for review

POLICY RECOMMENDATIONS FOR REDUCING COASTAL STORM DAMAGES

DECEMBER 1978

A Report to the Governor's Committee on Coastal Development and Conservation

Coastal Zone Management Program

Prepared by the

MAINE LAND AND WATER RESOURCES COUNCIL

Richard Barringer, Chairman
Craig W. Ten Broeck, Executive Secretary

The author, Craig W. Ten Broeck, wishes to thank Dr. Kenneth Fink and Bruce W. Nelson, University of Maine, for contributing information on Maine's beaches and beach processes; Charles Colgan, State Planning Office, for contributing the acquisition economic model and analysis; Rich Rothe, State Planning Office, for contributing analysis of the State's Shoreland Zoning Act and program; Robert Doyle, Maine Geological Survey, for contributing information on beach nourishment; Leslie MacRae, Attorney General's Office, for contributing information on Maine's and other states' laws; and Nancy Ross, Maine Department of Conservation, for providing editorial guidance and organization.

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Coastal storms annually cause damage to structures on Maine's coast, especially on the sand beaches south of Boothbay Harbor. Damages from wave impact and flooding result primarily because structures are located on low-lying and erodable beaches close to storm tides and waves. An average of two storms per year can be expected to cause significant coastal damages. Since sea level is rising, the frequency and intensity of damages can be expected to increase on the beaches during future coastal storms.

Reducing coastal storm damages will require that the State of Maine take an active role in private land use decisions on the sand beaches. Existing state and municipal land use laws were not designed with the objective of reducing coastal storm damages. Therefore, new approaches must be initiated.

Any successful storm damage reduction strategy will have to involve cooperation among federal, state, and local government, affected private parties, and the general public. It will also require widespread understanding of the relationships among beach processes, coastal storms, and human structures.

This report makes the following seven recommendations to reduce future coastal storm damages:

(1) that the Governor issue an Executive Order assigning to the State Planning Office the responsibility for assisting Maine's municipalities with drafting and enactment of Flood Damage Prevention Ordinances, and that the State Planning Office seek federal funding for the staff neces-

sary to carry out the Executive Order;

(2) that the Governor request the Congressional delegation to seek federal funding of Section 1362 of the National Flood Insurance Act that provides funding for public acquisition of certain flood-prone areas of high public interest;

(3) that the jurisdiction of the Alteration of Wetlands Act be extended to regulate building of structures on sand dunes and accreted land; and that the Department of Environmental Protection draft the amendment to the Act and submit it in the Governor's Call for the first regular session of the 109th Legislature;

(4) that upon completion of the Flood Insurance Rate Maps, the State Planning Office review with the responsible municipal officials, each coastal municipality's shoreland zoning ordinance to determine that all undeveloped areas in the 100-year flood zone are designated Resource Protection;

(5) that the Bureau of Parks and Recreation, in conjunction with the Economic Analysis Division of the State Planning Office, assess the feasibility and advisability of acquiring Moody, Hunnewell, Scarborough and Parsons Beaches. It is further recommended that the results of this study be transmitted to the Governor for inclusion in his Call to the second regular session of the 109th Legislature;

(6) that the current Board of Environmental Protection policy of prohibiting new seawall construction, and only allowing for reconstruction of existing seawalls, be continued; and that there be no public support for private seawall construction in Maine;

(7) that a Division of Marine Geology be created in the Maine Geological Survey, and that the Division be responsible for (a) evaluating flood proofing techniques required by the National Flood Insurance Program's Flood Damage Prevention Ordinance, (b) study the feasibility and make recommendations for sand nourishment for certain Maine beaches, and (c) monitor shoreline changes so that this information can be used to advise the Board of Environmental Protection on permits under the Alteration of Wetlands Act, and advise private individuals on shoreline development.

INTRODUCTION

This report recommends measures for reducing coastal storm damage through specific State and municipal government actions. Section I states the problem and identifies the location and impacts of coastal storms. Section II describes the relationships between beach processes, coastal storms, and human structures on the beach. Human structures means residences, commercial and industrial buildings, seawalls, roads and public utilities. Section III poses and defines two questions to be answered in Sections V and VI: (1) Given our current level of knowledge, what are the best measures of reducing coastal storm damages? (2) What additional information is needed to reduce storm damages? Section IV evaluates the available measures of reducing storm damages and recommends how each can be best used. Section V identifies additional information needed to reduce damages and recommends approaches for collecting this information.

Technical information developed as a part of this study is included as Appendices to this report.

SECTION I

STATEMENT OF THE PROBLEM

Recurring coastal storms cause severe damage to Maine's coastal properties and human structures. The geographic location and the exposure of its shorelines subject the State to both hurricanes and "northeasters." Although hurricanes have higher wind velocities than northeasters, their smaller size, faster transit speeds, lower recorded surge heights, and infrequent occurrence (every six years on the average) make them less of a threat. Northeasters last longer, develop larger waves, cause higher water levels, and occur with regularity in late fall, winter, and early spring. The Maine shore receives damage from northeasters once or twice each year.[1]

Two winter storms in 1978 caused 47 million dollars of damage to public and private property along the Maine coast.[2] Although sand beaches constitute only 36 miles or 1% of Maine's shoreline,[3] most of the damage from the 1978 storms occurred on the beaches. The majority of the beaches are south of Boothbay Harbor (see Figure 1).

Maine beaches are subject to damages because they are low-lying relative to storm tides, easily eroded, and extensively developed. Maine's beaches have a total 1,888 acres of sand dunes; 1,168 acres or 62% are developed.[4]

Coastal storm damage to structures results from storm tide flooding, wave impacts, wind blown surf, and beach erosion. Northeast storm tides generally elevate tide levels from one to two feet above daily average levels, but storm "surges" may exceed four feet during particularly strong northeasters. If storm tides coincide with spring tides, water levels may exceed six feet beyond normal high tide levels, allowing storm waves to impact upland areas and structures.

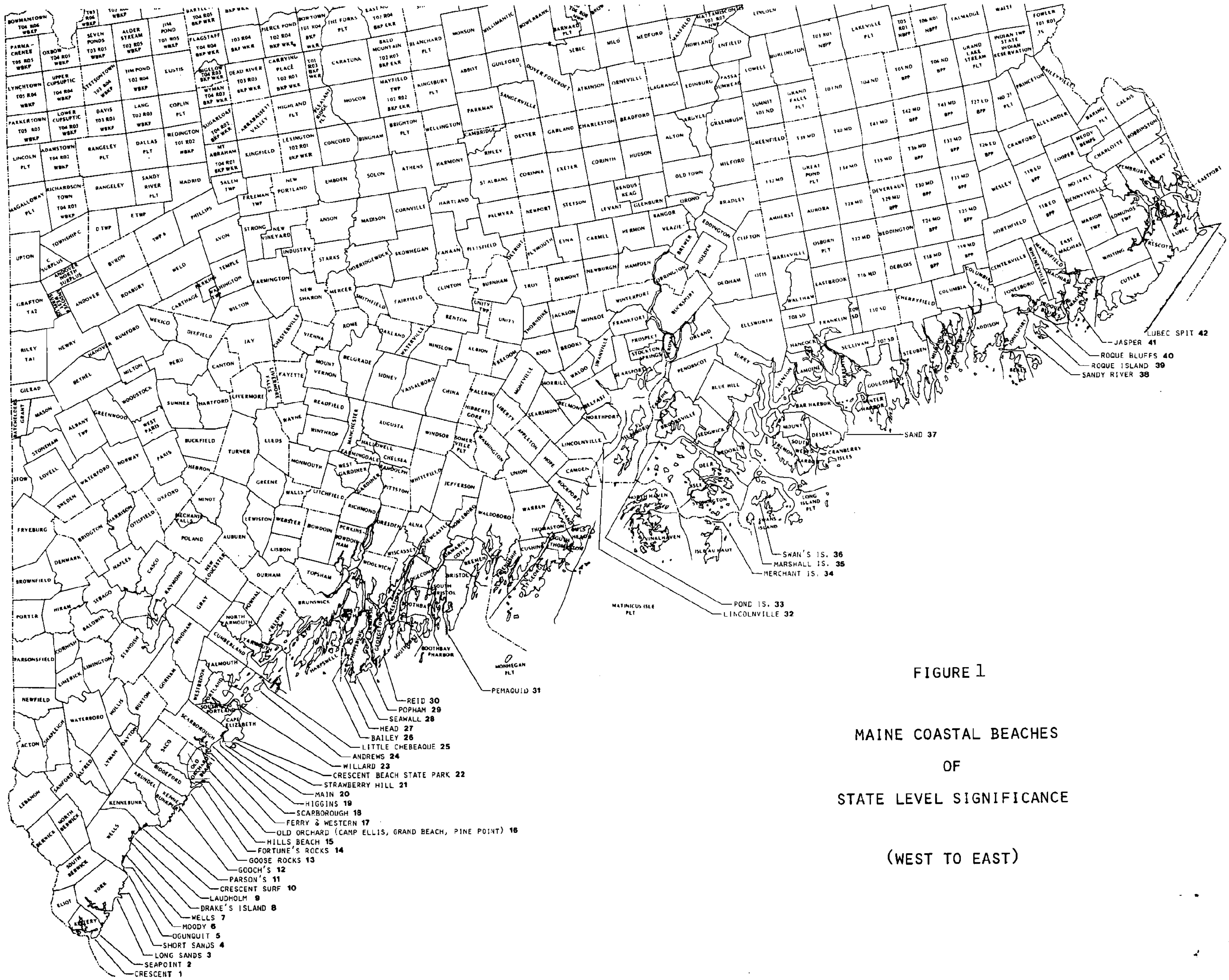


FIGURE 1

MAINE COASTAL BEACHES

OF

STATE LEVEL SIGNIFICANCE

(WEST TO EAST)

In addition, sea level is rising everywhere along the Atlantic coast. In Portland, Maine, the average rate of rise since 1912 has been 0.09 inches per year. Over a 100-year period, this amounts to a sea level rise of 9 inches.[7,9] The sea is constantly encroaching on to the land, subjecting structures to storm effects with greater intensity and frequency.

The rise in sea level and continuing development of Maine's beaches can be expected to cause greater absolute levels of property damage during future coastal storms.

Existing state and municipal laws were not intended or designed to affect private land use decisions to the end of reducing coastal storm damages. If damages are to be reduced, new approaches must be initiated. Any successful storm damage reduction strategy will have to involve cooperation among federal, state, and local government, affected private parties, and the general public. It will also require widespread understanding of the relationships among beach processes, coastal storms, and human structures.

We now turn to a discussion of these relationships.

SECTION II

BEACH PROCESSES, COASTAL STORMS, AND HUMAN STRUCTURES

Sand beaches are unstable and go through annual cycles of erosion and accretion. Coastal storms, in winter and early spring, result in erosion of sand from the beach and dunes. However, lost sand is replaced by wind and waves in summer and early fall when storms are infrequent.

The beach and sand dune system act as a natural storm buffer. In a storm, waves remove sand from the upper more elevated part of the beach and deposit sand on the lower part of the beach. The result is that the beach is flattened (see Figure 2). The flatter the beach, the greater the distance waves can travel. As travel distance is extended, the amount of wave energy remaining to impact the upper part of the beach is lessened.

Sea level is rising, causing encroachment of the sea on to the land. The result is a very gradual movement of the beach and dunes landward and slightly upward.

A few Maine beaches have radically fluctuating shorelines: the Popham Beach shoreline, for example, has fluctuated hundreds of feet between 1858 and 1976 (see Figure 3). On the Hunnewell section of the beach, between 1975 and 1978, 14 homes and one restaurant were destroyed, three homes were moved prior to flood damages, and one home was moved after some damages.

Because Maine's beaches are attractive locations with recreation and other benefits, they have undergone extensive development. Development often involves excavation, bulldozing, and removal of a significant portion of the sand from the upper part of the beach and dunes. When this occurs, the loss of sand reduces the natural storm

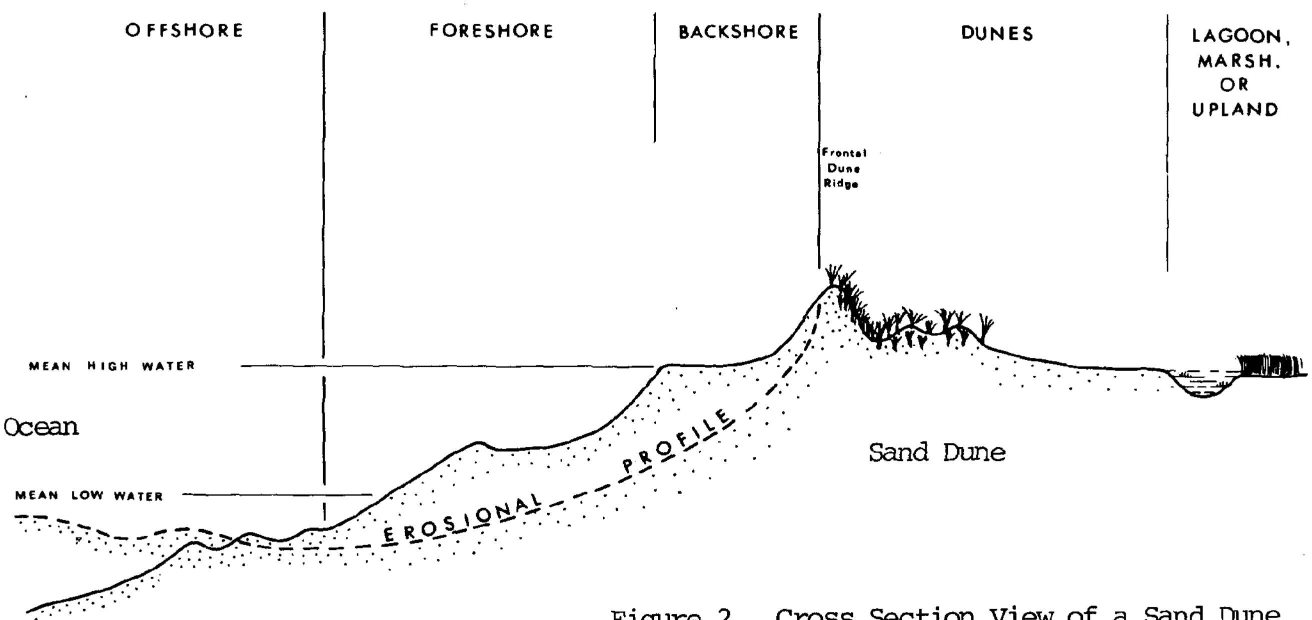
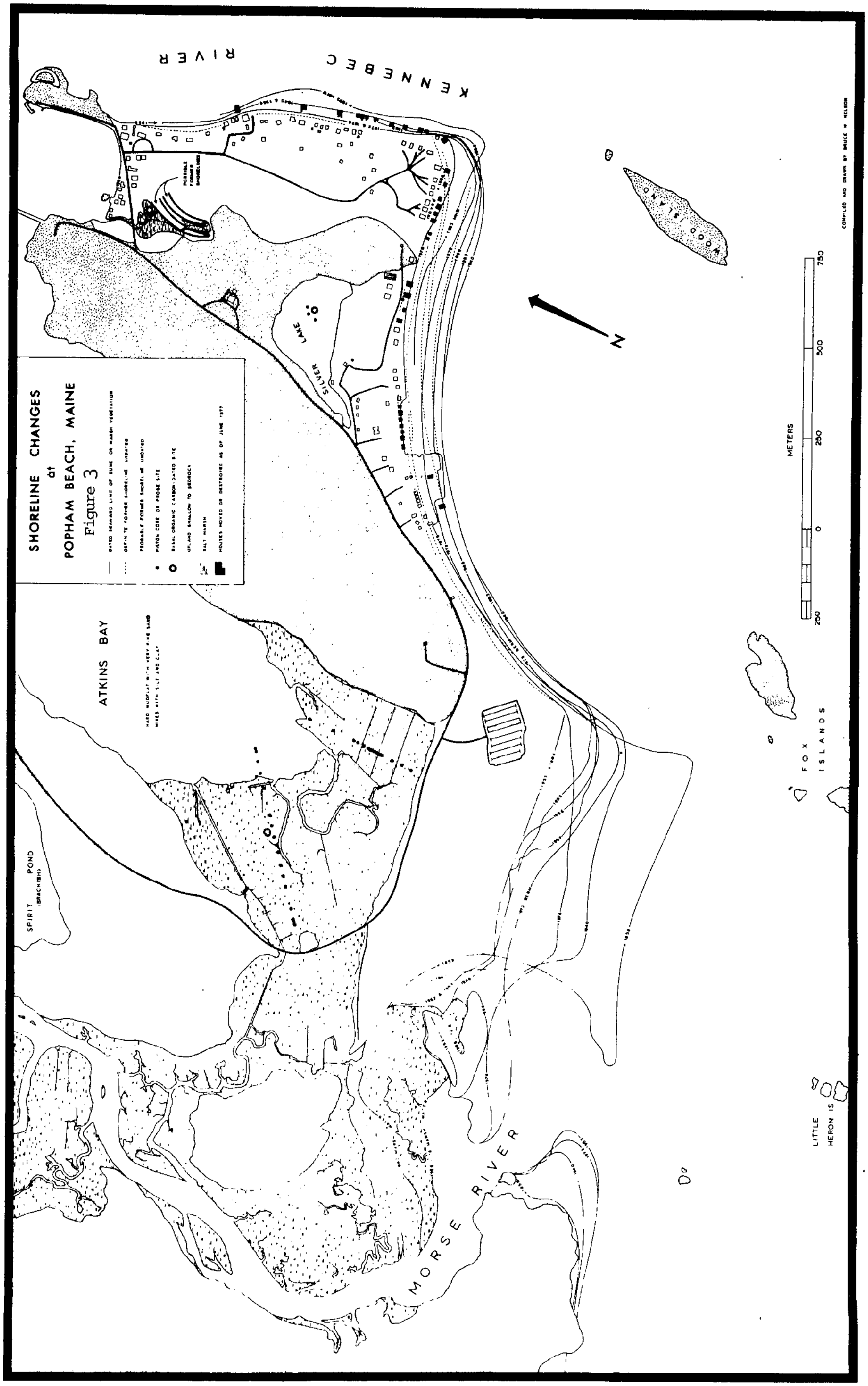


Figure 2 Cross Section View of a Sand Dune


SHORELINE CHANGES
at
POPHAM BEACH, MAINE
Figure 3
DATED SEAWARD LIMIT OF DUNE OR MARSH VEGETATION
DEFINITE FORMER SHORELINE UNDATED
PROBABLE FORMER SHORELINE UNDATED
PISTON CORE OR PROBE SITE
BASAL ORGANIC CARBON-DATED SITE
UPLAND SHALLOW TO BEDROCK
SALT MARSH
HOUSES MOVED OR DESTROYED AS OF JUNE 1977
KENNEBEC RIVER
ATKINS BAY
HARD MUDFLAT WITH VERY FINE SAND MIXED WITH SILT AND CLAY
SILVER LAKE
SPIRIT POND (BRACKISH)
MORSE RIVER
WOOD ISLAND
FOX ISLANDS
LITTLE HERON IS
N
METERS
250 0 250 500 750
COMPILED AND DRAWN BY BRUCE W. NELSON

buffer capacity of the beach. In some cases, seawalls hold sand behind them, making the sand unavailable to replace sand eroded from the beach during storms. Seawalls reflect wave energy back on to the beach, thereby increasing erosion of the beach in front of them. Sand lost to erosion in this manner can move out of the beach's localized sand supply. system or off-shore, becoming unavailable to replenish the beach.

The potential for damages on beaches from coastal storms varies. The more directly oriented the beach toward the storm waves, the greater the impact of the storm on the beach and structures (see Figure 4). Other factors that influence the potential for damages on beaches include: (1) density of structures, (2) protection by seawalls, (3) character of sand, (4) height of the sand dune, (5) volume of sand in the dune, and (6) cross sectional area of the sand dune.

This report categorizes Maine beaches for the purpose of making specific policy recommendations to reduce storm damages. The scheme places beaches in three categories relative to potential for damages from coastal storms (a complete discussion of the categorization scheme is included in Appendix A). The three categories are: (1) beaches with potentially high damage costs, (2) with moderate damage costs, and (3) with low damage costs.

The categorization of Maine's major beaches according to their potential for storm damage costs is shown in Table 1.

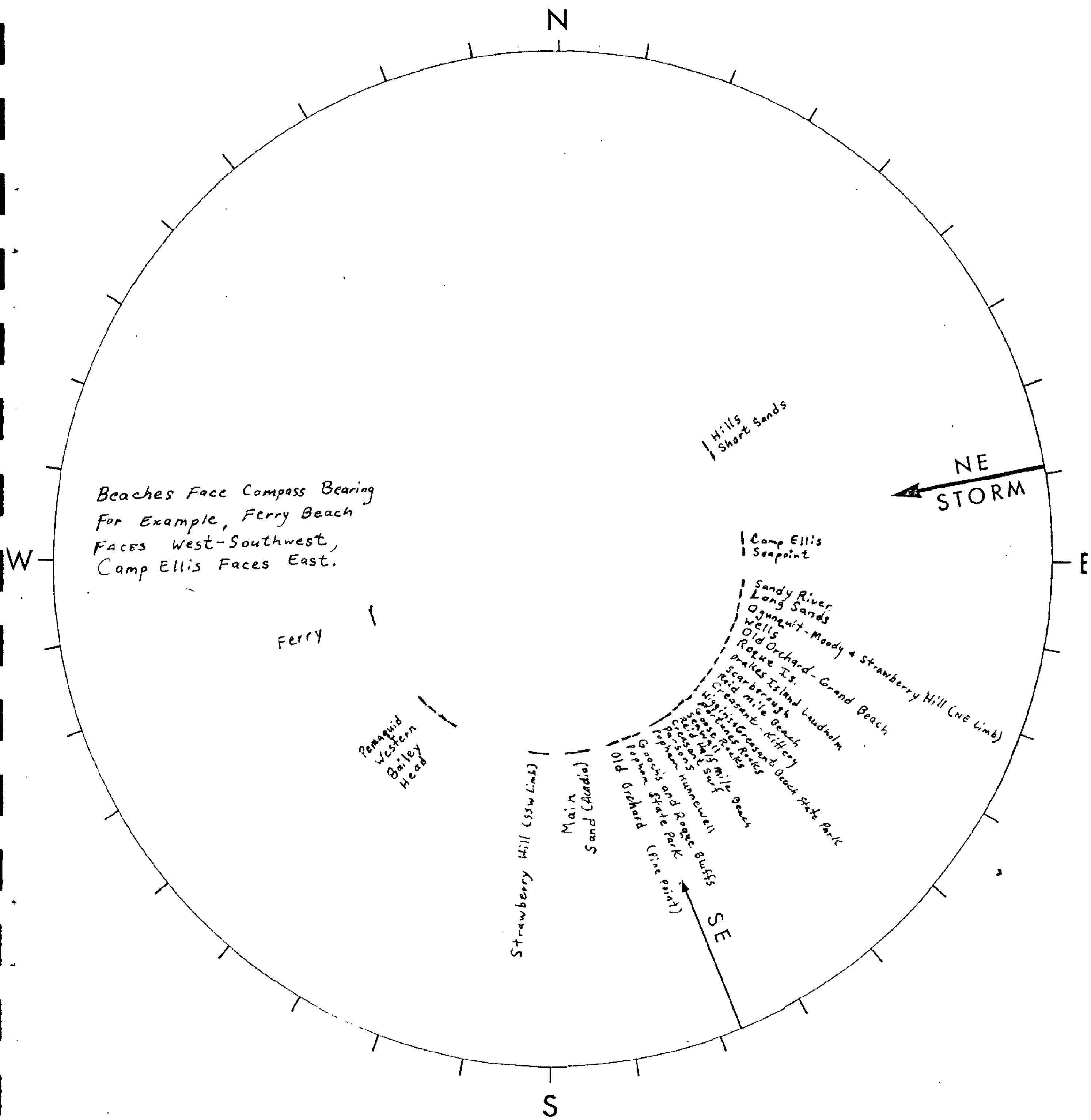


FIGURE 4

Relationship Between NE & SE Storm Average Approach Directions & Beach Orientation

Table I. Beaches' Potential for Storm Damage Costs

Beaches with Potentially High Damage Costs

Long Sands	Fortune's Rocks
Short Sands	Hill's
Moody	Old Orchard-Camp Ellis
Drake's Island	Higgins
Gooch's	Ogunquit
Wells	Popham-Hunnewell

Beaches with Potentially Moderate Damage Costs

Parsons	Old Orchard-Grand Beach Section
Scarborough	Strawberry Hill-Eastern Section
Sandy River	

Beaches with Potentially Low Damage Costs

Laudholm	Head
Western	Pleasant Island
Crescent Beach State Park	Seven Hundred Acre Island
Bailey	Jasper
Seawall	Lubec Spit
Reid State Park	Andrews
Loud's Island Cuspate Foreland	Crescent Surf
Pond Island	Main
Marshall Island	Strawberry Hill-Western Section
Merchant Island-2 beaches	Roque Bluffs
Swan's Island-2 beaches	Pemaquid
Sand Beach	Goose Rocks
Roque Island	Ferry
Crescent-Kittery	Old Orchard Pine Point
Seapoint	Popham State Park Section

SECTION III

MEASURES TO REDUCE COASTAL STORM DAMAGES

The measures available to reduce storm damages are: (1) National Flood Insurance Program; (2) State and Municipal Regulations; (3) Acquisition; (4) Natural Sand Dunes; (5) Beach Sand Nourishment; and (6) Seawalls; we shall discuss each separately.

National Flood Insurance Program: The National Flood Insurance Program provides flood insurance to private individuals who would be unable otherwise to obtain insurance in the private market. The program underwrites, with federal money, private insurance companies' insurance sales to flood plain residents.

The Act requires flood proofing of all new construction (or for reconstruction of 50% damaged structures). Insurance premiums are calculated on a sliding scale and decrease as a structure is elevated relative to the 100 year flood level. Flood levels are established by Flood Insurance Rate Map Studies financed by the federal government. Within six months after completion of the flood level study for a municipality, the municipality must adopt a Flood Damage Prevention Ordinance, and control thereby building activities in the flood hazard zone. If a community fails to enact and enforce a federally approved ordinance, the federal government may, first, deny federally assisted financing such as mortgages, loans, and guarantees to property owners in the flood hazard zone; and, after storm damage, deny federal disaster assistance for permanent restorative work.

State and Municipal Regulations: The state laws which have some impact on development activities in the coastal flood hazard zone are the Mandatory Shoreland Zoning and Subdivision Control Act, the Alteration of Coastal Wetlands Act, the Site Location of Development Law, the Maine Land Use Regulation Law, the Subdivision Law, and Municipal Zoning Authority. Only two of these statutes, the Alteration of Coastal Wetlands Act and the Mandatory Shoreland Zoning and Subdivision Control Act can, or can readily be amended to, control development to reduce coastal storm damages.

1. Alteration of Wetlands Act - The Alteration of Coastal Wetlands Act protects wetlands by requiring that applicants wishing to build any permanent structure, causeway, bridge, marina, wharf, or dock obtain a permit from the Board of Environmental Protection. The jurisdiction of the Act covers all tidal and subtidal lands, including beach areas subject to tidal action or normal storm flooding. The portion of the beach regulated by the Act includes areas below identifiable storm debris lines; however, sand dunes are excluded from coverage under the Act. The Act is not specifically aimed at reducing storm damages.

2. Shoreland Zoning Act - The Shoreland Zoning Act regulates activities within 250 feet of the normal high water mark of any navigable pond, lake, river, or salt water body. The stated purposes of the Act include the maintenance of "safe and healthful conditions", prevention of water pollution, protection of fish and wildlife habitats, and "control of building activities." State imposed or municipally adopted ordinances regulate activities in three districts: (1) Resource Protection, (2) Limited Residential-Recreational, and (3) General Development. Coastal beach areas placed in the Resource Protection District are protected from all permanent residential and commercial development. Development in the Limited Residential-Recreational District and certain types of non-residential and commercial development, when permitted in the Resource Protection District, must be set back 75 feet from mean high water. Structures and uses existing prior to enactment of ordinances are not regulated. Again, the Act is not specifically aimed at reducing storm damages.

Acquisition: Acquisition is the expenditure of public money for purchasing private property in the coastal flood hazard zone, removing the structures, and dedicating the area to public use. Acquisition accomplishes two public purposes: it allows individuals, with the compensation they receive, to relocate outside the coastal flood hazard zone; and it provides recreational opportunities and other values for the general public.

Natural Sand Dunes: Sand dunes often provide an effective natural barrier to storm wave action and flooding. Sand is held on the dunes by dense root mats of beach grass. Storm waves expend their energy eroding the sand. Storm waves can; however, overtop or breach dunes and flood back dune areas. This is the only way sand dunes can be maintained during this period of rising sea level. Structures built behind the dunes are afforded relatively greater protection from wave impact then those located on top of, or seaward of the dunes.

Beach Sand Nourishment: Beach nourishment is the addition of sand to an existing beach in order to widen and heighten the beach. This method of shoreline protection uses the beach and dunes as a natural storm buffer to protect beach fronting structures. The wider and higher the beach, and the greater the volume of sand, the more effective the beach is as a storm buffer. Beach replenishment also can provide a wider, more aesthetic recreation surface.

Seawalls: Seawalls are vertical structures usually constructed in three styles in Maine: (1) poured concrete reinforced with steel rods, (2) loose stone blocks contained by wood cribwork, and (3) placed stone blocks or stone rip-rap. Solid seawalls act to protect structures by reflecting wave energy back on to the beach. Open cribwork and stone block seawalls absorb some wave energy. Seawalls can stabilize the shoreline temporarily stopping the advance of the sea on to the land. They offer varying levels of protection for structures from storm damage depending on their design, location and type of storm.

SECTION IV

ASSESSMENT AND RECOMMENDATIONS OF MEASURES TO REDUCE COASTAL STORM DAMAGES

This report has reached the following conclusions on which the recommendations are based.

* The State is the level of government best able to coordinate the overall management strategy to reduce coastal storm damages. Storm impacts and beach processes have little respect for municipal boundaries.

* Municipal government needs to be directly involved in efforts to reduce coastal storm damages, since it is the level of government with most responsibility for making land use decisions and regulating building in the coastal flood hazard zone.

* The best direction for State actions to reduce coastal storm damages is to support and further the wise public use and conservation of Maine's limited beach resource.

* The most desirable goal of public policies to reduce coastal storm damages is to require flood-proofing of all structures in the "coastal flood hazard zone," which is the beach area subject to the 100-year coastal flood and storm wave impacts.

* Direct expenditure of State funds will be made only in support of actions in the coastal flood hazard zone which have benefits for the general public, such as land acquisition and beach nourishment studies.

Storm damages are due to various natural and human-created conditions and are difficult to control. Action on several fronts will be required to solve the variety of underlying problems and reduce coastal storm damages.

The following discussion of recommended measures is intended to demonstrate, first, how each can reduce storm damages, and, second, what actions need to be taken so that each measure can work effectively. The measures are presented in order of their importance to the State of Maine.

National Flood Insurance Program

How the Program can Reduce Storm Damages

Municipalities participating in the program are required to enact and enforce a flood damage prevention ordinance as strict or stricter than the federal model ordinance. The ordinance applies to the flood hazard zone identified by the Flood Insurance Rate Map Studies. The ordinance for the coastal flood hazard zone requires that all new construction or substantial improvements shall:

(1) have the first habitable floor elevated to or above the 100-year flood level, or, if below the 100-year flood level, then walls must be water tight,

(2) be anchored so as to resist flotation or lateral movement, and,

(3) be certified by a registered professional engineer or architect as meeting the above requirements.

The ordinance requires stricter standards for that portion of the coastal flood hazard zone subject to the impact of the storm waves. All new construction or substantial improvements shall:

(1) be elevated so that the lowest supporting member is located no lower than the 100-year flood elevation, with all space below open so as not to stop the flow of water,

(2) be securely anchored on pilings or columns,

(3) not be built on fill, and

(4) be certified by a registered professional engineer or architect as meeting these requirements.

These are minimum standards that the municipality must impose on individuals undertaking construction. The sliding scale of insurance premiums further encourages individuals to achieve the highest possible elevation economically feasible above the 100-year flood level.

The federal model ordinance also requires that there shall be no alteration of sand dunes which would increase potential flood damage. However, no standards are provided in the model to determine acceptable and unacceptable alterations. The model ordinance also does not prohibit building on accreted land.

The National Flood Insurance Act provides in Section 1362 for the acquisition of certain flood hazard areas, although this section has never been funded by the Congress. This approach might provide for more complete protection from coastal flood damages than any other.

What Actions Need to be Taken

Coastal municipalities must enact a Flood Damage Prevention Ordinance in order to receive federal loans, grants, and direct assistance. The federal model ordinance needs to be tailored to each municipality's situation and resources. A municipality may wish to require stricter standards than those in the model ordinance, to reduce specific coastal storm damage problems. These problems can include protecting specific scenic locations and public facilities from damages which might be caused by private actions. It may be necessary to provide greater protection to private structures in some locations subject to severe wave impacts through more strict design and elevation requirements.

Municipalities without full-time planning staff will need technical assistance in revising the model ordinance to meet their needs. Approximately nine communities along the southern coastal area are in the process of having Flood Insurance Rate Map Studies conducted. It is estimated by the Federal Insurance Administration staff that it will take 4 to 5 years to complete the studies from Kittery to Harpswell.[5] The federal regulations require that each municipality enact a Flood Damage Prevention Ordinance within six months after the studies are completed. The timing is such that State involvement in the program and assistance to municipalities in ordinance drafting and adoption will be appropriate in the immediate future.

This report recommends that the Governor issue an Executive Order assigning to the State Planning Office the responsibility for assisting Maine's municipalities with drafting and enactment of Flood Damage Prevention Ordinances; and that the State Planning Office seek federal funding for the staff necessary to carry out this Executive Order.

Effectiveness of municipal Flood Damage Prevention Ordinances will depend on adequate code enforcement. This study did not explore the need for municipal code enforcement. Based on the State's experience with code enforcement problems under the municipal shoreland zoning ordinances, there is a need for improved code enforcement. (For complete discussion, see Appendix B).

It is, therefore, recommended that the State Planning Office conduct a study of municipal code enforcement needs for Maine's coastal municipalities, and report its recommendations to the second session

State of Maine
Executive Department
State Planning Office
184 State Street, Augusta, 04333

Joseph E. Brennan
GOVERNOR

ALLEN G. PEASE
STATE PLANNING DIRECTOR

TEL. (207) 289-3261

January 12, 1979

Dear Reviewer:

Enclosed you will find a draft report, "Policy Recommendations for Reducing Coastal Storm Damages." This report was prepared for the Governor's Advisory Committee on Coastal Development and Conservation by Craig Ten Broeck, Executive Secretary of the Maine Land and Water Resources Council.

The project was undertaken as a result of a request by Governor Longley, March, 1978, "to prepare a policy report for coastal flood plain management with appropriate recommendations." The Governor noted in his letter that, "recent severe winter storms (last winter) have demonstrated that present land use patterns still expose valuable properties to the hazards produced by the naturally rising sea level, shoreline erosion, and storm driven flooding."

The Committee on Coastal Development and Conservation received the report ~~at its meeting on December 19,~~ and asked that an opportunity be provided for interested people to review and comment on the report.

We are scheduling three public meetings to receive your comments on this report:

February 8, Thursday	February 13, Tuesday	February 15, Thursday
Oblate Fathers' Retreat House	Wells High School	City Council Chambers,
136 State Street, Augusta	Wells, Maine	3rd Fl., City Hall, Bath
1:30 - 4 P.M.	7:30 - 9 P.M.	7:30 - 9 P.M.

If you are unable to attend any of these meetings, please call or send your comments to: Esther Lacognata, Coastal Program Manager, State Planning Office, 189 State Street, Augusta, Maine, 04333 or telephone (207) 289-3154, before February 20th.

The Committee must take action on the report prior to March 12th in order to support legislation in the current session.

Sincerely,

Jean H. Childs

Jean H. Childs, Chairman
Committee on Coastal
Development and Conservation

cc: Coastal Legislators
Coastal Tech Advis Com.
Selectmen & Mgrs, beach towns

of the 109th Legislature. Such a study would examine municipal code enforcement staff needs, costs, and funding sources. A determination of code enforcement requirements for enforcement of the Flood Damage Prevention Ordinances would also be made.

Funding of Section 1362 of the National Flood Insurance Act would provide funds to the State for acquisition of certain property in the coastal flood hazard zone of special public interest. This study recommends that the Governor request the congressional delegation to seek federal funding of Section 1362 of the National Flood Insurance Act.

State and Municipal Regulations

Alteration of Wetlands Act

How The Act can Reduce Storm Damages

The Alteration of Wetlands Act can effectively reduce coastal flood damages only if its jurisdiction is extended to regulate building on sand dunes and accreted land.

As a result of a century of building, Maine's 36 miles of major sand beaches have 14 miles of seawalls fronting the sand dunes, and 62% of the dune area is covered by development.[4] Protection of the remaining 38% of the sand dune area from development will allow the dune system to act as a natural storm buffer.

Maine law grants private individuals ownership of beach land accreting seaward of their properties. Individuals have frequently built on accreted land even though it is usually unstable. Because beach shorelines fluctuate in response to sea level rise and storm tides, structures built on accreted land are subject to rapid undermining through erosion. The fate of structures built on accreted land at Popham Beach illustrates this problem.

What Actions Need to be Taken

Some states, notably Rhode Island and Delaware, have state laws regulating development on their beach and sand dune systems. The Rhode Island Act not only prohibits construction on the State's sand dunes, it also prohibits restoration or substantial improvements to structures on the beach or dunes.

Only one Maine municipality, Scarborough, has a local dunes protection ordinance. The State is the most logical level of government to regulate activities occurring on sand dunes because it has available an existing regulatory review process and enforcement capability. Projects under the jurisdiction of the Alteration of Wetlands Act are reviewed by the Board of Environmental Protection. Conditions in permits granted under the Act are enforced by the Department of Environmental Protection. Field staff of the Department of Marine Resources and Inland Fisheries and Wildlife provide information to potential applicants and also alert the Department of Environmental Protection of violations of the Act.

This report recommends that the jurisdiction of the Alteration of Wetlands Act be extended to regulate building of structures on sand dunes and accreted land. It is recommended that the Department of Environmental Protection draft the amendment to the Act and submit it in the Governor's Call for the first regular session of the 109th Legislature.

Shoreland Zoning Act

How Shoreland Zoning Can Reduce Storm Damages

The State of Maine Shoreland Zoning Guidelines required that municipalities apply the Resource Protection District to all undeveloped areas within the 100-year flood plain. Applying the Resource Protection

District to the undeveloped area in the 100-year coastal flood plain would prohibit all residential and commercial development, thus, reducing the potential for future flood damages. Because of the lack of data for the coastal area, this difficult task has not been carried out heretofore by most municipalities.

What Actions Need to be Taken

The Flood Insurance Rate Map Studies will eventually provide maps to each coastal municipality delineating the 100-year flood plain. This information may then be used to rezone undeveloped areas in the 100-year flood plain to Resource Protection. This study recommends that the State Planning Office review with the responsible municipal officials, each coastal municipality's shoreland zoning ordinance upon completion of its Flood Insurance Rate Maps to determine that all undeveloped areas in the 100-year flood zone are designated as Resource Protection.

Acquisition

How Acquisition Can Reduce Storm Damages

Among the various proposals for reducing coastal storm damage, no measure is likely to be as effective in reducing damages and preserving the beach and dunes as the acquisition of beachfront property and the return of the beach to its natural condition.

Without structures on the beach, there would be no need for federal subsidies, such as Disaster Relief, National Flood Insurance payments, and Small Business Administration loans, to promote the recovery of the area after a coastal storm. Also, municipal expenditure for some services to the acquired beach area could be reduced, since there would be fewer residents in the beach area.

At the same time, no measure will require as great a degree of investment, nor be as fraught with difficulties. The question to be answered is whether or not it is cost beneficial for the State to acquire beachfront property already developed with residences, remove the existing structures, and return the beach to a natural state.

Over and above economic considerations, sound public policy requires that the use of acquisition for the purpose of reducing storm damages meet two criteria: (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 and other values for the citizens of the State. Some beaches, although suffering recurrent storm damage, because of their size, location and accessibility, do not offer significant public recreation opportunities. Some beaches with significant public recreation opportunities do not suffer severe enough storm damages to warrant acquisition. Acquisition is a measure best suited to alleviating the most severe damage problems. For a complete discussion of the acquisition economic model see Appendix C.

What Actions Need to be Taken

Based on this study's categorization of beaches (see Section II), and discussions with Bureau of Parks and Recreation personnel as to beaches with significant recreation opportunities, the following beaches meet both criteria stated above: Moody Beach, Wells; Hunnewell Beach, Phippsburg; Scarborough Beach (southern end), Scarborough; and Parsons Beach, Kennebunk.

This report recommends that the Bureau of Parks and Recreation, in conjunction with the Economic Analysis Division of the State Planning Office, study the feasibility and advisability of acquiring Moody, Hunnewell, Scarborough and Parsons Beaches; and that the results of this study be transmitted to the Governor for inclusion in his call to the second regular session of the 109th Legislature.

Beach Sand Nourishment

How Sand Nourishment can Reduce Storm Damages

Addition of sand to a beach increases the beach's width and height and, therefore, its total sand volume. The greater the volume of sand, the more effective the beach is as a natural storm buffer. Because coastal storms remove sand from the beach, addition of sand is usually necessary as an annual maintenance procedure.

The U. S. Army Corps of Engineers will provide up to 100% of the initial cost of a nourishment project, as well as 75% of the annual maintenance costs, if they determine that the project is cost effective in protecting the area from storm damage and providing public recreation. The Corps of Engineers examined sand nourishment for approximately 50 miles of Delaware's beaches. The initial cost would have been 50 million dollars, with an annual additional maintenance cost of 2 to 3 million dollars for sand replenishment. Delaware did not implement the project because of the high annual cost-to-benefits ratio for the State. In general, sand nourishment limits its use to publicly assisted projects. Only Maine beaches with significant public recreation and high property values to be protected will, therefore, be eligible for the Corp's sand nourishment programs.

The energy dynamics of each beach must be evaluated before nourishment is undertaken to determine if sand will remain on the beach after it is placed there. Sand nourishment may be more successful in Maine then in other areas where it has been considered, because Maine beach systems are often contained between rocky headlands, are shallow offshore, and are, therefore, subject to low wave energy. However, a few Maine beaches, such as Fortunes Rocks, have too much wave energy moving onshore for sand placed there to remain.[6]

What Actions Need to be Taken

According to scientists knowledgeable about beach sand nourishment, it would be worthwhile studying the following Maine beaches:

1. Camp Ellis Beach: This is a 410 meter[7] beach in the Town of Saco, and is the beginning of the Old Orchard Beach System. Camp Ellis has suffered storm damage to structures during recent years. A large quantity of sand in the bars parallel to, and north of the Saco River jetty, could be used to nourish the beach.[6] Nourishment may be necessary on an annual basis to resupply sand lost during winter storms.

2. Ogunquit-Wells Beach: Ogunquit and Wells Beaches in the Town of Wells are 4370 meters[7] in length. Ogunquit is one of the most heavily used recreational beaches in Maine. Ogunquit Beach has undergone some erosion in recent years; the new sewage treatment plant in Ogunquit will need protection from the encroaching shoreline. Wells Beach has more severe erosion problems due to the Wells Harbor jetties which were built in 1962. The sand on Wells Beach is being transported to the north end of the jetties.

3. Surfside Beach (portion of Old Orchard Beach): Surfside Beach is a part of the northern end of the 1850 meter long Old Orchard Beach system.[7] It is rapidly eroding due to the presence of seawalls.[8] The erosion may eventually migrate north and southward causing degradation to the now healthy beach at Old Orchard Village. A study of the beach would address wave patterns, sand movement, impact of seawalls, and closing of the tidal inlet.

4. Higgins Beach: Higgins Beach is a 910 meter[7] long, heavily developed beach in the Town of Scarborough. The beach is a wide, shallow, low energy beach with a lot of sand in the system. The feasibility of dredging the tidal bar at the north end of the beach across to the rocky headland at the south end of the beach, and depositing the sand within an artificially created "fishhook" rock barrier at the south end of the beach would be studied.[6] The result of such activity would be a crenulate bay form headland which would protect the deposited sand from rapid removal by wave action.

5. Popham-Hunnewell Beach: Popham Beach is a 4030 meter[7] beach in the Town of Phippsburg. The Hunnewell portion of the beach was accreting sand from the late 1800's until 1940. The current trend since 1940 has been erosion. Dredging in the Kennebec River channel may have created a sink cutting off sand to Hunnewell Beach. Therefore, sand nourishment could be feasible; however, the costs and benefits will be a primary determinant of the viability of nourishment for the beach.

6. Long Beach and Short Sands Beach: Long Beach is 2180 meters[7] long and Short Sands Beach is 410 meters long, both in the Town of York. Both of these beaches are fine grained, isolated pocket beaches, with an east-northeast orientation, all of which factors make them susceptible to storm damages. Replenished sand might easily be removed during

storms, the replenishment interval is critical to the success of nourishment. The critical factor of the viability of nourishment will be its economic feasibility.

This report recommends that a Division of Marine Geology be established within the Maine Geological Survey, and that the studies identified above be conducted by the Division of Marine Geology; and that the Maine Geological Survey secure funding for the studies from appropriate sources. The Maine Geological Survey has already requested in their FY 80 budget, $48,000 to fund a Division of Marine Geology. It is estimated that approximately $150,000 will be needed for beach process and nourishment studies.[6]

Seawalls

How Seawalls can Reduce Storm Damages

Seawalls can slow the rate of erosion of shorelines, particularly on beaches with low wave energy. The effectiveness of a seawall depends on its size, design, location, and the types of coastal storms to which it is subjected. Since sea level is rising, seawalls can only forestall storm damages for a period of time. Seawalls act as dikes to hold back flood waters. When they are overtopped or broken-up, severe damages are likely to occur.

Publicly funded, massive seawalls are used to protect some low coastal areas of the United States which are subject to severe hurricanes. For example, in Galveston, Texas, the elevation of the city is very low and hurricanes are frequent. The cost of a huge, multi-million dollar, publicly funded seawall is justified to protect large public and private investments: without a seawall, a large portion of the city would suffer frequent and extensive storm damages.

In Maine, most beaches have not served traditionally as the location for towns; our forebears were wise. They are now used predominantly as sites for seasonal homes. Maine beaches have a relatively low amount of private investment compared to the high investment values found at Galveston, Atlantic City in New Jersey, Ocean City in Maryland, Virgina Beach in Virgina and Miami Beach in Florida. The expense of a massive publicly funded seawall might be justified only at Old Orchard Beach. Old Orchard, however, is relatively stable and is not in need of such a seawall at this time.

In Maine, seawalls are built by private individuals to protect single, or in some cases, several structures. Of the 36 miles of major sand beaches in Maine, 14 miles or 38% is seawalled.[4] There are 9 miles of beach (25.5%) which is developed with structures, but which is not seawalled.[4]

The size of Maine's beaches has minimized the level of private investment in their development. Most Maine beaches are thin barriers backed by tidal wetlands. The wetlands are now protected from most filling and all intensive development. Development potential on the thin barrier is limited due to the available space. In addition, the relatively short "beach season" has limited large scale private investments in condominiums, hotels, and other resort structures. Since these factors have limited intensive development, public funding of large-scale seawall construction has not been necessary.

Only one proposed massive, publicly funded seawall has been considered to control storm damages in Maine. The Town of Saco proposed a seawall for the Camp Ellis Beach; however, in a referendum in June of 1978, the seawall was rejected by Saco voters four to one, and in the Camp Ellis portion of Saco, by two to one.

The Maine Board of Environmental Protection has taken the position of prohibiting new seawall construction. However, they allow the rebuilding of existing damaged seawalls. This policy recognizes that once seawalls are constructed, their maintenance is generally imperative if the property investments behind them are to be protected. A trend in many coastal locations has been the reconstruction of damaged seawalls with "bigger and better" seawalls. This trend encourages the construction of additional and improved structures behind the seawall. Once this happens, there is no alternative except to maintain the seawall in order to prevent massive storm damages.

What Actions Need to be Taken

This report recommends no public support for seawall construction in Maine. This report also recommends that the current Board of Environmental Protection Policy of prohibiting new seawall construction, and only allowing for reconstruction of existing seawalls, be continued.

SECTION V

ADDITIONAL INFORMATION NEEDED TO REDUCE STORM DAMAGES

What Information is Needed

The additional information needed to reduce coastal storm damages is:

1. the extent of the 100 year coastal flood zone and, within that zone, the area subject to direct wave impact, so the information may be used by municipalities to regulate the location of development;

2. an evaluation of the performance of flood-proofing techniques on Maine's sand beaches, (as required by the National Flood Insurance Program) so municipalities may incorporate in their Flood Damage Prevention Ordinances the most appropriate techniques; and

3. the rates of shoreline changes for all beaches, so the Maine Geological Survey may advise the Board of Environmental Protection on applications under the Wetlands Act, as well as private individuals wishing to undertake construction in the coastal flood hazard zone.

How the Information Will or May be Acquired

Coastal Flood Zone

The 100 year coastal flood zone and, within that zone, the area subject to direct wave impact, is being identified by the National Flood Insurance Program's Flood Insurance Rate Map Studies. The federal Department of Housing and Urban Development's Federal Insurance Administration is contracting with private firms to map the zones in each of Maine's coastal municipalities. Nine communities are currently being mapped. It will take four or five years for maps to be prepared for all towns from Kittery to Harpswell.[5] The maps will be used by municipalities to regulate development and by the Federal Insurance Administration to set flood insurance premium costs. Information will be provided to Maine's coastal municipalities as the studies are completed.

Evaluation of Flood-Proofing Techniques

The performance of those flood-proofing techniques required by the National Flood Insurance Program's Flood Damage Prevention Ordinance must be evaluated for Maine's beaches, particularly for the area subject to direct wave impact. The evaluation can provide information on the best flood-proofing techniques for particular types of structures and for specific locations. Municipalities may then incorporate this information in the form of performance standards in the Flood Damage Prevention Ordinance.

This report recommends that the Division of Marine Geology in the Maine Geological Survey conduct the evaluation of flood-proofing techniques and that the Director of the Maine Geological Survey seek funds for this effort. The Division of Marine Geology may, from time to time, require engineering assistance for this effort. Approximately $10,000 will be needed to pay for this engineering assistance.

Rates of Shoreline Change

Information on shoreline change rates can be used by the Division of Marine Geology in the Maine Geological Survey to advise the Board of Environmental Protection on Alteration of Wetlands Act permits, particularly if the Act is amended to extend its jurisdiction to include regulation of building on dunes and accreted land. This information can also be used to advise private individuals conducting activities in the coastal flood hazard zone. The landward extent of historical shorelines may be used as a guide to locate structures. Information on rates of shoreline changes and the location of historical shorelines is being developed by the University of Maine's Department of Oceanography. The data will soon be published in an "Atlas of Maine's Sand Beach Systems."

This report recommends that the Division of Marine Geology in the Maine Geological Survey continue monitoring shoreline changes through its own efforts and/or with the assistance of the University of Maine's Department of Oceanography, and that it establish the annual costs for these studies and request the necessary funds in its operating budget.

FOOTNOTES

1 U. S. Weather Bureau, Hydrologic Services Division, Hydrometeorological Section (1963) Criteria for a standard Project Northeaster for New England North of Cape Cod, 91 pp.

2 Personal Communication, Leslie Higgins, Maine Office of Civil Emergency Preparedness.

3 National Geographic Society (1978), Our 50 States, N65, Washington, D. C., 304 pp.

4 Fink, L. K. Jr. and Nelson, B. W. (In preparation) An Atlas of Maine's Sand Beach Systems, A Report to the Maine State Planning Office, Coastal Zone Management Program.

5 Personal Communication, Edward Thomas, Federal Insurance Administration, Department of Housing and Urban Development.

6 Personal Communication, Miles Hayes, Department of Marine Science, University of South Carolina.

7 Nelson, B. W. and Fink, L. K. Jr. (1978) Geological and Botanical Features of Sand Beach Systems in Maine, Critical Areas Program, Planning Report No. 54, 269 pp.

8 Personal Communication, John C. Kraft, Department of Geology, Newark, Delaware.

9 Hicks, S. D. and Crosby, J. E. (1974) Trends and Variability of Yearly Sea Level, NOAA Technical Memorandum, NOS 12, 14 pp.

10 St. Pierre, James A. (1978) Maine's Coastal Sand Beaches: Recreation and Conservation, prepared for the Bureau of Parks and Recreation, Department of Conservation, 69 pp.

APPENDIX A

Description of Coastal Beach Systems

and Categorization of Maine's Beach Systems

Prepared by

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(All Figures referenced in this
Appendix are in the text of the report)

APPENDIX A

DESCRIPTION OF COASTAL BEACH SYSTEMS

Beach Definition

Maine court cases have tended to define beach to be the margin of the sea between mean low and mean high tide. This is too limiting a definition for the purpose of examining ways to reduce the impact of coastal storms and erosion on Maine beaches. By definition storm flooding and wave surges affect an area higher up on the beach profile than the normal extent of mean high tide.

Nelson and Fink[4] in their report, "Geological and Botanical Features of Sand Beach Systems in Maine", take a comprehensive approach by defining beaches as not only the intertidal areas, including salt marshes, but also the supratidal (above limit of high tide) sand bodies such as beach berm, frontal dune ridge, and backdune areas and associated vegetation, thereby treating the beach as an ecosystem. Nelson and Fink's definition is assumed in this study.

General Beach Morphology

Maine's beaches have formed because of :(1) the availability of sediment with an abundance of sand-sized particles and (2) a coastal configuration which enhanced both an initial accumulation of sand as well as the long term maintenance of the beach as an equilibrium product of the interaction between the coast and the natural physical forces. Maine's beaches are accumulations of sand derived from wave reworking of glacially derived sediments. The persistent equilibrium is best described in terms of a process-response model. The process agents are the natural physical forces (waves, tides, currents, and winds) the specific characteristics of the sand, and the periodic changes in sea level. The sand, once it has accumulated sufficiently to form a beach, is the passive side of the equilibrium model and responds to the process agents. The progess agents act in unison to establish the general forms and characteristics of the beach systems.

Figure 2 illustrates the spatial relationship of the sand accumulation forms on Maine beaches as well as the nature of the profile change caused by storms. The beach face, berm, frontal dune ridge and backdune area comprise the principal subdivisions of a beach system and the functional role of each, individually and collectively, is basic to understanding the response of beaches to storms. The beach face,i.e. the area between high and low tide,is that part of the beach which undergoes daily change with the influence of the uprush and backwash of the waves. The area between the limit of high water and the frontal dune ridge is the berm which is an accumulation form. The berm is best developed on Maine beaches between early summer and early fall and attains its greatest width in late summer or early fall. The berm provides a dry sand source from which winds transport sand to the next accumulation form, the frontal dune ridge. The frontal dune ridge forms at the seaward limit of the zone in which American beachgrass can survive. The ridge develops because the beachgrass plants trap the sand moved by the wind from the directly adjacent berm. The accumulation of sand stimulates the plant to send out horizontal runners under the new sand surface. At intervals along these runners new shoots grow up through the sand and the main plant also sends up new growth to provide continual vegetation traps for wind-blown sand. By this process a frontal dune ridge of variable height is built at the landward berm edge. Behind the frontal dune ridge is the backdune area which receives sand only by wind transport and wave overwash. These two supply processes occur less frequently and with irregularity to maintain the backdune area as sea level continues to rise. Each of the accumulation forms of the beach profile is a temporary reservoir of sand which is called upon during storm events. Since wave energy is expended in moving the sand, the volumes of sand accumulated during the accretion processes which build the beach face, berm, and frontal dune determine how far erosion proceeds. The beach face and berm are the first line of defense and the frontal dune ridge is the final bulwark of defense. Therefore, it is important to sustain the sand volumes of individual beaches as well as those processes which transfer sand from one part of the profile to another, both during and in between storms.

Important to understanding the process-response model is the concept of feedback mechanisms. Feedback mechanisms explain how a beach can respond to a process agent in such a way as to influence or alter the process agent itself to make the interaction between the beach and the process agent self-limiting. The best example is one response of a Maine beach to a Northeast storm. The resulting erosion makes the beach face longer; in this way wave energies are increasingly dissipated on the lengthening beachface. A most important corollary of the concept of feedback mechanisms is that time, in varying amounts, is required to establish the equilibrium between the various process agents and the final beach response. When energy levels are high, as during a northeast storm, the time required to establish a new equilibrium between the waves and the beach is proportionately short.

The process-response equilibrium model for Maine's beaches describes several general characteristics of the process agents and response forms which should be considered in the formulation of a policy to mitigate storm damage. These characteristics are as follows:

1. Beach Alignment in Plan View: The geologic fabric of bedrock units in Maine exerts a pronounced control on the location and nature of the beaches. The limited sand supply has been reworked into an equilibrium with the wave approach angle. When the waves arrive parallel to the shore, the beach is said to be swash-aligned. This contrasts with drift-aligned beaches where waves arrive at an angle to the beach face and establish an alongshore transport of sand or drift. In Maine beaches are swash-aligned

since waves approaching the beaches almost never arrive at an angle but usually strike the beaches parallel to the strand line, except for those beach segments with substantial intertidal sand accumulations such as ends of spits and cuspate forelands.

2. Sand Transport Within Beach Systems: The sand accumulations of Maine's beach systems comprise discrete circulation cells usually contained between rocky headlands. The transport of sand takes place within these cells and, because of the swash-aligned nature of the beaches, occurs primarily as an onshore-offshore directed movement. Although alongshore transport of sand certainly takes place, it is secondary in volume and rate. It is probably safe to conclude that the annual net longshore transport is near zero, although confirming studies have not yet been done. As a consequence, major redistributions of sand occur within the system and do not usually result in a major loss of sand from the system.

3. Maturity of Maine Beach Systems: The low sand volumes, high quartz to feldspar ratios, fine to medium grain sizes, and well to very well sorted sands suggest highly evolved, mature beach systems. The maturity suggests finite sand sources for continuing re-supply to the beaches. There are important exceptions to this generalization and they will be discussed later.

4. Sea Level Rise in Maine: The geological record of sea level rise in Maine over the last 7,000 years indicates an average rate of rise of 6 cm/century (2.4 inches/century), while tide gauge data from Casco Bay indicate an average rise rate, since 1912, of 23 cm/century (9 inches/century). This long term transgression of the sea over beach areas has several significant impacts:

a. Beach erosion, and subsequent retreat, is the rule rather than the exception.

b. The rates of process-response cycles become important in determining whether beaches can maintain an equilibrium with the rise of sea level.

c. The beach face, frontal dune ridge, and backdune area must migrate upward and landward over marsh and upland.

d. Unless new sand deposits are becoming involved in the sediment selection process of waves and currents, the sand supply to beaches from submerged offshore deposits of glacial outwash sediments are diminishing. The sediment-starved nature of most of Maine's beaches implies either a diminishing supply or such relatively rapid retreat that the present supply rate is inadequate.

e. Instability of beaches is an inherent and necessary characteristic.

f. Interferences by man which prevent landward migration of beaches and their associated dune fields could have dire consequences for the future integrity of Maine's beach systems.

5. Wind Characteristics: While waves are the dominant process agent of the intertidal zone, the wind is the dominant agent for the supratidal areas. For Maine, the northwest and southwest winds exert the greatest influence on those beach processes controlled by the wind.

Because Maine's beach systems consist predominantly of fine to medium size quartz-rich sand, wind transport processes are important in shaping the various supratidal forms. All wind forms become stabilized with beach vegetation. The plants which help stabilize wind forms are susceptible to damage from fire, foot traffic or other human activities. Frontal dune ridges, which serve as reservoirs of sand and natural barriers to storm waves, are present on almost all undeveloped beaches in Maine, but are conspicuously absent on beaches with seawalls and extensive structural development.

6. Wave Characteristics: Because Maine's beaches are predominantly fine to medium grain sands, waves less than 0.75 meters in height are constructional; that is they transport sand onto the beach face; higher waves cause erosion of sand from the beach.[7] This is based on a critical steepness (wave height to wave length ratio) value of 0.012 and a wave period of 6 seconds.

7. Storms: Farrell, Rhodes, and Colonell (1971) summarized wind records to show that the average Northeast storm winds approach from N79°E with velocities of 18-36 knots, and the storm waves have 5-8 sec periods and 0.9 to 1.4 m (3-4.6 feet) wave heights in the surf zone for storm waves with 6.5-7.5 seconds. Southeast gales occur when the track of the storm center passes inland of the coast, such as occurred on January 9, 1978. In the southeaster case, the typical winds blow 8-12 knots from 157.5° and the surf zone waves have average heights of 0.4 m (1.3 feet) and periods of 2.5 seconds. Although storms are process agents which occur for only brief periods in the annual cycle of beach processes, they are clearly the most important agent in accretion and erosion events. Storm frequency, intensity, coincidence with spring tides, and other storm behavior all figure prominently in both short and long term responses of the beach. In a regime of sea level rise, storms are the agent which cause the landward and upward migration of the beach to maintain the equilibrium through frontal dune ridge erosion, overwash of sand into the backdune, and intertidal redistribution of sand within the system. Storms also cause the efficient dispersal of American Beachgrass fragments to promote the vegetation of new areas of sand accretion.

8. Erosion-Accretion Cycles: For Maine beaches there are recognizable cycles of erosion and accretion which occur on more than one time scale. In general, sand is always accreting on Maine's beach faces. This occurs slowly but persistently. The accretionary phase is punctuated by brief periods of erosion usually due to storm waves of varying magnitude. The frequency and magnitude of the storms determine which phase dominates. During the summer and early fall, storms are infrequent and beaches respond by building wide berms. Significant wind transport of sand to the frontal dune ridge also occurs. During the winter and spring, storms occur more frequently and erosional beach profiles develop. Thus a seasonal cycle on

an annual basis is established. On a longer time scale, there is a net retreat or advance of the shoreline depending on the rate of sea level rise. Despite the average rise rate of 23 cm/century (9 inches/century) since 1912, there were significant departures from this long-term trend. For example, sea level dropped between 1918 and 1927 and didn't attain its previous level until 1938. This period of no net sea level change may account for the high intertidal sand volumes apparent in the 1940 vertical aerial photographs. In contrast, sea level rose rapidly during the 1960's by about 10 cm (4 inches) and, in part, may explain the degree of erosion which has taken place in the 1970's Therefore, there are certain predictable erosion-accretion cycles, such as seasonal variation and net retreat due to long term sea level rise, but reversals of any erosion-accretion phase can also be expected but must be recognized as random, superimposed phases. For example, it cannot be emphasized too strongly that the dramatic changes resulting from the 1978 storms, although essential to longterm processes, are not permanent changes at this time. The shoreline and frontal dune ridge retreats represent a short term equilibrium event and during the next year or two after such storms, the frontal dune ridge will be reconstructed by natural processes, probably only slightly landward of its pre-storm location.

Erosion and potential storm damages are greatest on unstable sand structures such as spits, cuspate forelands, tidal re-entrants, ebb tidal deltas, tombolos, and wherever the shoreline radically changes orientation. Some beaches, such as Popham, are subject to wide fluctations of their shorelines and show periods of both accretion and erosion. Figure 3 illustrates the radical fluctuations in the Popham Beach shoreline for the period 1858 to 1976. On the Hunnewell section between 1975 and 1978, 14 homes and one restaurant were destroyed, three homes were moved prior to flood damages, and one home was moved after some damages.

9. <u>Extent of Human Development of Maine Beaches</u>: On the basis of old topographic maps, coastal charts, and aerial photographs dating from 1940, the development of Maine beaches began in earnest in the late 1800's. At that time the development consisted primarily of summer cottages on the back slope of the frontal dune ridge on 50' x 50' or 100' x 100' lot sizes. As might be expected the larger beaches in southern Maine were developed to the greatest extent first. After World War II a new surge of development began, coincident with the general housing boom of the late 1940's and 1950's. The current trend has been away from second homes toward year round housing either by remodeling or new construction. Subsequent to developing the frontal dune ridge, seawalls were placed in front of the cottages to protect them. This usually occurred shortly after the first erosional cycle threatened the cottage.

As a result of a century of development, 58 kilometers (36 miles) of beach shoreline has a total of 22 km (14 miles) of seawalls replacing the frontal dune ridge.[4] These figures are based on 1977 photos which predate the 1978 construction phase of new seawalls. Therefore, 38 percent of the natural beach shoreline has been fronted by seawalls in some form. There are an additional 15 km (9 miles) which are developed but not yet with a seawall. Looking at the supratidal sand dune part of the beaches, of 764 hectares (1888 acres), 473 hectares (1168 acres) or 62% of the major beach systems in Maine have been developed.[4] In most instances this figure represents total obliteration of the backdune or frontal dune vegetational community by loam and grass, or asphalt. In some beaches; however, structures have been built with only minimal disruption of the supratidal morphology and vegetation. Examples of both extremes can usually be seen on each heavily developed beach. Despite the high percentages of beach alteration by development, the type of development, primarily residential and small hotel, must be considered light when compared to the high cost commercial development so characteristic of beach areas elsewhere along the East Coast.

The above general characteristics of Maine beaches are important considerations, since they comprise the basis for any policy developed to reduce coastal storm damages.

CATEGORIZATION OF MAINE'S BEACH SYSTEMS

Criteria for Categorization

Although the general characteristics describe the process-response equilibrium model for Maine's beaches on a regional scale, each beach has inherent characteristics which require a more detailed description of the response side of the equilibrium both from a historical perspective as well as in a predictive sense. A previous study of 27 of Maine's beaches[7] has identified critical natural areas and features for these beaches which have subsequently been registered as significant critical areas in Maine. The inherent characteristics of the individual beaches and the identification of a critical area or feature form the basis for this categorization of Maine beach systems. The categorization can then be used as the foundation for developing and applying specific policy recommendations to reduce coastal storm damages.

The criteria used to determine the categorization can be subdivided under four general headings, as follows:

1. Erosional Potential and Character
2. Susceptibility to Washover
3. Nature of Historical Shoreline Changes
4. Significance of Critical Area

The inherent characteristics or other details used in determining each criterion are discussed below.

1. Erosional Potential and Character: The general response of a beach to a particular storm event can be described as its erosional potential; the manner in which the erosion proceeds is the erosional character. The characteristics of a beach which can be used to describe this criterion are as follows:

a. Sand Textural Characteristics - These include the mean grain size and sorting as determined by a standard grain size analysis of sand samples from various beach compartments. Fine-grained, well-sorted sands respond more quickly to storm events and even short duration storms can cause significant erosional response. In contrast coarser grained beaches respond more slowly and exhibit a lesser degree of erosion for the same storm. Also, less intertidal transport occurs for coarser grained sands than for finer sands under equivalent conditions. Fine well-sorted sand beaches lose the summer constructional berm and develop an erosional, concave-upward beach profile (Figure 2) early in the season which persists until the accretionary phase begins to dominate during the summer. The coarser grained beaches retain the accretionary profile longer into the winter and this profile usually develops at intervals throughout the storm season, since higher energy levels are required to develop and maintain erosional profiles on these beaches.

b. Permeability - The permeability of the beach face sand is related to sand texture since it is determined by the mean size and sorting. Most of Maine's beaches have a low permeability which limits the infiltration of the uprushing wave swash, and therefore promotes erosion of the beach to areas high up on the profile.

This usually results in frontal dune ridge erosion in addition to offshore transport of the sand from the summer-fall berm.

c. Sand Budget - The sand budget of a beach is concerned with the gain and loss of sand to the system. In Maine, only qualitative data exist for sand budgets. It is assumed that relatively little sand is lost from the system and that net gains are probably restricted to those beaches with riverine sources or with mineralogically youthful sand. Some inferences about sand gain can be derived from the shoreline change maps.[7]

d. Sand Volume - This refers, again, to a qualitative assessment of the relative volumes of sand in a system as derived from supratidal dune field width and relief, berm width, and slope and width of the foreshore.

e. Impervious Layer - Many beaches have an impervious layer of peat or bedrock which further limits swash infiltration and also limits the depth to which erosion can occur. Consequently the storm energy can be transmitted further up the beach profile and erosion may be more severe than in those locations on the foreshore where there is no such limit. The presence of such a layer at shallow depth also enhances the probability of washover events. Often this impervious layer is directly overlain by pebbles and cobbles which represent erosional lag debris. In some instances this coarse lag material could provide projectiles during major storms. For some beaches a cobble storm ridge is evidence of such situations. Gravel and cobble overwash fans occurred on several Maine beaches during the 1978 storms.

2. Susceptibility to Washovers: Whenever wave runup exceeds the frontal dune ridge height or seawall height, waves continue into the backdune area accompanied by sand and storm debris. It is during such events that significant damage to structures in the backdune area occurs. When wave runup or the storm surge itself is considerably in excess of the dune ridge or seawall height, waves can break directly on structures with correspondingly greater likelihood of destruction. Since the frontal dune ridge can be eroded during storms, it is possible to breach weakened frontal dune ridges or reduce the ridge height by cutback and slumping to such a low height that washover takes place. Where complete removal of the

frontal dune ridge by storm waves occurs, the greatest amount of washover has been observed. Inadequate seawalls can also fail and permit washovers. Therefore, the susceptibility to washovers on undeveloped beaches depends on the frontal dune ridge height and the volume of sand in the frontal dune ridge. Both of these measurements have been made on beach profiles collected during the last three years. For seawall heights, there are no data. It is obvious; however, that the very presence of seawalls inhibits or completely prevents natural frontal dune ridge constructional upgrowth and is seen on vertical aerial photos to cause a decrease in intertidal sand volumes.

3. Nature of Historical Shoreline Changes: Shoreline change maps have been prepared for all of Maine's major beaches from a time series of vertical aerial photographs dating from 1940 and from earlier map data when the map proved reliable. The maps can be used to determine average rates of accretion or erosion over varying periods of time and to discern any general patterns of shoreline change (Figure 3). The shoreline change maps indicate retreat rates which vary from no significant change since 1940 to 4.69 m/yr (15.4 ft/yr) for periods of time between 3 and 98 years. This does not include Popham Beach where rates at Hunnewell Point exceeds 390 cm/yr (153 in/yr). It is important to recognize that many beaches have undergone accretion along some part of the shoreline at the same time that erosion is occurring elsewhere. Accretion rates varied between 0.53 m/yr (1.7 ft/yr) and 3.5 m/yr (11.5 ft/yr) with an average for 13 sites of 1.32 m/yr (4.3 ft/yr). One inference is that the accretion represents a re-distribution of sand within the system as a new equilibrium develops between the physical forces and the responding shoreline. The shoreline change maps show two general patterns of change:

a. A general recession of the shoreline, probably in response to the secular trend of sea level rise. This pattern fits undeveloped, low sand-volume pocket beaches and long straight beaches. Where sea-walls have stabilized the shoreline and recession is prevented, the photos indicate a general loss of intertidal sand over the interval covered.

b. The most variable beaches and sections of beaches have oscillating shorelines in a zone of recognizable historical instability (e.g. See Figure 3) Such zones are associated with meandering tidal inlets, ebb tidal deltas or ends of barrier spits, cuspate forelands, tombolos, or riverine sand supplies which can be affected by dredging, dam construction, or natural bedload transport rate changes.

4. Significance of Critical Area: In developing criteria for determining the significance of a beach, both geological and botanical criteria were used.[7] The criteria are as follows:

a. The beach and dune areas in a natural state - Since 62% of Maine's limited coastal dune areas are developed, a significant portion of the natural beach and dune forms and dune vegetation have been obliterated. Beaches with extensive seawalls are eliminated since such seawalls alter the shape of the beachface profile and preclude frontal dune ridge development by preventing normal responses to storm waves, constructional waves and wind. Therefore all undisturbed coastal sand dune and berm plant habitats in Maine are significant simply because of their limited extent. The three beaches with large undisturbed dune fields (Popham, Reid, and Seawall Beaches) represent only 8.7 km (3.5 miles) of coastline length and 111.8 hectares (276 acres or 15% of the supratidal beach area in Maine). Smaller scale dune and berm plant habitats which remain undisturbed are also significant because such habitats are rare north of Reid State Park and there are no large dune fields or broad, accretive berms.

b. The location of a beach - Along those sections of the Maine coast where beaches are rare, the presence of even a small beach and dune area assumes a disproportionate significance.

c. Scientific and educational values - A beach or dune area may have excellent examples of geomorphic or botanical features and geological or botanical processes. Some beaches and dune areas either through their dune and beachface morphology or actual response behavior, manifest the interaction between the physical elements of beach systems and various process agents. Also, there are several dune and berm plants in Maine which do, or may, reach their range limit along the East coast in Maine and therefore have educational and scientific significance and any stands, must be protected.[7] These plants are, as listed below:

Wormwood	-	Artemisia caudata
Beach Plum	-	Prunus maritima
Jointweed	-	Polygonella articulata
Pinweed	-	Lechea maritima or L. intermedia
Seaside Spurge	-	Euphorbia polygonifolia

Disjunct populations, especially stands of American Beachgrass north of Reid State Park, are of value for scientific study of speciation as well as geographic trends in environmentally and genetically controlled traits.[7] To discern and study geographic trends, it is necessary to maintain a continuum of natural habitats along the geographic axis in question. It is also vital to protect good stands of those sandy dune habitat plants with limited acreage in the state, such as American Beachgrass, Beach Heather, Wormwood, and Jointweed. Again, much of the previously existing habitat for these plants has been obliterated by development.

Beach Groups and Categorization

Using the considerations from the section describing the criteria for categorization a number of beach groups are presented. The groups are subjective subdivisions of the range of values[4] determined for each characteristic used for the four criteria, as well as the human development information. The beach groupings are then combined to form a final categorization based on potentially high, moderate, or low damage costs due to coastal storms. This final categorization can be used to determine specific policy or management recommendations appropriate for the combination of inherent characteristics associated with each category. It must be emphasized; however, that the categorization utilizes prevalent features of beaches. A future improvement in the categorization would deal not only with whole beach systems, but specific sections of beaches since exceptions to the general rules are known to occur on many of the beaches.

Beach Groups - The beaches are subdivided into a number of groups corresponding to increasing degree, for each characteristic, or a single group which includes all beach systems with a particular characteristic. For example, the degree of development of the beaches becomes undeveloped, lightly developed, moderately developed and heavily developed. The boundaries of each group were determined subjectively, but follow the frequency distribution of the per cent development measurements of the beaches. The undeveloped beaches were further subdivided into those with and without registered critical areas. By this method, all measurements of the beach characteristics were used to establish the beach groups. Additional explanation is provided for those cases when it was considered necessary to clarify the basis for establishing the subdivision.

Undeveloped Beaches

With Registered Critical Areas

Laudholm
Western
Crescent Beach State Park
Bailey
Seawall
Reid State Park
Loud's Island Cuspate Foreland
Pond Island
Marshall Island
Merchant Island (2 beaches)
Swan's Island (2 beaches)
Sand Beach
Roque Island

Without Registered Critical Areas

Crescent Beach-Kittery
Seapoint-Kittery
Head
Pleasant Island
Seven Hundred Acre Island
Jasper
Lubec Spit
Andrews

Developed Beaches

(numbers in parentheses are measured % of development)

Lightly Developed (<10% of Dune Area Developed) with Registered Critical Areas

Crescent Surf (4.5%)
Main Beach - Ram Island Farm (1.4%)
Strawberry Hill - Ram Island Farm (8.5%)
Roque Bluffs (4%)

Moderately Developed Beaches (10-30% of Dune Area Developed) with Registered Critical Areas

Ogunquit (20%)
Parson's (13%)
Ferry (Scarborough, 20%)
Scarborough (26%)
Popham (19%)
Pemaquid (15%)
Sandy River (28%)

Heavily Developed Beaches (>55% of Dune Area Developed)

Long Sands (100%)
Short Sands (100%)
Moody (81%)
Wells (93%)
Drake's Island (90%)
Gooch's (82%)
Goose Rocks (100%)
Fortunes Rocks (55%)
Hill's (100%)
Old Orchard (92%)
Higgins (87%)

Seawall Development
(numbers in parentheses are measured % of shoreline with seawalls)

In some cases seawalls were built during some historical erosional phase and have subsequently been nearly buried by accretion in front of the seawalls. For example, Well's, Drake's Island, Goose Rocks, Hill's, and parts of Old Orchard beaches have seawalls which are not involved at present in the shoreline dynamics. These shorelines were measured as part of the shoreline without seawalls.

Developed Beaches with Seawalls along 25% or less of Shoreline

Ogunquit (20%)
Crescent Surf (13%)
Parson's (25%)
Popham (8%)
Pemaquid (3%)

Developed Beaches with Seawalls along 26-50% of Shoreline

Old Orchard (49%)
Scarborough (28%)

Developed Beaches with Seawall along 50% or more of Shoreline

Long Sands (100%)
Short Sands (100%)
Moody (100%)
Wells (89%)
Drake's Island (74%)
Lord's Point (100%)
Oak Neck (100%)
Gooch's (72%)
Goose Rocks (77%)
Higgins (52%)
Hill's (60%)
Fortunes Rocks (60%)

Sand Volumes

Beaches with Large Sand Volumes

Ogunquit
Goose Rocks
Old Orchard
Western
Seawall
Popham
Sand
Reid

Beaches with Small Sand Volumes

Laudholm	Crescent Beach State Park
Gooch's	Seapoint
Fortunes Rocks	Crescent-Kittery
Pemaquid	Lincolnville
Roque Bluffs	Marshall Island
Swan's Island Beaches	Merchant Island Beaches

Beaches with Intermediate Sand Volumes

Long Sands	Scarborough
Short Sands	Higgin's
Moody	Main Beach
Wells	Strawberry Hill
Drake's Island	Bailey
Crescent Surf	Head
Parson's	Pleasant Island
Hill's	Sandy River
Ferry	Roque Island

Beaches with Impervious Layers
(Bedrock, Peat Layers, and Erosional Lag Surfaces)

Moody	Fortunes Rocks
Wells	Higgins
Drake's Island	Southern Section of Scarborough
Laudholm	Pemaquid
Parson's	Roque Bluffs
Gooch's	

Storm Orientation Index

Since Maine's beaches are swash-aligned systems and Northeast storms have such a significant affect on the alignment of the beach and location of the tidal re-entrants, one factor which determines the level of energy arriving on a beach for any particular storm event is the orientation of the beach relative to the storm waves' approach direction. Some beaches are oriented in such a direction that storm waves undergo little or no refraction (bending) before arriving parallel to the shore. For other beaches, the storm waves undergo significant refraction to arrive parallel to the beach. The refraction and, in some cases, diffraction of storm waves reduces the energy level. This orientation relationship is why some beaches undergo more erosion during storms with winds from the southeast (as during the January 9, 1978 storm) than during northeast storms. Figure 4 shows the orientation relationship between the average northeast storm and southeast storm directions. For purposes of grouping the beaches on the basis of their orientation to storms, a storm orientation index has been calculated for each beach. Beaches for which average northeast storm waves undergo no refraction before breaking on the beachface have an index of 100. Those for which storm waves must bend 90° to arrive parallel to the shore have an index of 0. Beaches for which northeast storm waves must refract more than 90° have negative orientation indices.

Beaches with Negative Orientation Index for NE Storms

Sand (but is very exposed to open ocean)
Main
Strawberry Hill (only the SSW-facing section)
Head
Bailey
Western
Ferry
Pemaquid

Beaches with Low Orientation Index (0-50)

Higgins (41)
Crescent Beach State Park (41)
Fortunes Rocks (38)
Goose Rocks (36)
Seawall (33)
Reid-Half Mile Beach (29)
Crescent Surf (28)
Parsons (28)
Popham-Hunnewell Section (24)
Gooch's (12)
Roque Bluffs (12)
Popham State Park (9)
Old Orchard-Pine Point (0)

Beaches with Moderate Orientation Index (50-80)

Old Orchard-Grand Beach Section (75)
Drake's Island - Laudholm (63)
Scarborough (59)
Reid-Mile Beach (55)
Crescent-Kittery (52)

Beaches with High Orientation Index (80-100)

Old Orchard-Camp Ellis Section (100)
Seapoint-Kittery (100)
Long Sands (88)
Ogunquit-Moody (86)
Wells (82)
Short Sands (85)
Hills (81)

Beaches with Low Exposure-Protected by Islands or Headlands

Roque Island
Sandy River
Main
Strawberry Hill-South Southwest facing section

Textural Characteristics of Sand

(numbers in parentheses are averages of mean grain size and sorting coefficient)

Medium to Coarse Sand

Reid-Mile Beach (0.48mm, 0.38)
Reid-Half Mile (0.41mm, 0.34)
Hills (0.40mm,0.48)
Ferry (0.37mm, 0.55)
Western (0.35mm, 0.56)
Sand (0.34mm, 0.53)
Old Orchard (0.34mm, 0.49)
Fortunes Rocks (0.32mm, 0.40)
Crescent Surf (0.28mm, 0.51)
Popham (0.26mm, 0.43)
Head (0.26mm, 0.57)
Moody (0.26mm, 0.53)
Short Sands (0.26mm, 0.51)

Fine to Medium Sand

Strawberry Hill (0.24mm, 0.60)
Scarborough (0.24mm, 0.47)
Pemaquid (0.23mm, 0.36)
Drake's Island (0.23mm, 0.48)
Well's (0.23mm, 0.45)
Seawall (0.22mm, 0.36)
Gooch's (0.21mm, 0.47)
Roque Bluffs (0.21mm, 0.47)
Ogunquit (0.20mm, 0.33)
Parsons(0.20mm, 0.43)
Higgins (0.20mm, 0.40)
Goose Rocks (0.20mm, 0.38)
Jonesport (0.20mm, 0.50)
Crescent Beach State Park (0.20mm, 0.45)

Fine to Very Fine Sand

Laudholm (0.18mm, 0.48)
Roque Island (0.17mm, 0.36)
Marshall Island (0.17mm, 0.54)
Seapoint (0.17mm, 0.26)
Long Sands (0.16mm, 0.28)

Frontal Dune Ridge Heights

(numbers in parentheses are measured ridge heights in meters)

Low Frontal Dune Ridge (1.0 meter or less)

Gooch's (0.5)
Hills (0.7)
Goose Rocks (0.3,0.7)
Strawberry Hill - Eastern Section
Higgins (0.8)
Popham Beach State Park - Western Section (0.8, 0.9, 1.0)
Pemaquid (0.2, 0.6, 0.6, 0.8, 0.8)
Pond Island (0.4, 0.8)
Roque Bluffs (0.5, 0.6)

Average Frontal Dune Ridge Height (1.0-1.5 meters)

Sea Point (1.0, 1.2)
Laudholm (0.25, 1.4)
Crescent Surf (0.25, 1.3)
Fortunes Rocks (1.0, 1.8)
Old Orchard (0.7, 1.2, 1.3)
Western (0.8, 0.9, 1.0, 1.4)
Crescent Beach State Park (0.9, 1.8, 1.8)
Head (1.1, 1.2, 1.95)
Sand (1.7, 1.8)
Sandy River (1.0, 1.1, 1.2)

High Frontal Dune Ridge (more than 1.5 meters)

Parson's (1.3, 1.4, 2.1)
Scarborough (1.3, 1.4, 2.3)
Strawberry Hill-Western Section
Seawall (0.2, 1.3, 1.4, 2.9)
Popham Beach State Park - Eastern Section (1.7, 1.8, 2.2)
Reid (3.9, 4.0, 4.1, 2.0, 2.2, 2.9, 3.9)
Roque Island (0.3, 0.75, 0.8, 1.5, 2.4)

Cross-Sectional Area of Frontal Dune Ridge
(numbers in parentheses are measured cross-sectional areas in square meters)

Average Cross-Sectional Area Less than 10 meters square

Laudholm
Goose Rocks (7.0, 11.8)
Hills (6.3)
Ferry (0.4, 11.7, 12.5)
Strawberry Hill-Eastern Section
Crescent Beach State Park (5.8, 10.4)
Seawall (5.2, 8.3, 12.3, 14.0)
Pemaquid (1.0, 2.0, 2.6, 7.3)
Sandy River (2.8, 4.3, 23.1)
Roque Island (0.8, 6.0, 8.2)

Average Cross-Sectional Area Between 10 and 24 meters square

Crescent Surf (14.2, 20.2)
Parsons (9.4, 19.1)
Fortunes Rocks (13.4, 19.0)
Old Orchard (1.8, 21.1, 46.2)
Scarborough (0.7, 14.1, 18.8, 23.5)
Popham (3.1, 4.1, 15.6, 22.7, 53.8)

Average Cross-Sectional Area Greater Than 25 meters square

Ogunquit
Strawberry Hill-Western Section
Reid (30.5, 52.7, 5.5, 60.8, 136.4, 229.4)

Results from Shoreline Change Maps
(numbers in parentheses are measured erosion-accretion rates)
*-beaches with shorelines stabilized by seawalls
+-beaches with houses located seaward of historical erosional limit or relict shoreline.

Beaches Showing No Significant Change Over Interval Studied

Crescent-Kittery
*Long Sands
*Short Sands
*Moody
*+Wells
*+Drake's Island
*Gooch's
*Fortunes Rocks - some sections without seawalls have an average recession rate of 0.56m/y for period, 1940-1977
Ferry

Beaches Characterized by Accreting Shorelines

+Goose Rocks (+.53 m/y and 0.74 m/y for 1940-1977)
+Parsons-southern section due to modication of tidal inlet
+Pine Point-Old Orchard (+2.03 m/y for 1940-77)
Western (+0.97 m/y, +1.20 m/y, +2.32 m/y at 3 locations for 1940-76)

Beaches Characterized by Oscillating Shoreline Positions

Ogunquit
Popham
Laudholm
Crescent Surf
*Old Orchard-Grand Beach Section
*Scarborough

Beaches Characterized by Shoreline Retreat

Seawall (0.34-0.44 m/y for 1940-72)
Reid
Pemaquid
Crescent Beach State Park
*Hills (-0.45 m/y amd -2.87 m/y at 2 locations for 1940-77 accretina on southern end at rate of +0.70 m/y for 1940-77)
*Higgins (-0.56 m/y for 1851-1976)
Seapoint (-0.84 m/y for 1959-77)
Camp Ellis-Old Orchard (-0.33 to -0.76 m/y for 1953-77)

Categorization of Beaches

Since this study is concerned with the reduction of damage costs due to coastal storms, a categorization was created which utilizes the characteristics developed for the four criteria and assigns beach groups to three categories which are distinguished by the potential damage costs. It is the characteristic of the groups which makes a beach more or less susceptible to storm damage and the beaches listed in a particular group become eligible for inclusion in each of the potential cost categories. Since some characteristics are more important than others in determining the potential damage and since some beaches are listed under groups which would qualify them for all three categories, some subjective culling has been done. The numbers in parentheses following the beach name refer to the group in which the beach is found. The number of groups as well as the importance of a group characteristic to storm risk ultimately determines the category in which a beach is placed.

Beaches with Potentially High Damage Costs

This category includes beaches from the following groups:

1. Heavily Developed Beaches (>55% of Dune Area Developed)
2. Beaches with High Orientation Index for Northeast Storms (80-100)
3. Developed Beaches with Seawall Along ≥ 50% of Shoreline
4. Beaches with Small Volumes of Sand in System
5. Beach with Very Fine to Fine Sand
6. Beaches with Low Frontal Dune Ridge Height (1.0 meter or less)
7. Beaches with Cross-Sectional Areas of Frontal Dune Ridge <10 meters^2
8. Beaches with Impervious Layers
9. Beaches with Structures Located Seaward of Historical Erosional Limits
10. Beaches Characterized by Steady Shoreline Recession

Long Sands (1,2,3,5)
Short Sands (1,2,3,6)
Moody (1,2,3,8)
Wells (1,2,3,8,9)
Drake's Island (1,3,8,9)
Gooch's (1,3,4,6,8)
Fortune's Rocks (1,3,4,8,9)
Hill's (1,2,3,6,7,9,10)
Old Orchard-Camp Ellis (1,2,3,6,7,10)
Higgins (1,3,6,8,9)
Ogunquit (2)-special case because of contract between Village of Ogunquit and U. S. Soil Conservation Service. Storm damage costs for 1977 and 1978 totalled $137,000.
Popham-Hunnewell (10- up to 3.9 m/y since 1940)

Beaches with Potentially Moderate Damage Costs

This category includes beaches from the following groups:

1. Moderately Developed Beaches (10-30% of Dune Area Developed)
2. Developed Beaches with Seawall Along 26-50% of Shoreline
3. Beaches with Intermediate Sand Volume
4. Beaches with Moderate Orientation Index for Northeast Storms (50-80)
5. Beaches with an Average Frontal Dune Ridge Height (1.0-1.5 meters)
6. Beaches with Average Frontal Dune Ridge Cross-Sectional Areas (10-25 meters^2)

Parson's (1,3,6)
Scarborough (1,2,3,4,6)
Sandy River (1,3,5)
Old Orchard-Grand Beach Section (2,4,5,6)
Strawberry Hill-Eastern Section (3,4,5,6)

Beaches With Potentially Low Damage Costs due to Coastal Storms

This category includes beaches from the following groups:

1. Undeveloped Beaches with Registered Critical Areas
2. Undeveloped Beaches without Registered Critical Areas
3. Lightly Developed Beaches ($<$10% of Dune Area Developed) with Registered Critical Areas
4. Developed Beaches with Seawall along 25% or less of Shoreline
5. Beaches with Large Volumes of Sand in System
6. Beaches with Negative Orientation Index for NE Storms
7. Beaches with Low Orientation Index for NE Storms (0-50)
8. Beaches with Medium to Coarse Sand
9. Beaches with High Frontal Dune Ridge Heights ($>$1.5m)
10. Beaches with Frontal Dune Ridge Average Cross-Sectional Areas $> 25m^2$
11. Beaches Characterized by Accreting Shorelines

Laudholm (1)
Western (1,5,6,8,10,11)
Crescent Beach State Park (1,7)
Bailey (1,6)
Seawall (1,5,7,9)
Reid State Park (1,5,7,8,9,10)
Loud's Island Cuspate Foreland (1)
Pond Island (1,5)
Marshall Island (1)
Merchant Island-2 beaches (1)
Swan's Island-2 beaches (1)
Sand Beach (1,5,6,8)
Roque Island (1,9)
Crescent-Kittery (2)
Seapoint (2)
Head (2,6,8)
Pleasant Island (2)
Seven Hundred Acre Island (2)
Jasper(2)
Lubec Spit (2)
Andrews (2)
Crescent Surf (3,4,7,8)
Main (3,6)
Strawberry Hill-western section (3,6,8,9,10)
Roque Bluffs (3,7)
Pemaquid (4,6)
Goose Rocks (5,7,11)
Ferry (6,8,11)
Old Orchard Pine Point (7,11)
Popham State Park Section (7,8,9)

APPENDIX B

SHORELAND ZONING

Information contributed by
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APPENDIX B

SHORELAND ZONING

The State Mandatory Shoreland Zoning Act was primarily written to regulate activities on the shorelands of inland water bodies; however, the Act does legally pertain to coastal shorelands as well. As stated in the legislation, the purpose of the Act is:

> "To aid in the fulfillment of the State's role as trustee of its navigable waters and to promote public health, safety and the general welfare, it is declared to be in the public interest that shoreland areas defined as those land areas, any part of which are within 250 feet of the normal high water mark of any navigable pond, lake, river or salt water body be subjected to zoning and subdivision controls. The purposes of such controls shall be to further the maintenance of safe and healthful conditions; prevent and control water pollution; protect spawning grounds, fish, aquatic life, bird and other wildlife habitat; control building sites, placement of structures and land uses; and conserve shore cover, visual as well as actual points of access to inland and coastal waters and natural beauty."

In order to implement the Act, the State developed "The State of Maine Guidelines for Municipal Shoreland Zoning Ordinances" which incorporates the objectives of the Act by establishing shoreland districts and permitted uses.

In most municipalities, ordinances are based on the State Guidelines Ordinance and in all cases must be equally effective, even if they differ in format. Most ordinances contain three districts and establish permitted uses, see Table 1.

Table 1 Relationship between Districts, Areas and Permitted Uses for Shoreland Zoning Guidelines

District	Area Where Applied	General Use
Resource Protection	Wetlands, steep slopes, flood plains	No residential, commercial, or industrial structures
Limited Recreational-Residential	Land not in other two districts	Mix of uses, including forestry, agriculture, and residential dwelling units set back at least 75 feet
General Development	Areas devoted to intensive development	Mix of development uses with no required setback

Shoreland Zoning has been effective in achieving many of the purposes of the Act; however, it does not appear to be an effective tool for reducing storm damages to beaches and structures in built-up coastal areas. There are some serious shortcomings which render municipal shoreland zoning ordinances only minimially effective in reducing future storm damages. The following discussion will focus on the limitations of the Act and the "State Guidelines Ordinance", on which most municipal ordinances are based.

Limitations of the Act:

1. Jurisdiction of the Act is unclear. The jurisdiction of shoreland zoning extends 250 feet landward from normal high tide. While this point is readily discernible in most areas of the coast, it is extremely difficult to determine in beach areas. Many municipalities use an ever-changing debris

line, while others consider the beach to be seaward of the beginning of shoreland zoning's jurisdiction, in the latter case, shoreland zoning controls have no effect on beach protection, and do not regulate structures which are built there. Also the normal high tide line can fluctuate as the shoreline advances or retreats.

2. The Act addresses future uses. Shoreland zoning is no exception to the general zoning principal by which existing uses are allowed to be continued. In built-up areas, it can be argued that shoreland zoning may exert an effect as structures are replaced. However, in the short run, shoreland zoning has no effect because existing structures and uses are unaffected by shoreland zoning's standards. Existing structures, as well as beach areas, will continue to suffer the ill effects of coastal storms.

Limitations of the Guidelines:

1. The Shoreland Zoning Guidelines Ordinance was designed primarily for inland communities. The ordinance is oriented primarily toward problems normally encountered in the regulation of shorelands in and around lakes and ponds in excess of 10 acres. There are no standards aimed at the protection of coastal beaches and dunes, and there are no standards aimed specifically at reducing coastal storm damages.

2. Shoreland Zoning Allows Expansion, Replacement, and Change of Non-Conforming Uses. Most zoning ordinances prohibit the expansion, change, or replacement of non-conforming uses with the objective of phasing out such uses over time. However, the Guidelines do not incorporate these prohibitions. It was felt by the task force that drafted the guidelines that being too restrictive would result in a backlash against the program.

Under traditional zoning ordinances, the non-conforming use is usually something, such as a gas station in a residential neighborhood, which can utlimately be converted to a conforming use, such as a residential dwelling. Under shoreland zoning, the conversion of a non-conforming residential dwelling to a conforming use means virtually no use of the land in most circumstances. The Guidelines were written to permit the expansion, change, or replacement of a non-conforming use provided that a Planning Board permit is issued assuring that the action will not have an adverse environmental impact.

The language of the Guidelines permits the perpetuation, rather than the elimination, of structures and uses subject to coastal storm damages. An obvious solution is for municipalities to enact more restrictive "non-conforming uses" provisions. Requiring such provisions at the State level may involve serious political, legal, and financial problems.

3. The Guidelines Ordinance regulates, but does not prohibit filling.

Filling can make possible the building of structures in areas which would otherwise be undevelopable. However, building on fill frequently places structures in too close proximity to storm tides and fill can also be unstable and easily eroded. However, a prohibition on filling would probably not be supported by the public and may not be justified in all cases.

4. The Guidelines do not require a Resource Protection District in all areas subject to flooding. One misconception about shoreland zoning is that all areas subject to flooding must be placed in a Resource Protection

District. Many heavily developed areas subject to flooding qualify for inclusion in the General Development District as well as the Resource Protection District. No attempts have been made at the state level to require municipalities to apply the more restrictive designation to these areas. There would be overwhelming public opposition if the state tried to require municipalities to rezone all such areas as Resource Protection Districts.

5. There is a great deal of difficulty in establishing coastal flood levels. For undeveloped areas, the Guidelines required that municipalities apply the Resource Protection District to flood plains as defined by the 100-year flood, the flood of record, or, in the absence of these, by soil types identifiable as recent flood plain soils. In most communities, coastal and otherwise, it was virtually impossible to establish such levels much less map them in a comprehensive fashion. Additional flood level data has been made available by the coastal storms of 1978, but there are legal and political questions as to whether the State can now require municipalities to use the new information in the establishment of Resource Protection Districts.

Limitations of Municipal Administration and Enforcement:

In addition to the limitations in municipal shoreland zoning ordinances there are also serious weaknesses in local administration and enforcement to which even the best of ordinances are subject. These weaknesses include the following:

1. Municipal abilities to administer and enforce local ordinances vary widely. With 442 municipalities administering and enforcing a shoreland zoning ordinance (4 are exempt due to lack of water bodies), there is a wide range in municipal abilities and actions in the administration and enforcement of local ordinances. According to the State Planning Office, medium sized towns and cities have done the best job of administering and enforcing local shoreland zoning ordinances. Planning Boards in many small towns, often have a less thorough knowledge of ordinance regulations and procedures while in larger towns and cities there is sometimes confusion in the administration of the ordinance, stemming largely from a lack of knowledge about "who is in charge."

2. Municipalities seldom appear to take court action when it's necessary. Even the best administrative practices will not prevent some individuals from deliberately violating the ordinance. In such instances, its important to take court action, if for no other reason than to discourage other individuals from acting in a similar manner. Unfortunately, municipalities seldom take court action in such instances. There are several reasons for this non-action :

a. Many town officials are reluctant to take court action. In many small towns, ordinance violators may be related to, or friends of, the municipal officials, thus making the social costs of taking court action very high. In some towns, municipal officials do not believe in the purposes of shoreland zoning, and feel deeply that individuals should be able to do whatever they want with their land. In these instances, municipal officials usually have no desire to take court action.

b. Many town officials do not have the time or municipal funds necessary to take court action. In most of Maine's smaller towns, selectmen are working men and women who cannot afford to take time off from work for the two, three, or even a half-dozen court appearances that may be necessary to successfully prosecute a single violation. Many towns do not have the funds to hire an attorney and therefore rely upon the district attorney's office for the prosecution of municipal ordinance violations.

c. Maine's court system is not set up to enhance the prosecution of municipal ordinance violations. Municipal officials sometimes encounter a great deal of difficulty in obtaining timely cooperation and action from the district attorney's office. Municipal officials unable to hire an attorney sometimes find that district attorneys and their assistants are too overworked to devote much time to their case. In at least one alleged instance, municipal officials made three scheduled court appearances, only to have the case continued because the assistant district attorney failed to show up in court. The failure to get timely court action has been a disillusioning and discouraging experience for municipal officials in several instances.

Limitations of State Administration of Shoreland Zoning:

The State has a specific responsibility to see that municipal ordinances are administered and enforced. Section 4814 of the law states in part:

> "If a municipality fails to administer and enforce zoning ordinances adopted by it or the State, pursuant to the requirement of this chapter, the Attorney General shall seek an order of the Superior Court of the county in which the municipality lies, requiring the municipal officials to enforce such zoning ordinance."

Unfortunately, this legislative mandate is difficult to implement for the following reasons:

1. There is no State monitoring of local administration and enforcement. While most local ordinances contain provisions requiring that the State Planning Office be notified of amendments to the ordinance and of variances granted in the shoreland area, there is not complete compliance with this requirement. In addition, because municipalities are not required to notify the State of shoreland zoning permits which are granted, the state has no way of determining whether permits are being issued in accordance with the requirements of the municipal ordinance, except through reports from concerned citizens. In every case where a serious failure to administer and enforce a local ordinance received State attention, it was through the citizen-informant process. The Attorney General's Office has no one specifically assigned to actively check compliance with the Act. The State Planning Office has assigned one half of one person's time to shoreland zoning, but most of this time is spent on other shoreland zoning matters.

2. The penalty provisions of the law are weak. While the law requires the Attorney General to act where there is a failure to administer and enforce a municipal or State-imposed ordinance, there is no mandate or apparent authority to take court action where local ordinance administration is of very poor quality, or where municipal interpretation of various ordinance provisions

is contrary to the intent of the Guidelines. Moreover, the directive to "seek an order of the Superior Court . ." would, if utilized, result in a judge telling the municipal officials to do what the law already tells them to do. Presumably, municipal officials could then be held in contempt of court for subsequently failing to obey the court order. The current wording of the Statute has made the Attorney General's Office reluctant to initiate court action when such action has been officially requested by the Board of Environmental Protection and the Land Use Regulation Commission.

3. There is no authority for the State to over-ride local decisions. The Shoreland Zoning Act states that if BEP and LURC find that a local ordinance is "lax and permissive," the Boards shall, in consultation with the State Planning Office, adopt an ordinance for that municipality, which the municipality shall then administer and enforce. However, no similar authority exists with respect to municipal permit decisions, or municipal amendments.

4. Additional, Mandatory Standards do not appear to be feasible. The obvious solution to correcting the lack of coastal oriented standards in the Guidelines is to amend the Guidelines. There are two problems with this course of action:

a. Section 4812 of the Act requires that the Board of Environmental Protection and the Land Use Regulation Commission adopt the Guidelines by December 15, 1973. The law does not provide for any subsequent amendments.

b. An amendment to the Guidelines will not automatically change regulations in local ordinances. Even if the Guidelines are amended, municipalities would have to be informed of the changes and amend their ordinances or face imposition of a State ordinance. Section 4813 would also have to be amended to allow BEP and LURC to impose an ordinance on a community whose ordinance was not "lax and permissive", as it would be questionable whether the failure to include additional standards would render a local ordinance "lax and permissive".

APPENDIX C

ACQUISITION OF STORM HAZARD AREAS

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APPENDIX C

ACQUISITION OF STORM HAZARD AREAS

Among the various proposals for dealing with the problem of coastal storm damage and erosion none is likely to be as effective in reducing storm damages and in preserving the beach ecosystem, as the acquisition of beachfront property and the return of the beach to its natural condition. At the same time no proposal will be as expensive nor as fraught with difficult questions. The general question is whether or not it is feasible for the State to acquire beachfront property which is already developed with residences, or dedicated to other uses, remove the existing structures and return the beach to a natural state for use as a state park or natural preserve.

Recreation can be justified as a major public benefit when coastal storm hazard areas are acquired for recreation. The Bureau of Parks and Recreation, in its publication Maine's Coastal Sand Beaches, reported that approximately four-fifths of the beaches on the Maine coast are in private ownership. The Bureau has twelve parcels of beach totalling 29,177 feet. This amount of State beach is not sufficient to meet the current demand in the Cumberland and Mid-Coast Districts according to the 1977 Maine Comprehensive Outdoor Recreation Plan. In the spring of 1977 a leisure time use and preference telephone survey found that three-quarters of those interviewed supported additional expenditures by the State to develop swimming areas on the coast.[10,p.21] A 1973 opinion survey also found that coastal beaches and scenic areas were top priority for acquisition.[10,p.21] In the York and Cumberland Districts coastal beaches were favored as acquisition priorities by 61 and 70% of the respondents respectively.[10,p.21]

This section proposes a general economic model for evaluating the feasibility of acquiring beach property. The model is an application of cost/benefit analysis to the problem of beach acquisition. An example, using Higgins Beach is presented to show how the model can be applied. It is obvious; however, that beach acquisition is a solution which is likely to be employed only in relatively few severe problem areas where no other alternative for saving the beach or associated structures is considered feasible and where significant public recreation benefits can be realized.

In analyzing the costs and benefits involved in beach acquisition, the costs can be divided into two categories: direct and indirect. The most obvious, and probably largest part of the costs for beach acquisition are the direct costs of purchasing the property itself, including the buildings already in place. In order for the State to purchase this property, it will be necessary for the Legislature to enable some agency to acquire the property through the exercise of eminent domain. This approach requires the payment of fair compensation for the property. The compensation needs to be determined through the use of assessments of the property's value, using two or more independent appraisals.

The other direct cost which is incurred in the acquisition of beach property is the demolition and removal of existing structures and the return of the area to a natural condition. The costs involved depend on the number of structures to be removed and the contractual arrangements made for the demolition and removal.

Further direct costs will be incurred if the beach is to be converted to a park. These costs are primarily construction of parking and other facilities, and any special preparations which might be required by the site.

Once in use the operating and maintenance costs of the park are counted as direct costs.

There are two major sources of indirect costs. First is the loss of tax revenues to the municipality resulting from the removal of the beach property from the tax rolls. A second form of indirect cost is the loss of the taxes to the State from expenditures for goods and services by the seasonal residents.

The fact that it is only the incomes of seasonal residents which would be lost must be more closely examined. Beach front property in Maine is owned to a great extent by seasonal residents because of the great attraction of Maine beaches for summer recreation. Once acquired, seasonal residents would no longer use the beach in the same manner as before, and their expenditures, which are counted as income to the state's economy, would be lost. It may be argued that those displaced form the acquired area would simply move to another area of the coast, and thus their expenditures would not be lost. However, because the supply of beachfront property is fixed, and the demand for beach property high, the removal of a portion of the supply will mean that, even if those whose property is acquired are able to move to other areas of the coast, they will only displace someone else from owning a piece of beachfront property. The net effect will be that the removal of the beach from use for seasonal homes will mean that the land will no longer be able to generate expenditures from seasonal homeowners. Thus the total expenditures (income) of seasonal homeowners will be lost to the state.

There are, also of course, year round residents on all developed Maine beaches. If the beach property is acquired from current owners, it is likely that year round residents would remain in the community since their presence is tied to jobs, etc. A survey of potentially affected individuals could determine the impact on the municipality's tax rolls.

The benefits from beach acquisition are considerably more difficult to calculate. The benefits fall into two principal categories, the benefits from the beach as a recreation area, and the benefits which accrue in the form of savings of public dollars used to subsidize the continuation of private investment in the high hazard storm area.

The recreational benefits, in turn, also fall into two general categories. The first set of benefits might be described as the "forever wild" benefits. It is possible for the beach property acquired to be re-established as a natural ecosystem and simply left as a "wild" preserve. This action would require that the value of the beach in its wild state to the citizens of the state be equal to the costs. That is, if simply having a beach in its natural state is sufficiently valuable to the people of the state, the cost could perhaps be justified. The benefits derived from savings in public subsidies discussed below would still exist.

However, a number of factors militate against the likelihood that an acquired beach would be left "wild". Because the costs involved are relatively high and because the supply of beach land available to the public is very limited, it is likely that the public would support the acquisition of beaches only if they could later be used for direct recreational uses. Moreover, even in its "wild" state there would be continued need to protect the fragile beach ecosystem from adverse human intrusion. Since the most effective means of assuring continued management of the beach resource is probably the establishment of a park of some type, the most likely choice for use of the acquired property would be as a park.

If the acquired land is developed as a park, it is possible to identify the benefits in clearer terms. First, there would be the revenues generated by the park from users, normally a parking fee under current practices. There would also be indirect benefits in the form of expenditures of the users of the park, which like the expenditures of the seasonal residents can be counted as tax income to the state.

In addition, there is the benefit to the people who use the park which can be defined as the value of the recreational opportunity provided by the new park to those who use it. Economists usually measure these benefits, at least conceptually, in terms of the individual's willingness to pay". . . That is, since the park provides its recreational opportunity and charges either no price for the opportunity or only a price which covers the marginal cost of a small part of the total costs, such as parking, there is no market-determined price which would allow estimation of the value of the resource. The criteria of willingness to pay is generally defined as the price at which individuals would purchase a non-priced good or service. In other words, if the admission price of a park were $5.00, the number of people willing to pay that amount to use the park, times $5.00 would equal the total recreation benefit to the public.

It is apparent, of course, that while the "willingness to pay" criterion is conceptually simple and appealing, in fact, it is very difficult to measure accurately. Although it can be measured through a survey, the essentially hypothetical nature of the concept would make it difficult to attain accurate results. Studies on the value provides sufficiently similar features to the beach acquisition problem to be usable.

Despite the difficulties involved in measuring the recreation benefits, it is, after all, the value of recreation which causes people to use beaches and it is nevertheless essential that the value is measured in some manner. One relatively simple way which does not directly measure the benefits, but does allow their consideration in a decision, is to assume that the recreation benefits will equal the difference between total costs and total benefits. Subtracting total benefits from total costs (use the net present value of both if appropriate) will yield a figure which can be considered to equal recreation benefits; this total can then be divided among the expected users to derive a per user estimated benefit. The question will then have to be asked whether or not the investment will be worth that per user benefit.

The other major source of benefits from beach acquisition takes the form of savings in public subsides. These subsides are directed at maintaining public and private investment in beach storm hazard areas and consist of three principal forms: Federal Disaster Relief, Federal Flood Insurance, and Small Business Administration Loans available after disasters.

Federal Disaster Relief is available to pay the costs of cleanup and repairs to public facilities, such as roads and public buildings. This assistance takes the form of direct grants to the municipalities or states.

Small Business Administration Loans are available for disaster relief to a variety of eligible individuals and businesses. The loans are normally very low interest, and are paid back over a long period of time. Although the money is paid back, there is a public subsidy which is measured as the difference in interest payments on the low-interest loan offered by the government and the loan which would be obtained in the regular loan market.

The National Flood Insurance Program under the "emergency" phase, provides an insurance subsidy by charging only a maximum of $2.50 per $1,000 of insurance, regardless of real risk. This subsidized rate is also carried over for existing houses once the "regular" program is implemented in the community. New houses built in the hazard area must pay rates based on actuarial assessments of the risks, and no subsidy is involved.

In assessing the savings in public subsidies, it is necessary to know the total number of houses covered by the National Flood Insurance Program, and calculate the difference between the actuarial and subsidized rates for insurance for that number of houses. Since these actuarial rates are not calculated until a community enters the regular phase of the program, it may be very difficult to obtain these figures for communities only covered by the emergency program.

The subsidy involved in the National Flood Insurance Program is an on-going subsidy. The subsidy in the other programs is based on incidence of damages, that is on the occurrence of storms. This creates certain difficulties in estimating the future levels of savings. While the January and February 1978 storms are considered 75 year storms, the level of damage from other, less severe storms, may over a period of time equal or exceed the damage levels from these 1978 storms. The accurate projection of savings from these damage-incident related programs will depend ultimately on the accurate projection of storms and damages.

There is one other area of savings which may be included in the benefit calculation, but only under special circumstances. As there are costs involved in the loss of tax revenues to the towns, there may be savings in public services which no longer must be provided to the area acquired. However, the kinds of public services on which savings can be made are in fact very limited. Since most of the services provided by the town are available to all the citizens of the town on an equal basis; it is not possible to reduce the share of services such as police, fire, library, schools, and similar services. This is especially true of schools, which form a large part of local budgets, but which seasonal residents do not fully utilize. For the majority of public services, therefore, no real savings are realized.

There may be higher assessments, and hence higher property taxes, resulting from the increased value of houses left on areas adjacent to the acquired beach. This will depend on market conditions, assessment practices, and local budget decisions, but if realized the increased tax value could partially offset tax losses.

Table 1 summarizes the various costs and benefits to be calculated in the analysis of beach acquisition.

Table 1 Costs and Benefits of Beach Acquisition

COSTS	BENEFITS
Direct:	Recreation
Price of Land/Buildings	User Fees from the Park
Demolition, Carting, Restoration	Tax Benefits to the State
Park Development	
Park Operations, Maintenance	
Indirect:	Savings and Subsidies
Loss of Property Tax Revenues	Disaster Relief
	Small Business Loans
	Federal Flood Insurance
	Municipal Expenditures

While this cost/benefit model of beach acquisition is conceptually sound in economic terms, it must be pointed out that there is a very real and potentially serious political aspect to the model. The costs and benefits of acquiring beach property accrue to various groups of the public and at various levels of government. The cost of acquiring the property would be paid by the state, but the taxes lost would be by the municipality, recreation benefits from the new park would accrue to citizens of the municipality, as well as the state, and also to out-of-state. The public monies paid as a subsidy against disasters are paid by the federal government.

It is thus not possible for the State to make the investment in acquisition and have the benefits accrue clearly and unambiguously to the same citizens who bear the costs. Although it may be possible to partially compensate some of these inequities, such as relying on payments in lieu of taxes by the state to the affected local government.

A Limited Hypothetical Test of the Model

The following test of the model is a limited one, since certain key elements of data are not available.

The test chosen was an analysis of beach acquisition at Higgins Beach in Scarborough. Higgins Beach is the name given to the northernmost stretch of a beach system which extends from Black Point in the South to the Spurwick River in the north. Higgins Beach is a heavily developed stretch of beach, with houses and seawalls constructed over the length of the entire beach. Table 2 presents the data which has been developed. An explanation of the method used for developing the data is presented after the table, followed by a discussion of the findings.

TABLE 2 Model Application to Higgins Beach

Costs	Benefits
Acquisition 1,120,000 (3,227 feet of beach)	Park Fees 23,000/yr.
Demolition 185,000	Savins in Disaster Relief Grants 16,915
Development Costs 130,000	Savings on Federal Flood Insurance Not Available
Operations/Maintenance 22,500/yr.	Savings on SBA Disaster Loans Not available
Taxes Lost 29,574/fiscal yr.	

Cost figures presented in Table 2 were developed as follows:

Acquisition Costs: Based on the geomorphology of the beach system, the area which should be acquired (3227 feet) in order to most effectively preserve the beach was identified, and the included properties were examined in the Scarborough tax records in order to identify their assessed value. The property tax assessments were last done on a town-wide basis in 1972, so the assessed values were adjusted to current market value.

Demolition: A contractor estimated costs for demolition to be an average of $5,000 per structure, for 37 buildings. The figure includes carting of the debris, but not resale of any salvaged materials.

Development Costs: Figures from the Bureau of Parks and Recreation on the costs incurred in the development of several other coastal beach parks, notably Reid, Popham, Crescent Beach, Scarborough Beach, and Ferry Beach were used. The average development costs for these parks is $40.28 on a per front foot basis. This figure was then multiplied by the number of front feet in the Higgins Beach area hypothetically to be acquired.

Operating and Maintenance Costs: A similar procedure was followed to develop average operating and maintenance costs per front foot. In this case, the Bureau of Parks and Recreation figure of $7.05 for the operations and maintenance in fiscal year 1977 for coastal beach parks was used. The figure of $7.05 was then multiplied by the front footage at Higgins Beach.

Taxes Lost: The assessed value of the area that would be acquired was multiplied by the current Scarborough tax rate to yield the taxes lost. The Scarborough fiscal year is on an 18 month basis, and therefore this loss was adjusted accordingly.

Benefit figures presented in Table 8 were developed as follows:

Park Fees: The estimation of these figures required that figures be developed on the number of visitors likely to use a park at Higgins Beach. Using coastal beach park usage figures over the past ten years, from the

Bureau of Parks and Recreation, park visits per front foot of beach were developed. Since there is a strong correlation (r=.94) between front footage and the number of visitors at a park, this figure can be considered a good estimator of the number of people who will use a new park. In this case, this procedure yielded an estimate of 69,000 park visitors per year.

The park usage figures from the Bureau of Parks and Recreation were developed from figures on parking at the parks. Since the Parks and Recreation figures were developed using a constant ratio of cars to visits, it was possible to estimate the number of cars that could be expected to park at a new park (this would obviously assume the presence of suitable parking facilities). Since the only fee charged at the coastal beach parks is a parking fee, currently $1.50 per car, it was possible to estimate the park fees as a function of the estimate of cars and the current fee.

Tax Benefits to the State: In this example, the taxes were calculated from a multiplier estimated in the Northeast Markets/Arthur D. Little study entitled, Tourism in Maine: Analysis and Recommendations. The state taxes were calculated as a percentage of the estimated daily expenditure of $11.65 per person (A. D. Little study estimated $9.70 per person per day, this was transposed into 1977 dollars). However, it should be noted that the tax estimator from the Northeast Markets/Arthur D. Little study was based on the tax structure in effect in 1973-1974. There have been changes in that tax structure, notably in the income tax, since the original survey. Therefore, in order to assure accurate results, it will be necessary to resurvey coastal beach users to estimate taxes paid as a percentage of daily expenditures.

Disaster Relief: The only figures for the public subsidy savings that were available were those Federal Disaster Relief claims by the Town of Scarborough resulting from the 1978 winter storms. The claims from the town were examined, and the damages at Higgins Beach were excerpted. This damage consisted primarily of damage to seawalls and roads, including cleanup and removal of debris. Also included was the costs of extra police services during the cleanup period.

The figures, which were developed for this test are, for the most part, are only rough approximations of the figures which would have to be developed if a real analysis were to be undertaken.

Despite the limited nature of this test, there are several conclusions possible. First, it is apparent that one key to determining whether or not acquisition is a viable option in any given instance, is the savings to be expected from subsidies.

However, there are difficulties in measuring these benefits which arise from two separate sources. First, the records keeping procedures of the federal agencies responsible for administering Federal Flood Insurance and SBA loans are not amenable to easy access on the question of what damage is sustained in areas as specific as beaches. It is probably possible to examine individual records of policies and loans, but such an examination would be very time consuming. While this procedure may be the only one available at the time an analysis is done, improvements in the federal record keeping would facilitate future work with the question of government subsidies to flood plain inhabitants.

A second problem in projecting these benefits relates to the fact that two subsidies, SBA loans and Disaster Relief grants, are used only when an actual disaster has occurred. The problem arises, therefore, of predicting first, the frequency of storms, and second the level of damage which will be caused by the storms. Being able to predict the level of damage is critical to the overall estimation of the subsidy saving benefits. The susceptibility of beaches to damage will be a key variable (see Appendix A). To the extent that high risk beaches can be identified, it may be possible to make projections on the level of damages which might be expected. Such estimates would confirm that a beach area was in sufficient danger from future storms and therefore acquisition should be considered.

The importance of estimating the value of recreation benefits from the new park was mentioned. Because data is lacking on two key components of the benefits, it is not really possible to estimate the value of recreation benefits in the Higgins Beach example. Any attempt to estimate these benefits without a full accounting of the other benefits would yield an overestimate of the benefits, which would be in reality an overpricing of the beach. To illustrate this point, subtracting the total benefits for which data is available from total costs, and dividing by the expected number of visitors per year yields an estimate of $11.75 per person. This figure would be judged by most as being too high; that is, most people would not value a beach visit at $11.75. Only when the other benefits are calculated are more realistic figures likely to be available.

Pay Back Period: One aspect of the cost/benefit analysis of beach acquisition which has not yet been discussed is the length of the pay back period. On the cost side of the equation, two of the costs are "one-time" costs, that is the acquisition of the beach and removal of structures, and a certain portion of the development costs required for the initial construction and establishment of park facilities. The other costs, and all the benefits are recurring, either on an annual basis (fiscal year) or on an incident basis following storm damage. This raises the question of over what period should the costs and benefits be figured, and whether the benefits will exceed the costs over time.

Since a park has no real limit on its useful life, there is not any one period of time for which the analysis can be conducted. If a bond issue were made for the acquisition and initial development costs, the time period of that bond issue could provide a convenient time frame for the analysis, but it would remain true that even after the bond issue was retired the recurring costs and benefits would still continue to accrue. This yields the conclusion that if the recurring benefits are greater than the recurring costs, on an annual (or other comparable basis), then at some time in the future the benefits will exceed the costs of acquisition. The calculation of that time period will be accomplished using the formula:

$$P = \frac{(C2-C1)}{(B-C1)}$$

where:
C2 is the one time only costs
C1 is the recurring costs
B is the (recurring) benefits
P is the period of payback

This formula will only yield meaningful results when (B-C1) is positive; that is when the benefits exceed the identified recurring costs.

In the case of Higgins Beach, the benefits (measured without the benefits from subsidy savings) would yield a payback in approximately 22 years. Placing the benefits and cost figures into the formula for Higgins Beach yeilds:

$$22.23 = \frac{1,435,100-52074}{114262-52074}$$

The above approach is a direct accounting of the benefits and costs to the Maine public. If the benefits of subsidy savings were included these would accrue to all the tax payers of the country.

A pay back period of 22 years for Higgins Beach means that acquisition is viable in terms of return on investment in a reasonable period of time. If the ratio between benefits and costs increases, the payback period will decrease, and if the ratio decreases, the payback period will increase.

The payback period formula assumes that the ratio between recurring benefits and recurring costs (B and C1) remains the same into the future. This is an assumption not likely to hold. To take one example of how the ratio may change, the user per front foot ratio, which is the principal means of determining the number of users expected at a new park, has actually been increasing over the past ten years (the analysis in this paper uses the most recent figure). Given the assumption of continued expansion of demand for beaches, it is likely that the ratio will continue to grow with accompanying growth in the state tax benefits from expenditures and from user fees.

The conclusion is that accurate projections of future park use are essential to the acquisition analysis.

Income costs and benefits have not been estimated and applied in the model. An indirect cost of acquiring beach property is the resulting loss of income in the form of expenditures for goods and services of seasonal residents. Once their property is acquired seasonal residents, many of whom are from out-of-state, might not reinvest in Maine property. The income they generated to the state conomy would be lost. Year round residents might relocate elsewhere in the municipality and their expenditures would still contribute to the state economy. Income benefits to the state in the form of expenditures for goods and services by the "new" state park users would definitely offset income losses due to loss of seasonal residents. The application of these income benefits and costs therefore results in a much shorter payback period.

Conclusions:

1. Although expensive, a policy of acquiring already developed beaches, removing the structures, and transforming the beach into a park may offer, in some cases, the possibility of preventing severe storm damages to structures and subsequently providing increased recreational opportunities to the public.

2. The model developed in this study permits decisions to be made based on complete information about the economic aspects of a beach acquisition

policy but the model must be applied on a case by case basis.

3. The most significant costs likely to be encountered are those involved in actually purchasing the beach properties. The most significant benefits are likely to be those of increased tax income to the State economy from the expenditures of beach park users.

4. Further work must be undertaken in order to fully utilize the model. Of prime importance will be improved estimation of subsidy levels for the National Flood Insurance Program and the Small Business Administration Loan Program. Improved estimation of this data will only come with improved federal record keeping and improved projections of future storm damage. Also of importance will be better estimates of future park usage for coastal beach parks.