areas susceptible to hurricane and storm forces. Acquisition of these lands in these cases serves multiple local goals. Certain mitigation policies, such as setbacks and density restrictions, for instance, may also serve to advance local goals of preserving aesthetic resouces and ensuring the economic attractiveness of the area. It is important to integrate mitigation goals with other pertinent local goals and objectives. This will almost certainly tend, as well, to enhance the political and financial acceptability of such measures.

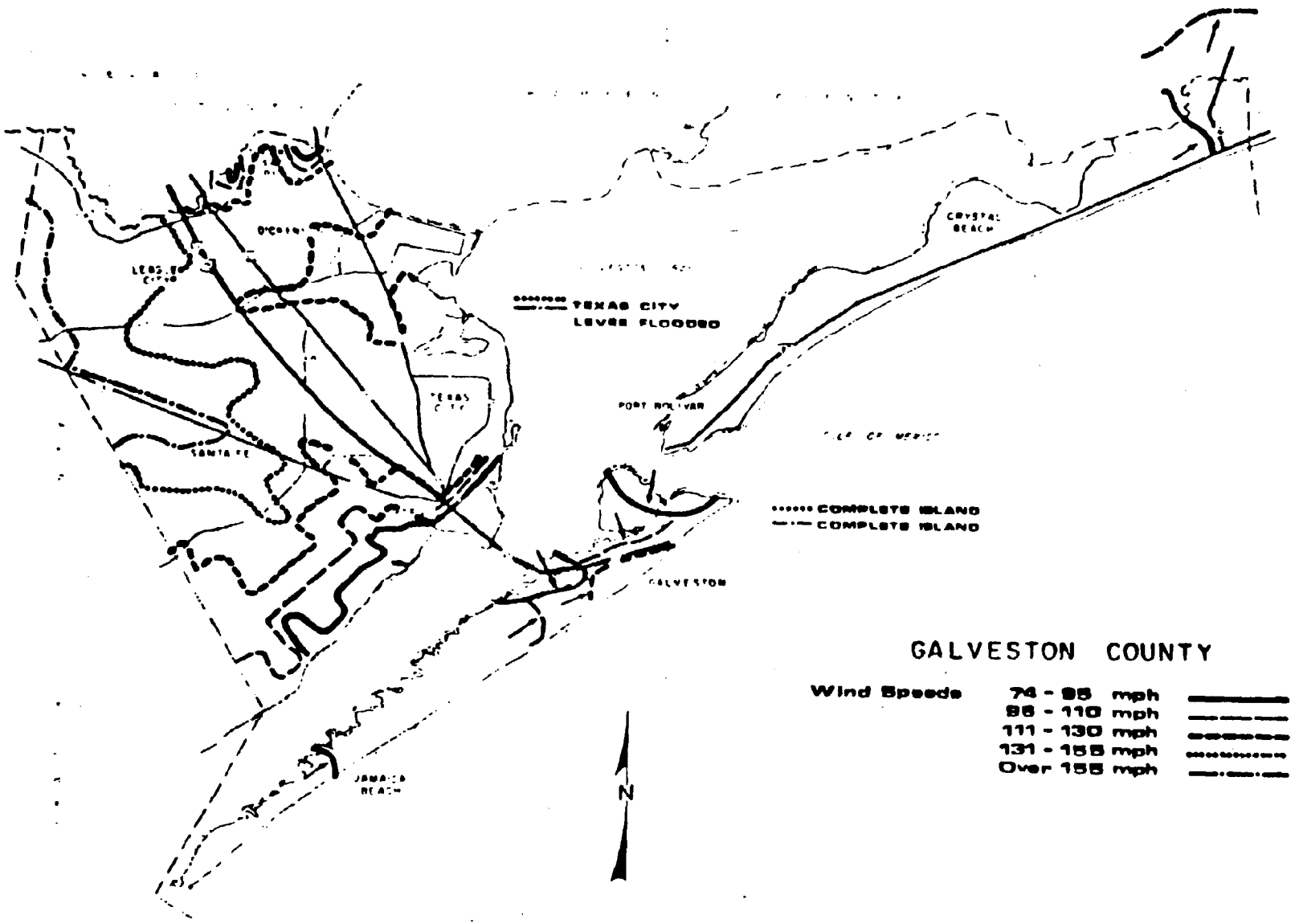
III. Assessing the Local Storm Threat: Hazard Mapping and Risk Analysis

Before beginning its analysis of appropriate mitigation measures, a jurisdiction must fully understand the nature of the hazards and risks associated with hurricanes and coastal storms. This begins with an assessment of the storm phenomenon itself, and the nature and probability of this phenomenon. This should include a review of the storm history of a locality or region, including the history of storm strikes by different intensity levels, as well as the different tracks and meteorological characteristics of these events where possible (e.g., historical points of landfall). This will serve as a general description of the types and magnitude of storm events that a jurisdiction might expect, and will, along with information about the natural and built environment, provide a general indications of the levels of disaster risk to which it is subject.

In most coastal areas the complexity of this risk assessment task has been simplified through the hazard mapping requirements of the National Flood Insurance Program. While these maps say nothing about potential wind risks, they do provide a location-specific delineation of flooding and wave hazards for certain primary return intervals (i.e., the 100 year floodplain). More complex modeling procedures such as SLOSH (Sea, Lake and Overland Surges from Hurricanes) can provide more detailed information concerning the wind and surge effects of hurricanes. The SLOSH model has been or will eventually be applied in 22 coastal metropolitan areas (U.S. Congress 1983). From the SLOSH model, maximum wind and surge penetration levels can be computed for an area (see Diagram 2), as well as information concerning when key evacuation points will experience hurricane forces (e.g., when key bridges will be unindated and thus incapable of further evacuation) (see Ruch 1981). Despite the analytical possibilities of such a sophisticated form of hazards mapping, NFIP hazard maps will likely remain the major basis for delineating local storm hazard areas, at least until all coastal areas are analyzed under SLOSH.

National flood insurance maps are developed according to the type of flood hazard associated with a particular location and the probability or chance that such flooding will occur in any given year. "A" Zones or 100 year flood zones, are areas which have a probability of 1% of being flooded in any one year. "B" zones are 500-year flood zones and consequently have a lower chance of flooding, while the risk in "C" zones is negligible. "V" or "Velocity" zones are "A" zones which are determined to be susceptible to significant wave action. In combination, these zone types permit local officials to identify and delineate areas where storm forces are most likely and to take appropriate mitigative actions. Further discussion of the requirement of the National Flood Insurance Program is provided in Section IV.

Diagram 2: Estimated Galveston County Storm Surge Penetration



Source: Ruch, 1981.

These hazard areas can then be supplemented through the delineation of areas of high erosion, incipient inlets, washover zones, wetlands, and other local areas of particular concern. For example the State of North Carolina, under the Coastal Areas Management Act, makes provision for such additional zones under its Area of Environmental Concern (AEC) program. Two categories of AEC are relevant to storm hazard mitigation: the estuarine system and ocean hazard areas. Three types of ocean hazard areas have been identified: ocean erodible areas, high hazard flood areas, and inlet hazard areas. Ocean erodible areas are zones where the possibility of significant erosion exists and where new buildings are required to adhere to setback requirements. High hazard flood areas are coterminous with "V" zones under the National Flood Insurance Program, while inlet areas are extensions of the ocean erodible zone and subject to a high degree of fluctuation of coastline. Two types of estuarine AEC's are of relevance to storm hazard mitigation: coastal wetlands and estuarine shorelines. In addition, localities where finger canals have been created will want to include these on the hazards map, as they tend to be very susceptible to inlet formation during severe storms. The Town of Holden Beach, N.C., for instance, has three separate developments built around fringe canals and representing a substantial storm hazard (Town of Holden Beach, N.C. 1984).

These different types of hazards can be depicted in composite form for a locality. Diagrams 3 and 4 are composite storm hazards maps constructed for the Town of Surf City, as contained in their storm hazard mitigation and reconstruction plan (Town of Surf City, N.C. 1984). In this case, one map delineates NFIP zones, and another delineates AECs.

Diagram 3

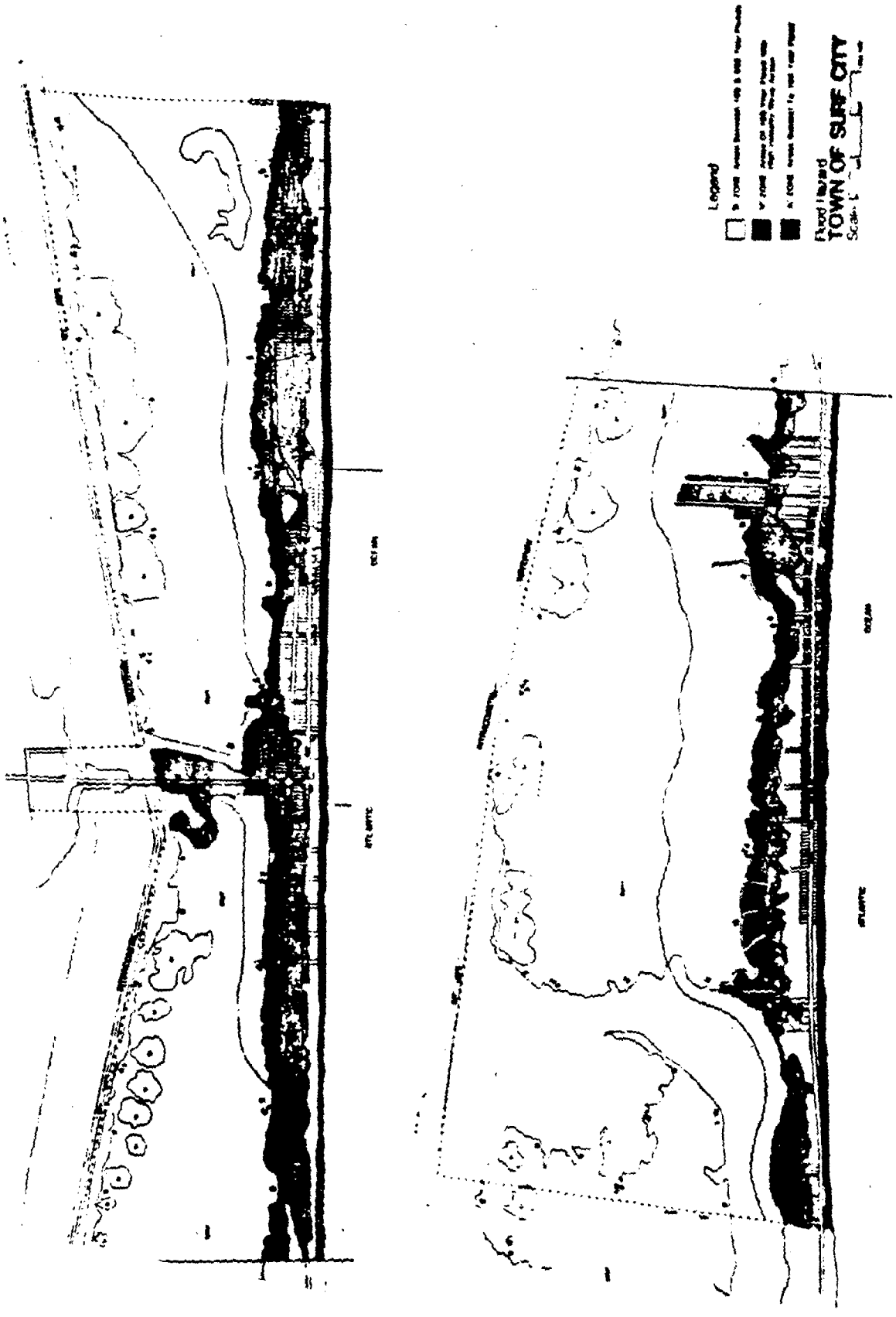
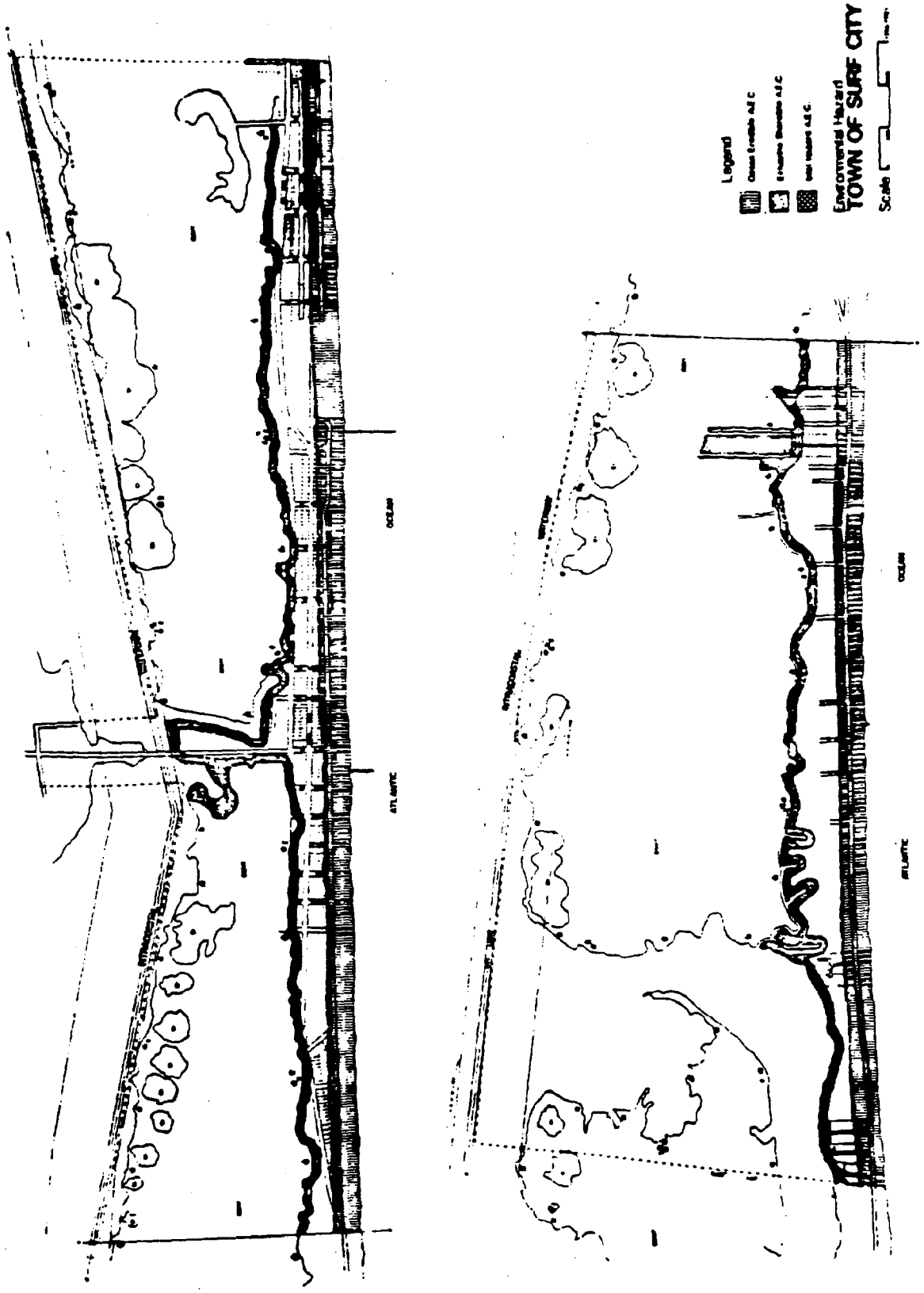


Diagram 4



Risks from natural phenomena are not created, however, until population and development locate in or in close proximity to these hazard areas. A second step is to identify the quantity of property and population currently at-risk. This information can be obtained from tax maps, windshield surveys, and data on land use and development. As well, this analysis should identify and assess the vulnerability of property and population. This should include, for instance, the ability of residents in different locations to evacuate expeditiously, their ability to find adequate shelter, the ability of buildings and facilities to resist storm damages, and features of the built and natural environments which may offer protection from storm forces (e.g., the existence of a seawall). From this the community can identify existing areas currently at-risk. Researchers at Texas A&M have recently applied the SLOSH modeling technique to computing expected damages and casualties from potential hurricanes (under different assumptions), for delineated hazard zones (see Berke and Ruch, forthcoming.)

An assessment of the extent of public and private property at-risk can be undertaken for each of the hazard areas delineated in the hazard mapping process. For instance, Table 1 below provides summary information on the amount of private property at risk in the Town of Nags Head (1984), by NFIP zones. Some 544 structures, valued at over $25 million are located within the V-zone, for example. This information can generally be obtained from local taxation and revenues departments. The U.S. Army Corps of Engineers may be an additional source of information on extent of property at-risk. A 1982 survey of Surf City buildings, for instance, indicated that some $5.5 million in damages to residential structures could be expected under a 100-year storm, as well as some $1.7 million in commercial damages (Town of Surf City, N.C. 1984).

Table 1: Summary of Private Property At-Risk by Flood Hazard Area, Town of Nags Head, N.C.

	Number of Buildings	Value ($)	Number of Parcels	Value ($)	Total Value ($)
V-zone	544	26,951,000	722	25,321,100	52,272,100
A-zone	1126	60,835,300	1968	47,230,100	100,073,400
B-zone	563	33,194,500	674	29,929,800	63,124,300
C-zone	329	18,740,000	640	15,286,000	34,026,000

Source: Town of Nags Head, NC. Hurricane Hazard Mitigation and Post-Storm Reconstruction Plan, prepared by Coastal Resource Collaborative Ltd., 1984.

Included in this vulnerability assessment, as well, should be the extent of public facilities, such as roads and sewer lines, which are at risk. These should at least be identified, if not estimated and valued in the same way that structures at-risk are. Table 2 below indicates, for instance, the extent of roads and sewer mains at risk in the Town of Nags Head.

Table 2: Public Investment Vulnerable to Storm Damage

Water Mains in Flood Zone (in feet)

Size of Main

Zone	24"	14"	12"	8"	6"	4"	2"
V	0	0	0	0	6850	1650	6500
A	33070	230	26200	32110	57880		5440
B	0	0	8350	250	0	0	200
300	0	0	0	0	2300	250	1330

Table 2 (cont.)

Zone	Street Length (feet)
V	10500
A	134300
B	3100

Source: Town of Nags Head, N.C. Hurricane Hazard Mitigation and Post-Storm Reconstruction Plan. Prepared by Coastal Resource Collaborative, Ltd. 1984.

Risks to human life may be assessed in several ways. One approach is simply to document and analyze population trends and the proximity of populations to expected storm forces. This in effect indicates the expected exposure to storm hazards should residents remain in their homes. Because most residents are likely to evacuate and/or occupy a storm shelter, storm risks to residents can be assessed according to local evacuation and shelter capacity. As roads and highways can accommodate only so many vehicles at a given time and because approaching storms can cause substantial hazards to evacuation (e.g., downed trees, flooded bridges) it is important to carefully examine the evacuation capacity of a locality and to accurately identify risks to human life. Sophisticated traffic and evacuation models have been developed for both metropolitan (e.g., Tampa Bay Regional Planning Council 1981) and nonmetropolitan localities (e.g., Stone 1983). Stone calculates, using a relatively simple methodology, that it would take between 8 and 13 hours to evacuate Holden Beach, North Carolina. As conditions change, however (e.g., as development increases and evacuation capacity does not), the levels of risks will tend to change as well.

Together this information can be used to identify and prioritize mitigation opportunities according to the nature and magnitude of local risks. Ideally, an assessment of the benefits to be obtained from permitting development to occur in storm hazard areas should accompany the above considerations of cost (e.g., see Petak and Atkisson 1982). While in most cases a detailed examination of these economic benefits is not made, the jurisdiction should at least consider them. What follows is an examination of the alternative programs, policies and institutions that can be employed by a jurisdiction to reduce storm risks, both before and after a storm strikes. Emphasis is placed on the use of development management techniques and consequently a more detailed presentation of these approaches is provided.

IV. Alternative Storm Hazard Mitigation Options

Several alternatives exist for the reduction of hurricane and storm hazards. These fall into three main categories or "mitigation strategies": 1) programs designed to structurally alter the coastal environment so that it better withstands storm forces; 2) programs designed to strengthen buildings and accompanying facilities; and 3) development management, the topic of this report, designed to reduce the exposure of people and property to storm forces (see Table 3). An outline and discussion of the specific types of programs and mechanisms which fall within each of these categories follows. Because development management is the focus of this paper, it receives the bulk of attention.

A. Structural Programs

Structural actions are designed to reinforce the shoreline environment to better protect this development from storm wave and surge forces. Four primary approaches exist within this category.

1. Sandtrapping Structures

Sandtrapping structures are designed to protect, maintain, or enhance beaches and dunes which absorb storm impact and energy. Groins are structures extending into the ocean at right angles to the coast, typically constructed of concrete, timber, steel sheetpiling or riprap. Groins induce deposition of sand on the updrift side, and in turn block lateral deposition in down drift areas. Jetties are also built at right angles to the shore but generally extend further into the ocean and are often constructed in pairs to prevent shoaling in coastal inlets.

2. Sandmoving Programs

Natural processes of beach accretion can be supplemented through programs designed to move sand to "starved" areas from other areas where it is in greater abundance. Beach nourishment programs transport large amounts of sand to an area experiencing high rates of erosion, using pumps, dredges, and/or trucks. In this way beach and dune structure are preserved by redistributing sand resources to correct for accretion-erosion imbalances. Large scale nourishment programs can be very expensive, and in areas of high erosion may require constant investment even to maintain existing shoreline levels. Sandscraping may be undertaken to reinforce a beach structure, e.g., filling-in behind protective seawalls and bulkheads using bulldozers and other earth-movers.

Table 3: Approaches to Reducing Coastal Storm Hazards

A. Structural Alteration/Reinforcement of Coastal Environment

1. Sandtrapping Structures

   a. Groins
   b. Jetties

2. Sandmoving Programs

   a. Beach nourishment
   b. Sandscraping

3. Shoreline Protection Works

   a. Seawalls
   b. Revetments
   c. Bulkheads
   d. Terraces
   e. Breakwaters

4. Flood Control Works

   a. Dams
   b. Dikes and levees
   c. Retaining ponds
   d. Flood channels

B. Provisions to Strengthen Buildings and Facilities

1. Strengthening Buildings

   a. Floodproofing
   b. Elevating
   c. Windproofing

2. Strengthening Facilities

   a. Floodproofing
   b. Burial
   c. Elevating

Table 3 (cont.)

C. Development Management

1. Development Regulation

   a. Zoning
   b. Subdivision regulations

2. Land and Property Acquisition

   a. Fee-simple acquisition of undeveloped land
   b. Relocation of existing development
   c. Purchase of development rights/easements
   d. Transfer of development rights

3. Taxation, Fiscal and Other Incentives

   a. Differential taxation
   b. Special assessments and impact fees

4. Capital Facilities Policy

5. Information Dissemination

3. Shoreline Protection Works

Shoreline protection works are structures designed to protect buildings and property from wave and water forces. Seawalls are vertical walls embedded in the earth to absorb wave energy, typically constructed from heavy concrete sheetpile, with a stepped-down or curved face (see U.S. Army Corps of Engineers 1981; Yasso and Hartman 1976). Bulkheads are smaller vertical walls used to protect headland areas and inlet channels. A revetment has a similar purpose, but may be angled and typically uses rip-rap or interconnecting concrete blocks to protect dunes and beaches from erosion. Terraces are used in cliff areas, and involve the insertion of vertical pilings and planks at different levels. Breakwaters are fixed or floating structures that parallel the coast, serving to reduce the energy of waves before they hit the shoreline.

4. Flood Control Works

Flood control works are designed to manage and reduce the damaging effects of flooding. They range from relatively small projects such as the construction of retaining ponds to hold excess stormwater, to the undertaking of large dams, to control the movement of water in river systems. Dikes and levees are elevated earthen works used to protect against rising flood waters. Flood channels are used to funnel and divert flood waters away from developed areas. A number of examples can be cited of the use of these approaches in addressing hurricane and coastal storm risks. A series of levees and locks are being constructed on Lake Ponchartrain (New Orleans) to protect against and manage hurricane flooding (U.S. Army Corps of Engineers 1980). Kiawah Island, South Carolina, has developed a stormwater management plan which includes a lagoon system, which can be emptied prior to a storm landfall (S.C. Water Resources Commission 1982). Texas City (near Galveston, Texas) is nearing completion of a 16-mile long, earthen levee system (maximum height of 23 feet MSL), along with a concrete floodwall drainage system, a closure gate, and pumping drainage stations (Texas Division of Emergency Management 1984). It is designed to provide protection from storms creating 15-foot surges. A similar project is found in Freeport (also near Galveston). It includes 38 miles of earthen levees, as well as drainage and pumping facilities, and a tide control gate.

B. Provisions To Strengthen Buildings and Facilities

Rather than relying on improvements to strengthen the surrounding coastal environment, building strengthening efforts seek to strengthen the building structure, along with accompanying facilities such as sewerage collection lines, water distribution lines, and roads.

1. Strengthening Buildings

The adoption of building codes and construction standards to floodproof and elevate buildings in flood prone areas has been the most widespread response to hurricane and coastal risks. These building strengthening actions were required by the National Flood Insurance Program. Along with windproofing requirements in building codes, these types of actions seek to decrease the vulnerability of buildings exposed to storm forces.

Under the regular phase of NFIP, new residential structures lying within the 100-year floodplain (A-zones) must be elevated to or above this 100-year flood mark (the BFE, or Base Flood Elevation). Commercial and industrial structures must either be elevated or flood-proofed (e.g., flood resistant materials, floodwalls) (see FIA 1976). In the "V-zones," velocity or Coastal High Hazard Areas where the incoming storm surge is expected to support a minimum three-foot wave (see U.S. Army Corps of Engineers 1975), buildings must be elevated to or above 100-year wave heights and built on pilings (rather than landfill). New mobile homes are prohibited in V-Zones, and the alteration of certain sand dunes and mangroves is prohibited if likely to lead to increased flood damages. In both A and V Zones, if flooding damage of more than 50% of the value of an existing structure occurs, the rebuilding of the damaged structure must be consistent with elevation and floodproofing requirements. (For a good history of the NFIP see Burby, French, and Kaiser 1979).

Some communities have mandated building elevation in excess of that required under the 100-year BFE. Referred to as "freeboard" elevation, this can further minimize the impacts of wave and surge forces. The City of East Providence, R.I., for example, has enacted provisions which differentiate a high- and low-hazard zone. In the high hazard zone (near the beach)

residential buildings must be elevated to 15 feet MSL, rather than the 10 feet required under the NFIP requirements (Kusler 1982, p. 46).

Building codes vary widely in the resistance they provide to hurricane forces. Depending on the state and the code in use, storm strengthening requirements may be either local option or state-mandated, or some combination. Standard codes may not have adequate requirements. In the Texas model Hurricane Resistant Building Standards (Texas Coastal and Marine Council 1981), stringent wind loading standards were proposed to protect against storm winds of 140 mph (as compared with, say, 105 mph in the Southern Standard Code). This model code was, however, not enacted by the Texas Legislature.

2. Strengthening Facilities

Inhabited structures located in hazard areas must also be served by basic support facilities. These facilities, like the structures themselves, can be strengthened to better resist storm forces. Primary among these are wastewater collection, water distribution, electric and telephone lines, and roads. Sewer and water lines can be floodproofed, while utilities can be placed underground for better protection. Roads are best protected through elevation.

C. Development Management

Development management programs are designed to affect the location, density, timing, and/or type of development (see Godschalk and Brower 1984.) In this sense they can be described as "non-structural" approaches to mitigation. This discussion of specific development management techniques indicates the range and diversity of different tools and approaches available. Ideally, a locality should seek to find that package of development management programs and policies particularly suited to their political, social and

economic conditions. Types of techniques include development regulation, land acquisition, taxation and fiscal incentives, capital facilities policies, and programs for information dissemination.

1. Development Regulation

The primary development management tools are those which regulate and control in a direct fashion the location, amount, density, and type of development in a coastal community. Regulations can address the reduction of exposure of property to hurricane and storm risks, and reduction of vulnerability of property, and can lead to the enhancement of the protective features of the natural environment. Basic types include zoning and subdivision regulations and various specialized applications of these standard regulations.

a) Zoning

- Conventional zoning: Reducing the quantity of development exposed.

Conventional zoning ordinances control the type of land uses allowed in particular parts of a community (e.g., residential, commercial, recreational) as well as their intensity (e.g., bulk, height, floor area ratio, setback provisions). As a result, zoning provisions can control the amount and type of property exposure to hurricane and storm hazards. For instance, open space and recreational uses may be the most appropriate activities to be permitted in high risk areas (e.g., high wave and erosion areas). Restricting such areas to commercial or public recreational activities will substantially reduce the amount of property at-risk and in turn the property losses to accrue from future hurricanes and storms.

One zoning option is simply to designate hazard areas as an open space or conservation zones in which all future development is prohibited. Even if

this were a politically feasible option, in coastal areas where agricultural and other non-developed uses do not yield reasonable economic returns, a challenge of a "taking" of private property without just compensation is opened up (see Bosselman, Banta,and Callies 1976). Depending upon specific state statutes and case law, such an approach is not likely to be defensible unless some economic use, such as agricultural, forestal, or commercial recreation can be supported. The community must examine the local viability of these non-developed uses and modify its regulations accordingly.

The legal and political feasibility of a zone where all development is prohibited may depend on the precise design and configuration of this zone, and its relation to land ownership patterns in the community. If, for instance, the zone constituted a "strip" which was long but not deep, a typical landowner might work around such a prohibition, essentially building on other portions of lots. Such a zone then essentially becomes much like an ocean setback. Moreover, even if the zone is not of a "strip" type but rather encompasses a large amount of land in one area, if landholdings are quite large, it might be argued that reasonable development potential (economic use) has been preserved.

In most instances, in the absence of land acquisition or some substantial form of landowner compensation, large scale prohibition of new development in hazard areas is not likely to be feasible. A more sensible approach is one which seeks to reduce the overall quantity of development at-risk. While a residential designation in an oceanfront area may still permit considerable development to occur at high risk to hurricane damages, this quantity may be considerably less than what the unregulated market would support. Moreover, reducing a zoning designation from relatively dense multi-family development to single family uses may reduce substantially the amount of property at-risk.

Also, the legal and political feasibility of development limitation can be maintained by coupling it with other techniques such as the transfer of development rights and the acquisition of less-than-fee simple interests in land. For instance, if the regulated landowner is able to transfer a portion of the pre-regulatory development value of his parcel to another site where it can be used (or sell it to someone who can use it for such a purpose) this will afford the landowner at least some economic return. These techniques are further discussed in subsequent sections of this report.

Examples of reductions in densities along high hazard coastal shorelines are not hard to find. Several localities along the highly vulnerable South Shore of Long Island, New York, have reduced permissible densities (see Long Island Regional Planning Board 1984.) Hollywood, Florida, in an effort to protect a relatively underdeveloped segment of its shoreline, and to keep the area's population within existing evacuation capacity, severely downzoned this area from high density hotel and condominium uses to single-family detached residences. In its recent hurricane hazard mitigation and post-disaster reconstruction plan, the Town of Emerald Isle, North Carolina, notes its efforts to reduce storm hazards by keeping hazard area densities down.

"The Towns growth policy encourages relatively low density residential development; high rise developments along the ocean are not typically found in Emerald Isle. The Town has also downzoned lands that originally allowed up to 13.5 dwelling units per acre to 8 dwelling units per acre. This may reduce the ultimate number of units by 2,200 or about 7,300 seasonal sites" (Town of Emerald Isle 1984, p. 10).

In the hurricane hazard mitigation and reconstruction plan for Onslow County, North Carolina, it is recommended that future permissible densities be

lowered considerably in West Onslow Beach (Topsail Island), to facilitate evacuation. Moreover, while it recommends a reduction in overall density for the area, it recommends more extensive reductions where the hurricane hazard is greater.

The Onslow County plan illustrates that zoning can be used to reduce the amount of property at risk in coastal hazard areas in proportion to the extent and nature of the storm-related hazards in various locations. The quantity of development permissible could be a function of the aggregate risks on a particular site. For instance, less development may be permitted in an area subject to both wave velocity action from storms and a potentially-shifting inlet than in a location subject to velocity effects but without the inlet hazard. Different hazard zones can be designated with varying degrees and combinations of hazards, with the density of development adjusted accordingly. Proximity to ocean and sound waters may serve as a good proxy for storm risks, with the most extensive amounts of new development permitted on locations further inland. An important factor here is that in a typical coastal community there will be gradations of hazard risk, with the primary (mitigation) objective of zoning often being to orient future development away from high hazard areas to lesser hazard areas.

As with many of the other development management techniques discussed in this paper it is important to utilize zoning provisions to preserve, to the extent possible, the protective features of the natural environment. It may be desirable, for instance, to permit only very low densities of development (where permitted at all) around wetlands. Development in close proximity may threaten the health and vitality of these areas and in turn reduce their utility in absorbing storm forces (e.g., Conservation Foundation 1980; Benton et al. 1980).

This density can be reduced in several ways. One approach is to raise the minimum lot size required for structures. For instance, in a high hazard zone, the zoning ordinance may be modified so that new residential structures here must be situated on a minimum lot size of five acres, rather than the previous one acre minimum. A complimentary approach is simply to reduce the number of dwelling units permitted per acre in high hazard areas. An existing permitted density of 30 dwelling units per acre may be reduced to that of 15 dwelling units per acre. Either approach serves to reduce the overall quantity of permissible development in a particularly hazardous location.

Where an existing zoning ordinance already exists, this reduction in density may be most expediently accomplished by rezoning hazard areas to existing zoning designations which exclude higher density uses. For instance, the hurricane mitigation and post-storm reconstruction plan for the Town of Nags Head, North Carolina recommends that the town consider rezoning certain portions of its beachfront from CR to R1 or R2, in order to prevent the location of high density hotel and motel uses.

Reductions in the densities of development permitted by zoning in high hazard areas can occur in either the pre-storm stage or during recovery and reconstruction. It may be difficult to overcome the political obstacles to such changes in the pre-storm stage, while storm devastation may present unique opportunities for this. The community may decide in advance that certain pre-determined density reductions would be installed according to the extent of overall damage occurring in particular areas of the community. For instance, in areas where structures have been damaged by 50% or more of their market value on average, the community may automatically impose

a density reduction of, say, 50%. This would permit structures to be rebuilt, but would as well reduce substantially the amount of future property at-risk. The pre-specified reductions would likely be tied to the damage zones delineated during the early stages of recovery and reconstruction (see Section VI) and would resemble a sort of floating zone which would become binding only upon the occurrence of certain damage conditions. Many of these objectives might also be accomplished through the concept of nonconforming use, described below.

Table 3: Potential Post-storm Reductions in Density

Damage Areas*	Extent of Density Reduction
Major damage (50% or more of market value)	50%
Moderate damage (20% to 50% of market value)	20 to 50%
Minor damages (less than 20% of market values)	no change

*See Section VI for a discussion of the delineation of storm damage zones.

This reduction of risk is also contingent to some extent on the quality and type of structures to be built. Multifamily structures, designed by engineers and architects, for instance, may be built to withstand the forces of hurricanes and storms much more effectively than builder-designed single family structures. While limiting development to the latter type may reduce the quantity of property at-risk, this property may be more vulnerable to storm damages.

One traditional zoning concept that can be readily applied to density reduction is the notion of "nonconforming uses." A nonconforming use is created when a land use or activity is no longer permitted to occur by right in a zoning district, but rather is considered a "grandfather" use. That is, it is permitted to continue, yet is not generally permitted to expand (or to expand beyond a certain extent) and if destroyed or discontinued is not permitted to reestablish itself. For instance, a commercial establishment may be considered a nonconforming use in an exclusive residential zone. While it is permitted to continue in the short-term, it may not be permitted to expand its size, and if destroyed by, say, a fire, will not usually be permitted to rebuild in this zoning district.

This concept can be used to reduce storm hazards in several ways. Certain high density uses in high hazard areas can be declared nonconforming uses, i.e., through changes in zoning districts, and in time a slow process of land use change might be expected. A shorter-term perspective views the nonconforming use concept as a way of preparing for and managing reconstruction after a hurricane or storm occurs. For instance, while a major hotel or condominium may be acceptable in a high storm hazard zone because it already exists (it would be economically inefficient to tear it down), storm destruction provides the opportunity to change the use of this land. Declaring this a nonconforming use in advance of the storm prevents its reconstruction and relieves local officials of the need to make such a zoning change after the storm. This may, as well, simply be a way of bringing older structures "up to code" in the event that they are faced with substantial repairs.

Several issues are raised by use of this approach. The first is a question concerning the financial and other impacts of declaring an existing

use to be non-conforming. To what extent, for instance, does this lower the fair market value of this property and the ability of its owners to secure continued financial backing? Furthermore, will this result in lower tax assessments and reduced property tax revenues for the locality? A controversial issue is the extent or degree of damage required before reconstruction to its original use or condition is not longer permitted. The National Flood Insurance Program has used a 50% fair market loss criterion to distinguish between damaged structures which do or do not have to be repaired to NFIP standards (e.g., elevation to the 100-year BFE). It may be, however, that a community wishes to define a destroyed structure in some other way, for instance structures which have incurred damages of 80% or more of their fair market value.

A variation on the nonconforming use theme is the concept of "amortization." Typically employed to regulate billboards, this mechanism permits a use to continue in its present state, but only for a certain number of years, presumably to permit the achievement of a certain level of economic return. This tool might be used to reduce the location of certain property in high hazard areas in situations where it is considered equitable to provide the property owner with a certain amortization or compliance period. A locality might require a single-family homeowner in a high erosion area, for instance, to relocate his home on a safer parcel by some reasonable period of time.

• Coastal setback. The concept of development setback has long been part of zoning and land use controls. Setbacks are used in urban settings, for instance, to ensure that sufficient land is available for future public improvements (e.g., roads), and to ensure adequate light, access, and separation of structures. Required setbacks from coastal hazard areas are an

extension of this zoning concept and have become relatively popular as a technique both for minimizing the impact of development on beach and dune areas and reducing exposure to storm hazards (e.g., see Kusler 1982; CURS, 1984). Setbacks can be required from the ocean itself (e.g., from mean high tide), the first line of vegetation, or dune ridges. Such setbacks may be either state-mandated or local option. A number of states require development to be set back from the ocean. The State of North Carolina requires small coastal developments to be located landward from the first line of vegetation (or crest of dune), a distance 30 times the annual rate of erosion for that particular segment of the coast. This setback is 60 times the annual rate of erosion in the case of multifamily structures of four units or more and structures of more than 5,000 square feet in size. Florida imposes a similar requirement under its Construction Control Line (CCCL). Seaward of the control line, a permit must be obtained from the state to develop or excavate land. The line is meant to encompass the 100-year flood area and varies from jurisdiction to jurisdiction, based on local erosion and shoreline changes. While construction seaward of the CCCL is not prohibited it must satisfy certain structural and design requirements, to ensure protection of structures and the beach and dune system. These mitigative requirements can discourage or reduce the amount of development in high risk areas, as it may be easier to obtain development approval in locations outside the CCCL.

The State of New York has recently established a setback requirement, although it has yet to be implemented (Long Island Regional Planning Board 1984). Under the state's Coastal Erosion Hazard Areas Act, localities are required to adopt local erosion control ordinances which are approved by the state. Two hazard areas are defined in the regulation: natural protective feature areas and structural hazard areas. The boundary line of the natural

protective feature area must be 25 feet from the landward edge of the dominant natural protective feature. (e.g., edge of dune formations, edge of beach). Structural hazard areas are locations experiencing at least an average annual erosion rate of one foot, with the hazard zone extending to a landward depth of 40 times this rate plus 25 feet. Permits will then be required for new development in these hazard zones, as well as reconstruction following a storm, and will be subject to certain performance standards. For instance, for development to gain approval in a natural protective feature zone, it must not aggravate coastal erosion and must minimize adverse effects on natural features. Within structural protection zones, permanent structures are prohibited, but movable structures can be located here if set back 50 feet from the edge of a bluff, provided they include no permanent foundation and their permit applications include adequate plans for relocating the structures at a later date.

A number of individual localities have established their own setback provisions (e.g., see Kusler, 1982). For example, Glynn County, Georgia, has enacted a Beach and Dune Protection District as an overlay district to its zoning ordinance. For stretches of oceanfront which have an active/stable dune sequence, new development must be setback at least 40 feet landward of the crest of the most seaward stable dune. In areas where this dune sequence does not exist, the requred setback is 20 feet landward of the mean high water mark. Kiawah Island, South Carolina, has also implemented development setbacks which are completely private or non-governmental. The Kiawah Island Company will only sell development lots with deed restrictions that require the structure be setback considerably landward of the tertiary dune.

• Contract and conditional zoning. Under contract zoning the jurisdiction agrees to allow a land use activity not normally permissible in a particular area (e.g., a rezoning from low-density residential to commercial, or higher-density residential) in exchange for a certain desirable feature provided by the developer (e.g., a deed restriction, certain public improvements). Conditional zoning is similar to contract zoning, but without the community selling or bargaining away its regulatory authority. Here, zoning changes are permitted only if they satisfy the stipulations laid down by the community at the time of project review. For example, a community may agree to rezone low density residential to commercial uses in a high hazard zone, only if the developer agrees to ensure, for example, that such structures can be used for sheltering the public in the event a hurricane threatens. These are conditions which generally flow from the project review process and are typically not formalized or uniform from project to project.

An additional approach to enhancing the flexibility of land use controls is the use of "conditional" or "special" uses. These are uses which are permitted by right as long as proposed development meets certain standards and criteria. These conditions typically relate to the provision of public facilities and the protection of environmental resources. Such standards could also incorporate storm risk reduction actions, for instance permitting special uses only when adequate evacuation capability exists, or only when such uses do not disrupt the ability of the natural coastal environment to resist and protect against storm forces.

• Bonus or incentive zoning. Bonus or incentive zoning is a formal mechanism through which developers are granted extra development density (e.g., square footage, dwelling units, etc.) in exchange for certain public

amenities or desirable project features. It has been used for some time in New York City and San Francisco. In New York, for example, a developer can obtain a 20% increase in permissible floor area for projects which incorporate a legitimate theatre (i.e., within a designated theatre district). Density bonuses have been given to encourage the incorporation of low and moderate income into development projects (e.g., See Fox and Davis 1978). In the case of coastal hazard areas, developers may be granted additional development units if projects incorporate certain hazard-reduction features. These features may include the purchasing and deeding to the public of high hazard lands, or the provision of certain design features which may increase the ability of structures to withstand storm forces. It may not be wise public policy, however, to encourage or permit additional densities in such areas, even if certain public amenities and hazard-reduction features are provided.

- Population caps and annual development limits. One approach to addressing the hurricane threat is simply to restrict the number of individuals permitted to reside in the community. This may be particularly appropriate in barrier island communities where only limited numbers of people can evacuate safely should a hurricane or severe storm threaten. It may be, as well, that a strategy to reduce future property damage is simply to restrict the amount of such property permitted in the community. Usually, however, such restrictions are employed for other purposes, such as to protect the aesthetic quality of a community or to ensure that a natural resource is not overtaxed.

Two basic approaches can be identified. One approach is to establish an absolute "cap" on the amount of future growth permitted in the community. (For a general review and comparison of these, see BGRS 1974.) This may be assessed in terms of overall population or development units. The City of

Boca Raton, Florida, has become a classic example of an attempt to use this approach. Citizens here voted in 1972 to enact a charter amendment restricting the absolute number of dwelling units in the jurisdiction to 40,000, with a series of down zonings to implement this provision (see Godschalk et al. 1979; Meador 1979). The courts have found, however, that the Boca Raton System is violative of basic constitutional rights, and such an absolute growth restriction is unlikely to be judically defensible.

A second and more legally acceptable approach is to limit growth on an annual basis. The City of Petaluma, California, is a prime example of the use of this approach. Here provisions were enacted which restrict the issuance of building permits to roughly 500 residential units per year. Development applications are evaluated according to the Petaluma General plan and environmental design plans (see Godschalk et al. 1979). A program of restricting the amount of annual growth may have several advantages for a storm-vulnerable coastal locality. It will reduce the speed of new development and growth, and consequently the extent of people and property at-risk in the short-term. In the long run, however, the absolute extent of development may remain unchanged. Timing growth in this way may afford a community more time to plan for the storm hazard, and may place the community in a better position to make intelligent land use and other decisions which in the long-run will reduce the extent of local storm hazards (e.g., being better able to review individual development designs for their consistency with local storm reduction goals). As a further example, a community may need additional time to finance and put in place certain public facilities critical to the safety of people and property, e.g., perhaps a new bridge to the mainland, or an offshore breakwater to protect development. The concept of a temporary building moratorium serves essentially the same functions.

The preceding comments suggest the possibility of closely tying permitted new growth to the capacity of a coastal locality and its residents to respond to a storm hazard. Such an approach has been employed in the growth management system adopted by the Sanibel Island, Florida. Prior to its incorporation in 1974, this barrier island had been zoned to permit some 30,000 dwelling units, or some 90,000 residents. Condominiums had already been constructed on frontal dunes and serious damage to the island's ecosystem had already occurred (e.g., dredging and filling of wetlands) (see Godschalk et al. 1979; Clark 1976; City of Sanibel 1980). Shortly after the island was incorporated, a moratorium on new development was instituted, and a comprehensive plan was developed. The Sanibel plan was explicitly based on the capacity of the island's natural and built environments new development and growth. The plan itself includes an extensive discussion of the hurricane threat, including an analysis of the different types of hurricane that could hit the island, the evacuation and refuge facilities in place, and a calculation of evacuation capacity. The plan sets out policies in several key areas to address the island's hurricane risks: evacuation facilities, population limitation, on-island refuge, building codes and capital improvements with regard to population growth and evacuation capacity. The plan concludes the following:

"1) The city should limit and manage growth so that the population on the island when a hurricane warning is issued will not be substantially in excess of the evacuation and on-island refuge capacity of the island. Overloading the emergency system will reduce efficiency and deprive residents and visitors of a reasonable opportunity to reach safe refuge.

2) Future growth should be accompanied by and coordinated with to the maximum extent practicable, improvements in the island evacuation system and

increases in the amount of on-island refuge. It is only in anticipation of such improvements that the present population should be allowed to expand, because the evacuation capacity is already taxed during certain times of the hurricane season" (pp. 42-43).

Analysis of evacuation capacity indicated that the island could accommodate between 4,900 and 6,250 cars. Based on this factor and the capacity of the island's facilities and natural systems, an intermediate development cap was established of approximately 6,000 dwelling units, or a 50% increase over the number existing in 1974. The actual allocation of these units to areas of the island was intimately tied to different natural zones and systems existing on the island. Numerous performance standards have been developed to minimize the effects of development on these systems should future investments in, say, evacuation facilities occur (e.g., bridges, roads), these development restrictions might be reduced.

The Sanibel case illustrates well the use of the concept of "carrying capacity." By carrying capacity is meant the natural and manmade limits development beyond which significant harms will occur (see Godschalk and Parker 1975; Schneider et al. 1978; Godschalk et al. 1974). Carrying capacity can be used to assess the effects of development on such natural factors as ground water supply and drainage, and manmade factors such as sewage treatment and roadway capacity. This concept has been applied in practice to a number of coastal localities (e.g., Nags Head 1984; DCRP 1983). Several implications for storm hazard reduction arise from the application of this concept. The first is that, as the Sanibel case illustrates, the concept is particularly relevant to assessing evacuation capacity (see particularly DCRP 1983). Second, natural and manmade limitations on coastal development may provide a rational means to regulate the location and quantity of new growth, which in

turn may serve to reduce storm hazards. Carrying capacity objectives, in other words, may serve to reinforce and complement efforts to reduce storm hazards generally.

The recent efforts of Hollywood, Florida, to restrict the absolute number of dwelling units in its North Beach Development Development District has provided an example of strong judicial support for this concept. Permissible development here was downzoned to an overall capacity of 3,000 dwelling unit equivalents. These restrictions were supported by a number of detailed planning studies, including a hurricane evacuation analysis. While losing at the district court level, the plan was found to be legal at the Appellate level. In writing its opinion the court made specific reference to the Boca Raton case, and the major differences between the two.

"..... the facts in that Boca Raton case reveal that the cap was established by public referendum, the City planning department was never even consulted and when examined, the Boca Raton City Planning Director knew of no compelling reason for imposing this fixed limitation. In the case before us now, the city did not adopt any such Alice-in-Wonderland approach. The record is replete with comprehensive plans, studies, reports, public meetings and actual discussions with the developer over a period of years. Unlike the Boca Raton case, the City of Hollywood did not present its community purpose in the abstract, but presented a more than adequate case for the proposition that the City has been attempting to accomplish a density slash since 1971 and that the developer has owned most of its holdings for fifty years. As a consequence, this was no sudden municipal zonig karate chop such as transpired in the Boca Raton case" (p. 6).

b) Subdivision Regulations

• Subdivision and site plan review process. Subdivision regulations govern the conversion of raw land into developed uses, and the type and extent of improvements made in this conversion. Subdivision regulations can control the density, configuration and layout of development. They operate in ways similar to zoning to control the amount and density of development on a particular site. The requirement of a minimum lot size can reduce the amount of new development exposed to storm hazards. Site plan review and other requirements of subdivision approval can provide the opportunity to orient the location of development sites in ways which minimize storm risks. For instance, subdivision provisions may require that new single-family dwellings on lots in hazard areas be sited in ways which maximize distance from high hazard oceanfront areas.

Subdivision approval might be made contingent upon mitigative actions, such as the protection of dunes, wetlands and natural vegetation. For instance, subdivision and site plan provisions may require that structures be located a sufficient distance from protective dunes. This may, in fact, amount to a setback, but this is not necessarily so. Subdivision approvals may also be made contingent upon the planting of certain vegetation and the restoration and repair, to the extent feasible, of existing dunes.

A promising alternative is to protect the option of moving a structure back from the ocean by requiring lots which are sufficiently deep for their purposes. Such areas could be considered analogous to the "repair" areas often required for septic tank use. If necessary, a structure could be moved to the landward portion of the lot, in a safer location.

• Clustering. Perhaps some of the most promising requirements from a storm mitigation perspective are clustering provisions (see Whyte 1968). Such

provisions would not affect the overall density permitted on a particular site, but would seek to amalgamate this density on portions of the site which are less hazardous (e.g., outside of the flood zone, at a distance from velocity zones and active inlets). These provisions may either be required or be presented to developers as an option. Clustering could have several advantages from a storm mitigation perspective. By directing density to a particular portion of a site, it can both permit and encourage development to locate on the less-hazardous portions of a site, while preserving hazard-prone areas in an undeveloped state. In Gulf Shores, Alabama, development regulations encourage clustering new development on the landward side of the ocean highway, with parking and recreation open space areas on the seaward side. These may typically be areas, such as wetlands and vegetation areas, which in themselves serve to protect against storm forces. Clustering may also encourage the construction of buildings which are more structurally resistant to storm forces, and may provide a more economical provision of certain storm protection improvements (e.g., sea or floodwalls). Clustering can, as well, economize on the public facilities, such as sewer, water and roads, which must accompany development, in turn reducing the amount of such property at risk (RERC 1974). Clustering may also offer advantages in the provision of community storm shelters and evacuation services.

The possibility exists for requiring or encouraging the clustering of structures on safer sites during reconstruction following a damaging storm. This is a primary strategy proposed for Long Island communities by the long Island Regional Planning Board (1984). More specifically, this approach is suggested for communities in the Fire Island Reach:

"Should a major hurricane wipe the slate clean at Saltaire, destroying a majority of the existing structures, the first step for the village would be

to initiate an immediate moratorium on all redevelopment. The Village would then have the opportunity to move away from single-family development in vulnerable areas and encourage clustered development at less vulnerable inland locations. ...it would probably be necessary to condemn certain private inland properties, as well as use all publicly owned properties, to provide sufficient areas to accommodate this redevelopment. Owners of properties along the oceanfront would be prohibited from rebuilding, using the mechanisms already mentioned, and these property owners would be encouraged to participate in the inland clustered development." A transfer of development rights system (see Section V-C) is proposed as well to facilitate and encourage this clustering.

- Exactions and development conditions. Traditionally, subdivision approval is contingent upon the provision by the developer of certain land or facilities, or monetary contributions in lieu of such dedications. Referred to as "exactions," they have conventionally taken the form of requirements to construct and dedicate, or to pay for the construction, of such immediate facilities as sewer and water lines, curbs and gutters, and roads. Typically included, as well, are requirements that developers contribute a certain amount of land for open space, parks and recreation, and future school sites. These are generally needs directly related to the new development. This exactions process offers potential for storm hazard mitigation in several ways. It may require, for instance, that when private developers build and dedicate public facilities, these facilities be constructed in ways which are hurricane-resistant (e.g., flood proofing sewer and water lines, elevated roads, etc.). Moreover, in the dedication of lands, or fees in lieu of such dedications, the community can require that lands which are particularly hazardous be dedicated -- in turn ensuring that such areas are used for

non-developed (non-intensive) uses. An in-lieu land acquisition fund may allow the community to combine resources and to acquire in a more aggressive way large tracts of high-hazard land. Consideration of public reconstruction requirements may also be appropriate. For example, the community may wish to make subdivision approval contingent upon the contribution of the developer to a "reconstruction fund," which would be used to finance both immediate recovery and longer-term reconstruction tasks.

Some communities have attempted to tie subdivision approval to the adequate provision of off-site community facilities and services, such as police and fire. Similar reasoning applies to hurricane hazard reduction. Subdivision approval might be contingent, for instance, on adequate community-wide evacuation capacity, or the provision of community storm shelters.

Approval of repair or reconstruction following a storm (i.e., the issuance of a building permit) may also provide a situation in which certain "exactions" can be obtained. For instance, it may be possible to hinge reconstruction permission on the elevation of a certain amount of open space, or fees in lieu of such acquisitions. There are numerous of other standards and requirements, such as clustering and restoration of the dune structure, that may be imposed as a condition to permitting redevelopment and which may reduce damages from future hurricanes.

- Planned unit development (PUD). Planned Unit Development (PUD) provisions are intended to increase flexibility and innovation in project design by relaxing stringent zoning and subdivision requirements, and a more creative design resulting from negotiation between the developer and public officials. A PUD process may permit the mixing of residential and commercial uses in ways which conventional zoning would not. Storm hazard reduction can

be advanced through PUD project design, for instance, by permitting deviation from normal land use and subdivision standards for more innovative developments (and perhaps more profitable from the developer's point of view) when these designs incorporate storm hazard reduction features, such as the provision of protective land and vegetation buffers, and the provision of on-site storm shelters. (For a discussion of PUD provisions see Burchell 1973; 1972.)

2. Land and Property Acquisition

The acquisition of land and property, or interests therein, may in many cases be the most effective approach to reducing the extent of exposure to storm forces. Several acquisition approaches are discussed here: 1) fee-simple acquisition of undeveloped land; 2) acquisition of less-than-fee-simple interests in undeveloped land; and 3) fee-simple acquisition/relocation of existing development.

a) Fee-Simple acquisiton of undeveloped land. Fee simple acquisition entails the public's obtaining of the full "bundle of rights" associated with a parcel of land. With respect to the storm hazard, acqusition may have several immediate functions. The first is to secure in public hands high hazard areas, thus in turn preventing the future exposure of property and people to storm hazards. On a larger scale public acquisition of land can serve to influence the direction and timing of growth and development in a locality. Urban landbanking programs, particularly popular in Europe, have attempted to regulate growth by preventing development in undesirable locations while strategically releasing other land more suitable (see Strong 1979; Kamm 1970; Parsons 1973). Or perhaps, on a much smaller scale, single parcels of land may be purchased to prevent the location of certain

growth-shaping private activities, e.g., the construction of a shopping center, boat marina, manufacturing complex, and so on. Land acquisition can also be used to secure in advance, and typically at lower prices, land that will be needed at some point in the future for public facilities and services, e.g., school sites. The primary focus of the following discussion will be on the acquisition of undeveloped high hazard parcels as an attempt to reduce the extent of property and people at risk.

The use of fee-simple acquisition poses a number of practical questions. The most significant perhaps for most coastal localities have to do with cost and how such acquisitions are to be financed. Fee-simple acquisition in coastal areas experiencing moderate or high levels of market demand will tend to be very expensive -- prohibitively expensive for many communities. The purchase of already-improved land (i.e., land with homes and facilities) will be even more expensive, although damaged properties purchased in the aftermath of a storm may reduce these expenses substantially. The locality must be prepared, however, to take advantage of "bargain sales" after the storm.

The expenses associated with fee-simple acquisition can be reduced in several ways. First, a locality may seek to acquire land a number of years in advance of development, when its market value is relatively low. It may also be possible to obtain reduced acquisition costs through the use of eminent domain. Official mapping is another technique for keeping acquisition costs down. This identifies areas where the public expects to purchase land in the future and where inconsistent activities and developments will not be permitted. Such an approach can serve to squelch rising development expectations which can lead to higher land acquisition costs.

The costs of fee-simple acquisition might also be reduced through th use of "preemption" or "right of first refusal." Such a mechanism would

essentially permit the local governing body to insert itself in the place of a property-buyer in any local land transaction. In other words, it would allow the locality to oversee all land transactions and to spend its limited resources in acquiring only those lands which are truly threatened by development (i.e., are in fact in the process of being sold for development uses). This technique has been used extensively in France under their SAFER program. Here, right of preemption is used to purchase farmland, which is in turn reassembled and sold in larger and more agriculturally-efficient tracts (Coughlin et al. 1977). The technique has also been used by the State of Oregon in protecting its scenic waterways from damaging development. While this concept has legal precedents in real estate law, enabling legislation will likely be necessary in most states before it could be used.

Acquisition costs can also be kept down through resale of properties, with certain covenant restrictions placed on their use. This would also address the problem of managing lands and property once they have been acquired. Placing land back into private hands, where possible, may do much to keep costs down. This decision, however, will also depend upon other important community objectives which may exist. If there exists a local need for parkland, maintaining these lands in public hands will then make more sense. A locality should in its acquisition decision making be aware of other local goals and objectives that can be advanced simultaneously with hurricane/storm hazard reduction. The greater the overlap of such objectives, the greater will be the social efficiency of these acquistions. The State of Maine, for instance, has recommended that purchases of coastal properties give equal weight to two factors: "1) the beach to be acquired must be subject to potentially severe and recurring storm damages, and (2) the beach must offer significant public recreation opportunities" (Maine Land and Water Resources Council 1978).

Where possible a locality should seek to obtain "bargain buys," and land and property donations. Bargain purchases may be particularly attractive in the aftermath of a storm where damages are substantial and some property owners may wish to vacate the hazard area. The locality must, however, be prepared prior to such damages to act upon these bargains when they present themselves.

Acquisition costs may also be reduced by taking advantage of all available federal and state funding sources. Historically, where acquisition has been used most extensively as a mitigation tool, there has been substantial federal and state financial involvement (Kusler 1979). For instance, Section 1362 of the Federal Disater Assistance Act provides for federal funds for the purchase of federally-insured properties damaged by a storm (or other disaster). NFIP provisions also provide for what is known as "total constructive loss," or payments to FIA-insured property owners for the complete amount of policy coverage even where damages are not this extensive, if owners agree not to rebuild. The policy has, however, apparently lost favor with FEMA officials in recent years and is no longer used.

A locality may also be able to more efficiently use its available acquisition funds by coordinating its acquisition decisions with private organizations, such as the Nature Conservancy and the Trust for Public Land, that are actively involved in land acquisition. These organizations are often in a better position to engage in extensive acquisition than are single jurisdictions. Although their acquisition decisions are typically based on non-hazard objectives, a community may be able to influence these private purchase decisions in several ways. This may occur, for instance, simply by better communicating their perception of which acquisitions will be in the public interest or by convincing them that by purchasing specific parcels or

parcels in particular areas of the locality, multiple social objectives will be furthered. As well, the locality may be able to devise a cost-sharing arrangement, in which the local government, through some form of financial contribution, is entitled to share in specific decisions concerning acquisition. The locality may also be able to facilitate certain private foundation acquisitions which are favorable to local storm hazard mitigation.

Even where acquisition costs can be kept down, the locality must address the issue of how it will finance the inevitable local expenses involved in acquisition. One approach is simply to finance these expenses through general revenue funds. In turn, local taxes must either be raised to pay for these costs, or funds must be diverted from other local needs. Because acquisition of hazardous lands reduces "general" or "community-wide" damage liability, it can be argued that general revenue financing makes sense from an equity point of view. An alternative approach would be to obtain these funds through special means, which might include the collection of a special acquisition (impact) fee from new development, or through special district levies and assessments. Land acquisition as part of the exaction process during development approval has been discussed in an earlier section. The use of special assessments or levies would appear contingent, at least from an equity (as well as a legal) standpoint, on the extent to which these acquisitions will benefit existing property owners (i.e., the property-owners to which the tax is applied). To the extent that such acquisitions serve to enhance protection from future storm damages, as well as provide other benefits to nearby landowners (e.g., scenic and recreational benefits) such a mechanism seems a reasonable approach to financing acquisitions.

b) Relocation to reduce exposure. Development management may also involve the relocation of structures and facilities from high storm hazard

areas to areas of the locality which are less hazardous. Relocation can take at least two forms: 1) relocation of the structure and its contents to another site, and 2) relocation of the contents of a structure while demolishing or putting to a new use the remaining structure. Johnson (1978) has suggested that the first option entails the following steps:

- locating and purchasing land at a new site;
- preparing the new site; services, driveway, sidewalk new foundation;
- raising the structure off its existing foundation, transporting it to the new site, and placing it on the new foundation;
- moving contents from the existing to the new location;
- removing, disposing and backfilling the foundation at the existing site;
- providing temporary lodging during relocation (p. 47).

Johnson (1978) suggests that the second option entails the following steps:

- locating an existing structure, or building a new structure, at a flood free site;
- moving contents from an existing to a new location;
- either demolishing, and where possible salvaging the existing structure, or reusing it for a less damage susceptible use (p. 47).

Relocation of the structure to a hazard-free or less hazardous site, while physically possible, may be economically infeasible. This will depend on the type of structure involved. It is generally not feasible with respect to most commercial or industrial structures and multifamily residential structures. Single-family residential structures (one or two stories) and light commercial structures are most feasible (those with wood frames and with basements or raised foundations). These are structures which generally weigh less and contain accessible floor joists (Johnson 1978). Structures with slab-on-grade foundations are difficult to relocate. Reducing the

distance a structure must be transported may increase the feasibility of this technique. It may be, for instance, that significant additional protection can be afforded a structure by moving it back from the ocean or high hazard areas.

Relocation of families and their belongings to new housing outside the hazard or "high" hazard area will generally be a more feasible approach. This is particularly true following extensive storm damage, where demolition of damaged properties (rather than extensive reconstruction) involves fewer opportunity costs. The recent efforts in the Town of BayTown, Texas, to purchase properties in the Brownwood subdivision -- an area devastated by Hurricane Alicia -- are illustrative of the technique. Here some 300 destroyed or heavily damaged single-family homes have been prevented from being rebuilt (see FEMA August 1983; December 1983). Federal monies are being used to acquire the land the structures sit on (Section 1362), while SBA loans are being used to make up the difference between federal flood insurance payments and the replacement costs of these homes. This particular subdivision had been flooded at numerous times in the past, and federal officials saw this as an excellent opportunity to reduce future property losses and the federal insurance liabilities that would accompany them. Once these lands are acquired by the federal government they will be deeded to the City of BayTown, which in turn must agree to keep these lands in an undeveloped state. This type of relocation becomes more feasible, then, when storm damages are great and where a perception of the hazard as "perennial" on the part of public officials and property owners exists.

Up to this point we have been discussing the option of relocation as it pertains to a small number of buildings or residents. A perhaps more radical approach is to consider moving an entire community to a safer location. The

immensity and expense of this type of approach will generally prevent its use, and I have not considered it in this paper as a serious alternative except in very unique situations (e.g., Adler and Jansen 1978; see also David and Mayer 1984). The BayTown experience also indicates that even in situations where severe damages have occurred, relocation efforts will meet with substantial resistance.

c) Purchase of development rights/donation of easements. Where the fee-simple purchase of hazardous lands is, for various reasons, not feasible, a locality may consider the purchase of less-than-fee-simple interests in land. One such approach is the acquisition of rights to develop, from owners of high-hazard parcels. Under this arrangement, a jurisdiction would pay the landowner the fair market value of this right in exchange for agreeing to leave the land in an undeveloped state for some specified period of time, typically perpetuity. This is usually accomplished through a restrictive covenant which runs with the property deed. Throughout the section we will refer to this technique as the Purchase of Development Rights (PDR).

As with fee-simple acquisition a number of immediate practical questions arise. First, in what manner are these rights to be acquired? Does the jurisdiction use its powers of eminent domain, or instead simply bargain for them on the open market, acquiring such rights only from those who wish to sell them? This question may have significant implications for the ability of PDR to protect large blocks of high hazard land. For instance, relying upon voluntary sales may permit substantial development in an otherwise undeveloped high hazard area; it may do little more than shift new development from some parcels to other parcels (with perhaps denser development) within high hazard areas. Through the use of eminent domain, this potential "checkerboard effect" in high hazard areas may be prevented.

There is, as well, the question of what a "development right" is to consist of, i.e., exactly what rights are being purchased by a locality. Clearly, extensive residential development should be precluded, but should this include private recreational uses and developments which do not place substantial amounts of private or public property at risk? The greater the economic use which remains for the property owner, the greater will be the parcel's remaining fair market value, and the less costly will be the development rights purchase. Exactly what uses are permitted after development rights have been purchased may also influence overall property at risk on other parcels/areas. For instance, if private recreational activities are permitted in PDR circumstances, this may in turn induce further residential and other development in adjacent areas (lands where development rights have not been purchased). These types of development influences and side effects should be considered when defining the rights to be purchased (and the types of uses and activities that will be permitted in the future).

While a leading reason for preferring development rights acquisition over fee-simple acquisition is that public expense will be less, PDR may still be a very expensive mitigation approach. In areas where market demand for developed uses is high, the purchasing of a development right will constitute the major portion of the parcel's fair market value (Coughlin and Plaut 1978). Because of this fact, PDR may be no more financially feasible than fee-simple acquisition. A locality can, however, investigate alternative techniques for keeping down the costs of these rights. For instance, the Maryland Agricultural Land Foundation, a state-funded agency which purchases development rights from farmers, seeks to get the most from its limited funding by giving preference to parcels where the following ratio is highest: development rights (easements) value-asking price/development rights

(easement) value (Furuseth and Pierce 1982; Nielson 1979). Under this arrangement farmers wishing to sell their development rights submit bids to the state foundation, which in turn gives preference to high value parcels with low sale prices. A similar procedure might be applied in coastal communities. A jurisdiction might designate a general area of high storm hazard from which it will accept bids for development rights sales -- in turn maximizing limited local monies by purchasing those rights which consist of the "best deals." A system could also be developed by which to evaluate the extent of relative storm hazard for each parcel (e.g., distance from the ocean) in turn incorporating this information into the evaluation procedure (i.e., getting the largest hazard reduction for the dollar).

The period of time for which the development rights are purchased will also have significance for the cost of such a program. The Maryland program requires that development be restricted for a minimum of 25 years. A shorter period of time may serve the needs of the locality (e.g., in directing growth into certain areas) and preserve for the landowner a greater portion of the market value of the land, thus reducing the overall cost of development rights to a locality. Instead of purchasing these rights, the locality may find it more economically efficient to "lease" them for shorter periods of time.

As with fee-simple acquisition, there arise important questions of how the securing of these rights will be financed. Again, where possible, outside assistance should be utilized along with attempts to collaborate with the purchasing efforts of private groups. As before, developers of projects in hazardous areas might be required to purchase such rights themselves, or contribute to a local development rights purchasing fund, based on the magnitude of the project (e.g., square feet, number of bedrooms). The purchase of development rights may advance other community goals, as already

noted, such as the preservation of open space and the protection of natural amenities, and as such funding by the general public may be justified. The general public will also benefit to the extent that future public expenditures for recovery and reconstruction are reduced. It should, however, be remembered that the purchasing of such rights may also reduce the local tax base, as may be the case with fee-simple acquisition. This impact will, of course, depend upon the extent of the local purchase program and characteristics of the local tax base. Generally the impact on local tax base is not likely to be substantial.

PDR can be used effectively in collaboration with development regulation. On the one hand, restricting development in a particularly hazardous area of the jurisdiction may prevent the checkerboard effect that sometimes results from a voluntary PDR. In turn, PDR may serve to soften the economic effects of development regulations, and reduce as well the political opposition typically arising around such regulatory programs.

While not widely used, the prime example of its use, in this case specifically to protect farmland, is in Suffolk County, Long Island (NY) (see Peterson and McCarthy 1977). Financed through the sale of bonds, development rights have been purchased for 3,400 acres (as of 1981), at an average cost of $3,120 per acre (Duncan 1984). The State of Connecticut has also been experimenting with this concept and has acquired development rights for over 2,500 acres of land. King County, Washington, as a further example, has also been engaged in PDR. Closer to home, the PDR concept has recently been proposed for North Carolina's Forsyth County (Zaneski 1984). Under this proposal the county would spend $1 million each year to purchase development rights to prime farmland in the county. These lands could then not be developed for at least 25 years. At the end of this period the landowner

would be given the option of buying back the development rights if he so desired but at their current (new) market value. As currently proposed this program would be completely voluntary.

As an alternative to the purchasing of development rights, a locality might investigate encouraging the donation of scenic or conservation easements. Landowners can be encouraged to make such donations in large part becasue of the income tax deductions permissible under Section 170 of the IRS Code. For easements to qualify as charitable deductions, the instrument must be for perpetuity, must run with the land, and all subsequent owners must be subject to the restrictions. Under new provisions (1980), the Treasury Department is now required to make a determination that the easement "will yield a significant public benefit." This does not appear, however, to have been an impediment to receiving the charitable deduction.

The locality can take either an active or passive role in soliciting easement donations. It may, for example, actively search out and encourage these donations by landowners in hazard areas. In contrast it may simply assume a passive role as the recipient of easements. In either case, the jurisdiction must carefully evaluate the significance of each charitable easement for local storm hazard mitigation. Accepting easements located in the wrong places simply because they are donations (or at least inexpensive) may do more harm than good in the long run. Easements in perpetuity may lock the locality into land use and development patterns that it may later find undesirable or inappropriate. In the case of extreme coastal hazard areas, this is unlikely to be a significant problem, but in certain situations it may prove to be an important consideration.

If an easement is accepted, the jurisdiction and donating party should seek a clear understanding of the precise restrictions to the use of the land

which will be in place. Experience with easements by the U.S. Park Service and others indicates that substantial difficulties can arise where misunderstandings about easement restrictions exist (Coughlin and Plaut 1978). This highlights the importance of educating landowners concerning easement restrictions both at initial time of donation and during subsequent sale or transfer of the land. The jurisdiction accepting the easement should also ensure that certain positive rights of entry are included, so as to facilitate public inspection and ensure compliance with easement provisions. Administrative processes need to be devised to detect these violations at an early point.

d) Transfer of development rights. One potentially effective approach to reducing the amount of property at-risk is to permit the transfer of development rights from a high storm hazard zone to a non-hazard or "safe" zone in another part of the jurisdiction (see generally Carmichael 1974; Costonis 1973; Rose 1975). Such a system could either be voluntary or mandatory. Under the latter, a locality would simply zone the storm hazard area so that fewer units of development are allowed (or prohibit new development entirely), and the owner of land within this zone would then be permitted to transfer all or some of this unused development density to parcels in designated safe areas or to sell these on the open market to others who own land in areas designated for development. The locality would then permit increased levels of development in the "safe" zone as a result of possessing extra development rights; thus a natural market for the transfer of these rights is created. A voluntary approach would simply present this transfer as an additional option for the landowner -- a way of maintaining the land in its undeveloped use if the landowner wishes. The landowner in this

case would still have the option of developing his land or selling it for development purchases.

A number of practical issues must be considered in using the TDR approach. First, there are several alternative institutional approaches to operating such a program. On the other hand, the transfer of development rights can be left entirely to market dynamics, with the locality involved only in designating "sending" and "receiving" zones and determining the number of rights to be allocated. Whether a selling landowner receives a fair price for his rights will depend simply on what the market will provide. While there are decisions which must be made in the initial allocation of rights, the locality adopts essentially a "hands-off" stance once the system is created. An alternative institutional structure would have the jurisdiction play a more direct and active role in the development rights transaction itself, perhaps serving as a broker -- buying and selling rights as needed. This in turn helps to ensure that an adequate price is obtained (e.g., overcoming short-term market oscillations). While the latter approach would permit greater control over the price and quantity of rights sold, it would also require greater government expense and oversight. An intermediate position might permit the local government to enter the market at occasional critical points, e.g., to stabilize prices, etc., yet leaving transactions, by and large, to the dynamics of the local market.

An initial difficulty is devising a methodology for assigning rights. They might be allocated, for instance, strictly according to acreage (e.g., one right per acre), or according to the market value of the property (i.e., the greater the value of property the more rights assigned). Eventually at some point in the future the question will arise as to whether additional rights should be allocated. If this is considered appropriate, a practical

and fair procedure for allocating these additional subsequent rights must be devised.

The locality must also decide how rights transferred from hurricane-prone sites can be used. If a developer purchases ten development rights from land in a high hazards area, and seeks to apply these in a non-hazardous (or less-hazardous) receiving zone, what will this entitle him to? Each additional development right, for example, might translate into a certain amount of additional floorspace (e.g., square footage) allowed in the receiving zone. In the case of residential development, these additions may be measured in terms of additional dwelling units, bedrooms, etc.

The transfer of development rights can also be viewed as a form of compensation when restrictions are placed on development in storm hazard areas. For instance, although an oceanfront landowner may be prevented from developing his land (i.e., it is now zoned for open space or recreational uses), he may be able to realize a portion of this development potential by transferring (or selling to those who will transfer) his allocated development rights to areas of the jurisdiction less susceptible to storm hazards. Viewing TDR primarily as a form of compensation raises several questions: key among them is the extent of compensation deemed to be desirable or equitable. At what point will the market value of a development right be unacceptably low as a form of compensation? If full or substantial compensation is a goal, this may require a more active role for government in the development rights market, say, by entering the market to buy rights at times when demand is low.

A large-scale TDR program requires extensive information and knowledge about local market conditions and land development trends, and this can represent a major limitation. How large, for example, should the receiving zone be (by how much should the locality raise permissible densities?) to

ensure an adequate demand for development rights? How readily will landowners in sending zones sell their development rights and when? One reasonable approach to these empirical limitations is to develop a modest TDR program, at least initially, with relatively small receiving and sending zones which can be monitored closely over time.

A number of illustrations of the use of TDR can be cited. It has been used extensively in protecting urban landmarks (e.g. Costonis 1974). Perhaps one of the better known applications is that of Buckingham Township, in Bucks County, Pennsylvania, a suburb of Philadelphia. Here the TDR concept was coupled with performance zoning. The Township was initially divided into two major districts: 1) a development district, designed to accommodate some 20 years of future growth; and 2) a rural district. The development zone was further divided into more specific use and density zones, and the rural district was divided into agricultural and resource protection zones. The TDR program here is entirely voluntary. Owners of land in agricultural protection zones are able, if they wish, to transfer unused development rights to development areas. Each landowner has been awarded one right per acre. If, instead of transferring development rights the landowner wishes to develop his land, he can do so but only under stringent performance standards. Landowners might be required, for example, to preserve as much as 90% of the area of the land in permanent open space, under clustering provisions (see Merriam 1978).

Collier County, Florida, is an example of the use of TDR in a coastal setting. Here the intent was the protection of the coastal ecosystem. The county has placed more than 80% of its land area in what is called a Special Treatment (ST) zone, where a permit is required for development (including portions of barrier islands). The County will issue a permit, however, only

in instances where development will not cause "significant environmental damage." If the County finds that such damage will occur and thus prohibits development, or if the landowner simply wishes to leave his land in an undeveloped state, he may transfer unused development rights to areas outside of the Special Treatment zone. As of 1979, some 40,000 acres of land had been included in ST zones, and 374 residential units had been transferred to less environmentally-sensitive areas (e.g., see Spagna 1979).

Two Maryland localities have also recently initiated TDR programs: Montgomery and Calvert counties. Montgomery operates a development rights bank, while Calvert County operates an "unfettered" program in which development rights are transferred on an open market. Calvert does provide assistance, however, in matching-up prospective buyers and sellers. Both programs are designed primarily to protect local farmland. In the case of Calvert County, development rights transfer is available only for parcels located either in a voluntarily-created "agricultural presentation district," or a "designated agricultural area" identified by the county. Landowners within these areas are generally allotted one development right per acre, although development rights are subtracted for existing residences and additional rights are allocated for existing lots of record. Owners of land within transfer zones can increase their allowable densities by one single family residential building lot for each five development rights purchased. Increased density may not exceed one dwelling unit per acre and in most cases one dwelling unit per two and one-half acres. If a landowner who has already sold his development rights wishes to subdivide a lot for a family member he may do so by purchasing five development rights from other landowners in the district. However, this lot may not be smaller than 25 acres.

The City of Hollywood, Florida, recently enacted a TDR program to encourage the preservation of one of its few remaining undeveloped oceanfronts. The program downzoned this oceanfront area from high density condominium and hotel uses to relatively low density residential uses, permitting the developer either to develop at these reduced densities or to transfer development rights to an inland area where increased development could be permitted. In exchange the developer would agree to dedicate the beachfront areas to the city to be put to open space and recreational uses. More specifically, the city's program established two zones (within the North Beach Development District): a Development zone and a control zone, with an unpaved roadway separating the two.

The owners of the downzoned land -- unsatisfied with either development option -- sued the city, and won at the district level. On Appellate, however, the district opinion was overturned and city's ordinance vindicated. In the Appellate decision, the legality of using TDR is strongly supported. The appellate opinion employs criteria established in the premiere federal case on TDR: Penn Central Transportation Co. v. City of New York (438 U.S. 104, 98 S. Ct. 2646, 57 L. Ed. 2d 631 (1978)). The three factors or criteria taken into consideration in this case are: "1) the character of the government action involved; 2) whether the land use restriction or real property may be held to constitute a taking if it is not reasonably related to a valid public purchase, and 3) the economic impact of the regulation..." The court concludes,

"Applying these three criteria to the case at hand, we have already found the government action to be proper and reasonably related to a valid public purpose. As to the economic impact of the transfer, it involves the loss of the right to build 79 single family units vis-a-vis the gain of 368 more multi-family units on adjoining land, both parcels already owned by the

developer. We cannot quarrel with the economics of that exchange especially when the value of all the multi-family units will be enhanced because the buildings will have an uninterrupted oceanfront position and view." (p.11).

3. Taxation and Fiscal Policies

The specific provisions included in this broad mitigative category are designed primarily to affect indirectly the use of hazardous parcels and the quantity and type of development to occur in storm hazard zones. In contrast to the public acquisiton of storm-prone lands, a taxation policy might seek to reduce development by decreasing the holding costs of open space and vacant land, in turn reducing the opportunity costs of not developing such lands for more intensive uses. While the broad category of taxation and fiscal policy can entail numerous specific tools and mechanisms, primary attention in this paper is given to differential property taxation and special assessments and impact fees.

a) Differential taxation. The use of differential taxation is based on the theory that by reducing the property tax burden on undeveloped parcels of land, this will decrease their holding costs and increase the profitability of their current uses, and in turn their ability to resist pressures to convert to more intensive uses. Almost every state now has a provision for some form of differential assessment (Coughlin and Keene 1981; Keene et al. 1976). The uses which are typically eligible for such reductions are farm and forestland, open space and recreational uses. These are all uses which could occur in coastal high hazard areas and which could in turn reduce the amount of property and people exposed to the storm threat.

Three basic variations of differential assessment are currently in use: 1) pure preferential assessment; 2) deferred taxation; and 3) restrictive

agreements (see Keene et al. 1976). Under the first type of program, preferred land uses are assessed for local property tax purposes not at their fair market value (i.e., the potential development value) but rather at their value in their current uses. If the land is in farmland, for instance, it is assessed according to its value in this use (usually based on a state-determined capitalization formula). If the benefitting landowner decides after several years of receiving this lower assessment that he wishes to develop his land, he is still permitted to do so, without having to repay the property taxes foregone as a result of this lower assessment. In contrast to this pure approach is that of deferred taxation. The difference here is that the landowner changing the use of his land is required to repay a portion of the tax benefits he has received. This recapture period is, however, not typically very long, with five years perhaps average. In addition, most states using this approach require the landowner to pay interest on these recaptured funds (although usually at a below market rate). A third approach, the use of restrictive agreements, is best exemplified by California's Williamson Act (see Gustafson and Wallace 1975). Here, in order for qualifying landowners to obtain lower tax assessments, they must be willing to enter into written agreements to keep their land in its current use for a minimum period of ten years. This contract is a "rolling-front" agreement which is self-renewing each year unless the landowner explicitly notifies the locality of an intention to change the use. There are also provisions which permit the landowner to break his contract subject to certain penalties (see Coughlin et al. 1977).

While differential taxation has been used in most states as a technique to preserve farmland, its effectiveness at retaining land in undeveloped uses is generally found to be low (see, for instance, Keene et al. 1976; Coughlin

et al. 1977, 1981). Preferential assessment may indeed reduce holding costs somewhat or even substantially, but in the face of high market prices, and thus high opportunity costs of maintaining land in open space, the pressures to develop will generally far outweigh these incentives (e.g., Dressler 1979; Duncan 1984). Consequently, differential assessment is likely to be most successful in circumstances (perhaps specific locations in the jurisdiction) where development pressures are slight-to-moderate, and where landowners are actively interested in maintaining the present undeveloped use of the land.

Differential assessment will also be a more effective tool at reducing development of hazardous sites when used in collaboration with other approaches, such as the regulation of new development, the fee-simple purchase of land, and the transfer of development rights. For instance, reducing the permissible development density in a hazard location together with preferential assessment may reduce opportunity costs to the landowner enough to reduce actual conversion of hazard lands to developed uses.

To maximize the effects of these tax benefits, a locality should consider establishing mechanisms for funneling these benefits to those lands with the greatest hazard-reduction potential. This might entail, for example, the reduction of local assessments/rates of taxation in excess of what is provided under normal differential assessment provisions. This would provide greater tax benefits for parcels of open space, forestland, etc., which are designated as particularly hurricane-prone. Such additional tax benefits would be directly tied to the zones delineated on hazard boundary maps. Obviously, this approach would reduce local tax revenues, and thus in turn cost a jurisdiction more than the typical differential assessment program would. The extent of this cost would depend, of course, on the degree of property tax reduction deemed necessary to retard the conversion of hazardous

parcels. Moreover, providing these additional tax benefits will raise significant questions concerning whether the community has legal authority for such a program. If this is viewed as a desirable policy direction it may be necessary to seek state enabling legislation.

b) Special assessments and impact fees. Building in, and inhabiting, high hazard areas often involves substantially greater public costs than in similar less-hazardous sites. These costs are seen when a hurricane or coastal storm strikes, or even threatens, a locality. As we have already mentioned, there are, for instance, public costs of evacuation, search and rescue, temporary housing, the reconstruction of public facilities such as roads, utilities, water and sewer lines, and so on. One public policy approach is to acknowledge that such additional public expenses will exist as a result of permitting this development to occur and to attempt to assess those who will ultimately benefit from these expenditures. This can be accomplished through several means.

One approach is to attempt to tie more closely benefits received and costs incurred through the use of special benefit assessments. A common example is a special assessment charged to property owners benefiting from the public installation of curbs and gutters or the improvement of roads, drainage, and sewer and water services. Such assessments are typically tied to a geographically-delineated district in which property owners are generally determined to receive a distinct and substantial benefit in excess of the general benefits received by the public at large (Hagman and Misczynski 1978). Applying this concept to storm hazard management, a locality would thus be required to delineate an area in which "special storm services" are provided, and in which residents would be subject to the special assessment.

This approach raises a number of issues. The first is how the extent or magnitude of the special assessment is determined and justified. This may require a number of assumptions, and rather rough estimates, about the public costs associated with an actual or potential hurricane. The magnitude of these costs will, of course, depend on the assumed size and severity of the storm event, among other things. The special assessment required to cover the expenses associated with a Category 5 hurricane (on the Saffir/Simpson Scale) will be substantially greater than those associated with a Category 1 storm. The actual delineation of a special assessment district is dependent on these assumptions as well.

An additional question has to do with the manner in which this assessment will be levied. A traditional approach is the use of an ad valorem property tax, in which the size of the levy for an individual property owner is a function of the market value of land and property. This is sensible from the perspective of ability-to-pay as well as the fact that it seems intuitively fair that those who have the greatest property at risk ought to be required to contribute the most. An alternative basis is to assess an equal amount for each home or dwelling unit (or other similar units). The locality must decide the most equitable approach.

A variation on this theme is the impact fee. Here the levy may be designed to recoup and mitigate the overall "impacts" of a project or development on the community at-large -- impacts that may extend beyond the immediate environs and requirements of a project or development. For instance, while a special assessment may be levied to cover the immediate costs associated with the floodproofing of sewer and water service, an impact fee might assess broader and perhaps more diffuse consequences, less clearly related to services or benefits received directly by a specific site or

development. Rather, it is less an issue of direct and visible benefits received, so much as the negative impacts on the locality created by the developer or landowner which must be mitigated. For example, the jurisdiction might levy an impact fee according to the extent to which a new project further reduces the overall ability of the locality to evacuate in the event of a hurricane. While it may not be designed to cover the costs of a specific improvement or set or improvements by which the particular development will benefit in a unique and special way, it is designed to require the developer (and presumably future residents who purchase these properties) to compensate the public for the costs of these consequences.

Unlike a special tax assessment and accompanying tax district, there may be greater freedom in how and in which areas of the locality the proceeds are used. Under an impact fee scheme, it may be possible for the jurisdiction to use proceeds to improve hurricane evacuation or to provide additional hurricane shelters in parts of the locality quite distant from the development the impact fee is levied upon. The impact fee proceeds might, for example, be used to purchase hazardous land, which would in turn reduce overall local risk, but which only indirectly benefits the contributing project or developer.

The impact fee may be instituted as a separate instrument, or more typically attached to the exactions process during development review and approval (Hagman and Misczynski 1978). The impact fee also usually represents a way of getting around legislative and court-imposed limitations on the extent of exactions permissible (e.g., for the installation of roads, sewers and other facilities, and the donation of open space, school sites, and other land) (Stroud 1978).

How the impact fee is assessed is an important question. Commonly considered approaches are to assess the tax according to the number of bedrooms, number of dwelling units, or square footage involved. Which of these is closer as a proxy for impact will depend on the types of these local impacts the tax is meant to address, and the primary kinds of new development it will be imposed upon. If new commercial development is considered as "impacting" as residential development is, a fee based on number of bedrooms will be inappropriate. On the other hand, if the primary concern is evacuation-ability, it may be an appropriate gauge. On the other hand, if public emergency services and reconstruction/recovery expenditures are the concerns, the total amount or value of property at risk may be the most suitable indicator.

The impact fee in its ability to construct a formal system or procedure for calculating and assessing impacts may present a greater level of certainty for the developer than is the case under the exaction process, which may tend to be highly negotiated. Adjusting the expectations of the development community and creating a relatively clear and consistent set of public storm safety obligations on their part may be an important local objective.

4. Capital Facilities Policy

Coastal development -- its type, location, density and timing -- is highly influenced by capital facilities such as roads, sewer and water services. Such public investments have been aptly called the "growth shapers." In this section we will briefly review the potential role to be played by the location, type and timing of capital facilities in reducing local storm hazards. Issues relating to the financing of these facilities have been discussed in a general way in the taxation and financial incentives section of this paper. The use of particular pricing policies may also

significantly affect patterns of development, but this strategy is not discussed here (see Downing 1975).

Two primary dimensions to capital facilities emerge which have implications for local storm hazard mitigation: one is geographical (where capital facilities are placed), and the other temporal (when these are placed there) (see Nugent 1976). With respect to the first dimension, a locality can develop an explicit set of capital facilities extension policies designed to avoid high hazard areas, thus reducing the amount of development and property which is placed at risk and reducing the potential threats to personal safety. This will only become an effective deterrent, however, if development in high hazard areas is dependent upon -- or deems as highly attractive -- the existence of these public facilities. For instance, if coastal development is able to obtain water through individual site wells and dispose of wastewater through septic tanks, a reorienting of sewer and water facilities by the locality will do little to impede growth in hazardous zones. It may be necessary for the locality to foreclose other service/facility options available to development by restricting the issuance of septic tank permits, for example. Without valid health reasons, foreclosing such alternative options for development may be legally difficult. It is advisable that the jurisdiction closely coordinate its environmental protection, health, and other community objectives with those of reducing storm hazards. Restricting the depletion of coastal groundwater supplies, for instance, may also serve to advance the effectiveness of capital facilities policy at reducing the number of people and property at risk in high storm hazard areas.

Redirecting capital facilities, and thus the development which accompanies them, into "safer" areas of the locality can be facilitated through several means. One is the clear delineation of an urban service area

or district in which the jurisdiction agrees to provide certain facilities and services. This district would also likely entail a temporal dimension, for example including sufficient land to accommodate ten or twenty years of future growth, under certain assumptions (e.g., alternative densities). Such a practice has several advantages. It provides a long-term perspective on growth and development and permits developers, residents, and the locality generally to visualize where and when such facilities will become available in the future (and in turn where they cannot be expected). This, in effect, modifies long-term expectations about where future development will and will not be acceptable to the community. Development pressures may tend to shift naturally as a result of this public designation, as developers, landowners and others realize that certain facilities will not become available outside of these designated areas. The provision and availability of facilities may determine the amount of overall development that can take place in a locality, and suspicions of "no growth" objectives are often held. Designation of a service area in "safer" parts of the locality and a good faith effort to satisfy growth demands here will tend to enhance the political and legal acceptablility of such an approach.

In perhaps more intermediate terms, the locality needs a policy instrument by which to systematically identify, finance, and sequence specific capital improvements. This is typically the function of a capital improvements program (CIP). Ideally, the CIP follows closely designated service boundaries, as well as the comprehensive plan, zoning and other regulatory and planning provisions. The CIP provides a specific framework for making short-term (i.e., each year) decisions about which improvements to make and where. Avoidance of storm hazard areas can be incorporated into this instrument and decision framework, as a specific CIP policy.

A close connection between the designation of service areas and the capital improvement program, and the overall planning process in a jurisdiction (including the local comprehensive plan), is essential. Such a close link will tend to enhance their effectiveness in advancing overall local objectives, and their legal fortitude. From a practical standpoint, the concept of guiding growth through capital facilities should be closely linked to the objective of reducing the public costs of such facilities and the extent of public investment at risk in high storm hazard areas. The latter is, by itself, a legitimate argument for denying facility extension. This is a facility-related reason which is likely to enhance the legal standing of hazard-sensitive capital facilities extension policy (Nugent 1976).

A number of localities have been able to more effectively tie the provision and planning of capital facilities to desired local development patterns and objectives. A highly touted example is the case of Ramapo, N.Y., which established a six-year capital improvement program identifying improvement priorities and specific projects to te undertaken each year (e.g., see Godschalk et al. 1979). This was buttressed by a long-range capital plan identifying the location and sequence of capital facilities in the twelve years following the short-term CIP. At the end of this 10-year period it was anticipated that the entire town would have access to public facilities. The town tied the location and timing of development with capital improvements planning by requiring proposed residential development to obtain a special permit, contingent upon the availability of certain minimum public facilites. Developers were required to obtain at least 15 points on a point system designed to evaluate a parcel's access to these facilities. Five types of facilities contributed to the points assigned: sewers, drainage, parks and recreation (including school sites), roads, and

fire protection. If a parcel did not amass the necessary points it would not be approved for development, unless the developer agreed to finance the needed improvements himself. This system has withstood a takings challenge because of the "temporary" nature of the development restrictions. While a constructive approach to managing growth, the Ramapo System has in recent years came under fire for failing to live up to its promises.

Several recent hurricane hazard mitigation planning efforts illustrate the potential role of capital facilities in guiding growth into less hazardous areas. The recent Surf City, North Carolina, hurricane hazard mitigation plan suggests the use of sewer service as a way to avert growth to less hazardous areas of the locality.

"The Town should actively encourage development in the southern section of the town. Specifically, it is the area where future higher density development should be concentrated. Additionally, if an actual sewer system is developed in the near future, it should be designed to serve these areas rather than another section of the community where development in hazard areas would be encouraged by such a system" (1984, p. 13).

The hurricane hazard mitigation and reconstruction plan for the town of Nags Head contains similar recommendations, particularly in an attempt to discourage future growth in an incipient inlet area.

"In the short term, the Town will explore the possibility of limiting future water service extension in the largely undeveloped area in the Whalebone incipient inlet area. While this does not preclude future growth, it ensures that the town will not be a willing participant in placing property at risk" (1984, p. 57).

Public investments encompass more than sewers and roads and include numerous structures and buildings from town halls to schools to police and

fire stations. Again, it may be possible to locate these investments in areas which are less susceptible to storm forces, in turn serving to reduce the quantity of actual public property at-risk, and discouraging the location of other private development. By locating such structures in particular strategic locations, and by constructing them to certain specifications, it may be possible to use them as storm shelters.

- Relocating or strengthening capital investments after the storm. Opportunities may exist after a storm has occurred to implement these capital facilities objectives. It may be possible, if facilities are sufficiently damaged, that facilities such as public roads and sewers can be rebuilt in areas which are less susceptible to damage from the next storm. Even if such facilities are not relocated, they may be repaired and reconstructed in ways which make them stronger or less susceptible to storm forces. Roads and sewers can be elevated, for instance, and sewer and water lines can be floodproofed.

It may be possible that such facilities can be reconstructed in ways that not only reduce the possibility of their own damage but which reduce other storm-related hazards. As before, the presence of certain public facilities will influence development patterns. If certain facility repairs are not permitted to occur after a storm has hit, this may preclude or discourage the private redevelopment of this area. This technique was used subtly in the BayTown, Texas case. The option of selling out and leaving the Brownwood Subdivision was made much more attractive to homeowners because they were uncertain that sewers and roads would be restored and maintained. As a further example, placing power and telephone lines underground after the storm will ensure safer evacuation when the next storm threatens.

A similar approach might be taken to the rebuilding or reconstruction of damaged public buildings such as town halls and fire stations. If sufficiently damaged, it may be logical to move these structures to safer sites in the locality. After Hurricane Camille, for instance, the Pass Christian Town Hall was rebuilt on higher ground, and consequently much more protected from future storm damages than it would have been if rebuilt in the same location. When structures are not relocated, it may be possible to repair or rebuild them in ways that reduce their susceptibility to future storm damages (e.g., through elevation). It may be desirable, as well, to rebuild these structures in ways which permit their usage as storm shelters.

5. Information Dissemination

Classical economic theory supposes that the more informed consumers are, the more rational and allocatively-efficient their market decisions will be. This implies an additional set of mitigation strategies which aim primarily at supplementing and enlightening individual market decisions regarding the hurricane and storm threat. Several approaches can be taken in this vein.

The first approach is to seek mechanisms and processes which facilitate the effective informing of potential consumers of homes and other buildings of the actual risks associated with their location (e.g., in a high hazard district). This can be done in several ways. It might be required that real estate agents and those selling homes inform prospective buyers about the potential dangers from storm forces. Exactly this approach was proposed in Texas, but was not enacted due to stiff opposition from real estate and development interests (e.g., Texas Coastal and Marine Council 1981). While no other examples of this approach can be cited with respect to storm hazards, this approach has been used in California in an attempt to inform prospective homebuyers of the risks of living near earthquake fault lines (see Palm

1981). Under the Alquist-Priolo Special Studies Zones Act a real estate agent or individual selling property must disclose to the prospective buyer the fact that the property lies in a special studies zone (earthquake fault zone). A recent study (Palm 1981) indicates, however, that such a requirement has had little measurable effect on the market behavior of housing consumers. Among the problems identified are the tendency for homeowners to place a low priority on the earthquake threat, the issuance of the disclosure in the latter stages of a home purchase, a downplaying of the importance of the earthquake hazard zones, and a disclosure vehicle (e.g., a line that simply says "in Alquist-Priolo zone") that conveys little or no real information about the earthquake risk. As Palm observes, "At present, real estate agents are disclosing at the least sensitive time in the sales transaction, and are using methods which convey the least amount of information about special studies zones" (p. 102).

Consequently, if a similar disclosure approach is to be applied to hurricane and storm hazards in an effective way it must learn from the California experience. Namely, the disclosure must be provided early in the sales transaction, preferably during the initial agent-purchaser meeting, and this disclosure must convey real and accurate information about the location and nature of the hazard. Not only should the disclosure form or process be "labeled" in a meaningful way (e.g., the home is in a "storm hazard zone" as opposed to an ambiguous "special studies zone") it must provide a full description of the nature of storm related risks. Strong resistance from the real estate industry in coastal areas can be expected, and efforts to convince them of the utility of such a process may be essential to its success. More "passive" types of hazard disclosure might also be used. Included in this category would be requirements that hazard zone designations be recorded on

deeds and subdivision plats and public signs be erected indicating the boundaries of storm hazard areas (and perhaps the location of past storm damages).

Another approach is to institute programs which attempt to directly educate the housing consumer about storm risks. This might take the form of brochures and other materials distributed to new and prospective residents of the locality, informing them of the nature and location of storm hazards and information about what to look for in a new home or business structure (e.g., elevation and floodproofing). For existing residents, this approach may be one of educating them about actions which can be taken to enhance the integrity of their existing structures (e.g., installing "hurricane clips") and reducing future property damages.

Another approach is to attempt to reduce storm hazards by increasing information on the "supply side." This might take the form of construction practice seminars for coastal builders and developers, introducing both conventional and innovative approaches both to building and designing structures, as well as siting and planning the orientation of buildings in vulnerable locations. This approach was proposed as a primary mitigation strategy following Hurricane Alicia in 1983 (see FEMA 1983). The success of such a strategy, however, depends essentially on the integrity of builders and developers, and those who are conscious of storm threats are probably already planning their projects accordingly. Perhaps the most significant impediment to this type of private sector mitigation is that real estate development is a competitive industry in coastal regions and the incurring of substantial mitigation costs by one developer may place him or her at a competitive disadvantage. This is a major reason, for example, why building codes, subdivision restrictions, zoning ordinances, and other jurisdiction-wide

requirements are to be preferred -- they set general rules for all developers to adhere to and in this sense create a common set of expectations which do not require one developer to be placed at a competitive disadvantage.

VI. Institutional Approaches to Managing Reconstruction After the Storm

While most of the development management techniques described above are equally relevant to post-storm circumstances, there are certain factors which make the post-storm situation unique, and its decision making demands special. The first of these factors is the multiplicity and magnitude of the tasks which must be undertaken in the post-storm context. They range from such immediate concerns as the clearance of debris, the location of adequate water supplies, and the restoration of public utilities, to less immediate questions about redevelopment and reconstruction. An additional factor is that even those activities which are not immediate, do require relatively rapid actions and decisions, and even more rapid analysis and information-gathering, before such decisions can be made. A locality recovering from a hurricane or severe storm should be prepared to effectively manage this process and should have the appropriate institutions and tools available to bring this rational management about. The following sections examine these institutions and tools in a relatively general way. Again, I am concerned primarily with reconstruction, and will say little about how to organize emergency and short-term recovery activities.

A. A Post-Storm Reconstruction Plan

A locality should, to the extent possible, foresee alternative damage scenarios from hurricanes and severe storms and have in place a set of policies or planning instruments which will facilitate post-storm decision making. That is, a substantial portion of the reconstruction decision making

can in this way be undertaken prior to the actual storm event. This will permit a less pressured, and more deliberative set of decisions concerning reconstruction options. This in turn permits a focusing of the energies and attention of governing officials after the disaster on questions of a highly "contingent" nature, which could not be completely foreseen prior to the event -- or which were simply unexpected. The locality should always be prepared to take stock of factors and circumstances that have not been considered (or not considered fully) in pre-storm planning.

B. Redevelopment Plan v. Reconstruction Policies

The actual product of pre-storm reconstruction planning can take several forms. On the one hand the jurisdiction may develop very specific and detailed reconstruction/redevelopment plans, indicating sites and locations which should not be re-developed, areas where changes in uses and activities should occur during redevelopment, where certain capital improvements should take place, and so on. Such a detailed plan would provide a blueprint for reconstruction decisions after the storm. Its primary advantage is that it reduces the deliberation and decision making pressures on local officials after the storm (assuming that local officials generally concur with the substance and content of such plans). One of the disadvantages of such a detailed redevelopment plan is that for it to be accurate it must be updated frequently (i.e., land use circumstances change). A second limitation is seen in the fact that it must make specific assumptions about the extent, location and nature of damages, as well as the political and economic opportunities which may emerge after the storm (e.g., the nature of demands to rebuild, amount of external disaster relief). These are factors which undermine any very precise program or design for reconstruction.

In contrast is the development of a set of general policies concerning reconstruction following the storm. This would provide general guidance to more specific reconstruction decisions. For instance, a reconstruction policy may state that rebuilding shall not occur in areas where homes have been destroyed an average of 50% or more. This policy then, would not attach itself to a particular location or site until after the storm occurred. Such policies would simplify public decisions, but would depend heavily upon contingent factors and an analysis of the relationship between reconstruction and other community objectives. Such an approach has the advantage of being more flexible and sensitive to the numerous contingent factors which will exist in the aftermath of the event. Such a plan or set of policies (whether a detailed redevelopment plan or more general reconstruction policies) should address at least the following issues:

- Identification and mapping of coastal hazards, and identification of high hazard areas (presumably occurring prior to the event), and a process for updating this information following the storm.
- A process for identifying the extent and nature of actual damages from the storm event, by geographical location and zone.
- Identification of instruments and tools that can be applied in the post-storm context to address hazard reduction goals. In the case of a detailed redevelopment plan these mechanisms may be designed to "spring into place" following the event. More general policy plans may simply identify the range of alternatives leaving for post-storm decision makers to choose which are most relevant.
- Identification of redevelopment opportunities (in addition to hazard reduction) that may be present should certain locations, types, and magnitudes of damage result. Again, the extent of detail and advance precision can vary tremendously.
- Description of a post-storm decision-making process by which potential reconstruction decisions are structured and organized in logical fashion, and in which relevant actors and decision makers are brought together to solve reconstruction problems.

C. Institutional Structures and Frameworks

Post storm reconstruction places unique decision-making pressures and requirements on local officials, which in turn require special institutional and decision-making arrangements to cope effectively with them. Several of these specific arrangements are described briefly below. This discussion is meant to be exploratory and not necessarily intended to be recommendations for organizing reconstruction -- rather, possible approaches which may or may not be relevant in particular situations.

1. Post-Storm Damage Assessment

Critical to public decisions concerning redevelopment and reconstruction is a clear understanding of the magnitude, type, and causes of damages from the storm. Moreover, the assessment of local damages must occur quickly. A sensible approach is to prepare for this need by constituting, in advance of the storm, a damage assessment team. Such a team would be organized so as to come into existence immediately following the emergency phase and should be comprised primarily of individuals with appropriate technical expertise. Procedures for estimating and documenting the extent and nature of storm damages should be established in advance of the storm (e.g., damage assessment forms, field guides). Adequate local resources and authority must be invested in this group for an expeditious damage assessment.

More specifically, the damage assessment team might be assigned the following responsibilities (Town of Nags Head, N.C. 1984):

a) to assess the extent and location of storm damage, both to public and private structures and facilities and the natural environment;

b) to document the type and location of storm forces, including the identification of following:

   1) incipient inlet areas

   2) high wave action areas and areas of high erosion;

3) high flooding and overwash zones.

c) from the above information, to determine, to the extent possible, the likely causes of damage (e.g., faulty construction, proximity to an incipient inlet).

The damage assessment team(s) would collect this information and present it to the recovery task force, preferably in graphic form and consistent with the damage area delineation scheme suggested below. The damage team should also be asked to compare the actual damages incurred in the community with the hazard maps available prior to the storm and to adjust the delineation of the hazard areas accordingly.

The precise composition of this damage assessment team will depend upon the resources and expertise available in the locality. It might include some of the following individuals:

- town (county) planning director
- town (county) building inspector
- town (county) engineer
- town (county) tax assessor
- town (county) public works director
- local real estate agents/appraisers
- environmental scientist/individuals familiar with coastal dynamics and processes.

It is important that this group of individuals be appointed as quickly as possible so that they may organize procedures and develop appropriate forms for this assessment function. The assessment team will also serve as an expert advisory group during the period in which specific reconstruction decisions are being made. For instance, in the case of a proposal to prohibit reconstruction in a particular portion of the town, they may be called upon to provide more detailed information about the degree of damages.

Humphries and Johnson (1984) in their storm hazard mitigation plan for Ocean City, Maryland, propose the creation of three different sets of damage assessment teams. An initial damage assessment team is the first in the field, providing initial inspection of damages (to be completed in a couple of hours), and is responsible for determining whether an emergency should be declared, whether a redevelopment moratorium should be enacted, and whether state and federal disaster aid should be requested. The second stage of damage assessment would involve more detailed records of damages and different teams would be organized to assess different types of damages (e.g., private residences, mobile home, etc.). A third team will accompany federal and state damage assessment teams and will assist in the preparation of damage survey reports required for obtaining disaster assistance.

2. Recovery Task Force

The creation of a special task force to deal with the unique issues and problems of reconstruction has occurred in a number of disaster circumstances and is a result of recognition that normal local decision-making capability often needs to be supplemented. Under the North Carolina program coastal localities are required to consider the creation of such a group. For instance, the Onslow County hurricane hazard mitigation and post-disaster reconstruction plan proposes a recovery task force with the following responsibilities; it shall:

"(1) Review the nature of damages, identify and evaluate alternate program approaches for repairs and reconstruction, and formulate recommendations for handling community recovery.

(2) Recommend to the County Commissioners the declaration of a moratorium on repairs and new development.

(3) Set a calendar of milestones for reconstruction tasks.

(4) Initiate orders for repairs to critical utilities and facilities.

(5) Recommend the lifting of a moratorium for "minor" repairs.

(6) Recommend the lifting of a moratorium for "major" repairs to conforming structures.

(7) Evaluate hazards and the effectiveness of mitigation policies and recommend the amendment of policies, if necessary.

(8) Initiate negotiations for relocations and acquisitions of property.

(9) Recommend the lifting of moratorium on "major" repairs (with approved changes to conform).

(10) Participate in federal hazard mitigation planning.

(11) Recommend the lifting of moratorium on new development." (Onslow County 1984)."

Thus a primary function of such a body is to receive and review the damage and other analysis of post-storm circumstances, and to compare these circumstances with mitigation opportunities identified prior to the storm to discern appropriate areas for post-storm change and innovation. Where needed, it can review in a more specific fashion alternative mechanisms for bringing these changes about and go about harnessing internal and external resources for achieving these ends. Essentially, then, a primary function of this group is comparing contingent factors and circumstances (physical, economic, political) with pre-storm mitigation opportunities, to arrive at and implement a set of post-storm changes. Such a task force would also ideally undertake a similar process for non-mitigative local objectives and opportunities. Among these other goals which would be considered during reconstruction decision making might be the following:

1) enhancement of local recreational and open space opportunities; enhancement of public access to beach and ocean;

2) enhancement and restoration of local natural ecosystems;

3) reduction of traffic congestion, noise, and other transportation-related problems;

4) enhancement of the long-term economic vitality of the local commercial and industrial base;

5) others.

The composition of this body also presents a question. Several options exist. One possibility is to assign these responsibilities to a completely new group of individuals, perhaps broad-based in its representation of community interests. This group might be composed of the following:

- one or more elected officials;
- planning director or planning department representative;
- public works official;
- one or more representatives of the business community;
- representatives of adjoining communities.

Such a group would have the advantage of a fresh perspective on development opportunities in the locality as well as perhaps a stronger political base. A major issue in this case is the extent to which this body is directly accountable to the elected governing body or has some degree of independent decision-making authority.

Another option is to assign these responsibilities primarily to the local planning board. Allocating responsibilities to this group would consequently have the advantage of capitalizing on the existing knowledge and expertise of the development process and the actions involved in it. Unlike the creation of a new recovery committee, commissioners would generally not have to be brought up to speed on development issues. Moreover, using the planning board would still serve to release the elected board from many of these decisions (at least at a detailed level of consideration), a highly desirable feature given the number and gravity of decision-making requirements these individuals are tyically faced with in the aftermath of a hurricane.

Another option is simply to place these reconstruction opportunities squarely and completely in the hands of elected officials, with this body serving the function of the task force. This option has the advantage of placing these reconstruction issues and decisions in the hands of those officials who will be ultimately responsible for their ramifications. This often may be more politically expeditious, as well. A major disadvantage is that elected officials are typically faced with myriad and numerous decisions in the storm aftermath, and it may seem appropriate to reduce rather than add to their decision-making responsibilities.

Humphries and Johnson (1984) in their storm mitigation plan for Ocean City propose several different recovery and reconstruction committees to more efficiently address all the necessary issues. A Disaster Recovery Task Force would oversee recovery decision-making and would perform many of the supervisory tasks mentioned above. In addition, a Property Acquisition committee would be established which would have the primary responsibility for identifying and recommending properties for acquisition after the storm. A permitting Task Force would also be formed which would assist in the management of the permit process following a storm. Finally, a Property Owner Notification Committee would be established principally to inform non-resident property owners of damages incurred by the property and post-disaster conditions and requirements imposed by the city.

3. Delineation of Damage and Hazard Zones: The "Triage" Concept

A primary task of the local damage assessment team, in conjunction with the reconstruction task force, is to graphically designate damaged areas in the community by severity level. A three-tiered delineation would function much like a "triage" does in emergency medicine: "major," "moderate," and

"minor" damage areas would be designated, perhaps according to the following damage criteria:

a) major damage areas: where buildings experience damages amounting to 50% or more of their market value;

b) moderate damage areas: where buildings experience damages amounting to over 20% but under 50% of their fair market value;

c) minor damage areas: buildings receiving damages of less than 20% of their fair market value.

These damage cut-off points are largely for illustration and, of course, could be considerably different. The triage suggests that a community prohibit reconstruction in major damage areas (at least in the short term) and permit immediate rebuilding in minor damage areas. The bulk of the task force's immediate attention should be directed to determining whether structures in moderate damage areas ought to be allowed to rebuild and if so under what conditions. In addition, existing designation of local hazard zones (e.g., flood hazard areas) should be reviewed and modified to reflect changes in natural processes and topography and new knowledge gained about these processes. For example, if a new inlet has been created, this should be designated and considered by the task force or governing body when making reconstruction decisions.

The triage damage zone concept, while largely untested, has been incorporated, in one way or another, in a number of local disaster planning programs (e.g., Rogers, Golden, and Halpern 1981; the North Carolina Mitigation and Reconstruction Plans; see Haas et al. 1977 for a general description of this idea).

4. Temporary Reconstruction Moratoria

After the storm a locality may be swamped with requests by individuals to rebuild their structures immediately. Typically the pressure to rebuild is

great and local governments are not prepared to say "no" to such requests. One effective approach to this problem is the immediate declaration of a temporary moratorium on rebuilding. This would provide sufficient time for the local damage assessment team to do its job and the task force to consider appropriate mitigation opportunities. Once the damage assessment is completed, the moratorium can be lifted for minor damage areas. A time limit to the moratorium, such as six months from its initial designation, is probably advisable. As well, the jurisdiction may wish to permit the immediate rebuilding of certain "lifeline" structures and facilities, such as hospitals, regardless of the damage zone they are located in.

5. Taking Advantage of Redevelopment Opportunities

The ease with which opportunities can be capitalized upon in the aftermath of a hurricane will be in large part dependent on the extent and nature of the damages incurred (Ciborowski 1981). That is, if in an impacted area destruction is both widespread in terms of the number of structures affected and the extent of damage for each structure, substantial changes in land use patterns will be more feasible. The greater the variation and mixture of these damages, the less likely are major land use changes during reconstruction. The existence of undamaged or moderately damaged homes and buildings will tend to increase the political resistance to such changes.

The extent and size of this damage area will in turn determine the magnitude of the mitigative opportunities which are feasible. Substantial redirecting of urban settlement patterns away from high storm hazard areas will simply not be possible in circumstances where the damage area is relatively small. However, less ambitious mitigative programs may be more appropriate and feasible in these circumstances (e.g., the purchase of smaller damage sites and their use as open space).

It is important to remember as well that hurricane damages may open up the possibility of changes in land uses which are responsive to various local objectives not directly related to hurricane hazard mitigation. Destruction from a hurricane may provide opportunities to advance these objectives, and the locality should be prepared to act quickly to capitalize upon the circumstances. The recovery task force can serve as the body which oversees and advances this "opportunities-pursuing" process. Again, ideally the reconstruction process should be guided by (in varying degrees of specificity) the reconstruction policies and redevelopment plans developed before the storm hits.

VII. Conclusions

This paper has argued that coastal localities must face up to and adequately plan for future hurricanes or severe storms. It has examined alternative approaches to mitigating storm hazards both in advance of the event and during reconstruction. The use of development management measures has received the bulk of attention and it was argued that such approaches to mitigation should be pursued more aggressively. A variety of development management measures were reviewed and applied to the reduction of storm hazards, from conventional zoning to the public acquisition of undeveloped land. It should be remembered that the economic, political and ecological situation of each coastal locality will be unique and that specific measures should be considered with these factors in mind.

A recurrent theme in this paper is that it is important to place storm hazard reduction in the context of other local development goals and objectives. This observation has several implications. The first is that in storm hazard reduction efforts, the presence of opportunities to advance

other community goals may increase substantially the feasibility of such hazard reduction measures. While it may not be feasible to purchase high hazard parcels solely to reduce the extent of property at-risk, when the locality determines that such lands are also badly needed for open space and recreational uses, these overlapping objectives may together cause such a program to be feasible. Secondly, in the local development management process, the reduction or permission of storm risks must be balanced against other legitimate public goals. For instance, a locality may permit a certain development in a high hazard area if these risks are counter-balanced by other amenities and project features provided by the developer and highly valued by the public.

References

Adler, Steven P. and Edmund F. Jansen. Hill Reestablishment: Retrospective Study of a Relocated New England Town. Prepared for U.S. Army Corps of Engineers Institute for Water Resources, Ft. Belvoir, VA. May, 1978.

Baker, Earl J. "Hurricanes and Coastal Storms: A Resource Paper on Risk Assessment, Warning Response, Non-Structural Damage Mitigation, and Awareness" prepared for NOAA. May 1979.

Beatley, Timothy, David J. Brower, and David R. Godschalk. The Hurricane Hazard: Literature Review and Conceptual Framework. Chapel Hill, NC: Center for Urban and Regional Studies. January, 1984.

Benton, Arthur R., Carolyn A. Clark and Wallace W. Snell. Galveston Island-A Changing Environment, Texas A&M University. January, 1980.

Berke, Philip and Carlton Ruch. "Application of a Computer System for Hurricane Emergency Response and Land Use Planning," Journal of Environmental Management, forthcoming, fall, 1985.

Bosselman, Banta and Callies. The Taking Issue. Washington: Council on Environmental Quality. 1976.

Brower, David J., Lee O. Einsweiler, and Luther Propst. Carrying Capacity Analysis, Town of Nags Head, N.C. Coastal Resources Collaborative, Inc. 1984.

Brower, David J. et al. Development Management in Small Towns. Chicago: APA, Planners Press, 1984.

Burby, Raymond, Steve French and Edward Kaiser. A Conceptual Framework for Evaluating the Effectiveness of Flood Plain Land use Management. Chapel Hill, N.C.: Center for Urban and Regional Studies. April, 1979.

Burchell, Robert (ed.). New Frontiers of Planned Unit Development: A Synthesis of Expert Opinion. New Brunswick, NJ: Rutgers University. 1973.

Burchell, Robert (ed.). Planned Unit Development. Rutgers University: Center for Urban Policy Research. 1972.

Bureau of Governmental Research and Service. Local Government Policies for Urban Development: A Review of the State of the Art. Eugene: University of Oregon. April, 1974.

Carmichael, O.M. "Transferable Development Rights as a Basis for Land use Control." Florida State University Law Review, Vol. 2, pp. 35-107. 1974.

Center for Urban and Regional Studies. Review of State Programs and Policies to Reduce Coastal Storm Hazards. Chapel Hill, N.C.: UNC. 1984. Draft.

Cibrowski, Adolf. "Urban Design and Physical Planning as Tools to Make Cities Safer in Earthquake Prone Areas." Institute of Urban Design and Physical Development. Warsaw Technical University. February, 1981.

City of Sanibel, Florida. Comprehensive Land use Plan. Adopted July, 1976, revised May, 1980.

Clark, John. The Sanibel Report: Formulation of a Comprehensive Plan Based on Natural Systems. Washington, DC: The Conservation Foundation. 1976.

Collier, Courtland et al. Guidelines for Beachfront Construction with Special Reference to the Coastal Construction Setback Line. Florida Sea Grant. 1977.

Conservation Foundation. Flood Hazard Management and Natural Resource Protection. Prepared for FEMA, October, 1980.

Costonis, John. "Development Rights Transfer: An Exploratory Essay," 83 Yale Law Review. 1973.

Costonis, John. Space Adrift: Landmark Preservation and the Market Place. 1974.

Coughlin, Robert and John Keene (eds.). The Protection of Farmland: A Reference Guidebook for State and Local Governments." Washington: USGPO. 1981.

Coughlin, Robert E. and Thomas Plaut. "Less-Than-Fee Acquisition for the Preservation of Open Space: Does it Work?" AIP Journal. October, 1978.

Coughlin, Robert E. et al. Saving the Garden: The Preservation of Farmland and Other Environmentally Valuable Landscapes. Philadelphia, PA: Regional Science Research Institute. 1977.

Dames and Moore. Design and Construction Manual for Residential Buildings in Coastal High Hazard Areas. Washington, DC: HUD. 1981.

David, Elizabeth and Judith Mayer, "Comparing Costs of Alternative Flood Hazard Mitigation Plans: The Case of Soldiers Grove, Wisconsin," Journal of the American Planning Association, Vol. 50, No. 1, Winter 1984, pp. 22-35.

Department of City and Regional Planning. Currituck County Outer Banks Carrying Capacity Study. University of North Carolina at Chapel Hill. June, 1983.

Downing, Donald. "Sewer and Water Pricing and Investment Policies to Implement Urban Growth Policy," Water Resources Bulletin, Vol. 11, No. 2, April 1975.

Dressler, J.H. "Agricultural Land Preservation in California: Time For a New View. Ecological Law Quarterly 8: 303-38. 1979.

Duncan, Myrl E. "Toward a Theory of Broad-based Planning for the Preservation of Aricultural Land," Natural Resources Journal, Vol. 24, pp. 61-135. 1984.

FEMA. Interagency Hazard Mitigation Report. Covering Brazonia, Chambers, Fort Bend, Galveston, Harris and Matagorda Counties. September 1, 1983.

FEMA. Interagency Post-Flood Recovery Progress Report, Denton, Texas. December, 1983.

Fox, G.M. and B.R. Davis. "Density Bonus Zoning to Provide and Moderate Cost Housing," Hastings Cont. L.Q. 3: 1015-71, Fall 1978.

Furuseth, Owen J. and John T. Pierce. Agricultural Land in an Urban Society. American Association of Geographers. 1982.

Godschalk, David R. and David J. Brower. "Mitigation Strategies and Integrated Emergency Management," Public Administration Review, January, 1985.

Godschalk, David R., Francis Parker, and Thomas R. Knoche. Carrying Capacity A Basis for Coastal Planning? Department of City and Regional Planning, University of North Carolina at Chapel Hill. June, 1974.

Godschalk, David R. and Francis H. Parker. "Carrying Capacity: A Key to Environmental Planning?" J. of Soil and Water Conservation 30(4): 160-165, 1975.

Godschalk, David R., David J. Brower et al. Constitutional Issues of Growth Management. Chicago: APA Planners Press. 1979.

Gustafson, Greg and Wallace. "Differential Assessment as Land use Policy," J. of the American Institute of Planners. 1975.

Haas, Eugene, Robert Kates and Martyn Bowden (eds.). Reconstruction Following Disaster. Cambridge, Mass.: MIT Press. 1977.

Hagman, Donald and Dean Misczynski. Windfalls for Wipeouts: Land Value Capture and Compensation. Chicago: ASPO. 1978.

Humphries, Stanley M. and Larry R. Johnston. Reducing the Flood Damage Potential in Ocean City, Maryland. Prepared for the Maryland Department of Natural Resources, April, 1984.

Johnson, William K. Physical and Economic Feasibility of Nonstructural Flood Plain Management Measures. Ft. Belvoir, VA: Institute for Water Resources. March, 1978.

Kamm, Sylvan. Landbanking: Public Policy Alternatives and Dilemmas. Washington, DC: Urban Institute. 1970.

Keene, John et al. Untaxing Open Space. Washington, DC: Council on Environmental Quality. 1976.

Kusler, Jon. A Perspective on Flood Plain Regulations for Flood Plain Management. 1976.

Kusler, Jon. Innovative Local Floodplain Management: A Summary of Local Experience. Boulder, CO: Institute of Behavioral Science. 1982.

Kusler, Jon A. Floodplain Acquisition: Issues and Options in Strengthening Federal Policy. Washington, DC: U.S. Water Resources Council. October, 1979.

Long Island Regional Planning Board. Hurricane Damage Mitigation Plan for the South Shore - Nassau and Suffolk Counties, New York. October, 1984.

Lynch, Lisa. "Potential Inlet Zones on the North Carolina Coast," School of Forestry and Environmental Science, Duke University. December, 1983.

Maine Land and Water Resources Council. Policy Recommendations for Reducing Coastal Storm Damages. Prepared for Governor's Committee on Coastal Development and Conservation. December, 1978.

McElyea, William A., David J. Brower and David R. Godschalk. Before the Storm: Managing Development to Reduce Hurricane Damages. Chapel Hill, NC: Center for Urban and Regional Studies. September, 1982.

Meador, Toni I. "Managing Growth on Florida's Gold Coast: Boca Raton and the Growth Cop," Fla. Environmental and Urban Issues. February, 1979.

Merriam, Dwight. "Making TDR Work," 56 North Carolina Law Review. 1978.

Neumann, Charles et al. Tropical Cyclones of the North Atlantic Ocean, 1871-1980, NOAA. June 1978, revised July, 1981.

Nielson, C.A. "Preservation of Maryland Farmland: A Current Assessment," University of Baltimore Law Review, 3: 429-460. 1979.

Nugent, Michael. "Water and Sewer Extension Policies as a Technique for Guiding Development," Carolina Planning, Vol. 2, Winter, 1976.

Onslow County, N.C. Hurricane Storm Mitigation and Post-Disaster Reconstruction Plans. Prepared by Henry Von Olsen and Associates, Inc. April, 1984.

Palm, Risa. Real Estate Agents and Special Studies Zones Disclosure: The Response of California Home Buyers to Earthquake Hazards Information. Boulder, CO: Institute of Behavioral Science, University of Colorado. 1981.

Parsons, Kermit C. Public Land Acquisition for New Communities and the Control of Urban Growth: Alternative Strategies. Ithaca, NY: Cornell University, Center for Urban Development Research. March, 1973.

Petak, William and Arthur Atkisson. Natural Hazard Risk Assessment and Public Policy. NY: Springer-Verlag. 1982.

Peterson, C.A. and C. McCarthy. "Farmland Preservation by Purchase of Development Rights: The Long Island Experiment." DePaul Law Review, 26: 447-91, Spring, 1977.

Platt, Rutherford. Options to Improve Federal Nonstructural Response to Floods. Washington, DC: U.S. Water Resources Council. December, 1979.

Real Estate Research Corporation. The Costs of Sprawl. Washington, DC: Council on Environmental Quality. 1974.

Rogers, Golder and Halpern. Hurricane Evacuation and Hazard Mitigation Study for Sanibel Florida. November, 1981.

Rose, Jerome. Transfer of Development Rights. New Brunswick, NJ: Center for urban Policy Research, Rutgers University. 1975.

Rose, Jerome G. "The Transfer of Development Rights: A Preview of an Evolving Concept," Real Estate Law Journal, Vol. 3, 1975.

Ruch, Carlton. Hurricane Relocation Planning for Brazoria, Galveston, Harris, Fort Bend and Chambers Counties. College Station, TX: Texas A&M University. June, 1981.

Schneider, Devon M., David R. Godschalk and Norman Axler. The Carrying Capacity Concept as a Planning Tool. PAS Memo, Report 338, 1978.

Simpson, Robert and Herbert Riehl. The Hurricane and Its Impact. Baton Rouge, LA: Louisiana State Univ. 1981.

South Carolina Water Resources Commission. Floodplain Management Program Newsletter, June-July, 1982.

Spagna, Neno J. "Transfer of Developmental Rights: The Collier County Experience," Fla. Environmental and Urban Issues, Vol. VI, No. 3, 1979.

Stone, John R. Hurricane Evacuation Planning: Estimating Evacuation Times for Non-Metropolitan Coastal Communities. Raleigh, NC: UNC Sea Grant, 1982.

Strong, Ann L. Landbanking: European Reality, American Prospect. Baltimore: Johns Hopkins Press. 1979.

Stroud, Nancy. "Impact Taxes: The Opportunity in North Carolina," Carolina Planning, Fall, 1978.

Tampa Bay Regional Planning Council. Tampa Bay Region Hurricane Evacuation Plan. June, 1981.

Texas Coastal and Marine Council. Model Minimum Hurricane Resistant Building Standards for the Texas Gulf Coast. Austin, TX. June, 1981.

Texas Division of Emergency Management. Hazard Mitigation Plan for the Counties on the Upper Texas Coast Affected by Hurricane Alicia. Austin, TX: January, 1984.

Town of Nags Head, N.C. Hurricane Hazard Mitigation and Post-Storm Reconstruction Plan. Prepared by Coastal Resource Collaborative, Inc. 1984.

Town of Surf City, North Carolina. Hurricane Evacuation, Hazard Mitigation and Post-Disaster Reconstruction Plan. Prepared by George Eichler and Associates. 1984.

U.S. Army Corps of Engineers, Lake Ponchartrain, La., and Vicinity Hurricane Protection, Description and Diagram. September, 1980.

U.S. Army Corps of Engineers. Low Cost Shore Protection...A Guide for Local Government Officials. 1981.

U.S. Congress, House Committee on Government Operations. Federal Assistance to States and Communities for Hurricane Preparedness Planning. House Report No. 98-557. 1983.

Whyte, William. The Last Landscape. Garden City, NY: Doubleday. 1968.

Yasso, Warren E., and Elliott M. Hartman. Beach Forms and Coastal Processes. Albany, NY: NY Sea Grant Institute. April, 1976.

Zaneski, Cyril. "Preserving Farmland: County Questions Proposal for Slowing Urban Sprawl," Winston-Salem Journal. January 29, 1984.